GLOBAL CONFERENCE ON ENGINEERING AND TECHNOLOGY MANAGEMENT

"Gaining a Competitive Edge through Engineering and Technology Management"

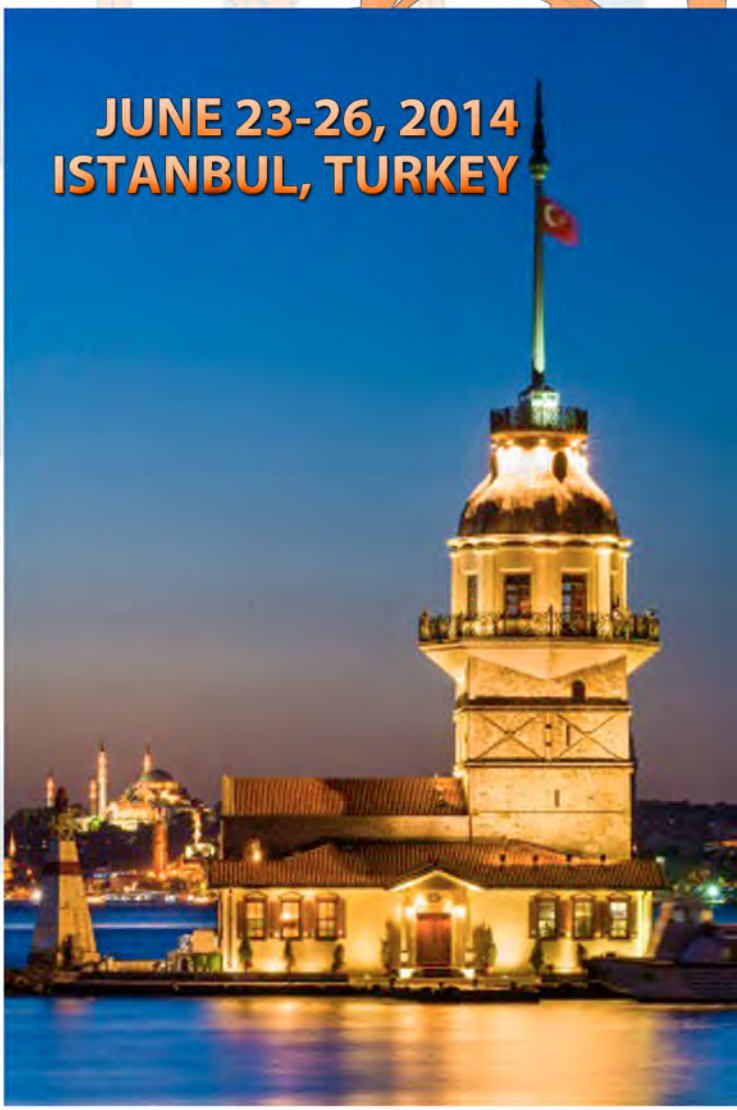


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of

Global Conference on Engineering and Technology Management 2014





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Global Conference on Engineering and Technology Management

"Gaining a Competitive Edge Through Engineering and Technology Management"

23rd to 26th June 2014

Istanbul - Turkey

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Accepted Papers Received from the Following Countries:



Australia, Austria, China, Germany, Iran, Jordan, Lebanon, Libya, Pakistan, Romania, Russia, Saudi Arabia, Thailand, Turkey, United Kingdom (UK), United States (USA)

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WELCOME MESSAGE FROM CONFERENCE CHAIR



Fethi Calisir, PhD.

Dean, Faculty of Management

Istanbul Technical University, TURKEY

On behalf of the GCETM 2014 Organizing Committee, I welcome you to the GCETM 2014 in Istanbul, Turkey. The GCETM will be a forum for academics, managers and solution providers, which brings together researchers and practitioners from all over the world, promoting opportunities to share experiences, debate ideas, identify tendencies, and introduce the latest developments in the largely multidisciplinary fields of Engineering & Technology Management. This will be accomplished through the following three modes of communication: keynote presentations, parallel sessions, and poster sessions. This is especially important since these fields can largely benefit from increased collaboration.

The world is transforming at an unprecedented rate and companies' efforts to turn themselves into better competitors in the emerging world are attracting growing attention across the globe. The GCETM 2014 will shed light on the role of engineering and technology management in this endeavor. We have a great program and fantastic keynote speakers this year. The participants will receive a wide range of perspectives of industrial and scientific approaches and out of academia knowledge from our esteemed keynote speakers.

The GCETM 2014 will be held at Istanbul Technical University, Management Faculty, Macka Campus. Istanbul Technical University prides itself on being the third oldest university in the world. Istanbul is the only city in the world built on two continents. Its rich history has given it a multitude of museums, historical buildings and mosques, Byzantine churches and Roman aqueducts. This exciting venue is alive with the hustle and bustle of business and trade which for centuries has made it a vital trading hub between east and west. Straddling Europe and Asia, Istanbul is the largest and most monumental city in Turkey, and is a melting pot of cultures which mix harmoniously on both sides of a city split geographically by the Bosphorus strait. This bustling city is home to over 13 million people, and from 23 to 26 June 2014, will also be home to the GCETM 2014.

I would like to welcome you to the GCETM 2014 and wish you a wonderful time in Istanbul, Turkey!

Best regards,

Fethi Calisir, PhD.
Conference Chair

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TOPICS

Engineering and Technology Management Education and Training

Engineering and Technology Management in Developing Countries

Engineering and Technology Management in Service Industries

Engineering and Technology Management in Small and Medium Enterprises

Human Factors in Engineering and Technology Management

Human Resources in Engineering and Technology Management

Information and Communication Technology Management

Innovation and Entrepreneurship

Managing Emerging Technologies

New Product Development

Project Management

R&D Management

Science and Technology Policy and Regulations

Science and Technology Parks

Strategic Management

Supply Chain Management and Logistics

Sustainability and Technology Management

Technology and Competitiveness

Technology and Knowledge Management

Technology Foresight and Forecasting

Technology Transfer, Marketing, and Commercialization

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KEYNOTE SPEAKER

The Role of Management Science in Engineering Management: An Example from Enterprise (Accounting) Risk Management



Professor Sardar M. N. Islam

Victoria University

Melbourne, Australia

Opening Keynote Speaker, June23, 2014

Keynote Abstract

Management science or quantitative models play an important role in engineering management. An important area of engineering management where this role of management science has not been explored enough yet is the area of accounting risk management which is an essential part of enterprise risk management. This emerging area of accounting risk management (i.e., analyzing, modelling and managing accounting risks) is a relatively new research agenda. In addition, accounting risk management is imperative for improved enterprise risk management and corporate governance, and for avoiding corporate collapses, financial crises and economic slowdowns as an evidence of improved engineering management. Analyzing and managing accounting risks by adopting management science models is useful for enterprise risk management to be effective. Some of the management science models which can be applied for accounting risk management include the following: 1. risk analyzing methods including risk measures such as variance, probability of loss; risk prediction methods, and other statistical and econometric methods for accounting risk analysis and management; 2. optimization methods for accounting risk management including the following conventional deterministic optimization methods (liner programing, non-linear programming, etc.) and optimization under uncertainty (simulation optimization, stochastic, scenario and robust optimization, decision (tree) analysis, etc.). Stakeholders, such as engineers, need to contribute to these research agenda and risk management practices for achieving good engineering management via accounting risk management to avoid corporate, financial and economic risks and crises.

Bio: Professor Sardar M. N. Islam is Professor of Business, Economics and Finance; and Director, Decision Sciences & Modelling Program, Victoria University, Australia. He has also been appointed as a Visiting Professor of Management Science. One of the areas of Professor Islam's specializations is Applied Managements Science/ applied quantitative modelling. He is currently undertaking research, teaching and doctorate supervision work in Applied Management Science addressing issues in a wide

range of disciplines in accounting, economics, finance, business, and law. He has published 21 finance, accounting, business, economics and law research books. Each of these books makes significant secular scientific contributions to the literature and most of these books are published by very prestigious publishers in their highly regarded book series. Many university libraries around the world including all top universities such as Harvard, Cambridge, etc. have many of his books. He has published many articles (total about 200) including journal articles in international journals (including 3 A*, 15 A, 19 B & 16 C grade journal articles and a good number of articles in other indexed and reputed journals) such as the following leading journals: Journal of Optimization Theory and Applications, Review of Quantitative Finance and Accounting, Economic Modelling, and Journal of Policy Modelling. He is the Principal Supervisor of a big group of doctoral (PhD and DBA) students in Management Science addressing issues in Finance, Accounting, Economics, Supply Chain Management/Applied Industrial engineering, and Business. He has successfully completed a good number (total 18) of doctoral (PhD and DBA) students, many of these students have done very well in their careers. He has been actively involved in teaching (full subject) or guest lecturing for different DBA subjects at Victoria University since 1995 (for 18 years).

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KEYNOTE SPEAKER

Technology Management Practices in a Growing Company



Iffet Iyigun Meydanli,

Arcelik A.S.

Turkey

Second Day Keynote Speaker, June 24, 2014

Keynote Abstract

In the last 25 years, parallel to Turkish economy Arcelik A.S. (A global home appliance company based in Turkey) has been transformed its operations from a licensee company to a technology leading company. One of the main factors behind this transformation is establishment of R&D activities. We'll discuss the role of technology management practices for such a change. The use of technology management tools advantages as well as the challenges and difficulties will be shared as well.

Bio: Ms. Iyigun Meydanli, has graduated from Bogazici University (Istanbul, Turkey) Mechanical Engineering Department. She continued to her education at Portland State University – Engineering Management Program.

She had started to work as R&D Engineer at Arcelik R&D Center and continue to her career as R&D Specialist. Since 2003, she has been working as R&D Manager with main responsibilities on project management, R&D management, technology planning and innovation. As being one of the first members of Arcelik R&D Center, she has more than 20 years' experience on different perspectives of R&D management.

Main mission of her responsibility is to integrate strategic focus of research as a part of Arçelik strategies. As a part of technology management process at Arcelik, her team is coordinating the product – technology road mapping and technology radar activities. One of her current assignments is, to initiate open innovation activities and projects to identify new areas for collaboration with the right partners.

During her studies; she had established Project Offices for effective management of Project portfolio at different locations of Arcelik. To obtain and utilization of different R&D funds for R&D Project Portfolio including EU funds, is also a part of her department job. Ms. Iyigun Meydanli was a team member of TUBITAK – Vision 2023 Foresight Project, Machine – Materials sub-group. She is the author of more than 15 papers, including a book chapter on knowledge management.

DAY 1: June 23, 2014 (Monday)

09:00 – 10:00 **Opening Keynote Speaker:** "The Role of Management Science in Engineering Management: An Example from Enterprise (Accounting) Risk Management", *Professor Sardar M. N. Islam*, Victoria University, Melbourne, Australia

Session	1 F-133	Technology Transfer, Marketing, and Commercialization Chair: Umut Asan	
10:00	An Empirical Analysis for Measuring Technology Transfer Performance of US Universities	Isikli E., Istanbul Technical University, Turkey	

Session	2 F-135	Engineering and Technology Management in Developing Countries Chair: Alp Ustundag	
10:00	Effective Energy Management Through Effective Systems Engineering	Fechtelkotter P., IBM, USA Amaba B., IBM, USA Tufekci O., IBM, Turkey Cakmak K., IBM, Turkey Soyler Akbas A., University of Central Florida, USA	

Session	3 F-133	Engineering and Technology Management in Service Industries Chair: Emre Cevikcan	
11:00	Reference Model Application for Large Scale Industry Management	Valeev S., Ufa State Aviation Technical University, Russia Kondratyeva N., Ufa State Aviation Technical University, Russia	
11:30	A Lean Approach To Process Management In Public Institutions By Applying Value Stream Mapping Techniques	Bal A., Istanbul Technical University, Turkey Budak A., Istanbul Technical University, Turkey Durmusoglu M.B., Istanbul Technical University, Turkey	
12:00	Development of a Prediction System for Ship Fuel Consumption using a Least Median of Square	Bal E., Istanbul Technical University, Turkey Arslan O., Istanbul Technical University, Turkey	

Session	4 F-135	Innovation and Entrepreneurship Chair: Erkan Isikli	
11:00	Creativity in Precipitation of Oil Cooling Tanks, in Plastic Injection Molding Machine, Using the ARIZ 71 Algorithm	Harsej F., Islamic Azad University Branch Nour, Iran Mohajeri S., Islamic Azad University Branch Nour, Iran	
11:30	The Effect of Organizational Learning, Transformational Leadership and Market Orientation on Firm Performance	Calisir F., Istanbul Technical University, Turkey Altin Gumussoy C., Istanbul Technical University, Turkey Basak E., Istanbul Technical University, Turkey Gurel G., Istanbul Technical University, Turkey	

Session	4 F-135	Innovation and Entrepreneurship Chair: Erkan Isikli	
12:00	Use of Cognitive Maps for Investigating the Success Factors of Innovation Technologies in Service Sector	Isik M., Istanbul Technical University, Turkey Ozaydin O., Dogus University, Turkey Celepcikay O., Dogus University, Turkey	

Session	5 F-133	Supply Chain Management and Logistics Chair: Mirela Sohaciu	
13:30	Information Technology, Information Systems Management and Supply Chain Management Applications in Logistics Industry	Suder A., Istanbul Technical University, Turkey	
14:00	An Application With Fuzzy VIKOR to Supplier Selection	Yazici I., Istanbul Technical University, Turkey Akman G., Kocaeli University, Turkey Alkan A., Kocaeli University, Turkey	
14:30	Proposed of a Grey System for Return Weee Product Quantity Forecasting in Reverse Logistics Network	Ayvaz B., Istanbul Commerce University, Turkey Bolturk E., Istanbul Technical University, Turkey Kactioglu S., Istanbul Commerce University, Turkey	

Session	6 F-135	Sustainability and Technology Management Chair: Ali Turkyilmaz	
13:30	Maintenance Management of Production Systems with Sensors and RFID: A Case Study	Bal A., Istanbul Technical University, Turkey Satoglu S.I., Istanbul Technical University, Turkey	
14:00	Technology Roadmapping and Acquisition Planning in Aerospace Sector	Kara G., Turkish Aerospace Industry (TAI), Turkey Solakoglu E., Turkish Aerospace Industry (TAI), Turkey Gokpinar S., Turkish Aerospace Industry (TAI), Turkey	

Session	7 F-133	R&D Management Chair: Mehmet Sevkli	
15:30	Agile Technology Development: A Model for Turkish Aerospace Industry	Songur E., Tusas Engine Industries Inc. (TEI), Turkey Gokce E., Tusas Engine Industries Inc. (TEI), Turkey Toprak S., Tusas Engine Industries Inc. (TEI), Turkey	
16:00	Lean Principles in R&D Projects	Al E., Fatih University, Turkey Ali Z., Fatih University, Turkey Türkyılmaz A., Fatih University, Turkey Zaim S., Istanbul Technical University, Turkey	

Session	8 F-135	Information and Communication Technology Management Chair: Sule I. Satoglu
15:30	Factors Affecting the Use of E-Learning System among Undergraduate Students in Turkey: An Extended TAM	Altin Gumussoy C., Istanbul Technical University, Turkey Kisa O., Istanbul Commerce University, Turkey
16:00	Human Capital Development by Improving the Environmental Engineer Skills with Master Programs	Sohaciu M., University Politehnica Bucharest, Romania Predescu C., University Politehnica Bucharest, Romania Ecaterina Matei E., University Politehnica Bucharest, Romania Csáki I., University Politehnica Bucharest, Romania Berbecaru A., University Politehnica Bucharest, Romania

DAY2: June 24, 2014 (Tuesday)

09:00 – 10:00 **Keynote Speaker:** "Technology Management Practices in a Growing Company", *Iffet Iyigun Meydanli*, Arcelik A.S., Turkey

Session	9 F-133	New Product Development *Chair: Ayberk Soyer*	
10:00	The Role of Contemporary Marketing Tools in Concurrent Engineering		Ozturk N., Marmara University, Turkey Vayvay O., Marmara University, Turkey
Session	10 F-135	Technology and Competitiveness Chair: Cigdem Altin Gumussoy	
10:00	Dynamic Modeling of Critical Factors in Energy Service Contracting Using Fuzzy Time Cognitive Mapping		Kadaifci C., Istanbul Technical University, Turkey Kucukyazici G., Istanbul Technical University, Turkey Asan U., Istanbul Technical University, Turkey Bozdag E., Istanbul Technical University, Turkey
Session	11 F-133	Information and Communication Technology Management Chair: Sagit Valeev	
11:00	Information Technology and Security Policy for Organizations and Applications in Istanbul Technical University		Suder A., Istanbul Technical University, Turkey
11:30	Development of a Framework to Enhance Information Provisioning Support for Site-based Construction Workers in The Kingdom of Saudi Arabia		Alaboud N., University of Salford, UK Zeeshan A., University of Salford, UK
Session	12 F-135	Technology and Knowledge Management Chair: Gulgun Kayakutlu	
11:00	A Methodology with Analysis of Production Management in ERP Systems: A Case Study in an Industrial Sector		Erbiyik H., Yalova University, Turkey Erdil A., Yalova University, Turkey
11:30	RFID Based Warehouse Management System in the Wool Yarn Industry		Ustundag A., Istanbul Technical University, Turkey Oner M., Istanbul Technical University, Turkey
12:00	Measuring the Efficiency of Intellectual Capital: for the Case of Fabricated Metal Products, Machinery and Equipment Sector		Calisir F., Istanbul Technical University, Turkey Isik M., Istanbul Technical University, Turkey Bayraktaroglu A.E., Istanbul Technical University, Turkey

Session	13 F-133	Human Factors in Engineering and Technology Management *Chair: Seyda Serdar Asan*	
13:30	Balancing U-Shaped Assembly Lines by Considering Human Factors	Oksuz M.K., Istanbul Technical University, Turkey Satoglu S.I., Istanbul Technical University, Turkey	
14:00	Analysis of Factors Affecting Satisfaction Level of Employees: A Case Study of Heavy Mechanical Complex, Taxila, Pakistan	Rukh L., University of Engineering and Technology, Pakistan Choudhary M.A., University of Engineering and Technology, Pakistan Abbasi S.A., King Fahd University of Petroleum and Minerals, Saudi Arabia	

Session	14 F-135	Technology Foresight and Forecasting *Chair: Tufan Vehbi Koc*	
13:30	Reintroducing the Technology Life Cycle into Technological Forecasting: Reconceptualization and a Model of System Disaggregation	Hauptman O., University of Western Sydney, Australia Intepe G., Istanbul Technical University, Turkey	
14:00	Modeling a National Policy Making in the Areas of Superconducting Technology Development Based on Technology Foresight	Attari M., Amirkabir University of Technology, Iran Rahmati F.S., BTF Institute, Iran	

Session	15 F-133	Project Management Chair: Selim Zaim	
15:00	Significant Factors Affecting the Selection of the Appropriate Project Delivery Method in Electricity Company's Projects	Alebarkous A., General Electricity Company of Libya, Libya Aburwees A.F.A., General Electricity Company of Libya, Libya	
15:30	Sales Quotation and Order Process Value Stream Mapping: A Case Study	Baysan S., Istanbul Technical University, Turkey Durmusoglu M.B., Istanbul Technical University, Turkey	

Session	16 F-135	Information and Communication Technology Management Chair: Umut Asan	
15:00	The Evaluation of Implementation Levels for RFID Applications using Fuzzy Information Axiom	Cevikcan E., Istanbul Technical University, Turkey Ustundag A., Istanbul Technical University, Turkey	
15:30	A Research on Measuring Computer Network System Productivity and Efficiency with Simulation Modeling	Salkin S.C., Istanbul Technical University, Turkey	

DAY3: June 25, 2014 (Wednesday)

Session	17 F-133	Special Session (in Turkish)	
09:00	Ulusal Akademik Ar-Ge Proje Destekleri, *Fatih Sinan Esen*, TÜBİTAK – ARDEB., Turkey		
Session	18 F-133	Special Session	
10:00	American Society for Engineering Management (ASEM) - Master's Program Certification		
Session	19 F-133	Supply Chain Management and Logistics Chair: Ben Baliga	
11:30	Approximations to Aggregated Orders Bullwhip Effect Variance in Two-Echelon Supply Chains	El-Tannir A.A., Beirut Arab University, Lebanon	
12:00	Modeling a Stochastic Multi-objective Order Allocation Problem in Uncertain Supply Environment	Liu X., Dalian University of Technology, China Li Z, Dalian University of Technology, China He L., Dalian University of Technology, China Nan Zhang, Dongbei Special Steel Group Co., Ltd., China	
Session	20 F-135	Innovation and Entrepreneurship Chair: Hulya Behret	
11:30	Identifying the Need for Innovation Risk Management	Boothe K.O., Karlsruhe Institute of Technology, Germany Kasteren T.V., AGT International, Germany Terzidis O., Karlsruhe Institute of Technology, Germany	
12:00	A Literature Based Model to Measure Innovation Capability	Calisir F., Istanbul Technical University, Turkey Argun B., Yalova University, Turkey Calik E., Yalova University, Turkey	
Session	21 F-133	Human Factors in Engineering and Technology Management Chair: Akram A. El-Tannir	
13:30	A Study to Evaluate the Familiarity and Usage of Theories of Motivation	Baliga B., St. Cloud State University, USA Shah H., St. Cloud State University, USA Bista M., St. Cloud State University, USA Chebolu V., St. Cloud State University, USA	
14:00	Effects of CIOs' Positive Characteristics and Competencies on their Perceived Management Effectiveness in a Transformed IS Organization	Yokkhun A., University of Vienna, Austria Quirchmayr G., University of Vienna, Austria Chutimasakul W., King Mongkut's University of Technology Thonburi, Thailand	

Session	21 F-133	Human Factors in Engineering and Technology Management Chair: Akram A. El-Tannir	
14:30	Enhancing Health & Safety Management in Construction Sites by Using Mobile Computing in Saudi Arabia	Balgheeth Y., University of Salford, UK Alaboud N., University of Salford, UK Zeeshan A., University of Salford, UK	

Session	22 F-135	Engineering and Technology Management in Service Industries Chair: Basak Argun	
13:30	Lean Manufacturing Principles Applied to University Library: A Lean Library	Kantar S., Fatih University, Turkey Shahbaz M., Fatih University, Turkey Turkyilmaz A., Fatih University, Turkey	
14:00	Alliance Management Process Design With Design for Six Sigma	Tuna B., Erciyes University, Turkey Behret H., Erciyes University, Turkey	
14:30	A Review of Small Scale Distributed Power Generation Technologies Using Solar Energy	Ghozzi S., The University of Nottingham, UK Boukhanouf R., The University of Nottingham, UK	

Session	23 F-133	Strategic Management Chair: Alp Ustundag	
15:30	A Model Suggestion for Measuring Dynamic Capabilities	Gul S., Halic University, Turkey Soyer A., Istanbul Technical University, Turkey Cevik Onar S., Istanbul Technical University, Turkey	
16:00	Conceptualization of Organizational Modularity	Eris O.U., Istanbul Technical University, Turkey Soyer A., Istanbul Technical University, Turkey Umut Asan U., Istanbul Technical University, Turkey	
16:30	Developing Strategic Plan for Manufacturing Companies Located in Developing Countries	Bataineh K., Jordan University of Science and Technology, Jordan	

Session	24 F-135	Project Management Chair: Atcharaporn Yokkhun	
15:30	Total Quality Management of Projects in the Saudi Construction Industry: A Critical Review	Hijazi S., The University of Salford, UK Aziz Z., The University of Salford, UK	
16:00	Current Status of Offsite Construction in Saudi Arabia	Almutairi Y., The University of Salford, UK Arif M., The University of Salford, UK	

DAY4: June 26, 2014 (Thursday)

Session	25 F-133	Human Resources in Engineering and Technology Management Chair: Emre Cevikcan	
10:00	An Application of MCDM in Competence Sourcing	Erensal Y.C., Istanbul Okan University, Turkey	

Session	26 F-135	Managing Emerging Technologies Chair: Asli Suder	
10:00	Potentials of Laser Technologies in Processing Panel Display Glass	Grochowski E.M., University of Stuttgart, Germany Dewes K., University of Stuttgart, Germany Heber D., University of Stuttgart, Germany	

Session	27 F-133	Supply Chain Management and Logistics Chair: Selim Zaim	
11:00	A Web Based Optimization System for Supply Chain Network	Ustundag A., Istanbul Technical University, Turkey Budak A., Istanbul Technical University, Turkey Oner M., Istanbul Technical University, Turkey	
11:30	Creativity in Supply Chain Performance of Eram Sanat Company by Using the ARIZ71 Algorithm	Harsej F., Islamic Azad University Branch Nour, Iran Mohajeri S., Islamic Azad University Branch Nour, Iran	

Session	28 F-135	Strategic Management Chair: Yasemin Claire Erensal	
11:00	Strategic Evaluation of High Technology Companies Based on Game Theory and Hierarchical Balanced Scorecard	Oleyaei-Motlagh S.Y., Islamic Azad University, Iran	
11:30	Risk Management Efficiency Analysis in Banks Using Data Envelopment Analysis (DEA) Approach Based on Hedge Accounting: Perspectives and Implications	Zakaria S., Victoria University, Australia Islam S.M.N., Victoria University, Australia	
12:00	Assessment of Sustainability Performance Indicators in Manufacturing	Eseoglu G., Marmara University, Turkey Vayvay O., Marmara University, Turkey Simsit Z.T., Marmara University, Turkey	

An Empirical Analysis for Measuring Technology Transfer Performance of US Universities

Erkan Isikli
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Macka, Istanbul 34367, Turkey

Abstract

Research and technological innovation are two of the most important purposes of modern universities. In the US, following the Bayh-Dole Act, universities have established technology transfer offices (TTOs) to share their latest technologies and knowledge with other parties in the community and they are surveyed annually by the Association of University Technology Managers (AUTM) on their patenting, licensing, and related activities. There has been a debate on how to treat the metrics measured in this survey, especially when employing efficiency methods such as data envelopment analysis (DEA) and stochastic frontier analysis (SFE). In this study, the AUTM data from 2000 to 2008 were examined to discover which metrics should be used together when analyzing university technology transfer activities. Canonical correlation analysis was employed in the first part of our two-stage approach and its results were used in the next stage to find out whether having a medical school or being in a given region has an effect on technology transfer. Canonical correlation analysis allows for both metric and non-metric variables unlike a traditional factor analysis; however, using this method, only a single relationship between inputs and outputs can be obtained. Structural Equation Modeling (SEM) can offer a solution to this problem if a strong theoretical background for the relationship between inputs and outputs are obtained.

Keywords

University technology transfer, AUTM data, canonical correlation, clustering.

1. Introduction

Along with providing higher education, one of the main purposes of universities is research and therefore technologic innovation. In this context, technology transfer offices (TTOs) in universities play an important role in identifying the latest significant research, and sharing technologies and knowledge with other institutions and the public. Today, most of the universities have TTOs that provide faculty and researchers with patenting, licensing, and other commercialization support. Powers (2003) defined university technology transfer as the process of transforming university research into marketable products. Following the Bayh-Dole Act of 1980, which provides US universities the rights and incentives to control their inventions and other intellectual property that resulted from federal government funding, US universities attempted to formalize technology transfer by establishing technology transfer offices (TTOs). Basically, TTOs transmit technological innovation from laboratories to industries.

The number of TTOs has increased substantially over the course of time since the Bayh-Dole Act was enacted. There were about 20 TTOs in 1980; today nearly every major research university has such a unit (Markman *et al.*, 2004). Several products from a wide variety of industries have been developed through university technology transfer such as Boyer–Cohen “gene-splicing” technique, Richard Axel’s co-transformation process, Fax technology, Taxol, Vitamin D technologies, the Cisplantin cancer treatment drug, Gatorade (Feldman *et al.*, 2002; Powers, 2003). However, the road to market is rough. For every 100 invention disclosures, 10 patents and 1 commercially successful product result.

US universities are surveyed annually by AUTM, a professional association governed by and for TTO officers, regarding their technology transfer activities. The information obtained by AUTM has been a great source for research on university technology transfer. Most of the studies that used this data have focused on determining the intertemporal efficiency of universities in transmitting technology in which Data Envelopment Analysis (DEA) and

Stochastic Frontier Estimation (SFE) have been adopted the most often. AUTM data consists of various variables, some of which can be treated as an input of technology transfer, while some of which are indisputable outputs. How to treat these variables might be context dependent as some of them can be used both as an input and an output of technology transfer process. For instance, patents, number of disclosures, and industry sponsored research are an intermediate good as well as a final product (Thursby and Kemp, 2002; Jensen and Thursby, 2001).

In this study, the most fundamental outputs of the innovative power of US universities and their determinants are explored by employing canonical correlation analysis (CANCORR) and clustering analysis. Specifically, the study addresses four main research questions:

1. What are the main inputs and outputs of the technology transfer activities and how are they related?
2. Does having a medical school make any difference at all?
3. How do the skills of universities in transferring new technology change in time?
4. Do universities differ across regions based on their effectiveness in technology transfer?

Measuring the efficiency of US universities or comparing their efficiencies is not aimed in this study. Instead, a data-driven approach was adopted to easily retrieve information on the relationship between inputs and potential outputs of university technology transfer.

2. Literature Review

The technical efficiencies of the North American and European universities has been the primary focus of the related literature (Caldera & Debande, 2010; Siegel *et al*., 2008; Anderson et. al., 2007; Chapple et. al., 2005; Markman et. al., 2005; Markman et. al., 2004; DiGregario and Shane, 2003; Siegel et. al., 2003b; Siegel et. al., 2003a; Powers, 2003; Feldman et. al., 2002; Thursby and Kemp, 2002; Thursby and Thursby, 2002; Thursby et. al., 2001) and there has been a small effort to build a metric that measures the efficiencies of institutions in their technology transfer activities (Sorensen & Chambers, 2008). Ho *et al*. (2013) proposed a two-stage model to measure the efficiencies of US universities in technology transfer, where output factors of the first stage (innovation research) served as inputs in the next stage (value creation). A total of seven variables, which represent funding resource, patenting activities, and licensing and entrepreneurships, were used in their data envelopment model.

Friedman, J. and Silberman, J. (2003) employed regression analysis using AUTM data from fiscal years 1997 to 1999. The authors analyzed the factors affecting the number of invention disclosures (ID) at the first stage, and then they treated ID as an input at the second stage when estimating technology transfer output of a university. They concluded that greater rewards for faculty involvement in technology transfer, location of the university in a region with a concentration of high technology firms, a clear university mission in support of technology transfer and the experience of the university's technology transfer office would enhance university technology transfer. Chukumba and Jensen (2005) modeled the problem as a multistage game with four players: the TTO, the inventor, an established firm, and an investor/entrepreneur. They found that TTOs have significantly influenced university licensing. Their results indicate positive and significant impacts of the TTO age and the number of disclosures made to the TTO on licensing to either start-ups or established firms. On the other hand, TTO size has no effect on start-ups, but does increase licenses. Conversely, universities that earn greater licensing royalties have fewer start-ups but more licenses (Chukumba and Jensen, 2005).Bulut and Moschini (2009) conducted an econometric analysis of university licensing income and found that most of the revenue gains were concentrated in private universities with medical schools. The authors estimated quantiles of the distribution of net licensing returns conditional on some of their structural characteristics. The quantile regression is used since the distribution of net economic returns of US universities is highly skewed.

In the search of a more balanced metric that focuses on the mission of the research institution instead of patents and money it accumulates, Sorensen and Chambers (2008) suggested an advancement of the conventional technology transfer metrics by tracking citation analysis, research exemptions, humanitarian use exceptions, alliance management, exclusivity shifting, capacity building in developing regions, open source business modeling and patent pooling or bundling for incremental or related technologies, where possible.

There has been no research focusing on the relationship between/within potential outputs and inputs of university technology transfer (UTT). However, it has been discussed several times that there are multiple outputs of UTT and that studies should definitely consider this fact. This study aims to fill this research gap by using canonical

correlation analysis (CANCORR) that helps to find the set of inputs and the set of outputs that are maximally correlated with each other as an input.

3. Data and Variables

A panel data set covering the fiscal years 2000-2008 was drawn from AUTM's database, which contains information on many aspects of university technology transfer. The variables that have been traditionally used in the literature can be classified as inputs and outputs; or organizational variables and regional variables as shown in Table 1 below:

Table 1: Classification of university technology transfer metrics measured by AUTM

Inputs	research expenditure, research quality (faculty quality), TTO size (full time employees in TTO), TTO experience (age: the length of time a university has had a TTO), industrial R&D, legal expenditures, invention disclosures
Outputs	number of patents, number of licenses, number of university spin-offs, royalty revenue, licensing income
Organizational (Institutional) Variables	private school dummy, medical school dummy, engineering school dummy, university science park dummy, incubator dummy, TTO age and size
Regional (Environmental) Variables	R&D intensity of local firms, the availability of venture capital, state-level economic growth (a proxy for the ability of firms in the local region to sponsor R&D at the university)

Based on previous research along with exploratory analysis, nine were selected out of 28 variables provided with the AUTM data: number of cumulative licenses (NOCLIC), equity (EQUITY), number of licenses generating more than 1 million dollars (MAJOR), number of startups (STARTUPS); TTO experience (EXPERIENCE), TTO size (SIZE), legal fees reimbursements (FEE), funding from federal government (FEDGOV), industrial funding (INDUSRTY). The first four variables have been conventionally treated as outputs. It has been debated that EXPERIENCE can both enhance and impair technology transfer. Thursby and Kemp (2002) also claimed that industry sponsored research can be both treated as an output and an input, since it is, in part, an 'intermediate good' as well as a 'final product. Therefore, any results regarding these two variables should be carefully approached.

Fukugawa (2009) reported that proxy variables used as an input of technology transfer include the research expenditure of the university, the research quality of the faculty, the size and experience of TTOs, and the incentive mechanisms for faculty and TTO employees. The output of university-based technology transfer programs are represented in terms of the number of patented university inventions, the number of licensed university patents, the number of university spin-offs, the total factor productivity of university licensing, and royalty revenue. However, as Siegel *et al*. (2008) stated, the importance of patents in this process is often overstated. They explained that many firms license technologies long before the university patents them and some of them may not even be patented. The authors also added that patents were not important in the computer software industry or in the design of integrated circuit. According to Siegel et al. (2008), relative efficiency in university technology transfer is also likely to be related to environmental and organizational factors such as the presence of a medical school on campus, the type of university (public or private), the existence of a university science park, incubator, and region. Similarly, Phan and Siegel (2006) mentioned that the extant literature on TTOs suggested that the key impediments to effective university technology transfer tended to be organizational in nature. Thursby and Thursby (2002) excluded two widely exposed metrics in the measurement of technology transfer efficiency: ''patent issued'' and ''licensing income''. This is because of the time lag involved in the process of converting key inputs into those two outputs in their respective stages.

After partial correlations and variance inflation factors were calculated, in line with the information provided by the related literature, variables such as royalty revenue, research expenditure, number of patents, number of new patent applications, and number of total patent applications were excluded since they might cause multicollinearity in further analysis.

Canonical correlation analysis (CANCORR) aims to develop a linear combination of each set of variables so that the correlation between the two sets is maximum. It requires linearity assumption satisfied; however, normality and

homoscedasticity are not required. Unless there is a reason, it is also not necessary to check for multicollinearity (Tabachnick & Fidell, 2007). Bivariate correlations and variance inflation factors did not signal multicollinearity problem. Logarithmic transformations were applied to the variables in hand so that any violation to linearity assumption is prevented and the effects of potential outliers are minimized. 1241 observations were left after handling outliers and calibrating for missing values. There are more than 15 cases per variable, thus more than 80% of reliability is anticipated (Tabachnick & Fidell, 2007). CANCORR was performed on data for each year separately and the estimation results were compared with those obtained from a "pooled" model that combines time series for the cross sections.

It is first aimed to find two sets of variables, derive a set of weights for each set of inputs and outputs so that the linear combinations of each set are maximally correlated, and explain the nature of whatever relationships exist between these two sets. Then, the best combination of inputs and outputs are selected and their temporal effects are investigated to detect changes or abnormalities. Finally, the universities are clustered using proxies for organizational and regional variables along with the most significant canonical variate(s), and the clusters are analyzed.

4. Experimental Results

4.1. First Stage: Canonical Correlation Analysis

It is hypothesized that EXPERIENCE, SIZE, FEE, FEDGOV, and INDUSRTY (predictor variables) have an effect on NOCLIC, EQUITY, MAJOR, and STARTUPS (criterion variables). Four canonical correlations were obtained for each year separately and at $\alpha = 0.05$ only the first canonical correlation was found significant in all the subsamples. The second canonical correlation was also significant at $\alpha = 0.05$ excluding the fiscal year 2000; however, the remaining canonical correlations were insignificant in each subsample. Figure 1 illustrates how these four canonical correlations change over time. The first canonical correlation seems more reliable to use in further analysis as it is distinctly stable compared to the other three.

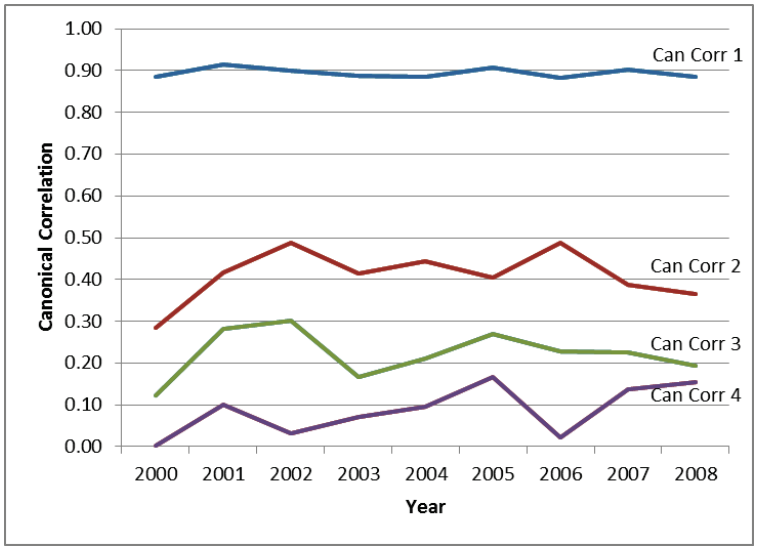


Figure 1: Canonical correlations by year

In addition, a pooled model was built to crosscheck whether the use of the first canonical correlation would be meaningful. CANCORR is vulnerable to the change of data and its results should be validated either using split sample or holdout analysis or some other methodology (Sharma, 1996). Combining time series for the cross sections led to canonical correlation estimates of 0.875, 0.367, 0.106, and 0.060, respectively. As seen in Figure 1, only the first canonical correlation does not heavily deviate from the corresponding pooled estimate, thus further analysis will not take into account the results regarding the other three.

In the pooled model, the redundancy analysis shows that the first canonical variate for the predictor variables extracts 41.3% of the variance in the criterion variables and 45.3% of the variance in the predictor variables,

whereas the first canonical variate for the criterion variable extracts 53.9% of the variance in the criterion variables and 59.1% of the variance in the predictor variables. The amount of variance accounted for by the remaining canonical variates is relatively small (max = 16.8%).

Only two of the four "pooled" canonical functions are significant at multivariate level. As seen in Table 1, the canonical loadings of the first canonical variate for the criterion variables suggest that NOCLIC has the biggest, whereas STARTUPS has the lowest influence on forming the first canonical variate. Similarly, SIZE and INDUSTRY are the most and the least important variables, respectively, in forming the first canonical variate for the predictor variables. The variables other than equity have loadings on the first variate greater than the practical threshold of 0.60, indicating a high degree of intercorrelation among these variables. So, all or one of these measures are representative of university's innovative power.

Table 2: Canonical loadings for each "Pooled" canonical variate

VARIABLES	CANVAR1	CANVAR2	CANVAR3	CANVAR4
NOCLIC	-0.975	0.222	-0.016	-0.026
EQUITY	-0.490	-0.290	-0.196	0.798
MAJOR	-0.711	-0.590	-0.342	-0.172
STARTUPS	-0.679	-0.314	0.661	0.059
EXPERIENCE	-0.789	0.448	-0.121	-0.388
FEE	-0.741	0.404	0.069	0.353
FEDGOV	-0.724	0.008	0.065	0.386
INDUSTRY	-0.621	0.040	0.707	0.123
SIZE	-0.935	-0.336	-0.064	-0.062

In this stage, each fiscal year was treated as a subsample of the original AUTM data and CANCORR was run for each subsample separately to validate CANCORR results since it is sensitive to data changes. Orthogonal transformation was also employed, but no significant change was observed. Due to limited space, transformation results were not reported; however, it is available upon request. Next, the first canonical variate for the criterion variables will be treated as a proxy of technology transfer efficiency and using dependence techniques with exploratory data analysis, it is aimed to demonstrate whether there are any regional and institutional effects on the efficiency scores. As mentioned before, technology transfer cannot be analyzed by considering only one type of output. Since the first canonical variate is a linear combination of possible outputs mentioned in the related literature and its behavior is more stable over time compared to the others, it is more reasonable to use it in further analysis instead of solely depending on one variable (output).

4.2. Second Stage: Clustering

About 45% of the universities included in the data set reported information in at most two fiscal years. Even though it is possible to build panel data models in such cases, working with unbalanced panels could be challenging and tiresome. In the first stage, without excluding any information by balancing the panel, canonical variates were formed for each fiscal year separately and the canonical correlation values were compared to the pooled estimate obtained by ignoring the time component. The results show that the first canonical correlation for criterion variables do not fluctuate heavily over time and its values are very close to the corresponding "pooled" estimate. Multivariate statistics also suggest that the first canonical correlation is statistically significant at $\alpha = 0.01$. Hence, further analysis considered only the results regarding this construct.

In this step, universities are clustered based on the proxy for technology transfer output (first canonical variate) along with a dummy variable that denotes whether the university has a medical school or not and a categorical variable that denotes the region (Northeast, Midwest, South, West) the university is located in. A dendrogram was drawn first to decide how many clusters should be formed. Gower dissimilarity measure was preferred since the set of variables contains a dummy variable. The cut-off was determined as 0.28 and four clusters were obtained. However, note that this is an exploratory analysis and one can choose a different cut-off point and pursue the analysis with preferably more or less clusters.

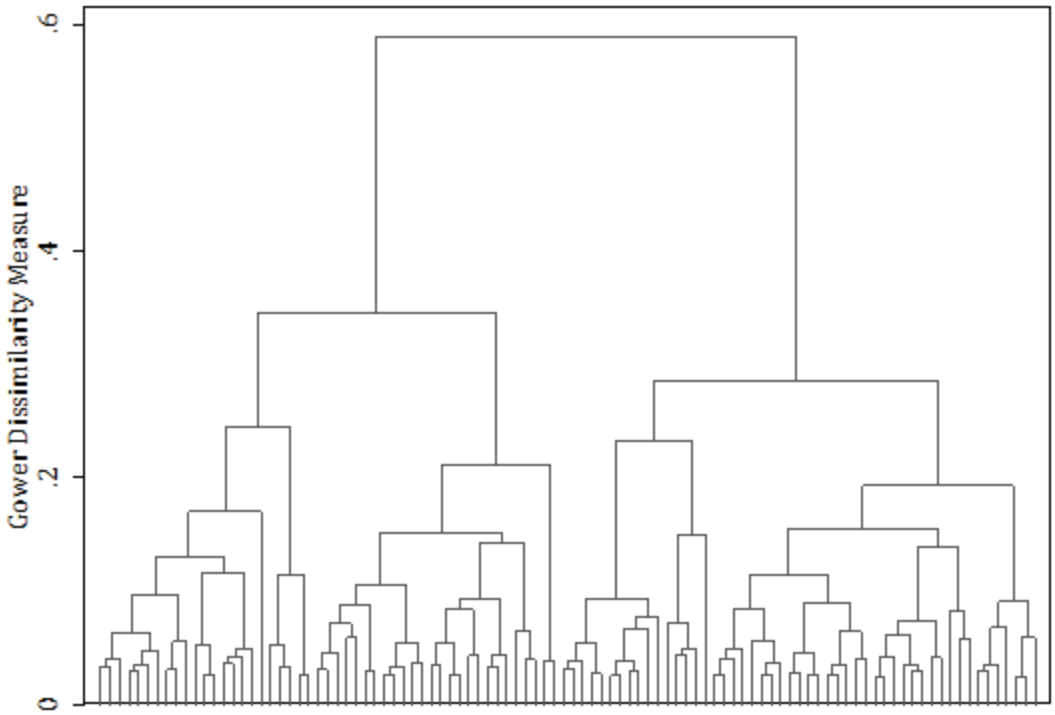


Figure 2: Dendrogram

Table 3 below shows the number of data points each cluster contains and the group means for each variable included in the analysis. Those universities in Cluster 1 have lower values on the variables considered and none of them has a medical school. Conversely, Cluster 4 consists of universities with higher values both on the criterion and the predictor variables.

Table 3: Cluster means

VARIABLE	MEAN CLUSTER 1	MEAN CLUSTER 2	MEAN CLUSTER 3	MEAN CLUSTER 4
MEDSCH	0	1	0	1
NOCLIC	3.419	4.361	3.969	4.855
MAJOR	0.118	0.470	0.233	0.580
STARTUPS	0.763	1.059	1.050	1.194
EQUITY	1.322	4.177	2.999	4.295
EXPERIENCE	4.595	5.319	5.198	5.597
FEE	8.582	11.746	10.743	12.508
SIZE	1.064	1.579	1.313	1.782
INDUSTRY	15.095	16.076	15.487	16.575
FEDGOV	17.584	18.462	17.982	18.923

Table 4 below shows that the second and the fourth clusters are composed only of those universities with a medical school (MS). The distinction is very clear; there is not even a single case where this rule is overruled. It does not seem possible to make a region-wise distinction between the clusters; however, an interesting result is that the second cluster contains only five universities from the West, whereas the third cluster contains only two universities from the Northeast.

Table 4: Distribution of universities based on region and presence of medical school

	Region & Medical School							
	Northeast		*Midwest*		*South*		*West*	
	NMS	*MS*	*NMS*	*MS*	*NMS*	*MS*	*NMS*	*MS*
Cluster 1	9	0	7	0	16	0	11	0
Cluster 2	0	15	0	13	0	19	0	5
Cluster 3	2	0	9	0	16	0	8	0
Cluster 4	0	7	0	13	0	19	0	6

Finally, Figure 3 illustrates the temporal change in the first canonical variate over time for those universities with a medical school and those lacking a medical school separately. Even though there are possible outliers in both groups, there is a clear difference between their efficiency scores. A university with a medical school can be expected to do a better job in transferring technology compared to those without a medical school.

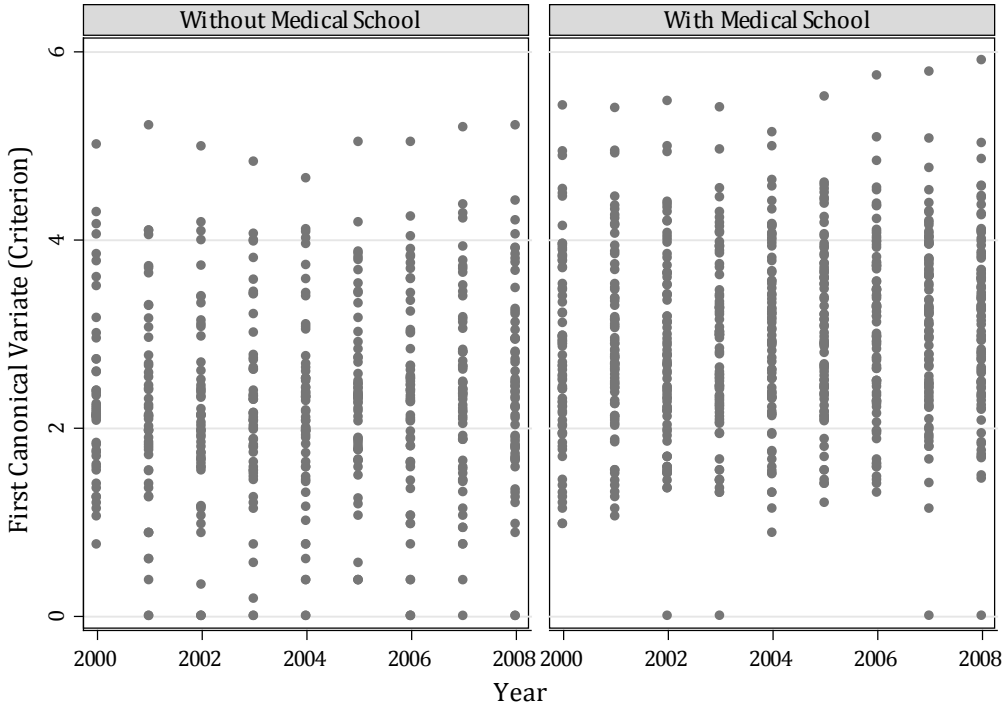


Figure 3: Intertemporal change of efficiency scores

5. Conclusion

TTOs serve as an entity that improves technology transfer between academia and industry. In the literature there has been a small effort to build a metric that measures the efficiencies of institutions in their technology transfer activities. No one has studied the relationship between/within potential outputs and potential inputs; however, everyone has agreed that there are multiple outputs of university technology transfer. The paper by Siegel et al. (2008) contains the first econometric evidence on the relative efficiency of university TTOs that is based on multiple outputs. Thus, upcoming research effort should be definitely put on this fact. In this study, at first CANCORR was employed to find the set of inputs and the set of outputs that are maximally correlated with each other, and then the universities are clustered using some extra variables such as the presence of a medical school in a university and the region the university is located in along with CANCORR results. In this setting, organizational variables such as size and experience of the TTO, and legal fees reimbursements have a positive effect on the number of cumulative licenses universities obtained.

Even though it will not imply any causal relationship, CANCORR can be useful in leading the debate on whether variables should be treated as an output or as an input of the licensing activities in the US universities. Why canonical correlation analysis instead of any other interdependence technique such as factor analysis? CANCORR allows for both metric and non-metric variables unlike a traditional factor analysis. It is a dependence technique that has become so popular in the last few decades. However, clustering with panel data under the objective of developing meaningful and mutually exclusive subgroups of a sample of entities can create an interesting literature stream should also be considered. Unlike discriminant analysis, the groups are not predefined in cluster analysis. Groups can be formed after running DEA and assigning inefficiency scores to universities. In this way, one can see whether the growth rates of US universities' efficiencies are similar. Zheng et.al. (2009) applied panel data clustering to discount rate of B Stock in China in order to avoid heterogeneity of the dependent variable before estimating any panel data models. This way it could be possible to account for the lagging effect of the inputs of university licensing activity on the output.

Only a single relationship between inputs and outputs can be obtained in canonical correlation analysis. Structural equation modeling could be very useful since it can reveal more than one relationship between variables. Variables such as patents, number of disclosures and industry sponsored research can be used both as an input and an output (Thursby and Kemp, 2002; Jensen and Thursby, 2001). It has been long debated that it is possible for the variables faculty quality and TTO experience can enhance or impair technology transfer. Structural equation modeling could improve CANCORR results in such cases where the multiple relationships of input and output variables are valid. The only downfall is that outputs must be metric.

Structural Equation Modeling can offer a solution to this problem; however, there is still a need to establish a strong theoretical background for the relationship of variables. A possible avenue for future research could be estimating the model illustrated in Figure 4 below and check its validity.

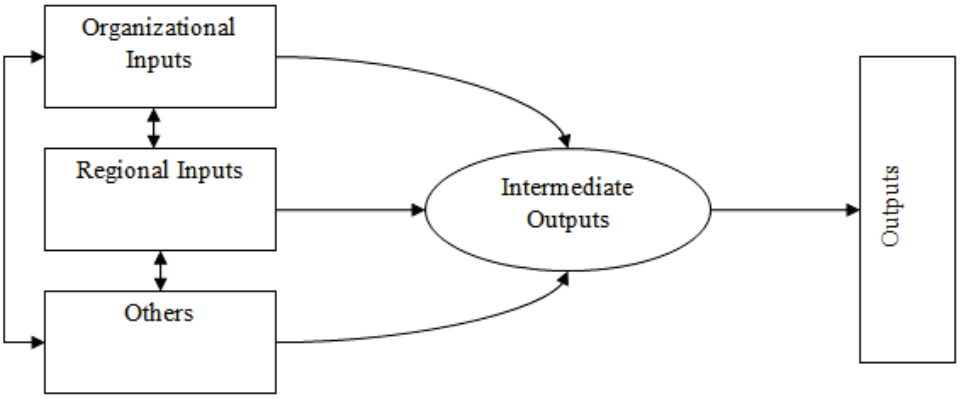


Figure 4: Outline for a possible structural equation model

The literature points out that the effect of one factor may not be observed in the current year, so lagging is necessary. Gregario and Shane (2003) explored whether lagging patent applications and invention disclosures changes the conclusions drawn when lagging is not considered. The results were found substantively the same; however, in this study, equity and startups were found relatively less important in predicting licensing activities. This might be due to ignoring the lagging effect and it is one the limitations of this study. Additional variables that account for regional effect, faculty quality, and economic performance are also necessary for an expansive future study.

Finally, non-stationary dynamic panel data modeling might be useful since the time period is relatively short in AUTM data-stemmed research. Besides, in order to obtain a balanced panel, too many observations are dropped out since not all universities are willing to report on their technology transfer activities. Interval regression can also be considered as an alternative to overcome this problem.

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Biography

Erkan Isikli is an Instructor of Industrial Engineering at Istanbul Technical University. He received his bachelor's degree in mathematics engineering in 2004 and his MBA in 2007 from Istanbul Technical University (ITU), and his PhD degree in Industrial & Systems Engineering in 2012 from Wayne State University, where he pursued his studies as a recipient of a fellowship granted by the Higher Education Council of Turkey. Since February 2013, he has taught several undergraduate and graduate courses such as Theory of Probability, Statistics, Experimental Design, Stochastic Processes, and Engineering Mathematics. Isikli aims to employ statistical models for real-world problems in various fields such as non-profit organizations, sports, environment, marketing, supply chain, and healthcare.

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Abstract

Global changes, exponential growth in population, safety, security and environmental protection issues are continuously increasing the need for more complex efficient and better-integrated energy systems. Life cycle processes, best practices and modeling approach originating from systems engineering discipline will enable the design and deployment of more effective energy management systems. This paper includes not only describes a systems engineering approach to energy systems but also discusses a demonstrated and proven way to simplify and automate this approach through some examples of where the solution has been applied. The approach and solution has been proven in the aerospace, defense, nuclear, oil / gas, medical and automotive industries.

Keywords

Systems engineering, energy management, safety, security, regulatory compliance

1. Introduction

Modern energy systems and networks continuously face increasing environmental, social, and economic pressures compounded by security and safety concerns. The rising diversity of energy system components and the need to effectively predict the interactions between the energy system's component further complicate the problem.. The current body of knowledge on energy systems from different domains displays this field's scale as well as the amount of variation and complex interactions among its components and subsystems. Such intricacy and scale requires the designers, implementers and operators of energy systems to involve new stakeholders from different fields and introduces additional expectations and requirements. Furthermore, nearly continuous re-assessment and resulting shifts in environmental, societal and economic factors often causes stakeholders to adjust their

requirements which effect the overall system. These issues and characteristics drive the need to design, manage and maintain energy systems and investigate associated risks and trade-offs using a holistic and robust approach.

In this paper, a Systems Engineering (SE) approach combined with best practices that IBM has codified through its work with customers are proposed as a means to better optimize power and energy systems. In Systems Engineering, the overall complex system, such as an electricity generation and distribution grid, is thought of and modeled as an interconnected collection of its components. The overall system is decomposed into its components and the associated interrelationships, requirements, input/outputs, actors and states are modeled and optimally designed to support the objectives of the overall system. This approach, often referred to as Model Driven Development (MDD), allows the designer to capture and abstract the complexity of the actual total system in the model.

For sustainable prosperity, energy generation systems need to be designed and managed optimally. The systems need to become smarter, more robust and more efficient, which heightens the need to take a smarter approach to the way we design systems to generate, distribute, and consume energy.

In this paper we provide an introduction to how SE principles can be applied to the design and management of complex energy systems. We start by highlighting the main concepts of SE (Section 2), discuss the transformation the energy value chain is experiencing (Section 3), and briefly identify the methodologies and applications supporting SE using IBM Rational toolkit (Section 4).

2. Systems Engineering

Systems engineering is a discipline that concentrates on the design and application of the whole (system), as distinct from the parts. It involves looking at a problem in its entirety, taking into account all the facets and all the variables and relating the social to the technical aspect (INCOSE, 2006). The discipline of systems engineering has been formally recognized by the introduction of the international standard ISO/IEC 15288 in 2002. The Systems Engineering discipline has been in existence for decades and has matured in the automotive, aerospace and defense industries. It has proven to be a very effective means to manage complexity and change, improve safety, and reduce risk and cost/schedule overruns.

The “Architecture Vee” described by Forsberg et al. (Forsberg, 2000) relates systems engineering to the project life cycle (Figure 1). The V represents the overall system’s evolution from the perspective of system decomposition, integration and validation/verification activities.

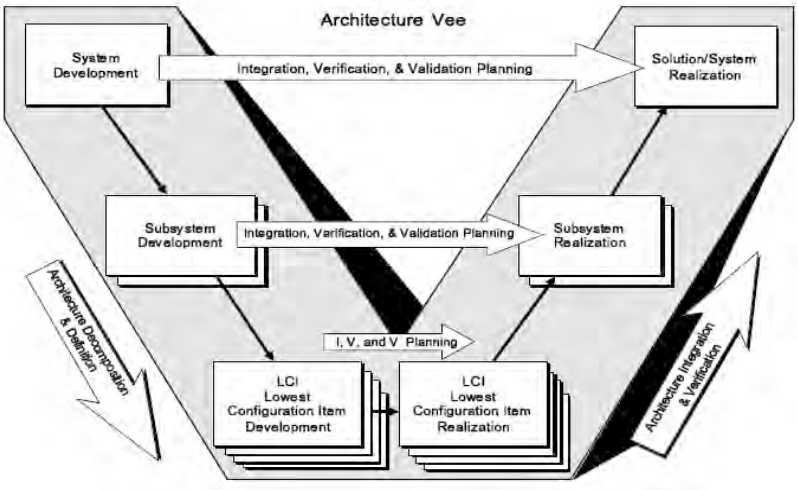


Figure 1: Architecture Vee

Systems engineering is usually an iterative and evolutionary process that with a definition of the overall system at the highest level (e.g. power grid) and then proceeds through the functional decomposition to a subsystem level (e.g. transmission or generation asset (s)), all the way to component level (e.g. an individual transformer or pump in a generation asset). Systems Engineering Modeling Language (SysML) has been developed to support the

specification, analysis, design, verification, and validation of complex systems that may include hardware, software, data, personnel, procedures, and facilities.

Systems engineering is accepted as a best practice in multiple industries such as aerospace, defense, and medical devices. It has proven especially valuable when the system is subject to safety or other regulation or is regulatory certification is required. The primary outcome of systems engineering is specification, which differs systems engineering from downstream engineering, whose outcome is implementation of a solution that fulfills specifications (Fechtelkotter et al, 2013).

3. Transformation in Energy Value Chain

The traditional energy value chain that has operated well for decades is characterized by a one-way flow of both power and information, limited competition in distribution, declining costs from increased usage, cost-effective but polluting carbon-based generation, and undifferentiated, passive consumers. However this value chain is in the midst of a fundamental transformation. Driven by changes in energy policy, technology, and consumer focus as well as concerns about energy security, environmental sustainability, and economic competitiveness. With these shifts, as can be seen form Figure 2, the traditional hierarchical and typically centralized structure of the energy value chain is transforming into a much more complex structure characterized by a distributed structure with more complex information flows.

In addition to dealing with concerns about delivering reliable power while minimizing costs, utilities now have to deal with new challenges that include changing customer expectations such as immediate and accurate notifications regarding power outages, more interactive, proactive and customized interactions across the grid that may include electric vehicles, smart meters, "dispatchable" peak load control, home energy services, and distributed solar generation.

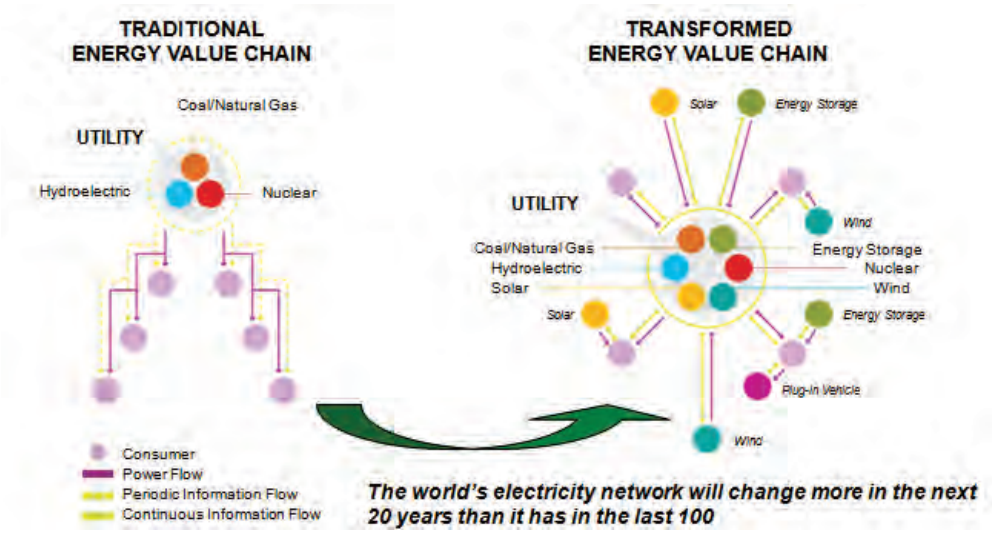


Figure 2: Evolving energy value chain

The utilities and energy companies that design, build, maintain, and operate the world's electric power systems must respond to these critical but difficult challenges. In order not to miss the chances to capitalize on the new business opportunities, they are making investments to upgrade the capabilities of the grid: improving its efficiency and flexibility, developing new capabilities for integrating renewable energy into the grid and installing equipment for storing energy. Unfortunately there is not yet consensus on the best approach, technical standards to effectively transform the industry to a new operating model.

When looking at how to respond to the new operating paradigm. IBM advocates using the term "smarter energy system" instead of the more confining term "smart grid". A smarter energy system is 1) instrumented, with sensors and controls embedded into the fabric of its operations. 2) highly interconnected, enabling the two-way flow of information (including near real-time consumption and pricing) and energy across the network, and 3) is intelligent,

using analytics and automation to turn data into insights and to manage resources more efficiently. In IBM's work with hundreds of energy and utilities organizations around the world, three key imperatives have been identified to help address the challenges and opportunities facing the industry: transforming the utility network, improving generation performance and transforming customer operations. (IBM, 2012).

There are common elements to every stage of the transformation to smarter energy. It is important to view the highly complex smarter energy projects as a complex, integrated "systems of systems". Section 4 focuses on how leveraging best practices, methodologies and technology from IBM Rational can help energy and utility organizations better plan and execute the above mentioned transformation.

4. Leveraging Best Practices and Technology

Leveraging best practices, methodology and technology from IBM Rational can help energy and utility organizations to

- More effectively plan and execute the multi-decade transformation to a software-intensive smarter grid
- More effectively plan for, design for, and respond to regulatory mandates related to Safety, Security and Environmental Protection (SSEP).
- More effectively design and implement or construct complex, safety-critical systems such as new generating assets/plants or execute upgrades to existing generating assets.
- Improve the overall efficiency, effectiveness, and business value delivery of their SW/IT organizations that will be critical in providing the software applications that will help make future energy systems smarter, whether they develop software themselves or rely upon partners for implementation

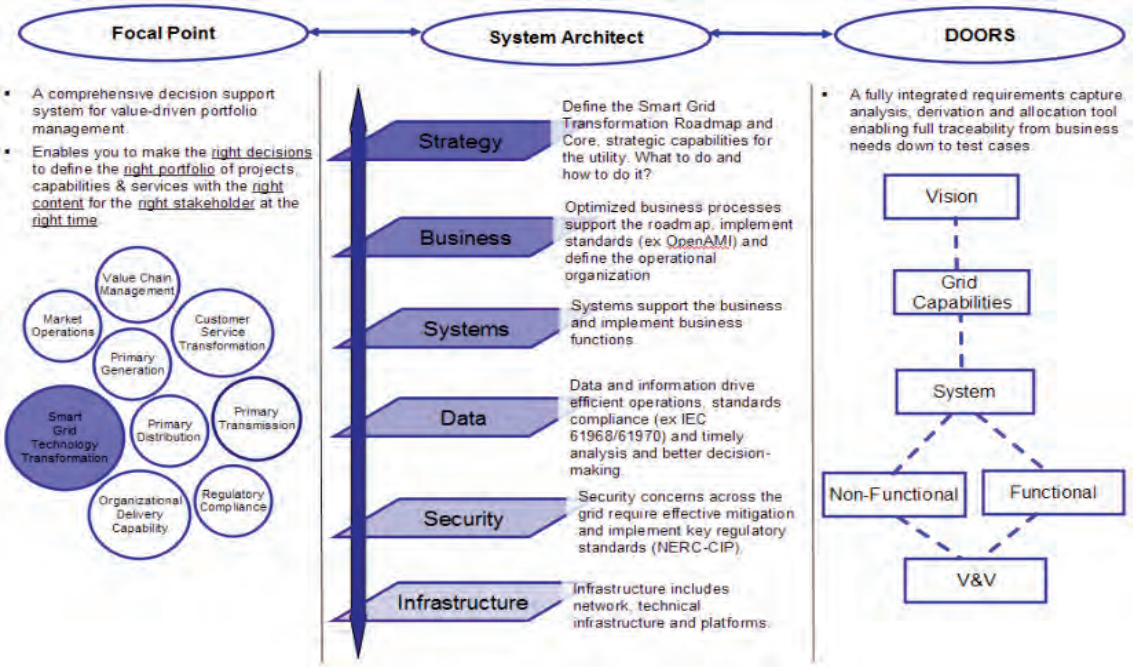


Figure 3: IBM rational solutions as key pieces of the puzzle

Enabling utilities to intelligently transform involves decomposing the strategy and vision, creating a transformation roadmap and aligning the portfolio of investments and projects to the roadmap. Rational solutions help aid this transformation through enabling program planning, architecture & prioritization, technical architecture leveraging industry standards, program governance & delivery of smart grids that are complex, software-intensive System-of-Systems. Another critical component of a successful transformation is assuring and minimizing the cost of

compliance of energy systems in terms of safety, security and environmental protection. Design and execution of new builds & upgrades in generation will also be necessary. Finally, a tremendous amount of software will be needed to support the overall system's operation. Figure 3outlines the basic pieces of technology offered by IBM Rational that are being used by utilities to aid the transformation. Following subsections of this paper will focus each of these aspects.

4.1 Strategy and Portfolio Management

Managing the shift in business models, evaluating energy supply chain options and defining the optimal Smart Grid Project Portfolio are crucial tasks in strategy and portfolio management. The emerging marketplace for energy services has to be visualized to make offerings more competitive. Better, more informed decisions have to be made regarding in-home device acquisitions that maximize both customer and supplier benefits. Projects have to be monitored based on budget, schedule, risk, compliance and business value delivered.

Strategy and portfolio management capabilities enable senior executives to better articulate the vision and strategy for the utility and aid in the identification, analysis and determination of the right investment portfolio structure by using key priorities and performance benchmarks across the portfolio that align with vision and goals and provide scenario planning tools to optimize the investment mix.

Successful practices for efficient and complex energy systems require traceability, safety & security, routine and organization. IBM Rational Focal Point™ has been created to assist organizations to manage complex projects for smarter cities and smart energy and utility projects management. Focal Point™ supports SE, human trade-off analysis and data integration to optimize energy usage and maximize distribution efficiency (Ahram et al, 2013).

4.2 Requirements Management

Given the complexity of energy systems, it is important to for an organization to effectively manage the full scope of requirements. Many organizations try to manage requirements through managing documents but this leads to both missing requirements and the introduction of quality issues into the process. IBM Rational has created a pragmatic, reusable process and technology for managing the full scope of requirements and the inter-relationships that will enable preservation of the "right" legacy requirements, incorporation of new regulatory and cyber-security standards, more effective tracking of ever-changing regulatory requirements, better governance of 3rd party suppliers, as well as better requirements inspection and impact analysis to avoid schedule delays, budget over-runs, and compromised compliance posture. In addition, the ability to scale and manage the constantly growing set of engineering change paper work and relevant engineering documentation is an important asset. IBM has a demonstrated and proven way to simplify and automate how power generators more efficiently and effectively answer current and emerging regulatory compliance requirements. IBM Rational's collaborative platform provides traceability across the entire safety-critical system lifecycle, which enables better impact and gap analysis and reduces costs and risks. Söderholm and Lestinen (2013) outlines the requirement management process developed in Finland's Loviisa nuclear power plant (NPP) as well as the challenges and benefits gained. The benefits recognized from requirements management can be summarized as providing easier communication with the supplier, more effective prioritization of requirements that provides a better foundation for the risk management, and easier follow-up, control, review and approval process.

The criticality of leveraging a proven requirements and change management system is the ability for an organization to manage key performance elements that can be met, tracked, and verified in a way that ensures adherence to the compliancy and immediate needs of the organization while effectively planning for the future. In terms of compliance, it brings structure to audit preparation and response by providing requirements decomposition and rich traceability, linking systems and software assets to safety criticality, identifying where applications are installed in the plant, prioritizing them based on the criticality, establishing responsibilities, documenting and tracking the policy and procedure to follow for change requests and potential modifications to the system.

4.3. Model Driven Systems Development

Model Driven Systems Development (MDSD) is an approach to understand and model complex system behavior using a holistic method by supporting requirements management, design, analysis and verification and validation efforts that align with the Systems Engineering principles. Although it has been commonly used in the electrical and mechanical engineering fields since the early 1980's due to the limitations in technology such as computing power, storage capacities, it wasn't extensively used for large scale complex systems until approximately the last two

decades. The advancements in technology have created these necessary capabilities that allowed Systems Engineering field to more broadly adopt MDSD approach.

The dynamic complexity of energy systems come from its characteristics, which are also commonly observed in complex systems in other industries (Levin, 2002; Morel and Ramajujam, 1999) - such as the emergence of a pattern and the continual appearance of new entity types and the large number of interacting entities. Such behaviors require the design, maintenance and management solutions of energy systems to be dynamic, which can allow the system model to evolve as the conditions change. As a result, methods providing static solutions become invalid due to continuously changing global and system factors, such as population growth and technology advancements respectively.

Starting with decomposition of the overall system (e.g. a power grid) into its smaller components (Balmelli et al, 2006), MDSD aims to improve the overall comprehensibility of a complex system by modeling, managing and maintaining its simpler components and their inter-relationships. The robustness and flexibility of this modeling approach enables traceability both within and between these components as well as the capability to adapt to changing environmental conditions and stakeholder needs throughout overall system.

5. Conclusions

In this paper we have introduced the driving factors and methodology that can be used to provide support for better managing the complexity of energy systems (its requirements and behavior), and optimizing its overall design. We have briefly discussed Systems Engineering (SE) principles, which focus on providing a holistic view of the system (capturing its complexity and multi-disciplinary nature), by modeling the overall system as a inter-linked combination of its components. The use of SE principles in modeling and managing energy systems provides a proven path to improve the design of future efficient and integrated complex energy systems by utilizing the best practices that have been proven to work in space exploration, medical devices, airplanes, and defense systems. The adoption of SE methodology in energy and power generation can lead to more efficient yet secure power grids that will allow for the successful introduction of renewables and smart energy applications. IBM Rational has a proven set of practices and solutions to plan for and execute for successful transformation of the energy value chain.

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Reference Model Application for Large Scale Industry Management

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Abstract

In the paper, the problem of information technologies and modeling application for large scale industry management using tourism industry example is considered. The results of the state of the art analysis in the applied computer science and engineering management in tourism industry are presented. On authors' opinion, it is reasonable to consider large scale industry management as a complex system. For instance, in tourism industry, the elements of the system are tourism services including tour order and execution, air travel, airport tourist services, hotel accommodation etc. Authors explain the peculiarities of system approach to tourism services simulation on the base of reference models.

Keywords

Reference model, large scale industry, real-time management, risk evaluation, system approach

1. Introduction

Nowadays, under condition of economy complexity and globalization, most of service industries can be considered as large scale systems. Let's consider tourism as a bright example of large scale industry. Today, tourism has become a phenomenon, which came into the everyday life of almost one third of the population of the planet. Worldwide, the number of international tourists has been raised from 25 million to 699 million between 1950 and 2000. According to World Tourism Organization (UNWTO), the major world organization representing tourism, their number will continue to go up to one and a half billion, spending an estimated annual total of $3 000 billion by 2020 (Aksu & Silva, 2009).

Moreover, in the beginning of XXI century, tourism took third place among the leading sectors of the world economy by income. As a result of 2008, tourism industry has formed 12% of global domestic product and swallowed more than 11% of consumer spending (Arzeni, 2010). A reason for that may be people mobility growth by means of transport (mostly air and railway), infrastructure and information and communication technology (ICT) development.

2. Tourism as a Leading Economy Area

In many countries and regions, tourism is one of the main sources of income. As the number of employees, the tourism industry has also become one of the largest in the world: it employs more than 260 million people, i.e. each 10-th employee. Income from tourism travel is more than 500 billion dollars worldwide annually. The greatest profits belong to the countries of Western Europe and the U.S.A. (Arzeni, 2010; Franklin & Vella, 2010).

Considering, for example, the results of 2008, UNWTO notes that the largest number of tourists visit Europe: 44.7% of the total. Almost all regions of the world have shown considerable growth in tourism, but especially impressive results are achieved, as expected, by America, where the amount of travel has increased by 11%. Another 8% of tourists travel across Asia-Oceania (Figure 1) (Arzeni, 2010).

If we analyze the activities of tourism all over the world for the past ten years and identify leaders to attract tourists to their country, arranging them in place on the basis of work in 2008, it will give the following distribution (Arzeni, 2010). Traditional leaders of the old world were France (8.6%), Spain (6.2%) and Italy (4.6%). The U.S.A. shows significant growth rates (6.3% in 2008) with average annual growth 8% in 2007/2003. China also became a leader with annual growth 13.5% in 2007/2003 with 5.7% arrivals segment in 2008.

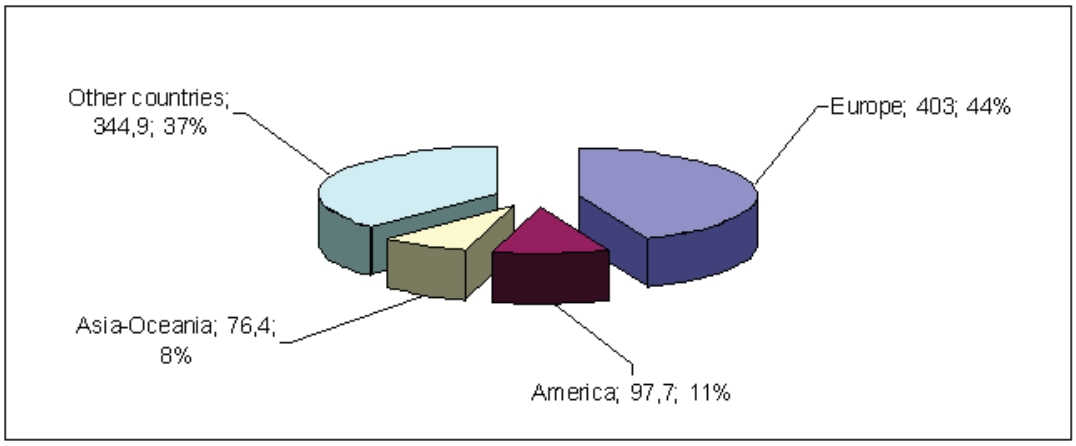


Figure 1: Distribution of tourists visiting the regions of the world (mln) (Arzeni, 2010)

Thus, on identifying the leaders of the reception of foreign tourists, it can be stated with confidence that the greatest impact on the economy of a small tourism industry is in these countries exactly. Income from foreign currency as a percentage as follows: 43.4% in the European countries; 15% in America; 10% in Asia-Oceania; and 32% in other countries (Arzeni, 2010).

As it is shown, leadership of the reception of foreign tourists belongs to the part of the world which is mostly involved into ICT development and implementation as well as transport infrustructure. Under these circumstances, tourism is a promising source of new work places, and it is projected over the next five years, 2 500 new work places will be created in the world per a day. The cost of creating one work place in tourism is 20 times less than in other industries, and turnover of investment capital is 4 times higher than in other industries. That is one of the few industries where the attraction of new technologies doesn't lead to the staff reduction (Arzeni, 2010).

3. Information Technologies in Tourism Industry Management

The analysis results for the research condition in the field of information technology in tourism over the past ten years are presented below. The material for analysis would be more than a thousand papers presented at an international thematic conference "Information and Communication Technologies in Tourism", the most significant in this area (Cantoni & Xiang, 2013).

The analysis have shown that information technology in tourism is actively promoted by scientists all around the world, including such countries as Canada, the U.S.A., Australia, New Zealand, Japan, Korea, and China. Among the European countries developing ICT in tourism, Italy, Spain, Germany, Switzerland, United Kingdom, Turkey, and Greece should be mentioned. Also, the analysis has allowed finding out the major research directions and trends in this area. The most stable and widely distributed areas of research include the following:

- Tourism Information Systems, Services and Architectures
- ICTs and Destination Management Organizations
- ICT Use by Hotels
- Mobile Tools and Applications
- Travel and Trip Planning
- E-Marketing.

In addition, the results of the analysis show a shift of emphasis from the use of simple information systems in management of tourism companies to high technology and the development of complex distributed information systems.

Besides, tourism market is becoming very large and various. Rather often, it's not easy for a tourist to choose most suitable destination, hotel and flight among all the variety. Usually, this task is solved by travel agencies. Though, current trend in tourism industry is increasing number of independent travellers oriented to self-booking and travel preparing. For instance, tourist profile in Antalya region of Turkey shows the following (Aksu, et al., 2009; Aksu &

Silva, 2009). The most of tourists are from Western Europe, their average age is 25-34, and they are college or university graduates and professionals. About 30% of them come to Turkey independently. Profile of French tourists visiting Australia is also significant (International Visitors in Australia – June 2010 Quarterly Results of the International Visitor Survey; International Visitor Profile 2009 – France). About 67% of them are unaccompanied travelers. Their average age is also 25-34, and they are college or university graduates and professionals. About 35% of them plan their trip within 3 month and book flight tickets via Internet. World Wide Web is also the main information source for the visitors (65%). The main reasons to use Internet are to find out more about Australia after deciding to visit (30%), to find out about airfares or air schedule (25%) and accommodation in Australia (20%).

Nearly the same distribution is seen for Japanese tourists (International Visitor Profile 2009 – Japan). About 62% of them are unaccompanied travelers or adult couples. Average age of travellers is 25-34, they have high education levels. About 35% of tourists also plan their trip within 3 month and book flight tickets and hotels via Internet. So, rather wide consumer segment is the most interested in and ready for ICT usage and development.

However, the main findings of the analysis undertaken in this area of research should be pointed as lack of engineering management methods in regarding tourism industry. It disables considering tourism industry as a complex system. So, currently, it's impossible to manage and develop tourism and travel industry integrally.

According to the authors, this may be a significant disadvantage. Modern travel and tourism industry is a complex large scale system that includes services such as the selection and implementation of the tour, air travel, airport services, distribution and management of tourist services in hotels, supply industries (power engineering and agriculture) etc. Thus, it seems reasonable to provide information logistical support throughout the life cycle of tourist services (Sigala, 2003, 2004).

On the other hand, it allows building reference stochastic models to manage tourism industry in real-time mode under uncertainties and risks conditions.

4. Reference Models Building for Large Scale Industry Management (Tourism Example)

To date, tourist services are usually limited to tickets selling, reservations at the hotel and ensure "airport-hotel-airport" transfer. Herewith, many problems related to passengers' behaviour at the airport, information support at a hotel and other are not solved (Kondratyeva & Yangirova, 2012; Valeev et al., 2012). Problems are worsen when you take into account the large size of modern international airport and a huge flow of passengers and flights (Sheremetyevo (Russia), Istanbul and Antalya (Turkey), Frankfurt / Main (Germany), Charles de Gaulle (France), Heathrow (United Kingdom) and so on). Most of modern hotels are also very complex organizational and technical objects serving thousands of tourists.

Some situations often lead tourists to psychological stress and may lead to a breakdown of the tour package (for example, if the passenger did not have time to make connecting flights at the transit airport due to lack of information support or don't have a hotel booked etc.). With this differentiation of responsibility, information exchange difficulties arise often that is caused by lack of information logistics support for the life cycle of the tourism service.

In terms of logistics approach, reference models of tourism services can be represented as a graph (Figure 2), where $p_{1,2}$ – the probability of transition from state S_1 (Home) to state S_2 (Hotel) relevant to processes of air traveling to destination (a recreation zone) and subsequent "airport-hotel" transfer; $p_{2,1}$ – the probability of transition from state S_2 (Hotel) to state S_1 (Home) corresponding to "hotel-airport" transfer process and the air traveling home from recreation zone; $p_{1,1}$ – the transition probability corresponding to the situation when a tourist skips his tour (or he skips any tourism services); $p_{2,2}$ – the transition probability corresponding to the processes of service for tourists in the hotel.

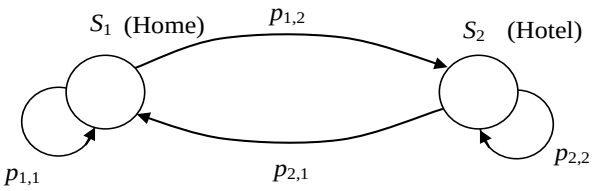


Figure 2: Transition graph corresponding to the processes of life cycle of tourism services in general

Given graph corresponds to the transition table presented in Table 1.

Table 1: Transition probabilities for the processes graph of tourism services

States i	Transition probabilities p_{ij}	
	$j = 1$	$j = 2$
1	$p_{1,2}$	$p_{2,2}$
2	$p_{2,1}$	$p_{2,2}$

Let us consider a more detailed representation of the scheme. Traditionally, the tour start point is check-in for the flight to destination (recreation zone), and the end point is luggage reception on arrival after return flight. The responsibility for air travel is carried by airlines (transitions $p_{1,2}$ and $p_{2,1}$). "Airport-hotel-airport" transfer (also in transitions $p_{1,2}$ and $p_{2,1}$) is provided by tourist company directly. Tourists stay in the hotel is supervised by the hotel managers, as well representatives of tourist companies ($p_{2,2}$).

It is possible to decompose each transition to some more detailed stages. For instance, passengers' transfer at the airport, check-in and boarding the flight can be considered as separate processes too. Thus, it is appropriate to make the presented on Figure 3 graph more detailed (Figure 3).

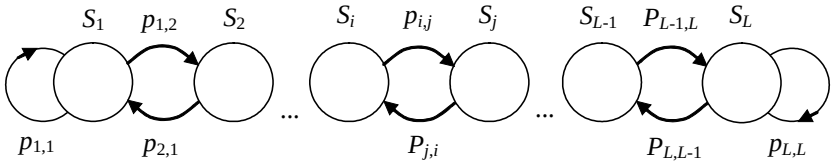


Figure 3: Detailed transition graph corresponding to the processes of life cycle of tourism services

It is possible to describe mathematically the graph on Figure 3 as the following. Let $S = \{ s_1, \dots , s_L\}(j = 1 \dots L)$ be the state space which is the same for every step of random process presenting life cycle of tourism services. One-dimensional array of probability distribution on the set of indices j for the n-th step (transition) is denoted as $\pi_n = (\pi_n^{(1)},\dots,\pi_n^{(L)})$. Herewith $\pi_n^{(j)}$ is probability of the event when a tourist is in a state j on n-th step.

Let's determine a state probability π_n distribution on every single step. Let us define T as an event corresponding to the situation when a tourist is in a state j on $(n + 1)$-th step.

In accordance with agreed notation, the event probability will be $P(T) = \pi_{n+1}^{(j)}$. Let us define S_i as an event when a tourist is in a state i on n-th step, therefore $P(S_i) = \pi_n^{(i)}$. Thus p_{ij} is probability the tourist is state j on $(n + 1)$-th step if he was in a state i on n-th step, i.e. $p_{ij} = p(T \mid S_i)$. We can find the event probability by the total probability equation:

$$\pi_{n+1}^{(j)} = \sum_{i=1}^{L} \pi_n^{(i)} p_{ij}\,, \quad j = 1,\dots,L\,. \tag{1}$$

Equation (1) allows sequential (step by step) determining the change in the probability distribution of tourist's states while tourist service providing. The initial distribution of probabilities should be a priori given.

The probabilities are directly dependent on the risk of failure $R_i(\mathbf{I})$ at each step of the tour due to lack of logistic information support **I**. The components of vector **I** are presented on the example of general scheme of information flows in tourism industry as a large scale complex system (Figure 4).

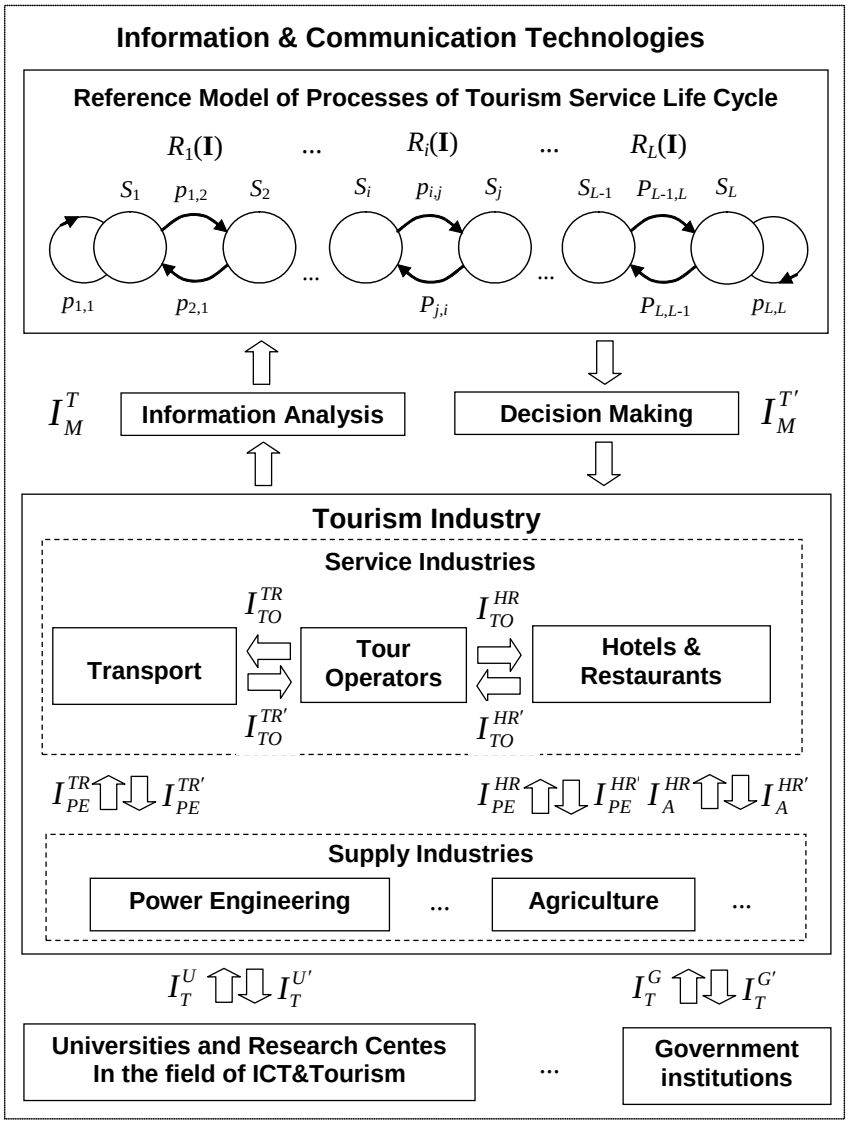


Figure 4: General scheme of information flows in tourism industry for reference model building

In tourism industry, service industries and supply industries may be allocated. Service industries interact with a tourist directly and include tour operators, transport and hotels. Supply industries are related with a tourist indirectly and include power engineering, agriculture and so on. Thus, tourism industry is a complex system aimed to provide a tourist with safe and joyful tourist service process. Besides that, modern tourism industry functioning is impossible without cooperation with universities preparing specialists in the field of ICT and tourism as well as without government institutions (Calisir et al., 2013)). All these subsystems are connected with material and information flows.

According to the scheme, the following forward and backward information flows presenting components of vector **I** can be singled out: $I_M^T, I_M^{T'}$ – between tourism industry and reference model of tourism services life cycle;

$I_{TO}^{TR}, I_{TO}^{TR'}$ – between tour operator and transport; $I_{TO}^{HR}, I_{TO}^{HR'}$ – between tour operator and hotels and restaurants; $I_{PE}^{TR}, I_{PE}^{TR'}$ – between power engineering and transport; $I_{PE}^{HR}, I_{PE}^{HR'}$ – between power engineering and hotels and restaurants; $I_{A}^{HR}, I_{A}^{HR'}$ – between agriculture and hotels and restaurants; $I_{T}^{U}, I_{T}^{U'}$ – between ICT&Tourism universities and research centres and tourism industry; $I_{T}^{G}, I_{T}^{G'}$ – between government institutions and tourism industry.

In this case, the risk of failure $R_i(\mathbf{I})$

$$\sum_{i=1}^{L} R_i(\mathbf{I}) \to min; \tag{2}$$

$$\mathbf{I} = \left(I_M^T, I_M^{T'}, I_{TO}^{TR}, I_{TO}^{TR'}, I_{TO}^{HR}, I_{TO}^{HR'}, I_{PE}^{TR}, I_{PE}^{TR'}, I_{PE}^{HR}, I_{PE}^{HR'}, I_A^{HR}, I_A^{HR'}, I_T^U, I_T^{U'}, I_T^G, I_T^{G'} \right),$$

Interrupting the information flows or information lack or invalidation lead to increasing the risks $R_i(\mathbf{I})$. Therefore, on authors' opinion, it is urgent to provide reference model of tourism services as well as system information support through all the tourism industry elements (Fettke & Loos, 2006).

As it can be seen, such the approach requires huge information content processed at national and world wide level. Herewith, the following urgent tasks may be allocated for the flows $I_M^T, I_M^{T'}$ processing (Batini & Scannapieca, 2006; Triantaphyllou, 2010) (Figure 5):

- Data mining as the tool of information flows analysis
- Building a large amount data warehouse
- Forecasting and optimizing processes in tourism industry
- High technology tools and equipments to provide information support of tourist services.

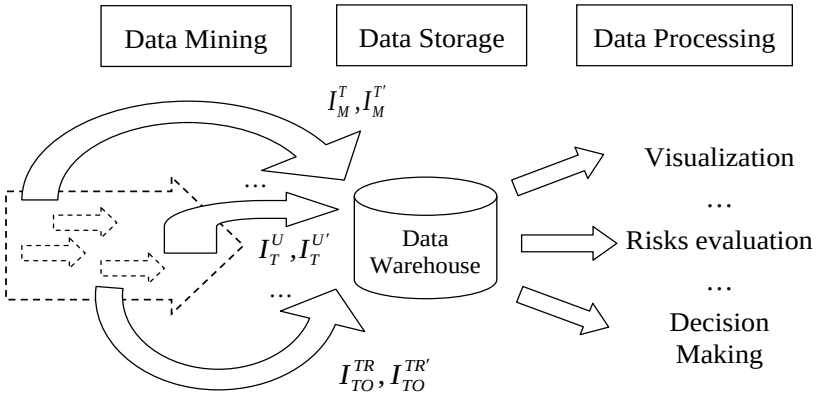


Figure 5: The main tasks based on information processes in tourism industry

The tasks may be solved with help of interconnected information and communication systems based on innovative technologies.

Multi-agent approach is suggested to build the reference model of tourism service life cycle (Shoham&Leyton-Brown, 2009). For now, it is applied effectively for buisness process optimization as well as complex social and technical systems management and control (Guichvarov & Kondratyeva, 2001; Vasilyev et al., 1996).

5. Conclusions

Nowadays, under condition of economy complexity and globalization, most of service industries are becoming large scale complex systems. Tourism industry is a bright example of such a system. Tourism has come into the everyday

life of significant part of the population of the planet. Worldwide, the number of international tourists has increased by more than 20 times during last 50 years. According to UNWTO, number of travelers will continue to go up to one and a half billion by 2020. Besides that, in the beginning of this century, tourism took third place among the leading sectors of the world economy by income. A reason for these phenomena may be people mobility growth by means of transport infrastructure and ICT development.

By the number of employees, the tourism industry has also become one of the largest in the world: it employs more than 260 million people, i.e. each 10-th employee. It may be noticed the greatest profits belong to the countries of Western Europe and the U.S.A., i.e. the world regions with the most developed ICT.
Thus, the leadership of the reception and serving foreign tourists belongs to the part of the world which is mostly involved into ICT development and implementation. So we can say that modern tourism directly depends on computer science level in the countries.

For sure, the situation has some reasons. As one of the most rapidly progressing and distributed fields of world economy, modern tourism industry is based on intensive information flows and amounts of data.
The analysis results for the research condition in the field of ICT in tourism industry over the past ten years were provided by authors. The material for analysis was more than a thousand papers presented at an international conference “Information and Communication Technologies in Tourism”.

The analysis have discovered that ICT in tourism is actively provided by scientists all around the world, including the U.S.A., Canada, Japan, Australia, New Zealand, Korea, and China. European countries developing ICT in the tourism industry are Italy, Spain, Germany, Switzerland, United Kingdom, Turkey, and Greece.
The analysis has shown the major research fields and trends in the area ICT in tourism. The most stable and widely distributed research fields are tourism information systems, services and architectures, ICT and destination management organizations, ICT use by hotels, mobile tools and applications, travel and trip planning and E-Marketing. Also, the analysis show a shift from the use of simple information systems in management of tourism companies to high technology and the development of complex distributed worldwide information systems.

Besides, tourism market is becoming very various. Rather often, it’s not easy for a tourist to choose most suitable destination, hotel and flight among all the variety without using ICT. Usually, this task is solved by travel companies. Though, nowadays, number of independent travelers oriented to self-booking and travel preparing is increasing. So, rather wide consumer segment is the most interested in ICT application and development.

However, the main findings of the analysis undertaken in this area of research should be mentioned as no system approach in regarding ICT in the tourism industry. It disables considering tourism industry as a complex system and developing tourism and travel industry integrally with help of reference model of the industry.

The tendency of large scale industries development can be world wide integration of its elements on the basis of common information space. Under these circumstances, ICT tasks look even more important. These tasks are data mining, building data warehouse, high technology tools and equipments creating, and forecasting and optimizing processes in large scale industries on the base of modeling. The tasks may be solved with help of interconnected information and communication systems based on innovative technologies.

Multi-agent approach is suggested to build the reference model of complex industry. The reference model implementation will improve the information structure of the industry, which, in turn, will reduce costs and increase revenues in the area.

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A Lean Approach to Process Management in Public Institutions by Applying Value Stream Mapping Techniques

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Abstract

In todays' world process management especially in public institutions has improved because of expectations of customers. In this context large organizations such as public institutions or universities include a great amount of workflow of basic organizational units. The study deals with process management and consider a real case study from a public institution. For this purpose workflows of the public institution was classified in terms of their processes. After that current state value stream map was drawn for the selected workflow. After assessment of current status VSM, a future state VSM was designed to eliminate unnecessary non-value adding wastes.

Keywords
Value stream mapping, lean principles, process management

1. Introduction
Lean thinking is a set of principles, philosophies, and business processes that enable the elimination of waste and add value to customers (Vlachos 2012). According to lean thinking, waste can be anything other than the equipment, materials, parts, space, and working time required to provide the product or service. Lean tools and practices have become popular among manufacturing and service industries since their adoption by Toyota. As a lean tool value stream mapping (VSM) is an invaluable tool to grasp current condition and identify improvement opportunities. According to Rother and Shook, (1999) VSM is a pencil and paper tool, which is created using a predefined set of standardized icons .The aim of VSM is to minimize all wastes such as time, products and information so provide a continuous flow of process. VSM is a visual tool that analyze flow of materials, information, and process and helps to identify unnecessary waste, relationships between interactions and simplify the system which approaches lean concept (Abdulmalek, 2007).

VSM can be used in different sectors especially in public institutions. Service sector have complicated information processes and need to optimize the workflow in public institutions. Non-value added process can cause errors, faulty

processes and cost. Hence VSM shows activities by their respective value, service become more valuable and effective. On the other hand application of VSM in process management, have been far fewer (Jimmerson, 2005).

There are many studies available related with VSM and various methodologies are utilized. Some of the relevant studies are given below. Teichgräber et al.(2012) Used VSM tool to eliminate non-value-adding (NVA) waste for the procurement of endovascular stents in interventional radiology services. The current state VSM demonstrated that out of 13 processes for the procurement of stents only 2 processes were value-adding. Therefore NVA activities, could be eliminated. Abdulmale et al., (2006), designed VSM for process sector case study they also developed a simulation model for value stream maps. Ar and Al-ashraf (2012) apply lean production principles for the process sector of an automotive part manufacturing plant.

Chen et al.(2013),developed lean production and RFID (Radio frequency identification) Technologies for supply chain network. So, the efficiency of the network could be improved. The results show that total operation time can be saved by 81% from current stage to future stage with the integration of RFID and lean. VSM helps to visualize the current and future state mapping.

When analyzing existing literature it's seen that there is no study about VSM for process management in public institutions. Hence this is a unique aspect of this study.

In this study, workflows of the public institution is classified in terms of their processes. For case study, Graduate school of science engineering and technology in Istanbul Technical University is presented. Changing graduate advisor process is considered in the university. For this, real situation and data are used. In section 2 materials and methods are presented than current and future state of VSM is presented.

2. Materials and Methods

Graduate and postgraduate students are working with advisors in the universities. They choose their advisors according to their study area. Sometimes they feel the need for advisor changing related to some reasons such as changing study area or due to personal issues. In this study advisor changing process examined at a graduate school of a university. Considering current situation of advisor changing process it was very challenging process. Since it was including a lot of steps and most of the buildings was in different locations when different locations of campuses was taken into account. Students had to take approvals manually on paper form and must push the process. When current process analyzed those seven wastes determined as indicated on Table 1.

Table 1: Determined 'seven wastes' for advisor changing process

Step	Process	Comment
1.	Overproduction	Not typically applicable in service sector. On the other hand some repeat details on forms, copy information across, answer queries from several sources within same organization can be considered as waste.
2.	Waiting	A great part of the process causes waiting. Students wait for advisors to meet and documents waits in queues for data entry etc.
3.	Transportation	In this process the form travels between head of department, GSSE and student affairs department.
4.	Inappropriate processing	Due to confusion over the form it may result in misuse or duplication.
5.	Unnecessary inventory	All the forms finally goes to archive.
6.	Unnecessary motion	The form queuing several times, need for more ergonomics design.
7.	Defects	Defective forms results rework.

3. Current State Value Stream Map

When the advisor changing process taken into account initially the current state intended to be analyzed. Therefore some disruptions determined such as no flow of work due to lack of standardization and miscalculation of human and process planning. In addition we can say that most of the time was consumed for waiting due to transportation

and queuing. Beside there was insufficiency of IT infrastructure and it was causing deficiencies on flow of information.

The current state VSM was created according to the standard value stream mapping icons and it was shown that total lead time was 21.3 days however total cycle time was 48,5 minutes. Considered eight steps at the process can be seen on Table 2.

Table 2: The current state VSM was created considering eight steps.

Step	Process	Comment
1.	Approval of ex-advisor	Students takes approval of ex-advisor on the forms
2.	Approval of new-advisor	Students takes approval of new-advisor on the forms
3.	Approval of department head	Head of department gives approval for the demand after approvals of advisors
4.	Submission of the document	The forms delivered to Graduate School of Science and Engineering
5.	Control of the form	The forms checked by secretary of GSSE
6.	Approval of administrative board	The forms evaluated by administrative board of GSSE
7.	Data entry	Student affairs department makes data entry for the forms
8.	Archiving	The returned forms from the student affairs goes the archive of GSSE

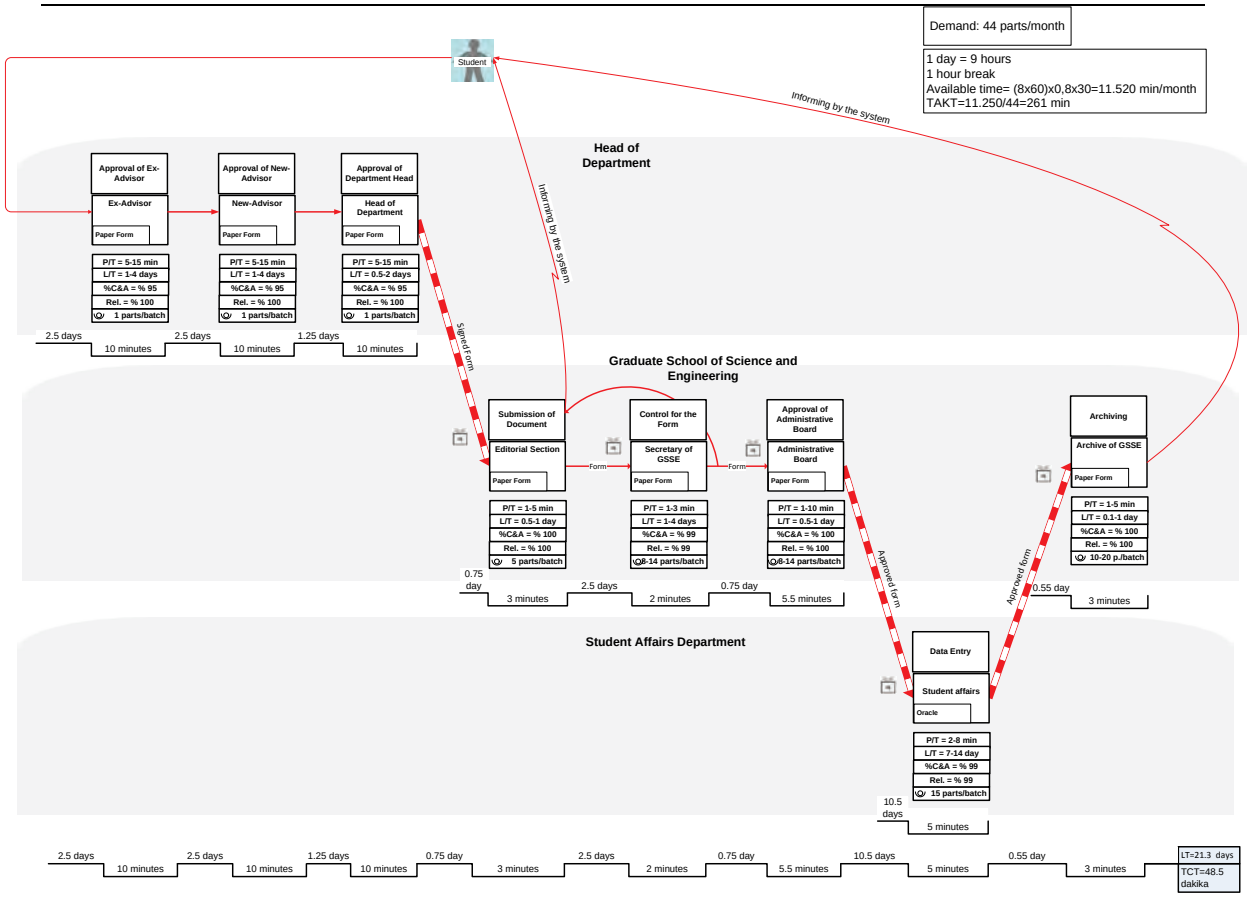


Figure 1: Current state value stream map of adviser changing process for graduate students

4. Future State VSM

Creation of future state map was disclosed the elimination of waste. Future state offers electronic information flow via online form usage for the whole process. Beside job smoothing and visual aids offered at form control and data entry processes.

According to the future state VSM students firstly speak with their ex-advisors. Then they open an advisor changing form and starts the process. After that students talk to new advisor and take their online approval. This form electronically arrives in front of the head of department. After this approval the forms are received by the secretary of GSSE. All the forms checked by them and if there is not any missing or wrong information forms go to administrative board for evaluation. The board gathers weekly therefore all the forms has to wait at the end of the week even though they arrive at the beginning or at the end of the week. If the board confirms the form then it is sent to student affairs department. By means of kaizen activities on this process the data entry of forms done and sent to electronic archive of GSSE. In this study it was offered to continue archiving process not physically but electronically. So according to proposed value stream total lead time reduced to 10.5 days and total cycle time 43 minutes.

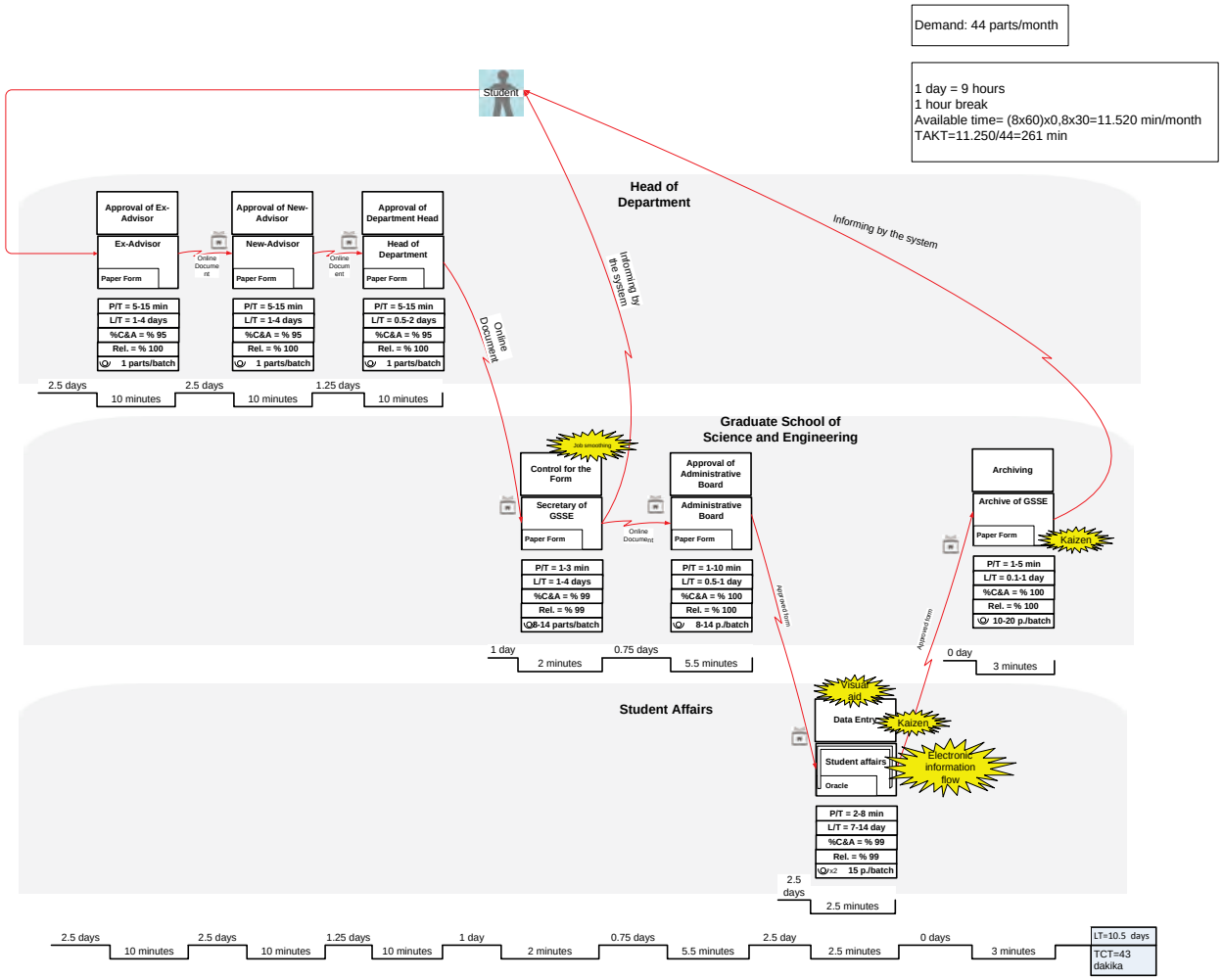


Figure 2: Future state value stream map of advisor Changing Process for Graduate Students

5. Conclusion

The main goal of VSM is the elimination of waste. This research uses VSM to analyze a graduate student advisor changing process at a university. Thus it is intended to obtain an overall view of the process and to eliminate wastes. Current state of the process showed us that students wait for a long period of time with very little value added activity. Mainly process had queue problems and transportation problems. Beside there was a bottleneck on data entry process. Considering these issues a future state VSM was designed. It is shown that with small changes lead time can be reduced significantly. The fact that it has a significant impact on students, instructors and officers workload. It is clear that if other processes considered at GSSE too there is a good opportunity to gain a significant performance increase. As a future study other processes can be included and their value streams can be drawn.

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Biography

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Development of a Prediction System for Ship Fuel Consumption using a Least Median of Square

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Abstract

Fuel consumption has become a primary concern in terms of ship energy efficiency. In recent years, there has been an increasing focus on reducing economic and environmental impacts from the shipping industry. Decreasing fuel consumption is the main contributor towards this. Although there are many factors which will affect the fuel consumption of a ship, however, in the present system the impact factors for fuel consumption are simply decided as revolutions per minute (RPM), mean draft, trim, condition, cargo quantity on board, wind-sea-current-swell effects, which are used as input information for fuel consumption forecasting procedures. A predictive system for ship fuel consumption using Least Median of Squares (LMS) is proposed in this paper. The R^2 was 0.669 and 0.586 for training and validation of the developed model, respectively. There was significant association between RPM (P=.0001) and trim (P=.002) in fuel consumption. This study aims to estimate ship fuel consumption by using the ship noon data. The prediction results demonstrated that the proposed system is effective in fuel consumption prediction.

Keywords

Ship, Fuel Consumption, Energy Efficiency, Least Median of Squares (LMS)

1. Introduction

Maritime transportation is highly dependent on fossil fuels due to the limits in use of alternative fuel types and technologies. The rising energy prices and fuel costs pose a major problem for ship operations. Fuel costs constitute a significant portion of the ship operating costs. In addition, carbon emissions from shipping industry represent a significant part of world total emissions. As a result of economic pressures and environmental concerns, reducing fuel consumption has become an important issue in recent years.

It is possible to increase the potential of fuel savings with the implementation of ship energy efficiency measures. These measures offer various options to ship owners and operators to reduce fuel consumption and thus carbon emissions. According to International Maritime Organization (IMO), all new ships have to comply with an Energy Efficiency Design Index (EEDI) and all ships have to carry a Ship Energy Efficiency Management Plan (SEEMP) since 1st of January 2013 (IMO, 2011). EEDI offers technical measures (for technology and design) for new ships at a minimum level. SEEMP intends to improve energy efficiency for ships through a set of operational implementations that are developed by using existing technologies in ships.

Rousseeuw (1984) introduced least median of squares (LMS) as a robust regression method. The Least Squares Regression (LSR) is a method for constructing predictive models when the independent variables are a lot and highly collinear while the sample size is not enough.'Noon Data' provides valuable information on the fuel consumption of ships under various conditions (RPM, weather conditions, trim and etc.) that can be used for forecasting.

This paper aims to estimate ship fuel consumption by using the using LMS regression. The overall purpose of this paper is to develop a model for predicting ship's fuel consumption using the 'Noon data' from which the information and fuel consumption data of the ship are obtained. The following sections will describe the modelling of ships' fuel consumption and least median of squares method.

2. Methods and Data

2.1 Modelling of Ship Fuel Consumption

We modeled ship fuel consumption in three parts: data collection for predicting ship fuel consumption, fuel consumption forecasting algorithm and performance analysis.

In the data acquisition, database of ship fuel consumption was constituted from shipping companies. In the data acquisition, tanker ship noon reports were collected to get required information for predicting ship fuel consumption. Seafarers record noon reports each day at noon time while ship is at sailing period. Noon reports are a major indicator of the amount of fuel consumed by ships in different operating conditions. Noon reports include important information such as ship speed, trim, draft, weather conditions and etc. in order to observe and evaluate the changes in ship's operation systems.

This study is carried out ship noon report data in the year 2012 and 2013. Table 1 describes the main characteristics of analyzed tanker ship in this study: the ship is equipped with a one fuel propulsion engine with internal combustion. Fuel consumption, expressed as metric tonnes per hour (mtons/h), is a measurement of fuel consumption.

Table 1: Main characteristics of the analyzed tanker ship

Type	Oil Tanker
Built	21.6.2012
Lenght (m)	266.07
Breadth (m)	48
Moulded Depth (m)	23.7
Summer Draft (m)	17
Deadweight (t)	156597
Shaft Power (kw)	18660
Break Horse Power (kw)	25023

Nine important impact factors for ship fuel consumption which include revolutions per minute (RPM), mean draft, trim, loaded or ballasted condition of ship, cargo quantity on board, wind-sea-current-swell effects are examined in this system, which are used as independendant variables for LMS for fuel consumption prediction model.

Lowering the ship's speed is the most efficient method in terms of fuel saving due to the non-linear relationship between ship speed and fuel consumption. The ship speed is related by a third power function of engine power (Ronen, 1982; Fagerholt et al., 2010; Norstad et al., 2011, Cariou, 2011; Qi and Song, 2012). This means that, if the ship speed is increased by two times, the power of the used engine will increase eight times (Faber et al., 2012)

The ship condition states if the ship is loaded with cargo or ballasted. Rising in the amount of cargo quantity increases the draft of ship and thus causes greater fuel consumption. Ship hull forms usually have been designed by taking into consideration the specific drafts. If the trim of the ship is set according to these drafts, the resistance of ship and fuel consumption will decrease.

The ship is exposed to various weather conditions (wind-sea-current-swell). These various dynamic factors lead to increase the ship resistance and the used engine power by the ship and hence, fuel consumption.

All of the impact factors mentioned above provide effective parameters to train LMS for fuel consumption estimation model.

2.2. Least Median of Square

The least median-of-squares (LMS) regression is among the best known robust method and widely used in variously, which is classical statistical method to extract data and interpret data (Rousseeuw, 1984).

The criterion of the least median of squares (LMS) is to estimate the parameters of the model by minimizing the median of the absolute residuals. In other words, the sum is replaced by the median of the squared residuals. LMS's breakdown point is almost 50% (Rousseeuw, 1984).

While LMS method aims to minimize the median of the residuals, it does not consider the remaining (n-1) observations. Therefore, LMS presents a better performance especially in a smaller number of samples (Ryan 1997). The LMS estimator (with intercept) is defined formally as follows. Consider a set $P = \{p_1, p_2, \ldots, p_n\}$ of n points in IR^d, where $pi = (x_{i,1}, x_{i,2}, \ldots, x_{i,d-1}, x_{i,d})$. We would like to compute a parameter vector $\theta = (\theta_1, \theta_2, \ldots, \theta_d)$ that best fits the data by the linear model

$$x_{i,d} = x_{i,1}\theta_1 + x_{i,2}\theta_2 + \cdots + x_{i,d-1}\theta_{d-1} + \theta_d + r_i \quad (1)$$

for all i, where $r_1, r_2, \ldots, r_n$ are the (unknown) errors, or residuals. The LMS estimator is defined to be the parameter vector θ that minimizes the median of the squared residuals. This estimator is widely used in finance, chemistry, electrical engineering, process control, and computer vision (Rousseeuw, 1997)

3. Model Design and Performance Evaluation

In this study, Least Median of Squares has been implemented with Stata Statistical Software. The data set used to architecture the LMS was 300 noon reports. Initially, a sample of 240 (80%) of noon reports were randomly selected for training, and the remaining sample of 60 (20%) of the data was used for validation. The output parameter of the LMS model was ship fuel consumption (mtons/h). Table 2 shows the average fuel consumption consumed by ship.

Table 2: Statistics of fuel consumption (mtons/h)

	Min.	Max.	Mean	SD	95% confidence interval	
					Lower	Upper
mtons/h	0.58	3.13	1.89	0.50	1.80	1.98

We run the LSM regression and find the iteration results and median regression as shown in Table 3 and Table 4. Using LMS regression, we regress each parameter's effect on ship fuel consumption. (Table 5)

Table 3: Iteration Results

Iteration 1:	WLS sum of	weighted	deviations	= 46.761506
Iteration 1:	sum of abs.	weighted	deviations	= 68.493942
Iteration 2:	sum of abs.	weighted	deviations	= 51.036693
Iteration 3:	sum of abs.	weighted	deviations	= 46.390042
Iteration 4:	sum of abs.	weighted	deviations	= 45.168229
Iteration 5:	sum of abs.	weighted	deviations	= 45.162732
Iteration 6:	sum of abs.	weighted	deviations	= 45.097791
Iteration 7:	sum of abs.	weighted	deviations	= 45.086734
Iteration 8:	sum of abs.	weighted	deviations	= 44.834538
Iteration 9:	sum of abs.	weighted	deviations	= 44.715953
Iteration 10:	sum of abs.	weighted	deviations	= 44.677231
Iteration 11:	sum of abs.	weighted	deviations	= 44.638352
Iteration 12:	sum of abs.	weighted	deviations	= 44.588914
Iteration 13:	sum of abs.	weighted	deviations	= 44.52628
Iteration 14:	sum of abs.	weighted	deviations	= 44.525217
Iteration 15:	sum of abs.	weighted	deviations	= 44.522003
Iteration 16:	sum of abs.	weighted	deviations	= 44.520929
Iteration 17:	sum of abs.	weighted	deviations	= 44.519651
Iteration 18:	sum of abs.	weighted	deviations	= 44.515308
Iteration 19:	sum of abs.	weighted	deviations	= 44.513739
Iteration 20:	sum of abs.	weighted	deviations	= 44.507843
Iteration 21:	sum of abs.	weighted	deviations	= 44.507656
Iteration 22:	sum of abs.	weighted	deviations	= 44.506263
Iteration 23:	sum of abs.	weighted	deviations	= 44.506236

Table 4: Median Regression

Raw sum of deviations	76.08 (about 1.92)
Min sum of deviations	44.50624
Number of obs	240
Pseudo R2	0.4150
p	0.043

Table 5: Model results for selected inputs and fuel consumption and their statistical significance (P value).

Fuel Consumption	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
draftmean x_1	.0143017	.0304071	0.47	0.639	-.0456105	.0742138
trim x_2	-.1276662	.0403883	-3.16	0.002	-.2072446	-.0480879
condition x_3	-.2100084	.2354082	-0.89	0.373	-.6738407	.2538239
Cargoquant~y x_4	-1.27e-06	2.92e-06	-0.43	0.665	-7.02e-06	4.48e-06
wind x_5	-.0001514	.001449	-0.10	0.917	-.0030064	.0027036
sea x_6	-.0023897	.0140032	-0.17	0.865	-.0299807	.0252012
current x_7	-.0389724	.0431088	-0.90	0.367	-.123911	.0459662
swell x_8	-.008843	.018909	-0.47	0.640	-.0461	.0284141
rpm x_9	.0483756	.0023388	20.68	0.000	.0437673	.0529839
_cons	-1.143335	.5195554	-2.20	0.029	-2.167031	-.1196382

The estimated equation is;

Fuel consumption$_{median}$=-1.143335+.0143017 draftmean -.1276662* trim -.2100084* condition- 0.00000127* cargo quant- .0001514* wind- .0023897* sea- .0389724* current- .008843* swell+ .0483756 *rpm*

The LMS could predict ship's fuel consumption accounted for around 67% of the variance (Figure 1) in the validation data. Figure 1 and 2 illustrate the training and validation of the LMS model for observed and predicted values for fuel consumption. The R^2 was 0.669 and 0.586 for training and validation of the LMS model, respectively.

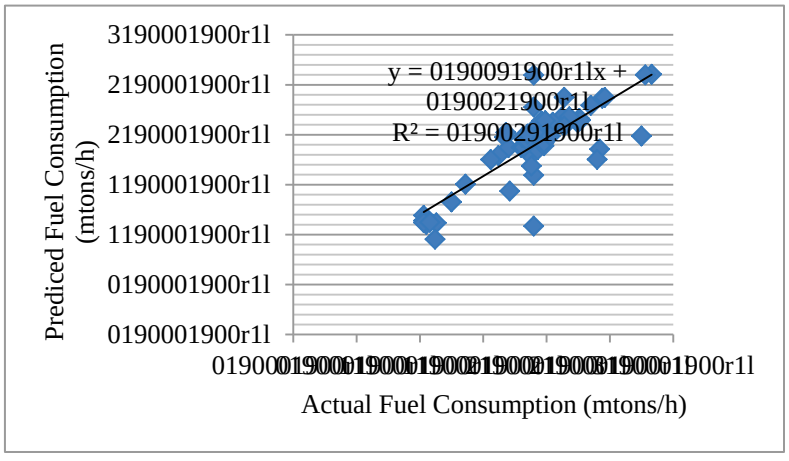


Figure 1: Relationships between observed and predicted fuel consumption (Training)

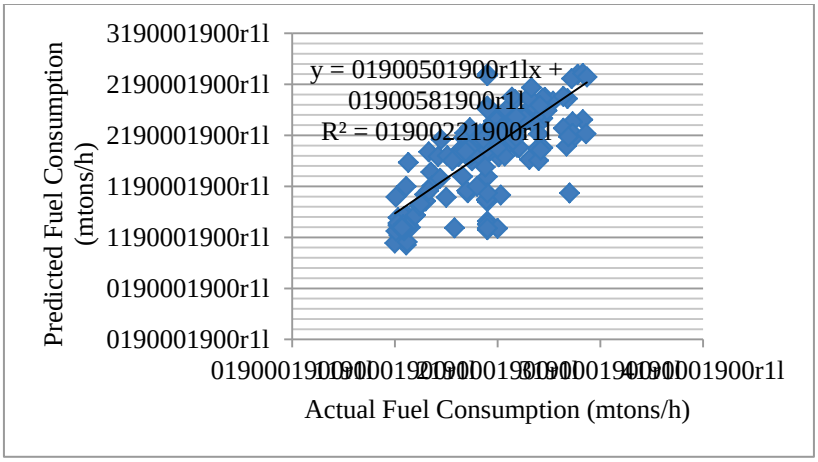


Figure 2: Relationships between observed and predicted fuel consumption (Validation)

Conclusion

In recent years, fuel savings has become a primary issue in terms of ship energy efficiency. As a result of economic pressures and environmental rules, reducing of fuel consumption is aimed by shipping companies and operators.

In this study, effective model, least median of square model, for estimating ship fuel consumption was presented. This study was the first time that LMS model was designed and constructed to predict fuel consumption in ship operations using ship's noon report data. The various potential of factors on fuel consumption based on different daily operational conditions has been used to estimate ship fuel consumption. The model results show that the LMS regression can predict accurately the relationships between the input variables and a ship's fuel consumption.

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Creativity in Precipitation of Oil Cooling Tanks, in Plastic Injection Molding Machine, Using the ARIZ 71 Algorithm

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Abstract

One of the problems in industrial machine work with water, is of sedimentary that is closed Inside pipes and tanks of the devices and cause a lot of problems such as: reduction efficiency of the system, decrease the rate of water transfer, energy dissipation in the path and reduction lifetime of the devices and pipes, that annually Factories have to spend a lot of time and money to replacing or cleaning parts and equipment. The purpose of this paper is examine ways to minimize or remove water sedimentation in, oil cooling tanks in Plastic injection molding machine, without the use of chemical de-sedimentation materials that depletes the environment, That is checked with using ARIZ 71 algorithm. ARIZ71 algorithm is a systematic instruction to identify solutions for non-standard matters using technological capabilities and creative methods. Suggestions which can be obtained from ARIZ71 algorithm to minimize the amount of sediment In order to reduce waste of energy, time and cost, are :Use of supplement mechanical equipment before coolant reservoir To reduce the fluid temperature and precipitation , Use of distilled water Fluid , Use a water purifier in the water inlet to the cooling tower , Use of refrigerant gas as closed circuit in the oil coolant reservoir in plastic injection molding machine that this item has not been used for plastic injection machine and water with cooling duty is removed from the system and Refrigerant gas is used instead of water.

Keywords
Ariz71, sediment removal, cooling, refrigerant gas, plastic injection machine

1. Introduction
Today, sediment existence in heat exchangers and heat transfer equipments are main economic problem. Annually billions of dollars are spend for sediment losses in industries and imposes heavy expenditure to consumers. Besides metal corrosion damage that is due to sediment blockage, a significant amount of gas energy, electricity or oil will waste, for lack of heat exchange. Sediment reduces efficiency of facilities, Tube obstruction force artisans to water deposits pickling which is harmful to the environment.

2. Statement of the Problem
Deposition of radiator raise hydraulic oil temperature, slow down water transfer and reduce cooling; corrosion and decay through electrolysis between the deposited layer and the metal body, reduce the lifetime of devices and pipes since with increasing, hydraulic oil temperature, reduction of oil viscosity is happen, then hydraulic valves will leak and this subject couse damaging to the hydraulic system and high costs. The cooling tank precipitation for each device causes suspension of injection equipment and productivity and ultimately reduction of selling and profitability

3. Importance and Necessity of Research
To minimize the costs and harmful effects of precipitation in oil cooling tanks in plastic injection molding machine.

4. Solving Approach

In this research, ARIZ 71 algorithm is used which is a systematic instruction to identify solutions for non-standard matters using technological capabilities and creative methods in 6phases:

- selection of the problem
- exact Defining of problem
- Analysis
- Preliminary analysis to achieve the concept
- operation
- Synthetic

Innovation is used too. Innovative enterprises typically achieve stronger growth or are more successful than those that do not innovate. It is innovation in process.
Innovation is our lifeblood,' Siemens about innovation

4.1 First Phase: Selection of the Problem

4.1.1 The Ultimate Goal of Solving the Problem

a) What is the technical purpose? (What characteristics of the object should change?)
Create a proper cooling system for a long period of time and minimizing the amount of sediment in the pipe network

b) What attributes of the object cannot be changed during problem solving?
Dimensions of cooling oil tank designing cannot be changed.

c) What is the economical target with solving problem?(If the problem is resolved which cost will reduce?)
To minimize the cost of deposits, including savings tips from manpower and costs of repairing damage or replacement of hydraulic valves

d) What are the overall acceptable costs?

- Using appropriate tools and equipments
- Skilled staff
- Improvement of procedure in system maintenance

e) What are the main technical features / economy that should be corrected?
Deposits in the oil cooling system for plastic injection machine

4.1.2 Find the Best Status

Imagine that the problem cannot be solved substantially. What other more general problem can solve to reach this favorable final result?
General purpose can be attention to create a series of chemical and physical liquidation.

4.1.3 Determine Which Problem has the Main Method or the Best Alternative to Solve the Problem

a) Compare the main problem with the same item within the same industry.
Benoplast company: uses a closed system chiller with distilled water.
Ses plastic company: uses a closed system chiller.

b) Compare the main problem with the same item within an other industry
At refinery, they use chemical methods or light water and even light chemicals or gases for solving this problem

c) Compare the best status of problem replacement with the same item in the same industry.
Benoplast company in Turkey which is successful company in the field of plastics manufacturing , uses a closed system chiller with distilled water cooling fluid that has the least amount of sediment.

d) Compare the best alternative status with the same in an other industry
Using an inert gas.in refrigerator to do cooling operation and there is not sedimentation problem.

e) Compare main problem with the problem which has the best similar status and choose one.
Using the refrigerant gas in refrigerators is considerable subject and it will be choose.

4.1.4 Specify the Required Quantitative Features
1-Required equipments 2-The amount of budget

4.1.5. Introduce the Modification Time For Quantitative Features
At least two months

4.1.6. Define Cases for Particular Circumstances Which Invention is Applied in
Acceptable and quite advanced equipments due to reduce the cost of (frequency and time), repairs and maintenance.

a) Consider specific conditions for crop production, especially acceptable agreement from level of complexity, Through a field research and with the use of scientific techniques of problem solving, conflicting factors should be understood and appropriate solution should be provided and performed.

b) Consider the curve for future applications

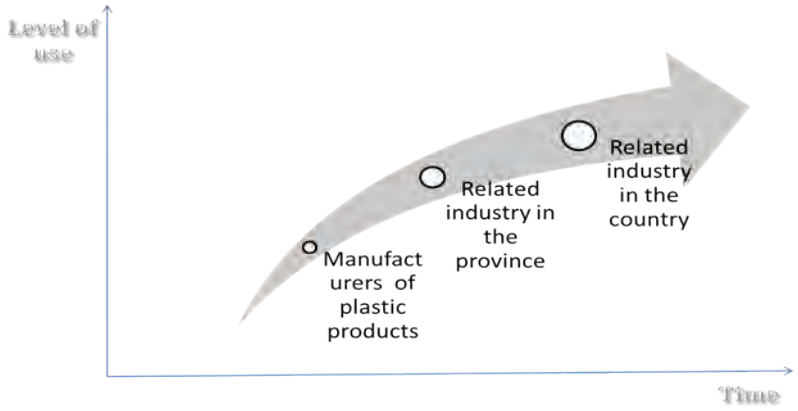


Figure 1: The curve for future applications

4.2 Second Phase: Define the Problem Precisely:

4.2.1 Define the Problem Using Patent Information
a) How much is this problem near to the issues have been resolved in other inventions?
Didn't use in plastic injection industry

4.2.2. Use Operations (size, time, cost). STC
a) Imagine changing in the size of an object, from the amount of data to zero, Is this problem solvable In this case? How?
No. Reduction dimensions of oil cooling system is incorrect

b) Imagine changing in the size of an object, from the amount of data to extreme, Is this problem solvable now In this case? How?
If oil cooling tanks be larger, cooling surface will be greater but it will not have a significant impact on reducing sediment.

c) Imagine changing in the flow rate time and speed of an object, from the amount of data to zero. Is this problem solvable In this case? How?
If purpose of the flow of an object Is the sediment, It is good value given a zero
d) Imagine changing the cost and speed of an object, from the amount of data to extreme. Is s this problem solvable In this case? How?

In such a situation systems and processes should be led to the mechanization

e) Imagine changing in the cost and speed of an object, from the amount of data to zero. Is this problem solvable In this case? How?
It is not solvable and need to spent. Targeted budget.

f) Imagine changing in the cost and speed of an object, from the amount of data to extreme. Is this problem solvable In this case? How?
Cannot say it is good. High cost also reduces profit. If that is targeted can be useful.

4.2.3. Describe the Conditions of Problem in Two Sentences like Following Form
a) The provided system (including components)
1-Mechanical equipments complement 2-The main mechanical equipments 3- Cooling material (liquid or gas)

b) Elements (explaining the elements),in Situations(explained modes) have undesirable effects(effects expression)
Heavy water: if not precipitation, the number and timing of Repairing mechanical equipments and hydraulic circuit will be raise.

4.2.4. With Inserting Elements of 4.2.3.a.
We will have the following table;

Table 1: Elements of 4.2.3.a

Elements	Elements describe
Mechanical equipments complement	Are partially controllable
The main mechanical equipmens	Are wholly controllable
Cooling material (liquid or gas)	Are partially controllable

4.2.5. Select From Step 4.2.4.:
a) The easiest element to change, redesign or adjustment.
We use mechanical equipments complement and cooling material (liquid or gas)

b) If an element in steps 4.2.3. a. .is related to adverse effect, we choose it only as a last step.
The cooling fluid that is heavy water .

c) If the system is just have step of 4.2.3.b. consider it as an element of external environment.
The main problem is sediment in the water of the oil cooling systems

4.3. Third phase: Analysis

4.3.1 Formulate the Ideal Final Result as Following Figure: IFR
a)Select element from step 2-5 : Mechanical equipments complement and cooling material (liquid or gas)

b) Exert It's doing

c) Announce It's act.
3 months

d) Announce its operating conditions. : For mechanical equipments or a liquid supplement, manufacturing Workshop is needed that act according to the order. (It has not external shopping source)

4.3.2 Drag Two Image
Initial conditions (before IFR) and ideal conditions (after IFR)

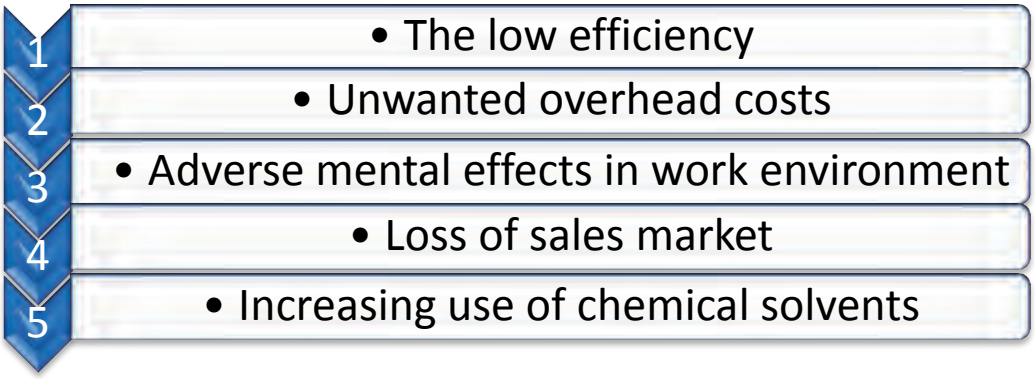


Figure 2: Initial conditions

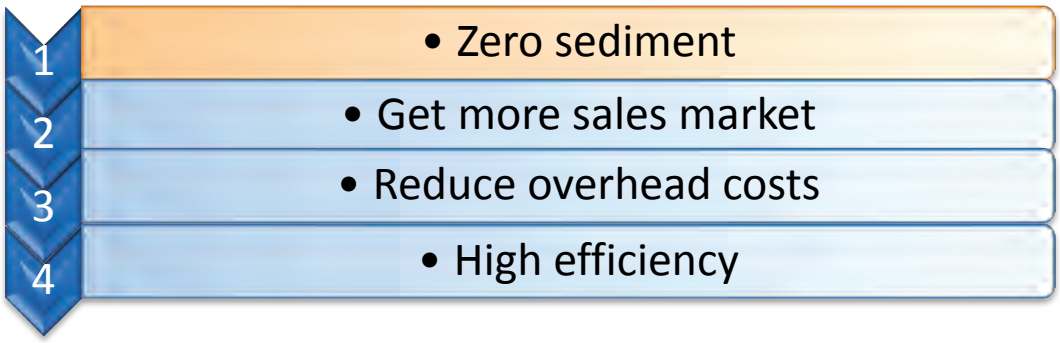


Figure 3: Ideal conditions

4.3.3 In Ideal Conditions Find Specified
Element in 4.3.1.a. -and highlight it (The part that cannot perform necessary functionality under necessary conditions) using mechanical equipments complement cannot guarantee reaching to zero sediment .

4.3.4 Why cannot it (by itself) does This Function?
Toward work it is external element

4.4 Fourth phase: Preliminary Analysis to Achieve the Concept

4.4.1 Meanwhile the Use of Theory or New Concept, What Is Better And What Is Worse?
Worse: More quarterly cares and the high cost of organization in short-time
Better the enterprise resource, Organizational processes. More reasonable speed of work progress, satisfied customers (better quality of product) , Safety machines and equipments , More profitability

4.4.2 Is It Possible To Prevent Worsening Of The Situation, Which Has Been Accured By Changing The Used Method Or Program?
Plot a sketch of tools or modified method.
Create external source of income and reduce costs permanently, Learning at work, devolution further works to Supervisors

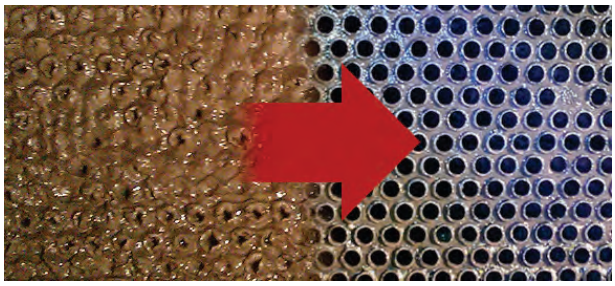


Figure 4: Object is modified

4.4.3 What is Worse Currently (More Complex or More Expensive)?
Quarterly care and the costs in the short term are raised that it is justifiable

4.4.4 Compare Achievements and Losses
There will not be disservice to the company and manufacturing conditions will be improved

- If achievements are more than the losses (even future) go to the sixth phase (synthetic Phase)
- If losses are more than achievements back to.4.3.1.step.

4.6. Sixth Phase: Synthetic

4.6.1 Determine How Much Major System That Our Defined System Belongs To It Should Change.
Major system is the plastic packaging industry. If this project (use refrigerant gas instead of the fluid of water) is used by other contributors commonly, it will be valuable. Improve quality in cooling system for plastic injection molding machine is leading to improve quality and quantity of production.

4.6.2 Investigate How Our Defined System Might Be Used Otherwise
It uses in all production systems that working with plastic injection molding machine. Just selection the type of refrigerant gas may be different

4.6.3 Use New Technically Theory (Or Opposite the Original Theory) For Solving Other Technical Matters
Separating: In dams reduction of sedimentation entrance to tank through the construction of sediment basins upstream of slave branches of river
Changing chemical and physical properties of an object: Using antifreeze and distilled water in the car radiator

5. Perfect Plan

- Is this utility function necessary to create other useful functions?

Yes. – the product with higher quality , Greater sales market , Higher profitability , Encouraging more investment , Providing health and better performance in longer periods in machines , Less waste material , Lower overhead costs

- Is this utility function will cause harmful effects?

no

- Is this useful function has been proposed to removing detrimental effect?

Yes. Adverse effects that have been deleted

- Is it necessary using other useful functions to run this utility function?

Yes. 1-Instructions for supervisors should be established, 2- Education on the job 3- Purchasing the appropriate equipments and tools
'

5.5. Is this harmful function makes more detrimental functions?
Sedimentation damage to mechanical equipment and hydraulic circuit

5.6. Is this harmful function created by other detrimental functions?
No

5.7. Is this harmful function created by useful functions?
Yes. Due to the cooling system process

5.8. Is a utility function proposed to remove harmful function?
Yes, using a refrigerant cooling system or complementary systems.

6. Conclusions

Towards the desired parameter of increasing productivity and inconsistent parameter of changing the level of automation, complexity control, the accuracy of measurement, the accuracy of production and external damaging factors aside maintaining existing functionality, the suitable suggestion that can be extracted from algorithm is adding a mechanical system, changing the chemical and physical properties of an object, separating and dividing are the perfect solution. To achieve the final perfect sketch use the following guidelines:

- Towards the desired parameter of immovable object of consumable matter and inconsistent parameter of energy losses, the suitable suggestion that can be extracted from algorithm is that with changing in coolant get to minimum sediment until have less waste of energy, time and money. So that if we use the neutral gas for oil injection molding machine cooling we will see improvement of production processes and sales and we can act successfully in changing this undesirable phenomenon (creating sediment).

- Using distilled water instead of ordinary water that preventing of creating sediment to good extent. This approach is a second priority and has a proper executive costs

- mechanical systems supplement can used with adding equipment such as radiators and putting it on the path that it is the third priority

Use a water purifier in water entrance path to cooling tower that it is fourth priority

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The Effect of Organizational Learning, Transformational Leadership and Market Orientation on Firm Performance

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Abstract

The aim of this study is to analyze the effects of organizational learning, market orientation and transformational leadership on the organizational innovation and firm performance amongst the firms performing in Turkey. A structural equation-modelling approach was applied to identify the variables that significantly affect the firm performance. Using LISREL, data collected from 330 employees were used to test the proposed model. Results indicated that 32% of firm performance is explained by organizational innovation and market orientation. Between them, organizational innovation has the strongest effect. Besides, organizational learning has no significant effect on firm performance, while transformational leadership is found to have insignificant impact on organizational innovation. The study concludes with the implications of this study for managers and recommendations for possible future research.

Keywords

Firm performance; organizational innovation, organizational learning; transformational leadership; market orientation

1. Introduction

Firm performance can be considered as the quantitative evaluation of the efforts conducted by the firms to achieve firm's objectives. Several indicators can be used to measure firm performance such as perceptions of the employees about return on investment, market share, sales, profitability, earnings, gross margin, and market value (Akgün et al,

2009) or through publicly available financial reports (Fleming et al., 2009). The increased competition enforces companies to look new ways to have an increased progress with respect to the competitors. However, today the factors that enhance the performances of the firms are a challenging problem that researchers and companies face with.

The literature directs us that organizational innovation is an important predictor of firm's survival and performance. Organizational innovation is prescribed as a means to improve firm performance with the application of new ideas into firms (Damanpour and Evans, 1984). Therefore, firms must be innovative in order to survive in a competitive environment (Argyris & Schön, 1996; Damanpour & Evans, 1984; Han et al, 1998; Hurley & Hult, 1988; Senge et al., 1990). Besides, innovation has also been an important concern in Turkey. The statistics show that 49.4% of firms with 10-49 employees, 58.9% of firms with 50-249 employees and 69.7% of firms with more than 250 employees conduct innovation activities with a high intensity between the years 2008-2011. Moreover, R&D expenditures of firms between 2008-2011 years in Turkey have been increased by 62% (Turkish Statistical Institute, 2011). These statistics demonstrate that more emphasis is given to the innovation related activities in Turkey.

Additionally, organizational learning, transformational leadership and market orientation play a key role in enabling firms to achieve high performance within the innovation process. Because, organizations performing in a competitive environment not only use the relevant information, but also creates and distributes the information in order to improve organization's development by means of innovations (Calantone et al., 2002). Moreover, organizations pioneered by transformational leaders supports the creativity and innovation by prompting exploratory thinking process throughout the organization to enhance firm performance (Jung et al., 2003). Furthermore, market orientation provides access to gather new ideas from environment and respond to the changing market conditions in order to adjust market requirements improving innovative activities, thereby leading a greater performance (Kasper, 2002).

The aim of this study is to analyze the effects of organizational learning, market orientation and transformational leadership on the organizational innovation and firm performance amongst the firms performing in Turkey. This study makes a contribution to the existing literature in several ways. First, this study provides evidence to the impact of organizational learning, market orientation and transformational leadership on the organizational innovation and firm performance. In the literature several studies also researched the impact of organizational learning and transformational leadership on both organizational innovation and firm performance (Aragón-Correa et al., 2007; García-Morales et al., 2012; Hsiao & Chang, 2011; Noruzy et al., 2012). However, to our knowledge, there has been no study in which these variables were modeled together with market orientation. Market orientation was selected as a possible predictor of firm performance, since in the literature market orientation is one of the important components which is an antecedent of organizational innovation and firm performance (Jaworski & Kohli, 1993; Han et al 1998; Narver & Slater, 1990). As it is compared to Turkey, market orientation is also an important subject for firms. According to the Turkish Statistical Institute's Report (2011), 35.55% of firms in Turkey conducted innovations related with market orientation in order to increase market-share or introduce new product or service. Second contribution of the current study is that, data was collected from the employees working in different sectors and different firms in Turkey, whereas similar studies that try to explain the factors affecting firm performance and organizational innovation have some differences from the current study: García-Morales et al. (2012) conducted their studies by collecting data from the Spanish firms from the automotive and chemical sectors; Noruzy et al. (2012) collected data from the managers of large and small scale manufacturing companies in Turkey; Hsiao & Chang (2011) conducted their studies by collecting data from teachers working in postsecondary schools in Taiwan; Aragón-Correa et al. (2007) collected data from Spanish companies in farming, manufacturing, construction, and services sectors.

The next section of this paper discusses the research model and the hypotheses. This is followed by the methodology and the analysis of the surveys. Then, the results of the surveys are presented and, this paper concludes with a discussion of the findings, its managerial implications and recommendations for further studies.

2. Research Model and Hypotheses

2.1 Organizational Innovation

Organizational innovation refers to the application of new technical idea or a new administrative idea into the firm (Damanpour & Evans, 1984). Innovativeness is one of the aspects of organizational culture. An organization must be open to new ideas to gain advantage in order to survive in a competitor environment (Calantone et al., 2002). Either an opportunity or a threat which occurs in the environment, may affect organizations to adapt new innovations. The adoption of any innovation requires changes in the organizational level. Thus, organizations are willing to apply these required changes into their external and internal functions in order to- increase firm performance, improve operation effectiveness, and respond to environmental demands (Damanpour et al., 2009), so that the desire of improving firm performance can be suggested as the main reason behind organizations' innovative approach. Therefore, firms achieve higher productivity according to the degree of their attitudes toward innovation (Gunday et al., 2011). Furthermore, there are other studies that confirm the effect of organizational innovation on firm performance (Bolívar-Ramos et al., 2012; García-Morales et al., 2012; Jiménez-Jiménez & Raquel Sanz-Valle, 2011; Noruzy et al., 2012; Uzkurt et al., 2013). Therefore, we hypothesize as follows:

H1: Organizational innovation has a positive effect on firm performance

2.2 Organizational Learning

Organizational learning is defined as "the capacity within an organization to maintain or improve performance based on experience. This activity involves knowledge acquisition, knowledge sharing, and knowledge utilization" (DiBella et al., 1996). A learning environment is necessary in the organizations for survival and maintaining competitiveness. Therefore, organizational learning is a key function of development and progress to achieve high performance (Calantone et al., 2002), however organizations must be flexible and open to increase their learning capabilities which enable organizational learning in order to obtain high performance (Aragón-Correa et al., 2007). On the other hand, organizational learning is not only about individuals' self-learning and self-development, but also about share of knowledge and information that will result in achieving performance objective (López et al., 2005). Furthermore, there are other studies that confirm the effect of organizational learning on firm performance (Bolívar-Ramos et al., 2012; García-Morales et al., 2012; Jiménez-Jiménez & Raquel Sanz-Valle, 2011; Noruzy et al., 2012). Therefore, we hypothesize as follows:

H2: Organizational learning has a positive effect on firm performance

Organizations committed to learning can increase their innovation capabilities by adapting the latest technologies into the innovations, using the knowledge and ability to understand the market, monitoring closely their competitors, and learning not only from their successes but also from their failures (Calantone et al., 2002). Inspiration of new ideas and support for creativity are the necessary motivation for employees throughout the organizational learning in order to provide sustainable innovative process (Aragón-Correa et al., 2007). Furthermore, there are other studies that confirm the effect of organizational learning on organizational innovation (Bolívar-Ramos et al., 2012; García-Morales et al., 2012; Hsiao & Chang, 2011; Jiménez-Jiménez & Raquel Sanz-Valle, 2011; Liao & Wu, 2010). Therefore, we hypothesize as follows:

H3: Organizational learning a positive effect on organizational innovation

2.3 Market Orientation

Market orientation is defined as "the organizational culture that most effectively and efficiently creates the necessary behaviors for the creation of superior value for buyers and, thus, continuous superior performance for the business" (Narver and Slater, 1990). It is a set of organizational activities that focus on the customers' needs to satisfy them (Kohli & Jaworski, 1990). Market-oriented organizations act according to the feedbacks which are provided from customers and competitors through formal or informal channels (Kara et al., 2005), so that it is not surprising that these firms achieve greater firm performance, because they are able to acquire knowledge about their rivals' strategies, understand their customers' needs, and can better satisfy their customers (Jaworski & Kohli, 1993). Therefore, firms with strong market orientation enable higher business performance than the firms with weaker market orientation by matching the optimal market conditions among target market selection, product development, pricing strategy, distribution, and promotion (Baker & Sinkula, 2009). Furthermore, there are other studies that

confirm the effect of market orientation on firm performance (Charles et al., 2012; Hafeez et al., 2011; Tsiotsou & Vlachopoulou, 2011). Therefore, we hypothesize as follows:

H4: Market orientation has a positive effect on firm performance

The relationship between market orientation and firm performance can be mediated by organizational innovation. Jaworski & Kohli (1993) have suggested that market orientation is an antecedent of innovation, because it requires new or different changes in the organizations to respond changing market conditions. In marketing, innovation usually refers to the product-related changes, however market orientation cannot narrowed by only product innovation. It also requires improvements in administrative level in the organizations. Thus, market orientation incorporates organizational innovation to increase firm performance (Han et al, 1998), so that organizations with greater market orientation are expected to develop newer product and process by means of technical innovation, and newer system, policy, and service by means of administrative innovation (Xie et al., 2007). Moreover, strong market orientation easily increases organizations' motivation to develop new ideas and creates an environment where organizations are able to innovate easily by adjusting to the market requirements (Jiménez-Jimenez et al., 2008). Furthermore, there are other studies that confirm the effect of market orientation on organizational innovation (Beck et al., 2011; Choi, 2012; Rhee et al., 2010; Zhang & Duan, 2010). Therefore, we hypothesize as follows:

H5: Market orientation has a positive effect on organizational innovation

2.4 Transformational Leadership

Transformational leadership refers to "the leader moving the follower beyond immediate self-interests through idealized influence (charisma), inspiration, intellectual stimulation, or individualized consideration" (Bass, 1999). Idealized influence and inspirational leadership means to motivate followers to have self-confidence in themselves in the process of achieving goals. Intellectual stimulation means to encourage followers to become innovative and creative in their work. Individualized consideration means to pay attention to the needs of followers and support them in order to develop their work (Bass, 1999; Bass & Avolio, 2000). Owing to these characteristics of transformational leadership, effective leadership is an inseparable part of successful learning organizations, because these leaders have a fundamental role in developing learning capabilities of the organizations for the sustainability of learning process itself (Cooksey, 2003). To promote organizational learning, transformational leadership must encourage and support the members of the organization through communication, experimentation and teamwork. In this way, a leader acts like a guide or mentor in order to facilitate learning process as increasing learning capacity, proposing new ideas, and creating new opportunities (Lloréns Montes et al., 2005). Furthermore, there are other studies that confirm the effect of transformational leadership on organizational learning (García-Morales et al., 2012; Hsiao & Chang, 2011; Noruzy et al., 2012). Therefore, we hypothesize as follows:

H6: Transformational leadership has a positive effect on organizational learning

The influence of top management is undeniable on the actions like strategy development and cultural implementation (Webster, 1988), so that leadership which is a fundamental need in determining the vision or identifying the performance objectives, is required to form the organizational culture (Day, 1994). Hence, it is not possible to create a market orientation without appropriate transformational leadership (Narver et al., 1998), because transformational leaders influence and motivate their followers to perform market-oriented actions in order to meet the customer needs and understand the competitors' strategies (Kasper, 2002). Additionally, they can better see the opportunities and threats in the market and interpret the current market situation to foster changes in organizational culture that leads to market-oriented organization (Menguc et al., 2007). Furthermore, there are other studies that confirm the effect of transformational leadership on market orientation (Kimura, 2012; Menguc & Auh, 2008). Therefore, we hypothesize as follows:

H7: Transformational leadership has a positive effect on market orientation

Transformational leadership is critical in the organizations in order to establish an innovative organizational culture. Transformational leaders play a major role in inspiring creativity among their followers (Jung et al., 2003). They provide an appropriate working environment where organization members trust each other, participate in creativity process, take responsibility, and come up with new ideas (García-Morales et al., 2008). Therefore, transformational leadership increases the capabilities of organizations to innovate by sharing strong vision of innovation, prompting

creative ideas, and showing confidence to the followers in the exploratory thinking process (Gumusluoglu & Ilsev, 2009a). Furthermore, there are other studies that confirm the effect of transformational leadership on organizational innovation (García-Morales et al., 2012; Gumusluoglu & Ilsev, 2009b; Hsiao & Chang, 2011; Noruzy et al., 2012). Therefore, we hypothesize as follows:

H8: Transformational leadership has a positive effect on organizational innovation

3. Methodology

A survey methodology was used in the present study. The target population for the study comprised employees working in companies operating in Turkey. A questionnaire was formulated based on an extensive review of the literature in the area of organizational learning, transformational leadership, market orientation, organizational innovation and firm performance (Baker and Sinkula, 2009; Baker and Sinkula, 1999; Bass and Avolio, 2003; Akgün et al., 2009). The final questionnaire consisted of four main parts. The first section covered the demographic questions designed to solicit information about the respondents. Potential participants, who are the members of Istanbul Chamber of Industry, were contacted via an e-mail which included a link to a web-based survey. A total of 330 questionnaires, from 330 different companies were returned to the researchers during the period from November 2010 to January of 2011. Of the respondents, 45.9% were female and the average age of the respondents was 31.

The second section asked the respondents to indicate their agreement level to the items related with organizational learning, transformational leadership and market orientation in the proposed research model. The items related with organizational learning were measured using a seven-point Likert-type scale (1:'strongly disagree' and 7: 'strongly agree'). The items related with transformational leadership were measured using a five-point Likert-type scale (1:'strongly disagree' and 5: 'strongly agree'). The items related with market orientation were measured using a ten-point Likert-type scale (1:'strongly disagree' and 10: 'strongly agree'), The third section asked the respondents to compare the performance of their company in comparison to the competitors with regard to the items related with firm performance. The items related with firm performance were measured using a 7-point Likert scale, where 1 represented a much worse performance than the competitors and 7, a much better performance. In the last part, each respondent was asked to think their current company's last three years organizational innovation activities and respond to the questionnaire with respect to the those organizational innovation activities. In this part, organizational innovation items were measured on a 10-point scale anchored by low-high. A pretest of the survey using a pilot study was conducted to test the general readability and overall flow of the survey. 40 employees were included in the pilot study. Based on the information provided by these users, a few questions were reworded to improve the readability. Subsequently, the instrument was finalized.

4. Results

In the analysis stage, our study followed a two-step approach recommended by Anderson and Gerbing (1988). This approach allows specifying the measurement model a second time to achieve unidimensional construct measurement (Anderson & Gerbing, 1988). The model was tested using LISREL 8.54 (Jöreskog & Sörbom, 2003) with SIMPLIS project.

4.1 Measurement Model

The model was tested for reliability and validity of the constructs using confirmatory factor analysis (CFA). The measurement model included 55 items describing 5 constructs: firm performance (Perf), organizational innovation (Innov), organizational learning (OL), transformational leadership (TL) and market orientation (MO). In this study, the constructs of the organizational learning and transformational leadership have dimensions. The dimensions of organizational learning are: commitment to learning, shared vision and open mindedness, and the dimensions of transformational leadership are: idealized attribute, idealized behavior, inspirational motivation, intellectual simulation and individual consideration. Therefore, a second-order confirmatory factor analysis is performed for the organizational learning and transformational leadership.

4.1.1. First-Order Factor Model

In the first-order confirmatory factor analysis stage, some construct revisions were needed after the initial analysis of the measurement model. The decision to specify the construct was taken based on the differences in the values of $\chi 2$ for the competing models if the theory and content allowed for changes (Anderson & Gerbing, 1988). After specifying the constructs again, 44 items were retained for further analysis.

The fit statistics show that the model provided a reasonably good fit to the data. The values of $\chi 2$, degrees of freedom, root-mean-square error of approximation (RMSEA), adjusted goodness-of-fit index (AGFI), normed fit index (NFI), comparative fit index (CFI) and standardized root mean residual (SRMR) were selected according to the recommendations of Hair, Anderson, Tatham, & Black (1998). They stated, "the researcher should report one incremental and one absolute index, in addition to the $\chi 2$ value and associated degrees of freedom, and at least one of these indices should be badness-of-fit indices" (Hair et al., 1998, p. 752). The overall $\chi 2$ for the model is 1539, with 847 degrees of freedom. The p value associated with this value is 0.00. This shows that the observed covariance matrix does not match the estimated covariance matrix. Because the $\chi 2$ statistic is sensitive to sample size, this was considered as an acceptable condition (Bentler, 1990; Hair et al., 1998). Thus, other fit indices such as the absolute fit indices (RMSEA = 0.048, SRMR = 0.047 and AGFI = 0.80), incremental fit indices (NFI = 0.95 and CFI = 0.98), and $\chi 2$ to degrees of freedom ratio (at 1.81) can be used, and all the fit indices are within acceptable levels (Hair et al., 1998; Chau, 1997; Chau & Hu, 2001), suggesting that the model provided a reasonably good fit to the data. In addition, the improved model has fit indices that are better than the untrimmed model.

The convergent- and discriminant validities of the constructs were tested using the confirmatory factor analysis. Convergent validity is the degree to which two or more items measure the same concept (Bagozzi & Philips, 1982). We examined the convergent validity of measurement items by their t-values, factor loadings, composite reliability, and average variance extracted (AVE). All the t-values of the items were significantly greater than the critical value of 1.96 at the 0.95 confidence level (Bagozzi, Yi, & Philips, 1991). All items, except OLCL1, OLOM1, OLOM4, TLIA3, TLIM3, TLIM4, MO2, MO9, exceed the recommended factor loading value of 0.70 (Hair et al., 1998). However, since these have factor loadings that are close to 0.70 and are validated by previous research, they were retained. The AVE estimates range from 0.54 for both idealized attribute and open mindedness to 0.73 for idealized behavior. All the AVEs exceed the recommended value of 0.50 (Fornell & Larcker, 1981). Composite reliability measures the internal consistency of the measurement model (Chen, Gillenson, & Sherrell, 2004), and all the composite reliabilities exceed the 0.60 threshold (Diamantopoulos & Siguaw, 2000). In addition, the value of Cronbach's alpha for each construct is more than 0.60, indicating an acceptable level of reliability. Thus, all these statistics show that the convergent validity requirement is satisfied.

Finally, discriminant validity was assessed using a series of $\chi 2$-difference tests for every possible pair of constructs in the measurement model. For each test, only one correlation parameter was fixed to 1. A significant $\chi 2$ difference indicates that the constructs are statistically distinct. The $\chi 2$ differences were all above the critical value of 3.84 at the 95% confidence level. This showed that all the models in which the correlation was set to '1' displayed a worse fit. This demonstrates adequate discriminant validity for all constructs (Bagozzi & Philips, 1982).

4.1.2. Second-Order Factor Model

To confirm the multidimensionality for the constructs of organizational learning and shared vision, a second-order CFA is conducted for these constructs. The results indicated that all the fit indices for both organizational learning and shared vision are within acceptable levels, suggesting that the model provided a reasonably good fit to the data. Further all the paths are significant and all the factor loadings of the items, except OLCL1 and OLOM1 for organizational learning and SVIA3, SVIM3 and SVIM4 for shared vision, are greater than the recommended value of 0.70 (Hair et al., 1998). However, these items have factor loadings that are close to 0.70 and are validated by previous research, they were retained.

4.2 Structural Model

The structural model shows the relationships between the constructs and specifies the constructs that are related to each other (Hair et al., 1998). The fit indices are within acceptable levels. The parameters determining the ratio of $\chi 2$ to degrees of freedom - at 2.46, RMSEA - at 0.068, CFI - at 0.96, and NFI - at 0.93, SRMR – 0.089 are all within the recommended values (Bentler, 1990; Hair et al., 1998; Chau & Hu, 2001). This suggests that the model provides a reasonably good fit to the data.

Figure 1 shows the standardized path coefficients with their respective significance levels and the explanatory power of the model for each construct. All the hypotheses were supported except H2 and H8. Additionally, the model explained the modest variance of firm performance (R2 = 0.32), organizational innovation (R2 = 0.26), organizational learning (R2 = 0.27) and market orientation (R2 = 0.12).

The results showed that organizational innovation and market orientation were found to be significant predictors of the firm performance. The relative strengths of their explanatory power were different. Organizational innovation is a much stronger predictor of the factor firm performance compared to the market innovation. Whereas the direct effect of organizational learning on firm performance is found to be insignificant.

The other result suggests that, both organizational learning and market orientation have significant effects on organizational innovation, whereas the effect of transformational leadership on organizational innovation is found to be insignificant.

Another result of our study is that, transformational leadership has a positive effect on both organizational learning and market orientation.

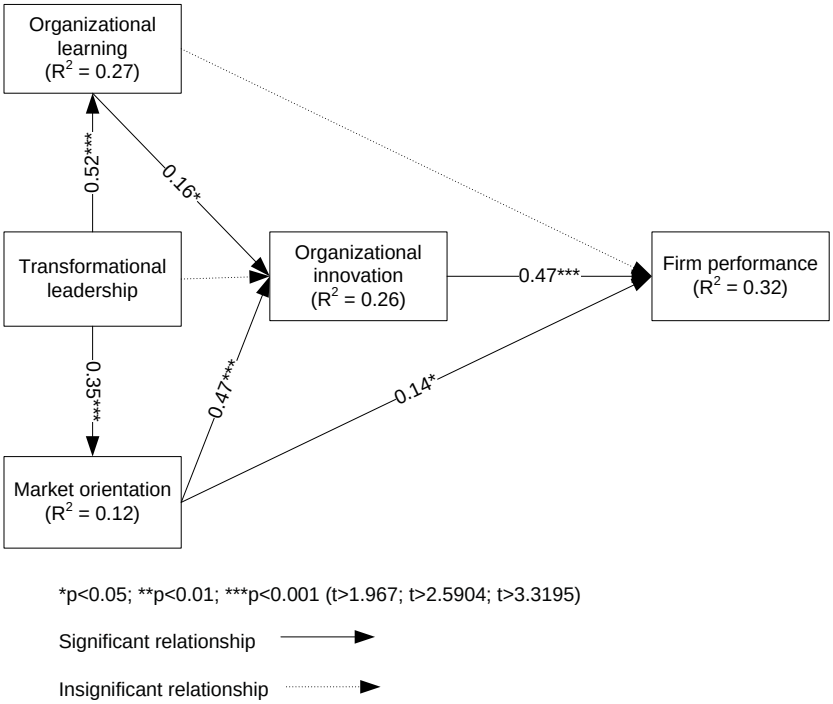


Figure 1: The results of the research model

Figure 1 shows the direct, indirect, and total effects of each construct on the firm performance. As shown in Figure 1, organizational innovation has the highest direct and total effect on firm performance. Although direct effect of organizational learning on firm performance is found to be insignificant, it has a significant indirect effect on firm performance through organizational innovation. Furthermore, transformational leadership has a significant indirect effect on firm performance through organizational innovation and market orientation.

5. Conclusion and Discussion

This study has examined the influence of transformational leadership, market orientation, organizational learning, and organizational innovation on performance of firms in Turkey. A total of 330 questionnaires were collected from different firms in Turkey between November 2010 and January of 2011. Structural equation modeling approach was used to analyze the relationships defined in the research model. Both measurement and structural model fitted well to data. Furthermore, amongst eight hypotheses, six of them supported by the data collected from the firms which have operations in Turkey.

First, this study shows the significant direct impact of organization innovation and market orientation on firm performance. Our research supports the findings of previous studies on the positive relationship of organizational innovation (Bolívar-Ramos et al., 2012; García-Morales et al., 2012), market orientation (Charles et al., 2012; Hafeez et al., 201) with the firm performance. The findings of the study also confirm that organizational innovation

plays a key role in enabling firms to perform high productivity and efficiency. The higher level of organizational innovation leads to better firm performance. Therefore, it is suggested that firms need innovative developments to improve their performance in order to survive in business environments. They should increase their innovative capacities, resources, technological competences for achieving sustainable competitive advantages. Besides, organizations should not ignore the market-oriented activities, because a successful marketing program provides better services to the customers than their expectations. Thus, higher market-oriented organizations are more successful in satisfying their customers than weaker market-oriented organizations.

Second, this study also showed that transformational leadership has an indirect impact on both organizational innovation and firm performance through organizational learning and market orientation. Similar to our findings, transformational leadership is found to have indirect effect on both factors through organizational learning in the previous studies (García-Morales et al., 2012; Aragón-Correa et al., 2007; Noruzy et al., 2012). However, to our knowledge, the effect of transformational leadership on organizational innovation and firm performance through market orientation has not been studied before. Therefore, it can be suggested that transformational leadership is required to integrate market-oriented vision as organizational culture, influence organization members to have a better understanding of market needs, and promote market-oriented strategies in order to adjust to the changing business world as being innovative and enhance firm performance.

Third, organizational learning is found to have insignificant direct effect on firm performance in our study. Inconsistent with our findings, previous studies confirms that organizational learning has a direct impact on firm performance (Jiménez-Jiménez & Raquel Sanz-Valle, 2011; Noruzy et al., 2012). However, our study also shows that there is a low indirect effect of organizational learning on firm performance through organizational innovation Thus, it can be suggested that higher level of organizational learning is linked to higher organizational innovation, so that it leads to develop better innovative strategies and performance.

Although the findings of this study provide a better understanding of the factors affecting firm performance in Turkey, finally, the results of the current study may be shared with the managers to have a further understanding about the findings. With the opinions obtained from the managers, a qualitative analysis may be combined with the current quantitative analysis' results.

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Use of Cognitive Maps for Investigating the Success Factors of Innovation Technologies in Service Sector

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Cognitive mapping, innovation, service industry

1. Introduction
Generally, management of innovation has been based on manufacturing industry as the stakeholders in this area have tangible products. These products are developed under predefined processes. On the other hand, the importance of service industry that is responsible for more than 60% of GDP in Turkey is constantly increasing. Since innovation is a powerful tool, which provides a capability of adopting the rapidly changing needs of the World, the contribution of innovation to service industry is indisputable. So there exist a necessity to investigate this invaluable potential of service innovation to provide maximum utility.

2. Methods
Cognitive mapping is utilized to reveal the cause and effect relationships between the factors and their respective impact levels that influence the success of the innovation technology on service industry. A cognitive map is a type of mental representation which serves an individual to acquire, code, store, recall, and decode information about the relative locations and attributes of phenomena in their everyday or metaphorical spatial environment.

To this end, “e-tohum”, the platform with its investor and entrepreneur members leading the innovation for service industry, provides the expert pool of this study. Experts are interviewed in order to identify their opinions and finally related success factors and consequences are revealed via cognitive map.

3. Results
Amongst the potential criteria, integration of technical/organizational strategies, agile development and collaborative networks are the most important factors of success.

4. Conclusions
The results show that for an establishment in service sector to increase its innovative capabilities, they should focus on simplifying their processes to establish an agile development environment and create collaborative networks. Reliability of services/products in addition to providing flexible customisation are also of notable importance.

Biography

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Information Technology, Information Systems Management and Supply Chain Management Applications in Logistics Industry

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Abstract

Today's business world generated considerable knowledge on the importance of information technology (IT), information systems management (ISM) and supply chain management (SCM) for improving business performance. Key issues concerning the effectiveness of IT, ISM and SCM needs careful attention. The understanding on the alignment of IT, ISM and SCM will contribute to improvements in business performance. The examination of the complementarities in the philosophical emphases of IT, ISM and SCM is very important. Logistics managers try to investigate how IT, ISM and SCM could complement on the performance implications of their company. This study advances knowledge on the alignment practices and highlights the importance of recognizing the complementarities of IT, ISM and SCM in their implementation efforts. The applications of IT, ISM and SCM in Turkish logistics sector have drawn too much attention lately.

Keywords
Information technology, information systems management, supply chain management, logistics industry

1. Introduction

Today, companies are in the race for improving their organizational competitiveness in order to compete in the 21st century global industry. The role and implications of information technology (IT) is very important in logistics industry. The adoption of IT in organizations has been growing at rapid pace. Modern IT can reduce the costs of communication by improving the quality and speed of information processing and management's decision making, leading to more centralized management. At the same time, IT can also provide management with the ability to reduce costs through improved monitoring capabilities and performance evaluation schemes, inducing decentralization of decision making (Gurbaxani and Whang, 1991). Organizations have unique security needs and dynamic business environments and factors which policy development should take into account (Baskerville and Siponen, 2002). The use of IT is found to provide a significant competitive advantage for firms. The use of IT need to be linked with organizational competitive priorities. The advanced IT firms focused primarily on quality and flexibility, competitive priorities in line with the customization orientation of these firms. These firms are also found to succeed on performance measures that are in line with these priorities, documenting the linkage between competitive priorities and organizational advantages. Companies that focus on a different set of priorities, or operate in mass production environments with standardized products, may not require as much flexibility from their IT systems but need greater efficiency in processing routine information (Grover and Malhotra 1999). Even the companies with high IT capability were found to primarily use operations-oriented information technologies. Managers should clearly understand their company's competitive priorities and evaluate information technology adoptions for their ability to support these priorities, rather than follow current competitors. Although IT usage is found to be positively linked with a number of performance measures, managers need to be realistic in their expectations of the achievements IT usage can bring. The primary advantages were associated with operations performance measures such as cost, time, quality, and product development. IT has potential benefits in the areas of innovation, competitive intelligence, and access to new product opportunities. IT usage can clearly contribute to improved organizational performance by serving as a tool to enhance business functioning. But it cannot solve for all the organization's competitive problems (Sanders and Premus 2002). As information technology (IT) continues to spread, there will be an increasing awareness of a fundamental need to address privacy concerns, and that doing so will require an understanding of policies that govern information use accompanied by development of technologies that can implement such policies. In addition to this situation the adoption and use of IT in organizations affects its structure. IT implementation is, however, ongoing in the public sector at all levels of government. The rapid advancement of the use of information technology in industry, government, and academia

makes it much easier to collect, transfer, and store personal information (PI) around the world. This raises challenging questions and problems regarding the use and protection of PI. A privacy consideration in technology for the future includes philosophical, legal, and practical dimensions, any or all of which can be considered as within the domain of the field of human–computer interaction (HCI). IT highlights the work of identifying organizational privacy requirements and the needs of providing flexible privacy enabling technologies. Recent studies present a broader perspective and an understanding of IT in terms of the values of organizational perspective. It uses an approach to identify 'fundamental' objectives for IS security and 'means' of achieving them in an organization. Increased concern for IT at a technical and organizational level is important; 'its implementation must also take cognizance of ethical and human considerations'. Clearly, such a broad perspective can be realized if the concerned managers are convinced of the value of also focusing attention on people issues rather than exclusively on technology. Social and organizational factors must be considered together. Therefore, any explicit presentation of social and organizational factors is a discussion of people's underlying assumptions and values. The relationship between organizational structure and information technology (IT) has long been of interest to researchers. Opinions vary as to how IT affects organizational structure. It is often supposed that IT creates a flatter organizational profile by reducing the number of managers in an organization and that it may also affect decision making by increasing the number of decision makers through improved communication channels. It has also been suggested that flatter organizational structures are not actually caused by the use of IT; rather, IT facilitates such changes.

Recently high demands are being made on logistics and both production industries and logistics service providers face significant challenges in the field of IT applications. Low costs, speed and security must be achieved in combination with flexibility in the logistics chain. It is all too easy to believe that the application of modern software can solve all of a logistics manager's problems. But the right methodology is what is needed if objectives are to be reached. Nowadays, a company which used to have to coordinate its procurement, production and distribution processes using significant human and other resources. New information and communication technologies (ICT) and applications should help revolutionize procurement, production and distribution processes. Whereas organizational difficulties and insufficient IT applications have almost completely prevented cost savings to date, there are apparently now no further such barriers to developments. Faster processing times, self-managing intra-logistic processes, the automatic location of operational and production materials, comprehensive tracing, and transparency throughout are envisaged. This is all made possible by logistics and supply chain management software, as well as through the use of auto-ID solutions which enable the control and tracking of goods and products in semi-automated and networked distribution processes. An RFID chip containing all information needed from source through use to final destination is attached to the input products when they are produced. When the product gets to the customer, then the chip automatically transmits its own data, so that it can be transferred to its correct location immediately. Following processing, new information is added to the product's chip, and it is then directed into the distribution process, where the destination is determined with the help of the RFID chip. The middleware is important here as it translates the signals of the RFID application and inputs these into the company's internal IT system. In order to avoid media breaks during data transfer between various partners, a standardized middleware must be used which has a standardized data format or exchange protocol which can be applied beyond the company's boundaries. Systematic behavior leads to the appropriate use of technology. Although these scenarios have already proved themselves in a number of cases they are still linked to technological uncertainty and high costs. In addition, the use of new applications, characteristics, interfaces, or technologies requires clearly defined objectives. The present RFID fashion gives the impression that every convert who is also marketing the system wants to sell the technology as a means in itself and not a means to an end. In the future appropriateness of the technical and economic feasibility of auto-ID technologies will considered. Its success depends on its strictly methodological application ensuring that it is used to achieve specific objectives in logistics. These could, include reductions in tied-up capital, adherence to legal guidelines such as the production of technical documentation in the defense industry, or the continuity of information flows throughout all locations and business areas. The combination of the right methodology with appropriate innovative ideas often plays a central role in the optimization of a company's value chain. The logistics company must give importance for setting priorities, documentation of the supply chain process activities, and adaptation of the system environment.

2. IT and Logistics Managers

Managers should be aware of the problems of the misalignment of IT, ISM and SCM in their implementation and, more importantly, recognize the complementarities of IT, ISM and SCM for improving performance when formulating plans to implement IT, ISM and SCM. In such a case, the IT, ISM practices, which reflect the endogenous and organizational attributes and the SCM practices, which reflect the exogenous and supply chain

conditions, are better to be aligned in their implementation. The managerial issues that should deserve management attention when companies seek to better implement their IT, ISM and SCM. The examination of the complementarities in the philosophical emphases of IT, ISM and SCM is very important. A logistics manager has primary responsibilities and tends to juggle with three priorities: cost, speed and security. The simultaneous optimization of these targets is almost impossible to achieve as the three priorities stand in conflict with one another: the consumer in the supermarket for example wants to be able to trace back foods to their source and to know which fertilizers were used to grow the vegetable that they have selected. This information cannot be made available without additional process costs and greater IT effort. On the other hand, the value that logistics can add to a product or service is often not even contemplated. And this is even though the success of companies based to a large extent on their very effective logistics concepts and excellent product quality is also due to good logistics. Basically the logistics managers should also consider a fourth priority: flexibility. This enables the added value in the logistics chain to be developed into a competitive advantage. The latest generation of material and logistics managers have concentrated on cost reduction in their work. Cost reductions alone will, however, not suffice when changing market conditions are endangering the very survival of a product. The definition of an optimization strategy for logistics processes can take place within the new frameworks. Activities are allocated to the priorities, which reflect the strategic aims of implementing new technologies. Recommendation concerning supply chain process activities and supply chain management (SCM) has now become established as a core process in many larger companies. In the enhanced Telecom Operations Map (e-TOM), the standard used in the telecommunications industry, supply chain development and management is the basis of the core process 'strategy, infrastructure and product'. For a high technology company supply chain management, customer relationship management and product lifecycle management are the three key processes. At the same time the 'Supply Chain Operations Reference (SCOR) Model' has become common. This model takes on the perspective of cross-plant supply chain management. SCOR is based on the process method 'source-make-deliver'. Companies which supply or sell significant services to complement their products – as is common in the high-tech industry – find that reverse logistics are an add-on at the end of the traditional SCOR model. Taking into account the fact that new processes in the warehouses – e.g. vendor managed inventory, outsourcing of specific construction tasks, o commissioning supported by speech-to-text – carry significant cost reduction and process optimizing potential, the subject of storage should be a particular focus of the logistics manager's attention. (Cuny, and Bremicker, 2007). Therefore logistics managers recommend that an activity list is derived from the core management and support processes which can be used to create a map of activities and applications. This applications map can then be used to identify gaps in the logistics process, to group activities into clusters, and to draft basic catalogs of requirements for systems and project roadmaps. By allocating the specific activities to information and communication technologies an appropriate foundation is provided for discussions with the providers of solutions such as ERP, logistics, SCM and TM systems in order to agree on processes using standard documents or business maps. Logistics service providers are going to benefit particularly from increasing outsourcing as a result of improved IT systems. These can also extend their product and service portfolio to cover both auto-ID and intelligent software solutions and can offer better quality or flexibility. Companies should, however, beware of becoming too dependent on their external logistics service provider, in distribution as well as tracking and tracing logistics. Lock-in effects can result in high follow-on costs for the companies if processes have to be integrated or changed. To ensure competitive behavior amongst external service providers, and in order to limit their market power, attention should be paid to the application of a software architecture which is as service oriented as possible (SOA) and which supports the flexible integration or exit of logistics service providers in the medium to long term and not just in the short run. Sensor fusion and intelligent sensors represent a promising research development. The former describes sensors, such as GPS, temperature sensors or pressure sensors, which forward their combined data to an intelligent sensor which then evaluates them using an intelligent software system and derives appropriate measures to be taken. The main area of application is the monitoring of sensitive freights being transported by logistics service providers like air freight organizations (Cuny, and Bremicker, 2007).

3. Logistics Management Information Systems

Generally, definition of systems is significant to definition of information. For instance "information is that intellectual that in a certain domain can be acquired, preserved, transferred and applied as non-empty sets of information elements, such that each element determines a certain aspect entity" (Long, 2003). Hence, the definition of an information system should then bed a system that can manage knowledge. Lambert, (2004), defines it: "An information system is a system for collection, adaptation, storage, transfer and presentation of information in an, for the users of the information system, effective way. The information system can be totally or partly computerized." Logistics is "the process of strategically managing the acquisition, movement and storage of materials, parts and

finished inventory (and the related information flows) through the organization and its marketing channel in such a way that current and future profitability is maximized through the cost-effective fulfillment of orders (Somuyiwa and Sangosanya, 2007; Christopher, 1992; CLM, 1998). Logistics adds value by making products available in the right place and at the right time. If a product for instance is available at the place it is needed, logistics is said to have added place utility, if it is delivered at the right time, logistics has added time utility. Then the aim of logistics can be phrased in terms of getting the highest customer utility or perceived value. In essence, it is trying to maximize the difference between perceived value and actual costs.

The concept of logistics is ancient. There is nothing new about the components of the field of logistics. Things have been moving by transport since people first learnt that logs float downstream. Moreover, storage has been in existence since people first discovered that, that was a way to survive long and cold winter, and what is done is perhaps synonymous to logistics management (Waidringer and Eng, 2001). In the same time, electronic commerce and associated business-to-business transaction capabilities have changed the way in which supply chain operates. The Internet has for instance, enabled information exchange on an unprecedented scale, often at a pace too fast for normal consumption. Hence, companies are now equipped to make effective use of data, from warehouse management systems, which contain information on supplier/customer warehouse inventory levels and key customer ordering patterns and transportation management systems within which information pertaining to the location of important supply chain assets, such as products or vehicles is typically stored. The integration of these systems leads to global inventory visibility which, in turn, leads to reduced costs and improved customer services by decreasing shipping and receiving cycle times, increasing shipment and inventory accuracy, and decreasing lead time variably that all have impacts on logistics cost (Moberg, 2002; Somuyiwa, 2010). However, the theoretical basis of the information has not been fully understood within the context of logistics system, such that it will give a pointer to those inherent cost could be managed or saved, as well as enhanced supplier-customer collaborative relationships. Lately, there are considerations on how those basic objectives of logistics can be achieved and its ultimate goal can be realized.

4. Information Technology in the Supply Chain

Supply chain management (SCM) is global operations strategy for achieving organizational competitiveness. Companies are attempting to find ways to improve their flexibility, adaptability and responsiveness and in turn competitiveness by changing their operations strategy, methods and technologies that include the implementation of SCM and IT. Nowadays markets are electronically connected in dynamic in nature. Companies are trying to improve with objective of being flexible, adaptable, responsive and competitive to meet the changing market requirements. Successful companies have developed focused e-business solutions for improving customer service elements that are most important in their business. Improved efficiency allows company personnel to focus more on critical business, logistics and transportation activities. The use of e-business solutions improves information quality. E-business solutions support planning collaboration and improved agility of the supply network. Generally to gain strategic benefits, the use of IT has to be coupled with process redesign (Auramo et. al, 2005). IT in supply chain has enabled the gathering, storing, and analysis of unprecedented amounts of data. It equally facilitates planning at all levels through data analysis and sharing, which enable planning to occur at the strategic, tactical, and operational levels. Similarly, IT gathers, integrates, and analyzes logistical data to streamline local and global supply chain. Every trading partner in the supply chain must be working from the same data shared in real time through a common hub. Sequentially passing information across each link of the supply chain perpetuates duplication of data, missed information, and time delays. In a related development, IT orchestrates the flow of demand supply, and cash in supply chain networks, with equal information flow, material flow plus cash flow that include: Information flows replace or delay inventory flows whenever possible. Logistics and cost information aspects of each physical materials flow are performed electronically for better reliability and velocity, lower cost, and higher levels customer service. Electronic cash flows such as secure Electronic Fund Transfer (EFT) free up cash faster for reinvestment. The faster information flows along the supply chain, the faster operational decisions can be made. The faster material and cash flow along the supply chain, the faster a company's money is freed from the manufacturing or procurement cycle. One of the main areas of interest that has emerged in recent years concerns the effects of ICT on logistics. ICT can help complete integration of logistics (Suder and Durucu, 2013). These technologies in logistics, considering the wide range of possible effects on the supply chain efficiency improvements related to ICT usage can be analyzed with three functions; Information/Order processing and management, Distribution and Sharing of Data and Information, their transfer and lastly, the Processing and Utilization of information for supply chain specific technologies used as a support tool for the three functions identified.

Information sharing: is an essential prerequisite for securing information accessibility to all supply chain partners involved in logistics operations. The availability of consistent information improves decision-making process for operators. Data sharing has always been important in the transport and logistics of manufacturing companies.

Information transfer: is probably the most relevant function in the SCM concept, because it takes place through several technologies ranging from the most recent e-business applications or extranet, Electronic Data Interchange (EDI) systems, to the most traditional communication technologies such as telephone, telex or fax. The widespread dissemination of the internet and e-business technologies allow to a large extent overcoming problems relating to systems and applications interoperability. This allows to extend the use of these technologies, including EDI, to smaller companies since internet application technologies require relatively low implementation costs and show a high flexibility in information transfer. In supply chain operation planning, ICT also plays a major role to the extent that the benefits obtained from the application of SCM logic depend almost entirely on a company's capability to establish electronic links with customers, suppliers and third party logistics 3pls. ICT investments made by companies can range from Enterprise Resource Planning (ERP), to new applications that integrate all the stages of the supply chain and are able to support the entire planning process as the Enterprise Integration Application (EIA), or the Advanced Planning System (APS). Through these new systems, companies are able to combine and align their planning with that of other supply chain partners by covering the whole area of supply chain stage and thus making the planning process more efficient.

Enterprises resources planning: Enterprise Resource Planning (ERP) is a planning and communication system that affects all the resources of a company. Another similar term Enterprises System (ES) is an information system that manages all the resources available in a company. It is a common term for a co-operating software that manages and co-ordinates much of a company's resources, assets and activities (Boyle, 2004).

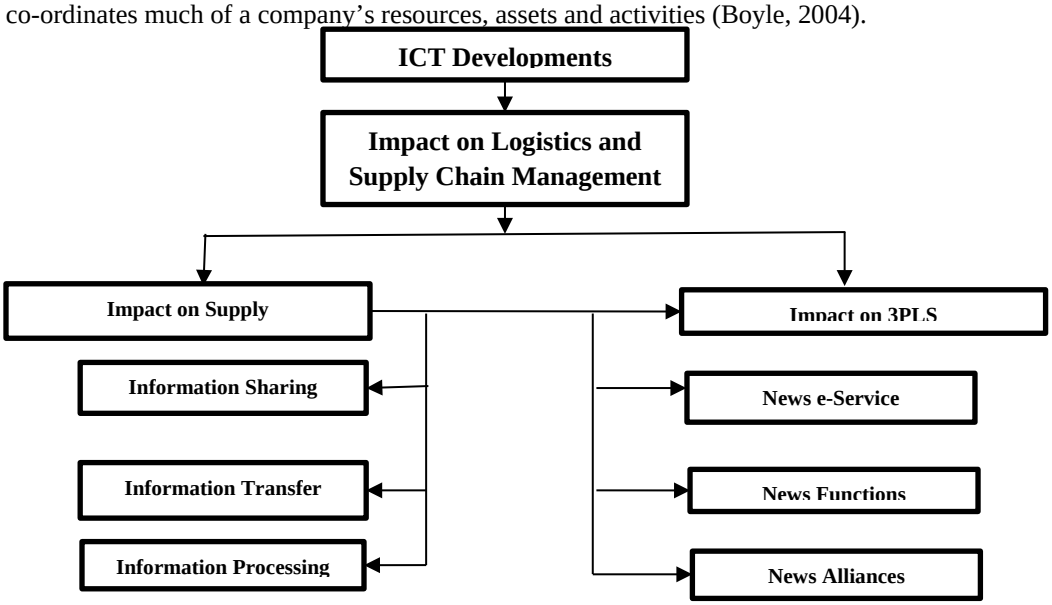


Figure 1: The impact of ICT on logistics and SCM adapted from Carlson (2005) and Collins (2005)

Customer order cycle: The customer order cycle occurs at the customer/retailer interface and includes all process directly involved in receiving and filling the customer's order. The customer initiates this cycle at a retailer site, and the cycle primarily involves filling customer demand.
Customer order entry: The term customer order entry refers to customers telling the retailer what products they want to purchase and the retailer allocating products to customers. At a mail order firm's telemarketing center or Web site, order entry will involve customers informing the retailer of the items and quantities they selected.

Customer order receiving: In the customer order receiving process, the customer receives the order and takes ownership. Records of this receipt may be updated and cash payment initiated. For a mail order firm, receiving occurs when the product is delivered to the customer.

Extent of the use of IT devices in order processing and information cost: This refers to how companies have made products and services available to customers. It also involves how various types of information technology devices are made available in the companies. The identified technologies are computer systems, electronic data transfer, electronic data interchange, magnetic ink character reader, local area network, wide area network and Electronic Resource Planning. Basic ICT developments are in Figure 1.

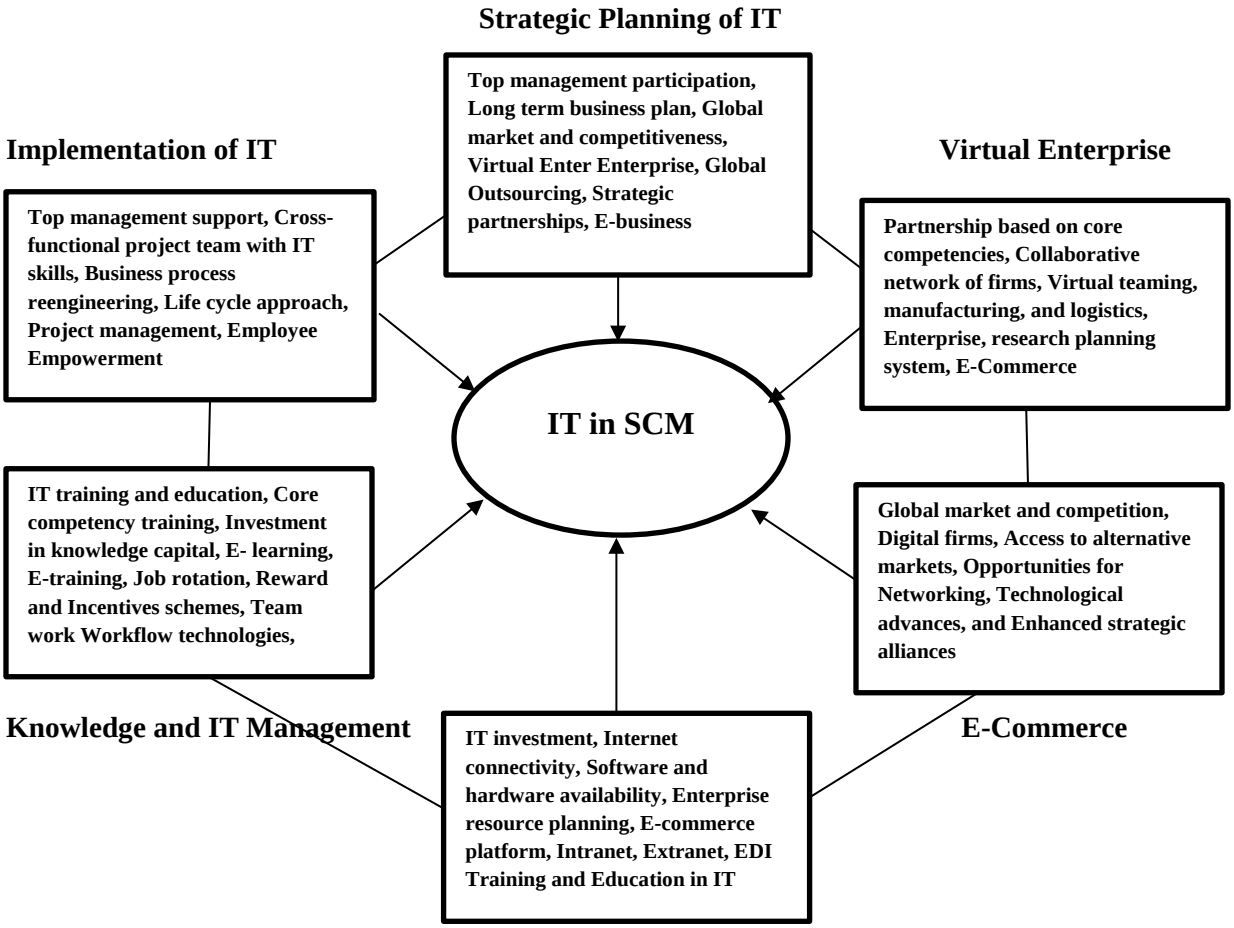


Figure 2: IT for effective Supply Chain Management adapted from Gunasekaran and Ngai, 2004

In todays' competitive environment organizations need strategic planning. Differences in strategic orientation of firms should lead to differences in the emphasis on specific IT applications (Hayes, et. al, 1988). Strategic planning of IT in SCM has the objective of making long-term decisions such as the selection and productive implementation of IT with the objective of achieving an effective and well-connected supply chain. Companies' long-term decisions should promote functional co-operation as well as extended enterprise integration. IT plays an important role in both integration and creating demand for products and services in SCM. Top management participation is important in making strategic decisions in IT investments to achieve an effective SCM system. It requires some major changes in business processes and a way the company operates. This requires investment in both capital and people. Without IT, it is difficult for a company to develop a virtual enterprise. This type of enterprise is made up of collaborating partners who are offering different products and services based on their core competencies. Nowadays, virtual logistics using e-commerce (web-enabled logistics information system) will contribute to the agility and partnership development of organization. The impact of e-commerce on SCM is much larger in organizational communication and reduces cycle times and improves collaborative work. E-commerce provides opportunities for an organization to expand their markets worldwide. Recently, more and more companies are trying to sell their products and services on e-commerce. Developing IT infrastructure requires investment in Internet services, web development and updating. There are many strategies to overcome this; strategic alliances with partnering IT firms and other partners

would help to overcome the technology problems. Organizations should decide the type of networks (Intranet and Extranet) that would be suitable for their business. They need to invest in developing the IT skills of their employees. Lately, in global world most successful companies are flexible, adaptable and they are learning organizations. Many companies are building knowledge management system for organizational learning. This requires a systematic evaluation of various knowledge and IT management strategies and techniques. There many ways to manage the knowledge and IT. Virtual logistics using e-commerce will contribute to the flexibility, adaptability, responsibility and the agility of an organization. Many companies have been successful with the virtual enterprise based on strategic alliances and partnership development (Gunesakaran and Ngai, 2004). These developments are in Figure 2.

5. IT in Logistics Industry

Companies in Logistics industry are faced with the necessity of using appropriate Information Technology (IT) solutions effectively, under the pressure of competition and costs, in order to keep up with the gradually growing business volume, improving international trade and increasing customer demands which undergo rapid changes. Growing expectations in Supply Chain Management necessitate the management of work processes as a whole. Integrated logistics will help companies to be more effective. Companies in the logistics sector today must produce quality service with a flexible and agile organization of high efficiency. Enterprise Resource Planning (ERP) System for companies in Logistics Industry operating in integration with applications of Information Technology and it provides the necessary infrastructure for ISO 9000 Quality System and Total Quality Management System as an important tool for improving customer satisfaction with a standardized and highly efficient and effective working environment for logistics companies. Integrated logistics will help companies to be more effective. Customer Relationship Management Application consists of; comprehensive data for customers, prospects and markets; marketing and sales activities; campaign management; sales and customer representatives' management; complaint management; and, statistics and reporting system. This application, which operates in integration with logistics work processes, constitutes a Customer Relationship Management (CRM) system with enhanced features. Sales and customer representatives' activities can be effectively tracked; the corporate customer data bank generated can be used by all personnel according to the level of authorization they have. Tendering correct offers and tracking them can help to increase the number of new customers, along with the help of analyses based on customers, representatives and competitors. Effective management of marketing on customer basis, sales and other operational activities can promote customer loyalty and increases the cross-selling opportunities of companies. Recently, logistics and transportation operations management applications constitute an integrated software solution related to all stages of transportation operation. With these applications, companies can run the whole process consisting of offers, booking, orders, instructions, documents, financial data, invoices and reports. Expected and actual cost can be tracked; profit and loss per file, shipment, km, customer, country and route can be calculated. In this context, enhanced applications are available for Freight Forwarders, Domestic and Foreign Transport Companies, Agents, Brokers, Line Operators, Container Transportation and Warehousing Operators, RO-RO Operators, Ship-owner Companies and Bonded Warehouse and Warehouse Operators. Trip, fuel and driver expenses can be taken under control with facilities providing tracking of costs related to each stage of transportation and logistics work processes. Drivers' performance can be measured; analyses by which correct selection between different routes, truck types, and transportation modes and types can be made. Performances of agents and suppliers can be tracked.

Logistics and transportation operations management applications are used in integration with IT in Warehouse, Purchasing, Sales and Inventory Management applications, and very effective a new Supply Chain Management (SCM) System can be created. With the help of the integrated structure which allows management of work processes as a whole, logistics outsourcing projects can be undertaken and managed, work flows can be tracked, and the related companies can easily be informed at each stage. Integration with the data systems of customers, producers, suppliers, distributors, agents and other companies taking place in the logistics work process is provided via Electronic Data Interchange (EDI). All types of documents related to logistics work processes can easily be defined to the applications; they can be created quickly and accurately wherever and whenever necessary. All types of external documents can be linked to work processes. By having a common document archive used for the whole company, all kinds of correspondence can immediately be accessed on customer, trip, date, document type, work process and similar basis. When project management applications and transportation operations management applications are appropriately used together, a Project Management System (PMS) can be created; and large scale transportation projects realized by long-term contracts can be managed. With the help of Maintenance Management System (MMS) generated by using IT, Service Management, Tire Management, Purchasing Management and Inventory Control Applications together, it is possible to have company assets operating continuously and to take

their maintenance and repair costs under control. Using General Accounting, Budget, Accounts Payable and Receivable, Checks and Notes Management, and Fixed Assets Management Applications together leads to the formation of a Financial Management System (FMS) structure. Lately, logistics companies' credits and debits can be managed accurately and effectively; customer risks and financial losses can be taken under control; incomes, outcomes and expenses can be tracked by effective and efficient budgeting.

Human Resources Management (HRM) System has a structure which meets all the requirements related to human resources management of both medium and large sized organizations. It comprises organizational management, personnel management, payroll, payroll accounting, training management, performance management, career planning and crew management modules. Applications consist of Electronic Data Interchange (EDI) modules and Intranet and Extranet Applications. EDI modules provide integration between a logistics company and its customers, suppliers, agents, customs and banks. Extranet Applications, on the other hand, provide such functions as order entry, shipment and order status inquiry, shipment inquiry, account statement inquiry in Web environment for Applications. All kinds of documents can be sent as e-mail or fax with MS Exchange Server System Integration, Mail/Fax Integration and Fax maker System Integration modules, all of which are integrated to all applications. With modules like Satellite System and Traxon Integration, location and status data for trucks and shipments can be transferred to related modules accurately and quickly. Interface modules for Radio Frequency (RF) hand terminals allow real-time tracking of material and shipment transactions, working together with Warehouse Management, Export Warehouse and Bonded Warehouse Management Applications. Using barcodes and RFID technologies transactions can be processed accurately and quickly. Throughout the logistics work processes. Exponential growth of technological capability has provided various choices in IT applications toward improving functional integration, coordination, and decision making. Selecting appropriate IT applications is a very hard task for managers given the wide array of rapidly changing and costly technologies (Sanders and Premus, 2002). Decisions relative to adoption of specific IT applications need to consider alignment with the organization's competitive priorities (Grover and Malhotra, 1997). Organizational competitive priorities should choose the types of IT applications used, with the expectation of high performance levels. Customization environments are generally characterized by dynamic product and process requirements. Decision making is often decentralized and there is greater worker autonomy. IT needed in this environment needs to support the creative process and should be flexible. The opposite is true in mass production environments characterized by greater stability in both product and process (Hayes and Wheelwright, 1979). All these applications which can be integrated with each other eliminate duplicate data entries and jobs, create an effective, fast and accurate working environment which can be managed, tracked and reported, on a corporate database. It is possible to access correct data quickly and supply correct information to customers on time. With the help of flexible and agile infrastructure, constantly changing and increasing customer requests and expectations are met; customer satisfaction is improved with higher service quality. Authorizations can be defined and logs are kept for all transactions on user basis. With a system robot which allows execution of some transactions automatically and with warning mechanisms, an effective system management can be performed. With the help of such as company, branch, section and operation group, it is possible to assign turnover and profitability targets as quantity and as amount, on week, month, period and year basis, and to track company performance continuously. Data required for strategic planning can easily be accessed with reporting and analysis facilities on company (Soft, 2014).

In Turkey, successful relationships between logistics providers and their customers can be accomplished by sharing of vision, information and strategies. OMSAN, MARS and EKOL, etc. are successful logistics companies in industry. Logistics companies serve its customers with end-to-end supply chain technologies to integrate their supply chain and to meet their business needs. These logistics companies are working with best IT solutions for their internal operations and also to run external business operations efficiently. Besides, they continue to follow new technologies and capabilities available in the market for its customers. Companies are using latest technologies such as GPRS, RFID in order to gather all available information's through supply chain and share its customers. All of their own vehicles has been using vehicle tracking systems and uses them for messaging, positioning and as a data collection system for trip details. E-logistics solutions enables its customers to enter their warehouse and transportation orders, to view order status, inventory levels, inbound and outbound movements and invoicing information. Also, logistics companies deliver what is required. These companies believe that collaboration and integration is one of the most important issue to add value to its customers supply chain. They have deep integration experience with different customers and industries via delivering many successful projects; especially in car logistics and warehouse management. They consult for determining value added integration points. Companies tend to be cautious when the subject turns to the breakdown of the data silos from the tried and tested backbone ERP

systems to include logistics, SCM software, or auto-ID technologies. SAP, Oracle, Microsoft and Infor's market leading software products generally also provide substantial functionality for logistics and supply chain management. At the same time the providers in question also have specific supply chain management solutions. This makes it clear just how blurred the boundaries between ERP solutions and supply chain management solutions are, and that the call for extended, specific solutions is justified. Users face the challenge of applying the right ratio in their own companies. They must find out whether a specific supply chain management tool should be used, which functionalities should be mapped in the ERP system, and which in supply chain management. During the implementation of supply chain management solutions a whole range of companies have come to the bitter – and expensive – conclusion that significant requirements could have been fulfilled using available functionality in the ERP system. A careful analysis and assessment can lead to the avoidance of unnecessary investments. The range of logistics related applications available using transport management systems is rounded off with tasks such as route optimization, fleet management, customs clearance, freight paper production, or tracing functions. Some functions are available in both the ERP and the supply chain management system. Alongside RFID there are much more intelligent and more complex systems on the drawing board at the moment. Their implementation is still not possible due to technological limitations which research has yet to deal with. Systems are presently being developed which not only transport data, but can also interpret them immediately following their collection or storage, and can then derive commands for further action from them. These, in turn, are sent back to the products or transport means and implemented. Sensor fusion and intelligent sensors represent a promising research development. The former describes sensors, such as GPS, temperature sensors or pressure sensors, which forward their combined data to an intelligent sensor which then evaluates them using an intelligent software system and derives appropriate measures to be taken. The main area of application is the monitoring of sensitive freights being transported by logistics service providers. The air freight organizations are a good example here. Sensor fusion can be used to check during transportation and storage that the goods are being handled as agreed. RFID technologies transfer information concerning the required and actual conditions concerning a particular good to an IT system using sensor fusion. The IT system can then raise an alarm in cases of deviation, and measures to correct the goods' storage conditions can be initiated immediately. Today, known companies in logistics industry have Research and Development Centers (R&D). In parallel to environmental conditions within the ongoing competition grounds, companies invests in R&D activities for improving scientific and innovative work and emerging technological applications, exploring new market opportunities and developing cooperative solutions that conform to its business expertise. Companies aim to set an example to other companies in the sector with its R&D vision. Attaching importance to Project management, they spread such created "know-how" over the entire sector and ensure new work is carried out with the higher value added R&D activities. These centers aims to implement and sustain systematic, creative, unique, scientific, experimental and technical studies which contribute directly to the competition ability of the company, sector and the country. In addition to that R&D centers ensure innovations or significant improvement/development in terms of service, process, system, organization and work applications. They also emphasize environmental awareness. R&D Centers with their staff carry out non-stop work for increasing productivity and developing new business models, ensuring to establish, progress and sustain R&D culture as a corporate behavior within the entire organization.

6. Conclusion

Consequently, in this paper information technology applications of logistics companies were examined. IT needed in environments that need to support the creative process. In addition to that IT investment benefits SCM. Today, companies in logistics industry have high responsibility on information technology and management. In globalization, companies in logistics industry tries to keep up with gradually growing business volume, improving and developing international trade and increasing customer, stakeholder and shareholder demands which undergo rapid changes. Companies in logistics industry must produce quality service with a flexible, adaptable and agile organization of high efficiency. Generally, the same type of information technologies are equally appropriate in environments that require customization and flexibility versus mass production of standardized products. Customization environments are generally characterized by dynamic product and process requirements. Decision making is often decentralized and there is greater worker autonomy. IT needed in this environment needs to support the creative process and should be flexible. The opposite is true in mass production environments characterized by greater stability in both product and process. These latter environments may need to focus IT that promotes efficient standardization of work processes. Generally, IT sophisticated logistics companies have achieved performance levels higher than firms with lower levels of IT. But only high IT use do not lead to high performance levels. It must be accompanied with all logistics functions as a whole in the company. Lately integrated logistics are very popular in logistics companies and results are very good. Future research should explore the specific information technologies that are best suited for each type of environment, considering not only benefits but the costs of

implementation. As technological capability and usage rapidly change, more ongoing research is needed to help academics and practitioners keep abreast of changes, capabilities, and key drivers of technological usage. Successful management can help deal with the complexity of innovations. The right method makes it possible to integrate innovations into a flexible applications landscape, and to optimize the support or even improvement of business processes. IT has the overall potential of providing significant competitive advantage to firms and can be generated in the logistics processes of the future.

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Biography

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An Application with Fuzzy VIKOR to Supplier Selection

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Abstract

Supplier selection is one of the important issues in logistics systems management. The selection process requires detailed efforts. Some of efforts is related to procedures such as fitting the quality procedures, national and international standards etc. After this part of efforts is accomplished, eligible candidate suppliers are selected according to the firms' criteria. So called firms' criteria is important in decision making on supplier selection, because a lot of method have been applied to supplier selection problems due to differences on firms' selection criteria. In this study, we applied Fuzzy VIKOR method to help decision maker operating in electro-mechanic sector in Kocaeli city in decison making issue. The aim of using fuzzy VIKOR method is the nature of the method's providing maximum group benefit and minimum regret of decision makers.

Keywords
Fuzzy VIKOR, supplier selection

1. Introduction
Supplier selection issue is one of the main interest area for researchers. Methods for the selection process vary from each other due to different nature of firms' selection procedures. When the methods are categorized, there will be four classes; total cost models, mathematical programming models, linear weighting models and multi-objective or criteria models. Total cost models are based on the cost of supply chain activities with direct and indirect costs. Examples are cost ratio models, total cost of ownership. The disadvantage of the model is to involve only costs. Linear weighting models are easy, but criteria selection and weighting must be correct to decide well. Examples are categorical method, weighted point method, analytic hierarchy method. Mathematical models are used generally when constraints are available for the problem. They can be linear, integer or mixed integer, and non-linear. We applied multi-criteria decision making model, VIKOR, to define the best supplier(s) for the firm. The papers' remaining parts are methodology, VIKOR method, application and results, respectively.

2. Methodology
We applied the model in a firm which produces the electromechanical apparatus and equipments. Firstly, it is shown how potential suppliers elected for eligible candidateship. Then, supplier selection criteria and suppliers comparison matrix was constructed, and this matrice's elements were converted to fuzzy numbers. Finally, eligible suppliers were ranked according to fuzzy VIKOR results with different compromising situations. Fuzzy numbers were applied to supplier selection criteria and suppliers matrice with reference to the study of Mohammady and Amid (2010).

The aim of using fuzzy logic is to increase the flexibility rate of verbal assesment. Due to not knowing the membership of verbal expression's exact mathematical value, verbal expressions are valued with fuzzy numbers to overcome with uncertainty of the information.

3. VIKOR Method

VIKOR method provides maximum group benefit and minimum individual regret where non-commensurable and different scaled criteria environment is available. Due to decision makers' position, the model can be applied for compromise, consensus and confliction (veto). VIKOR method's steps are as following:

Step 1: It is determined the best (f_i^*) and the worst (f_i^-) values. If criteria i is benefit criteria max of f_{ij}, otherwise the other value is determined.

$$f_i^+ = \max_j f_{ij} \quad f_i^- = \min_j f_{ij} \quad i = 1,2,\ldots,n \qquad (1)$$

Step 2: S_j and R_j values are calculated for j = 1,2,…..J. S_j and R_j values' show mean and the worst group scores for the j^{th} alternative.

$$S_j = \sum_{i=1}^{n} w_i(f_i^+ - f_{ij})/(f_i^+ - f^-) \qquad (2)$$

$$R_j = \max\left(w_i\,(f_i^+ - f_{ij})/(f_i^+ - f^-)\right) \qquad (3)$$

Here, w_i means the criteria weights that show the respective importances. Total weights will be equal to 1.

Step 3: Q_j values are determined for j = 1,2,…….J.

$$Q_j = \frac{\vartheta(S_j - S^+)}{S^- - S^+} + \frac{(1-\vartheta)(R_J - R^+)}{R^- - R^+} \qquad (4)$$

Here, $S^+ = \min_j S_j$, $S^- = \max_j S_j$,$R^+ = \min_j R_j$,$R^- = \max_J R_j$

where v indicates the weight of strategy that provides the maximum group benefit, (1-*v*) indicates minimum regrets' weight of opponents. Compromise solution can be obtained by majority votes (v>0.5) or consensus(v=0.5) or veto(v<0.5).

Step 4*:* The rank between alternatives is determined by ranking S,R and Q values in decreasing order.

Step 5: If two conditions are satisfied, alternative $a_{(1)}$, which orders the best according to Q values, is proposed as compromising solution.

C_1 Acceptable advantage

$$Q(a_{(2)}) - Q(a_{(1)}) \geq DQ \qquad (5)$$

Here, *a"* value is the second alternative when ordered according to Q value.

DQ = 1/*(J -1)*; J indicates alternative numbers.

C_2 Acceptable constancy in decision making

Moreover, alternative *a'* is the best alternative ranked according to *S* and/or *R* values. This compromising solution is constant in decision making process.

If one of these situations is not satisfied, compromising solution set is proposed as following;

- If C_2 situation is not satisfied *a' ve a"* alternatives
- If C_1 situation is not satisfied *a', a", … $a^{(M)}$* alternatives and for maximum valued *M, $Q(a^{(M)}) - Q(a') < DQ$* is determined.

The best alternative ranked according to *Q v*alues is one of the alternatives that has minimum *Q* value (Ertuğrul and Karakaşoğlu, 2009)

'For VIKOR application, these conditions needed to be satisfied;

- *Divergency in ideas must be acceptable,*
- *Decision maker must accept the solution close to optimal*
- *There must be linear relation between benefit for decision maker and each criteria*
- *Criteria must have different scales*
- *Alternatives must be evaluated for all criteria*
- *The preferences of decision makers must be expressed with weights*
- *It may start without active participation of the decision maker,and decision maker can give his/her preference for the final decision.'* (Opricovic and Tzeng, 2007)

4. Application

A firm that manufactures the electromechanic apparatus and equipments examined in terms of supplier selection in Kocaeli, Turkey. Firstly, how potential supplier candidates are identified procedure showed, secondly selected suppliers were assessed in terms of criteria, and ranked for the firm by means of fuzzy VIKOR method. In the study, fuzzy operations were used like in the study of Mohammady and Amid (2010), Kaya and Kahraman (2011).

First part of procedure is to define potential supplier. For this part questions (qualifications of supplier's) are systematic quality, production quality, definition, resource management, past reject rate, past delivery points, return to proposal, contract and legal liability.

After the candidates qualified these criteria, second part are applied to select the best supplier. The table shows the second part of criteria;

Table 1: Second part of procedure

2)Pointed 9 Evaluation Criteria(Average must be 5 wrt 10)			Pts.	Explanation
10	Machine Park	A-1 item 4 pts B- 2-3 items 6 pts		
		C- 4-5 items 8 pts C- 6 items and more 10 pts		
11	Personnel Capacity	A-1 person 3 pts B-2-3 people 5 pts		
		C-4-5 people 8 pts D-6-8 people and more 10 pts		
12	Annual Turnover	A-0-25000 Tl 2 pts		
		B-25001-50000 Tl and more expensive 4 pts		
		C-50001-75000 Tl 6 pts		
		D-75001-150000 Tl 8 pts		
		E-1500001 Tl more 10 pts		
13	Certificate	A-ISO 9001-2008 without certificate 0 pts		
		B-ISO 9001-2008 with certificate 10 pts		
14	Packaging	A-No box and paperboard usage 2 pts		
		B- Box and paperboard usage 10 pts		
15	Transport.	A- Elimsan does not send storage delivery material 2 pts		
		B-Elimsan sends storage delivery material 10 pts		
16	Geograph Location	A-Far from 150 km 4 pts B-Between75-150 km 6 pts		
		C- Between 50-75 km 8 pts D-Between 0-50 km 10 pts		
17	Price	A-%25 and more exp. 2 pts B-%20 and over 4 pts		
		C-%10 and more exp. 6 pts D-%0 and over 8 pts		
		E-It is more proper than available 10 pts		
18	Paying provisions	A-Cash 4 pts B-30 days 6 pts C-60 days 10 pts		

For VIKOR application, suppliers were compared according to second part criteria. Following table shows the comparison;

Table 2: Suppliers' comparison by each selection criteria

	M.P.	P.C.	A.T.	Cer.	Pac.	Trn.	G.L.	P.R.	P.P.
T1	10	8	6	10	2	10	4	6	6
T2	8	5	6	10	10	2	6	8	10
T3	6	10	8	10	2	2	10	8	6
T4	10	5	6	10	10	2	8	4	10
T5	5	8	8	0	2	10	6	8	5

Verbal evaluation criteria used in Kaya and Kahraman (2011) was used in order to convert the matrix value to fuzzy values.

Verbal Ass.	Fuzzy Value
Very weak	(0,0,1)
Weak	(0,1,3)
Mid. weak	(1,3,5)
Mid.	(3,5,7)
Mid. good	(5,7,9)
Good	(7,9,10)
Very good	(9,10,10)

Table 3: Fuzzy converison of Table 2

	M.P.	P.C.	A.T.	Cer.	Pac.	Trn.	G.L.	P.R.	P.P.
T_1	9,10,10	7,9,10	5,7,9	9,10,10	0,1,3	9,10,10	1,3,5	5,7,9	5,7,9
T_2	7,9,10	3,5,7	5,7,9	9,10,10	9,10,10	0,1,3	5,7,9	7,9,10	9,10,10
T_3	5,7,9	9,10,10	7,9,10	9,10,10	0,1,3	0,1,3	9,10,10	7,9,10	5,7,9
T_4	9,10,10	3,5,7	5,7,9	9,10,10	9,10,10	0,1,3	7,9,10	1,3,5	9,10,10
T_5	3,5,7	7,9,10	7,9,10	0,0,1	0,1,3	9,10,10	5,7,9	7,9,10	3,5,7

By finding the best and worst values for each criteria with respect to Eq. (1) in VIKOR Method section, the first part of fuzzy VIKOR method is constructed.

Table 4: The best and worst values of each criteria

	f_i^+	f_i^-
MP	(9,10,10)	(3,5,7)
PK	(9,10,10)	(3,5,7)
YC	(7,9,10)	(5,7,9)
SER.	(9,10,10)	(0,0,1)
PAK.	(9,10,10)	(0,1,3)
NAK.	(9,10,10)	(0,1,3)
CK	(9,10,10)	(1,3,5)
FİYAT	(7,9,10)	(1,3,5)
ÖD.Ş.	(9,10,10)	(3,5,7)

Fuzzy arithmetic operations were applied as in the study of Mohammady ve Amid (2010);

$\tilde{A} + \tilde{N} = (l_1+l_2, m_1+m_2, u_1+u_2)$

$\tilde{A} - \tilde{N} = (l_1-u_2, m_1-m_2, u_1-l_2)$

$\tilde{A} * \tilde{N} = (l_1*l_2, m_1*m_2, u_1*l_2)$

$\tilde{A} / \tilde{N} = (l_1/u_2, m_1/m_2, u_1/l_2)$

When we calculated S and R values for each supplier according to Eq.s (2-3) ;

For T_1 ,S = (-0.059,0.425,1.79)

For T_2 ,S = (-0.114, 0.227, 1.71)

For T_3 ,S = (-0.087,0.324,1.553)

For T_4 ,S =(0.012,0.428,1.78)

For T_5 ,S =(0.077, 0.568, 2.148)

S_j and Rj's according to above values are as followings;

S_1= (-0.059,0.425,1.79) R_1= (0.028,0.062,0.14)

S_2= (-0.114,0.227,1.71) R_2= (-0.079,0,0.36)

S_3= (-0.087,0.324,1.533) R_3= (0,0.18,0.73)

S_4= (0.012,0.428,1.78) R_4= (0.053,0.239,1.08)

S_5= (0.077,0.568,2.148) R_5= (0.08,0.293,1.03)

When we applied the third step of Fuzzy VIKOR section, Q_j values were determined v=0.25, v=0.5 and v=0.75 according to equation (4),and results are as followings table;

Table 5: Calculated Q values with different v values

v= 0.25	v= 0.5	v= 0.75
Q_1=(-0.44,0.48,0.48)	Q_1=(-0.55,0.51,0.51)	Q_1=(-0.67,0.55,0.55)
Q_2=(-0.42,0,0)	Q_2=(-0.55,0,0)	Q_2=(-0.67,0,0)
Q_3=(-0.44,0.4,0.4)	Q_3=(-0.56,0.36,0.36)	Q_3=(-0.67,0.32,0.32)
Q_4=(-0.38,0.69,0.69)	Q_4=(-0.51,0.66,0.66)	Q_4=(-0.63,0.63,0.63)
Q_5=(-0.36,1,1)	Q_5=(-0.48,1,1)	Q_5=(-0.6,1,1)

Table 6: Permanence investigation of S,R and Q

	S	R	Q (v=0.75)
T_1	(-0.059,0.425,1.79)	(0,0.18,0.733)	(-0.067,0.55,0.55)
T_2	(-0.114,0.227,1.71)	(0.025,0.09,0.32)	(-0.67,0,0)
T_3	(-0.087,0.324,1.553)	(0,0.18,0.73)	(-0.67,0.32,0.32)
T_4	(0.012,0.428,1.78)	(0.053,0.239,1.08)	(-0.63,0.63,0.63)
T_5	(0.077,0.568,2.148)	(0.08,0.293,1.03)	(-0.6,1,1)

If we convert fuzzy numbers to crisp numbers,we can obtain the following table for ranking.

Table 7: Permanence investigation of Crisp S,R and Q

	S	R	Q (v=0.75)
T_1	0.6425	0.27325	0.39575
T_2	0.5125	0.13125	-0.1675
T_3	0.5285	0.2725	0.0725
T_4	0.662	0.40275	0.1575
T_5	0.84025	0.424	0.6

According to crisp values' ranking, C2 criteria is satisfied but C1 is not satisfied. Then our compromise solution according to step 5,only compromise solution is T1. Decision about the selection of supplier must be first supplier.

5. Results

VIKOR method was accepted in the solution of the problem, and there is negative or positive linear correlation between benefit/cost and criteria, and criteria have different and discrete scales, but finally the solution was found.

After this application, difference between experience based evaluation and quantitative method evaluation were found. Quantitative method evaluation (Fuzzy VIKOR) results were given to decision makers to decide profoundly due to the importance of supplier selection's place in strategic management of the firm. The results with deeper information about the situation may provide alternative compromise solutions among supplier candidates to construct supplier strategies in management.

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Proposed of A Grey System For Return Weee Product Quantity Forecasting in Reverse Logistics Network

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Abstract

Reverse Logistics (RL) has gained much attention in recent years due to economic, social and governmental reasons. For firms, it has become essential to manage the reverse flow of materials in an efficient way to gain competitive advantage. One important aspect of RL is to provide a correct and timely estimation of return waste product quantity. Improved forecast accuracy leads to a better decision making in strategic, tactic and operational areas of an organization. Intrinsic and extrinsic forecasting are some of the well-known and frequently used forecasting techniques to predict return product in RL networks. In this study, we presented a grey forecasting system to predict return waste product quantity in RL network. To the best of our knowledge, this study is the first in return product forecasting literature by using grey system to predict return quantity. Solutions showed that grey forecasting system is very efficient to predict return quantity.

Keywords

Reverse logistics, uncertaintiy, grey systems, return product forecasting, e-waste

1. Introduction

Recently, because of growing consumer awareness, applied green laws by governments to collect and to recycle used products, intending of manufacturers to reduce manufacturing costs in order to maintain its competitive advantage, increasing use of reusable products, quality upgrading, popularity of re-manufacture, repair, recycle etc. activities, reverse logistics has become attractive for businesses. Due to increasing legislation and the realization that being 'green' can be profitable, sustainable operations has become an important issue in the field of operations (Clottey et al., 2012).

The European Working Group on Reverse Logistics defines RL as follows: The process of planning, implementing and controlling flows of raw materials, in process inventory, and finished goods from a manufacturing, distribution or use point to a point of recovery or point of proper disposal (Lee et al., 2009). Reverse logistics network is more complex to forward logistics network because of including uncertainities in terms of time, quantity and quality of return waste products.

Reverse logistics is practiced in many industries, including those producing steel, aircraft, computers, automobiles, chemicals, appliances and medical items. Reverse logistics has become increasingly important as a profitable and sustainable business strategy (Du and Evans, 2008). Therefore, more and more manufacturers have adapted the practice of recovering value from returned products and integrate product recovery activities into their processes (Lee and Dong, 2009).

Consequently, studies in the literature regarding reverse logistics have been concluded on different aspects such as network design, return forecasting, economic and environmental performance, lot sizing, vehicle routing, etc. Design of reverse logistics network is one of the challenging reverse logistics problems. In order to manage effectively transportation of used product from customers to recovery facilities, and supplying to market, facility location and allocation problem are among important decisions. These decisions need to be taken emphasize the importance of the issue of reverse logistics network design. Firms have to make large investments to adopt the reverse logistics activities. High installation costs make reverse logistics system design very important. The successful design of reverse logistics network helps firms to gain cost-effective recycling process, and competitive advantage. In brief, the accurate forecasting of product returns is important for procurement decisions, production planning, and inventory and disposal management in such remanufacturing operations (Clottey et al., 2012). However, Reverse Logistics Network Design (RLND) process is very difficult because of uncertainty.

Uncertainty is one of the main characteristics of reverse logistics networks. In particular, the strategic RLND has to take uncertainty into consideration. Especially, the time, quantity, and quality of returned products have a high degree of uncertainty. Therefore, the reverse logistics network should be designed in a way that it could handle the uncertainty in parameters; otherwise the impact of uncertainty will be more than expected (Pishvaee et al., 2009). Indeed, most important uncertainty of reverse logistics network is return quantity due to effect many decisions in network. Good forecasting for the amount of return products could bring more profits, customer satisfaction and a nice social picture for companies (Xiaofeng and Tijun, 2009). In this paper, it is developed grey forecasting method to predict product return quantity in RLND. The contribution of study, to the best our knowledge, is the first study that presented grey forecasting model for product return quantity in RLND literature by using real life data.

This paper is organized as follows. In Section 2, we reviewed grey forecasting and return quantity forecasting literature for reverse logistics network. In Section 3, we explained grey forecasting method. In Section 4, we applied proposed model to predict e-waste return quantity for reverse logistics firm in Turkey.

2. Grey Forecasting and Return Quantity Forecasting Literature Review

In this chapter, firstly we presented comprehensive literature review about grey forecasting systems and secondly we investigated product return quantity forecasting literature in reverse logistics network.

Yi (1987) used a grey model to forecast the number of talented persons. Xu and Wen (1997) applied the grey forecasting model to forecast accurately the number of passengers on international air transportation. Lin and Wang (2000) used the grey model to predict the number of engineering officers of a Taiwanese ship. They showed that a grey forecasting model has a higher prediction validity than the Markov Chain model. Lin and Yang (2003) constructed a grey forecasting model to predict the growth of Taiwan's opto-electronics industry. The proposed model can support government to draft pertinent policies for Taiwan's opto-electronics industry. Akay and Atak (2007) proposed grey prediction with rolling mechanism approach to predict the Turkey's total and industrial electricity consumption. Xie and Liu (2009) introduced grey modeling method optimized by genetic algorithm for prediction of natural gas consumption. Andrawis et al. (2011) developed a forecasting model for inbound tourism demand for Egypt, using the developed short-term/long-term forecast combination approach. Hsu (2011) put forward an improved transformed grey model based on a genetic algorithm ITGM (1,1) to forecast the output of opto-electronics industry. The model is compared with GM (1,1), rolling GM (1,1), and the transformed GM (1,1) and the results show that ITGM(1,1) is better than the others and improve the accuracy of short-term forecast. Lei and Feng (2012) proposed a novel grey model, PGM (1,2,a,b) for improving the forecasting performance for short-term electricity price efficiently and accurately. In their paper, the period-ahead electricity price sequence is defined as the reference sequence, and particle swarm optimization algorithm is used to identify the developing coefficient a and the grey input b. Ou (2012) suggested a genetic algorithm based improved GM(1,1) model called the GAIGM (1,1) to forecast the optimal parameters in agricultural industry. Truong and Ahn (2012) showed a new grey model, which is called "Smart Adaptive Grey Model" SAGM (1,1). In order to verify the model some numerical simulations have been applied. Cui et al. (2013) proposed a new approach called a novel grey forecasting model in

order to get a better forecasting model to enhance the forecasting accuracy. Xie et al. (2013) developed a new grey forecasting model based on non-homogeneous index sequence approximately. Because, GM (1,1) and discrete grey model are constructed on the hypothesis that the original data sequence is in accord with homogeneous index trend. Samvedi and Jain (2013) used grey prediction model in supply chain. They compared the model with moving average, weighted moving average methods and exponential smoothing during disruptions and stable situations in supply chain. The results showed that grey prediction model is better when the disruption frequency is high the disruption impact is gradual rather than sudden. In this study we presented grey forecasting method to predict return product quantity in RLND area.

In this section, we will discuss the return forecast models that have been studied in past. Then we will evaluate them. Design of RL networks involves generally high degree of uncertainty, especially associated with quality and quantity of the returned products, as well as the time, delay and location of recovery and redistribution (Chouinard et al., 2008; Ilgin and Gupta, 2010; Pishvaeeet et al., 2011). However, the uncertain nature of the reverse logistics environment has not been considered very often until now. Stochastic programming techniques present more flexibility to cope with uncertainty (Listeş, 2002). So, in order to deal with product return uncertainty, researchers developed various scenario based stochastic programming (SP) (Ayvaz and Bolat, 2013; El-Sayed et al., 2010; Gomes et al., 2011; Listeş and Dekker, 2005; Pishvaee et al., 2009).

Even though there are number of studies improvement methods available for forecasting in the forward supply chain, very few study is available for forecasting product returns. One important aspect of reverse logistics is to have a correct and timely estimation of product return quantities. Time series (intrinsic) and causal (extrinsic) are considered as some of the well-known methods that are used for forecasting in forward logistics. The similar techniques can be applied to estimation of product returns in reverse logistics (Potdar and Rogers, 2012).

Goh and Varaprasad (1986) was one of the initial efforts to address the statistical way of handling product returns. They used the product life cycle parameters and basic time series techniques to handle product returns for soft drinks reusable containers. Kelle and Silver (1989) addressed on forecasting return quantities of reusable containers to estimate demand. They used estimate of return ratio for forecasting the demand of reusable containers. Hess and Mayhew (1997) proposed a statistical model that direct marketing companies can collect data from the returned products and used it to forecast the returns. The proposed model was called ‘hazard rate model’ that showed effect of product category, price etc. on product returns. In a simple linear regression method, they modeled ‘time to return’ based on the past returns and factors that affects these returns. There are various forecasting method reported in the past. However, those studies were only based on time series. Marx-Gomez et al, (2002) presented an extended forecasting method in order to predict return product quantity and return time. They used neuro-fuzzy systems for their forecasting process.

Toktay et al. (2003) addressed on returned products forecasting at the operational level. The model forecasting quantity as a function of past sales data. Hanafi et al. (2007) presented an integrated collection strategy which combines a Fuzzy Colored Petri Net forecasting method and collection network model to collect EOL products. They presented a case study on mobile phone collection in Australia in order to test the collection strategy. Xiaofeng and Tijun (2009) developed a new model based on wave function to forecast the amount of returned products of reverse logistics. Zhou et al. (2010) studied on a new approach to the forecasting of returns. This research established a model by adopting the Graphical Evaluation and Review Technique (GERT) network theory combined with Bill of Material (BOM) to forecast returns. By using this model, the probability, the quantity and the expected timing of the returns could be predicted. Potdar and Rogers (2010) developed a methodology to forecast product returns for the consumer electronics industry using a combined approach of DEA/linear regression and a moving average.

Potdar and Rogers (2012) proposed a new forecasting methodology based on reason codes for the consumer electronics industry to forecast product returns. The methodology used two approaches, namely central tendency approach and extreme point approach. Clottey et al. (2012) presented a generic forecasting approach to determine the distribution of the return used products, as well as integrate it with an inventory model to enable production planning and control.

According to literature review, although return product forecasting is very important due to effect many decisions in RLND, there is very limited study. In this study, we presented grey forecasting systems to predict product returns in

RLND problem. The novel aspect of this research is that uncertainty associated with quantity of return product have not been forecasting with grey forecasting systems before. To the best of our knowledge, this is the first study to predict return quantity in e-waste reverse logistics network by using grey forecasting systems with real life application.

3. Grey Theory and Forecasting

A grey system, is developed by Julong Deng (1982), is a system with characteristics between white and black ones and. Grey System Theory (GST) has become a very effective method of solving problems within environments with high uncertainty, under discrete small and incomplete data sets (Deng, 1989). The Journal of Systems & Control Letters published the first article "The Control Problems of Grey Systems" about Grey Systems in 1982. In 1989, "The Journal of Grey System" is wound (Liu and Lin, 2011; Deng, 1989). From then on, the theory has been used in different areas with different aims and one of them is forecasting. The model focuses on the study of problems that comprise poor information and samples are formed small (Deng, 1989) (Hsu and Chen, 2003). The main feature of grey theory is its capability of using as few as four data items to forecast the future data (Akay and Atak, 2007). Moreover, the method is straightforward and little computational effort is needed to constitute the prediction model (Akay and Atak, 2007).

The systems with partially known and partially unknown information are named as grey systems. Grey System Theory (GST) is especially useful when the complete set of factors involved in the system's behavior is unknown or unclear, when the relationships of system factors to the system's behavior and inter-relationships among factors are uncertain, when the system behavior is too complex to determine completely or when only limited information on system behavior is available (Zhu et al., 2007). The application area of the system is wide such as engineering (Tang et al., 2008), chemical industry (Zhou et al., 1993), agriculture (Kang et al.,1998), health (Shi, 2011), meteorology (Wang et al., 2013), tourism (Wang, 2004), environment (Wang et al., 2003), energy (Kumar and Jain, 2010), machinery (Jiang et al., 2002), finance (Huang and Jane, 2009), geography (Kui et al., 2009), electric price (Lei and Feng, 2012) etc. Broadly, there are three methods which are used in uncertain systems: Grey Systems, Probability and Statistics and Fuzzy Maths. The differences between the Grey Systems, Probability and Statistics and Fuzzy Math are given in Table 1 (Chopra and Meindi, 2012).

Table 1: Comparison of the three methods of uncertainty research

Object	Grey Systems	Probability and Statistics	Fuzzy Math
Research Objects	Poor Information	Stochastic	Cognitive Uncertainty
Basic Sets	Grey Hazy Sets	Cantor Sets	Fuzzy Sets
Methods	Information Coverage	Mapping	Mapping
Procedures	Sequence Operator	Frequency Distribution	Cut Set
Data Requirement	Any Distribution	Typical Distribution	Known Membership
Emphasis	Intension	Intension	Extension
Objective	Laws of Reality	Historical Laws	Cognitive Expression
Characteristics	Small Sample	Large Sample	Experience

One advantage of GST over fuzzy approach is that GST fits better with multiple meanings (grey) environment (Zadeh, 1965). This type of uncertainty is produced due to the lack of accurate values (Salmeron, 2010). Because of that, Grey Theory is selected for this paper.

Grey systems theory has been applied in forecasting. The five main categories of grey prediction is given as: (1) time series forecasting, (2) calamity forecasting, 3) seasonal calamity forecasting, (4) topological forecasting and (5) systematic forecasting. GM (1,1) model is the main model of grey theory of prediction (Xie and Liu, 2009). Grey Forecasting has three basic operations: accumulated generating operator (AGO), inverse accumulating operator (IAGO) and grey model (GM). GM (1,1), i.e. first order grey model with one variable.

Grey Theory requires little effort to achieve result. GM (1,1) is comprised of three operations. The first operation is Accumulated Generating Operator. Original time series data with n samples is shown as:

$$X^{(0)} = (x^{(0)}(1), x^{(0)}(2), \ldots, x^{(0)}(n)) \quad (1)$$

AGO operator creates new time series sequence using the equation as below;

$$x^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i) \quad (2)$$

From Eq. (2), a droningly series, $X^{(1)} = (x^{(1)}(1), x^{(1)}(2), \ldots, x^{(1)}(n))$, is obtained . The second operation is creating the GM (1,1) by a first order grey differential equation.

$$x^{(0)}(k) + az^{(1)}(k) = b \quad (3)$$

In this Eq. (3), a, b and $z^{(1)}(k)$ are presented as follows;

$$\hat{a} = \begin{bmatrix} a \\ b \end{bmatrix} = (B^T B)^{-1} B^T Y \quad (4)$$

Where

$$B = \begin{bmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ \ldots\ldots & \ldots \\ -z^{(1)}(n) & 1 \end{bmatrix}, \quad Y = \begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \ldots\ldots \\ x^{(0)}(n) \end{bmatrix} \quad (5)$$

and

$$z^{(1)}(k) = 0.5\,(x^{(1)}(k) + x^{(1)}(k\text{-}1)) \text{ , } k = 2,3,\ldots, n. \quad (6)$$

Here, a is named the development coefficient and b is named driving coefficient.

The last operation is Inverse Accumulating Operator performing (IAGO). Grey forecasting equation (Eq. (7)) is obtained by grey differential equation.

$$\hat{x}^{(1)}(k+1) = \left[x^{(0)}(1) - \frac{b}{a}\right] e^{-ak} + \frac{b}{a} \text{ , } k = 1,2,\ldots, n \quad (7)$$

Here, $\hat{x}^{(1)}(k+1)$ shows the forecasting of x at the time k+1. The initial condition is;

$$x^{(1)}(0) = x^{(0)}(1) \quad (8)$$

By applying the whole data in GM (1,1), the forecasting is fullfilled.

Finally, in order to get the forecasted values, the final step is applied as follows;

$$\hat{x}^{(0)}(k+1) = \hat{x}^{(1)}(k+1) - \hat{x}^{(1)}(k) = (1 - e^{a})(x^{(0)}(1) - \frac{b}{a})e^{-ak}, \quad k = 1,2,\ldots,n. \quad (9)$$

3.1 Grey Prediction with Rolling Mechanism

Akay and Atak (2007) issued Grey Forecasting Rolling Mechanism (GPRM) by using electricity consumption data. They showed that GPRM is better than Model of Analysis of the Energy Demand (MAED) is a kind of forecasting technique in energy.

In GPRM, $x^{(0)}(k+1)$ is forecasted by implementing GM (1,1) to $X^{(0)} = (x^{(0)}(1), x^{(0)}(2), \ldots, x^{(0)}(n))$ under rule k<n and k ≥4. In this method, the model finds first value. After that, the first data, $x^{(0)}(1)$, is removed from old series and a new entry $x^{(0)}(k+1)$ is added to the end of the series.

3.2 Performance Measures

There are some forecasting methods and they have to be compared by some formulas called performance measures. There are four performance measures that used in this study.

Here some notations are given;

$\mathbf{E_t}$ is the Error term that means the difference between the forecasted and the actual value at the same time.

$$E_t = F_t - D_t \quad (10)$$

$\mathbf{A_t}$ is the absolute value of the error.

$\mathbf{F_t}$ is the Actual Value.

$\mathbf{D_t}$ is the Actual Value.

$\mathbf{Bias_t}$ is the total values of $\mathbf{E_t}$.

- **Mean Squared Error (MSE):** MSE expose the contribution of positive and negative errors to the lack of accuracy.

$$MSE_n = \frac{1}{n}\sum_{t=1}^{n} E_t^2 \quad (11)$$

- **Mean Absolute Deviation (MAD):** It is defined that the average of the absolute deviation over all periods (Chopra and Meindi, 2012)

$$MAD_n = \frac{1}{n}\sum_{t=1}^{n} A_t \quad (12)$$

- **Mean Absolute Percentage Error (MAPE):** It is the absolute error as a percentage of demand (Chopra and Meindi, 2012).

$$\text{MAPE}_n = \frac{\sum_{t=1}^{n}\left|\frac{E_t}{D_t}\right|100}{n} \quad (13)$$

- **Tracking Signal (TS_t):** It is the ratio of bias and MAD. Bias is the total error. (Chopra and Meindi, 2012).

$$TS_t = \frac{Bias_t}{MAD_t} \quad (14)$$

$$\text{Bias}_n = \sum_{t=1}^{n} E_t \quad (15)$$

If the TS_t values are between -6 and +6, the models are proper to forecast. If it is not, the forecasting method has to be changed (Chopra and Meindi, 2012).

4. Application

In this study, the goal is to predict the return quantity. The data comprise of 44 periods (see Table 2). To forecast the future data, three different levels of k are selected; k=4, 6, 8. The results and the actual values are shown in Fig.1, Fig.2, and Fig. 3.

Table 2: The actual and forecasted values of raw data

Period	Actual	Forecasted k=4	Forecasted k=6	Forecasted k=8	Period	Actual	Forecasted k=4	Forecasted k=6	Forecasted k=8
1	26,4				23	633,8	671,45	664	686
2	34,45				24	747,79	647,67	676	750
3	35,33				25	788,88	797,52	763	826
4	61,62				26	798,18	888,98	838	864
5	136,74	81,01			27	830,49	829,62	876	896
6	154,24	234,18			28	909,33	848,52	898	960
7	160,26	230,85	248		29	935,95	964,08	931	1001
8	173,23	175,08	242		30	1006,59	1001,26	982	1043
9	177,12	182,6	219	256	31	1038,48	1052,65	1064	1098
10	177,6	187,57	192	240	32	1144,32	1099,71	1107	1194
11	261,68	180,38	188	216	33	1182,64	1209,71	1192	1260
12	273,38	311,16	265	252	34	1254,8	1271,81	1264	1327
13	293	343,22	315	296	35	1358,24	1309,02	1330	1430
14	351,95	308,92	348	334	36	1372,74	1451,33	1437	1479
15	366,76	394,7	402	394	37	1554,66	1449,32	1463	1615
16	414,32	415,67	406	471	38	1998,73	1639,95	1625	1995
17	468,49	445,16	460	511	39	2063,74	2383,88	2111	2281
18	536,38	528,5	519	591	40	2360,22	2417,67	2379	2627
19	538,61	608,41	591	622	41	3060,12	2534,01	2720	3337
20	569,35	586,84	618	642	42	3698,41	3683,29	3435	4223
21	613	582,17	626	676	43	5167,4	4608,67	4291	5850
22	633,32	652,19	648	690	44	6066,91	6621,06	6297	7398

The results and the actual values are shown in Fig.1, Fig.2, and Fig. 3.

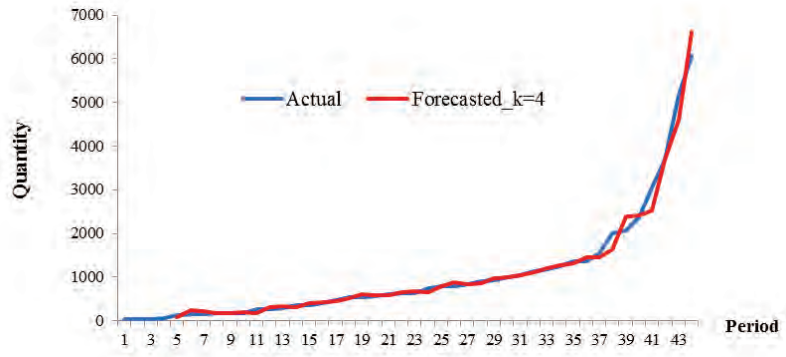


Figure 1: Actual and Forecasted Values under k=4

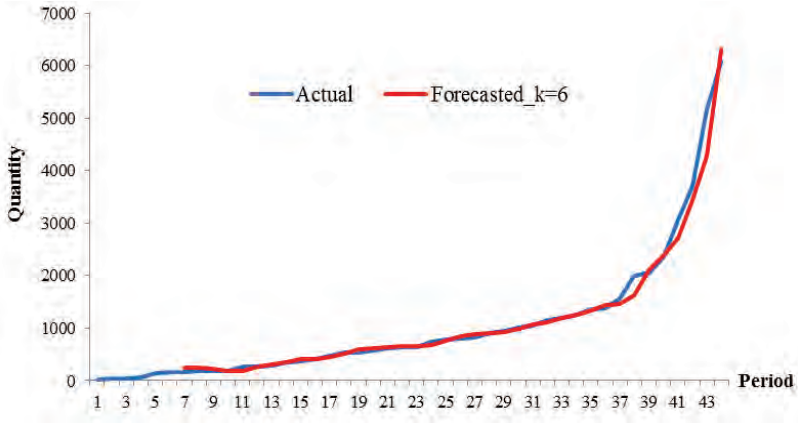


Figure 2: Actual and Forecasted Values under k=6

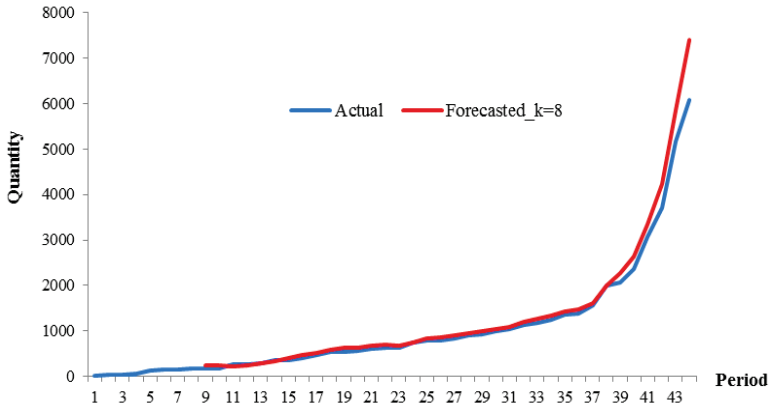


Figure 3: Actual and Forecasted Values under k=4

The performance values of the forecasted values are given in the Table 3.

Table 3: The measures overall

Period	MSE	MAD	MAPE	TSt
k=4	30322,0	92,3	10,3	-4,8
k=6	31647,6	79,7	7,9	-16,9
k=8	77980,1	135,0	8,9	34,7

It can be seen that, the TSt values of k=6 and k=8 are not appropriate for the raw data. Because the values are not between -6 and +6. As a result of that, k=4 is used for forecasting.

5. Conclusions

In recent years, due to economic, political, and environmental reasons more and more companies are engaged in the reverse logistics. Reverse logistics involves repair, remanufacturing, refurbishing, and recycling. Reverse logistics is practiced in many industries, including those producing steel, aircraft, computers, automobiles, chemicals, appliances and medical items. Reverse logistics has become increasingly important as a profitable and sustainable business strategy (Du & Evans, 2008).

Designing of reverse logistics network is one of the challenging reverse logistics problems. Reverse logistics network design is very difficult to develop an effective reverse logistics network design because of uncertainty. Reverse logistics network is more complex to forward logistics network because of including uncertainities. Uncertainties in term of return product quantity, quality and time are the main characteristic of RL networks. Therefore, the reverse logistics network should be designed in a way that it could handle the uncertainty in parameters; otherwise the impact of uncertainty will be more than expected (Pishvaee et al., 2009). Indeed, most important uncertainty of reverse logistics network is return quantity due to effect many variables in network. Good forecast for the amount of returned products of reverse logistics could bring more profits, customer satisfaction and a nice social picture for companies (Xiaofeng & Tijun, 2009).

In this paper, we developed grey forecasting method to predict product return quantity in reverse logistics network design. The contribution of study, to the best our knowledge, is the first study that presented grey forecasting model for product return quantity in reverse logistics network design literature. We applied proposed model to predict return quantity for third party e-waste firm at Turkey.

Results show that grey forecasting method is very successful to predict return quantity. From this study, it is observed that forecasting the future values, with small k, gives better results in GPRM.

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Maintenance Management of Production Systems with Sensors and RFID: A Case Study

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Abstract

At the production facilities maintenance policies extensively studied in the literature. With the growing technology maintenance systems developed. Therefore better reliability level become a vital issue. Especially at foundry facilities subject to this study sustaining a higher reliability level and maintainability is difficult than other facilities. Considering this problem a better maintenance strategy supported with a maintenance system can be considered necessary. On the other hand sensor based RFID systems introduce the opportunity for increased visibility by facilitating easy tracking and identifying assets on the production line. However high investment cost can be a critical factor for a RFID system implementation. For the first step of this study, time based maintenance policy was analyzed as currently used policy. Furthermore two maintenance approaches, namely opportunistic maintenance (OPM) and condition based maintenance (CBM) were compared, and feasibility of CBM that employs sensors and RFID was analyzed for a real manufacturing company in virtual environment using discrete event simulation. In addition, the performance improvement through the manufacturing system by the proposed CBM was tried to be estimated by simulation experiments and feasibility of the CBM was investigated.

Keywords

Maintenance policies, sensors, RFID, condition-based maintenance, time-based maintenance, simulation

1. Introduction

Sustainability of the systems or equipment has become a vital issue in today's highly competitive industrial environment. Therefore, maintenance of those mechanical systems has attracted so much attention from both the academia and the industry. Preventive maintenance (PM) and the condition based maintenance (CBM) are two of the well-known maintenance approaches. The PM includes well defined, periodic set of activities applied on an equipment in order to prevent or slow down its deterioration (Ebeling, 1997). It may possibly prevent unexpected failures and extends the useful life of the equipment (Das et. al, 2007). PM is also called time-based maintenance (Ahmad and Kamaruddin, 2012).

In time-based maintenance approach, the selected equipment is applied maintenance or component replacement activities on a periodic basis. This period of PM is determined such that the total machine repair and maintenance cost is minimized. An alternative way of period determination is the machine reliability approach. In the latter, the PM period is determined such that the reliability of the equipment does not fall below a threshold value. These PM approaches are called cost-based and reliability-based PM approaches, respectively (Das et. al, 2007).

One of the drawbacks of the time-based (PM) approach is that the deterioration characteristic and the associated probability of failure are assumed to be known in advance. However, if the equipment is heavily utilized, it will deteriorate more rapidly, and the assumed failure probabilities may become invalid. Hence, PM does not take into account the condition or degradation characteristics of a system while planning maintenance activities, which invalidates the maintenance plans, established (Kaiser and Gebraeel, 2009).

Opportunistic maintenance and condition-based maintenance are the two policies that were analyzed and compared in this study. Opportunistic maintenance is a policy that is appropriate for systems having multi-components that depend on each other, and failure of a component may affect other components (Wang, 2002). It helps reduce the

maintenance costs such that non-failed subsystems are applied preventive maintenance while failed subsystems are being repaired (Wang, 2002).

On the contrary, condition-based maintenance (CBM) is based on real-time monitoring of the health measures of the equipment, such that the current status and the remaining life of the equipment can be estimated by means of CBM (Lin *et. al*, 2002). In case of any performance deterioration of the machine, a maintenance activity can be quickly scheduled. The real-time monitoring of equipment is usually carried out by means of sensors attached to the critical components of the equipment. Since technological machines are complex and have multiple components with different characteristics, estimating their probability of failure based on probability distribution functions is difficult. Besides, workload of the machines also may cause rapid deterioration. Therefore, CBM approach may be more suitable for the complex equipment.

The purpose of this study is modelling and analysis of opportunistic maintenance and CBM policies for a selected manufacturing system by means of the simulation technique, so that the performance improvement achieved by each of the policies is estimated. Based on that, cost of applying each policy is approximately estimated and the economic feasibility of these policies will be decided upon.

To the best of authors' knowledge, there is no past study that analyzed CBM enhanced with sensors and RFID technologies to keep track of the condition and estimate the failure times. Although CBM helps prevent failure of complex equipment, it incurs some cost. So, in this study, minimum level of performance improvement that makes CBM economically feasible is estimated by means of simulation technique and return on investment (ROI) analysis. These are the two distinguished aspects of this study.

The reminder of this paper is organized as follows. In section 2, current state and maintenance practices of the selected facility are explained. The simulation model with alternative scenarios and model assumptions are presented in Section 3. Section 4 provides an overview about the cost and return on investment (ROI) analysis. Finally the conclusions and outlines further research are explained.

2. Current State of the Facility

The facility investigated in this study is a foundry company which has a 10,000 tons production capacity per year. In Figure 1, production made in such a way that ore is melted in the furnaces. After that it's poured to melting pot. On the other side sand is prepared for molding. Molten metal is poured into the mold, at the melting station. From here it moves to oscillating table. The molds are broken here and wait until they get cold. After parts proceed to the sandblasting machine, they are transferred to the quality control station.

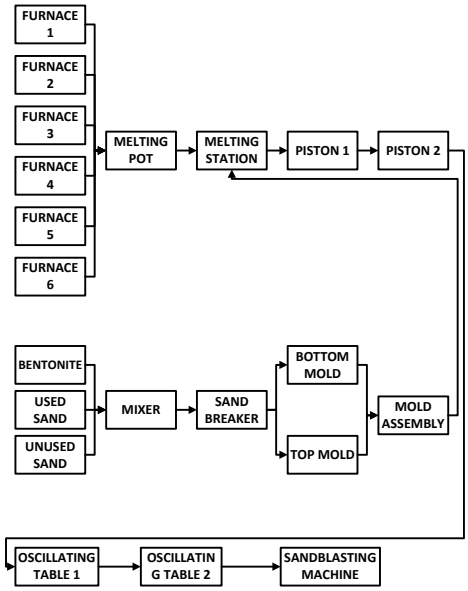


Figure 1. Facility Plan

The major problem in the facility was the frequent breakdowns. It was observed that the production line that is comprised of serially connected machines, stopped almost every day. There were seven people including an engineer that made the maintenance team. Their purpose was to take action immediately whenever a breakdown occurred. Beside they were carrying out maintenance activities every week for a whole day. In addition, the company was not using any sensors or RFID tags to track the status of the line and equipment.

Maintenance history for the facility was gathered from the historical data. To establish the model, maintenance data has been analyzed for two years. Totally 577 failure data of 21 machines has been used and distribution of 92 weeks data was determined using Chi-Square statistical distribution test. According to the results both mean time between failures (MTBF) and mean repair times are exponentially distributed. The results of these tests are illustrated in Figures 2a and 2b, respectively. It seems odd that mean repair times are exponentially distributed. However, this is due to the fact that data on hand refers to the repair times of many different components or machines, and their repair times are quite different from each other.

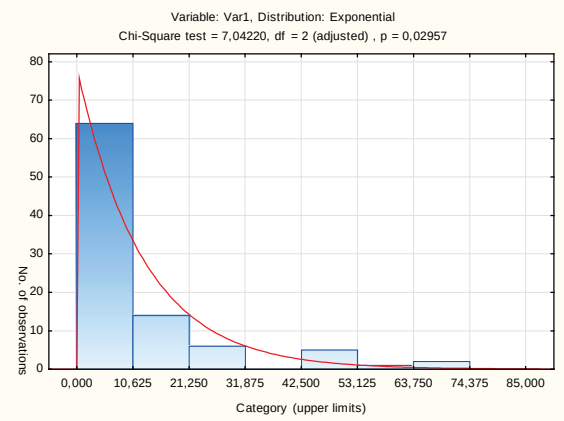


Figure 2a- Mean Time between Failures

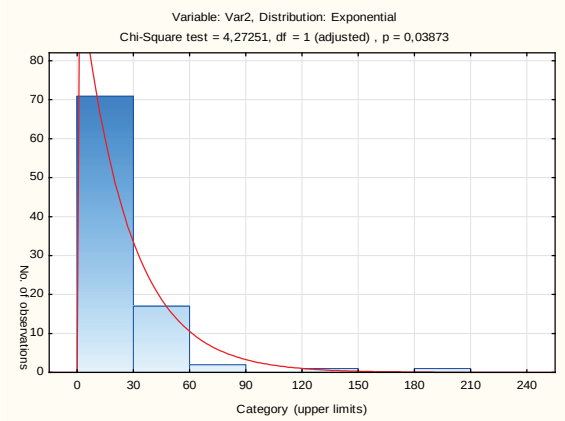


Figure 2b. Mean Repair Times

To analyze the current state of the facility, maintenance data was collected, the distribution of personnel, machine infrastructure and budget data were analyzed and evaluated. In the facility breakdowns were recorded according to time they occurred and applied maintenance activity but not to machine type. Due to that reason, breakdowns were analyzed and grouped into the machines after examining maintenance activity explanations. According to historical data weekly failure frequency shown in Figure 3.

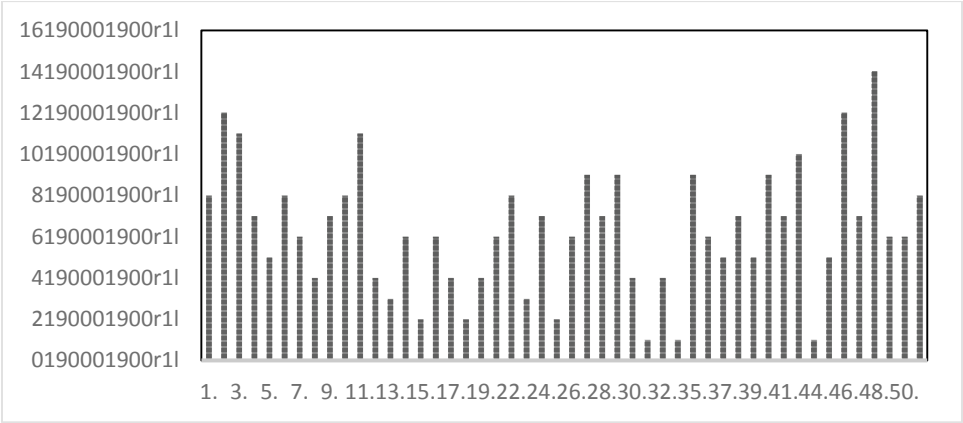


Figure 3. Weekly failure frequency

In order to calculate the value of Overall Equipment Effectiveness (OEE) for the facility, availability, performance and quality criteria were calculated. The OEE was calculated by multiplying 83% availability, 85% performance and 78% quality ratios. Consequently %55 percent OEE value was obtained. In order to determine the critical machines for the production line the critical machine analysis (Abdul-Nour, 1998) has been performed. According to the

results oscillating tables, melting stations, mixer and pistons that moves the conveyor were determined as the most critical machines.

The reliability of the system was calculated to understand how reliable the system was in a certain period of time. Equation (1) represents the reliability formula

$$R = e^{-\lambda t} \quad (1)$$

where t is time and λ is mean time to failures. Considering parallel and serial connected machines at the line, mean time between failures and one day working period (9 hours) the reliability of the line was calculated 22%. This reliability is extremely low that validates daily failures within the system.

Table 1. Current state measures of the facility for a year

	Number of Failures	Total Failure (hour)	Preventive Maintenance (hour)	Overall Equipment Effectiveness	Reliability of the line	Cost (USD)
Current state	301	162	468	55%	22%	420,085

According to the methodology that we proposed in this study maintenance costs are comprised of four main items as personnel cost, buffer stock (WIP) and spare part holding cost, inventory shortage and spare part shortage cost and unplanned downtime cost. So the ratio of total maintenance cost inside total budget was obtained as 12.27%.

3. Simulation Models of Maintenance Policies

In this study simulation technique has been used to determine the performance of the facility under random failures and different maintenance policies. Considering low level reliability ratio and OEE it was required to enhance the maintenance effectiveness of the production system. The key performance measure can be considered as the number of failure in a period of time. Of course we must keep in mind that while reaching smaller number of failures, the total maintenance cost must be balanced as well. Therefore, a reasonable maintenance staff must be employed. Besides, total time spent during failures and maintenance equipment investment must be considered. In order to analyze the performance measures of maintenance operations under different maintenance policies, simulation models were developed for the opportunistic maintenance and CBM.

In CBM, critical machines are attached sensors and mobile vehicles and equipment are attached RFID tags for condition-monitoring. Besides, RFID readers and software are also needed. All these incur some investment cost to implement the CBM approach.

Arena simulation software has been used for testing the maintenance policies. Models of the two scenarios have been created using actual facility production and maintenance data. After that, each replication of the model was run 2340 hours, and totally 3 replications were made.

As performance criteria, total number of failures in one year working period is determined. Beside maintenance cost is calculated using average entity waiting time in the queue and total failure (down) time. As mentioned above, total maintenance and repair cost constituted %12.27 of the total budget.

3.1. Assumptions of the Simulation Models

- We consider the production of a single item on a production process as used Ki-Ling and Warren's (1997) study for die-casting production process.
- Whenever a breakdown occurs, the whole production line stops and corrective maintenance is peformed.
- The machine is restored to its initial condition during a random amount of time that is normally distributed.
- Time between failures is exponentially distributed .
- Parts are processed at each machine based on the FIFO discipline.
- Maintenance costs consist of average wait time in the queue and number of failures in the simulation model.

3.2. Case 1. Opportunistic Maintenance Policy

After the assesment of current maintenance strategy with specific performance criteria, two different scenario were developed as Opportunistic Maintenance (OPM) policy and Condition Based Maintenance (CBM) policy. According to OPM strategy, duration of preventive maintenance activities which are implemented as one day for every week will be reduced by half (4,5 hours/week). As for corrective maintenance activities, maintenance staff will implement 0,75 hours (45 min.) PM with corrective maintenance (CM) whenever failure of a machine occurred. Beside operators will implement pre-defined PM activities to their work environment during that time. On the other hand due to additional workload for the maintenance team 3 additional staff will join the team.

For the OPM policy three experiments were tested. In the first experiment 5% decrease in total number of failures was assumed. For the second and third experiments 10% and 15% decreases have been assumed, respectively. According to simulation results total failure time and maintenance cost were calculated as shown on Table 2. It can be seen on the table if number of failures decreases then total failure time decreases comparatively. Here total time spent for maintenance activities were calculated adding opportunistic maintenance activities and repair time. In this policy considering current variables of the system with regard to simulation model 381.970 hours spent for unplanned stops without weekly scheduled stops. In this case our maintenance cost with additional maintenance personnel reaches 474,102 USD annually. To compensate this increase on maintenance cost a reduction on failure numbers essential. Therefore we can deduce from the table if we obtain 10% or 15% reduction on total failure number then this policy becomes feasible.

Table 2. Opportunistic Maintenance Policy Results

	Number of Failures	Total Failure + PM Time (hour)**	Cost (USD)
OPM_ACS*	301	381.970	474,102
OPM -5%	291	376.510	442,173
OPM -10%	271	348.140	409,825
OPM -15%	258	332.780	401,793

*OPM_ACS: Opportunistic Preventive Maintenance Scenario

**At every failure 45 min. preventive maintenance implemented.

3.3. Case 2. Condition Based Maintenance Policy

In the second scenario a Condition Based Maintenance System was designed for the production system. Proposed RFID and sensor based maintenance management system works in such a way that sensors and RFID tags are mounted on machines. Therefore machines are identified and maintenance staff provides for the data entry. Beside, sensors and status tracking devices make monitoring of real time status of the machine possible.

Table 3. Condition Based Maintenance Policy Results

	Number of Failures	Total Failure + PM Time (hour)**	Cost (USD)*
CBM_ACS	299	606.300	420,085
CBM %27.4	248	499.100	342,191
CBM %32.4	225	448.245	301,711
CBM %37.4	191	382.140	256,284

*Maintenance cost is not included investment cost of CBM system

**At every failure 90 min. preventive maintenance implemented.

According to CBM strategy, duration of preventive maintenance activities which are implemented as one day for every week will be reduced by half (4,5 hours/week) as it was proposed OPM policy. However these preventive maintenance activities will be carried out whenever the system reached maintenance level which could be tracked by CBM system. Additionally at this maintenance strategy 1.5 hour opportunistic maintenance proposed at any time a failure occurred. It means that whenever a failure occurs the maintenance team and operators carry out pre-defined maintenance activites beside repair activity. However in this policy no additional staff required due to the expectation of significant failure reduction.

Considering current maintenance data the CBM Policy was evaluated. Three experiments done for this case assuming 5%, 10% and 15% reliability improvement, respectively. Reliability is used as a variable here since reliability of the facility was relatively low and CBM system was intended to provide significant reductions on failure numbers.

According to table 3 it can be seen that initially actual scenario has been designed with condition based maintenance system considering current failure numbers and total failure time. As it was mentioned in section 2 before 22% of the reliability of the line has been used at Condition Based Maintenance Actual Scenario (CBM_ACS). Following three experiments respectively 5% reliability increase has been assumed therefore the amount of changing in number of failures and total failure times had observed. In addition to that the variance in the cost of CBM was obtained as well. The point here to be explained is about the cost of CBM policy shown on table 3. The costs were calculated according to simulation model without investment cost of CBM system. The detailed financial analysis including investment cost has been done next section. By the way Figure 4 shows failure numbers for actual scenario (ACS), OPM and CBM respectively. In brief we can conclude from Figure 4 according to proposed two maintenance policies failure numbers decreases gradually in our scenairos.

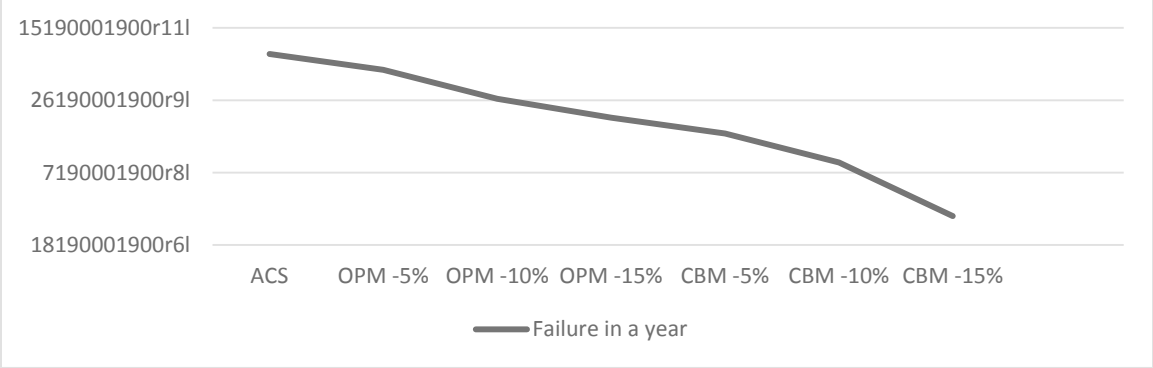


Figure 4. Failure decrease in a year according to scenarios

4. Cost Analysis

After the simulation run for the CBM policy a financial analysis has been done by obtained results. First of all to measure the value of an RFID and sensor based CBM investment, the cost elements must be examined in detail after the analysis of business and customer related benefits. Chen, Cheng and Huang (2013) expressed that the major advantage of an RFID application is the capability of reading simultaneously multiple tags. In order to facilitate reading process in the facility, long RFID reading range of up to several meters is required. UHF RFID equipment operating between 922 MHz and 928 MHz ranges is offered for the proposed CBM system, including fixed reader and passive tag. After the site analysis, location of fixed RFID readers and antennas were determined.

Table 4. An estimation of the investment cost for determined critical machines

Expense Items	Price (USD)
Hardware (PC, RFID reader, antenna, tag, sensor)	67,000
Software dev. (2 personnel) (design, codification, system integration)	84,000
Consultancy (Training, layout analysis, software education)	36,000
TOTAL COST	187,000

i=0, n=1,3,5

According to the critical machine analysis, passive tags with sensors must be mounted on critical parts of critical machines. Passive tags are preferred since they are less effected from the metal surfaces. The RFID tag offered to be used in this system has a storage capacity of 12 bytes sufficient for storing 24 ASCII codes. In the tag the stored information is a combination of part identification number, type, and failure date. An estimation of the investment cost for the critical machines for the CBM scenario has been shown in Table 4. In addition while estimating the cost of the system make decision has been considered instead of buy decision. Since these kind of systems can be obtained as service procurement or some asset tracking systems can be directly bought from some maintenance

companies. Nevertheless the reason behind choosing make decision here was to provide added value to the facility and to develop a research and development project.

As for the maintainability of the system one software developer spent 40% of its work time. In addition to this the hardware of the proposed system will indispensably wear down. Therefore %20 wear out factor (tag, sensor replacement, reader problems etc.) is considered calculating maintainability of CBM system. The maintainability cost is calculated in such a way that

$$42{,}000 \times 0.4 + 67{,}000 \times 0.2 = 30{,}200 \quad (2)$$

So beside the total investment cost of 187,000 USD the annual maintainability cost of the system was calculated 30,200 USD.

4.1. Cost Analysis Results

Return on investment analysis commonly used to evaluate investment in new technologies. Hence a ROI analysis is used to evaluate the CBM systems' feasibility. Equation (3) represents the ROI formula

$$\text{ROI} = \frac{\sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t}}{\sum_{t=0}^{n} \frac{C_t}{(1+i)^t}} \quad (3)$$

where i is the discount rate for the time value of money set to 0 due to very low interest rate, t is the time period, C_t is the required average annual cost for time t, B_t is the average annual benefit. As an example if reliability increase 15% and become 37.4% then according to investment analysis for five years' time period, the parameters become

B_t = 163,801.
C_t = 67,600.
B_t - C_t = 96,201.

Thus three different scenarios were evaluated for 1, 3 and 5 years period. The results were illustrated on Figure 5. As it can be seen on Figure 5 for 1 year time period there was not a positive value of ROI. In other words the system was not feasible in 1 year at any of the reliability levels. As for 3 year time period positive ROI values obtained at 32.4% and 37.4% reliability levels. So the system could be feasible within 3 years if 32.4% or 37.4% reliability levels reached. According to the results within 5 years the proposed CBM system was feasible at all scenarios as we concluded from the all positive ROI values.

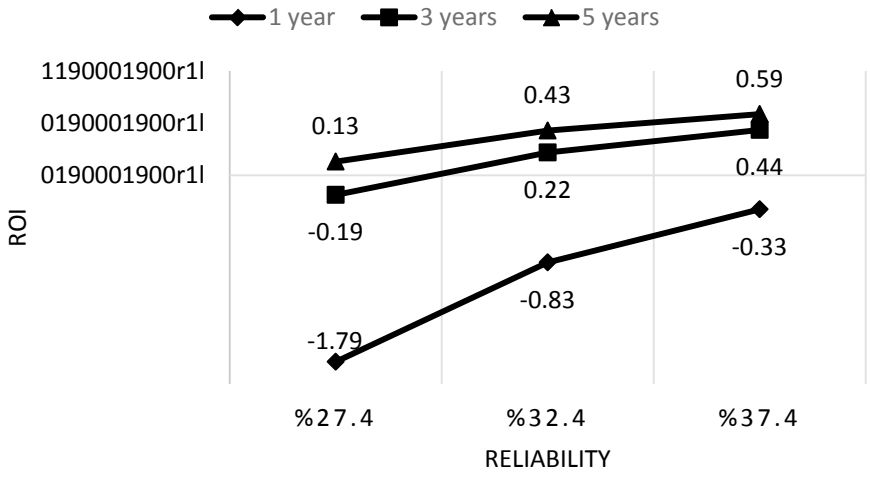


Figure 5. The results of ROI analysis

5. Conclusion

After the analysis the current state of the facility it has been clearly asserted that the implemented maintenance policy was far away to give a good performance. On the one hand it must be considered that the facility is a foundry company and for this type of facilities it is much harder to maintain high level of reliability. The opportunistic preventive maintenance policy that we proposed in this study fundamentally offers preventive maintenance activities at any failure occurred. Due to the requirement of additional workforce new workers were needed to join to the maintenance team. According to the results obtained in the simulation run the proposed OPM policy is applicable if desired failure decrease is obtained in spite of the requirement to hire new personnel. As for the condition based maintenance policy we basically offered tracking the actual situations of the machines via RFID and sensor technologies. Of course this technology requires significant amount of investment. Considering today's price of the hardware and cost of software development an estimation of the investment cost was made for determined critical machines. Since the CBM policy incurs a considerable investment cost, it must provide a significant increase on the reliability of the production system to make it feasible. We concluded that the CBM system can be a worthwhile investment at the long run if desired failure reductions are obtained. This study can be extended in several directions. As a future study, new maintenance policies can be created and also maintenance staff can be included in the simulation model. Thus personnel planning can be performed in a better way. Besides the suggested maintenance methodology can be investigated whether or not it is feasible for other production facilities using other production techniques therefore different type of machines.

Acknowledgements

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Biography

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Technology Roadmapping and Acquisition Planning in Aerospace Sector

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Abstract

Technology development and related product life cycle processes in aerospace sector last longer than any other kind of high tech sectors. In addition to the processes taking long time, the aerospace sector includes some export license restrictions that is reflected as a difficulty in the emerging technology development. In order to achieve this cumbersome process, technology roadmaps are generally used as a technology management method. In this study, technology roadmap approach and structured technology acquisition planning are presented as a case in TAI (Turkish Aerospace Industries Inc.).

Key Words:
Technology roadmapping, technology acquisition, technology management

1. Introduction

In aerospace sector, product life cycle subject is intensely used which contains research, technology development, product (goods/services) development, production and after sale activities. According to research activities, new scientific information and implementation knowledge with technology development studies are established. According to the product development activities, a prototype is developed and manufacturing process is started. Next, low rate production is started. After-sale activities in order to support the customers are carried out. This product life cycle approach is shown in Figure-1. In this cycle, research, technology development and product development activities are also called research and experimental development.

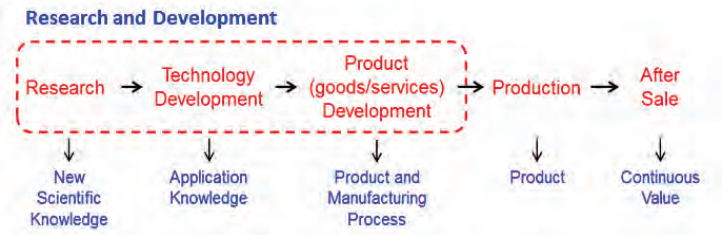


Figure 1: Product life cycle

With the aim of managing the product life cycle successfully, handling of R&D projects, technology and product development processes and offering these products to the market should be conducted in an integrated manner. Therefore, a multi-layer roadmapping approach is employed to reflect all these processes into the technology management activities. The multi-layer roadmap includes various layers; resources, R&D projects, technologies, products and markets/missions. A multi-layer roadmap is schematically presented in Figure-2.

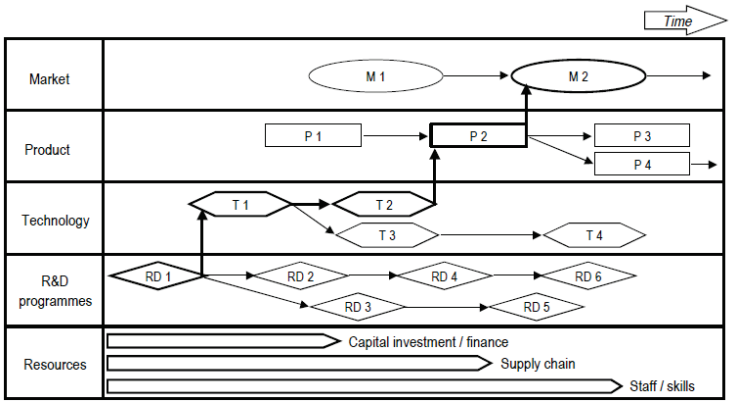


Figure 2: Multi-layer roadmap form for integration and alignment of strategic plans (Phaal, 2001)

The bottom layer is named as Resources which contains capital investment/finance, supply chain, staff/skills, etc. (personnel, infrastructure can be added if needed). In accordance with the availability of resources, R&D projects/programmes are instigated in such a way that their execution would not be hindered by lack of any resources.

Henceforth, the initiated R&D projects/programmes help ameliorate the maturity of targeted technologies, whose relation with relevant products are also established. Afterwards, sufficiently matured (evaluating with the help of TRL scales) technologies are ready to be inserted into the products.

At the top layer in Figure-2, products and market estimations are linked in such a way that the product availability at the correct time (with expected performance level) is assured. If, instead of market estimation, mission requirements are considered, the aforementioned links between resources, R&D projects, technologies and products are handled vice versa (top to bottom).

As seen in Figure-2, technology roadmap process forms only a part of multi-layer roadmap. Since technology within a product is the main factor affecting eligibility of the product in the market, technology roadmaps (in which maturation of technologies is planned) are crucial methods that support product life cycles.

Technology roadmaps are used in order to keep track of technological enhancements and changes (in a planned approach). Furthermore, these roadmaps help describe, select and develop critical technology alternatives that fulfill product requirements. (Phaal, 2001), (Bray, 1997).

Technology roadmaps provide that short, medium and long term technology development plans (in conjunction with the strategic goals) are carried out in a more efficient way. Also they provide firms with a couple of opportunities, such as using resources more effectively, accelerating access to the market and improving product variety (Bray, 1997).

1.1 Separating Technology and Product Development Processes

In the aerospace sector, being a high technology application area (ISIC, 2011), product development periods last quite long. As a result of long lasting efforts and difficulties in managing aspects, the technology and product development processes should be conducted separately from each other (Husniaux, 2012). Technology development tasks should not be embedded to a product development projects in order not to have any cost and schedule slippages, due to the inherent mostly unknown challenges presented in technology development stage. The fact, that these two processes are to be tackled relatively unattached with each other, is well described in DoD's Defense System Acquisition Cycle, as depicted in Figure-3.

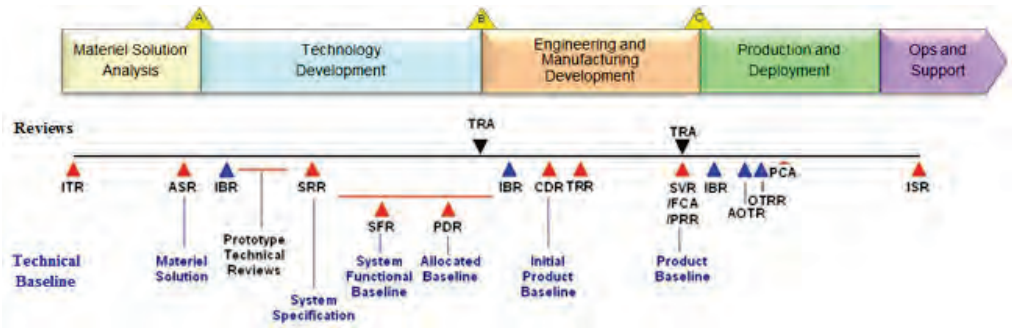


Figure 3: Defense System Acquisition Cycle (GAO, 1999)

According to this figure, material solution and analysis, which can also be called describing requirements and research, technology development, engineering and manufacturing development, production and deployment and finally operations and support activities are generated. From the beginning point to mile stone A there are R&D activities, from A mile stone to B mile stone there are technology development activities and from mile stone B to mile stone C there are product development activities are performed.

R&D can be defines as basic research, applied research and experimental development. The relation between R&D, product development and TRL can be established on NASA TRL thermometer as Figure-4.

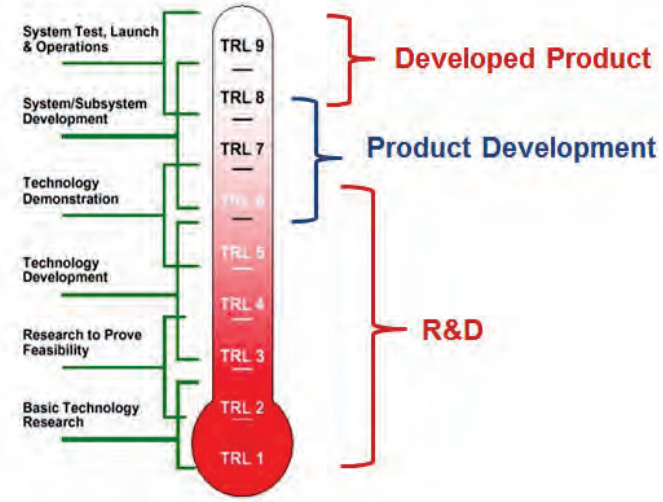


Figure 4: Relation between R&D, product development and TRLs

According to GAO, if technologies are not mature enough, there can be seen delays and incremental costs in programs. To avoid this situation, when product development process reaches PDR phase, technologies have to be greater than readiness level of 7 (TRL 7) (GAO, 1999).

2. TAI Technology Roadmapping And Acquisition Planning Activities

TAI deals with a wide range of aeronautical and aerospace industrial activities, such as development, production, modernization, system integration and life cycle support tasks of manned and unmanned, fixed and rotary wing aircraft, satellite systems and also, aerospace structural components. In order to successfully plan, manage and trace (eliminating uncertainties) the technical issues within these activities, technology roadmap method is adopted. Furthermore, technology roadmapping helps plan technology acquisition phase more effectively.

Technology subject, in TAI, is considered in two separate groups; one group contains those technologies that are directly used in products (i.e. carbon fiber wing technology) and the second group covers the technologies that are employed within the product development process. The technologies in the second group can also be broken down into three sub groups, namely production (i.e. additive manufacturing technology), design and development (i.e. design and analyses tools) and also, infrastructure (i.e. wind tunnel tests).

Technology roadmapping method has principally two driving forces; market pull and technology push. In market pull activities, market analysis is performed in order to obtain data about potential markets and trends. In light of these data, roadmaps for prospective products are established with the help of TAI's product/systems groups. Next, technologies required for the development of these products are compiled in a companywide (general) list. Since this list contains technologies applicable to more than one product, the technologies list is consolidated in order to elicit the technology contents intrinsically connected with each other. As a result, the limited resources and budget would not be spent for similar technology topics. These steps are depicted in Figure-5 in the market pull branch. These steps are iteratively conducted because of the harmonization of data.

In the technology push branch, in Figure-5, TAI's technology targets that strategically designate medium and long range development goals are analyzed as the first step. At this step, strategic decisions, that would improve company's competitiveness in aerospace sector, are to be taken. For example a technology, having a higher TRL in the company than worldwide, can establish a solid business baseline in the future. These technologies are not directly connected to the (current) products. Synthesizes to identify the gap between actual technological capabilities in the company and future required competencies are carried out, to evaluate how big this gap is. This evaluation would play an important role afterwards in the strategic technology selection. In a similar manner, science and technology trends in aerospace sector are taken into consideration by following scientific papers, conferences, interviews with technical domain experts, etc.

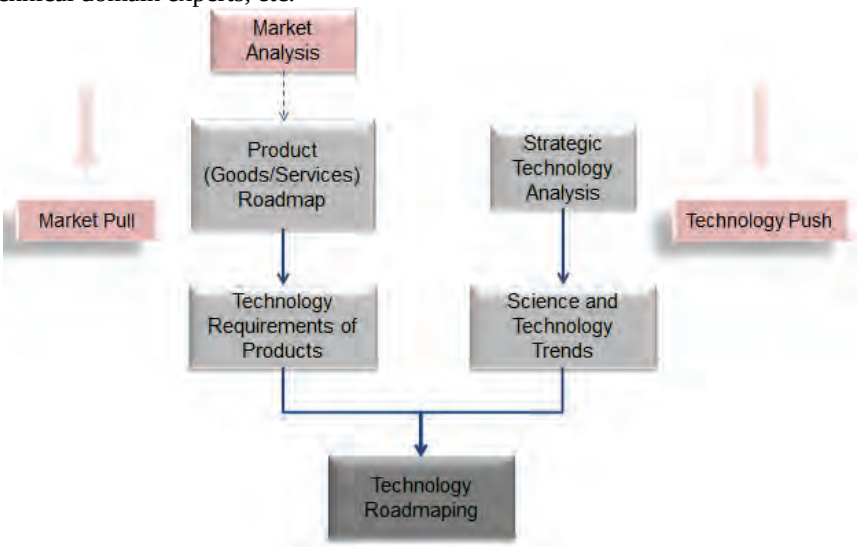


Figure 5: Technology Roadmapping Method

At the last step, two branches of technology roadmapping method merge together. Hence, the technology requirements of products (market pull) and the topics, arisen as the result of strategic technology analysis and science & technology trend analysis, (technology push) form a single companywide technology roadmap.

After the fact that technology roadmap is established technology acquisition plan is prepared. In this context, acquisition types can be classified as R&D in house, R&D with cooperation or procurement of technology. In parallel with the classification task, another task to make a prioritization among technology topics is conducted. The link between technology roadmapping and technology acquisition planning is basically depicted in Figure-6.

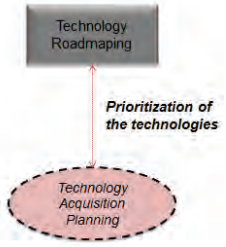


Figure 6: Technology Acquisition Planning Method

Two separate formats are devised for technology roadmapping and technology acquisition planning methods, respectively.

3. Formats

3.1.Technology Roadmap Format

A format, which shapes technology roadmap, has been formed up for collecting data in sufficient detail from TAI's product/system groups. This format is composed of parameters that are expressed in Table-1.

Table1: Parameters In Roadmap Format and Their Descriptions

#	Parameter Name	Description
1	*Department name*	Department that suggests technology topic
2	*Acquisition Time*	The time that technology will be acquired
3	*Capability Area*	Core competencies related to capabilities in engineering discipline
4	*Usage Purpose*	Purpose for which the technology will be employed
5	*Priority (In-department)*	Assessing and prioritizing the technology according to company goals
6	*Dependency to export license and restricting international regulations*	The effect of restricting regulations when technologies are obtained from foreign sources
7	*Supporting academic studies*	Thesis (prepared by TAI's personnel) and academic research activities in universities
8	*Dual-use characteristic*	Applicability of the technology in other sectors than defense
9	*TRL*	A method of evaluating the maturity level of technologies. TRLs of technologies are considered separately in TAI, Turkey and the world. TRL definitions (described by NASA) are shown in Table-2.

Table2: TRL Definitions

TRL	Definition
1	Basic principles observed and reported
2	Technology concept and/or application formulated
3	Analytical and experimental critical function and/or characteristic proof of concept
4	Component and/or breadboard validation in laboratory environment
5	Component and/or breadboard validation in relevant environment
6	System/subsystem model or prototype demonstration in a relevant environment (Ground or Space)
7	System prototype demonstration in an operational (space) environment
8	Actual system completed and (flight) qualified through test and demonstration (Ground and Space)
9	Actual system (flight) proven through successful mission operations

3.2 Technology Acquisition Planning Format

Another format has been generated for prioritization of the technologies identified in technology roadmap. The format is composed of parameters that are expressed in Table-3.

Table 3: Parameters Used In Acquisition Planning Format and Their Descriptions

#	Parameter Name	Description
1	*Criticality*	There are four criteria to assess critical technologies which are described by TUBITAK (The Scientific and Technological Research Council of Turkey). They can be seen below; I. Does the technology meet the national security requirements? II. Does the technology help develop global competition, collaboration or mutual dependency? III. Does the technology support national science and technology for developing infrastructure? Does the technology support for social prosperity?
2	*Current Infrastructure and Needs*	Current infrastructure's status and needs in order to develop technologies
3	*Competition Forecast*	The competitive effects that technologies create when used in products.
4	*TRL*	TRL plays an important role in the acquisition decision process. For instance; if TRL is 1-3 level in Turkey, while at around 8-9 in the world, the acquisition method will be, most probably, to obtain the technology through direct procurement.

The prioritization method is established in order to decide on the technologies which are developed by means of R&D, developed with cooperation or directly procured from external suppliers. According to the resulting decisions, potential investments and resource demands are determined.

4. Results

Technology roadmapping and acquisition planning method, actually, is a useful planning and technology management tool for aerospace sector as in many other sectors. Within this context, TAI adopts technology roadmapping and acquisition planning activities with respect to her internal processes.

Once this method is implemented, the following benefits are obtained;

- preventing duplications
- establishing technological capabilities and weaknesses
- easy planning of R&D projects with internal or external funding (government incentives)

TAI technology roadmapping and acquisition planning method will be updated at regular intervals. The updating intervals are going to depend on the strategic goals and sectorial developments.

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Agile Technology Development: A Model For Turkish Aerospace Industry

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Abstract

In aerospace companies in Turkey, most common project management methodology is the Waterfall methodology, known as the standard project methodology across different industries. The methodology is mostly induced by Undersecretariat for Defence Industries (SSM) and The Scientific and Technological Research Council of Turkey (TÜBİTAK). These organizations require the projects are managed in a certain structured way, so that the delivered product is on time and on budget, as well as, it meets the requirements, such as quality and safety. Besides, the international sub-contractors and vendors of the companies that develop the products usually use this methodology, since this methodology is the traditional one in the overseas companies, as well. Nevertheless, in recent years a new approach for managing projects has started to be used in development projects, both in software and product development, called Agile or Scrum project management. This paper provides an overview to the Agile (Scrum) project management methodology and how it can be used in Technology Development (TD) and Research and Development (R&D) projects in aerospace. Since TD and R&D projects include more uncertainties than product development projects, traditional project management methodology could slow down the process in TD projects. An explanation how Agile methodology increases the speed and flexibility in the TD projects is given. A case example is included to illustrate how the approach can be applied to this type of TD and R&D projects. At last, a methodology is recommended for these types of projects in the sector.

Keywords
Project management, agile, scrum, technology development, R&D

1. Introduction
Effective management of TD projects has become more challenging as the cost, complexity and technological novelty increase in competitive global market. Often times, the common methodology for managing projects, i.e., Waterfall Methodology does not suffice the deliver the products to market on time or in good quality. This is more so for TD or R&D projects, because of the uncertainty, urgency and the level of complexity they have.

This paper will provide an overview to less common methodology of project development, namely Agile (Scrum) project management. The Agile project management approach will be examined in order to explore the reasons why this approach could be more suitable for TD or R&D projects. A case example is included to illustrate how the

approach can be applied in aerospace sector, where high level of complexity and an organizational culture, which is used to working in a regulatory environment, is present.

Finally, a unique methodology, which is rooted to Agile project management methodology, is recommended for TD and R&D projects in aerospace sector. The approach will adopt the principles in Agile methodology, while keeping the environment, project characteristics, resources in mind. Also it will aim to reduce the timeframe to complete the TD projects in the sector.

2. Agile (Scrum) Project Management

Project management is a process that is used to deliver product or services that are unique and have a beginning and an end date. The temporary nature of the projects requires different management approach than the management of regular business operations. In order to overcome the challenges of managing projects, many tools and methodologies have been developed. Besides, there are a number of different approaches for managing projects. The most common one is known as Waterfall methodology, which divides project into sequences of steps, and utilizes schedules and plans to execute and monitor the development. Since the tendency is to define the timeframe and requirements in the beginning of the project and decrease the deviations from the initial plans as much as possible, this approach works better for well-defined projects. However, when there is more ambiguity, it often falls short. In order to succeed in these challenging conditions, a more adaptable, manageable and decisive approach is needed.

In the companies, as complexity increases, central control systems may break down. Controlling the systems that way might work for a while. However, people succeed more, when they figure out how to operate under certain rules with independency (Schwaber, 2004). The idea of managing projects with more independent teams became more popular over time. According to Agile Alliance, a nonprofit organization committed to advancing Agile development principles and practices, several methodologies began to emerge in the late 1990's, which emphasized close collaboration between the team, more face-to-face communication rather than written documentation, frequent delivery of business value by product increments and self-organizing teams (What is Agile Software Development, 2014).

The origins of much of today's agile movement can be traced to the Agile Manifesto, which was originally developed in February 2001 and consists of four value statements:

"We are uncovering better ways of developing software by doing it and helping others do it. Through this work we have come to value:

- Individuals and interactions over processes and tools
- Working software over comprehensive documentation
- Customer collaboration over contract negotiation
- Responding to change over following a plan

That is, while there is value in the items on the right, we value the items on the left more." (Cobb, 2011).

The most common agile processes include Extreme Programming (XP), Lean Development, Crystal and Scrum (Cohn & Ford, 2003). In this paper, the focus is given to Scrum methodology among these processes. According to Schwaber and Sutherland, Scrum is a framework for developing and sustaining complex products (Schwaber & Sutherland, 2013). Scrum is the result of the work and collaboration of Jeff Sutherland and Ken Schwaber. Agile reached a broader audience and became mainstream software development process with the book Agile Software Development with Scrum written by Ken Schwaber and Mike Beedle in 2001 (Correa, 2008).

Scrum is a framework based on some guidelines to manage projects, not strict engineering practices. In scrum, teams follow an empirical process control based on experience rather than detailed plans or fixed rules (Correa, 2008). Empirical process control is useful when defined process control cannot be achieved due to the complexity of the activities. Control is given to independent agents to deal with complexity, i.e., control is moved from a central authority to the individual teams performing the work. So, when the projects are more complex, it becomes more necessary to delegate decision making to the teams who perform the work (Schwaber, 2004). As Scrum is based on empirical process theory, it is assumed that decisions are made on the present knowledge which results from

experience. Incremental iterations in scrum are the tool for controlling the risks (Schwaber & Sutherland, 2013). Three items of empirical process control are:

- Visibility: Anything that affect the outcome should be observable
- Inspection: Detecting unacceptable variations in the process regularly
- Adaptation: Adjusting the process to alter unacceptable variations (Schwaber, 2004)

As being based on empirical process control, all of these three items are used for coping with complexity in Agile project management approach.

According to Rubin, a small set of core values, principles and practices covers Scrum, namely the Scrum framework (Rubin, 2013). The Scrum framework contains Scrum Teams with specific roles, as well as, certain artifacts and rules that are essential to Scrum's success and helps to achieve a goal (Schwaber & Sutherland, 2013). The projects are managed in short iterations called Sprints. The Product Owner defines the most important items, which the team needs to work. At the end of each iteration, team delivers a product, which is potentially shippable. The basic skeleton of the Scrum method with its key components like the Product Backlog, the Sprint Backlog, the Sprint, and the Daily Meeting are shown in Figure 1 (Correa, 2008).

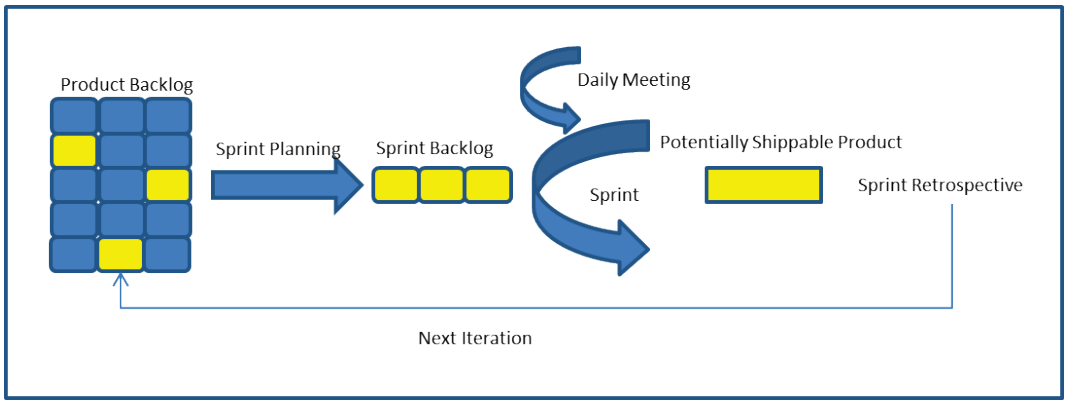


Figure 1: Scrum process overview (Correa, 2008)

Three main roles in a Scrum team are ScrumMaster, Product Owner, and Development Team (Correa, 2008). Responsibilities of these roles are as follows:

- The ScrumMaster is responsible from implementation and execution of the Scrum process including the training of the team
- The Product Owner considers all of stakeholders while defining the final product. Defines the initial requirements, prepares the Product Backlog by prioritizing them and revises the Product Backlog in every iteration. Also, finds the funding for the project.
- The Team is responsible for development activities. The cross-functional team members are self-managing and self-organizing. They are responsible for the development within the iteration. All team is responsible from the success together (Schwaber, 2004).

In Scrum, the work is completed in Sprints with a vision of the system to be developed, which might be uncertain at first, but becomes more certain as the project progresses (Schwaber, 2004). The development teams usually break down each targeted feature into a set of tasks, which is called the Sprint Backlog. Then the development team makes an estimate to complete the tasks. Breaking Product Backlog items into Sprint Backlog, than into tasks shows the team what the roadmap is in the project (Rubin, 2013). Each sprint cycle takes about 3-4 weeks, where the team develops the product (Clifton & Dunlap, 2003). The Scrum has certain types of meetings held in the beginning and at the end of each Sprint.

- Sprint Planning Meeting: It is held in the beginning of the Sprint to decide what will be done in the sprint. After that, the team works on the development (Clifton & Dunlap, 2003).
- Daily Scrum: Each day during sprint execution, the team members hold meetings, known as the Daily Scrum to manage work flow (Rubin, 2013). These 15-minute meetings help with the daily coordination of the work among the team members and planning any meetings that can be beneficial to the team for making progress (Schwaber, 2004).
- Sprint Review Meeting: After sprint is done, a Sprint Review Meeting is held. In the meeting, the progress is reviewed that is made in the sprint and any necessary changes are implemented to the project (Clifton & Dunlap, 2003).
- Sprint Retrospective Meeting: After the Sprint Review Meeting and before the next Sprint Planning Meeting, a Sprint Retrospective Meeting is held with the team. This meeting is a three-hour meeting held by ScrumMaster. In the meeting, the team reviews the structure and rules of the Scrum process and revises it to make it more effective for the team (Schwaber, 2004).

According to Schwaber, the empirical inspection and adaptation practices of Scrum is established by the Sprint Planning Meeting, the Daily Scrum, the Sprint Review Meeting and the Sprint Retrospective Meeting (Schwaber, 2004). At the end of each sprint, the team produces a potentially shippable product, which includes some of the product owner's vision (Rubin, 2013). When a Product Backlog item or a sprint is described as "Done", each member of the team must understand what "Done" means in order to ensure transparency (Schwaber & Sutherland, 2013). The sprint cycle will repeat until the product is complete, i.e., the variables of time, quality, competition, and cost are at a balance (Clifton & Dunlap, 2003).

Teamwork and self-organization of the team is the main driving force behind the Scrum success. In agile projects, team members from different functional departments act in a highly collective manner. They share the ownership of the product and the success. This results a more humanistic collaboration instead of a mechanistic teamwork in Waterfall methods, which are rigidly defined by processes and rules (Cobb, 2011). Iterations and the pace of the Scrum keeps the team informed (by the daily meetings) making the team sure they are working for the same goal (Correa, 2008). In addition to that, Scrum method allows merging ideas generated by different minds, hence creating a greater brainpower. Moreover, Scrum reduces the feedback loop time from the customer considerably (Schwaber, 2004). As a result, the product is much more focused on the needs of the customer and the user (Cobb, 2011).

Although Scrum provides better customer satisfaction as a result of a collaborative team that can have more frequent feedback from the customer, Cobb notes that Scrum is not suitable in every business environment, especially for:

- The businesses with highly uncertain product development environment. In this case, a pure agile method may be used.
- The businesses with very low uncertainty due to high-risk and/or regulated environment where a modified version of Scrum or Waterfall methods may be more suitable (Cobb, 2011).

Therefore, every business should assess its environment in terms of complexity and certainty, and adopt a suitable project management methodology.

3. A Case in TEI: Small Turbojet Engine Development Project

The aim of the Small Turbojet Engine Development Project (STEDP) was developing engine design capabilities and technologies within the company. STEDP was planned as a classical Waterfall with design, manufacturing, testing and validation phases. STEDP had a Project Manager who had two assistants: One administrative and one technical. Organization of the project was divided functionally under the Project Manager and there were six functional (mechanical design, systems, aerodynamics, controls, assembly and testing) responsibles. Meetings were held bi-weekly and spontaneously.

During the design phase, computer aided engineering (CAE) was the main tool for analyzing engine behavior. However, during the testing phase, some issues that could not be predicted or analyzed by CAE occurred due to the system complexity and design point extremity. This situation led to a process where many design changes and development testing needed to be performed frequently.

Primarily, engine design build and test cycle time were reduced. During design, changes and developments were introduced incrementally instead of defining the new product completely. This process led to a reduction in design and analysis time, as previous results could be used mostly. Manufacturing, assembly, test and inspection times were reduced via specialized methods, tools and equipment. As a result, assembly to test and design to test cycle times were reduced considerably. Hence, high number of iterations could be performed with an acceptable increase in design and assembly costs.

Furthermore, configuration management and part stocking procedures were modified to prevent increase in hardware costs of high number iterations. An intelligent engine enumeration system was developed to manage engine part stocks of newly designed and old parts, and ability to use maximal old parts was considered in design changes. As old parts were used in newly built engines, incremental design improvements were tested with incremental manufacturing costs.

Finally, project management is changed to a more dynamic form, as reduced cycle times and frequent testing of incremental design improvements allowed to implement a process similar to extreme programming. In the new project management process, four persons, who were The Boss, The Chief, The Coordinator and The Forerunner, were on the lead with the following roles.

- The Boss: Overall responsible of the project. Vision is determined and final decisions are made by the Boss. Weekly plans are prepared with the Boss.
- The Chief: Technical responsible of the product. As being the product owner, responsible from the design, analysis, manufacturing, assembly and test processes. Also, technical expert on the product.
- The Coordinator: Administrative responsible of the project. Responsible from schedule and cost. Manages the logistics. Tracks the processes and removes the obstacles. Executes the weekly plan.
- The Forerunner: Technical expert on the engine. Analyzes the test results and defines the new incremental design improvement alternatives. These alternatives are evaluated by the Boss and the Chief.

Weekly meetings with the Boss were performed in the beginning and at the end of the week. In these meetings, current status was discussed and weekly plan was prepared. At the end of the week, status was checked again. All meetings were performed with the Boss, the Chief, the Coordinator and the Forerunner.

Daily meetings with the Chief and the Coordinator were held early in the morning, at the Chief's desk. In these 10 minute meetings, daily plans were prepared. Daily meetings of the Chief and the Forerunner were held for technical discussion and evaluation. These 10 minute meetings were performed wherever needed, such as the test site, assembly or prototype manufacturing shops.

The team performed the tasks. They did not attend to the weekly and daily meetings. The Coordinator was responsible for coordinating the tasks and conveying the decisions made in the meetings to the team.

4. A Model for Gas Turbine Technology Development Projects in Aerospace Industry

According to Cobb, a pure agile approach, such as Scrum or Extreme Programming may not be used in the company because of the following reasons:

- The organizational culture may not be suitable
- The need of control due to risks and regulatory environment
- Implementing agile may need long time due to training needs
- The level of certainty may not require an agile approach

In the companies, where these reasons are present, a hybrid approach of Waterfall methodology and Agile methodology may be a good solution (Cobb, 2011). Moreover, only the initial teams in the organization may use Scrum and while implementing Scrum, the organizations should use Scrum framework, but can choose an appropriate blend of approaches for their Scrum implementations, instead of implementing the whole methodology, a cookie-cutter, one-size-fits-all formula (Rubin, 2013). Thus, the development process could be modified with a sophisticated project management approach by:

- Applying a level of control and agility suitable for the company's business environment
- Tailoring the development process for the needs of each project

As a result, if the development process is used by people and is appropriate with the business environment and projects, and increases value without unnecessary overhead, then it is a beneficial process (Cobb, 2011).

In the light of above discussion and the model applied in STEDP, we suggest a modified Scrum model for gas turbine TD projects (see Figure 2). The model would be beneficial for the projects, in which the requirements are altering due to unforeseen changes, issues or requirements, the team is crowded and are used to Waterfall project management approach, and the pace of the development process is faster and requires daily communication with the team. The main differences and similarities of the model with Scrum are as follows.

- Different terminology will be adopted instead of Scrum terminology for roles, namely:
  - **The Chief**: The role of Product Owner in Scrum. There will not be a boss role in this model, which is different than the approach used in STEDP, since it was a temporary solution to implement the methodology. The Boss responsibility will be performed by the Chief.
  - **The Coordinator**: The role of ScrumMaster in Scrum. The Coordinator will have traditional project management roles and coordinate project tasks with the team. This practice is especially more suitable, when people are not used to self-governing culture.
  - **The Forerunner**: New defined role for the model, while this role was performed in STEDP project. The Forerunner is responsible for suggesting the changes in requirements and solutions for the issues. The Forerunner is a problem solver and studies the technical details. More than one person may be used as Forerunner, if needed.
  - **The Team:** The Team is responsible for completing the sprint tasks.
- The Daily Scrums are performed by the Chief, the Coordinator and the Forerunner. The Team is updated daily by the Chief and the Coordinator. When the size of the team is large and the team members are located in different locations, this solution could be more convenient.
- Sprint planning with teams will be same as the Scrum process. The Sprint Planning Meeting will be held to plan the sprint and will include the team members, as well.
- At the end of the sprint, a Sprint Review Meeting will be held to review the progress. After the Sprint Review meeting, a Sprint Retrospective Meeting will be held with the team to review the Scrum process and practices.

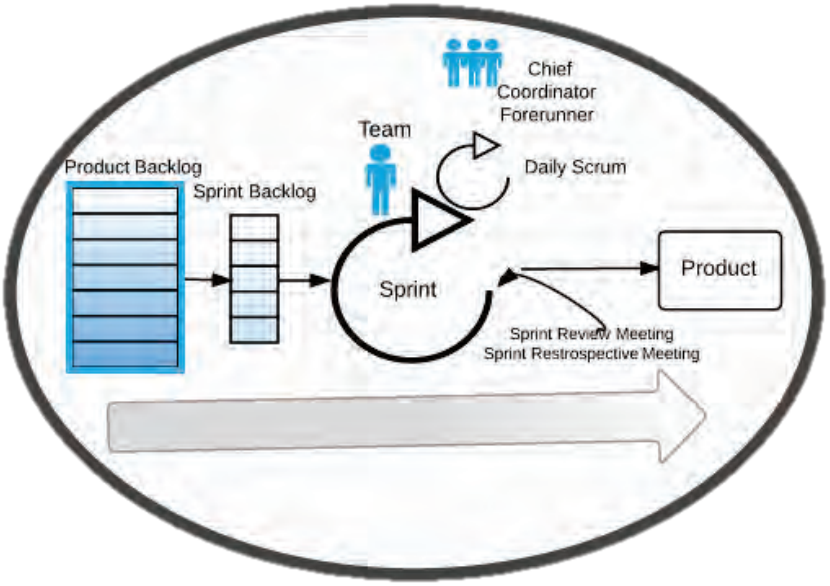


Figure 2: The skeleton of the proposed model

The model that is proposed in this paper may be applied to other TD projects within the aerospace industry, in which hardware manufacturing and testing is needed.

5. Conclusions

Being the common project management methodology, Waterfall methodology is used in the projects in most of the industries, as well as, in the aerospace industry. On the other hand, Agile methodology has emerged to develop software faster and is becoming widespread to meet the needs of different types of projects. When the Waterfall methodology is not suitable for development due to frequent changes and development cycle time, and Scrum methodology is difficult to implement due to company culture and product type, a different methodology, a hybrid approach, as was proposed in the previous section, could be used in these types of projects. Therefore, the proposed model could be useful in TD projects,

- When it is important to faster respond a change
- When the team size is large and geographically dispersed
- When the company culture is more adapted to traditional Waterfall methodology
- When the roles in Waterfall and Scrum methodologies are not sufficient, such as the need for Forerunner role
- When there is a need for more visibility and review
- When the team collaboration is important, but the team could not attend daily meetings due to time constraints and the Coordinator could collaborate with the team on a daily basis
- When the schedule tracking and documentation is minimized, but progress is followed frequently
- When the team needs to get results and create value as quickly as possible

In conclusion, the proposed model is assumed for the types of projects and environment that are explained above. By reflecting on the Waterfall and Scrum project management methodologies, a hybrid project management approach is suggested. This model has its own advantages, such as faster response and development times, whereas it deviates from certain practices and adheres to certain practices of Scrum and Waterfall methodologies, depending on the need of certain setting. Hence, the proposed model could be applied to similar technology and R&D projects in the aerospace industry.

Moreover, as aerospace industry has a high-risk and regulated environment, to manage product development projects by agile methods may not be possible. One of the reasons is that, this environment leads to an organizational culture, which is controversial with agile methods. Hence, a modified version of Scrum is proposed only for the TD projects in the industry, as that kind of projects are suitable for application of Scrum in spite of the organizational culture.

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Lean Principles in R&D Projects

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Abstract

Lean has long been used by manufacturers as a way to reduce costs, increase speed and deliver superior quality. In fact, it has proven to be so valuable to manufacturers that as many as 80% have implemented it. Lean in some form or another on the factory floor. By contrast, lean has been slow to reach R&D, perhaps out of fear that lean will somehow suppress innovation. In this research, we will emphasis to develop model to diffuse lean principles in R&D project activities by mapping and improving R&D project functions so that innovations can reach the market faster with less risk.

Keywords

Lean principles, R&D projects, innovation, lean tools.

1. Introduction

Research and development projects of today, as compared to past ones are getting more dynamic, unpredictable and forced to finish early with least cost and high quality (Levitt, 2011). Decreasing the duration of a project demands intense interaction between activities and resources in such ways that haven't been considered by traditional methods of project management. Intense interaction reduces total project duration but at the same it leads to complexity in projects. In addition to this technical and design complexity is growing as well (Howell&Koskela, 2000). Therefore, in small projects the resulting problems can be resolved without great difficulty. However, complex projects cannot be managed with traditional methods. Nowadays, managers need more agile R&D project management methods and tools which make them able to recognize and deal with uncertainty and risks. Until now (there is –out) only a handful of Lean R&D examples, especially in medicine field, have surfaced. (but in - out) In these examples, we find remarkable opportunity for the R&D function. In many cases, R&D output has more than doubled under constant budgets; innovation has soared; time to market has dropped as much as 50%; and customer satisfaction has greatly improved.

Lean principles have been implemented in various other fields other than just manufacturing. As mostly it is believed that lean is just narrowed to manufacturing industry only. Lean principles in research and development are very new concept especially in case of any ceramic company. Lean is about seeing and removing the dualities that hinder people in their environments (Ballard&Tommelein, 2012). There are some barriers between people and physical world are removed and assembly lines flows smoothly. Those hurdles are visible in manufacturing when we see inventory is hiding our ability to see our problems. We believe that some aspects of our work are necessary evils; we separate ourselves from the ability to see other possibilities where that evil does not exist. Toyota and others have proven how valuable the removal of barriers can be in the manufacturing, but manufacturing is inherently a physical endeavour.

Lean principles can be used to affect the physical side of R&D as well. Experiments are run, prototype are made, testing is performed – all of it in the physical realm. This means that the classic element of lean manufacturing that

remove physical barriers to success on the shop floor have a value place within the Lean R&D realm (Ballard&Tommelein, 2012).

Physical laboratory work is hampered by the seven wastes: overproduction, inventory, motion, waiting, transportation, over processing and rework. The lean path is not a straightforward, linear translation of lean principles from manufacturing to R&D. Like R&D or lean itself for that matter, the path to Lean R&D is a thinking, learning, experimental endeavour, and like many good approaches to batter thinking, the path to Lean R&D begins with an understanding of cause and purpose (Ballard&Tommelein, 2012).

2. Literature Review

The Lean Concept has been introduced first in Toyota Production System (TPS), as a tool in a manufacturing process in order to increase efficiency by reducing wastes. TPS is the base of what has been called lean thinking (Liker& Morgan, 2006). TPS focal point was about reduction of waste from value stream and most implication has been for high volume process with standardized products. The benefits of lean system on performance are remarkable in case of improving quality, reducing cost, and delivery (Lander&Liker, 2007). There are two points of view about lean, in first group of studies lean thinking have been mentioned as a philosophical concept regarding principles and goals (Womack & Jones, 1996; Spear & Bowen, 1999), in contrary recent studies spotlight is on practical issues, techniques and tools which are required in order to achieve the goal (Shah&Ward, 2003).

In order to implement lean in other functions such as service, banking and product development or in production systems which have different characteristics than high volume and standardized product, there are some difficulties. For example variation has different effect in R&D than manufacturing. Therefore some tools and techniques for variation reduction seem not applicable in R&D processes. Since implementation of TPS in Toyota, several scholars have studied lean manufacturing. Also, companies all around the globe have implemented lean in their manufacturing processes. On the contrary implementation of lean in R&D processes is in the beginning of the journey compare to lean manufacturing. Since R&D has different characteristics in case of economics and value creation process compare to manufacturing process, lean product development vary significantly from lean manufacturing (Liker&Morgan, 2006).

Variation limitation which is a key concept in lean manufacturing has been mentioned as the main difference between product development and manufacturing. Since variation is the driving force of developing new product, the concern in product development is to find (on finding – out) good or bad variations instead of eliminating all variations in process (Reinertsen &Shaeffer, 2005). Reinertsen&Shaeffer (2005) have mentioned three main differences between lean manufacturing and Lean R&D by considering manufacturing as a repetitive process which happens in sequences in order to produce goods. These processes can be repeated several times and create value. In manufacturing risk-taking does not have significant role in value creation. In a different way product development is non-repetitive and non-sequential that creates knowledge and information in addition in R&D risk-taking is key point in value creation.

The first difference is about repetitive and non-repetitive activities. In repetitive ones elimination of variability is important in process improvement while in R&D eliminating all variability will eliminate added-value. In this part, different view about variability is needed by distinguishing bad and good variability. Good variability is the ones which creates value in R&D (Reinertsen&Shaeffer, 2005).

Secondly, manufacturing process adds value to physical products and these products can be only in one place and it requires sequential activities. On the contrary, value creation in R&D happen as information and can be in more than one place simultaneously. This characteristic let them to work non-sequentially and create feedback which is not possible in manufacturing (Reinertsen&Shaeffer, 2005).

Thirdly, manufacturing processes are bounded rigorously by a defined start and finish line and the process should match the requirements. In contrast in R&D, managers need to decide and assess constantly the economic gain of improvement against associated costs (Reinertsen&Shaeffer, 2005).
Considering difference between product development processes and manufacturing, wastes which are core of lean concept should be redefined and adapted in LPD with characteristics of product development processes.
Womak and Jones (2003) redefined seven wastes of lean manufacturing by considering product development characteristics:

- Over production: extra analysis and studies, too much information, unnecessary stages such as prototypes
- Transportation: flow of information and information sharing, ineffective communication. Waiting: delay due to approval or testing,
- Inventory: redundant, stoppage in information and data system, unsynchronized processes
- Motion: wrong flow of information to people, seeking for unessential approval
- Over processing: extra gates due to design of stage gate processes, unnecessary analysis, and circulation of wrong decisions and out of place information.
- Defects: failure in tests, inaccurate data, and warranty costs.

In most of the studies researchers have identified the types of wastes in R&D projects. In our study, we will focus on the initiate stage of R&D project management model and human resource allocation which is the most important resource in all R&D projects. Also, we will validate the principles of lean tools by implementing them in a ceramic industry R&D projects.

3. R&D Project Management

R&D projects can be characterized as complicated and independent. In this context, R&D project management is defined as the tasks of innovation management. It consists of basic research, technology development, new product development, prototyping, technology transfer etc. R&D projects develop and involve new ideas, concepts and techniques. To develop new systems or products R&D staff push the limits of science and technology. Companies have recognised with specialized skills, new technologies or pieces of knowledge often is developed locally. Firms are therefore forced to create their own R&D departments to make their own innovation and add value to themselves. This action is created in need of to manage their own R&D activities. R&D management is discipline of designing R&D process, managing all R&D organizations and providing transfer of new know-how and technology. The following steps must be done in every R&D project by project manager (Barnes et al., 2006).

- The parameters that frame the scope, schedule, cost boundary conditions should be established for the project.
- Research elements of project must be identified.
- Research/experiment concepts to frame the research should be used.
- To assess progress overall scheduled review dates should be established.

3.1 Initiate Phase of R&D Project Management

A solid project initiation will not only set up project for success but it will also lay the groundwork for all future stages. During initiation, the project team members are assigned, the overall project goals are summarized, and as many possible questions are asked to the client or to the project staff to plan the project efficiently. As a brief summary, the initiate stages are consisted of creating a new project, assigning a project manager and assembling a project team.

4. Implementation of Lean Tools for Assembling Project Team

As we know that, human resource is the most important issue in R&D project management, we have implemented the basic principles of human resource allocation improvement for a R&D based project management system through a number of measures including:

- Standardizing to allocate staff, to improve the consistency of our biggest resource for project management
- 5S (sort, set in order, shine, standardize and sustain): Although it is a philosophy and method to organize and manage the workspace, we have implemented it to manage our initiate stage of the project.
- Line balancing: To determining how to best distribute staff across projects to meet project termination time.

4.1 Standardization

The standardization of all work project management phases is fundamental to all quality improvement. Especially for R&D centers standardization of scientific work frees up time for more experimentation. Every phase of project management needs to put much effort on definition and, most importantly, simplification wherever possible.
Standardization can be simple and effective even for the R&D centers of SMES without other changes to the work practice (Sewing et al., 2008).

4.2 5S

Project managers, scientists and laboratory staff are mostly interested in completing every phases of project management step due to the main aim, budget and termination time of each project rather than project team organization. Our adaptation on project organization with examples taken from the ceramic based research center implementing 5S was a considerable organizational change which ends as effective time management, energy and motivation which is lost through over or unbalanced workload.

The key steps, with examples from our setting are:

- Sort staff according to the requirements of individual projects. To make this step easier related with our lean philosophy we have prepared a questionnaire suitable for most of the R&D centers via literature review from different sources (Chang&Hsu, 1997;Cooke-Davias, 2003).
- Set proper staff according to the requirements of each individual projects considering the balance of their work load (Line balancing).
- Standardize these two steps considering the termination of projects (Repeat the steps above). It should be done by project management department to provide new projects on time after closing the current ones.
- Sustain by coordinating periodical meetings.

We have implemented a new lean tool, line balancing, to provide the necessity of this step. The general description of line balancing is given below.

4.2.1 Line Balancing

Line balancing is a production strategy that levels the work load through all process steps in a cell or value stream to remove bottlenecks and excess capacity (Robinson, 1990).

The benefits of line balancing are:

- Loads all workers to the work cells
- Obtains individual cycle time for each operation
- Defines the order in which work elements should be done
- Defines the number of workers needed
- Helps to create a future-state map

Table 1: The 6-step of line balancing

	General	Specified for our project
1.	Choose a process or work area	Choose a project
2.	Obtain individual cycle times for each work element	Obtain individual monthly basis project plan
3.	Add the individual cycle times to obtain the total cycle time	Obtain available working-hours (calculating daily work load, comparing time-based project plan for each staff)
4.	Create the operator balance chart of the current state	Create availability chart of the current state
5.	Determine the ideal numbers of operators	Determine the time requirement of the project (daily)
6.	Create the operator balance chart of the future state	Create balance chart of the future state

5. Case Study

Name of the project: Developing functional surfaces on ceramic tiles
Length of the project: 18 months

Table 2: Current organizational structure of R&D department

R&D CENTER MANAGER

Raw Material Preparation Department (R.M.P.D)	**Ceramic Coating Department (C.C.D)**	**Sanitaryware Department (S.D)**	**Technical Ceramics Department (T.C.D)**
Line Manager-Y.E*	Line Manager-Y.Y	Line Manager -N.S	-
Engineer-O.S	Chief-S.K	Engineer-A.T	Chief –U.A
	Chief-M.T	Engineer-A.E	Chief –B.T
	Engineer-M.K	Engineer-M.G	Engineer-E.A
	Engineer-E.D		
	Engineer-G.C		
	Engineer-C.P		
	Chemist-E.K		

The current organization structure is given above. Although the existing allocation of project members is belong to the main scope of the project (ceramic coating department, sanitary ware department, e.g.) the new project team was assigned according to our new lean methodology.
*Name of each project staff. (capital letters of name & surname)

5.1 5S Implementation

5.1.1 Sort

The first step was to sort people according to their expertise. Table 3 shows the new organizational structure of R&D department. Two additional staff from Design & Product Development Department (D.P.D.D) were placed in the new organizational chart.

Table 3: New organizational structure of R&D department

Material	**Chemistry**	**Ceramic**	**Mining**	**Geology**	**Nanotechnology**	**Characterization**
C.I	Y.Y	G.A	M.K	Y.E	C.I	Y.Y
	E.K	M.T	E.D	O.N	E.A	E.K.
	C.T	U.A				
	S.K	B.T				
	E.A	G.C				
	M.G	A.T				
	A.E					

The second step was to define our main requirements for our new project “Developing functional surfaces on ceramic tiles” from the questionnaire. Main requirements are:

1) Material, chemistry, nanotechnology, ceramic (main areas of expertise)
2) Collaboration
3) Team work
4) Laboratory-based experience (chemistry intensive)
5) Production-based experience
6) Familiar with ceramic characterization
7) Research-based experience

The third step was to sort our staff according to the main areas of expertise for the sample project.

Table 4: Organizational structure of sample project (according to the main areas of expertise)

Material	Chemistry	Nanotechnology	Ceramic
C.I	Y.Y	E.A	U.A
	C.T	C.I	B.T
	E.A		M.T
	E.K		A.T
	M.G		G.C
	A.E		G.A

The last step was to sort staff according to the overall requirements of the project.

Table 5: Organizational structure of the sample project according to the overall requirements (estimated)

	Research-based exp.	Laboratory-based exp.	Production-based exp.	Collaboration-based exp.	Characterization
Material	C.I	-	C.I	-	-
Chemistry	E.A	E.A, E.K	-	E.A	Y.Y, E.K
Nanotechnology	E.A, C.I	E.A	-	-	-
Ceramic	A.T, U.A, B.T	-	B.T	Y.Y	Y.Y

5.1.2. Set

The first step was to obtain individual monthly-based current project plan since work-loads of R&D staff in state-funded organizations are calculated in a monthly-based.

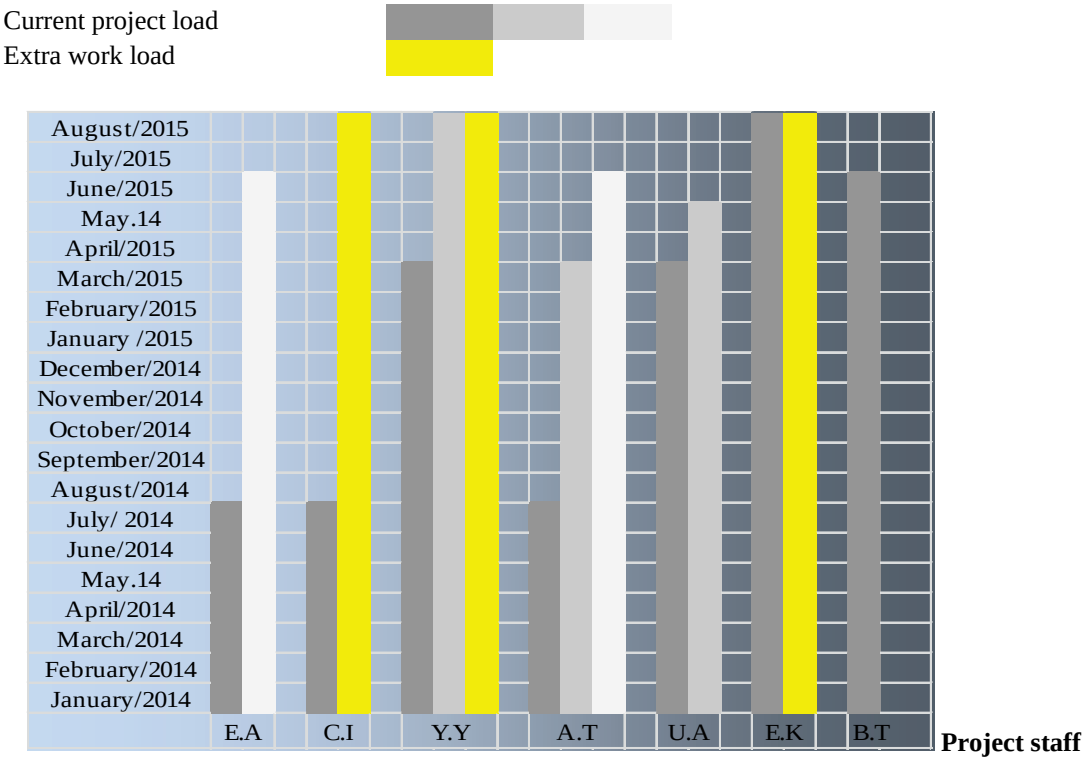


Figure 1: Individual monthly-based current project plan

The second step was calculating daily work-load. Some of the project staff have extra work- load e.g laboratory, production, characterization. Daily work loads of these staff were recorded and average working time for each day calculated. (Flexible)

The third step was creating availability chart of the current state.



Figure 2: Current state chart (available working hours)

The fourth step was determining time requirement of the sample project and alleviating proper staff.

E.A: Assigned as a project manager due to the project requirements, her qualifications and available time. ✓
C.I: Exceeding the time requirement of the new project plan, a lot of extra work load and probable unplanned current project does not provide necessary time and the capacity can be created by alleviate some of the work from C.I. ✓
Y.Y: Taking longer time than available work time. It is necessary to apply lean principles and try to alleviate workload to others that may be able be improved some of the workload. (X)
A.A: Very close to meeting available work time. Not an alternative staff but possibly some best practices and application of lean tools can improve her loading rates. (X)
U.A: Assigned as a ceramic-based researcher to fulfil his available daily work load. His available time is pretty enough for the requirement of the project. (ceramic-based research within the new project~10%) ✓
E.K: Assigned as a characterization-based researcher to fulfil her available daily work load. Although her available time is not enough for high laboratory work, it is enough for characterization and evaluating test results. ✓
B.T: Waiting to be assigned as a staff of different project since his qualification is based on research in ceramics and his gap time between available work time and his current duties excess the requirement of the project. (X)

After alleviating the suitable staff according to the project requirements, there was still missing staff for coordinating laboratory-based experiments. To balance the work load of each staff given above (E.A was assigned as a project manager to fulfil the requirements of research-based (chemistry), laboratory-based, collaboration-based), within the project new technical staff was hired to be alleviated some work from E.A.

The fifth step is creating balance chart of the future state

Current Project&Work Load
Available working hours/daily

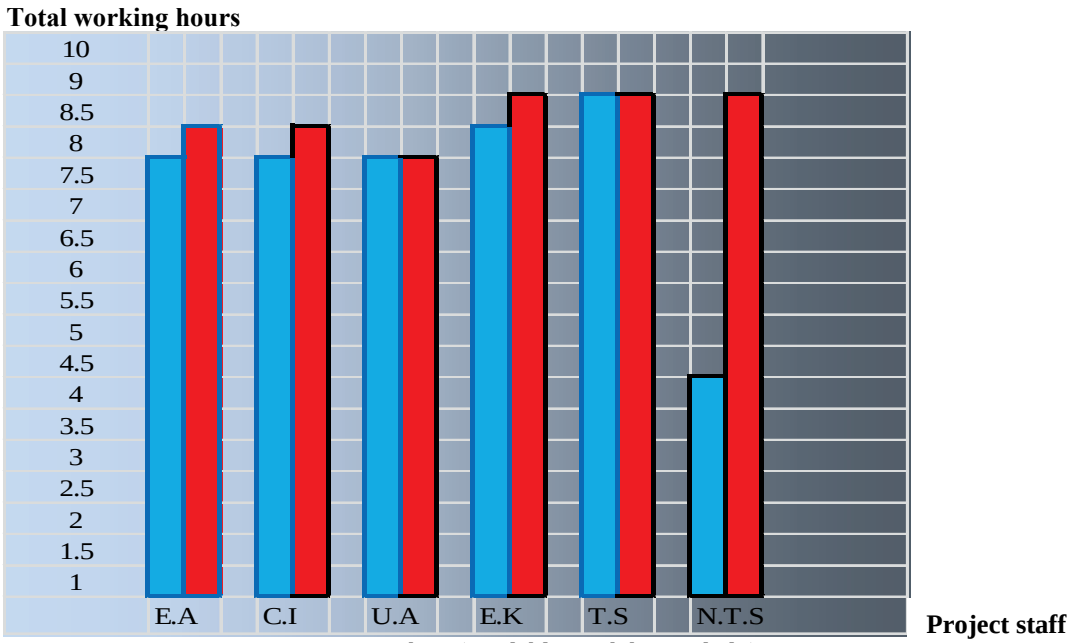


Figure 3: Future state chart (available work hours/daily)

T.S: Technical staff
N.T.S: New technical staff

5.1.3. Standardization&Sustain

- Individual monthly-based project plan for every staff in the R&D center was graphically represented and evaluated.
- Daily extra (flexible) work load of every staff and their available work time (instead of breaks, meeting, e.g) were calculated.
- Visual chart of availability for every staff were demonstrated and evaluated.
- Monthly-based project plans including time requirements and also milestones were created by every staff.
- Every step given above was repeated for technical staff.
- One technical staff was hired to fulfil laboratory works.

6. Conclusion

We have successfully implemented two lean tools at the initiate stage of project management cycle. The old organizational structure was only based on the main scope of the project. By using 5S, we first sort our project team according to their expertise. Within this stage, we prepared a questionnaire to understand the main requirements of sample project. Secondly, the project team was alleviated related with their experience in other fields, namely with their qualifications. To illustrate the monthly and daily work load of each member made us to be aware of the unbalanced work load. As it is seen from our graphical representations, some of the project members have over work while the others have gaps within their available work time. After carefully checking the requirements of sample project we alleviated our final project team to the sample project. Within this scope, we also evaluated the work load of every staff to balance the cycle of managing our projects which is the standardization step of 5S. We also made some improvements to standardize the allocation step of our project step. Finally, it was decided to arrange periodically meetings to sustain these new improvements.

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Factors Affecting the Use of E-Learning System among Undergraduate Students in Turkey: An Extended TAM

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Abstract

The aim of this study is exploring the factors affecting e-learning system usage, when e-learning system is used as a complementary system within a traditional education among undergraduate students in Turkey. Technology Acceptance Model (TAM) comprises the base of the research model and is extended with the following factors: system functionality, self-efficacy and Internet usage. A regression analysis was used to identify the factors affecting the e-learning system usage. The findings of the study indicate that perceived ease of use, system functionality and self-efficacy affect perceived usefulness positively, and perceived usefulness and perceived ease of use are the significant predictors of behavioral intention to use the system. In addition, perceived ease of use is explained by system functionality, self-efficacy and Internet usage. The study concludes with the practical implications and areas for possible future research.

Keywords
E-learning system, undergraduate students, system functionality, user characteristics

1. Introduction
E-learning is an Internet-enabled learning process (Gunasekaran et al., 2002) and "utilizes web-based communication, collaboration, multimedia, knowledge transfer, and training to support learners' active learning without the time and space barriers" (Lee et al., 2009). The growth as well as the advancement in Internet technology enables potential users to access the e-learning system in anywhere at any time, which lead to enhancements in online learning. Cortona Consulting, an agency working on new markets and developing business strategies and opportunities, predicts that in the year 2010 e-learning market value will reach to US$50 billion (Chiu & Wang, 2008).

The integrated e-learning system in universities yields many advantages to academicians and the students. The advantage of "anytime, anywhere learning" makes education more accessible than ever before (Little, 2001). With e-learning system, instructional interaction between academicians and students can be carried out synchronously or asynchronously (Pituch & Lee, 2006), which helps to increase the continuous and collaborative learning. Further, when the content is unstable and delivered a few times, e-learning may be an option (Piskurich, 2006). Despite the significance of e-learning systems for education, some students sometimes do not prefer to use these useful systems. This means a failed investment for institutions. Therefore, explaining and understanding the significant factors that affect the use of e-learning system is important, since these systems complement the academicians as well as the students during the learning and teaching process.

In the literature, several models such as Theory of Reasoned Action (TRA), Motivational Model, Theory of Planned Behavior have been used to analyze the factors affecting information system and information technology (IT) usage (Venkatesh et al., 2003). Technology-Acceptance Model (TAM) is a widely used model for explaining users' IT usage intention and actual usage (Davis, 1989; Legris et al., 2003). Davis et al. (1989) constitute the TAM from the TRA, which aims to understand the behavior of the human being. TAM is used to explain the individual acceptance of information systems. Although TAM is used widely in explaining the user behavior in IT usage, the extended model, which includes both human and social factors, enhances the understanding of IT usage (Legris et al., 2003; Lucas & Spitler, 2000).

Accordingly, this study aims to understand the factors affecting the acceptance of e-learning systems, which is used as a complementary system within a traditional class, from the perspective of undergraduate students in Turkey by including the following factors to the TAM: system functionality, self-efficacy and Internet usage. The next section is related with the research model and hypotheses. Then, the methodology and the results are discussed. We conclude this study with practical implications and recommendations for future studies.

2. Research Model and Hypotheses

In the research model, TAM is the basic model and we include the following factors to the TAM to develop the research model: system functionality, self-efficacy and Internet usage. The research model is shown in Figure 1.

2.1 Intention to Use

According to Theory of Reasoned Action, most behaviors are under volitional control and are predictable from behavioral intentions. Therefore, a person's intention to perform or not to perform a particular activity is the immediate predictor of actual action (Ajzen and Fishbein, 1980). Intention and the effort to conduct a particular activity are inseparable, that is why the likelihood of using a system will increase with the strong intention of the users for using a system (Ajzen and Madden, 1986). Behavioral intention captures motivational factors that influence a behavior. These factors are ''indications of how hard are people planning to try and how much effort they are planning to exert in order to perform the behavior" (Ajzen, 1991). In the current study, e-learning system is voluntary and supplementary to the course. Therefore, understanding the factors affecting behavioral intention to use e-learning system also enhances the understanding the actual system usage among undergraduate students.

2.2 Perceived usefulness

Perceived usefulness refers to the ''degree to which a person believes that using a particular system would enhance his or her performance". TAM posits that attitude towards use is predicted by both perceived ease of use and perceived usefulness. Further, both attitude towards system usage and perceived usefulness are predictors of intention to use the system (Davis, 1989). Among the factors, perceived usefulness is found to be most significant predictor of intention to use (Davis et al., 1989). On the other hand, Davis et al. (1989) explored that attitude towards the system usage does not fully transfer the effects of both perceived usefulness and perceived ease of use on behavioral intention to use. Therefore, a revised TAM, which asserts that both perceived usefulness and perceived ease of use predict behavioral intention to use in voluntary situations, is recommended

Academic performance improvement can be considered as the important part of usefulness perception. As the students perceive that the system improves their performance, then accordingly they may intend to use the system. Thus, for the usage of the e-learning system, perceived usefulness becomes important. Further, the significant effect of perceived usefulness on behavioral intention to use is confirmed by many studies (Lee et al., 2009; Li et al., 2011; Abbad et al., 2009; Sanchez-Franco et al., 2009; Saade et al., 2007). Therefore, the following hypothesis is proposed:

H1: Perceived usefulness has a positive effect on intention to use e-learning system

2.3 Perceived Ease of Use

Perceived ease of use can be defined as ''the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989). Davis et al. (1989) found that perceived ease of use affects behavioral intention to use a system directly together with perceived usefulness. Perceived ease of use is related with the required effort while using the system. The required effort for using a particular system is tried to be at the minimum by the users (Venkatesh, 2000). If using the system requires long learning and usage time and high effort, the potential user may prefer to- use the current system instead of the new system or stop using the new system. The revised TAM also

verified the significant effect of perceived ease of use on behavioral intention to use (Davis et al., 1989). The significant effect of perceived ease of use on behavioral intention to use e-learning system is verified by several studies (Li et al., 2011; Chang & Tung, 2008; Tung et al., 2008). Thus, we hypothesize:

H2: Perceived easiness of e-learning usage has a positive effect on intention to use

Furthermore, TAM proposes that perceived ease of use predicts both perceived usefulness and attitude toward use (Davis, 1989; Davis et al., 1989). The relation between perception of usefulness and easiness of use can be explained as follows: If the system usage is easy, then for the potential users learning time is minimized. This may be the potential reason to increase the system usefulness perception if we assume other factors are same (Davis, 1993; Venkatesh and Davis, 2000). In the literature, the positive effect of perceived ease of use on perceived usefulness is confirmed with the studies related with e-learning (Lee et al., 2009; Li et al., 2011; Abbad et al., 2009; Sanchez-Franco et al., 2009; Lee, 2010; Saade et al., 2009; Liu et al., 2009). Therefore, the following hypothesis is proposed:

H3: Perceived easiness of e-learning usage has a positive effect on perceived usefulness

2.4 System Functionality

"Functionality refers to the extent to which the web site operates in the way it is structured and is expected to perform as users desire" (Calisir et al., 2010; Bertot et al., 2006; Nielsen, 2003). Functionality in e-learning system refers to the "perceived ability of an e-learning system to provide flexible access to instructional and assessment media, such as allowing students to access course content, turning in homework assignments, and completing tests and quizzes online" (Pituch & Lee, 2006). The compatibility between the e-learning functionalities and user requirements will enhance the performance and further the perception of ease of use. The significant relation between system functionality and- intention to use (Pituch & Lee, 2006), perceived ease of use (Pituch & Lee, 2006; Li et al., 2011), perceived usefulness (Pituch & Lee, 2006; Li et al., 2011) is confirmed in the literature. Therefore, the following hypotheses are proposed:

H4: Functionality of the system has a positive effect on intention to use e-learning system
H5: Functionality of the system has a positive effect on perceived usefulness
H6: Functionality of the system has a positive effect on perceived ease of use

2.5 Self-efficacy

Self-efficacy is defined as "the confidence in one's ability to perform certain learning tasks using an e-learning system" (Pituch and Lee, 2006). When a learner has very strong self-efficacy about how to use an e-learning system, he/she may feel that while using the system the required effort is low and is more likely to accept an e-learning tool that facilitates his/her learning. Further, learning how to use the system would not take too much time if the potential users feel confidence in themselves. Park (2009) also confirms the significant effect of self-efficacy in using the e-learning system on perceived usefulness. Further, the significant relationship between self-efficacy and perceived ease of use is confirmed by several studies (Li et al., 2011; Park, 2009; Lee et al., 2011). Therefore, the following hypotheses are proposed:

H7: Self-efficacy in using the e-learning system has a positive effect on perceived ease of use
H8: Self-efficacy in using the e-learning system has a positive effect on perceived usefulness

2.6 Internet Usage

In this study, Internet usage is explained by Internet use per week. It is expected that as much as time spent on Internet use, users' skills in using the Internet may enhance, and eventually they perceive that the system usage is free of effort. Similar to our hypotheses, Cheong and Park (2005) find that Internet experience and perceived system quality predicts perceived ease of use of mobile Internet. Therefore, the following hypothesis is developed:

H9: Internet usage has a positive effect on perceived ease of use

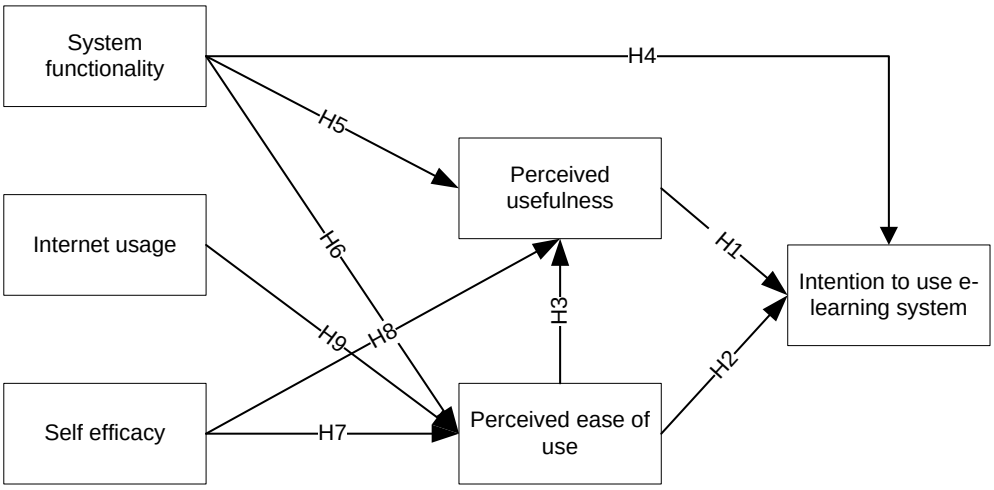


Figure 1: Research model

3. Methodology

3.1 Subjects

The target population comprised the undergraduate students, who are enrolled to the course, named "Introduction to Computers and Information Systems" in the Istanbul Technical University. This is an introduction course in the undergraduate education. A total of 310 questionnaires were collected during the period of April to May 2011. The questionnaire was carried out during the lesson at the end of the semester in groups of 10 to 35 people. Of the respondents, 39.5% were female, the maximum, minimum and average ages of the respondents were 28, 18 and 21 years respectively and 99% of the respondents owns computer. The respondents use computer 29.9 hours/week on the average and the average Internet use is 22.7 hours/week. The demographic profile of the respondents is given in Table 1.

Table 1: Demographic profiles of the students

Gender (%)		
Female: 39.5	Male:61.5	
Age		
Maximum: 28	Minimum: 18	Average: 21
Computer ownership (%)		
Has a computer: 99	Do not own a computer:1	
Computer usage in week (hrs)		
Maximum: 90	Minimum: 2	Average: 29.9
Internet usage in week (hrs)		
Maximum:80	Minimum: 2	Average: 22.7

3.2 Materials

We have used e-learning system, Moodle, to analyze in our study. Moodle is a software package used for the courses. Figure 2 shows the opening page of the e-learning system after the student enters the user name and password. This system is used to- integrate instructional materials such as text, video, complete quizzes and turn on assignments online, participate in forums and online discussions. Further, students can learn latest news, upcoming events and recent activities regarding the course.

The questionnaire related with e-learning system was developed with an extensive review of the literature related with technology acceptance model and e-learning (Lee et al., 2009; Pituch and Lee, 2006; Cheong and Park, 2005). The questionnaire has two main parts: questions related with demographic profiles and the questions related with the items of the constructs in the research model. The items of the constructs are shown in Table 2. The only change in these items is that items were changed to become related with e-learning system. Five-point Likert scale was used

to measure the items of the constructs. In the Likert scale, 1 represents 'strongly disagree' and 5 represent 'strongly agree'. Internet usage was measured as an open-ended question in terms of Internet use per week. A pre-test of the e-learning survey was conducted. Thirty students were joined to the pilot study. Some items were reworded based on the feedback provided by the participants. Then the final version of the questionnaire was prepared.

Table 2: Constructs and their corresponding items

Construct/ Reference	Items
Intention to use (Lee et al., 2009; Cheong and Park, 2005)	"I intend to use e-learning system" "I intend to use e-learning system as much as possible" "I prefer e-learning to traditional learning" "I think e-learning should be implemented in other classes" "I will recommend e-learning classes to other students"
Perceived usefulness (Pituch and Lee, 2006)	"Using the e-learning system allows me to accomplish learning tasks more quickly" "Using the e-learning system improves my learning performance" "Using the e-learning system makes it easier to learn course content" "Using the e-learning system increases my learning productivity" "Using the e-learning system enhances my effectiveness in learning" "I find the e-learning system useful in my learning"
Perceived ease of use (Pituch and Lee, 2006)	"Learning to operate the e-learning system is easy for me" "I find it easy to get the e-learning system to do what I want it to do" "My interaction with e-learning system is clear and understandable" "I find the e-learning system to be flexible to interact with" "It is easy for me to become skillful at using the e-learning system" "I find the e-learning system easy to use"
System functionality (Pituch and Lee, 2006)	"The e-learning system allows learner control over his or her learning activity" "The e- learning system offers flexibility in learning as to time and place "The e- learning system offers multimedia (audio, video, and text) types of course content "The e- learning system provides a means for taking tests and turning in assignments" "The e- learning system can present course material in a well-organized and readable format" "The e- learning system can clearly present course content"
Self-efficacy (Pituch and Lee, 2006)	"I am confident of using the e- learning system," "Even if there is no one around to show me how to do it" "Even if I have only the online instructions for reference" "Even if I have never used such a system before" "As long as I have just seen someone using it before trying it myself" "As long as I have a lot of time to complete the job for which the software is provided" "As long as someone shows me how to do it"
Internet use	"How many hours do you use Internet per week?"

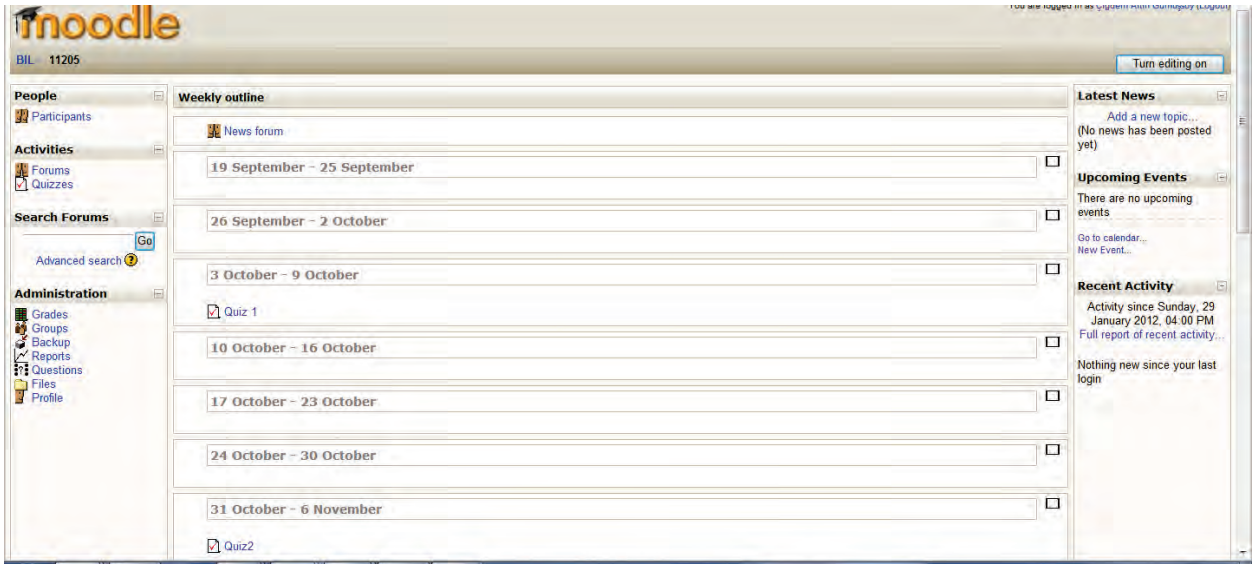


Figure 2: Opening page of the e-learning system

4. Results

A stepwise regression analysis was used to determine the factors affecting behavioral intention to use, perceived ease of use and perceived usefulness. First, the reliability of the constructs was examined and all the five constructs have acceptable Cronbach alpha values ranging from 0.62 to 0.71. The results of the regression analysis are shown in Figure 3 and Table 3. In particular, this analysis yielded a regression function with a R^2 = 0.49 based on two significant variables: perceived usefulness and perceived ease of use. It should be noted that perceived usefulness was weighted most heavily in the regression model predicting intention to use. The relatively high R^2 value indicates that the criteria selected in this study can explain a high percent of the total variance in intention to use. Furthermore, perceived usefulness is explained by system functionality, perceived ease of use and self efficacy positively; system functionality, Internet usage and self-efficacy are found to be significant predictors of perceived ease of use. The only insignificant path is found to be between system functionality and intention to use e-learning system.

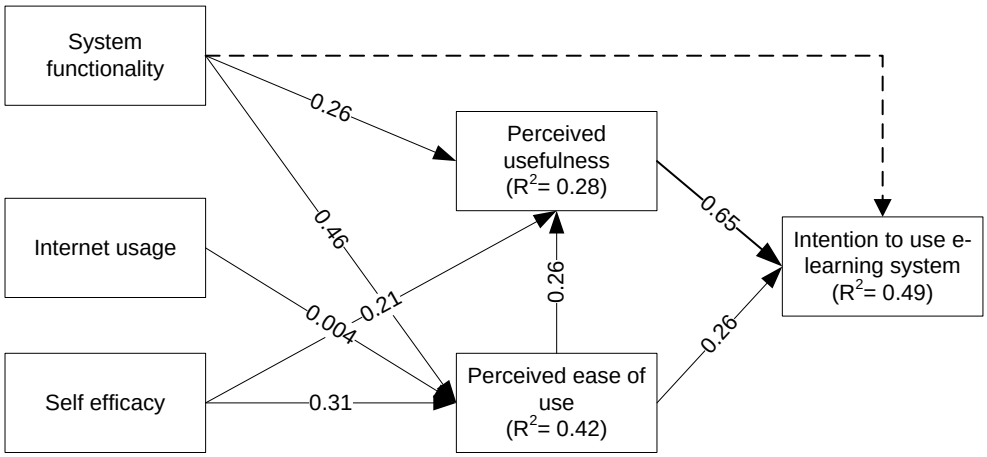


Figure 3: Results of the research model

Table 3: Regression analysis on intention to use, perceived usefulness and perceived ease of use

Regression on Intention to use						
	Sum of squares	df	Mean square	F	Prob>F	
Regression	84.718	2	42.359	148.511	0.000	
Residual	87.279	306	0.285			
Total	171.997	308				
Predictors	Beta	Std error	Partial R^2	Model R^2	F	Prob>F
Intercept	0.31	0.191				
Perceived usefulness	0.65	0.052	0.46	0.46	257.965	0.000
Perceived ease of use	0.26	0.056	0.03	0.49	21.680	0.000
Regression on Perceived Usefulness						
	Sum of squares	df	Mean square	F	Prob>F	
Regression	38.484	3	12.828	40.971	0.000	
Residual	95.809	306	0.313			
Total	134.293	309				
Predictors	Beta	Std error	Partial R^2	Model R^2	F	Prob>F
Intercept	0.77	0.231				
Perceived ease of use	0.26	0.068	0.21	0.21	83.673	0.000
System functionality	0.26	0.067	0.04	0.25	18.935	0.000
Self-efficacy	0.21	0.062	0.03	0.28	11.690	0.001
Regression on Perceived Ease of use						
	Sum of squares	df	Mean square	F	Prob>F	
Regression	48.354	3	16.118	74.00	0.00	
Residual	65.343	300	0.218			
Total	113.698	303				
Predictors	Beta	Std error	Partial R^2	Model R^2	F	Prob>F
Intercept	0.56	0.192				
System functionality	0.46	0.050	0.33	0.33	148.448	0.000
Self-efficacy	0.31	0.048	0.08	0.41	44.617	0.000
Internet usage	0.004	0.002	0.01	0.42	4.794	0.029

5. Conclusion & Discussion

This study deals with undergraduate students' intention to use e-learning system. TAM is used as a base model and is extended with the other related factors, such as system functionality, self-efficacy, Internet use. In terms of a theoretical contribution, this study contributes to the literature by extending the TAM with the following factors: system functionality, self-efficacy and Internet use. In the research model, system functionality, self-efficacy and Internet use affect perceived ease of use positively; and perceived ease of use, system functionality and self-efficacy affect perceived usefulness positively.

The results show that as the perception of usefulness and ease of use increase, and then the students more intend to use the system. Among the factors, perceived usefulness explained a high percentage of the variance. This result demonstrated the suitability of the TAM in understanding the students' intention to use e-learning systems. In consistence with our findings, Roca and Gagne (2008) have found that intention to use e-learning system is mostly affected by perceived usefulness and the sample for this study is collected from the workers working in the United Nations.

Further, functionality of the system predicts positively both perceived usefulness and perceived ease of use. That is, the users who perceive that the system has more favorable functions, the system is perceived to be easy to use and more useful. Among the predictors of perceived ease of use, system functionality is the most significant predictor. Similar to our finding, Li et al. (2011) found that system functionality is the most significant factor in explaining perceived ease of use and perceived usefulness among students in China.

Our results also validated the importance of user characteristics in which self-efficacy is significant factor in explaining perceived usefulness and both Internet usage and self efficacy are important factors affecting the perception of ease of use. Congruent to our findings, Pituch and Lee (2006) found that system interactivity, perceived ease of use, system functionality and system response have positive impacts on perceived usefulness; and system functionality, system response and self-efficacy impact perceived ease of use positively.

The impact of Internet usage on perceived ease of use is found to be relatively low with respect to other significant predictors of perceived ease of use. The possible explanation for this result may be that nearly all the young people including the students have considerable computer and Internet experience, so they are highly computer as well as Internet literates. Therefore, in this study, the time spent on Internet usage may not found to be so important for the ease of use perception. Parallel to our findings, Pituch and Lee (2006) found that Internet experience does not have a significant effect on using the system for supplementary learning as well as distance education, perceived usefulness and perceived ease of use among college students.

5.1 Managerial Implications

This study confirms the well-established importance of perceived usefulness and perceived ease of use. That is, a high proportion of perceived usefulness is explained by perceived ease of use; and both perceived ease of use and perceived usefulness have significant effects on behavioral intention to use the system. Therefore, the responsible of the e-learning system should describe the benefits of the system usage to the students and how the system helps them to learn course content or enhance synchronous or asynchronous communication. Then, among students a greater effort to use the system is unavoidable.

Further, system functionality affects both perceived ease of use and perceived usefulness positively. Therefore, identifying the actual needs of students prior to the implementation of the system and designing the e-learning system that conform the students' expectations is significant for the success of e-learning adoption. Prior to the design of the system, the needs and functions of the system should be identified by designers by taking the support and opinions of instructors and students.

5.2 Future Research

This study contributes to the literature by understanding the factors affecting e-learning system usage among undergraduate students in Turkey. However, we have some recommendations as a further study. First, perceived usefulness and perceived ease of use explain 49% of behavioral intention to use e-learning systems. Thus, approximately 51% of the variables remain unexplained, warranting the need to include additional variables in explaining user behavior. Examples of these factors include instructor characteristics, teaching materials, playfulness (Lee et al., 2009) and technical support (Sanchez & Heuros, 2010). Second, the results are only applicable to students. Testing this theoretical model among academicians who use the same e-learning system may be considered as a further study. Finally, a qualitative analysis in terms of adoption and usage may increase the understanding of the system usage.

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Human Capital Development by Improving the Environmental Engineer Skills with Master Programs

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Abstract

This paper proposes a solution for graduates' students to achieve cognitive and communication skills, practical – applicative knowledge, and to become specialists. The authors were involved in creating a master's program for environmental protection in the materials industry. This master program provides for graduated students added value from professional point of view, practical work as well as research knowledge. The graduated students will access thus the labour market in various fields as: materials industry, research, teaching, environmental agencies.

Keywords: Behaviour relationships, communication, competences, skills.

1. Introduction

Nowadays, the economical agents, from the sustainable development point of view of the natural resources, but also from the environmental protection management point of view, are preoccupied especially to realize and demonstrate a healthy ecological performance by controlling the impact of the activities, products and services on the environmental. Thus the identification of the entry and exit to generate effects on the environmental becomes mandatory and should be reduced concomitantly with increasing the benefits (increasing the performances for environmental protection results in increasing the economical performance).

Solutions to global environmental and development problems require engineers to design and construct ecologically and socially just systems, within the carrying capacity of nature and society, without compromising the welfare of future generations (James R. Mihelcic et al., 2006).
For the metallurgical engineering studies, we could say that the new type of development relies correctly and consistently on two fundamental features:

- sustainability, targeting:
    - the long term development potential, i.e. including that for the future generations;
    - the ability of the systems to be long-lasting by satisfying the values required by the system resilience, measuring the ability to recover of the system as a result for shocks (disturbance variables) of which the most important is the pollution;
    - the possibilities of the systems to develop viable entities.
- sustainability**,** which targets the capacity of the new type of development to support and maintain development processes within the systems; it is assessed through the support capacity of the systems (Nicolae et al., 2013).

The metallic materials engineering, in terms of sustainable development, approaches the metallic materials from several points of view of which we mention:

- the human activity must satisfy the restrictions imposed by the four systems (natural-ecological, social, economic and political);
- the materials are regarded as vectors of substance (matter), energy and information, crossing the four systems;
- when crossing the natural-ecological $\rightarrow$ technological $\rightarrow$ social system, the materials undergone transformations on the route resources $\rightarrow$ technological process $\rightarrow$ usable primary material $\rightarrow$ secondary material disposed in the environment or reintegrated (Nicolae et al., 2013).

In this context it is worth to underline the necessity for education, forming and information in the field of engineering and environmental protection field in industry to approach new objectives as in the metallurgist engineering contribution to preserving the natural capital as principal row of sustainable development (Sohaciu et al., 2010).

To meet the educational and human resource needs required for this new discipline, the technological and environmental awareness of society must be elevated and a sufficient and diverse pool of human talent must be attracted to this discipline (James R. Mihelcic et al., 2003).

Starting from the point where the metallurgist engineer vision in preserving the natural capital, can be realized by: optimizing the minimizing of the specific consumptions, projecting and application of the new technologies with minimum losses, recycling the materials and industrial energies, the author propose a solution for the graduating students from the Science and Engineering of Materials Faculty, Engineering and Science of Environment and Industrial Engineering to become specialist with cognitive competences, practically – applicative but also with competences in communication and behaviour – relationships (Nicolae et al., 2009).

This solution should realize a correlation between the educational needs and the labour market needs, thus the engineers to achieve formative competences as:

- Using the knowledge of socio – human nature and managerial ones to improved the ecosystems referring the indicators of the life quality;
- Potential to implement the wide spectrum specialty knowledge in the multi qualification systems, thus meaning the elastic possibility of adapting in changes produced in science and technique;
- Abilities regarding the extending the eco-technologies;
- Team working ability;
- Independent and creative action ability in order to find the solution of a problem and communication of the results;
- Capacity of critical assessment a new research;
- Creative application of the research methods;
- Formulation of alternative solutions interpretative relevant (Predescu et al., 2008).

2. Preparing and Creating the Master Degree Program

In this context, in our faculty a master program was developed and created in the field of Environmental Protection in Materials Industry.

Specialty in this program targets the amelioration of the fundamental preparation of the graduated students based on the following coordinates:

- Knowing and application of the last generation techniques for characterization and identification of the pollutant substances;
- Developing of a new recycling (recirculation) techniques of secondary materials and energetically (secondary energy resources RES and renewable energy sources);
- Conceiving and application of the modern eco-technologies in the vital sectors for fabrication and use of metallic materials;
- Fundaments of processes for pollutants generation the chemistry, physics and mathematics;
- Exploitation of the industrial ecosystems based on modern informatics (optimal conducting of ecosystems and informational systems in industrial ecology);
- Consolidation of the strategies and environmental policy based on the principals of the concept of sustainable development, of improving the process and products quality and amelioration of the life quality (Sohaciu et al., 2009).

By realizing this master degree program, organized based on a Learning plan well justified is followed the realization of a formal frame with applicative relevance where the future specialists in the field of engineering and environmental protection to achieve the formative competences but also specific competences as:

- Ability to apply the knowledge regarding the kinetics and dynamic of the processes of scrap generation and pollutant emissions in the metallic materials industry;
- Achieving the information and knowledge in the field of monitoring and analyzes by laboratory techniques of preventing and pollution control;
- Superior level education for designing the equipments and prevention technology control of pollution;
- Engineering potential to act for the purpose of preserving the natural capital by optimizing the specific consumption and recycling the secondary materials;
- Solid knowledge referring to management improving, environmental laws and informatics in the field of metallic materials industry;
- Capacity of optimal conduction of the engineering systems in condition of industrial pollution;
- The ability to conceive and improve the sustainable metallurgical eco-technologies.

The laboratory work is realised for phenomena better understanding and the students gain experience in working with different devices and installation as well as improving the behaviour and communications skills by team working. The students' team usually develop a project that will help the student solve the laboratory task and the team will present the project at the final exam. The team has to work together, to present the project together and the recognition and the mark will be given for every individual. When a teacher assess a project will also take into consideration the teamwork, how well the students collaborates with each other and how much amount of work performed each team member. Thus the students will be more prepared to work in a team as well as by themselves in order to solve tasks and resolve problems.

3. Material Base

For well developing of this master degree program it was necessary the modernizing and conceiving of a new materials base. This material base was designed and realized to fulfil a double role: for the teaching activity and research activity.

For this purpose it was realized the Laboratory of Pollutant Characterization and Analyze where the master degree students can achieve information and knowledge useful in the field of monitoring and analyses by laboratory techniques. In this laboratory they can effect analyzes with the aid of very good equipments as spectrophotometer of molecular absorption type GBC Cintra 5 UV – VIS (see Figure 1a) destined to the analyses of the content of some pollutants present in samples of water and soil, type cian, sulphides, nitrides, hexavalent chromium, phosphates and an atomic absorption spectrophotometer type GBC 932 AB PLUS (see Figure 1b) destined to the metals content analyses (Fe_{total}, Ni, Pb, Cu, Zn, Cd, Mn, Au, Ca, Cr aso) from soil, water, scraps and powders (Sohaciu et al., 2008).

In the energetically sources for recycling and renewable, the master degree students can achieve the knowledge regarding the non-polluting burning of the fuel and about the recycling the secondary energy sources (see Figure 2) (Predescu et al., 2008).



a)



b)

Figure 1: a) Molecular absorption spectrophotometer, type GBC Cintra 5 UV-VIS b) Atomically absorption spectrophotometer type GBC 932 AB PLUS



Figure 2: Device for testing fuel burning.

The master degree students' activity regarding the materials analyses formed in some phases of the flux (ore→fuels→metallurgical final product) is developing in the Laboratory for knowing the generation and processing secondary materials (see Figure 3) having a modern infrastructure.

To achieve solid knowledge referring to improving management of the environmental laws and informatics in metallic materials industry the master degree students can participate to research activities and crystalline phase's identification by X rays diffraction method for any polycrystalline material with the aid of a of X rays difractometer type Xpert Philips (see Figure 4) in the Laboratory of Identification of the Products of Sustainable Ecotechnologies.



Figure 3: Image from the Laboratory of secondary materials: knowledge, generation and processing



Figure 4: X rays difractometer type Xpert PRO Philips

In the Laboratory of Environmental Factors analyses factors (water and soil) by gas chromatography and mass spectrometry, master degree students can determine the organic compounds persistent representing a risk factor over the environment and their monitoring is imposed by the new legislation in the field of environmental protection.

They can use the latest generation composed by gas chromatography type Konik Tech HRGC 4000 B (see Figure 5a) for quantitative analyze and a mass spectrophotometer type Konik QMASS 12 (see Figure 5b) for quantitative analyses.



a)



b)

Figure 5: a) Gas chromatograph type Konik – Tech HRGC 4000B b) Mass spectrophotometer type KONIKQMASS 12

For achieving knowledge regarding prevention and control of the pollution, the master degree student can develop their activity under direct surveillance of the teachers in the Laboratory and prevention and Pollutant control. This laboratory has an optical emission spectrophotometer type GNR Metal Lab 75 – 80 (see Figure 6) with the spectral field of measuring between 120 and 800 nm. The equipment has specialized software on three bases (Fe, Al and Cu) and allows the quantitative analyze effecting to determine the chemical composition of the mechanical alloys.



Figure 6: Optical emission spectrophotometer type GNR Metal Lab 75-80

4. Conclusions

The sustainable development concept operationalization in metallurgy involves activities such as:

- Operationalization of the interconditionings and interactions that may arise in the convergence areas of the four systems: natural-ecological, social, economic and technological;
- Knowledge of events that occur in all the phases of the active circular lifecycle;
- Operationalization of new interdisciplinary fields: metallurgical econology and metallurgical ecosociology;
- Operationalization of the sustainable material notion (Nicolae et al., 2013).

Having professors with a wide professional experience and a modern infrastructure, the master degree students can improve the research capacity regarding the conceiving and operationalzing of sustainable metallurgical processes as well as the knowledge regarding the monitoring and analyzing the pollutant emissions but also the way they act for the purpose of preserving the natural capital by optimizing the specific consumption and the secondary materials recycling.

Graduating this master program the graduation students will be more valuable from professional point of view as practical workers as well as researchers having access on the labour market in various fields as: materials industry, research, teaching, environmental agencies etc.

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Biography

Mirela Sohaciu is a Lecturer at Faculty of Materials Science and Engineering – University POLITEHNCIA of Bucharest. She has a good experience in the field of producing, processing, characterization and expertise of metallic materials and development and implementation of environmental technologies for production and materials processing. She was member of team in more than 30 projects (national and international) regarding research, development and infrastructure, of which 9 as director or responsible. Her scientific activities resulted in publication of more than 55 articles (25 ISI, 10 books and 4 patents).

Cristian Predescu is a Professor at Faculty of Materials Science and Engineering – University POLITEHNCIA of Bucharest. His skills are in the field of producing, processing, characterization and expertise of metallic materials and development and implementation of environmental technologies for production and materials processing. He has a great experience in coordination of more than 46 projects (national and international) regarding research, development and infrastructure, of which 21 as director or responsible (3 international projects). His scientific activities resulted in publication of more than 130 articles (30 ISI, 15 books and 8 patents).

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Ioana Csáki, borne Apostolescu in 1975, Bucharest, Romania, graduated in 1999 Faculty of Engineering in Foreign Languages, English stream, Materials Science and Engineering, University "Politehnica" Bucharest as materials science engineer, PhD title in Materials Science and Engineering field in 2008 – In situ composites with aluminium matrix – working as a lecturer in Materials Science and Engineering Faculty, University "Politehnica" Bucharest specialist in composite materials with nonferrous metal matrix and powder materials processing and materials characterisation. She wrote over 35 articles and worked for 50 research contracts as a team member. She has experience with international contracts, working on 2 Leonardo projects and she was project manager for one research contract during 2007 – 2009.

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The Role of Contemporary Marketing Tools in Concurrent Engineering

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Abstract

The high competition, changes in market demands, technological improvements lead to change customer behavior. Today, companies try to assess market requirements and develop necessary products in shorter times to hold their profitability. Concurrent Engineering (CE) is one of the policies that companies apply to shorten time to market and decrease lead time. In CE it is aimed to involve all participants and groups contributing to product development. This study focuses on the ways that companies interact with their customers. Traditional tools (questionnaire, testing, and meeting) are compared with contemporary tools (social networking sites, online innovation market places, virtual game worlds…etc.). Additionally contemporary marketing tools like facebook, twitter, and blogs are assessed for the New Product Development (NPD) phases. In conclusion, contemporary tools are better almost overall assessment criteria but especially in comprehensibility, customer benefit, user acceptance, realisability, market size measurement, and portfolio fit. For NPD phases the quality of information gathered by Facebook, Twitter and Blogs varies between phases.

Key words:
Concurrent engineering, customer involvement, social networking sites

1. Introduction

In recent years customers have become more demanding. That caused by high competition, changing market demands and rising customer requirements. Meeting market demands correctly, rapidly, and profitably is the focus of many industrial companies for long term success. At that point companies have to develop new products in shorter times, developments must be more efficient and they have to provide superior products.

The product life cycles are being accelerated by the changes in technology, the diffusion of scientific and technical information around the world, and the growing interdependence of international markets. There is an economical implication of the shortening in product life cycles. (Cespedes, 1995)

In the last decades the competitive environment has let companies to refine their new product development (NPD) processes. In order to be able to shorten the time to market, decrease lead time, increase competitive advantage, profitability and market share, companies started to use Concurrent Engineering (CE). In CE, it is tried to knock down the barriers between departments and make people communicate during the whole product development cycle. The product development processes in the companies applying CE all related activities start as early as possible, mostly they work in parallel to shorten the process (Goa et al., 2000). Although there are many studies done on processing of the information received from customers or converting it to engineering language the way to interact with customers in CE was not issued in previous studies. In this study it is mainly focused on the ways that

companies interact with their customers. Traditional tools are compared with contemporary tools that are being served by social media platforms. Moreover three widely used contemporary marketing tools like facebook, twitter, and blogs are assessed for the NPD phases of CE.

2. Concurrent Engineering

The American Institute for Defense Analysis defines CE as to be "a systematic approach to the integrated, concurrent design of products and related processes, including manufacturing and support. This approach is intended to cause the developers to consider all elements of the product life cycle from conception through disposal, including quality, cost, schedule, and user requirements" (Winner et al.). In CE the work flows are concurrent, the involvement of all participants and groups contributing to product development is done at the very early stages and it is manly dependent on team-work (Gao et al.). As well as intra-organizational communication inter-organizational communication gains much importance in CE. Involvement of suppliers to new product design has been widely accepted by competent companies. However in CE that is not enough, the involvement of customer is essential as well. Because in current market conditions, the companies have no other choice than satisfying their customers to make profit. The general methodology of CE for NPD can be seen in Figure 1.

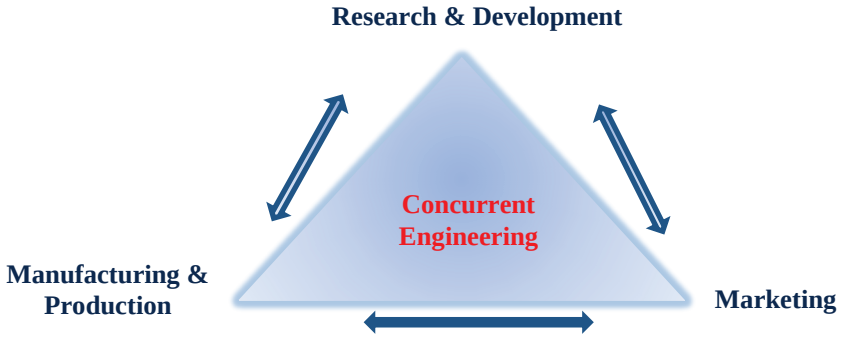


Figure 1: Concurrent engineering methodology for NPD

CE is firstly used in the late 80ies, however it gained popularity in last two decades due to the recent developments in IT and the growing market push. The new product design in CE is considering all elements of the product life cycle from conception through disposal. If the product development and the design cycle remains a linear process as it is in most companies, the motivation for cooperation and collaboration of various groups cannot be gained. This gap is filled in CE by bringing various groups to work together, creating a synergy and leading the way to innovation. Generally there are three main design methodologies like sequential, centralized and concurrent design (Scanlan, 2006). These three different methodolgy types are depicted in Figure 2. In traditional sequential design, there is a very limited information exchange between the different product development working groups and the flow of information is mostly in one direction. In current modern companies this type of design is found to waste a lot of time and sources (Camr, 2002; Ucler, 2009). Another methodology is the centralized design, in which a product leader or product manager is at the center of the process and responsible for the communication through the design groups. Here the capability of the leader is defining the product success(Camr, 2002; Ucler, 2009). Contrarily in CE there are communication channels where the flow of information is in two directions. Moreover CE involves cross-functional teams formed by engineers and managers to work together (Camr, 2002; Ucler, 2009).

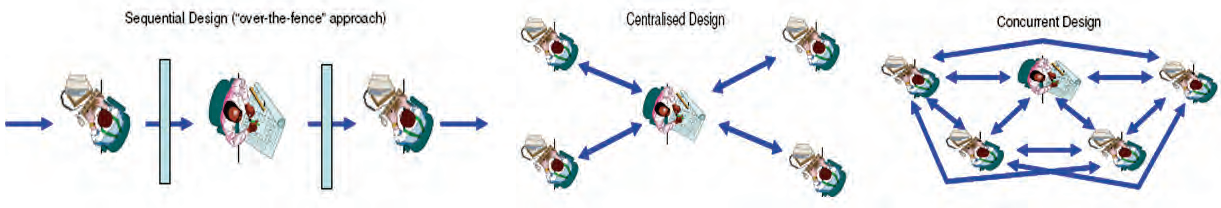


Figure 2: Design methodology types (Scanlan, 2006)

Since the design, testing, manufacturing and product introduction in CE are done interactively any possible problems in these phases can be identified and solved in the design stage (Izuchukwu, 1992). Parallel to the design process in CE early assessment of functionality, productivity, customer satisfaction, and profitability makes the process more efficient.

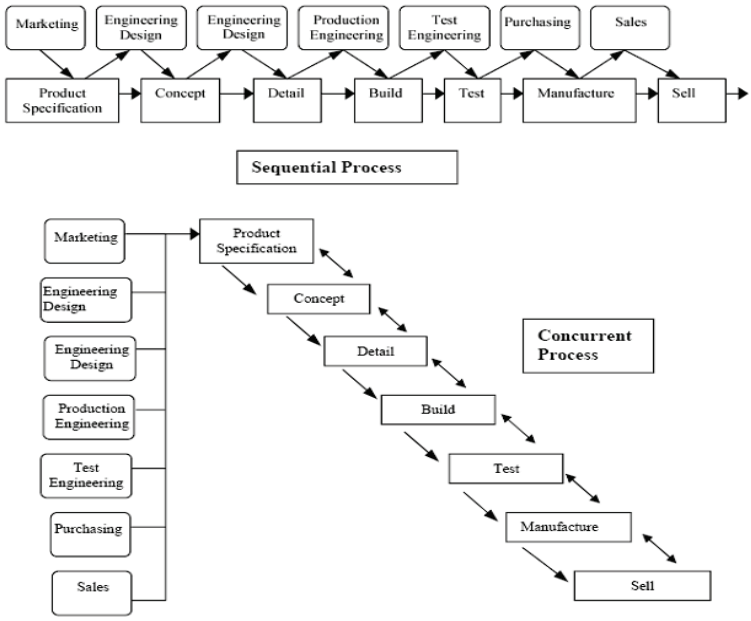


Figure 3: Sequential and concurrent processes for new product development (Camr, 2002)

The differences in flow of information between sequential and concurrent processes are better shown in the Figure 3. For instance in sequential process, the feedback from marketing is gathered at the very beginning of the process, later during the rest of the process there is no involvement. However the interactions between the cross-functional groups are continuous in concurrent processes. The barrier between designers and users is aimed to be overcome by CE in contrast to sequential design process (Prasad, 1996). By this way, the designer might become more sensitive to customer expectations. Thereby designing the right product reduces the development and manufacturing costs. For instance, Winner et al. claims that CE enables a dramatic rise of quality by reducing the number of engineering change orders by more than 50% and enabling a cycle time reduction of 40 to 60% compared to sequential design process. Furthermore they mentioned that by using multifunctional teams the manufacturing costs are reduced 30 to 40% and 75% reduction in scrap and rework is possible (WINNER et al., 1988).

Since CE is a customer focused methodology the necessitiy to design changes after the product launch is reduced. Chapman et al. showed the number of design changes during the product life cycle in traditional and concurrent engineering methodologies (see Figure 4). Obviously using CE methodologies enables the necessity of design changes to be less not only after the product release but also all over the process. Thus leading to minimize the cost of designing new products. (Chapman, 1992)

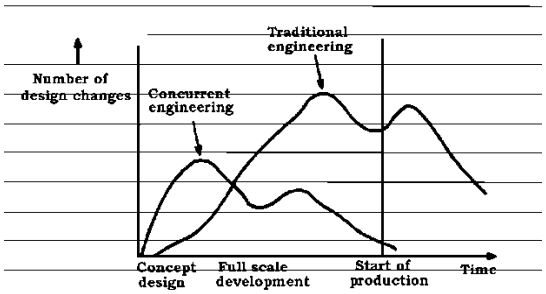


Figure 4: Number of design changes as a function of time in traditional and concurrent engineering methodologies (Chapman et al., 1992)

To be able to compete with current market conditions the new product development process supposed to enable the use of all technological tools both for the technical side and managerial side. Since the role of communication is enormous in CE, incorporating technological communication tools is crucial. Marketing is the unit which has close contact to the customers or broadly to the market. Analysis of market conditions, assessment of competition, and critically evaluation of customer needs are done in many companies by marketing. In CE the inclusion of marketing to the process is continuous through the project duration in contrast to other design methodologies.

3. Communication with Customers – Marketing

Communicating with the customers, which is mostly hard and time consuming, is the task of marketing unit since they are the interface of the company. Additionally the information received from the customers is not always in the form that they can be used directly by the designers. There are many studies that have been done on the models to incorporate and adapt customers' preferences into the CE methodology (Wang & Tseng, 2008; Chan & Ip, 2011; Cheung & To, 2010). Techniques like quality function deployment (QFD) and design for manufacturing (DFM) are very frequently used as well (Gao et al). Previously it was tried to involve customers by doing face-to-face meetings, questionnaires or testing/experiencing sessions. All of these methods hold one way communication. The data received is processed if it was worth to use otherwise waste. Rarely customers were invited to the office for a sit-down to get feedback about the products and services (Shiffman, 2007). But still this face-to-face appointments were not enough to make the customer to dream for the company. As well as the low quality of information the length of the process was very long in traditional marketing tools. The aim of companies has been to involve the customer's voice. The tools they were using did not let the customers to undertake a role more than being passive. Of course that was not only due to the technics or tools being used but the lack of information about products has also a crucial effect. The interaction could not be turned to a dialog; it stayed always in one direction. (Sawhney, 2005; Urban and Hauser, 1993; Giblet, 2010; Christ, 2011)

A revolutionary new trend is represented by media (Kaplan & Haenlein, 2010). With Web 2.0 the way of using internet has been changed. Internet has become User Generated Content (UGC). Not only speed of internet but also accessibility by large number of population makes it indispensable for business. By being UGC, internet plays an important role at gathering individuals and businessman at one platform. Moreover companies get benefit of communities in Social Media. Using Social Media channel became more challenging than accessing to customers one by one. In Social Media it can be either reached to a community or a new community can be formed.

The communication with customers can be done either via traditional interactions (assessments, questionnaires) or internet. The ways to communicate with customers via internet has also changed during the last decade. Previously, mostly mails are being used. But today with UGC more channels are developed such as collaborative projects, blogs, content communities, social networking sites, virtual game worlds, and virtual social worlds. Communication channels with customers that are available are given in Figure 5. In this figure the channels that are connected to the marketing with a solid line named as traditional tools and the once with dotted lines named contemporary tools. All of these tools are described briefly in Table 1. As it is depicted in Figure 5 although the interaction in meetings, questionnaire and testing sessions are one directional, the interaction in collaborative projects, blogs, content communities, social networking sites, virtual game worlds, and virtual social worlds are two directional. That means it is possible to communicate or to have dialogs with the customers. The ability of firms to engage with customers in the product innovation process is greatly enhanced with internet. It has also improved the communication process by serving a dialog environment instead of a one way, discontinuous communication. It is possible to get in contact and have a dialog with high number of customers by internet-based virtual environments, which is rich in content. (Sawhney et al., 2005)

Opportunities of internet as a platform for collaborative product innovation are mentioned by Sawhney et al. as interactivity, persistence, speed, flexibility, reduced constraints of geography, richness, accessibility, and intensity (Sawhney et al., 2005).



Figure 5: Communication channels of marketing

Table 1: Description of customer communication channels

Communication Channel	Description
Questionnaire	It was and still for some companies one of the mostly used ways of receiving the comments of customers. It also possible to motivate the customers to share their expectations by questionnaire. Well known examples are customer and product satisfaction questionnaires.
Meeting	Focused or special customers are invited for face-to-face meetings. The aim is to make customers to dream for the company (Shiffman, 2007).
Testing / Experiencing	Companies either form an individual platform for their customers or meet them in common places to let their customers test or experience their products physically. The aim is to get evaluations from customers about new or existing products.
Blogs	A blog is a special kind of web site which is created and maintained by mostly a person. There are also blogs of groups, companies or organizations. (Scott, 2010)
Content communities	They are the platforms formed by users who aimed to share media content between users. The aim might be sharing videos, presentations, photos…etc. (Kaplan and Haenlein, 2010)
Social networking sites	Sites where people easily create a profile about themselves and meet friends not only offline but also online. Some examples for currently most used social networking sites are Facebook, Twitter, and LinkedIn. (Scott, 2010)
Virtual game worlds	With massively multiplayer online and role playing games (MMOGs) networked games have been popular. Each game has its own environment, enormous groups of people come together to compete against each other. (Wertime & Fenwick, 2008)
Virtual social worlds	They are improved versions of reality. In virtual social worlds, participants are virtual characters and they spend physical world money to buy items there but they might also earn money by doing job. (Wertime & Fenwick, 2008)
Online toolkits	Special software programs that are used for instance to design new games for mobile phones. i.e. Webench toolkit of National Semiconductor company. (Sawhney, 2005)
Online concept labs	Mostly used for online surveys. Customer preferences are collected directly from customers. i.e. Volvo, GM. (Sawhney, 2005)
Online innovation market places	They are acting in between innovators and companies. Basically they maintain an online innovation community for users who are having ideas online collectively or individually. Moreover third-party companies seek ideas for their challenges and announce these for community members to solve. (Antikainen, 2011)
Collaborative projects	They enable the joint and simultaneous creation of content by many end-users. Wikipedia is a notable example of this type. (Kaplan and Haenlein, 2010)

There are also internet-based innovation market places which are hosted by third parties. Some examples for internet-based innovation market places are HelloBrain (www.hellobrain.com), Experts Exchange (www.experts–exchange.com), NineSigma (www.ninesigma.com), InnoCentive (www.innocentive.com), IdeaWicket (www.ideawicket.com). (Sawhney et al., 2005; Maria Antikainen, 2011)

3.1 Value of Information Received from Customers

Recently there is a huge source of information potential. Companies might get benefit of it by generating dialogs to receive information about customer expectations. In current high competitive market it is crucial to shorten time-to-market and increase the competitive power. Cespedes, 1998 stresses the importance of addressing the customer value for any product (Cespedes, 1998). If any company can understand the customer well enough and use this information in NPD it might increase the market share or profitability but being fast is also important. The title of Jason Jennings and Laurence Haughton's book stresses the strength of being fast obviously, "It's not the BIG that eats the SMALL, it's the FAST that eat the SLOW".

In this part of the study the value of information that is received by traditional and contemporary marketing tools in CE is going to be assessed. Assessment criteria are determined from a previous publication (Ebner, Leimeister and Krcmar, 2010). There are four main criteria like quality of involvement, creativity, market potential, and strategic fit. The quality of involvement is assessed with comprehensibility and elaborateness. There are two sub-criteria under creativity like degree of innovation and originality. Market potential is assessed with the following five sub-criteria: customer benefit, user acceptance, realisability, market size, and marketability. Portfolio fit and development of potential are sub-criteria for strategic fit (see Table 2). Several Marketing books are writing about the change with Web 2.0 (Shiffman, 2007; Scott, 2007; Wertime & Fanwick, 2008). Denise Shiffman says "Stop listening to your customers and start interacting with them" in her The Age of Engage book. With the impact of internet to the marketplace the customers has changed. They become ready and they even willing to deeply involve in brands, products and services (Shiffman, 2007). In short time, the web becomes a real time information center with a rich content. Moreover it is defined as alive by some pundits since it is constantly moving and changing. Today people use web to meet, converse, create, and learn. That situation gave chance to marketers to get in contact with their customers in a more relaxing environment. They can let their customers to create new attributes, properties or influence them by participating to the conversations. (Shiffman, 2007). Apart from marketing views or companies attitude even the web had changed greatly in last eight years. Instead of a static, flat, corporate-created web today we see a more interactive social, user-created web. This environment motivates consumers and accelerates their influence. Denise Shiffman defines the new age in marketing as "consumer-powered". With sharing, collaborating, and interacting environment of web 2.0, companies are able to innovate and differentiate products with their customers (Shiffman, 2007).

Besides the intensity of customer involvement the quality of involvement is critical, as well. First of all information received from the customers have to be comprehensible, the idea written supposed to be understandable. Through face-to-face meetings it seems easy to influence the customer to better define his idea. However it is not same for the questionnaires or the market research that are mostly driven paper-based. There, first of all participants have time stress on as well as limited source of information. Additionally participant has to represent himself by handwriting; no alternative tools can be used. Despite face-to-face meetings the comprehensibility in traditional marketing tools is moderate. The contemporary marketing tools based on internet. So the source of information is in hand. Other computer skills might be used to define the ideas better or illustrate something in more detail. With contemporary marketing tools it is possible to receive highly comprehensive information from customers. Elaborateness seems to be high with contemporary marketing tools but actually it depends on the prize or motivation mechanism. Antikainen (2011) stresses the importance of rewarding. So apart from the way the information is tried to be gathered the effort the company shows to motivate the customer is important in this case. Because of that reason elaborateness is dependent on the company's attitude rather than the source of involvement.

In the challenge of intense competition today uniqueness is crucial. It is stated by many marketers as one of the essentials of existence (Shiffman, 2007; Scott, 2008). Shiffman, 2007 stresses in her book the importance of uniqueness as "If you have nothing unique, you have nothing at all". It is not the correct way to wait the entire creativeness from the customers alone. However in traditional ways, receiving customer expectations or ideas is done by one direction communication. There is no interaction; no dialog can be built on. The degree of innovation is low in traditional marketing tools, it only depends on customer satisfaction or dissatisfaction. Company might only hope his customer to be innovative. However in contemporary ways it is possible to construct a dialog through which the

innovativeness can be managed or influenced. Additionally the infrastructure of the contemporary tools would influence the customers to be more innovative. They might compare with competitors' product or criticize with other customers. It is hard to estimate the originality of the ideas but being forced to think instead of you for a certain period of time might restrict the originality. Therefore rarely it is faced with originality in information received through traditional marketing tools. It is much more frequent to catch originality with contemporary marketing tools. Especially virtual environments would motivate the customers to have more original ideas. Since the environment is changing completely the way of thinking is changing parallel. The potential of the market is critical in CE. The information received should be assessed whether it is bearing a market potential and meeting the essentials of a number of customers. Digital marketing is defined by Wertime and Fenwick to be an effective way to get consumer feedback and insights. They stated that the interactivity of digital channels is used by some smart companies to listen their customers. It can be concluded that contemporary marketing tools act as an early warning system. (Wertime & Fenwick, 2008)

With the customer benefit it is tried to assess whether the idea is practicable and creates an additional value for the customer (Ebner, 2010). Since in contemporary ways there is an interaction it is possible to reach a higher customer benefit value. The proposal can be co-generated with the contribution of more than one consumer and the company representatives. In traditional tools the idea is mostly belongs to an individual consumer and might not represent the majority. User acceptance shows if an existing demand is met by the ideas (Ebner, 2010). This point is very close to the customer benefit. Interactivity of contemporary tools increases the potential of any idea to be accepted by the users. If the company has a dialogue with the customers it can easily assess the user acceptance and share this information with the customers thinking instead of them. With traditional tools it is almost impossible to realize this more stepped process.

The information received from customers is not always applicable to the products. Ideas coming from customers are being evaluated according to the various aspects based on engineering, design, economic feasibility…etc. As it is shown in Figure 3 the information flow in CE is not sequential rather real-time. So that potentially valuable suggestions of consumers is shared among the team members. In case of any deficiency or absence, marketing might turn back to the digital platform and communicate this point with the owner of the idea. The advantage of using contemporary tools is high for the realisability. There is a conversation platform in contemporary tools. The realization of ideas is defined by the expected demand of the market (Ebner, 2010). Similar to user acceptance the market size can be measured through contemporary tools. Due to existence of the dialog via contemporary tools the improvements can be done by the idea owner depending on the feedback. One of the measures of market potential is the market size. The realization of any idea is defined with the expected demand of the target market (Ebner, 2010). Being able to measure the potential market size is critical. The market size based process can be performed continuously by contemporary tools. Regardless of the way you let the consumer to co-create or improve any product you are engaging the customer. As Shiffman, 2007 stresses it as hottest issue (Shiffman, 2007). Once you engage consumers might even support the related marketing activities. It is very well known that viral effect is very effective for fast distribution of any marketing material or product information. As well as receiving customer expectations integrating customers to the marketing phase would strengthen the process. The advantages of contemporary marketing tools by various media in respect to marketability are much. The strategic fit of the ideas is evaluated by portfolio fit and development potential. Portfolio fit is defined by the expected fit of the idea into the company's product portfolio. Since via internet it is possible to get more information and details about companies recent conditions and even plans for future, portfolio fit of the ideas coming from contemporary tools is potentially high. Development potential is the adaptability to new business requirements. The vision in contemporary based environments supposed to be higher but still it is hard to differentiate the traditional and contemporary tools in respect to development potential. The interaction once more differentiates the contemporary tools from traditional tools. Contemporary tools have the advantage that any idea can be co-improved. (Ebner, 2010)

4. Degree of Customer Involvement in CE During the NPD Phases via Online Communication Channels

The product innovation is defined in the literature with five phases; ideation, concept development, product design, and product introduction (Ulrich and Eppinger, 2003; Urban & Hauser, 1993). Companies are looking for effective ways to invite consumers for receiving inputs to be able to create better new products (Sawhney, 2005). Shiffman stresses openness, sharing, and collaboration to create a broader opportunity for innovation, constant and a prosperous value creation. It is also stated that great ideas come from anywhere although the company might have a

Table 2: Comparison of the value of information received from customers for CE gathered by traditional and contemporary marketing tools

Assessment criteria	Traditional marketing tools	Contemporary marketing tools
Quality of involvement		
Comprehensibility	Moderate	High
Elaborateness	Depends	Depends
Creativity		
Degree of innovation	Low	Depends
Originality	Rare	Frequent
Market potential		
Customer benefit	Moderate	High
User acceptence	Hard to predict	Can be easily tested
Realisability	Low	High
Market size	Not easily measurable	Easily measurable
Marketability	Low	High
Strategic fit		
Portfolio fit	Low	High
Development of potential	Low	Moderate

smart team. The importance of differentiation is emphasized in this study before. Locating the company in the marketplace will unearth more ideas and opportunities which would undoubtedly beneficial at the point of differentiation (Shiffman, 2007). The value of information received through traditional marketing tools and contemporary marketing tools are discussed in the previous section. Obviously contemporary tools serve lots of benefits to companies. In this section, firstly there are brief explanations about some of the online-communication channels, like Facebook, Twitter, and blogs. Later these contemporary marketing tools are assessed according to the degree of customer involvement.

4.1 Social Networking Sites

Social networking sites are platforms where users create their own profile, establish friendships to access profiles of others, send e-mails and instant messages (Kaplan and Haenlein, 2010). Some examples are Facebook, Twitter, LinkedIn, and MySpace. They help people to cultivate a community of friends and share information (Scott, 2010).

- **Facebook**

Facebook originally initiated for communication between a group of people but recently it has participants more than 800 million as of October 2011. In short time it became one of the favorite platforms of business. Today there are many companies having accounts in Facebook like Blackberry, Nokia, Volkswagen, Avon, Akbank, Garanti, Danone, Pampers, Colgate, Palmolive, Doritos, Migros…etc. Companies do not use Facebook only for existing and presenting their products but via various applications and attractions they look for ways to communicate with their customers. Three useful ways to deliver information and ideas to a network via Facebook are friend-to-friend communication, groups and applications (Scott, 2010). A Facebook group is a great way for organizations of all kinds to keep interested people informed (Scott, 2010). It is aimed in Facebook groups to have in-depth communication around a subject (Scott, 2010). This form of use can be used as a chance for collaboration as some companies are already doing (Scott, 2010). For instance Migros, which is the pioneer of the modern retail sector in Turkey, conduct their campaigns according to the feedbacks or recommendations of their Facebook group members. The reasons that people join Facebook groups are interest to be engaged and stay informed. Since the group members are already there willingly Facebook groups can be used as a source for interacting with the customers. Depending on the type of information the group can be directed. A Facebook group can be used as a tool for receiving information for NPD. Although being an open source of information and basically can be a good source of information during the ideation, concept development, and product introduction phases of NPD it might not be useful at the phase of product design. Being able to construct a dialog with the group members makes the interaction continuous.

Consequently Facebook can be used as source of online-communication channel to communicate and build long-lasting dialogs with customers. Therefore the source of information received via Facebook over the scale from 5

(good) to 1 (weak) is 5 points for ideation, concept development, and product introduction but 3 points for product design. The ratings can be seen in Table 3.

- **Twitter**

Twitter is a mini-blogging application launched in 2006. It allows short messages to be blogged directly to the web from the mobile. Twitter gives chance to its users to tell people what they are doing. Twitter can be defined as a service for followers to communicate through the exchange of quick, short messages (Wertime & Fanwick, 2008; Scott, 2010). In twitter the messages cannot be longer than 140 characters. By companies it can be mostly used a way to inform about news, campaigns…etc. Furthermore Twitter might be used as a good feedback tool. By using the Twitter search engine it is possible to learn what people are saying about the products, the company, and the organization (Scott, 2010). With a limited messaging format Twitter might not be as a beneficial tool as Facebook and Blogs for NPD. Although it can be used effectively especially at the phase of ideation and product introduction, however for concept development and product design the way of information it serves might not be adequate. It is important to stress that the speed of receiving feeds during the ideation and product introduction phases would be faster than both Facebook and Blogs.

To sum up, Twitter is a good source of information at product introduction phase. At the ideation phase due to some limitations 4 points can be given out of 5. But for concept development and product design phases it is far from being good. For both phases Twitter gets 2 points, which means close to be weak as the source of information it provides. The comparison with other social networking sites can be seen in Table 3.

- **Blogs**

Blogs are mostly text based and allow relatively little information exchange. Blogs, which are special types of websites, represent the earliest form of Social Media. They include date-stamped entries in reverse chronological order. They are similar to equivalent of personal web pages but can come in a multitude of different variations. There are blogs like personal diaries, summaries of all relevant information in one specific content or product. Although blogs are usually managed by one person only, they provide the possibility of interaction with others by adding comments. Today it is also possible to come accross different media formats instead of text based blogs (Kaplan & Haenlein, 2010). There are a lot of companies that used blogs to interact with their customers, employees, and shareholders (Kaplan & Haenlein, 2010). Recently thousands of smaller companies, consultants, and professionals have a blog but no webpage (Scott, 2010). On the other hand blogs are well accepted among the consumers. There are lots of people who check the comments on blogs before they buy anything like car. It is stressed by Scott that by blogs it is easy to monitor what millions of people are saying about the company, the potential market, and the products. Since it is possible to built-up a dialog with customers that might include further information about the company and products blogs might be a good tool for NPD. The creativity at the first phases can be somehow lower due to the restricted format. However during the design phase companies can built-up deep interactions with interested customers and communicate the details further concurrently. Again in product introduction phase the comments of consumers might shape either marketing activities or improvements about the product.

In conclusion, Blogs are relatively better than Facebook and Twitter in providing information for NPD. During product design and product introduction they are good source of information and also at ideation and concept development phases they do fairly good (see Table 3).

Table 3: Degree of customer involvement in CE during the NPD phases via online-communication channels (source of information, 5: good, 1: weak)

Phases of NPD	Online-communication channels	**Facebook**					**Twitter**					**Blogs**				
	Source of information	5	4	3	2	1	5	4	3	2	1	5	4	3	2	1
I Ideation		x						x					x			
II Concept development		x								x			x			
III Product design				x						x		x				
IV Product introduction		x					X					x				

5. Discussion and Conclusion

The increasing competition in the market directed companies to develop new and superior products faster. The changes in Web 2.0 let the internet to become UGC. First of all, this let internet to be alive. Furthermore it enabled people to interact, engage, tag, socialize and collaborate. These new features are being used by companies to communicate and built up dialogs with customers. On the engineering site with CE processes, NPD in any organization is tried to be shorten by engaging marketing, engineering design, production engineering, test engineering, purchasing, and sales teams concurently.

In this study traditional ways of interacting with customers and contemporary tools that Web 2.0 serves are compared. Absolute superiority of contemporary marketing tools in respect to information received from customers is shown. Moreover some examples of Social Networking Sites and Blogs are discussed as a source of information in NPD. There are various pros. and cons. individually of all types. Companies should set their priorities and than try to get benefit of them. What is inevitable for companies to survive and grow is to build and influence their ecosystem by offering openness, sharing, and collaboration.

Further research should be done to assess the usage of contemporary tools in companies applying concurrent engineering. The effect of information received from customers on performance parameters of company is also one of the other points to be evaluated.

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Dynamic Modeling of Critical Factors in Energy Service Contracting Using Fuzzy Time Cognitive Mapping

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Abstract

This study examines the energy service contracting market in Turkey and identifies factors playing a significant role in its development. Fuzzy time cognitive mapping that allows dynamic modeling of the behavior of uncertain and complex systems was used to analyze the energy service contracting market. Accordingly, qualitative simulations were performed in order to predict changes in the system and to observe whether an equilibrium state is reached. The results are compared to the findings of an earlier study by Asan et al. (2011) which applied a fuzzy cognitive mapping approach. The analysis reveals the factors to focus on and provides a basis for recommendations for the energy service market in Turkey.

Keywords

Fuzzy time cognitive maps, dynamic modeling, energy service contracting, energy efficiency

1. Introduction

Energy efficiency has become one of the major concerns of many industries due to the overall climate change, increasing demand for and rising prices of energy resources, technological innovations and economic developments. The increasing awareness of sustainable development in recent years has promoted this growing interest. In this study, energy efficiency will be defined as reducing the energy consumption without causing any decline in production quality and quantity in industrial establishments (see EIE, 2007). Firms may avoid waste, increase their productivity, and decrease their costs and emission levels by implementing energy efficiency activities. These activities are not only handled inside the firm but can also be performed by outsourcing the required workforce, equipment, technology, etc. Energy service contracting is one such form of outsourcing which has a paramount role in dealing with the barriers firms are facing in energy efficiency activities (Sorrell, 2007). These contracts provide an inclusive service package to the clients through energy service companies (ESCOs) that enable firms to deal with various difficulties in planning, implementing and monitoring their energy efficiency projects. An ESCO guarantees energy savings to its clients and its payment is subject to the energy savings achieved or the renewable energy produced (Okay et al., 2008). The service package, which ESCOs offer, covers the analysis of energy saving opportunities, energy audits, as well as financing, installation, operation and maintenance of equipment. Also project design and management as well as measuring, monitoring and verifying energy savings of the project are provided (Bertoldi et al, 2006; Okay et al., 2008; Pätäri & Sinkkonen, 2013).

There are various reasons for considering outsourcing and contracting services for an industrial energy consumer. In this paper, the energy service contracting market in Turkey is examined. The high growth rate of Turkey's annual energy demand (approximately 5%), the high dependence on imports to meet the current demand, the high energy intensity of the economy and the geopolitical position of Turkey (i.e. east-west energy bridge and proximity to resources) indicate the need of energy-efficiency investments and also the necessity of planning, implementing and controlling these investments (Turkyilmaz, 2013). In the past few years the energy industry in Turkey has undergone a change in terms of restructuring and deregulation. However, there are still some barriers hindering the development of this industry such as economic instability, capital inadequacy of local firms, lack of effective risk management, transparency and disclosure problems of firms, risk-averse approach of the new banking system, difficult to fulfill principles and procedures in the recent legal communiqué on ESCOs, and insufficient knowledge of end-users and firms (Onaygil and Meylani, 2007; Okay et al., 2008; Akman et al. 2013).

To analyze the energy service contracting market in Turkey and identify factors playing a significant role in its development, a dynamic model is suggested. This model is essentially an extension of the prior work by Asan et al. (2011) which was based on fuzzy cognitive mapping (FCM). FCM allows modeling and visualizing the behavior of a complex system of causal reasoning in form of a signed fuzzy diagraph but it does not incorporate the time relationship into the analysis. To both address the complexity and uncertainty of the given problem along with its dynamic nature, the fuzzy time cognitive mapping (FTCM) approach developed by Park and Kim (1995) is applied. Experts who have knowledge and experience on energy service contracting were involved in the determination of the factors and their causal and time relationships. The constructed map was used to perform qualitative simulations in order to predict reactions to possible changes in the system and to observe whether an equilibrium state is reached. The results of the proposed dynamic model are compared to the results of the fuzzy cognitive map suggested in Asan et al. (2011). Considering the results provided the basis for developing recommendations for the energy service market in Turkey.

2. Fuzzy Cognitive Maps

2.1. Literature Review about Fuzzy Cognitive Maps

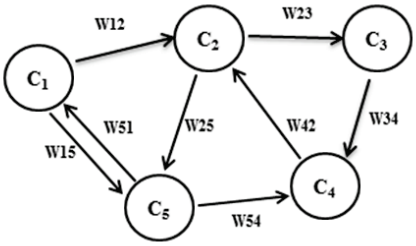
A cognitive map (CM) is described as an image of cognitive processes (Ülengin and Topçu, 1997; Hasıloğlu,2009). CM is used as a tool for a group of experts to negotiate on the definition and the modeling of a complex problem. Both measurable and immeasurable relationships between the ideas and events are used to generate a CM. Çoban and Seçme (2005) states that the method, originating from Euler's Graph Theory, was developed by Axelrod in 1976, and can be used in decision making problems, forecasting problems, explanation problems and strategic problems (Önsel Şahin, 2002).

Fuzzy Cognitive Maps (FCMs) are originated by CMs. FCM is described as a representative of complex systems, which uses illustrative causation and which can model and manipulate the dynamic behavior of systems (Bueno and Salmeron, 2009). Kosko (1986) created FCM as a combination of fuzzy logic and neural networks in order to model the systems especially where fuzziness and uncertainty exist (Papakostas et al., 2008).

A FCM can be constructed in many ways, ranging from questionnaires to document coding and interviews. Questions are sent to experts so as to determine the relationships between concepts in the questionnaire method. Concepts and causal relations are extracted from the articles or the studies of the experts in the document coding method. Information, which is necessary to determine the concepts and the causal relationships, is collected from the experts via open-ended questions in the interview method (Carley and Palmquist, 1992; Karaali and Ülengin, 2008).
A FCM is represented as a graph which consists of nodes and arcs. As explained by Georgopoulos, Malandraki and Chrysostomos (2003), nodes symbolize the concepts and arcs symbolize relationships between the concepts. The relationships (w_{ij}) indicate the direct relationship between concept i and concept j, and are shown in an adjacency matrix.

A simple FCM, consisting of five concepts C_i (i=1, …,5), is illustrated in Figure 1, where the influence degree from cause C_i to effect C_j is represented by w_{ij}. All w_{ii} elements equal to zero, since any direct connections between a concept and itself are not allowed in the FCM methodology. w_{ij} elements can take values in [-1, 1]. The meanings w_{ij} are explained by Papageorgiou (2010) as:

- If $w_{ij} > 0$, then there is a causal increase (i.e., C_j increases as C_i increases, and C_j decreases as C_i decreases)
- If $w_{ij} < 0$, then there is a causal decrease (i.e., C_j decreases as C_i increases, and C_j increases as C_i decreases)
- If $w_{ij} = 0$, then there is no causality.



$$E = \begin{pmatrix} 0 & w_{12} & 0 & 0 & w_{15} \\ 0 & 0 & w_{23} & 0 & w_{25} \\ 0 & 0 & 0 & w_{34} & 0 \\ 0 & w_{42} & 0 & 0 & 0 \\ w_{51} & 0 & 0 & w_{54} & 0 \end{pmatrix}$$

Figure 1: A hypothetical FCM model and the adjacency matrix

Matrix-vector multiplication is used as a start in order to analyze the FCM. The vector consists of concept values which indicate the activation degree of the concepts. Concept degrees can take values in [0,1], where 0 indicates no activation and 1 indicates a very strong activation. The initial value of each concept is represented as $C_i^{(k)}$, where C_i is the value of concept at step *k*, and simulated iteratively. According to Papageorgiou et al. (2009), the value of each concept in iteration is calculated as:

$$C_i^{(k+1)} = f\left(C_i^{(k)} + \sum_{\substack{j=1, \\ j \neq i}}^{n} C_j^{(k)} w_{ji}\right) \tag{1}$$

$C_i^{(k+1)}$ is the value of concept at step *k*+1, $C_i^{(k)}$ is the value of concept at step *k*, w_{ji} is the weight of interconnection between C_j and C_i. Papageorgiou (2010) describes *f(x)* as the threshold function (activation function) reduces the result of the multiplication into a normalized range (within [0, 1]). Yaman and Polat (2009) and Bueno and Salmeron (2009) list the following most common activation functions:

- Bivalent Function

$$f(x) = \begin{cases} 0, & x \leq 0 \\ 1, & x > 0 \end{cases} \tag{2}$$

- Trivalent Function

$$f(x) = \begin{cases} -1, & x \leq -0{,}5 \\ 0, & -0{,}5 < x < 0{,}5 \\ 1, & x \geq 0{,}5 \end{cases} \tag{3}$$

- Sigmoid Function

$$f(x) = \frac{1}{1 + e^{-cx}} \tag{4}$$

- Hyperbolic Function

$$f(x) = \tanh(x) \tag{5}$$

Bivalent function indicates only the increase of a concept, whereas Trivalent function can also indicate the decrease. However, neither of them indicates the degree of the increase or the decrease. Tsadiras (2008) suggests choosing the Sigmoid or Hyperbolic functions in order to indicate the both the increase and decrease, and the changes in the degree of a concept.

2.2. Fuzzy Time Cognitive Maps

Lack of time dimension is a weak point in FCM which causes too much criticism to the methodology. An increase in a dimension of the map will lead almost immediately to an increase in one dimension, while leading less immediate increase in another dimension. A FCM should include time lags in order to be more accurate. Park and Kim (1995) introduced Fuzzy Time Cognitive Maps (FTCM) where time lags are represented by dummy nodes. Time lags can be represented in fuzzy, relative terms by an expert. The set of {I, N, L} or any other appropriate set can be used as an expression of time lags. I, N and L, respectively are the abbreviations of “Immediate”, “Normal” and “Long”,

where relative fuzzy values such as {1, 2, 3} can be assigned to each term. "3" can be interpreted as a Long time lag, consisting of additional two dummy nodes, whereas "2" can be interpreted as a Normal time lag, consisting of one additional dummy node. "1" represents an Immediate time lag so no dummy node addition is needed. It can be generalized that if the time lag on C_{ij} is m delay units ($1 \leq m$), then m-1 dummy nodes are added which are named the same with node i. In this way, dummy nodes allow value preservation while translating an ordinary FCM to FTCM. An example of a translation is shown in Figure 2.

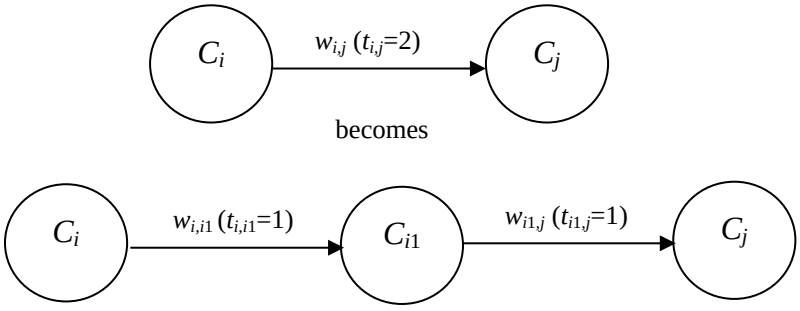


Figure 2: Value-preserving translation by using dummy node (Adapted from Park and Kim, 1995)

In Figure 2, Park and Kim (1995) explain that the causality of node i stays at node i1, since one unit is elapsed. After elapsing two-unit time, the causality of i imparts to j. Suppose $|w_{i,i1}| = |w_{i1,i2}| = \ldots = |w_{i(m-1),j}|$, then $|w_{i,j}| = |w_{p,p+1}|^m$. Thus, $|w_{p,p+1}| = |w_{i,j}|^{1/m}$. To identify the signs of the $w_{p,p+1}$, the following four cases are considered:

1) sign $(w_{i,j})$ = + , and m is an odd number,
2) sign $(w_{i,j})$ = + , and m is an even number,
3) sign $(w_{i,j})$ = - , and m is an odd number,
4) sign $(w_{i,j})$ = - , and m is an even number.

In the cases through (1) to (3), $w_{p,p+1}$= sign $(w_{i,j}) * |w_{i,j}|^{1/m}$ for all (p, p+1). In the case of (4), the number of minus signs on the $w_{p,p+1}$ must be an odd number. Thus, as a technique, the value of the first dummy node is calculated as $w_{k,k+1}$= -$|w_{i,j}|^{1/m}$, and the values of the rest of the dummy nodes are calculated as $w_{q,q+1}$=$|w_{i,j}|^{1/m}$. Considering time lags allows more accurate analysis of the system behaviors (Park and Kim, 1995).

3. Analysis of Critical Factors in Energy Service Contracting

In the literature, there are three very informative studies about the ESCO market in Turkey which helped identifying the potential factors influencing the market's development. Onaygil and Meylani (2007) give an overview of energy service contracting and ESCOs and provide policy suggestions for the forthcoming Turkish ESCO market. Okay et al. (2008) present views with regard to the funding and related risks that are likely to be associated with the forthcoming Turkish ESCO market. Also, the current situation of the Turkish ESCO market is analyzed through the latest communiqué by Akman et al. (2013) from the 2013 perspective by considering the present barriers and opportunities. Besides, there are studies focusing on the analysis of barriers and/or success factors of energy performance contracting projects in different countries (Bertoldi et al., 2006; Zhang et al. 2008).

As stated in the introduction part, in this study, a dynamic model will be developed to analyze the energy service contracting market in Turkey and identify the factors playing a significant role in its development. During the last decade, the energy industry in Turkey has been greatly affected by the deregulation and restructuring activities. The global competitiveness has become very critical especially being influenced by the role of cheap labor originated from countries like China. To be a powerful player in this competitive environment, Turkey has to make difference with its technological innovations, effective and efficient energy activities, production and service quality.

According to the report of International Energy Agency in 2005, ESCOs were not yet operating in the Turkish market, however energy efficiency activities have actually been being performed since 1995 in different sectors such as pharmaceuticals, chemicals, automotive, agriculture, paint, food and beverages, airport, hospital, and building by

several medium-scale energy companies (Akman et al, 2013). In Turkey, ESCOs (which are known as Energy Efficiency Consulting Companies) operate as consulting firms which are state authorized and obliged to obey the Energy Efficiency Law (EEL) and its communiqué, which primarily aims to increase competitive advantage of Turkey in the global market (Akman et al, 2013). Although the EEL has been developed in 2007 as a result of adapting with the European Union accession period, the communiqué of the EEL related to ESCOs was released in 2012. During the development process of this communiqué, ESCO licenses have been suspended by the Ministry of Energy and Natural Resources (MENR) and candidate companies had to wait until the regulations are approved (Akman et al, 2013). Today, MENR, EIE (the name of EIE has changed as General Directorate of Renewable Energy-GDRE) and National Energy Conservation Center (NECC) are responsible for energy efficiency activities and there are two certification categories for ESCOs: industrial and residential. Based on the data as of September 2012, there are only 6 certified ESCOs in industrial category, 15 certified ESCO in residential category and 13 companies are certified for both categories (Akman et al, 2013). The regional distribution of Turkish ESCOs can be seen in Figure 3.

A strategic plan for energy efficiency covering the years 2012-2023 have been developed by General Directorate of Renewable Energy (EIE, 2012). According to this plan, the decrease in the amount of energy consumed per GDP of Turkey in the year 2023 is targeted as 20%. The strategies reported in this plan, which are critical for the energy service contracting market, can be summarized as follows *i*) to reduce energy intensity and energy losses in industry and services sectors, *ii*) to decrease energy demand and carbon emissions of the buildings; to promote sustainable environment friendly buildings using renewable energy sources, *iii*) to provide market transformation of energy efficient products, *iv*) to increase efficiency in production, transmission and distribution of electricity, to decrease energy losses and harmful environment emissions, *v*) to reduce unit fossil fuel consumption of motorized vehicles, to increase share of public transportation in highway, sea road and railroad and to prevent unnecessary fuel consumption in urban transportation, *vi*) to use energy effectively and efficiently in public sector, and *vii*) to strengthen institutional capacities and collaborations, to increase use of state of the art technology and awareness activities, to develop financial mechanisms except public financial institutions (see EIE, 2012). These strategies can only be achieved in collaboration with ESCOs.

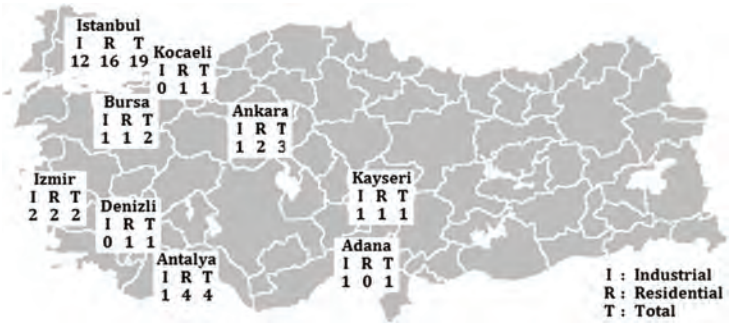


Figure 3: The regional distribution of Turkish ESCOs (Akman et al., 2013)

3.1 Data Collection

The final fuzzy time cognitive map of the energy service contracting market is an outcome of a three-stage procedure adapted from Nasserzadeh et al. (2008); see Figure 4. In this study, only the third stage has been applied to elicit the time relationship data necessary for a dynamic analysis of the map. Other essential data are obtained from the study by Asan et al. (2011). In the third stage, the constructed fuzzy cognitive map has been extended to a fuzzy time cognitive map by assigning time lags for each interconnection using a questionnaire applied to experts. Time lags are represented using the following fuzzy relative terms: “Immediate”, “Normal” and “Long” where the relative fuzzy values {1, 2, 3} have been assigned to each term. “3” is interpreted as a long time lag, requiring additional two dummy nodes, whereas “2” is interpreted as a normal time lag, requiring one additional dummy node and “1” represents an immediate time lag which does not need any dummy node. Expert opinions are aggregated using simple frequency data. Figure 5 presents the FCM of the energy service contracting market in Turkey.

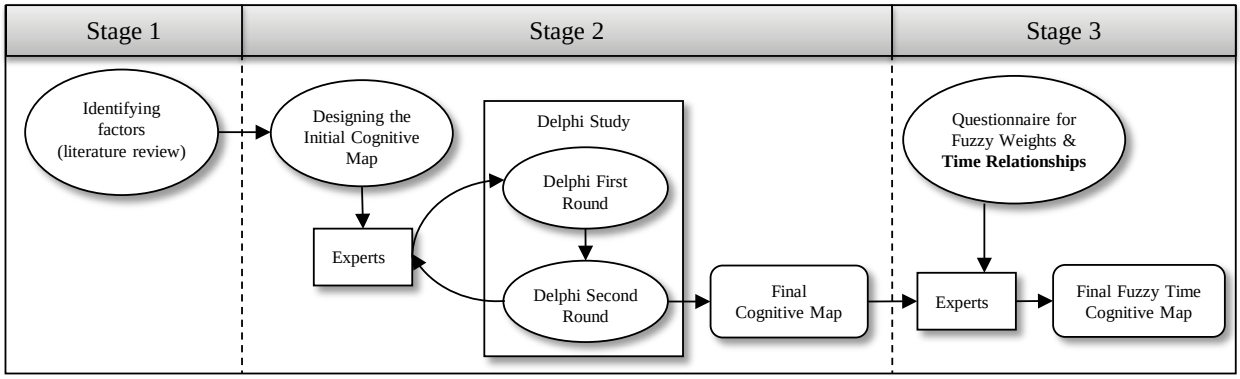


Figure 4: The three-stage data collection process (adapted from Nasserzadeh et al., 2008)

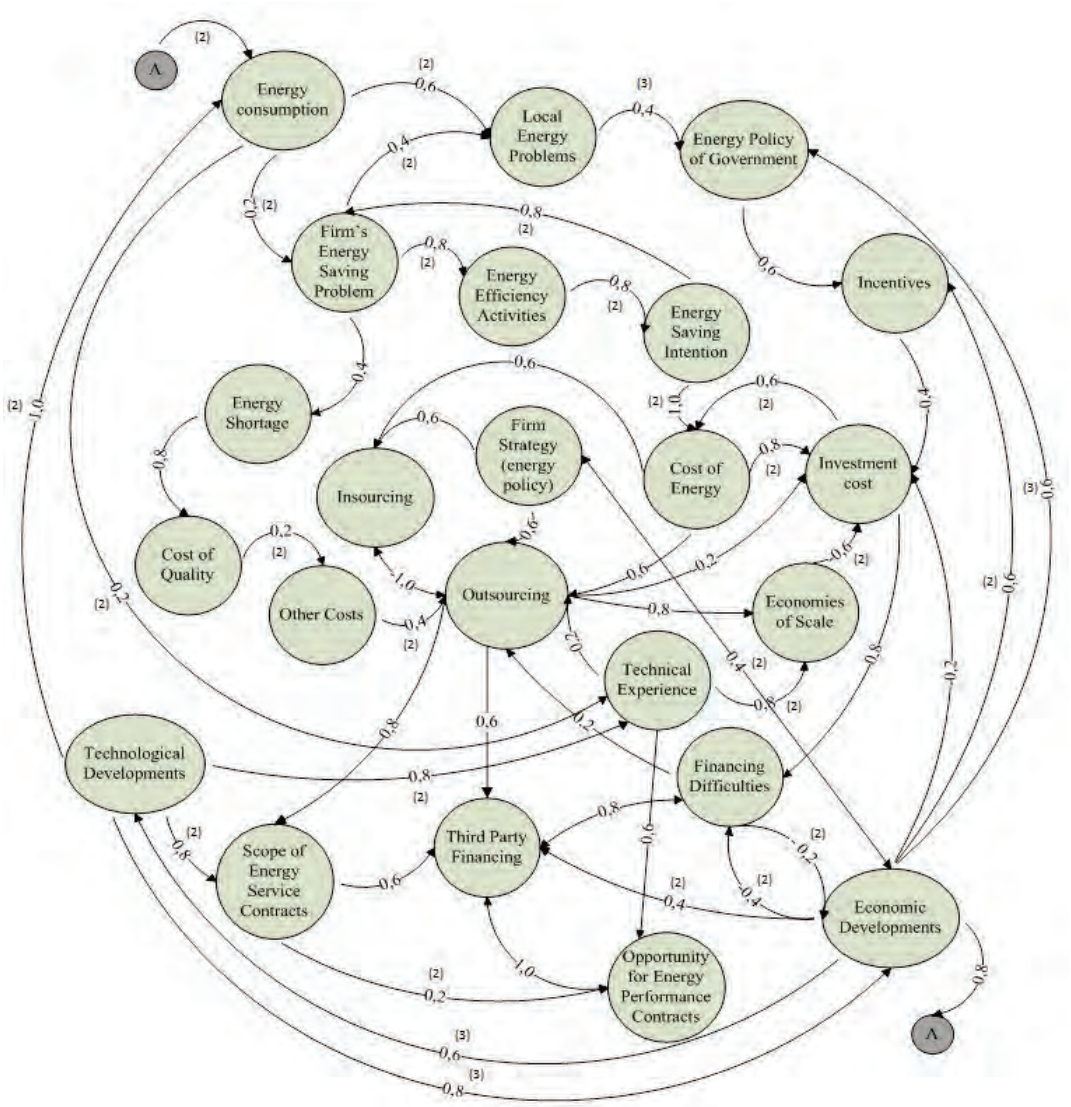


Figure 5: FTCM of the energy service contracting market (adapted from Asan et al., 2011)
(Note that the numbers given in parentheses represents the time lag data)

3.2 Results

The constructed fuzzy time cognitive map was used to perform qualitative simulations in order to predict possible changes and to observe whether the system converges toward a steady state. Alternative scenarios have been considered for the simulation of the energy service contracting model. In each of the test scenarios the fuzzy time cognitive map was first initialized, i.e. the activation level of each factor in the map took a value between 0 and +1 based on experts' opinions for the current state. For example, $A^{(0)}$ = [0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0] is an initial vector state where only the factor "Energy Policy of Government" was activated/fired. Then the factors were set free to interact according to Eq. (1); here, the sigmoid function with $\lambda = 1$ was used as a threshold function. Once the fuzzy time cognitive map reaches equilibrium, the values may be interpreted quantitatively or qualitatively (Sadiq et al., 2004). For example, $A_2^{(7)} = 0.899$ implies that, after 7 iterations, Factor 2 is 89,9% of its maximum normalized value or qualitatively described Factor 2 is significantly active. Figure 6 demonstrates a scenario with time lag data where only the factor "Energy Policy of Government" is activated. Since in all scenarios the system reached after seven iterations an equilibrium state (i.e. no change in activation levels is observed in two consecutive iterations) with almost similar steady state values of the factors, only the average final values for both maps with and without time lag data are presented in this paper, see Table 1. Similar scenarios were performed for the fuzzy cognitive map without time lag data; see Figure 7.

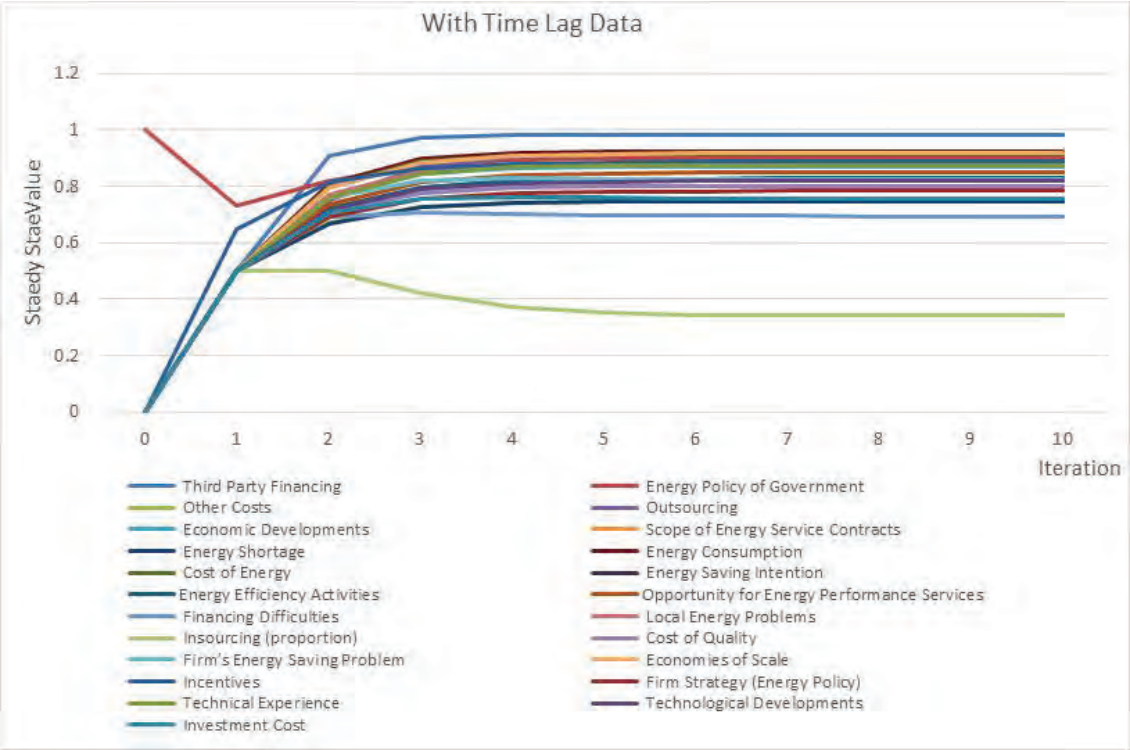


Figure 6: Results of a FTCM simulation process with time lag data

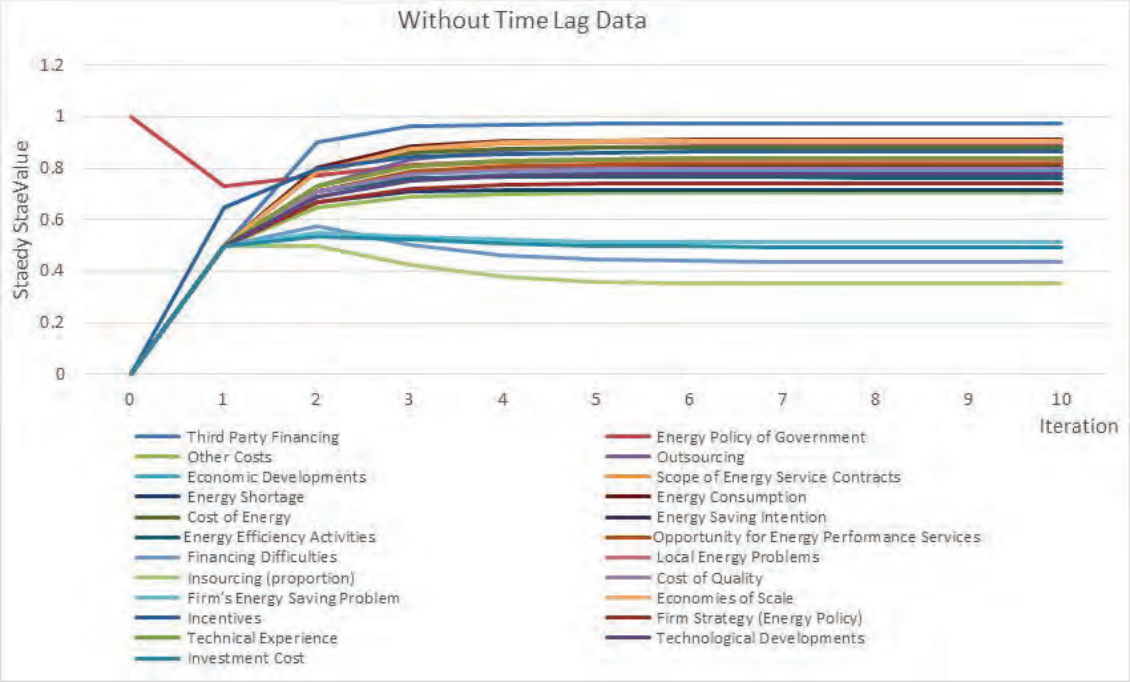


Figure 7: Results of a FCM simulation process without time lag data

Table 1: Steady state values of the factors

		With Time Lag Data		Without Time Lag Data	
#	Factor	Steady State Value	Rank	Steady State Value	Rank
1	Third Party Financing	0,982	1	0,971	1
2	Energy Policy of Government	0,899	7	0,838	8
3	Other Costs	0,747	20	0,703	19
4	Outsourcing	0,917	3	0,885	5
5	Economic Developments	0,869	11	0,790	14
6	Scope of Energy Service Contracts	0,916	5	0,903	4
7	Energy Shortage	0,746	21	0,715	18
8	Energy Consumption	0,925	2	0,911	2
9	Cost of Energy	0,915	6	0,879	6
10	Energy Saving Intention	0,827	13	0,805	12
11	Energy Efficiency Activities	0,827	14	0,764	16
12	Opportunity for Energy Performance Services	0,847	12	0,818	11
13	Financing Difficulties	0,694	22	0,434	22
14	Local Energy Problems	0,883	9	0,829	10
15	Insourcing (proportion)	0,342	23	0,351	23
16	Cost of Quality	0,802	17	0,797	13
17	Firm's Energy Saving Problem	0,824	15	0,513	20
18	Economies of Scale	0,917	4	0,908	3
19	Incentives	0,887	8	0,863	7
20	Firm Strategy (Energy Policy)	0,783	18	0,742	17
21	Technical Experience	0,876	10	0,838	9
22	Technological Developments	0,819	16	0,778	15
23	Investment Cost	0,756	19	0,493	21

According to the results of the FTCM simulations, the most critical factor influencing the energy service contracting market in Turkey is "Third Party Financing" with a value over 98%. This indicates that despite the new Energy Efficiency Law (EEL) and its communiqué, still the most critical barrier in the market is related to financing issues. This result supports the findings reported in the studies about the ESCO market in Turkey by Okay et al. (2008), Okay and Akman (2010), and Akman et al. (2013) which emphasize economic instability, capital inadequacy of local firms and risk-averse approach of the new banking system as the most critical barriers in the market (see Introduction). The factors with the next highest steady state values are "Energy Consumption", "Outsourcing", "Economies of Scale", "Scope of Energy Service Contracts", "Cost of Energy" and "Energy Policy of Government". In fact, the realized structural and legal reforms as well as the government's energy policies (see Section 3) guide firms in solving their energy consumption and saving problems by investing in energy efficiency projects planned and implemented by technically experienced energy service companies. This, in turn, helps firms reduce their energy costs. However, one of the important barriers to ESCOs, which are often small startup businesses, is the economies of scale needed to make the system feasible. Thus, generating economies of scale (e.g. by bundling projects) is indispensable for ESCOs.

The comparison of the two mapping approaches shows that the first ten factors with the highest steady state values are identical in both cognitive maps, but with slightly changing rank-orders. However, for the remaining factors, one can observe a greater difference in rank-orders between the results with time lag data and without. These findings confirm the influence of time delays on the system behavior, and suggest incorporating time relationships into the analysis.

5. Conclusion

This paper has examined and analyzed the critical factors influencing the energy service contracting market in Turkey. It was demonstrated that FTCM can be a useful tool for analyzing the dynamic, uncertain and complex system of energy service contracting by capturing experts' opinions. The method incorporates time data into the model to enhance the capability of FCM to represent uncertain knowledge within a dynamic context. The results provide basically soft evidence, which should further analyzed to make more detailed inferences about outsourcing decisions on energy efficiency projects.

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Informatıon Technology and Securıty Policy For Organizations and Applications in Istanbul Technical University

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Abstract

The information technology and security policy is an increasingly important business document, which is uniquely well placed to proactively safeguard the availability, confidentiality and integrity of corporate information resources. In today's world using information and communications technologies (ICT), has become an extremely complex and challenging activity. In this point of view it is a very important concern for high education institutions such as universities. Universities core activities are teaching and research is becoming ever more reliant on the availability, integrity and accuracy of computer-based information resources. In this study, we examined information security policy of universities focusing on the practices of IT department at Istanbul Technical University.

Keywords
Information technology, information security management, internet security, academic institutions.

1. Introduction

The adoption of information technology (IT) in organizations has been growing at rapid pace. Modern IT can reduce the costs of communicating information by improving the quality and speed of information processing and management's decision making, leading to more centralized management. At the same time, IT can also provide management with the ability to reduce costs through improved monitoring capabilities and performance evaluation schemes, inducing decentralization of decision making (Gurbaxani and Whang, 1991). There is an increasing movement towards organizations and an adaptation of web-based information systems (IS). Such trends raise new requirements for security policy development. Information security policy formulation has become emergent. However, existing security policy approaches do not pay much attention to policy formulation at all, much less IS policy formulation for organizations. To improve the situation, an information security policy is put forth. The information policy establishes how policies are created, implemented and enforced in order to assure that all policies in the organization have features to ensure swift implementation and timely, ongoing validation. There is wide agreement that good information security policy is the foundation of organization' information security. The creation of information security policy needs careful attention. There are different views, but two main ones can be distinguished: technical/computer security; and non-technical security management. In the literature, Abrams and Bailey (1995) differentiate three views concerning policy: corporate security policy (top management view); organizational security policy (users' view); and technical security policy (designers' view). Even though the adaptation of general information security management standards might shorten the time of policy development, the use of such standards as a basis for security policy development has several shortcomings. First and foremost, general information security management standards and guidelines fail to pay adequate attention to the fact that organizations differ, and therefore their security requirements differ (Baskerville, 1993). Second, standards do not take into account the social nature of the problems (Dhillon and Backhouse, 2001). Third, generic standards overlook the normal business requirements of organizations with the result that a conflict between the organization's normal business requirements and security requirements proposed by security standards may arise. Fourth, general standards are broadly written necessitating ad hoc managerial decision making and judgment (Ferris, 1994). However, general information security management standards do not provide any help concerning these decision-making problems. Organizations have unique security needs and dynamic business environments and factors which policy development should take into account (Baskerville and Siponen, 2002).

2. Information Security Policy for Organizations

The information security policy is an increasingly important business document, which is uniquely well placed to proactively safeguard the availability, confidentiality and integrity of corporate information resources. In today's world using information and communications technologies (ICT), has become an extremely complex and

challenging activity. In this point of view it is a very important concern for high education institutions such as universities. Universities core activities are teaching and research is becoming ever more reliant on the availability, integrity and accuracy of computer-based information resources. Protection of corporate information, is through the formulation and application of formal information security policy (InSPy). A good information security policy should: "outline individual responsibilities, define authorized and unauthorized uses of systems, define penalties for violations, and provide a mechanism for updating the policy" (Whitman, 2004). The critical role of the information security policy is to define the rights and responsibilities of individual users, and to communicate these successfully to each and every employee, so that a uniform, coherent and effective approach to information security is adopted in the organization (Hong et al., 2006). In recent years, the situation has been more made rather more complicated through the growth of newer forms of security documentation-such as: "the Internet and e-mail usage policies" (Arnesen & Weis, 2007); "copyright policies" (Loggie et al., 2006); etc.-that might complement the information security policy. Actual information security policies could differ from institution to institution.

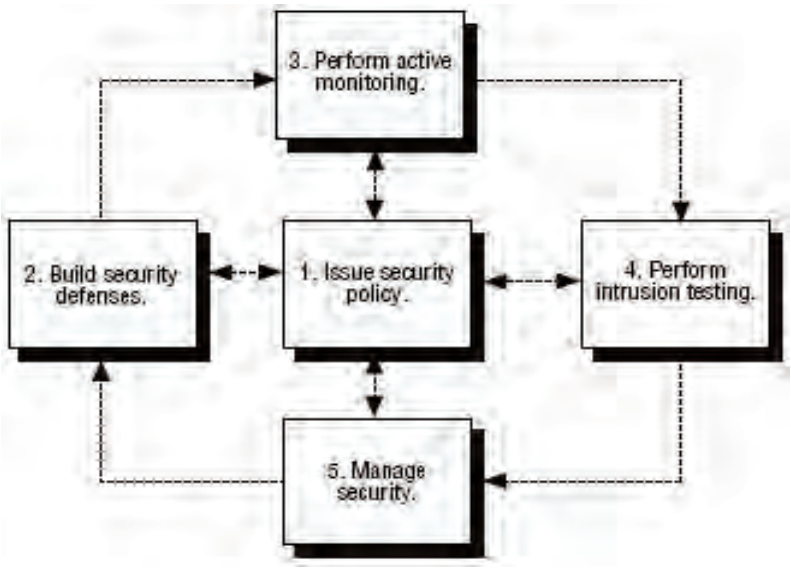


Figure 1: Information technology security governance (ISACA, 2005)

In the literature, there is a continuing debate about the ideal number of information security policies and in practice, organizations tend to have a single "corporate" information security policy. Other academics have focused upon the distinction between high level policies and the lower level practices that might usefully be produced, in support of the policy (Dhillon, 1997).The international standard ISO/IEC 27002 (2006) provides a useful indication of the types of issues that should be addressed, but these issues have been subjected to fairly academic scrutiny. Effectiveness of information security policy is also very important. Most of the organizations have formulated and implemented formal information security policy. Information security (IS) continues to present a challenge for organizations, executives and professionals. A large part of IS research is technical in with limited consideration of people and organizational issues. Information systems management (ISM) is management practice, and has a set of objectives and processes to satisfy the strategic and operational needs of organizations. A privacy consideration in technology for the future includes philosophical, legal, and practical dimensions—any or all of which can be considered as within the domain of the field of human–computer interaction (HCI). Most IS security managers pay more attention to technical issues and solutions such as firewalls, routers, and intrusion detection software, while pay less focus on soft issues such as the hazards caused by end users' lack of IS security awareness (Katz, 2005). Information security awareness can be described as a state where users in an organization are aware of their security mission (Siponen, 2000). There are two categories of security awareness: framework and content (Siponen, 2000). The former concerns standardization, certification and measurement activities, while the latter addresses the human and socio-cultural aspects of information security awareness. Furthermore, Puhakainen (2006) points out that 59 IS security awareness approaches have been put forward by practitioners and scholars. These approaches can be classified into two categories. Studies in the first category consider IS security awareness to mean attracting users' attention to IS security issues (e.g., Hansche, 2001; Katsikas, 2000). Studies in the second category regard IS security awareness as users' understanding of IS security and, optimally, committing to it. While IS security awareness is commonly recognized, the number of studies that considers it in-depth is limited. This may be attributed to (a) the non-technical nature of IS security awareness (Siponen, 2000), and/or (b) its scope, as it falls outside the traditional engineering and hard computer science domains (Dunlop and Kling, 1991). IS security awareness plays a significant role in the process of the overall information security of any organization (Thomson and von

Solms, 1998; Straub and Welke, 1998). The important role of the human factor in IS security has been recognized by both the research community and IS security practitioners (Parker, 1998, 1999; Siponen, 2000, 2001). As such, users' IS security awareness is reflected in their attitudinal and behavioural patterns (Beatson, 1991; Lafleur, 1992; Gaunt, 1998, 2000; Höne and Eloff, 2002; Mitnick, 2002; Puhakainen, 2006). However, these attitudinal and behavioral features have a socio-cultural and human dimension that need to be analyzed and understood to ensure full users' commitment and adherence to IS security regulations. The number of scientific studies that consider IS security awareness in developed countries, especially in higher education environments, is very limited (Marks, 2007). The situation is even more dire in the case of developing countries where the socio-cultural environment combined with a lack of resources and knowledge may present even more barriers to promote IS security awareness. Recently, there have been increased information security considerations in organizations (Straub and Welke, 1998; Schlienger and Teufel, 2003). This is mainly due to the fact that information systems and the Internet are today used not only by organizations to increase their competitiveness, but also by criminals. This is becoming a trend in higher education institutions that are experiencing an increase in security threats and attacks (Marks, 2007). Based on recent studies (Whitman and Mattord, 2005), staff errors are rated among the top threats to information assets in organizations. It is essential to convince IS security staff of the imperative need to enforce information security measures (Pfleeger and Pfleeger, 2003). In fact, a single case of abuse can cause more costs than the establishment of a security system (Czernowalow, 2005). It is essential to ensure that all users are aware of information security threats and concerns, and are equipped to support organizational security policy in the course of their normal work (BS7799, 1999).

3. The Internet Security Policies and Issues

Institutions and companies usage of the Internet is growing exponentially. Although the Internet may not be the ultimate model or technology for future national or global infrastructures, it is nevertheless an important landmark in the evolution of any future infrastructures. Therefore, any major problem areas associated with the Internet use need to be addressed. Hackers, competitors, disgruntled employees and ex-employees have been exploiting these and other vulnerabilities highlighting the changed nature of the Internet environment from collegial and trustworthy to competitive and hostile. There are also increasing concerns about threats emanating from trusted employees; for example, an employee may send out information over the Internet to a global audience, innocently yet falsely presenting as a spokesperson for an entire organization. Commercial usage of the Internet has brought a host of new threats, for example, interception of data in transit by competitors or criminals. The current vulnerabilities, together with an increasingly unfriendly environment plus heavy and rapidly growing usage of the Internet by technically sophisticated users globally combine to signal information security as major Internet problem area. Internet security policies and procedures should be the media by which the Internet security rules are provided to the Internet participants each of whom has their peculiar security interests. Inside a user organization participants include: owners, administrative managers, system managers, third parties (clients) and employees. External to user organizations participants include: government bodies, security system vendors and developers and site and network service providers. Some participants have already established policies. The internet organizational structure is loosely coupled coalition of organizations and activities without any management structure, possessing rules which must be followed in order to connect backbone its communication system, and the possessing protocols which must be followed in order to communicate via the network. Currently, within user organizations there is an urgent need for the Internet security policies. Very little rational selection of the Internet security mechanisms as implementations of any formal policy takes place. Instead, user organizations have been typically implementing security mechanisms such as firewalls to the Internet security problem and pointed out that there is a need to develop a model of those information security requirements which are actually enforced via a firewall. Thus, there is an important need for each user organization to specify an Internet security policy describing the requirements for the Internet security within the organization. These requirements should address the Internet-related risks for the organization. Mechanisms which implement these particular requirements can then be selected. The Internet security policy should be a key component of an overall Internet security program in the organization. In the development of an Internet security policy for a user organization, it is imperative that the risks to the organization arising from the Internet connection be addressed. This requires identification of the relevant risks, followed by a prioritization of the risks via risk assessment. Much has been written about the risks for organizations using the Internet. It is beyond the task of this paper to identify or discuss in detail the many and varied risks, however the above sources as well as others should be consulted in order to add richness to the Internet risks. A brief discussion of holistic Internet security issues which impact on policy follows, using the classification scheme in Yngstrom (1995) for holistic information security issues: legal; ethical, social and cultural; managerial; administrative and operational; and technical. In legal issues**;** the organization will need to be aware of relevant international, national and state laws, and relevant standards, before setting its policy. In ethical, social and cultural issues; **e**mployees will demand certain rights, and accept certain responsibilities and a certain degree of accountability, depending on the ethical, social and cultural climate of the organization and country. Employees will need to

have policy concepts explained clearly via security awareness sessions (Branstad *et al.*, 1995). Rannenberg's (1994) classified other ethical and multilateral security concerns. In managerial issues; management must ensure that the Internet security policies form part of a comprehensive Internet security program, which is in turn part of an organization's information security program. In administrative and operational issues; many administrative and operational tasks need to be considered and defined, for example "applying, monitoring and auditing the security procedures"(Branstad *et al.*, 1995). In technical issues; technical mechanisms must be installed and then monitored, in order to implement the security requirements specified by the policies. Procedures must be specified for ensuring that the mechanisms (for example, firewalls) are selected, installed, and monitored.

4. Information Security Risks

Innovation is at the heart of the growth of illegal Internet-based activities commonly known as cybercrime. Criminal organizations are not only incorporating emerging technologies in their activities, but are increasingly pioneering and seizing opportunities for new illegal enterprises made possible by the Internet and the continuing growth of electronic commerce. Arguably, many of these innovations represent the cutting edge of global criminal activity. They provide higher prospects for illicit profits at seemingly lower degrees of risk. Security analysts can have difficulty in identifying the locations from where the cybercriminals may be operating and find it difficult to identify the perpetrators. Cybercrime thus represents the growing sophistication of existing criminal behavior and the emergence of novel illegal cyber activities. It presents unique and difficult challenges for law enforcement officers charged with countering such activities. Despite being an innovation-driven phenomenon, most analysis of cybercrime has been undertaken from the perspectives of criminology, information and communications technology (ICT) security firms and journalists, rather than innovation scholars. There is a need for a new perspective on how cybercriminals innovate, organize and operate, and how law enforcement agencies must change to combat this growing trend (Kraemer-Mbula, Tang & Rush, 2013). Changes in the identification of threats, in the rollout of new technologies, and the identification of new threats may have dramatically shifted the organizational security focus. In order to identify the threats to be assessed, a dozen categories of threats were identified by Whitman (2003). These categories are Act of Human Error or Failure (accidents, employee mistakes), Compromises to Intellectual Property (piracy, copyright infringement), Deliberate Acts of Espionage or Trespass (unauthorized access and/or data collection), Deliberate Acts of Information Extortion, Deliberate Acts of Sabotage or Vandalism (destruction of systems or information), Deliberate Acts of Theft (illegal confiscation of equipment or information), Deliberate Software Attacks (viruses, worms, macros, denial of service), Forces of Nature (fire, flood, earthquake, lightning), Quality of Service Deviations from Service Providers (power and WAN service issues), Technical Hardware Failures or Errors (equipment failure), Technical Software Failures or Errors (bugs, code problems, unknown loopholes), Technological Obsolescence (antiquated or outdate technologies).

IT executives were asked to rank the threats to information security; to identify the priority of expenditures to protect against these threats; and to indicate the frequency of attacks attributed to each category. The respondents were predominantly IS directors, managers, or supervisors. With the extensive use of the Internet (99%), ITU could clearly be open to attack. Providing information via the Internet, there could be a great exposure information to potential crime, abuse, or misuse. With almost half of respondents indicating use of the Internet to support internal operations, there is also the risk of unauthorized disclosure or modification of information. What is ITU doing to protect its members? All members use passwords and virtually all use media backups and virus protection. What is not revealed is ITU's vigilance in updating virus definitions, or the type of media backup schedule, either of which could negate any benefit derived from use of these protection mechanisms. This indicated a consistent security policy. The security policy is the first and potentially most important layer of security available to any organization. Security policies define the security philosophy and posture the organization takes, and are the basis for all subsequent security decisions and implementations. Again, what is indistinguishable is the effectiveness, comprehensiveness, and quality of the security policies of those indicating the presence of a policy. Equally concerning is the low response in the area of ethics training. A fundamental part of an organization's security function is the implementation of a security education, training, and awareness program. Both the security policy and the program are relatively low-cost protection mechanisms with the potential for high returns on investment. Technologists often overlook the human solutions and instead opt for technology solutions, when in fact the human factors must be addressed first, with technology assisting in the enforcement of desired human behaviors (Whitman, 2013).

5. Information Security Policies in Universities

Concerns for Information Systems (IS) security and confidentiality in a university computer network environment were expressed as early as 1975 (Kerievsky, 1976). Colleges and universities have been a target for cyber-attacks for two main reasons (Katz, 2005): first, because of the vast amount of computing power they possess; and second, because of the open access they provide to their constituents and to the public. University

networking infrastructures are not only designed to serve the needs of faculty, staff, and students, but also to accommodate the needs of visitors, and geographically distributed researchers sharing large quantities of data. While the nature of higher education requires openness to the public and a continuous sharing of information, a balance must be maintained to ensure that information assets are not being put at risk or compromised. Unauthorized grade changes and persistent problems with registration or financial systems can undermine universities' credibility and viability. In this context, understanding IT security threats and challenges facing higher education is essential to avoid potential loss of university information and knowledge assets. In fact, experts in computer security agree that universities are among the least IS secured environments. Only a fraction of universities provide security and conduct awareness (Rezgui and Marks, 2008). In this context, information technology experts in developed countries, including the United States, are taking advantage of heightened awareness of public safety to urge college and university officials to take steps to secure their campus computer networks (Ronald, 2001). Universities today need to enforce exposure of their usage policies in order to achieve better results. Relying only on end users to read the policies is less effective. Repeated exposure could increase user retention of policies, thus increasing awareness (Cronan et al., 2006).

5.1 Management Perspective of IS Security

In hope of innovating out of this economic, university-industry interaction has come into the spotlight of public scrutiny. At the same time, the concern for information security, key to building secure network communication, is intensifying. Information security is not a mere technology, but is a requisite component of the infrastructure anticipated to support the emerging information society. And the innovation is essential in the information security industry (Ebato, Pechter and Matsuura, 2003). Promotion of university-industry interaction has become a key topic at many levels in Japan to reform the social infrastructure for innovation. This importance is recognized as more significant than expected, particularly in the area of engineering related to public affairs including the use of IT in e-society (e-commerce, e-government, and e-science). On the other hand, information security is the key to develop IT social network (Matsuura, 2005). In this context, what is the state of university-industry research collaboration in the information security field in Turkey? Due to their size, universities have complex organizational structures. Thus, information security has vital importance. Information security policy must take into account various parties of the universities such as academics, administrative personnel, visiting scholars, students, and visitors.

5.2 General Issues of Information Security Policy

In literature according to Doherty *et al*. (2009), the majority of universities have information security policy, acceptable use policy, electronic mail policy; however, most of them lack e-commerce policy, infrastructure policy, and freedom of information. On the other hand, some universities have copyright policy, privacy policy, data protection policy, web publishing policy, procurement policy, and web and domain names.

Personal usage of information systems: The information security policy should clearly articulate the individual employee's rights and responsibilities in their use of organizational information systems.
Disclosure of information: The security policy must highlight any restrictions with regard to the disclosure or use of such information.
Physical security of infrastructure and information: It is important that the policy articulates strategies for the protection of infrastructure and information resources.
Violations and breaches of security: The policy document must indicate the steps to be taken to recover from a breach or violation and the requirements for recording such security incidents.
Prevention of viruses and worms: The organization's policy should be clear with regard to the application of virus checking software, the use of attachments and the sharing of information.
User access management: The information security policy should provide clear guidance on how access controls are to be allocated and managed, in line with business requirements.
Mobile computing: The policy must highlight the organization's stance and practices with respect to secure mobile computing.
Internet access: It is important that the policy explicitly addresses the issue of Internet access, particularly with respect to issues such as the viewing of pornography and personal browsing.
Software development and maintenance: The policy must present guidelines for ensuring that effective security controls are built into all new systems.
Encryption: The policy must address the organization's requirements for encrypting/protecting such information.
Contingency/continuity planning: The security policy must specify how such contingency plans are to be written, tested, maintained, and ultimately implemented.

Threat Category Ranking
The 2002 CSI/FBI Annual Computer Crime and Security Survey (Power, 2002) ranked the following items as significant threats (in order of significance): Virus, Insider abuse of Net access, Laptop, Denial of Service, Unauthorized access by insiders, System penetration, Theft of proprietary info, Financial fraud, Telecom fraud, Sabotage, Telecom eavesdropping, Active wiretap.

6. Information Security Applications in Istanbul Technical University

Istanbul Technical University, one of the oldest and prestigious universities in Turkey, is a state university that has around two thousands faculty members and more than 30,000 current students. Especially, in the area of engineering, it is very famous and the oldest one. ITU graduates are in good positions all over the world. Based on its latest strategic plan, ITU aims to be the biggest research university in Turkey. The university has campuses in five different locations of Istanbul. There are 13 faculties, 6 institutes (Graduate School of Science, Engineering and Technology, Institute of Social Sciences, Eurasia Institute of Earth Sciences, Informatics Institute, Energy Institute, Earthquake Engineering and Disaster Management Institute), 360 laboratories, 76 different undergraduate and 101 graduate programs at Istanbul Technical University. The university also has a technopark called ARI Teknokent in which 108 firms are present and in total 3159 people are employed. The firms are specialized on a wide range of areas such as information technologies, transportation, telecommunication, energy, biotechnology, nanotechnology, and automotive technologies. There are also several research centers within Istanbul Technical University such as Center for Satellite Communications and Remote Sensing (CSCRS), which has a highly capable ground receiving station unit, and National Center for High Performance Computing, which provides computation and storage resources to national innovation system. After successful design, assemble and test stages of the receiving station through the years 1996-2000, ITU-CSCRS was established for operational working under the name ITU-SAGRES (Satellite Ground Receiving Station) in 2000 as a wide range communications and remote sensing integrated system. In the second half of the year 2003, it was restructured into ITU-CSCRS. The center has the capabilities of acquiring images from remote sensing satellites, processing data, and sending the products via satellite links to resident and foreign users. The station can receive images of the Earth's surface within a radius of 3000 km., which covers from Sweden to Sudan, and England to Kazakhstan. All software packages provided by ITU are licensed. Only academic personnel and other authorized personnel can have access to software via Internet under the permission of ITU Information Technology Department. Figure 2 demonsrates the organizational chart of Istanbul Technical University. ITU Rectorate has 12 administrative units and General Secretary is at the head of these units. ITU's library has access to academic databases such as Science Direct, Emerald, Harvard, and Oxford. Only members of the university have access to library documents. ITU has security concerns on its campuses and tries to control entrances and exits by personnel identity cards. Rectorate and related units are working hard on IS systems. The Internet and Intranet security programs are carefully selected. There is a high-level Internet risk for an Internet user organization. There is also a wider need for investigation of information security in universities. Nowadays, IT, IS policy and ISM is very important for universities. Advances in networked information and communication technologies (ICT), such as the Internet, Intranet, and the applications that run on them, are often promoted as a solution, able to simultaneously improve effectiveness, and maintain accountability. Universities have different problems with IS and they have to use different systems and programs. University as a whole and related faculties, institutes and graduate schools must have strong IS and ISM. Academics have personnel records and jury decision reports in different steps of their career and these need high attention of security managers. Confidentiality of student documents records, including registration and grade records have high importance. Only authorized academic and administrative personnel have access to these documents. Additionally, basic security concerns are confidentiality of administrative and academic documents. It can be done under the supervision of Higher Education Council, or the help of other universities, government institutions, etc. Today, it is important to bring various social and organizational factors together to ensure information security. Even though the Internet usage is under the control of the Ministry of Transport, Maritime and Communication, IS still needs careful consideration of university managers. As Oda *et al.* (2009) mentioned, ITU has three types of data: confidential, operational critical, unrestricted. For instance, personal documents of faculty and administrative personnel and exams of students are mostly confidential. On the other hand, exam scores announced publicly is an example for unrestricted data. Public announcements made online and offline are also an example for unrestricted data. Network security exists through the use of firewall rules, network scanning and monitoring tools, physical and logical network configurations. Patch management, Microsoft Active Directory Group Policy management, and hardware and software configurations also implement technology security (Oda *et al.*, 2009). ITU Department of Information Technologies follows Microsoft server hardening guidelines and industry standards and best practices on Windows platforms. These guidelines are encouraged throughout the organization.

ITU Computer Center

ITU gives paramount importance to the integration of appropriate information technologies in all aspects of education and research and allocates an important fraction of its resources to keep its information technologies (IT) infrastructure up-to-date. ITU computing resources are in service 365 days a year and 24 hours a day. A total of 2000 computers are in use in the student labs, all Internet connected. ITU-CC operates 55 labs at all ITU campuses. All students at ITU have named accounts to gain access to computers located in the laboratories and the whole ITU Information System. The domain accounts are implemented on a central database located at ITU-CC and managed remotely over advanced administrative interfaces on the WWW. All ITU students have e-mail addresses and are encouraged to build their own web pages. Currently ITU is connected to the Internet via one circuit: 100 Mbps connection to the Turkish National Academic Network (ULAKNET). ITU is also the point-of-presence of Turkish National Academic Network (ULAKNET) in Istanbul. VPN is also one of the network services provided by ITU-CC. A VPN is a virtual network, built on top of existing physical networks, which can provide a secure communications mechanism for data and other information transmitted between two endpoints. VPNs offer versatility and ease of use because they use the SSL protocol, which is included with all standard Web browsers, so the client usually does not require configuration by the user. VPNs also offer granular control for a range of users on a variety of computers, accessing resources from many locations (Harmening, 2013).

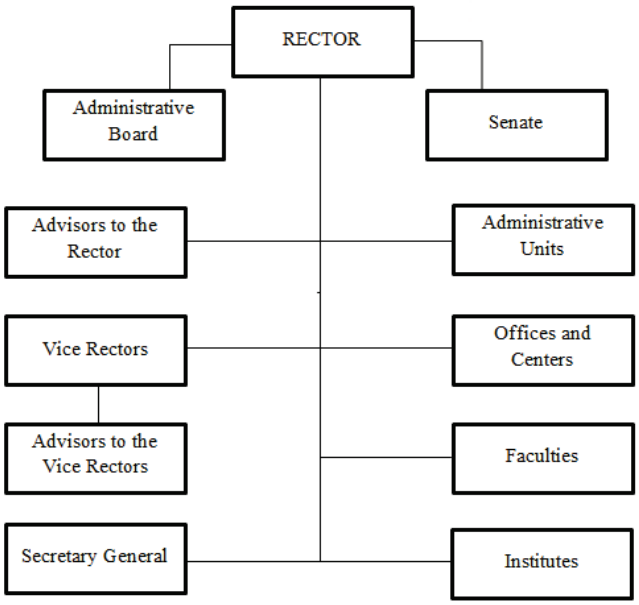


Figure 2: Organizational chart of Istanbul Technical University

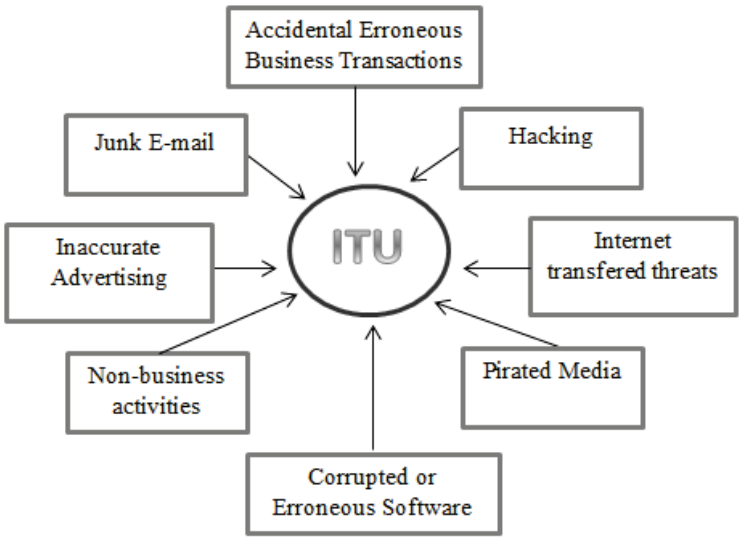


Figure 3: Internet risk for Istanbul Technical University

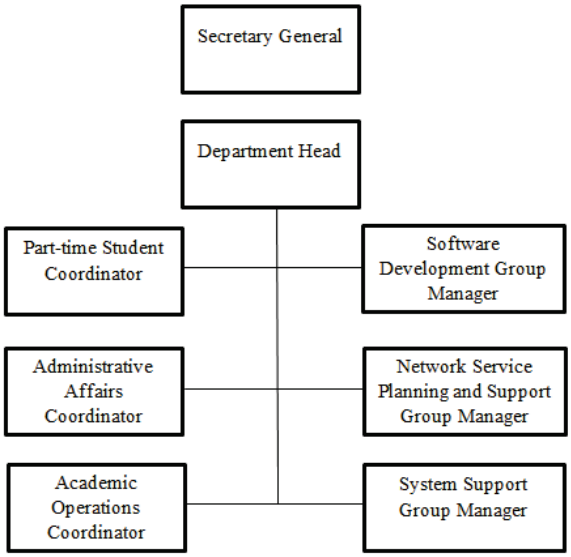


Figure 4: Organization chart of ITU Department of Information Technologies Department

7. Conclusion

In this paper, information technology and information security management applications of Istanbul Technical University (ITU) were explored. As an engineering-oriented university, recently, ITU has focused on being the biggest research university in Turkey; innovative research has been greatly encouraged by the university management. This brings high responsibility on information security policy and management. Information technology and security managers at ITU should be more informed of the potential for security breaches and they should increase their awareness in key areas such as deliberate software attacks. They should also recognize that their overall level of concern for security may underestimate the potential risk inherent in the highly connected environment in which they operate. In future, there will be more risks on information security; therefore, universities must improve their current policies and generate new policies. Istanbul Technical University is working hard on this subject to avoid future threats.

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Biography

Asli Suder is an Associate Professor of Management and Organization at Istanbul Technical University, Faculty of Management and Department of Management Engineering, in Turkey. She was graduated from Bosporus University Department of Management in 1976. She continued her education and also earned a Bachelor's Degree in Economics and Administrative Sciences from Marmara University, in 1981, a Master's Degree in International Management from Istanbul University, in 1982, and finally a Philosophy Degree in International Management in 1987 from Social Sciences Institute of Istanbul University. She begun to work as a Research Assistant in Istanbul Technical University in 1982 and she became an Assistant Professor in 1991 and Associate professor in 2007 at the same university. She has been a faculty member since 1982 and has published extensively in the field of Management and Organization, Human Resource Management, Project Management, Healthcare Management, Social Responsibility and Ethics, Logistics and Green Management, Crisis and Risk Management, Decision Making. She is the author of numerous scientific publications.

Development of a Framework to Enhance Information Provisioning Support for Site-based Construction Workers in The Kingdom of Saudi Arabia

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Abstract

Construction projects are very information intensive and a typical project generates tens of thousands of documents in the form of drawings, change orders, request for information, specifications etc. For effective construction communication and coordination, it is important to manage this information flow in an effective manner. Recent developments in technologies enable improvements to the construction methods and processes to overcome various communication and co-ordination challenges. In recent years, there is an increasing interest in use of mobile computing and wireless technologies both as a tool and a collaboration concept. With this remarkable growth there is a direct interest in its employment to enhance construction production. With increased computational power available on mobile devices and developments in high bandwidth wireless technologies, it is possible to extend the benefits of various collaboration technologies to the point of work. Construction Industry in Saudi Arabia is growing rapidly with Government financing huge infrastructure projects. However, the industry has peculiar characteristics such as multi-cultural workforce, high level of fragmentation, low education, extreme natural environment and transient nature of construction workforce. This makes implementation of new technologies and improvements in construction processes and practices particularly difficult. This paper focuses on understanding the key challenges in providing timely and relevant information to site-based construction workers particularly site supervisors and site engineers in Saudi Arabia which will help to develop the framework.

Keywords

Construction management, Communication, Mobile computing, Productivity

1. Introduction

The information and communications technologies (ICT) have extensively been applied to address communication and collaboration challenges and to enhance productivity, performance and quality in design and delivery of construction projects. However, the construction industry is still lagging behind other industries such as aerospace and automobile, in terms of deployment of more advanced ICT systems for communication and integrated design and manufacturing. The construction industry has its own characteristics such as the involvement of many participants, the separation between site offices and work sites, and the mobility of construction personnel. Many of construction projects have failed to meet cost, time and quality targets and were marred with poor communication and coordination problems between site-based and office-based staff. In recent years, there has been tremendous development in technologies such as cloud computing, wireless networking and mobile technologies which can assist to improve construction management. Mobile computing can play a key role in management of information generated during a construction project and improvement of the existing process by ensuring right information is delivered to the right person at right time were real-time progress is updated and better decision-making is taken.

However, before engaging this new technology to cope with the construction dilemma, it is essential to address and comply various factors. These issues can be categorised in to the technology itself, its usability, the construction organization and culture. In other words, it's necessary to explore the interactions between them because they are likely affect the design and the implementation of mobile computing. This paper present a doctorate research that reflects just how mobile computing could be best implemented to enhance on-site construction information in Saudi Arabia for site-based construction workers. Following a description of the study achieved, a model of the key challenges is presented with initial descriptions on its nature. The conclusion is drawn with a short argument on the proposed model.

2. Key Construction Project Management Challenges in Saudi Arabia

The Saudi construction industry become the "largest construction sector in the Middle East and remains a 'construction safe heaven' amid both wider political and financial turmoil" (Deloitte & Touche, 2013). "In 2008, the value of capital assets of the building and construction sector was $41,2 US billion dollars, up from about $ 19.9 US billion dollars in 2004, reflecting an average annual growth rate of 19.9%" (MEP, 2012). Furthermore, Figure 1 presents the tremendous growth of the industry which is driven mostly by the government. In recent years, the Saudi's strong economy reflected on its development plans and large-scale investment that established infrastructure, such as a network of trains and trams, roads, bridges, dams, airports, ports, facilities for electricity and desalination, etc.



Figure 1: The estimated construction growth in Saudi Arabia (Deloitte & Touche, 2013)

However, with this growth, the industry is facing various challenges as some projects have failed to meet its cost, time or quality targets. Generally, Deloitte & Touche (2013) indicated that the total value of delayed projects estimated by Saudi Arabian contractors in July 2012 is USD 146bn. With regarding to the doctorate research project, the researcher is focusing on the challenges that regarding the construction site. The industry suffers from different kind of delays such poor project management, low labour productivity, communication and coordination problems. These problems are well documented in recent literature (e.g. Alsuliman et al., 2012; Albogamy et al., 2012; Alkharashi and Skitmore, 2009; Assaf and Al-Hejji, 2006).

There is a wide body of literature focusing on productivity improvements on construction sites with a focus on sites in western developed countries. However, there is a great deal of variation between construction sites in Saudi Arabia when compared with Western construction sites characterized by multi-cultural, multi-language, low and semi-skilled labor and very low adoption of technology coupled with heavily subsidized AEC sector, fuelling various process inefficiencies (Alsehaimi, 2011). A recent survey by Sidawi (2012) of construction companies in KSA showed that 89% of respondents are still using traditional communication systems and tools such as fax machines, mobile phones (voice and texts), site visits, weekly/monthly reports and face to face meetings. Sidawi (2012) also found that 93% of survey respondents do not use advance mobile systems and tools, apart from basic use of mobile phones for voice communication. This should be seen in the backdrop of the fact that total population of construction workforce in the private sector is 3.5 million (45.1% of total construction workforce) in 2011 (Saudi Arabian Monetary Agency, 2013).

3. Mobile Computing and Construction Management

As known the construction project characterized as heavy workforce and generates tens of information which needs effective project management. Löfgren (2005) mentioned that part of the poor productivity figures in the construction industry could be explained by the fact that the information needs and communication behaviours in the production at the construction sites are not adequately met. Moreover, managing information in construction is the main success factor for performance. Thus, practical and efficient communication tool is required and targeted by many scholars and practitioners for many years. However, in the construction stage most of the technologies that being used stoped in the site offices. While very few technologies become available to use in the site.

Mobile computing address's a critical area in the hole project which provides great opportunity to extends the boundaries from the site offices to the work sites by connecting those moving personnel's and increasing their mobility. In other words, the potential improvement of using Mobile computing is regarding to "the enhanced mobility of computing devices, which allows users in any location to access and share important construction project information in an efficient manner" (Kim et al, 2013). "firmly believe that mobile computing-integrating mobile devices, wireless communication and mobile services- presents the missing link in Construction Information Technology, thus providing appropriate information flow in the life-cycle of a building product"(Danijel et al, as quoted by Anumba et al., 2012).

This new way of flowing the information influence the project team and force their existing processes of handling the information to change. Kim at el (2013) indicated that the advent of smartphones, coupled with state-of-the-art mobile computing technology, provides construction engineers with unprecedented opportunities to improve the existing processes of on-site construction management. Also, "the adoption of mobile computing devices can make a significant contribution to the ongoing drive for process improvement" (Bowden et al, 2005). The advances in affordable mobile devices, increases in wireless network transfer speeds and improvements in mobile application performance, gives mobile computing technology a powerful potential to enhance on-site construction information management. Furthermore, smartphones are currently fitted with high resolution color touch screen, GPS navigation, gyroscope, wireless communication capability, digital camera, sensors, high-speed data transfer with 4G, etc. These powerful features "enable a new generation of on-site management processes, such as high mobility, location-based customized work orders, real time information exchange, and augmented reality (AR)-based site visualization" (Kim et al, 2013).

4. Research Methodology

According to the existing improvements in mobile technology, information systems, wireless connection, etc. Which provide potential chances to mobile computing to be best utilized in onsite construction communication. This research has seven objectives but the critical one is to develop an understanding of key challenges in providing timely and relevant information to site-based construction workers engaged in public sector construction projects within the Kingdom of Saudi Arabia which are explored in a model. In order to develop an information provisioning framework to support information needs of site-based construction workers. In other words, this theoretical model will classify all main factors and their relations, which affect the design and implementation of the framework. Exploring the factors relations as well as validating and evaluating this model will be in the next stage after analyzing the data that collected by the questionnaires and the case studies supplemented by semi-structured interviews and observations. Which will aid to develop several scenarios to demonstrate how the framework of mobile computing can be used to support information needs of site-based construction workers in Saudi Arabia. and how mobile computing can enhance the effectiveness of the construction process for Site supervisors and Site managers.

To successfully meet the objectives of this research, a well-designed methodology was essential. The main research strategy used in this research is constructive research which contains seven steps as shown in Figure 2. Constructive research is supplemented by Case studies (Interviews and Observations) as primary method and Survey Questionnaire as secondary method for data collection. "Constructive research is used to define and solve problems, as well as to improve an existing system or performance, with the overall implication of adding to the existing body of knowledge" (Oyegoke, 2011). It aims at creating solutions for both practical and theoretical problems (Figure 2). Solutions are repeatedly recommended through managerial problem solving techniques over the construction of models, drawings and strategies. "Constructive research assumes that there are multiple interpretations of reality and the need to understand how individuals construct their own reality within their social context" (Oyegoke, 2011).

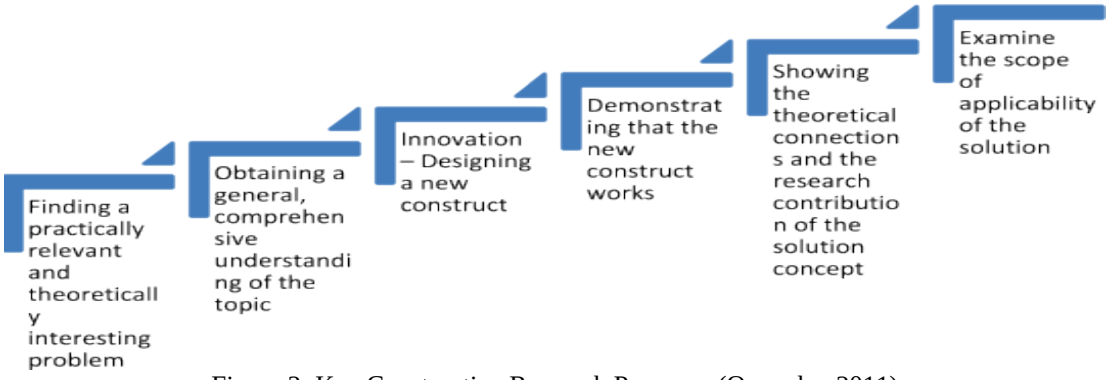


Figure 2: Key Constructive Research Processes(Oyegoke, 2011)

5. Model of Key Challenges That Affect the Implementation of Mobile Computing

After exploring the literature of Saudi construction industry characteristics also investigating literature in the area of the mobile computing application for site-based construction workers, a model is developed in order to understand the situation which will aid to build a framework for practical use of mobile computing. This model identifies the key issues of the technology itself, the construction organization, culture and its usability (Figure 3). The next stage in the research is to explore the interactions between them because they are likely affect the design and the implementation of mobile computing in Saudi Arabia. Generally, with the increasing interest in mobile computing in the construction industry, "it still meets with skepticism from the industry because of the relative lack of supporting data and a lack of understanding of mobile computing devices (Son et al, 2012). In other words, the construction professionals are aware and recognize of the benefits and the usefulness of the use mobile computing technologies in construction site. However, they are clearly unsure how to implement them on their projects and concerned about its complexity (Bowden, 2005; Chen, 2008; Son et al, 2012; Kim et al, 2013).

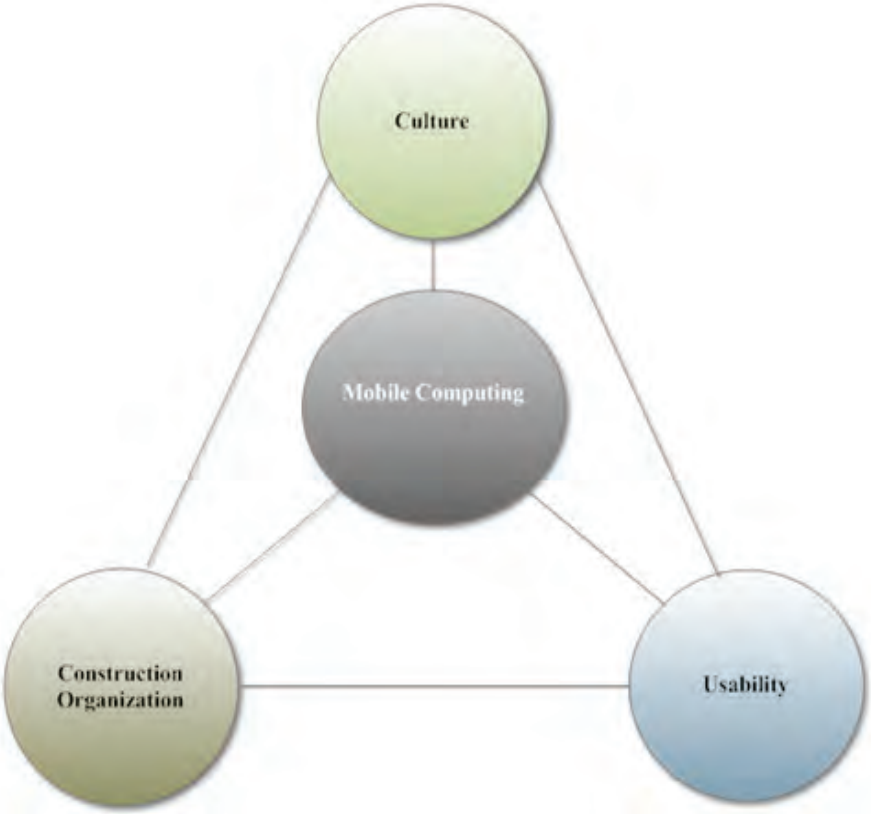


Figure 3: Keychallenges that affect the implementation of mobile computing

5.1. The Technology Challenges and Limitations

Frequently, technological complexity is one of the main constraint to the use of mobile computing devices which relatively regarding to the screen size, input difficulties, battery life, etc. Bowden (2005) found that half of the survey respondents believe that they did not think that hand-held computers could be used on site, thought that they would not stand up to the harsh site environment. Moreover, Chen (2008) indicated that there are some constraints regarding to mobile computing such as the limit of local computational resources resulting from size and weight restriction, more vulnerable to loss or damage regarding security considerations, the variety of connectional performance and reliability, and the concern of power consumption. Furthermore, in case of breakdown or damage to the device, there is possibility that "all the work that had been carried out since the last synchronisation could be lost. Also, with staff working a 8-10 hour day, the inconvenience of running out of battery power whilst out on site could create reluctance to rely on the device" (Bowden, 2005).

5.2. Organisational Barriers

Generally, the construction professionals are aware and recognize of the benefits and the usefulness of the use mobile computing technologies in construction site. However, they are clearly unsure how to implement them on their projects and concerned about its complexity (Son et al, 2012; Bowden, 2005; Kim et al, 2013; Chen, 2008). In other words, the success or failure of mobile computing or any technology provided by a firm is depend on the readiness of the staffs to utilise it in executing the tasks. Son et al, (2012) stated that the manager's return on investment in IT is often very low because of employees' refusal to use the IT that is available to them or their reluctance to use it to its full potential. Also, the training is another factor that effect the use of mobile computing. Moreover, strong support by the top management is vital for mobile computing use. Top management may defined as "the individual's perception of the degree to which top management understands the importance of IT and the extent to which top management is involved in the implementation of IT"(Ragu-Nathan et al, 2004 as quoted by Son et al, 2012). Even the technical support by the top management is needed to guaranteeing the utilization. Technical support includes practical aspects of the user requirements such as "specialized instruction, guidance, coaching, and consultation in using technology" (Son et al, 2012).

5.3. Cultural Barriers

Generally, different countries have different cultures and different adoptions of IT in construction projects. Which means that construction firms work get affected because they have many employees that come from different countries and cultures that likely tended to work using their routine of work processes and tools. Moreover, Son et al (2012) indicated that the social influence is another barriers for IT use also mentioned that according to the diffusion of innovation theory that established by Rogers (1983), an individual's decision to adopt a new type of technology is influenced by social forces because of the desire to reconcile one's own opinions or behaviors with those of others. Moreover, Bowden (2005) outlined four points regarding to the cultural barriers which are:

- Attitudes towards the devices and I.T. in general could be a barrier, one participant in the usability trials commented "Ought not to underestimate people, could just pick up a telephone instead…".
- The devices were perceived by some participants in the usability trials as a gimmick or a toy, and it was thought that they should only be used when appropriate rather than as standard.
- A lack of awareness about information and communication technologies (Love & Irani, 2001) and the lack of exemplars demonstrating its successful use by others (Anumba, 1998).
- A lack of IT literacy amongst site-based personnel is commonly cited as a barrier to the implementation of IT on construction sites (Coble & Baker, 1994, Picken, 2001)

5.4. Usability Challenges and Limitations

Kim et al (2013) stated that the data input and output method of a mobile computer has an impact on the users usability which effect the information process on construction sites and should represents the information efficiently and effectively according to the user abilities. The data input methods include keyboard, touch screen, camera for picture capture, video recorder, etc. The data output of the mobile computing which depends on the construction information format and the mobile capabilities which displayed generally in two types that are "the screen for the information formats of graphic, text, image, and speaker for verbal communication" (Chen and Kamara, 2011). Generally, The data output effected by the "screen size, visibility and resolution" (Chen and Kamara, 2011). Because of the size and weight of the mobile devise that may become too small to handle with larger hands and heavy to carry. These data input and output methods effect the battery life of the mobile which should be running for a long period of time to support the user when they outdoors on site construction (Bowden, 2005; Kim et al, 2013).

Bowden (2005) indicated that when the personnel become too reliant on the device, such that if it were to break down they would have to go back to pen and paper and the necessary protocols would no longer be available. Finally, Son et al (2012) suggested that construction firms and mobile computing device providers should put more effort into making and providing their devices easier to use, which can lead to better beliefs on its usefulness.

6. Conclusion

After all, with regarding to the previous studies, many of mentioned points considered in this research alongside with various aspects such as the users work requirements' and their capabilities', the usability of the mobile application which regarding to the numbers of the involved users with taking in mind the personnel's demand of easy to learn and use also the site environment. Also, consider and determine properly the various conditions and factors that affect the workflow of the construction projects such as culture and the organisational fragmentation of the project. Moreover, Davies and Harty (2013) stated that future study might aid our understanding by guiding the attention to the process and context along with the content and outcomes of similar construction IT innovations undertaken across a variety of project and organisational arrangements. Moreover, the selection of mobile computing should pay attention to the physical features to the site environment such as site rugged condition, water, humidity, dust, crash resistance and have good battery to support users' for long time on sites. Finally, the next stage will be to analysis the collected data to exploring the factors relations as well as validating and evaluating this model. In order to develop an information provisioning framework to support information needs of site-based construction workers. With taking in mind some other demands which for the construction management system for site engineers should meet: (Kim et al (2013)

- The on-site construction management system should be capable of site monitoring to understand the current status of the construction project.
- The system should provide information of work tasks for site engineers to effectively manage construction resources.
- The system should have the function of real-time information sharing to facilitate efficient interaction among construction participants.

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A Methodology with Analysis of Production Management in ERP Systems: A Case Study in an Industrial Sector

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Abstract

In this study the following issues are aimed to work on which are strictly related to each other; the conditions and rationales behind the effecient production systems, the steps towards ERP(Enterprise Resource Planning) implementation and also critical success factors, integration consideration. With the evaluation of X Automotive case study, it is intended to make the system more efficient and beter integrated.

To achieve an efficient production system design, MRP and JIT(Just In Time) systems are investigated as basic two philosophies behind production management and it was found that most of the production systems are designed according to the hybrid systems model which is the combination of MRP and JIT.
Therefore, for this section System Analysis Approach was found as suitable which claims that every production system is unique and need to be analyzed and designed according to requirements. Hence, X Automotive production system is analyzed with this approach.

In this phase, business process modelling and business blueprint approach is utilized which is directly related to system analysis approach. Also for integration considerations, relationship between X Automotive and its suppliers is investigated as an example of integrated database and system design.

In the last part of our study, The whole system and especially the CMMS3(Common Materials Management System)section is analyzed with the system analysis approach and deficiencies and inefficiencies are determined with respect to the information system aspects.
Consequently, a unique and shared database system was proposed where the MP&L(Materials Planning and Logistics) part is the central component of the system and BOMs(Bill of Materials), material masters, work centers and all the other parts are redefined on this new system to integrate all the processes and the departments that are related to production will be communicated to each other on-line and accurate data basis.

Keywords
ERP (Enterprise Resource Planning), JIT, CMMS(Common Materials Management System), Production Management. Bill of Material (BOM). MPS (Materials Production Scheduling)

1. Introduction

Efficient production management is very crucial for every manufacturing companies in today's fast changing world. Companies devote a lot of time and money in order to design their production system effectively. Hence, the two main philosophies that the manufacturing firms come across are MRP and JIT systems. In some cases these two approaches may conflict with each other and produces a complex problem of design for manufacturers.
While ERP systems provide the potential to bring substantial benefits, their implementations are characterized with large capital outlay, long duration, and high risks of failure including implementation process failure and system usage failure. As a result, the adoption of ERP systems in project-based firms has been lagged behind in the lots of

companies in many other industries. In order to ensure the success of ERP system implementations in project-based firms, sound risk management is the key. (Yajun Zeng,2010).
Another important issue is the building of information system which provides data for the production planning department and also for the other departments. Comparing both MRP and JIT techniques and their level of maturity for effectiveness. This study aims at helping manufacturing companies to design their system. Subsequently, this study also aims to investigate the logic behind the ERP implementation strategy, critical success factors and also integration consideration that are all crucial subjects.

Finally, with the theoretical knowledge regarding the MRP and JIT and also ERP implementation roadmap, X Automotive production roadmap, X Automotive production system will be analyzed with the system analysis approach and after this analysis X Automotive System CMMS3 (Common Materials Management System) will be analyzed with consideration of its deficiencies. After this analysis, a new proposal will be given to the existing X Automotive ERP system (Ravi S., Diatha Krishna S,2013).

2.Literature Survey- Review

2.1.Material Requirement Planning

"The material requirements planning(MRP I) is a computerized inventory control and production planning system. It is responsible for scheduling the production of all items beneath the end item level. It recommends the release of work orders and purchase orders and issues rescheduling notices when necessary."(Rusell and Taylor,1998)

Material Requirement Planning is essentially a computerized manufacturing system for ordering and scheduling of dependent –demand inventories. It has gained significant popularity in the 1990's when Orlicky and Wright rigorously advocated the potentials and benefits of MRP. The material plan, which is based on the MPS (Materials Production Scheduling), describes what material you need and when you need it. MRP I determines the period by period plans for all component parts and raw materials required to produce all products in the MPS. MRP aims at efficient scheduling of production requirements so that raw materials, components and sub assemblies can be provided in the right amount and at the right time. MRP I is the way to make the MPS happen. It is a deterministic planning model.That is, the results of each step are determined directly from the previous steps.
The MRP-related modules of these systems perform the steps (1)master production scheduling , (2)materials requirements planning, (3)capacity requirements planning and (4)short-term scheduling(Rice and Hatch,1997). Basic MRP I functionalities are as follows:
*Determine Requirements to Support MPS*Maintainning the Lowest Possible Inventory * Scheduling the Production *Keeping Schedules Valid and Up to Date * Especially Useful in Complex and Uncertain Manufacturing Enviroments *MRP I Services as a Long Range Planning Tool * Coordination and Synchronization of Goods Flows.

2.1.1 MRP Inputs

2.1.1.1 Bill Of Material

Bill Of Material(BOM) is one essential ingredient of the data for the production database in manufacturing . It shows how many percent of material provided for production, product costing, plant maintanence (Lee and Lu,1997).
The graph below shows some components of a chair that are included in a BOM as an example:

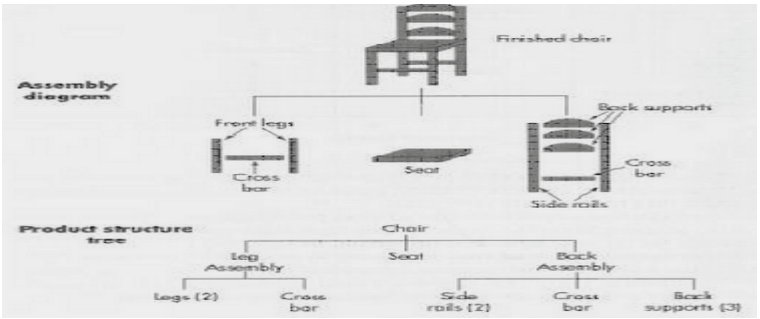


Figure 1: Bill of material structure (http://mcu.edu.tw/)

*BOM contains information on each input to the product, such as part number descriptions, quantity needed for each part and the unit of measure.

*BOM is used by the MRP I system in conjuction with the master production schedule to determine the items for which purchase requisitions and the production order must be realeased.
*In production planning a bill of material is a key input document for establishing a proper inventory control system.
*Since the inventory records are an important part of MRP I, an accurate BOM becomes a vital input to MRP I systems. A collection of these bills describes the flow of goods through the manufacturing process. Thus, BOM also describes the relationship between parts.
*BOM does not show the steps or process used to make parent or the components.The information is included in routing file.
Every item that needs to be planned and scheduled should be defined on the BOM because if it is not included on the BOM , your risk is not having the item when you need it.(Dary et al.,2013).

Principles of BOM Structuring
1-Data in the part number and BOM records should be complete enough to satisfy the needs of every internal customer in the company.
2-Parts numbers should be unique.
3-BOMs should consist of part numbers, not drawing numbers.
4-BOM should identify material not labor
5-The BOM must include all items to be scheduled and indicate relationship between them.
6-BOM must indicate levels of manufacture to generate low-level codes, and the number of levels in the BOM should be minimized. BOM should be as shallow as possible.

2.1.1.2 Master Production Planning
Master Production Planning is defined as an anticipated build schedule for manufacturing end items or product options by quantity per planning period. It represents what the company plans to produce expressed in specific configurations, quantities and dates. The authorization to produce the product must be translated to the MPS (Materials Production Scheduling).The MPS is a list of:
-The end items or major sub-assemblies – The quantity of each item to be produced. –When they are ready for shipment.
MPS is not a control technique or a system. If the MPS is done properly, the rest of the system can be harnessed to reach desired objectives of management.
**MPS is what the firm or plant expects to produce in the short run and the plan for the supplying to meet demand.
** Master production schedules are the inputs that drive MRP I. It is the first step of the implementation of overall manufacturing program of a plant. MRP I depends on the validity and realization of the MPS for effectiveness.

Functions of MPS:
MPS has two principal functions
-In the short horizon, to serve as bases for planning material requirements, production of components, order priorities and short term capacity requirements. Following are the functions performed by the MPS:
1.RCCP check:The MPS process limits the work to what can be done realistically.
2.Production Smoothing: It buffers the forecast by smoothing demand over time, reducing capacity constrained peaks and raising low-demand idle periods.
3.**Netting**:It subtracts exisiting inventories of products from the forecast so that shop does not make products that already exist in inventory.
4.**Lot Sizing**: MPS batches demands over time into convenient and economical groups for production so that scarce facilities and equipment are not wasted.
-**Over the Long Horizon**: To serve as bases for estimating long term demands on company resources such as people, plant and equipment, warehousing , money.
Resource Planning driven by invalid data(instead of realistic MPS) is often the single most common reason why expensive MRP I programs have failed to help manufacturing companies realize their enourmous benefits. There are also some other items which may be included in MPS:

- Shippable products.
- Major assemblies
- Planning modules
- Group of components covered by pseudo bills
- Individual parts used at the highest level in the product structure or subject to demand from sources external to the plant(Davide A et al.,2013).

2.1.1.3 Inventory Status File

The Inventory Record file contains data about the status of each item held in inventory. It containes the balance of each item currently on hand, as well as up to date information about any transaction effecting inventory status.The MRP uses this file information in conjunction with MPS to determine gross requirements for the components.

Basic Item Master File :This file typically contains all the data needed to completely describe each item number.It also has the linkage for the routing file.

The Dynamic Item Master File:This file is used for changing or dynamic data about individual part numbers.It includes inventory status data such as on hand balances, current allocations and the shop order number to each allocation is tied, time phased scheduled receipts and associated order numbers, time phased gross requirements, computer planned orders, firm planned orders, pegging data, and linkages to the item master file(Laufer,1984) .

2.1.2 MRP Outputs

Following are the three principal outputs of MRP I module:

2.1.2.1 Purchase Order Releases

This output schedules the quantity and time period in which purchasing should plan to issue a purchase authorization.

2.1.2.2 Schedule of Planned Factory Releases

This output schedules the quantity and time period in which production control should plan to issue a work order authorization.The schedule of planned factory order releases becomes a primary input for Capacity Requirement Planning.

*In many cases, requirements change daily. A computer based material requirements planning system automatically recalculates the requirements for sub-assemblies and components and reforms planned order releases to meet the shift in the demand.

*__The material planner works with three types of orders__ : planned, firm planned and released.

Computer Planned Orders(CPO)*:* Computer planned orders are automatically scheduled and controlled by the computer that is formed in the computer and will be deleted and recalculated.As gross requirements, projected available inventory, and scheduled receipts change, the computer recalculates timing and quantities of planned order releases. The MRP I program recommends to the planner the releases of an order when the order enters the action buckets but not release the order.

Firm Planned Orders(FPO): The computer planned orders are merely recommendations from the MRP II system.These orders will only be released by the planner when the correct time arrives.

FPOs are used to effect one-time deviations from standart item master data or system logic without modifying the item master data.FPOs include a heavy administrative cost because the computer is prevented from performing normal MRP plan and human planner must basically perform the entire MRP plan for this part.It should however be noted that although a firm order can not be changed automatically by the computer, the computer will stil recommend changes based on MRP I logic through exception and action messages.

Releasing or Opening the Order*:*It is the process of releasing or orders to the shop or to the vendors. Since the objective of MRP I is to have material when it is needed not before orders sould not bereleased until the order release date arrives.The MRP I logic is to provide a picture of the materials and capacity requirements of the horizon but to await specific action up to last minute(Jamie Y.T. Chang et al,2013).

-__Order release is invoked__. The standart single level BOM is red automatically in the database and displayed as the picking list for the released manufacturing orders.

-Order release is authorization to make or buy. Releasing an order means that authorization is given to purchasing to buy the necessary material or to manufacturing to make the component.

-Computer allocates the required components and capacity to taht order.When a manufacturing order is released,the computer will allocate the required quantities of a parent component to that order.The allocated quantity of components is still in inventory but they are not available for other orders.Similarly, the estimated hours required at various work centers to execute that order are allocated in corresponding work center.

-Drawings,bills of material,route sheets ,move tickets,labor tickets etc. are generated.

-Order review and release process normally takes only a few seconds.

-Order release process can be automated.With up to date data MRP I software, the entire process can be automated to a degree decided by the firm(Toomey,1996).

3.CSF (Critical Success Factors) of MRP (Materials Requirement Planning) Implementation

*Initiator****:*** The person or department championing MRP can affect the extent and rate of acceptance of the system in a company. First of all, it is a basic operation responsibility to implement MRP.

Data accuracy: This is widely recognised as a necessity for operational effectiveness. Due to MRP system calculates purchase and shop flor orders according to the data obtained, in order the system to perform these actions effectively the data that the system has must be correct and up to date.

Top management support: Top management has to be supportive of the MRP implementation effort. Managerial support is necessary to generate acceptance and participation, facilitate project management and promote adherence to formal plans and policies.
Clear MRP goals: Many of problems faced by companies when installing the MRP systems may be a result of their not having established clearly defined, quantified and measurable objectives.

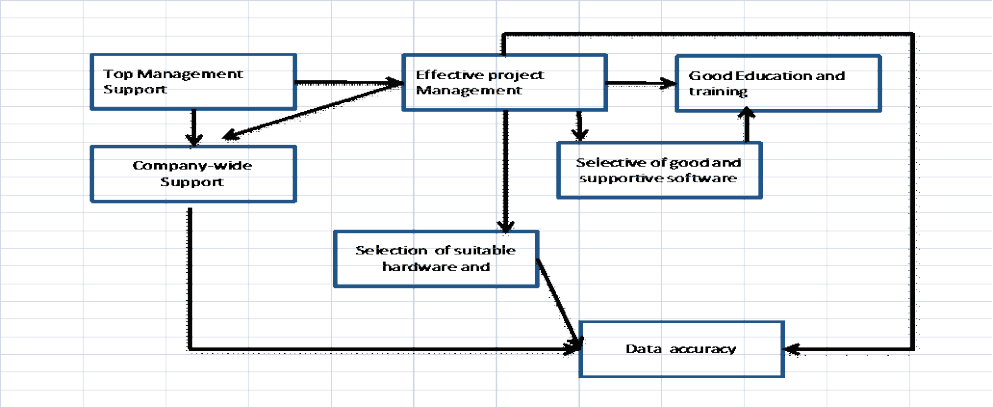


Figure 2- MRP Implementation Roadmap (Burns, 1991)

Support from marketing: Marketing plays a vital role in ensuring successful MRP impletion effort. Fischer indicated that marketing is in charge of forecasting consumer demand, which in turn drives some of the components (e.g. master production schedule, finished goods inventory) of the MRP system. In addition, the common database established through the MRP system allows both marketing and production to create a common game plan to work together.
The level of acceptance and overall usage of the system: In order to implement and benefit from the system, it has to be accepted and used by the related departments in connection.
Support from production: Production is directly affected by the MRP implementation. Production plays a vital role in developing and monitoring performance of some of the MRP components (e.g. master production schedule, bill of materials). It is also responsible for the establishment and maintanence of data accuracy(Sum and Quek,1999).

Followings are the output obtained as a result of successful MRP implementation:
-Improved competitive position. –Reduced inventory costs. –Increased throughput. –Improved product quality.
-Improved productivity. –Better meeting of delivery promises. – Shorter delivery lead time. –Better ability to meet volume /product changes. – Better production scheduling. –Reduced safety stocks. –Better cost estimations.
–Improved coordination with marketing and finance. –Improved morale in production. – User satisfaction (Sun and Queck,1999).

4. Research Methodology

4.1. A Case Study: X Automotive Company

Analysis of X Automotive Production System

A discussed in detail above for the production systems, design of the production system as a whole all depends on the system itself. Due to the having specific characteristics for every system , people responsible for the design of the system have to consider these unique properties and know both the basis of the MRP and JIT. In X Automotive case the same approach applies. It is in the automotive industry and produces final products.Therefore as compared to the other industries, demand is relatively stable and product variants are limited. Although they produce various types of products, the products are relatively similar and products follow the same assembly line in spite of the variations with each other. This case is not the same as for the job shops in which there are a lot of types of products, routings, assembly lines. Also for the customer side the range that they may demand different products is limited with comparison to the job shops. Due to stable demand and limited variations in products, for the supplier side it is also stable requirements and relatively similar products.Therefore it is so difficult as in the job shops to regulate the relationships with the suppliers.Generally negotiations for the components are made at the start of the period and the goods are transferred according to these negotiations throughout the period. It is easy to administrate the relations with the suppliers. For the customer side , demands are collected by ORBIT system from the customers realistically all in the year and transferred to the plants according to the their priorities and limitations. Therefore,demand is pulled from the customer and controlled(levelled) by the factory itself which leads the realistic and stable demand.For the factory inside the basic properties are as follows. As there are huge machines of different kinds in all the pressing, painting and assembly lines, the layout of shops are restricted and relatively scheduling flexibility is poor. Although,there are

different variations of same product, product flexibilty is narrow. Due to stable relationships with the suppliers, the stock levels are minimized which aims to work with minimum stocks and batch sizes and relatively set-up times are minimized. Also,in the factory the shelves are designed with some degree in order to capture the components easily and the storage capacity is limited in case of excess stocks. There are current and future state maps regarding the process flows for the related shops and all the factory was drawn with yellow line in order to regulate the people for the accidents. Additionally,there are a lot of panes to inform employees for subjects(Abdullah, L.M et al,2012).

At first the demands are collected through OVS system from the vendors of X Automotive all in Europe and these demands are allocated to the factories according to their priorities and limitations. There are some targets and adjustments from the administration and also from the sales department which determines so called Yearly Business Plan. Then this yearly business plan is converted to the aggregate plans to determine capacity requirements roughly and also produces material requirements for the long term suppliers. X Automotive uses 40 day period as a real, occurred plan. This 40 day period determines MPS indicating how many cars will be produced, which models will be produced, the order of cars that will be produced, how much overtime will be used and so on. Having decided these values realistically, simultaneously MRP is run in order to determine the component requirements for the suppliers by using the CMMS (Common Material Management System).Suppliers are informed through X Automotive Supplier Network after this process to transfer components. Basically, BOM structure determines the requirements from the suppliers and also from the shops which we use in classical MRP systems. However X Automotive uses different type of BOM structure which is composed of essentially three parts to define a product. In most cases vehicles are defined according to 80 digit EOC strings which determines the vehicle specific properties making each vehicle distinguishable from each other. Each EOC string defines some features of vehicles named SFI (Structed Featured Index). For example a car with special ABS sysetem defines a SFI system. Therefore each vehicle is composed of these SFI indexes. Each SFI is composed of different types material compositons, that are located under this SFI system. A vehicle composed of different SFI's pulls the materials from the system. This BOM structure is different from the classical BOM structure that levels the materials. As OVS is negotiated between German schedulers and here in Turkey, the vehicles are determined that will be produced in Turkey. Simultaneously, according to the this BOM structure CMMS is run and general material requirements are determined and these chosen vehicles are sent to the PVS pool which schedules the vehicles manually. PVS is worked with the locked period 9-12 days. The scheduling is done manually as mentioned, it is not regulated by the MRP I Scheduling technique as usual.

The following table summarizes the X Automotive Production System:

Planning Process: General MRP II tools are implemented.

- Yearly Business Plan is constructed according to the past data and sales and marketing requirements.
- Aggregate Plan is done according to the business plans and also the real demands coming from the OVS pool taking consideration of the priorities and limitations of the factory.
- These requirements are converted into the MPS plans which shows the numbers of vehicles to be produced, capacity requirements, overtime requirements if needed and the real occured demand for the period of 40 days.

Procurement Process:General MRP techniques are implemented.

- OVS which is negotiated between Germany and Turkey determines the vehicles that will be produced in Turkey factory.
- The determination of Turkey factory requirements automatically triggers special BOM structure of vehicles as in MRP I process.
- All the material requirements are determined after this process and material is supplied according to the JIT principle.

Shop Floor Control: Lean manufacturing principles are intensively applied.

- The job shops are not scheduled with MRP I, they work wşth the lower and upper limitations.
- Value Stream Mapping is constructed for the job shops, current and future state maps are drawn.
- Set-up times are very low.
- The factory works with the minimumu stock.
- The components are supplied just in time with X Automotive Supplier Network.
- The factory is visually designed with the lines surrounding all the factory.
- Continous improvements are done by the all the teams all the time.

In conclusion, X Automotive factory is designed in terms of the both principles of MRP and Lean Production in the factory as per the requirements of the process. The main objective here is to obtain the best solution to the process requirements independent of the classical theoretical approaches. This approaches proves that every production system is independent from the others and if an efficient production planning system and subsequently an efficient working ERP system is desired, every system requires to be analyzed independently and the system must be designed according to the specific requirements keeping in mind the basic approaches such as MRP and Lean Manufacturing.

5. Integration for Efficiency

Although system analysis approach and critical ERP implementation is a must and neccessity, in order to benefit from ERP system as demanded, that can only be done by integrating the production department processes with processes of the other departments through this information system. Therefore, integration of the system provides a lot of benefits such as: decreasing of costs, on-line and accurate control of stocks and processes, data share throughout the company, improvements in processes, development in operational decisions, unique information system, standard and easy business processes, integration of old business systems, unique graphical user-interface, reduction of costs in business, improvements in strategical decisions, strong communication between departments,strong relationship between customer and supplier.

5.1. X Automotive Case

It is also important to integrate the system also with the supplier which makes supply chains more effective.Even if we will analyze the whole X Automotive ERP system, now here we want to indicate supplier and X Automotive ERP system relation as a very good example of system design and ERP integration between departments and also suppliers.

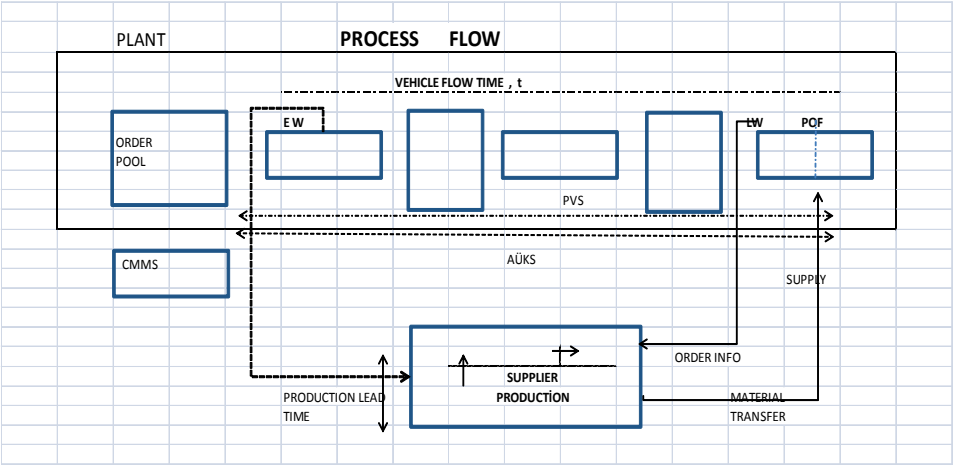


Figure 3-JIT Material Calling (X Automotive, 2006)

The Figure 3- indicates supplier and CMMS3 system and in the factory, presently there are a lot of points which can transfer signals to suppliers via integrated databases in order to call materials from the suppliers. Suppliers can take these signals where they want with the aim of transferring material on time. Suppliers taking these signals according to the company requirements and send materials with the just in time (JIT) principle. Since there are some problems in ERP system as a whole, for the supplier side this case is a very crucial example. The case shows the importance of effective system analysis according to the requirements and design of both processes with JIT principle and also the information system which is integrated also among suppliers which provides a lot of advantages such as: on-time delivery and minimization of stocks.

6. Results-Proposal to the Existing ERP System

At first, X Automotive started with Baan ERP provider company in order to implement the system twenty years ago but it did not work. Due to having a special and very complex BOM structure Baan Company had a lot of difficulties while implementing the system and finally they cancelled the project. After cancelling the Project, X Automotive built up a system which is integrated with the other 150 factories of X Automotive and project is implemented in America .Although it's primary function is to plan and manage the production with the negotiation between Germany and Turkey there are a lot of problems presently that system has. Firstly, it functions as MRP II system that means the system has no connection with other departments. In the Figure-4 the dashed lines arcs indicate data transfer through information system and the other arcs indicate different types of information. Here, X Automotive developed an ERP system by adding on software which are integrated to each other only with the critical points. This kind of improvements made the system unintegrated and inefficient (Daniel,Y. Guide,T,1997).

Therefore, there occurs alot of deficiencies in the system and also in data transfer and processes. Due to these facts in the system for example, sometimes sales department accepts an order which the factory can not make such properties of cars. In some cases product development makes some changes but this change (engineering or bill of material change) can not be transferred to the CMMS3 system on time which calculates material requirements for the factory. For example, OVS(Optimized Vehicle Scheduling) These EOC is central part of this system and it also controls the stocks the day after they are determined and decreased according to the special type of bill of material structure which depends on the EOC codes. EOC codes are unique properties of the vehicles which defines the material requirements

of that car. Additionally, PVS(Plan Vehicle Scheduling) which schedules the vehicles manually to the lines is not fully integrated to the CMMS3 part, it is integrated only in some critical points and the rest is done with other types of information transfer. This deficiency produces problem for the material requirements for the shop floors.

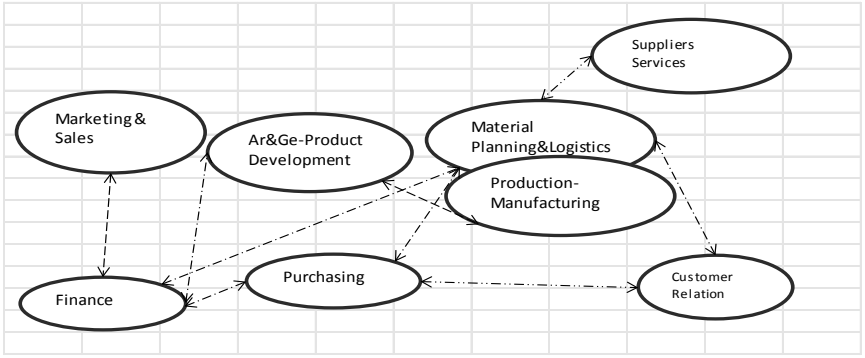


Figure 4: X Automotive data and information flow

6.1 Closer Look At CMMS3 Part and Deficiencies

CMMS3 part is the material requirements planning part of the X Automotive ERP system. It generally regulates the planning, procurement and control of the production. ERP system is consisted of three main parts; OVS, PVS and CMMS3.OVS is the part that determines the vehicles that will be produced in Turkey with the negotiation Germany according to the matrix organization. This selection is done for the priorities and limitations of the Turkey factory. After the selection, these vehicles automatically triggers special BOM structure which is consisted of EOC codes that determines the material requirements of that car. Therefore, CMMS3 part is simultaneously activated.CMMS3 part is directly related to the determining of material requirements and also procurement requirements for the suppliers inside and outside of the factory. The other element of the ERP system is PVS (Plant Vehicle Scheduling).PVS is the part that schedules the vehicles to lines in the lock period of then days and vehicles are scheduled according to the constraints that were determined by PVS part. Although this system functions obtaining the targets, there are a lot of deficiencies that this system has. OVS is the part that controls the inventories of the factory but this is done after one day. At the end of the day, the vehicles are counted and the stocks are decreased. Therefore they can not follow the stocks on-line but one day after. *PVS part is not integrated with CMMS3 part.* For the materials requirement PVS part is informed by the other forms of data transfer and sometimes informed lately. The changes made in the product development part is sometimes transferred late which causes inefficiencies. Due to the making engineering change manually, there are a lot of people working in this department which causes a lot of waste work-days.
At first, X Automotive started with Baan in order to set integrated information system, due to the difficulties for structuring BOMs in the system, but it did not work. Hence, X Automotive developed the system in America but it takes only consideration of manufacturing resource planning not the other extensions. They developed other extensions with add-on software and the system became nonintegrated. This is the basic reason of all deficiencies and inefficiencies.

6.2 Proposal to Existing ERP System

As mentioned that the basic reason for the deficiencies and inefficiencies behind X Automotive ERP System is add-on software and unintegrated information system, this structure causes problems that the factory faces. Our proposal to the existing ERP system is to integrate all the processes with regard to the nature of the production by using a unique and shared database. In order to prevent duplication of data and all the problems that the factory faces, all the departments must be informed on-line through an integrated database.

As shown in **Figure-5,** according to our proposal, this structure must be formed through MP&L (Materials Planning and Logistics) department because all the production and related processes are done with respect to the priorities and limitations of the factory which is decided by this department. This integration process through a unique database can only be done by defining bill of materials, material masters and work centers in this database and all the other components of the production must all also be defined in this system. Therefore, all the other departments such as OVS, PVS and CMMS3 department and also the other related departments can enhance the collection of on-line, real time, unique data. Only by this way, X Automotive may overcome such deficiencies and problems that occure in the coordination of the departments and also within the department regarding the planning, management and control of the production.

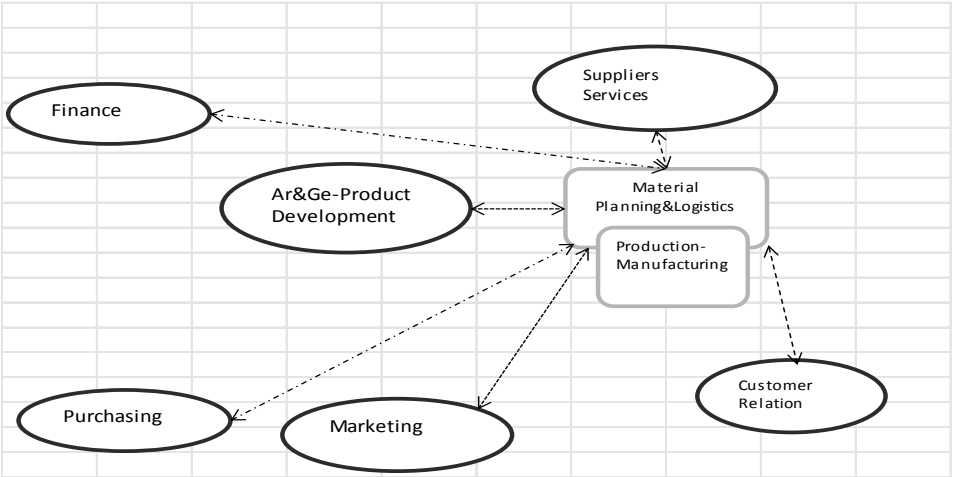


Figure 5: Proposal to the existing system

7. Discussions and Evaluations

In this study it is aimed at efficient production design and subsequently implementation of ERP system systematically and with success, there have been a lot of findings which can contribute both academic knowledge and business practices. For the production system design, with consideration of MRP and JIT production management techniques it is concluded that generally the system trends to be in hybrid state which means the combination of MRP and JIT systems. Therefore, there is no such rule that the production system will be designed either MRP or JIT. This approach is called system analysis approach.

For the ERP implementation, it is necessary to take into consideration of critical success factors and also integration with other modules and suppliers.This can only be done by using a unique and integrated database in order to prevent inefficiencies. The analysis of X Automotive ERP system also indicated that add-on software and unintegrated databases cause deficiencies and inefficiencies in the production system. There is certainly an ideal distribution of role of each system (PLM, ERP, and MES). From production point of view, ERP and MES would focus on the production management without product and manufacturing system data management contrary to ISA 95 specifications. Therefore, the PLM system would focus on product design, industrialization step and the manufacturing system design. This ideal solution may be feasible for the big enterprises (aviation, automobile, pharmaceutical, etc.) but it will certainly not be feasible for Small and Medium Enterprises (SMEs). Indeed, full integration of industrialization step within their PLM system would be too costly. Therefore, the SMEs lose probably their flexibility and responsiveness.

Traditional production systems offered no integration within the organization. Most production planning lacks coordination with the organization's manufacturing, particularly at the operational level.Organizations want material resource planning, JIT systems, and capacity planning. ERP systems offer both production planning and materials management

- Facilitating communications along the supply chain
- Improving e-Business opportunities

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RFID Based Warehouse Management System in the Wool Yarn Industry

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Abstract

Radio frequency identification (RFID) is one of the significant technologies that provide remarkable benefits such as increased traceability, accuracy, security and efficiency. In wool yarn industries, managing the work-in process inventory is not efficient enough since semi-finished products cannot be followed accurately. The conventional method in the industry is that goods in process, wools, are usually stored in bags or kept as clews. Since filling wools into bags and removing wools are done manually and each bag does not have to be filled or emptied fully, there is not a standard weight of the filled bags. The amount of wools in a bag cannot be estimated unless it is measured after filling and emptying. On the other hand, managing work in process inventory remains problematic even if each bag or clew is measured, since the measurement and the recording of results are made manually. Over the long run, inaccuracies caused from human based mistakes create unreliable useless warehouse system with inefficient operations and additional labor cost. This study considers a case study for the use of RFID technology in the wool yarn industry. Wool is filled into bags or stored as wool clews. While stock movements are being monitored automatically, a special designed scale which is working in sync with RFID reader is integrated to the system. The aim of this study is to demonstrate architectural framework of the RFID based information system for the wool yarn industry and also to indicate the usability of RFID technology in this industry.

Keywords
RFID system implementation, architectural framework, wool yarn industry

1. Introduction
Information technology has changed the business life considerably that companies resisting to use of it in global competitive environment may easily lose their power. There are many new technologies that surprise users by providing vital support as well as enabling different and better processes. Radio frequency identification (RFID) is one of the significant technologies that provides remarkable benefits such as increased traceability, accuracy, security, efficiency, real time controllability and reduced labor cost. It is possible to see a variety of well accepted applications in many industries. The most common areas for RFID applications are logistics and supply chain management (Zuo et al., 2012); besides, RFID based implementations according to application area appear as manufacturing, warehousing, transportation and traffic, retailing, digital documents, agriculture, environment, perishables, fuel and chemicals, clothing, healthcare, sports and games, human identification, finance and military (Ilie-Zudor et al., 2011).

In wool yarn industries, managing the work-in process inventory is not efficient enough since semi-finished products from different stages cannot be followed. A common conventional method in the industry is that goods in process are usually stored in bags or kept as clews. Since filling wools into bags and removing wools are done manually and each bag does not have to be filled or emptied fully, there is not a standard weight of the filled bags. The amount of semi-finished product in a bag cannot be estimated unless it is measured after filling and emptying. The weight of each wool clew is also not standard. On the other hand, managing work in process

inventory remains problematic even if each bag or clew is measured, since the measurement and the recording of results are made manually. In a long term period, inaccuracies caused from human based mistakes create unreliable useless warehouse system with inefficient operations and additional labor cost.

This paper considers a case study for the use of RFID technology in the wool yarn industry. The company covered in this study has aimed to maximize the level of traceability and ensure a more organized warehouse by utilizing shelf system and RFID technology through its processes so that maximum efficiency of work in process and cost reduction could be achieved. Nine different works in process warehouses exist in the company because of different production process. RFID system implementation has been carried as a pilot project for one warehouse. Analysis based on the pilot project result has been asked for the decision of further implementation to the other eight warehouses. The aim of this paper is to demonstrate the implementation and architectural framework of the RFID based information system for the wool yarn industry. In this study, RFID based work-in process goods warehouse management system is implemented in order to achieve better process with real time controllability of work-in process inventory. The architectural framework of RFID based work-in process goods warehouse management system for the wool yarn industry will be explained.

The remainder of this paper is divided into five parts. Section 2 covers a review of previous studies on the application of RFID technology applied to different fields. In section 3, a real case is illustrated in order to show how RFID technology could be useful for the industry. Section 4 explains the architectural framework of the RFID based information system for the wool yarn industry. Section 5, concluding notes and possible future directions are provided.

2. Literature Survey

Radio Frequency Identification (RFID) is applied to many different areas but especially utilized in logistics and supply chain management systems for identification, tracing and tracking. These conveniences provide monitoring the system with more precise and real time data (Zuo et al., 2012). In logistics, RFID provide increasing capacity and labor productivity by reducing operational mistakes (Mingxiu et al., 2012). In addition to supply chain management systems, Mishra et al. (2012) used RFID active tags for determining rock and metal location in mining services. Because of long reading ranges for specifying proximity is essential in mining actions, they integrated RFID technology to take precautions for hazardous areas. At the same time, in construction, RFID enables to counteract collusion accidents (Chae and Yoshida, 2010). As a different application area, RFID ensures evaluating fabric swatches, and helps select the most appropriate pattern for new product development process in fashion industry (Choy et al., 2009). In accordance with intelligent port, RFID could be utilized for identifying legal and illegal movements and risk situations of cargo (Siror et al., 2011). For monitoring food safety data with defining critical points, RFID supplies data about ingredients and manufacturing (Hong et al., 2011). In wood industry, RFID could be beneficial with RFID-marking connects to physical objects which provides analyzing of the supply chain (Björk et al., 2011).

This study is based on literature from two main areas: RFID system in warehouse application and architectural framework of RFID

2.1 RFID System in Warehouse Application

Ilie-Zudor et al. (2011) prepared a survey about applications and requirements of RFID techniques. In this study, they mentioned RFID based implementations according to application areas including manufacturing, warehousing, transportation and traffic, retailing, digital documents, agriculture, environment, perishables, fuel and chemicals, clothing, healthcare, sports and games, human identification, finance and military. According to survey, picking management, receiving management and shipping management are the application cases which are grouped in warehouse application areas.

Wang et al. (2010) put forward that most of previous studies about warehouse management system ignore the inaccuracy of the inventory and base on their argument to the assumption of correct inventory record while this assumption does not match the reality. Rekik (2006) also mentioned about inaccuracy of the inventory and present the sources of errors for the inaccuracy; transaction errors, misplacement errors, damage and spoilage, theft and supply errors and he indicate that RFID technology eliminate the inventory record errors. Lim at al. (2013) conducted a comprehensive literature analysis of the articles from year 1995 to 2010 and show the current state of RFID in warehouse. In this study, they assert that RFID increased accuracy in warehouse. “In a plane warehouse which is defined as a normal warehouse without high racks and automatic equipment”, products are placed disorderedly, throughput time is longer, and more mistakes emerge due to man-made operations (Wang et al., 2010). RFID technology changes the process and alters the way things are done which would not be possible in man-made systems. For instance, Poon et al. (2009) described a RFID case based logistics system in a

dynamic warehouse that enables resource location determination, as well as automatic assignment of them. Also, Ren et al. (2011) indicated the lack of accurate, active and embedded information flow in construction sector for material planning and monitoring inventory. With integrating RFID technology, real time material planning and dynamic ordering process could be applied in current site working system.

2.2 Architectural Framework of RFID

Since the individual historical data of each item transaction can be recorded, RFID technology enables enormous data storage. To be able to manage this information, a data structure should be established. Papers dealing with deployment of RFID information infrastructure mainly focus on separating related stages from capturing data to evaluation the information. For instance, Ngai et al. (2008) proposed five phases of RFID application in sushi management system: data capturing front end, data capturing layer, processing module, work flow layer and application layer. Similar with Ngai et al. (2008), Satoglu et al. (2013) suggested a general architectural framework comprised of physical layer, data capturing front end, data capturing layer, processing module and application layer for RFID implementation in library management system. Lee et al. (2013) also emphasized RFID implementation stages as physical information, RFID checkout stage (tagging), reading and middleware layers, and application layer works with middleware layer tools such as SCM, WMS, and MES etc. In addition to Lee et al. (2013), Martinez-Sala et al. (2009) introduced MEGASTAND system architecture which is a combined structure of RFID, middleware, customer and control framework. In this study, Martinez-Sala et al. (2009) indicated the importance of both hardware and software adaptation to the whole partnership between the firm and customers. Specifically, Björk et al. (2011) and Siror et al. (2011) concentrated on EPC (electronic product code) architecture which is a sub system of RFID. While Björk et al. (2011) constituted EPC framework based on measurement transaction, EPC capturing, EPC repository and EPC assessment, Siror et al. (2011) represented the integration of EPC network services, end user and partner end user. Note that Siror et al. (2011) utilized the similar structure appeared in Björk et al. (2011). In this study, RFID architectural framework is clarified associated with the proposed information structures appeared in these previous studies. Additionally, the framework considered both of hardware and software requirements of RFID and their interactions with each other.

3. Case Study: RFID Implementation Project at Ormo Company

The case study describes the RFID application which is developed by Portneo A.S. and supported by ITU RFID Research and Test Lab for the ORMO Group Company. The company has been serving for the textile industry for over 50 years. Nako Iplik and Ormo Art are other subsidiaries of Ormo Group. The company located in Bursa, Turkey currently employs 1.500 employees in its total 200,000m^2 plant which has 100,000m^2 closed production area. At this state-of-the-art plant combing and dying processes are done in addition to hand-knitting, knitwear and weaving yarn production. The total production capacity of the company is over 10.000 tons of yarn per year, and they export nearly 70% of their total production to more than 70 different countries. USA, Germany, England, France, Japan, Taiwan, Spain, Scandinavian Countries, Italy, Brazil, Russia, Korea are some of the main export markets of the company. Nine work-in process inventories exist because of the different production processes which are raw material preparation, dyeing, spinnery, packaging-balling, factory-subsidiary stoking, and shipping. Through these processes, the firm intended to maximize the visibility and traceability of work in process goods (wool) by utilizing RFID technology. Also, a shelf system was designed in order to eliminate the problems caused by disordered placement. RFID pilot project was implemented to the warehouse, at which a work-in process between dyeing and spinnery is conducted.

3.1 Previous WIP Warehouse System

As appeared in industry, wools are stored in bags or as clews. Once wools arrive to the warehouse, they are filled into the bags or turned into a ball of wool and then their weights are measured with weighting scale. Recording bags to the inventory are performed manually. When shipment for production is required, wool clew are directly sent to the production. Beside this, for the bagged wool, certain amount of wool are emptied from the bag and pushed into the production. Information about remainder WIP goods amount and shipped WIP goods amount to production are recorded by employees, and of course, manually.

From Figure 1, it is seen that work in process stock (wool) was kept in bags and bags were placed on the floor disorderedly in previous warehouse where shelf system and RFID had not been applied yet. When any kind of wool is needed for production, the operator had to find the correct type of wool among this disordered warehouses. Additionally, the amount of required wool had to be prepared by the operator accurately.



Figure 1: Disorderedly placed work in process stock (wool) before RFID and shelf system applied

3.2 Problem Analysis

A common conventional method in the industry is that goods in process are usually stored in the bags. Since filling those into the bags and removing those semi-products from the bags are done by humans and each bag does not have to be filled or emptied fully, there is not standard weight of filled bags. The amount of semi-finished product in the bag cannot be estimated unless it is measured after filling and emptying. On the other hand managing work in process inventory remains problematic even if each bag measured, since the measurement and recording of the results are made by manually. While the bags are recorded into the system manually, some fundamental issues are come into the existence;

- Due to the number of bags is manually counted; the firm could not be able to follow the wools in the bags.
- Manual records causes wrong or ignoring deregistration of goods.
- Because of unreliable records, one can confuse the bags or could not be able to know what kind of wool is in the bag.
- While employees are busy, they could not be mindful of WIP records.

Also other problem encountered is seen while preparing wool for production. The amount of required wool had to be prepared by the operator manually in a disordered store condition. For all those reasons, the operator's memory and experience played critical role in company with his carefulness. Meanwhile, if incorrect type of wool was sent to the production by mistake, the wool had to be returned to the warehouse and it would cost extra manpower and time. Furthermore, they might be used in production and cause improper product. In a long term period, inaccuracies caused from human based mistakes create erroneous warehouse records and unreliable system with inefficient operations and additional labor cost. When the work in process goods records does not match the realty it leads to difficulties in planning activities and warehouse management.

At the end of the problem analysis, critical issues which required improvement were identified as below;

- Redundant inventory cost
- Redundant labor cost caused by inefficient warehouse operations and non-value added activities
- Inadequate control system caused by disordered placement and insufficient traceability and visibility of work in process goods
- Inefficient manual processes in work in process goods warehouses
- Inaccuracies of records
- Difficulties in planning activities because of the inaccurate data and lack of real time data records.

3.3 Developed RFID System for WIP Warehouses

In the case study, semi-finished goods storage processes were reconsidered. By utilizing shelf system and RFID technology through processes, achieving maximum level of traceability and organized warehouse is targeted. Therefore, the company aims to minimize semi-finished goods inventory level and maximize operational efficiency in work in process warehouse in order to adapt to increasing competitive environment by reducing cost. For this purpose, RFID system is implemented with a shelf system which consisting of 36 steel cases. Each of these cases in the inventory comprises of RFID tags that contain information about the cases. In addition to these, the inside of storage has completely covered with the Wireless Network.

Software is also developed for the system at Microsoft Net platform in order to control the status of semi-finished goods warehouse inventories. Received reports and the program list parts that are related with the programme has been developed as a web-based parts. It could be used from any computer connected to the network and php programming language is utilized. There is two important phases of the software: Tagging phase and tracing the tagging raw materials (WIP goods).

In general, the first phase of the program is the section where raw materials (WIP goods) are labelled. Unlike traditional practice, in the case study, there is not individual product to follow. Wools are filled into the bags or kept as clews and passive RFID tags are attached to each bag or clews in order to identify the wool details. In the implemented system, hardware components are appeared as desktop computers, digital scales and desktop RFID Reader / Writer Device. Desktop computer is depended on database via Ethernet Server, also connected with RFID reader / writer device via USB and additionally depended on digital scales via serial port. The scale is working with RFID reader in sync. The amount of work in process inventory is measured and recorded automatically by the system. Figure 2 shows that use of automatic digital weighing scale and RFID reader while measuring the weight of RFID tag attached bag. Figure 3 shows that the users interface appeared during associating the measurement result and other information about wool to the attached tag on wool yarn bag.



Figure 2: Automatic digital weighing scale

While the new raw materials (WIP goods) are first received to the warehouse, they are filled into the bags or turned into clews. Then, RFID tag is attached to the bags or clews for further tracking of wool yarns. The following steps are performed in order to associate wool information to the RFID tag.

- Raw materials are first placed on the scale and the weight information is transferred to the application in computer via the serial port,
- A suitable ID is found from application database and RFID tag and this ID is written into RFID tag,
- The user makes the database registration as seen in Figure 3 by using the ID which user wants to match any other information.
- The RFID tag is placed on the raw materials.

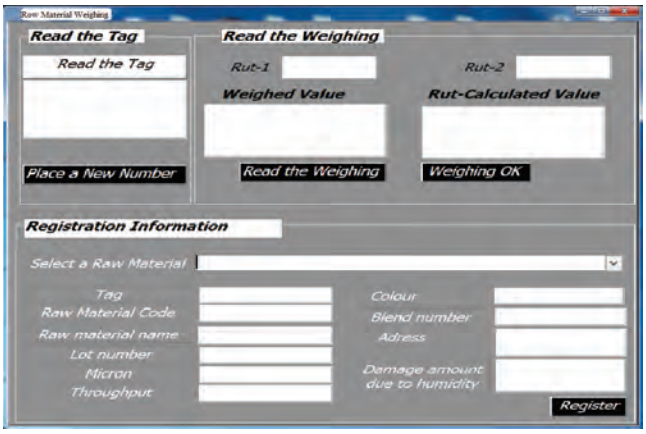


Figure 3: User interface for associating wool yarn information to the tag

At the end of this process, other information included weight information paired with this ID that has unique RFID tag on the raw material could be placed into database. Tagged bags and clews are sent to semi-finished goods warehouse to be placed. When wool yarns are required for the production, clews are directly sent to the production, on the other side, only some of the wool is discharged from the bags and sent to the production. Rest of wool in the bags is sent to the digital scale for the measurement of these wool yarns weights. After measurement, new updated weight information is associated to RFID tag.



Figure 4: RFID gate with sensors

The second phase is the movement of the tagged raw material from RFID transition point to the warehouse receipt or removed section. Hardware components are consisting of 660R Siemens RFID reader, four antenna, computers and sensors. Computer is connected with server database and RFID reader via Ethernet and also linked up with sensors via USB ports. Operating system is Windows 7 in this computer. The application running on this computer examines the accuracy of the read RFID tag in the transition point by controlling the database and the check out and check in status is processed as receiving semi-finished goods to warehouse or sending them to production. Associated information on tags is captured by reader on RFID integrated gate and the stock of work in process goods is automatically updated according to real time data. Movement sensors have been used in order to understand the direction while receiving and leaving goods occur. Warehouse exit and entrance gate with integrated RFID system and movement sensors allows the system perceiving the direction of wool yarn bags movement whether it is in or out and reading and recording of leaving and receiving info about the wool yarn bags automatically. This process is transmitted to the user on the computer screen. The gate and the devices are seen in Figure 4. By eliminating manual process, reducing labor cost and increased accuracy have been obtained



Figure 5: Wool yarn bags are stored in shelf and carried in steel cases

By the use of RFID technology and shelf system, work processes have been changed considerably. Wool yarn's bag started to be carried and stocked by using steel cases which are part of the shelf system. Figure 5 shows how the wool bags are carried and the shelf system where the wool bags are stored. RFID tag is attached to the product and goes through the process with the product. Generally, RFID tag leaves the product at the end of the process. On the other hand, the RFID application in wool industry mentioned in this paper, tags are used to measure sack weightiness. Each tag remains on the bags until the bag is emptied and used repeatedly. Therefore, the company takes the advantage of utilizing tags continuously.

Additionally, there are two applications that are developed in Microsoft.Net environment and working on (Psyion Teglogix) hand-held terminal. MSSQL database is used for these applications. Handheld terminals are used in the new system in a beneficial way such as counting process of physical inventory, wool yarn bags placement and picking process to the warehouse. The new system provided that faster inventory counting and increased accuracy of semi-finished good placement and picking.

4. Architectural Framework

RFID is an old technology. However, it is emerging technology for many industries since the cost and size of the equipment required were limiting the use of it until the recent past. It provides many benefits such as increased traceability, declining operational time and cost. Therefore its usage became widespread in several areas. On the other hand, there is another important factor that triggers the usage of RFID technology. Todays' information technology allows the storing and managing of huge data/information. RFID provide real time data about the product however the data would not be (that much) meaningful if the recent information technology did not support to keeping, processing, sharing such a huge data. Therefore integration of RFID with the information system is critical.

In this section, the architectural framework of the RFID system for the wool yarn industry will be explained. It has five cross sectional layers: Physical layer, data capturing front end, data capturing layer, processing modules, application layer. The layers are shown in Figure 6 and they are demonstrated as follows:

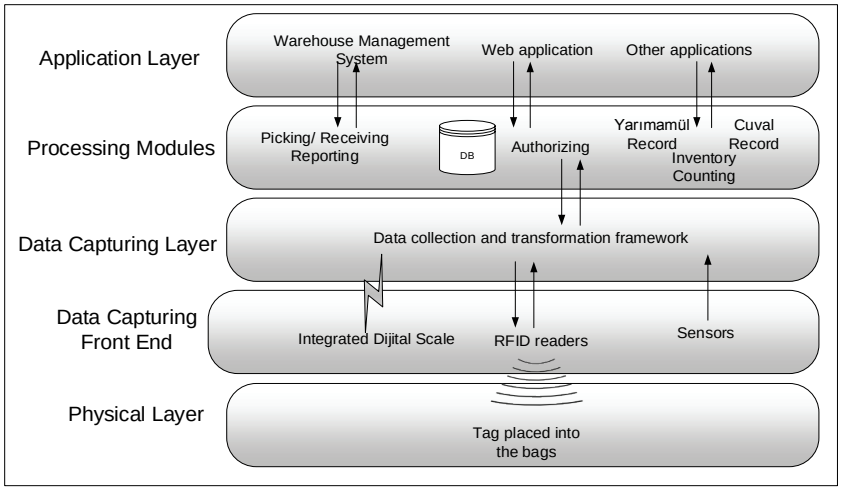


Figure 6: Architectural framework

4.1 Physical Layer

The first layer includes RFID tags that information about wools is kept in. Tags are inserted into the bags. Before replace the each tag to the bags, information about wools that will be filled in to the bags is recorded to the tags. If wools in the bags are used or new wools are added to bags, information carried by the tags will be automatically updated.

4.2 Data Capturing Front End

The second layer includes RFID readers, integrated sensors and digital scale which are used for data collection. As the work in process inventory received or sent from warehouse and also as their weight measured, the real time information is captured by the data capturing front end layer. Sensors let the system understand that the movement of wool bags is either input or output. There is a special designed digital scale working with RFID reader in sync. It provides the system automatically measuring the change in weight of wool bags. The amount of work in process inventory is measured and recorded automatically by the system. The reader has system software and antenna providing interaction between reader and tag. RFID readers provide functional application for writing information to the tags and reading information from the tags. The readers' antennas are located different place in warehouse such as entrance, in front of scale.

4.3 Data Capturing Layer

The third layer is a kind of software that acts as a bridge between the data capturing front end units and processing modules. Basic functions of this layer are;

- Converting RFID information to business information
- Distributing RFID information to business processes
- Filtering information
- Triggering business process from RFID process and vice versa
- Managing RFID devices
- Consolidating RFID information (Cardiel,I.A., 2012-middleware for RFID technology)

These functions provide clean, accurate useful and purposeful information from the huge amount of data stack captured by the readers, sensors and digital scale.

4.4 Processing Modules

The forth layer is processing modules which request RFID and other units events from data capturing layer and generates report and event include data such as historical data, time and location data. Some event and reports of this layer are picking and receiving reporting, authorization, work in process-good inventory record and inventory counting. The event and reports are stored in a relational database system and shared with application layer.

4.5 Application Layer

The last layer is the application layer where the core business processes are fulfilled. Application software at this layer such as warehouse management system, WEB applications and etc. support the business processes, assist in inventory and asset management. Required application interfaces are all located at this level. These interfaces

allow the user to utilize the applications such as entering the related data to the computer for querying the stock level of any WIP goods and gathering the inventory detail from the system. Warehouse management system is the main application of this level and some important existing user interfaces of WMS allow the user to use the below functions:

- Associating wool yarn information to the tag,
- Updating the stock record according to the received and leaving yarns to/from the warehouse
- Updating the amount of yarn in the each bag as it change during the filling or emptying them.
- Querying the stock level of yarns from the system
- Counting the physical inventory
- Querying the wool yarn bags or crew placement and picking to/from the warehouse

5. Conclusion

This paper focused on a case study that includes the use of RFID technology in the wool yarn industry in where maximizing the level of traceability and ensuring a more organized warehouse by utilizing shelf system based on RFID technology. In the former system, since number of bags is manually counted, the firm could not be able to follow the wools in the bags. Additionally, manual records cause faults in deregistration process. Because of unreliable records, one can confuse the bags or could not be able to know what kind of wool is in the bag. All these troubles conduce to redundant inventory and labour costs, inadequate control system caused by disordered placement, inefficient manual processes in work in process goods warehouses and inaccuracies of the records. The proposed RFID based shelf system overcomes these issues in terms of eliminating manual process, reducing labour cost and increased accuracy. For example, handheld terminals are used in the new system in a beneficial way such as counting process of physical inventory, wool yarn bags placement and picking process to the warehouse. In other words, the new system provides faster inventory counting and increases accuracy of semi-finished good placement and picking. In addition to physical implementation, architectural framework is also presented for the wool yarn industry.

For future studies, investigation of the RFID applications' economic feasibility would be considered with real data extracted from the applied RFID system.

Acknowledgements

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Biography

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Measuring the Efficiency of Intellectual Capital: for the Case of Fabricated Metal Products, Machinery and Equipment Sector

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Keywords
DEA, intellectual capital, VAIC

1. Introduction
Manufacturing sector in Turkey provides nearly 20% of the national income. In today's knowledge economies, where value added is created not only by physical assets but also by intangibles, to be able to sustain the success and growth of the manufacturing companies, determining and improving the efficiency level of intellectual capital of companies is crucial. Among all manufacturing sub-sectors, fabricated metal products, machinery and equipment sub-sector is one of the sectors in which intellectual capital is expected to have a significant effect on company performance. The purpose of this paper is to determine the intellectual capital efficiencies of fabricated metal products, machinery and equipment companies on the Istanbul Stock Exchange (ISE) using VAIC (Value Added Intellectual Coefficient)

2. Methods
In this study VAIC (Value Added Intellectual Coefficient), a method proposed by Pulic (1998) is used to assess the impact of Intellectual capital dimensions on company performance by adopting Data Envelopment Analysis for the period 2004-2012. Data required calculating the VAIC value and its dimensions and output measures were obtained from the annual financial reports of the companies.

3. Results
The results will allow fabricated metal products, machinery and equipment companies to see their position among their rivals in the sector in terms of intellectual capital efficiency and will help them develop strategies to enhance their performance and gain competitive advantage.

4. Conclusions
Since there is a general acceptance in the literature that intellectual capital has an increasing return to scale structure, CCR model (which is only valid for Constant Return to Scale) is not applicable for this study. In order to handle

with the change in the scale, for the data on hand techniques selected are BCC model with increasing return to scale, and Malmquist Index is used. The selected inputs are; human capital efficiency (HCE) coefficient, structural capital efficiency (SCE) coefficient and capital employed efficiency (CEE) coefficient as the components of intellectual capital are selected. Within the period 2009 to 2012, the relative efficiency of fabricated metal products, machinery and equipment companies on the transformation of IC into firms profitability is investigated. According to the results gathered. Firms can be divided into three sub-groups. First one consists of the firms that forms the efficient frontier with efficiency value is equal to one, which are EMNIS, ALCAR, BFREN, VESBE and EMKEL. Second group consist of the firms that are open for improvement namely; DITAS, TMSN and OTKAR with increasing Malmquist value through out the considered time period. The results release that the remaining firms are both have the lowest relative efficiency and Malmquist value lover than 1 consists the third group. Their scorings show that, their relative performance diminishes so they should increase their efficiency according to the benchmark firms immediately.

Biography

Fethi Calisir is a Professor of Industrial Engineering at Istanbul Technical University. He graduated with a BS from Istanbul Technical University in 1989, a MS from the University of Miami in 1993, and a PhD from Purdue University in Industrial Engineering in 1996. His current research interests include IT Project Management, Software Usability, and Human Computer Interaction. His research papers have appeared in Computers in Human Behavior, Computers & Industrial Engineering, Total Quality Management, Accident Analysis & Prevention, Technovation, Managing Service Quality, International Journal of Information Management, Management Research News, and Internet Research.

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Balancing U-Shaped Assembly Lines by Considering Human Factors

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Abstract

Assembly lines are mass production system which improve productivity, flexibility and production quality in industrial systems. Compared to traditional straight lines and parallel lines, U-shaped assembly lines have lots of advantages in terms of performance of workers and production system. Especially, by means of U-shaped layout, improved balancing of assembly lines can be achieved. Moreover, the implementation of Lean Manufacturing and Just in Time Production (JIT) systems entail U-shaped assembly line (Chiang, 2006). One-piece flow which significantly reduces manufacturing lead times is facilitated by this type of facility layout. Multi skilled workers can handle more than one machine in U-shaped assembly lines. An important issue in U-shaped line balancing problem is the consideration of human factors. There are a small number of studies about human factors in the literature. Some of the factors are the learning effect (Biskup, 1999; Toksari et al., 2008) and task time variability due to human factors (Becker and Scholl, 2006; Chiang and Urban, 2006). The purpose of this study is developing a methodology for balancing U-shaped assembly lines while considering the human factors to improve productivity of the production system.

Keywords
U-shaped line balancing, just in time production, human factors

1. Introduction
Assembly lines are flow-oriented mass production systems where the productive units or stations perform the operations. An assembly line consist of a sequence of *m* stations through which the product units proceed. Each station performs a subset of the *n* operations necessary for manufacturing the products. The design of an assembly line requires task to be grouped into stations such that the precedence relations among the tasks are satisfied and some performance measures are optimized. This problem known as Assembly Line Balancing Problem (ALBP). As a result of several simplifying assumptions, this problem was called Simple Assembly Line Balancing Problem (SALBP) (Baybars,1986).

Traditionally assembly lines are arranged in a straight line. However, U-shaped lines are used especially in lean production environments (Miltenburg, 2001). The associated line balancing problem is called UALBP which was introduced by Miltenburg and Wijngaard (1994). Compared to the traditional straight lines and parallel lines, U-shaped assembly lines offer several advantages in terms of performance of workers and production system effectiveness. Especially, by means of U-shaped layout, improved balancing of assembly lines can be achieved (Scholl and Klein, 1999). This is due to the fact that precedence constraints of the U-shaped lines are more relaxed than those of the the straight lines, such that, a task can share a station with any of its predecessors and/or any of its

sucessors (Scholl and Klein, 1999). This provides solution of the problem with a better line efficiency and lower line imbalance.

Moreover, the implementation of Lean Manufacturing and Just in Time (JIT) production systems entail U-shaped assembly lines, since one-piece flow can be implemented which significantly reduces manufacturing lead times is facilited by this type of facility layout. Due to high capital requirements when installing or redesigning a line, its configuration planning is of great relevance for practitioners. Cheng, Miltenburg, and Motwani (2000) proposed the following factors that enhanced the wider acceptance of U-shaped lines.

U-shaped line is preferred to a straight line because of its volume flexibility. By increasing or decreasing the number of operators on the line, a company can adjust the production rate as required. This level of volume flexibility is harder to obtain with a straight line. Besides, since walking distance is shorter in a U-shaped than on a straight line, it is easier for an operator to oversee several work station.

Another advantage of U-shaped lines is that the number of workstations required is never more than that required by a straight line. There are more possibilities for grouping tasks into workstations on a U-line. Moreover, a U-line eliminates the need for special material-handling equipment such as conveyors and other special material-handling operators those are necessary in straight line. Instead, production operators move products from machine to machine.

Moreover, U-shaped lines offer organizational and social advantages. The operators re expected to become multi-skilled and they are able to manage several tasks which provides job-enrichment. This prevents the daily activities of the operators from becoming routine. Since the operators can see the end product, they are motivated to achieve a higher quality level (Scholl and Klein, 1999). Moreover, a better visibility, communication and team-work can be achieved by means of the U-shaped lines. This facilitates a sense of belonging, and increases responsibility and ownership compared to a straight line.

For solving the UALBP, Miltenburg and Wijngaard (1994) employed a dynamic programming formulation to solve small problems with up to 11 tasks and proposed a heuristic to solve larger problems. Urban (1998) presented an integer linear programming formulation to solve small to medium sized U-line balancing problems with up to 45 tasks by using standart mathematical programming software CPLEX. Scholl and Klein (1999) developed a branch and bound procedure called ULINO to solve problems with up to 297 tasks. Becker and Scholl (2006) extended the problem by integrating practical and relevant aspects, like parallel lines or processing alternatives. In spite of these efforts, there is a wide gap between the academic discussion and practical applications (Boysen et al., 2007).

Since U-shaped lines are concerned with manual assembly operations, human factor is a vital aspect. However, there is a limited literature on human factors in line balancing. Ergonomic aspects were introduced in line balancing such as physical effort of operators and the risks that they face (Choi, 2009; Otto and Scholl, 2011; Xu et al., 2012), learning effect (Costa and Miralles, 2009; Toksari et al., 2008; 2010), fatigue (Digiesi *et al*., 2009), and workers' skills (Miralles et al., 2007, 2008; Wong et al., 2006). Avikal et al (2013) proposed a CPM based heuristic approach for UALBP, and observed that this approach yields solutions with higher labor productivity.

Learning affect must be considered in line balancing, because as a worker becomes more experienced in performing a specific task, in other words his/her cumulative production quantity increases, his/her task time per one piece of product decreases in a non-linear sense. This fact can significantly cause actual task times differ from the preassumed standard times. However, most researhers assumed that the time of task is independent from learning of worker(s) for repetition tasks. Mosheiov (2001) determined this phenomenon. It has been examined on assembly line balancing problems by only a few researchers so far (Chakravarty and Shtub, 1988; Cohen and Dar-El, 1998; Cohen et al., 2006, Toksari et al., 2008).

In this study, a heuristic methodology that intends to assign tasks to the operators of a U-shaped assembly line is developed. Since the workers have different skills and competence levels in performing assembly tasks due to the learning effect, workers' task performance times may vary from the standard times. An experienced worker can execute a task in a short time, while an inexperienced one can perform the same task in a time longer than the standard duration. Therefore, the learning effect and skills of workers affect the balancing of manual assembly lines. Thus, in this study, the learning effect that is a significant human factor was reflected to the U-shaped assembly line

balancing problem (UALBP). This is a unique aspect of this study. To the best of the authors knowledge, there is no past study that considers learning effect while balancing the U-shaped assebly lines.

The rest of the paper is organized as follows: The proposed heuristic methodology is explained in Section 2. Later, it was exemplified in Section 3. Finally, the concluding remarks and future studies are explained in the last section.

2. Proposed Heuristic Methodology

The proposed heuristic intends to balance single model U-shaped assembly lines while considering the operators level of competence in performing each task. Competence level of each worker was classified into four levels, namely very competent, competent, developing, inexperienced. The capability of the workers in performing each of the task are known in advance. These levels affect the performance index and thus the task performance time of each worker, provided that the task is assigned to that worker.

In addition, the authors employed ULINO methodology of Scholl and Klein (1999) while assigning the tasks to the stations/workers. The notation including the indices, sets and parameters of the methodology is presented below.

Notation:

C : Cycle time
k : index of worker/workstation
i : index of tasks
S : the set of tasks that can be assigned to workstations
S_u : the set of tasks unassigned to workstations
T_k : the station time of workstation k
T_i : Standard time of task-i
P_{ik} : Performance index of worker-k for performing task-i.

The performance index levels and their corresponding values are assumed as shown in Table 1. For instance, $P_{ik}=1$ implies that this worker-k is competent in performing task-i and it can complete the task within the standard time of the task (t_i), as $t_i*P_{ik}=1*t_i= t_i$. However, a worker-k having $P_{ik}=0.75$ for a task-i is very competent and can complete this task during the time as long as $t_i*P_{ik}=0.75t_i$. This means that this worker can complete the task less in a time that is less than the standard task time.

Table 1: Performance index levels of workers

Index Level Explanation	P_{ik}
Very competent	0.75
Competent	1
Developing	1.25
Inexperienced	1.50

The flowchart of the proposed methodology is illustrated in Figure 1. The methodology assumes that at each workstation, one worker is employed. The set of unassigned tasks are established, and the first temporary station is created. The tasks that are eligible for assignment to the U-shaped line according to the precendence constraints are determined. In other words, the tasks are eligible provided that either all predecessors or all sucessors are assigned before or there are no predecessors or sucessors of them. This is the precedence constraint of U-shaped assembly lines, as mentioned by Scholl and Klein (1999). Then, a worker whose performance index of P_{ik} is known in advance is picked from the set-W. For the selected worker possible taskgroup-worker assignments are determined such that the cycle time constraints as denoted in (1) are satisfied.

$$T_k + t_i P_{ik} \leq C; \ \forall k \quad (1)$$

In the left hand side of (1), t_i*P_{ik} is the standard time of task-i (t_i) multiplied by P_{ik} that is the worker's performance index of performing task-i. As mentioned above, each worker's task performance time changes based on his/her competence level and thus the performance index. Having a performance index of 1.25 or 1.5 increases the task performance time of the worker by 25 or 50%, respectively. However, a performance index of 0.75 reduces the task performance time of the worker. Here, cycle time constraints imply that the current station time summed with the task performance time of the worker-k must be smaller than or equal to the cycle time.

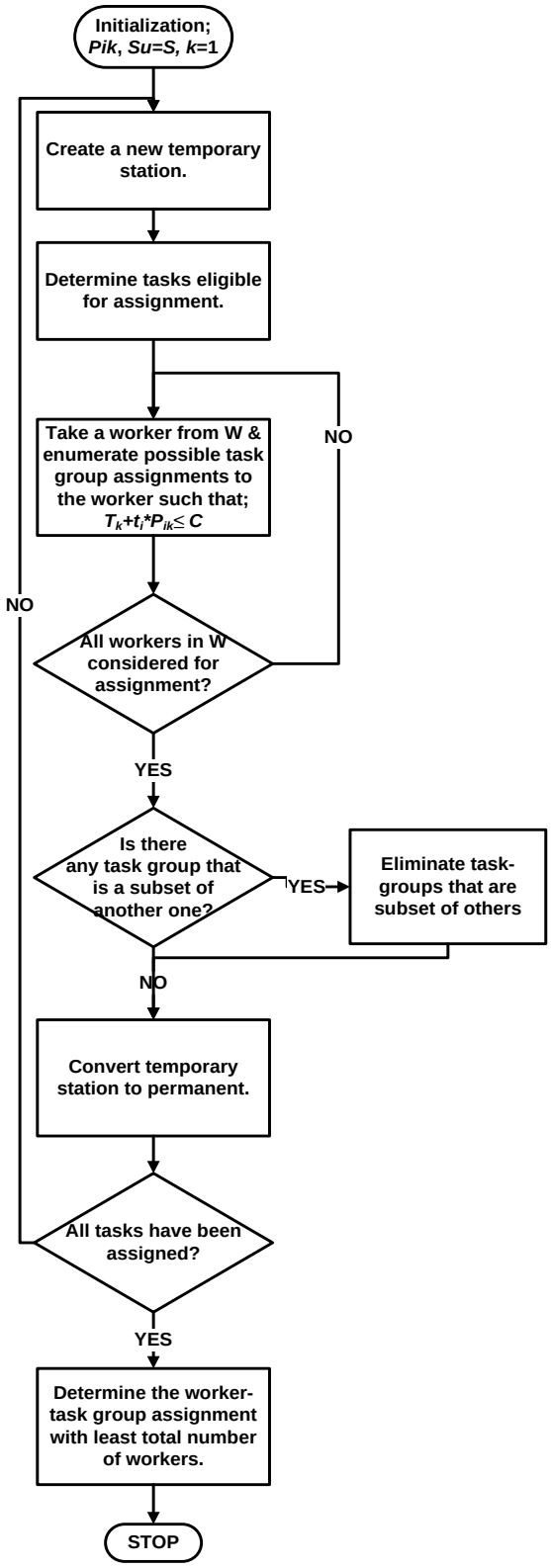


Figure 1: Flowchart of the proposed heuristic methodology

If all of the other workers are not considered yet, another worker is selected, and other alternative task-worker assignments are made for the current temporary workstation. Among the alternative task-worker alternatives, if there is a task group that is a subset of another, that one is eliminated at that stage. So, the alternative task-worker assignments are achieved for the first permanent station.

If there is still any unassigned tasks, the number of stations is increased by one, and the heuristic returns to the initial step where another temporary station is created. Next eligible tasks that have not been considered yet are determined. The workers not employed in the previous station are determined, and all of the worker-task group assignmenta are enumerated. As long as there are unasssigned tasks, this procedure is repeated. If all tasks are assigned to the workers and stations, all feasible worker-task group assignents are achieved. Among the alternaive assignments, the ones with the least total number of workers is selected as the best solution.

3. An Application of the Methodology

In this section, the methodology is exemplified by using a case partially adapted from (Scoll and Klein, 1999). Cycle time of the model is 10 minutes/product. In Figure 2, precedence diagram of the tasks is presented. Here, at the upper right hand side of the circles the standard task times (t_i) are presented. For simplification, performance indices of each worker for different tasks are assumed to be the same. Namely, P_{i1}=1, P_{i2}=0.75, P_{i3}=1.5.

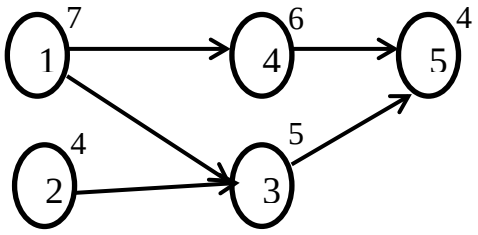


Figure 2: Precedence diagram of the example

At the first iteration, the eligible tasks are attempted to be assigned to the first station. The calculations are summarized in Table 2.

Table 2: Calculations of the first station

Iterations	**Decision**
k=1, i=1; → 7*1<10	**eliminated**
k=1, i=2; **i=5→**4*1=4<10, 4+4*1=8<10	**eliminated**
k=2, i=2; i=1→4*0.75=3<10; 3+7*0.75=8.25<10	**Alternative Solution**
k=2, i=2; **i=5, i=3→**4*0.75=3<10; 3+4*0.75=6<10**,** 6+5*0.75=9.75<10	**Alternative Solution**
k=3, i=2→4*1.5=6<10	**eliminated**
k=3, i=5→4*1.5=6<10	**eliminated**

So the first worker can perform only tasks 2 and 5. However, the second worker can perform tasks 2, 5, and 3 within the cycle time. Therefore, the former task assignment group is eliminated, and the second worker should perform either tasks 1, 2 or 2, 5, 3. In a similar manner assignment of the task 1 to the first worker is also eliminated, since the second worker can perform 1, 2. In addition, since the third worker is inexperienced, he/she can perform only either task 2 or 5 within the cycle time, but these are a subset of the tasks that can be performed by the second worker. Therefore, these assignments are also eliminated. So, for the first station, the second worker is employed. Assignments to the other workers are eliminated.

The iterations for the second station is summarized in Table 3, where it is assumed that tasks 1 and 2 are assigned to the first station. In this stage, assignments to the third operator are eliminated. So, not the third worker but the first worker is employed.

Table 3: Calculations for the second station given that (1,2) assigned to the first worker

Iterations	Decision
k=1, i=4; i=5; 6*1+4*1=10<=10	Alternative solution
k=1, i=3; i=5; 5*1+4*1=9<10	Alternative solution
k=3, i=4; 6*1.5=9<=10	**eliminated**
k=3, i=3; 5*1.5=7.5<10	**eliminated**
k=3, i=5; 4*1.5=6<10	**eliminated**

The third iteration executed for the second station is summarized in Table 4, where it is assumed that tasks 2, 5 and 3are assigned to the first station. The assignments to the thrid worker are either infeasible or eliminated. From Tables 3 and 4, it is concluded that the first worker will be employed in the second station.

Table 4: Calculations for the second station given that (2,3,5) assigned to the first worker

Iterations	Decision
k=1, i=4;6*1<=10	Alternative solution
k=1, i=1;7*1<=10	Alternative solution
k=3, i=4; 6*1.5=9<=10	**eliminated**
k=3, i=1; 7*1.5=10.5>10	**Infeasible**

Finally, at the third station the third worker will be employed. He/she will perform either task 3 or task 4. To visually represent the ultimate solution, a diagram is drawn as shown in Figure 3. The U-shaped assembly line has been balanced by using three stations. If the workers competence levels were higher, better results could be achieved. Therefore, training workers to become multi-skilled and competent in their work improves the balancing results.

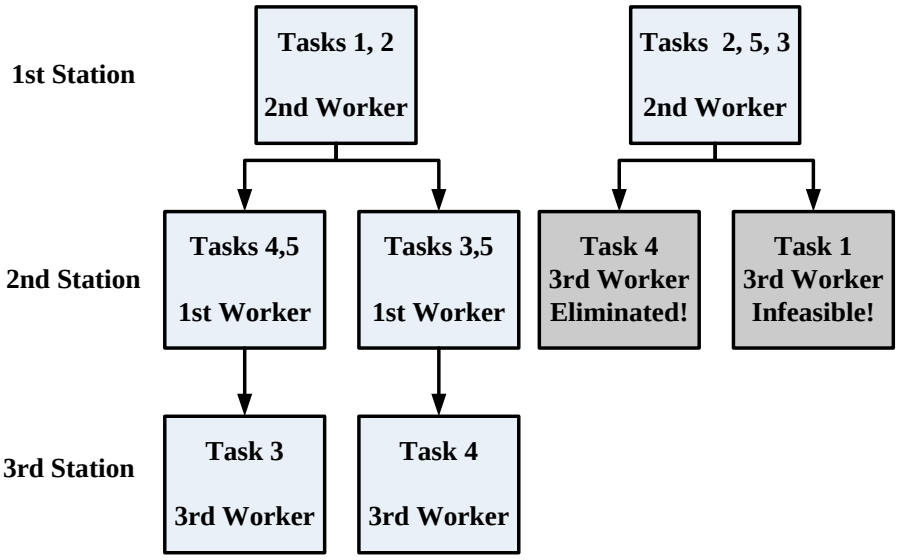


Figure 3: Task-worker assignment results

4. Conclusion

In U-shaped manual assembly lines, the workers skills, learning effect and thus their competence level plays an important role, because more competent workers can perform tasks in shorter times. However, this learning effect is usually neglected in assembly line balancing procedures, and workers are assumed to be able to complete the tasks within the standard task times. In this study, a U-shaped assembly line balancing methodology where tasks are assigned to workers having different competence levels is proposed. The limitaton of the methodology is that the line balancing results are sensitive to the workers experience and skills levels. In future studies, the methodology can be applied for well known data sets for different worker competence levels of performing tasks, to present its utility.

Moreover, a mathematical model of the U-shaped line balancing problem can be formulated where learning effect is considered.

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Biography

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Analysis of Factors Affecting Satisfaction Level of Employees: A Case Study of Heavy Mechanical Complex, Taxila, Pakistan

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Abstract

Employee job satisfaction has been a research focal point throughout the world. It is a key factor to measure the performance of an organization and individuals. Heavy Mechanical Complex (HMC) Taxila, a leading engineering goods manufacturing enterprise in Pakistan, has been used in this case study. In Pakistan, very limited research has been done on employee job satisfaction. This paper intends to cover this research gap by providing theoretical foundation for research on investigating factors affecting job satisfaction in large organizations. The objective of this research is to analyze various demographic, financial and non-financial factors affecting the satisfaction level of HMC employees and to study their effects across different employee groups. Information on job related factors have been collected from a sample of 250 (out of total 1100) HMC employees using self-administered questionnaire. Before conducting the survey, reliability of the questionnaire was measured using Cronbach's alpha. The normality of data was also examined using the Kolmogorov Smirnov test. Hypotheses devised to address the research questions were tested by using non-parametric Spearman correlation and Kruskal-Wallis tests. Research findings indicated the significant factors that affect the satisfaction level of employees. Median group differences exist between responses of different employee groups based on age, work experience, salary and designation. More over the strength of relation is shown to be positive for job satisfaction and other job related factors.

Keywords
Job satisfaction, demographic factors, financial factors, non-financial factors

1. Introduction

Employee satisfaction had become a center of attention in contemporary business field. With the growing competition and increasing customer demands, every organization must consider employee job satisfaction as a vital element to increase customer satisfaction and keep their business running. Dissatisfaction can affect the organizational productivity and progress. Employees are considered to be an important asset of any organization; hence their feedback is very important in enhancing the satisfaction level. Meaning of satisfaction has to be established first, as satisfaction level differs from individual to individual and designation to designation. A large number of studies have been conducted that not only analyze the term "job satisfaction" from different perspectives but also find its relationship with various organization variables. There is no common definition that depicts all the dimensions of employee satisfaction at the same time. Job satisfaction can be defined as "a person's feelings of pleasure or disappointment resulting from comparing a product's perceived performance or outcome in relation to

his or her expectations". (Gautam et al, 2006; Locke et al, 1969)

In Pakistan, very limited research has been done on employee job satisfaction, specifically with respect to factors affecting job satisfaction. Some research has been done on medical institutions, banks, universities and information technology sector organizations of Pakistan, but large public sector organizations have not yet been studied. **Heavy Mechanical Complex (Private) Limited**, located at Taxila is considered as the leading heavy engineering goods manufacturing enterprise in Pakistan. It is a large organization comprising of 1,100 employees and it has a covered area of 160,000 sq. meters. HMC has a standard organizational hierarchy i.e., it comprises of board of directors, administrators, supervisors, engineers, technical staff and shop floor workers. As it has a large number of employees, it is a huge task to find out their level of satisfaction and identify the factors causing dissatisfaction. HMC Taxila is the most feasible organization structure for this study because of its size, nature of work and organization hierarchy. So this study will ascertain factors impacting satisfaction at each level. The main aim of this research is to establish a certainty that there are some factors which can influence the satisfaction level of employees. The research objectives are:

- To analyze different demographic, financial and non-financial factors that affects job satisfaction at each level within an organization's hierarchy.
- To analyze the differences between employee responses based on age, work experience, salary, and designation and to measure the strength of the relationship between job satisfaction and job related factors.

2. Literature Review

Employee job satisfaction has been a center of attention for last two decades. It is considered to be a vital factor that affects organizational productivity. At the beginning of twentieth century, researchers haven't paid much attention on job satisfaction but later on it gained a lot of importance. Significant theories (such as the Scientific Management theory) as well as some important studies in the form of Hawthorne and Hoppock were conducted regarding job satisfaction. The scientific management theory, the Hawthorne and the Hoppock studies are quite valuable because they are a driving force for further research in this area (Roethlisberger, 1939; Hoppock, 1935). Based on these pioneer studies, researchers proposed new theories such as Herzberg's two factor theory, Job Characteristic model, Value theory, Model of facet satisfaction, Social Information theory, Dispositional theory and the Maslow theory of need. The objectives of these theories were to develop frameworks that cover factors which influence employees' behavior.

2.1 Factors Affecting Job Satisfaction

Literature related to Human Resource Management (HRM) also emphasizes the importance of employee satisfaction for organizational productivity and performance. It broadly analyzes the relationship between HRM practices and employee attitudes. Positive employee attitude includes overall satisfaction, loyalty towards work and organization (Edgar, F. and Geare, A. ,2005). High performance and productivity can be obtained by considering employees as a valuable asset and treating them accordingly (Silvestro, R. ,2002). Employee job satisfaction is positively correlated with job motivation, involvement, organizational behavior, organizational commitment, citizenship, employees' mental health, job performance and life satisfaction (Sek, 2009; Judge, 1993). Job satisfaction as a reaction towards various job facets (Cranny, et. Al, 1992; George and Jones, 2002) such as intrinsic factors which include employees' interest, skill variety, use of abilities (Tatsuse and Michikazu, 2010) and other factors like rewards, management practices, work environment and the work itself (Spagnoli et al., 2011).

Demographic factors include age, gender, and designation (position/rank) of employees. Researchers presented different opinions regarding the relation between these factors and job satisfaction. For example, some researchers (Warr, 1992) observed a U-shaped relationship between age and satisfaction while others (Hulin,C.L.,and P.C.Smith, 1964; Sweeny, 1982, Herman, 1980) found a positive linear relationship between them. Some researchers studied the impact of age on satisfaction level of academic (teaching) and research staff (Hickson and Oshagbami, 1999). They observed that age negatively affects job satisfaction of teaching staff whereas for research staff, job satisfaction increases with increase in age.

Financial factors include pay, promotion, salary etc. A significant statistical relationship was observed between pay, rank and job satisfaction of UK academics (Oshagbemi, 1997). Financial benefits, compensations and rewards play a major role in influencing the satisfaction of employees (Arnolds and Boshoff, 2001; Sweeny and McFarlin, 2005; Kamal et al , 2009; Chimanikire et al, 2007). Promotion evaluation system affects employees' morale to a greater

extent as compared to promotion policies (Hooi, 2012). Managers with frequent promotions were more satisfied than others (D'Souza, 2002). If employees are not satisfied with the promotion evaluation system, then they are more likely to leave the organization (Shields and Ward, 2001; Freeman, 1978; Ellickson and Logsdon, 2002). Many researchers believed that job satisfaction highly depends on promotional opportunities (Pergamit, 1999).

Non-Financial factors include work stress, working conditions, employee relations etc. For maximizing productivity of employees, organization's physical layout must be designed according to employees' need (Demet,1999 ; Stallworth and Kleiner, 1996). Absence of feasible working conditions has a negative effect on employee satisfaction (Robbins, 2005; Baron and Greenberg, 1995). Factors such as temperature, lighting, ventilation, hygiene, noise, working hours, and resources are also included in working conditions (Arnold and Boshoff, 2001). Satisfaction of employees is reduced when stress levels are higher, which in turns decreases productivity (George and Dimitrios, 2010). Stress has a significant effect on employee job satisfaction of cement industry employees (Tabatabaei et. al, 2011). Researchers found a strong positive relationship between job satisfaction and relation with supervisor and higher authorities (Trempe et al. 1985; Schroffel, 1998; Hohenshil and Brown, 1999).

3. Research Methodology

3.1. Proposed Framework

The possible factors that can effect job satisfaction of HMC employees have been categorized into three main groups i.e. demographic factors, financial factors and non-financial factors. Demographic factors include age, work experience, designation and department of employees; financial factors include factors directly and indirectly related with employee's financial aspects like salary, pay, promotion, allowances and facilities provided to them. Non-financial factors include factors which are not related to financial matters like working conditions, work stress, management, relations with supervisors and other higher authorities, relations with employees, colleagues, customers, end users and peers. These factors are then categorized in to sub factors. For example, pay is defined by sub factors: financial benefits, bonuses, relation between pay and performance, compensations and rewards.

3.2. Sample and Procedure

Total population of HMC comprises of 1,100 employees. The sample size taken for this research is 23% of total population. Stratified random sampling technique was used to conduct the survey. Total of 250 questionnaires were distributed from which 183 were returned back by the respondents; hence the response rate was 73.2%.

3.3. Data Collection

Questionnaire was used as a tool for data collection in this study. It was divided into three main parts. First part consisted of questions related to personal information and demographics of employees such as age, gender, work experience, department, salary, and facilities like transport, accommodation, medical and paid leaves. The second part consisted of questions related to factors affecting the satisfaction level of employees. The third part consisted of three detail questions that may help to understand what they feel for HMC and what are their suggestions in order to improve HMC as an organization.

3.4. Data Analysis

Statistical Package for Social Sciences (SPSS) version 20 was used for statistical analysis of data. A pre-test was performed to ensure the appropriateness of questionnaire by using Cronbach's Alpha reliability test. The reliability analysis scale is acceptable if the Cronbach's Alpha coefficient is between 0.6 and 0.8. In this study, the overall Cronbach's Alpha reliability coefficient for 57 items is 0.966 which is highly acceptable.

Table 1: Reliability statistics for job related factors

Factors	Pay	Promotion	Work Stress	Work Condition	Relation With Supervisor	Relation with Employee	Manag -ement	Overall Reliability
Cronbach alpha	0.803	0.913	0.798	0.839	0.833	0.687	0.941	0.966
No. of Items	5	5	5	11	7	4	20	57

4. Results and Discussions

4.1 Descriptive Statistics

Descriptive statistics were performed on collected data to obtain respondents demographics in terms of age, work experience, salary and designation, as shown in Figure1.

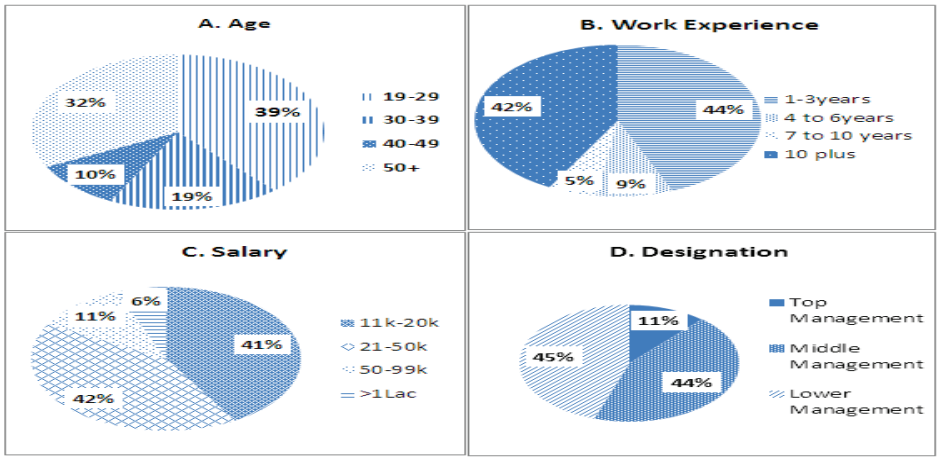


Figure 1: Pie charts for demographical data

Mean and standard deviation of individual factors were also determined, as reported in Table 2.

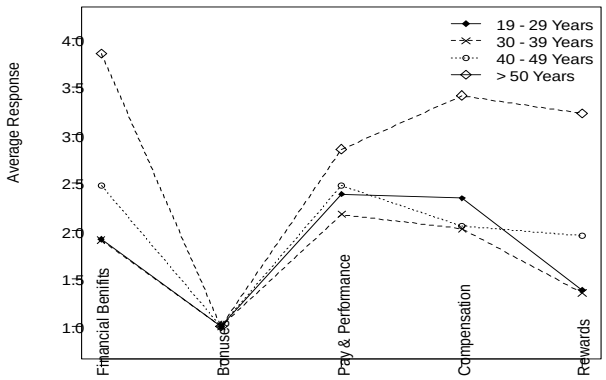
Table 2: Descriptive statistics of individual factors

Factors	Pay	Job security	Promotion	Work Stress	Work Condition	Relation with Supervisor	Relation with Employee	Manag -ement
Mean	2.02	3.95	1.69	3.14	2.44	3.58	3.76	3.38
Std. Deviation	0.75	0.82	1.17	0.81	0.69	1.01	0.72	0.75
Satisfaction level	Dis-Satisfied	Satisfied	Strongly Dissatisfied	Neutral	Dis-Satisfied	Satisfied	Satisfied	Satisfied

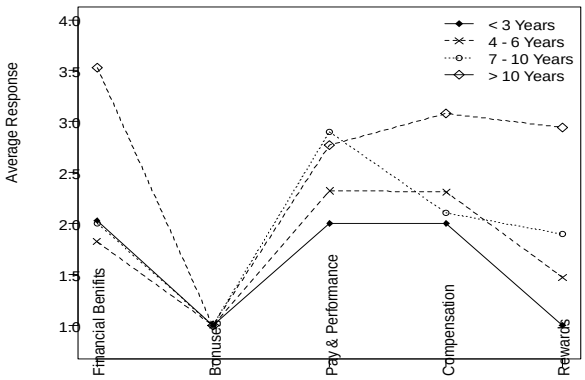
The mean response using the Likert-type scale for pay in the questionnaire is 2.02, which indicates an overall dissatisfaction among respondents regarding pay.

The average responses of the employees for the sub factors of pay have been compared graphically in Figures 2. In each figure, the employee responses are compared for different a) age groups, b) work experience groups, c) salary groups and d) designation groups. The different sub factors are plotted on x-axis whereas the average responses on y-axis. These sort of graphs can be easily prepared for other job related factors (promotion, work experience, work stress, work conditions, job security, management etc.).

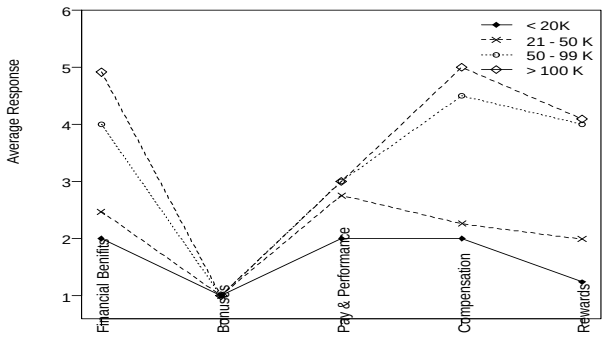
From Figures 2 , we can observed that older employees (age > 50 years) belonging to top management designation group having higher experience and greater salaries are more satisfied with almost all the factors of Pay as compared to other employees. Similar interpretations can be made for the behavior of other main factors across different groups based on age, work experience, salary and designation.



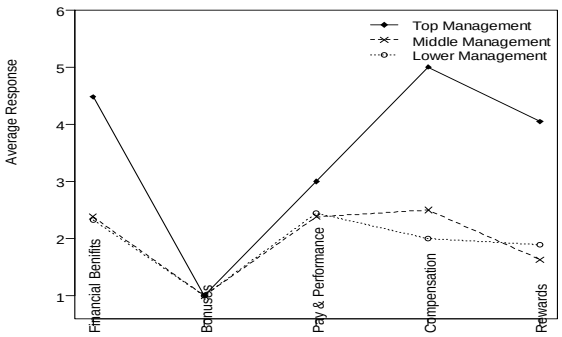
(a) Age groups



(b) Work Experience Groups



(c) Salary groups



(d) Designation

Figure 2: Effect of sub factors on Pay for different employee groups based on age, work experience, salary and designation

4.2 Test for Normality

The assessment of normality is the first step for many statistical tests. If the data is not normal, then the use of parametric tests can lead to unreliable results and in such cases, non- parametric tests are more suitable. The normality of the data was examined using the Kolmogorov Smirnov test. For normally distributed data, the significance value of the test results should be greater than 0.05. In our case, the significance value of all the factors is less than 0.05. Hence the data is not normally distributed and the non-parametric statistical tests should be used for the purpose of analysis.

4.3 Hypothesis Testing

On the basis of literature (as can be seen above), following set of null (H_0) and alternate hypotheses (H_a) have been devised. These hypotheses will be tested with the help of appropriate statistical tests.

Table 3: Set of hypotheses

Sr.No	Hypothesis
H_{01}	Median satisfaction level is same among different age groups of employees of HMC.
H_{a1}	Median satisfaction level is different among different age groups of employees of HMC.
H_{02}	Median satisfaction level is same among different work experienced groups of employees of HMC.
H_{a2}	Median satisfaction level is different among different work experienced groups of employees of HMC.
H_{03}	Median satisfaction level is same among employees belonging to different designations/ranks in HMC
H_{a3}	Median satisfaction level is different among employees belonging to different designations/ranks in HMC
H_{04}	Median satisfaction level is same among employees belonging to different departments of HMC.
H_{a4}	Median satisfaction level is different among employees belonging to different departments of HMC.
H_{05}	Median satisfaction level is same among employees having different salary ranges.
H_{a5}	Median satisfaction level is different among employees having different salary ranges.
H_{06}	There is a no significant relationship between Pay and Job satisfaction.
H_{a6}	There is a no significant relationship between Pay and Job satisfaction.
H_{07}	Median satisfaction level is same among employees having different allowances and facilities.
H_{a7}	Median satisfaction level is different among employees having different allowances and facilities.
H_{08}	There is no significant relationship between Job satisfaction and Work Stress level.
H_{a8}	There is a significant relationship between Job satisfaction and Work Stress level.
H_{09}	There is no significant relationship between Promotion and Job satisfaction
H_{a9}	There is a significant relationship between Promotion and Job satisfaction
H_{010}	Median satisfaction level is same among employees having different working conditions.
H_{a10}	Median satisfaction level is different among employees having different working conditions.
H_{011}	There is no significant relationship between Job satisfaction and Relations with Supervisor
H_{a11}	There is a significant relationship between Job satisfaction and Relations with Supervisor
H_{012}	There is no significant relationship between Job satisfaction and Relations with Employees
H_{a12}	There is a significant relationship between Job satisfaction and Relations with Employees
H_{013}	There is no significant relationship between Job Security and Job satisfaction
H_{a13}	There is a significant relationship between Job Security and Job satisfaction
H_{014}	There is no significant relationship between Job satisfaction and Top management of HMC
H_{a14}	There is a significant relationship between Job satisfaction and Top management of HMC

Similar hypothesis can also be defined for other factors like pay, promotion, work Stress, working conditions, relation with supervisor, relation with employees and their relationship with age, work experience, designation, department and salary. The group differences are investigated by the Kruskal Wallis test while to measure the association between different factors, the Spearman rank correlation test has been applied. Post hoc pairwise comparison test was applied on any significant Kruskal-Wallis results using '*pgrimess*' package in R statistical language.

4.3.1 Kruskal Wallis Test

The hypotheses (**Ho_1 –Ho_5 and Ho_7**) were tested by nonparametric Kruskal-Wallis test.

The results in Table 4 indicate that median of overall satisfaction level differs significantly for grouping variables like Age, Work experience, Designation, Salary and Facilities/Allowances at 5% significance level. Median satisfaction level do not differ significantly for Department [chi-square= .894, p = 1.000]. Hence, we can say that age, work experience, designation, salary and facilities/allowances significantly affect job satisfaction of HMC employees. Similarly, Table 4 also indicates that median Pay level differs significantly for grouping variables like age, work experience, designation, salary and facilities/allowances at 5% significance level. Median pay satisfaction level do not differ significantly for Department [chi-square= .67, p = 1.000]. Hence, we can say that Age, Work experience, Designation, Salary and Facilities/Allowances significantly affect job satisfaction of HMC employees

regarding pay factor. Similarly median satisfaction levels for other factors can also be interpreted from results in Table 4.

Table 4: Kruskal-Wallis test results for comparing median differences among satisfaction level of different factors

Overall Satisfaction		**Pay**		**Promotion**		**Work Stress**		**Working Condition**		**Job Security**		**Relation with Supervisor**		**Relation with Employee**		**Managem -ent**	
Ch Sq	*Sig (p)*	*Ch Sq*	*Sig (p)*	*Chi Sq.*	*Sig (p)*	*Ch Sq.*	*Sig (p)*	*Chi Sq.*	*Sig (p)*	*Chi Sq.*	*Sig (p)*	*Chi Sq.*	*Sig (p)*	*Chi Sq.*	*Sig (p)*	*Ch Sq*	*Sg (p)*
Grouping Variable = Age																	
33	0	81	0	38.8	0	34	0	75.4	0	71	0	10.8	0.01	37.8	0	75.5	0
Grouping Variable = Work Experience																	
19	0	88	0	44.7	0	25	0	69	0	113	0	21.2	0	92.1	0	68.5	0
Grouping Variable = Designation																	
68	0	72	0	114	0	61	0	81.9	0	38	0	63.7	0	63.8	0	76.5	0
Grouping Variable= Department																	
0.8	1	0.6	1	2.52	0.98	0.6	1	0.96	1	1.1	0.99	2.85	0.97	0.47	1	2.52	1
Grouping Variable Salary																	
99	0	13	0	50.9	0	7.0	0	102	0	116	0	86.1	0	101	0	92.4	0
Grouping Variable = Facilities/Allowances																	
56	0	70	0	50.3	0	30	0	69.5	0	146	0	111	0	165	0	88.3	0

4.3.2 Post Hoc Analysis

When the obtained value of a Kruskal-Wallis test is significant, it indicates that at least one of the group median is significantly different from the others. The group pairs which have observed differences higher than a critical value are considered statistically different at the given probability (p) level. Post hoc results for Kruskal-Wallis test are obtained by using 'pgirmess' package of the 'R' statistical language. Specifically Kruskalmc function is used for the post hoc analysis. Post hoc results for Age, Work Experience, Designation, Allowances/Facilities and Salary w.r.t satisfaction level are given in Table 5.

Age: Table 5 shows that there is no significant difference in satisfaction of employees belonging to age group 1 (19-29) with age groups 2 and 3 (30-39 and 40-49). But there is a significant difference in satisfaction of age group 1 (19-29) with age group 4 (50+). Similarly there is no difference in satisfaction between age group 2 (30-39) and age group 3 (40-49). But job satisfaction of age group 4 (50+) differs from age groups 1, 2 and 3.Similarly Post hoc results for Age, Work Experience, Designation, Allowances/Facilities and Salary with other factors (Pay, Promotion, Work Stress, Working Condition, Relation with supervisor, Relation with employees and management) can also be computed.

Table 5: Post Hoc results for overall job satisfaction

Factors	**Groups**	**Observe difference**	**Critical Difference**
Age	1(19-29) -4(50+)	39.6	26.45
	2(30-39)-4(50+)	38.8	26.58
	3(40-49)-4(50+)	43.2	36.86
Experience	1(1 to 3 years) -4(10+ years)	36.38	28.78
Designation	1(Top management) -2(Middle management)	84.41	31.09
	1(Top management) -3(Lower management)	83.01	31.01
Allowances	1(1 Facility) -2 (2 Facilities)	66.50	51.56
/Facilities	1(1 Facility) -3(3 Facilities)	102.2	48.72
	1(1 Facility) -4(4 Facilities)	90.75	51.81
	2(2 Facilities) -3(3 Facilities)	35.71	26.3
	2(2 Facilities) -4(4 Facilities)	31.66	24.25
Salary	2(11k-20k) -4(50-99k)	79.72	35.12
	2(11k-20k) -5(above 1lac)	104.7	45.08
	3(21k-30k) -4(50-99k)	70.77	35.12
	3(21k-30k) -5(above 1lac)	95.78	45.09

4.3.3 Spearman Correlation Test

The null hypothesis of Spearman correlation test states that there is no signification relationship between job satisfaction and other job related factors. The hypotheses (**Ho_6, $Ho_8 - Ho_{14}$**) were tested by Spearman Correlation analysis and it indicated the relationship between Satisfaction level and different factors.

Table 6: Results of correlation analysis

Factors	Job satisfaction		Strength of Correlation	Null Hypothesis
	Correlation Coefficient	*Significance (p)*		
Pay	.601**	.000	Strong	Ho6-Rejected
Working Condition	.676**	.000	Strong	Ho9-Rejected
Relation with Supervisor	.644**	.000	Strong	Ho11-Rejected
Promotion	.445**	.000	Moderate	Ho8-Rejected
Job Security	.435**	.000	Moderate	Ho13-Rejected
Relation with Employees	.514**	.000	Moderate	Ho12-Rejected
Management	.597**	.000	Moderate	Ho14-Rejected
Work Stress	.222**	.000	Weak	Ho10-Rejected

The results of Table 6 indicated that there is a significant relation between satisfaction level and the different factors as the p-value is less than the significance level (0.05) for each of the cases. That is, correlation exists between satisfaction and each of the factors (Pay, Promotion, Job Security, Work stress, Relation with Supervisor, Relation with Employees, Management). Strength of correlation is also mentioned in Table 6. Results of Spearman correlation coefficient helped us in the acceptance and rejection of null hypothesis. There is a significant positive relationship between Job Satisfaction and Pay, Promotion, Job security, Work stress, Working conditions, Relation with supervisors, Relation with employees and Management. Hence we can say that by increasing/decreasing these factors the satisfaction level of the HMC employees can be increased/decreased. Results of Kruskal-Wallis and Spearman correlation tests indicated the factors that can affect job satisfaction level of HMC employees; these are age, salary, facilities and allowances, designation of employees, pay, promotion, job security, work conditions, job stress level, management and relations with supervisor, higher authorities, employees and clients.

5. Conclusion and Recommendation

On analyzing the job satisfaction of HMC employees, it is concluded that: there are different factors that effects their job satisfaction. These are age, salary, facilities and allowances, designation of employees, pay, promotion, job security, work conditions, job stress level, management and relations with supervisor, higher authorities, employees and clients. Median group differences of responses exist for different employee groups based on age, work experience, salary and designation. Moreover, the strength of relation is shown to be positive for job satisfaction and other job related factors such as pay, promotion, etc. It is also concluded that employees having older age, higher experience, belonging to high management are more satisfied with sub-factors of pay, promotion, working conditions etc.

It is recommended to the top management and policy makers of HMC that they should utilize recognition, acknowledgement and favorable working conditions as a positive tool to keep their employees motivated towards the organization. Moreover, strategies by which management can increase satisfaction and reduce dissatisfaction among employees should be implemented. This study also recommended other large organizations of Pakistan that; they must provide their employees with favorable working conditions; that is, they must give them opportunities for advancement, facilitate their employees with new and latest technologies, provide them with sufficient resources, must give them chances to do jobs that matches their interest level. The more they are interested in their job task, the more they will be enthusiastic and motivated for organizational progression. The pay system must be improved by increasing salary packages, provision of financial benefits and bonuses. Employees must be provided with rewards, this will motivate them to do accomplish their job task more efficiently. There must be fair promotion system. Delay in promotion of eligible employees must be avoided, because it is a very big reason for their dissatisfaction. Organizations must pay attention on employee relations. There must be a good formal as well as informal level of communication between all employees belonging to the three management tiers. Low management must be provided with proper channel through which they can interact with top management for resolving their issues. Worthy suggestions of lower workers must also be listened, acknowledged and respected by senior authorities in order to

realize them that they are also a valuable part of organization. Organizations must pay attention to employee's training and education because it will increase their knowledge and ultimately satisfaction.

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Reintroducing the Technology Life Cycle into Technological Forecasting: Reconceptualization and a Model of System Disaggregation

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Abstract

Research by scholars of technological innovation illustrated the best practices of cross-functional integration in product and process innovation. It had major effect on research of technology forecasting, refocusing it on application and system level forecasting, substituting the technology life cycle (TLC) conceptual framework by the product life cycle (PLC) and diffusion related S-curves. In this paper, our initial objective is to reintroduce the TLC and its conceptual antecedents anchored in the interactions and mutual influence between scientific advances and technological progress. The second contribution of this paper is a conceptual model that disaggregates a product or system into its *Bill of Technologies*. This model is intended to facilitate more specific and informative analysis about the causal connections between technological progress of system's key technologies and system level performance attributes. Mapping the technological life cycles (TLCs) of these technologies, including the scientific-technological limits embodied in their S-curves, should also have significant practical application for resource allocation decisions, and technology strategy, planning, and roadmapping. We briefly illustrate the model with publicly available information about the Boeing 787 Dreamliner and a generic MRI system.

Keywords
Technology life cycle, technological progress, technological forecasting, technological innovation, product life cycle

1. Introduction
The discipline of technological forecasting is directly connected to the management of technological innovation, attempting to incorporate simultaneously the principles of science-based technological progress and the diffusion of technological applications (Foster, 1986; Hauptman & Pope, 1992; Rogers, 2010; Taylor & Taylor, 2012; Tushman & Anderson, 1986). The evolution of concepts related to technological innovation in theory and practice, as described by Rothwell (1994), is at the heart of the issues addressed in this paper. The more integrated and comprehensive understanding of the role and nature of technological innovation between the 2nd and 4th generations of innovation process evolution (Rothwell, 1994: 8-12), spanning the mid-1960s and early 1990s, made the concepts more useful for both policy makers and business executives. From the mysterious and arcane activities in the "dungeon" laboratory by nerdish eccentrics, technological innovations have been popularized broadly, from TED videos to "open innovation" and crowd sourcing frameworks, becoming part of mainstream business activities. This also put market need in the driving seat of the innovation process.

Interestingly but not surprisingly, this integration of technological innovation with business and marketing thinking (e.g., Sood & Tellis, 2005), took the research focus away from a factor the criticality of which for the management of technological innovation has never been in dispute – the evolution of technology, its patterns of progress and trajectories of performance. The rigorous study of these patterns and trajectories, focusing on scientific and technological imperatives, resulted in the initial models of technological progress (Frankel, 1955; Gilfillan, 1935; Griliches & Schmookler, 1963; Knight, 1966, 1968). Subsequently, they were elaborated upon by innovation researchers in various contexts (e.g., Dosi, 1982; Foster, 1987; Sahal, 1981).

Rogers's seminal work on the diffusion of innovation (2010, 4th edition of his 1962 book) added the understanding of social and psychological mechanisms that enable market penetration by diverse innovations spanning agricultural practices, pharmaceuticals and contraceptives. At the same time, his very influential work (according to Google Scholar®, the referenced book in all its versions was cited not less than 52,919 times) was based on the logic of two-stage diffusion of ideas, initially illustrated by Lazarsfeld and his students and coauthors (e.g., Coleman, et al, 1957; Katz & Lazarsfeld, 1955; Menzel & Katz, 1955). As Rogers has focused almost exclusively on the benefits and risk from the point of view of the end users, his and subsequent work on diffusion of innovation mostly avoided technological and scientific constraints that affect the underlying technological progress. The fact that the innovation diffusion curve, being one of the determinants of the product life cycle (PLC), is also S-shaped and that the PLC is dependent on patterns of technological innovation in products and processes (Klepper, 1996; Utterback, 1974), spurred the subsequent integration of these concepts. Furthermore, recently, the technology life cycle model is being substituted by product life cycle in terms of logic, concepts and categorization of phases (see discussion in Taylor & Taylor, 2012).

The central goal of our paper is to stimulate technological forecasting research for deriving technological progress trajectories at a level of aggregation that can be meaningfully addressed through the principle of natural science and imperatives of technology rather than mostly through the sociology of diffusion or economics of market attractiveness. We intend to accomplish it by: a) illustrating the connections among natural science, technology and use in terms of processes and information flows; b) describing the gaps in current research of technological forecasting that are mainly caused by focusing on the product life cycle or on measures of technological progress that are aggregated on a system's or product level; c) offering a disaggregation model that is based on the principles of MRP's Bill of Materials (BOM), which enables the derivation of the system's or product's Bill of Technologies (BOT); and d) illustrating the use of the BOT framework by applying it to several systems that integrate advanced technologies. We conclude with a brief outline of directions for future research.

2. Interdependence among Science, Technology and Use

As Rothwell (1994: 8) illustrates in the "1st-generation" innovation process, engineering and design, or technology-oriented activities, were directly and strongly connected to basic science. Marquis and Allen (1966: 1053) model of information flow among science, technology and use is consistent with this process, taking it into further detail to include "Market-pull", "Technology-push" and the less common but critical cycle of "Gap-filling-science" (see Figure 1 below for authors' adaptation of the model). As can be seen from the history of technology and its conceptualizations, this is not a new phenomenon. Salomon (1984: 124) points to the fact that "Bacon and Descartes

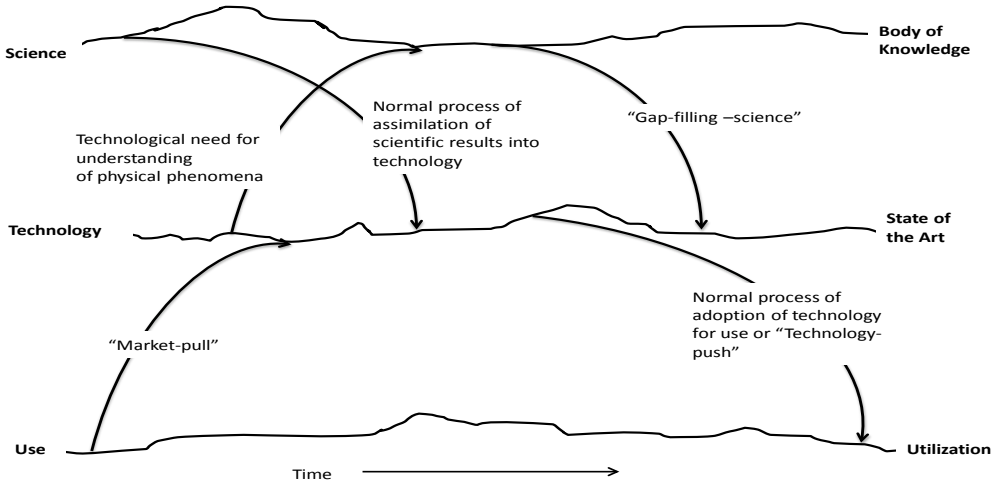


Figure 1: Flow of information in science, technology and use (adapted from Marquis&Allen, 1966: 1053)

were among the first to formulate the idea of institutions designed for the teaching and advancement of science for the benefits of the *crafts and arts* [authors' italics: paraphrasing it as *technology*]." He adds (Salomon, 1984: 124) that "… a much longer period was necessary, several centuries in fact, for this interaction between science and *technique* to be put into practice." According to Layton (1971: 568), who uses the strength of materials as an

example, after major advances in the use of iron and steel, in the 19th century, "… a scientific study of their properties would enable designers to avoid costly failures." He elaborates with specific reference to "Gap-filling-science" as follows (Layton, 1971: 568): "But another reason for the early emphasis on this science was that it represented one of the most promising avenues for the application of science to technology. It could draw upon the sophisticated body of physics accumulated since the time of Newton. Thus, it attracted scientists and others inspired by the vision of a *scientific technology* [authors' italics: paraphrasing it as *science-based technology*]."

The interdependence between scientific research and technological progress, and the subsequent economic benefits from use of technology-based products and processes, was initially illustrated by several seminal government commissioned studies – *Hindsight* Project (Sherwin & Isenson, 1967) and TRACES (Thompson, 1969). They spawned numerous studies in a similar vein (e.g., Gibbons & Johnston, 1974; Myers & Marquis, 1969; Langrish et al., 1972), all using critical event methodology and identifying similar patterns: a) that there is a definite causal interdependence between scientific research and technological applications in products and processes; b) that the relationship is complex and there is a significant time lag between the scientific and technological events, making these connection a challenging to research; and c) that "demand pull" is a very important factor in spurring technological innovation initiatives. For instance, the SAPPHO study (Rothwell et al, 1974: 259-260) determined that the dominant factors which discriminated between commercially successful and unsuccessful innovations were a better understanding of user needs, attention to marketing, being more efficiently executed, using external scientific and technical knowledge, and being managed by more powerful managers.

Consequently, the 2nd-generation process of innovation, as described by Rothwell (1994: 9), shifted the focus to market and demand imperatives: "During the latter part of this period, at least in the United States, public policymakers began emphasizing more the importance of demand side factors. This resulted in some experimentation in using public procurement as a means to stimulate industrial innovation… further stimulating the shift in perception towards the need-pull model of innovation…"

To summarize, the case of science to technology connection seems quite straightforward and well supported, including the empirical *Hindsight* and TRACES studies. But these and other studies spurred but their insight into economic benefits, and especially the SAPPHO research, triggered a transition away from the role of natural science in technological innovation. This had implications for the measurements of technological progress.

3. Measuring and Mismeasuring Technological Progress

3.1 General Principles

Technological progress, especially its time-based trajectory forecasting, has been the subject of numerous studies in the context of management of technological innovation and its sub-disciplines, such as technology innovation and strategy (Foster, 1986; Murmann & Frenken, 2006; Tushman & Anderson, 1986), technological forecasting (Ernst, 1997; Merino, 1990; Sahal, 1981, 1984) and more recently roadmapping (Phaal, et al, 2001).

There is a broad agreement by most researchers over time that the progress of technology can be depicted as an S-curve, very similar to the cumulative Product Life Cycle (PLC) S-curve. Innovations follow a common pattern for a new product (Klepper, 1996). In the early stages of the PLC, large amounts of money, effort and other resources expended on the new technology accumulate and progress becomes more rapid. As soon as major technical obstacles are overcome and the innovation reaches a certain adoption level an exponential growth will take place (Foster, 1986). During this phase relatively small increments of effort and resources will result in large performance gains. Finally, as the technology starts to approach its physical limit, pushing performance further becomes increasingly difficult. The growth curve forecasting method is helpful in estimating the upper limit of the level of technology growth or decline at each stage of the life cycle. This method of forecasting is also helpful in predicting when the technology will reach a particular life cycle stage (Firat et al., 2008).

New technologies undergo typical patterns of scientific, technological and economic developments, while the scientific-push is seen as prior to the technology-push and market-pull. More recently, strong positive relationships were identified between the inputs and outputs of scientific research, such as research expenditures and papers published, and technological innovation measured in patenting rates (Jaffe, 1989; Jaffe & Trajtenberg, 1996), although there is a difference in the magnitude of impact across technological fields (Mansfield, 1995). Thus

publications and patents, as indicators of scientific and technological performance, respectively, are commonly accepted measures in innovation research (Hullmann & Meyer, 2003).

Research in the field of technological forecasting used patent and publication databases to derive technology life cycle S-curves (e.g., Chen et al., 2011; Moon & Jeon, 2009; Ryu & Byeon, 2011). Bengisu and Nekhili (2006) used both patents and articles publication data to derive S-curves for twenty emerging technologies identified in a national foresight study in Turkey. They showed that there exists a high correlation between scientific publications and patents for most of the technologies investigated. Kucharavy and De Guio (2011a, 2011b) discussed application of several models based on S-curves in the context of technology forecasting. Daim et al. (2006) used bibliometric and patent analysis in technological forecasting, when sufficient historical data was not available, to forecast the performance of fuel cell, food safety, and optical storage technologies. Gao et al. (2011) contended that using simple patent counts alone to represent the development of a technology oversimplifies the situation and built a model based on multiple patent-related indicators. Chen et al. (2011) used bibliometric and patent analysis to derive logistic growth curve S-curves for hydrogen energy and fuel cell technologies. Ernst (1997) used patent data for forecasting technological developments of CNC technology and found that the diffusion of CNC technology, including the stages of technological life cycle, can be reliably illustrated by patent data. On the other hand, some researchers used different performance criteria to understand technological progress. Advances in technology for tractors were analyzed by Sahal (1981), using performance criteria such as average fuel consumption efficiency, average fuel mechanical efficiency and per gallon of fuel used, ratio of drawbar horsepower to belt horsepower, or horsepower to weight ratio.

3.2 Contradictory Conceptualizations of the TLC S-Curve

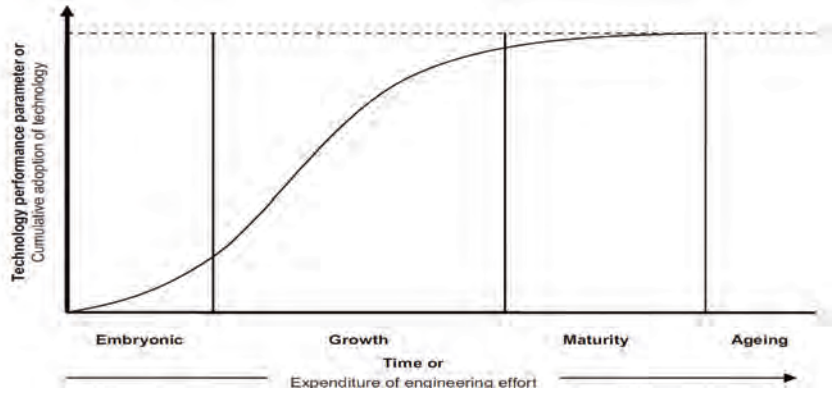


Figure 2: Typical technology life cycle (source: Taylor & Taylor, 2012: 545)

The graph in Figure 2 from Taylor & Taylor (2012: 545) incorporates two conceptualizations that are contradictory in terms of drivers and implications for research and practice. It is an excellent juxtaposition of what we define as science-based technological trajectories and those derivations that are based on concepts related to the Product Life Cycle and diffusion of innovation. Not to repeat the excellent review by Taylor & Taylor (2012), which also summarizes the various stream of research (in Table 2, 2012: 546), we present the differences between the two streams of research in Table 1 below.

3.3 The Problem with Aggregation

In their seminal work of technological discontinuities, Tushman & Anderson (1986) analyzed technological discontinuities in terms of performance improvements in barrels per day for cement kilns, seat-miles-per-year capacity of US airlines, and CPU cycle times of minicomputers in production. The measured performance was on a level of analysis (or aggregation) of what Taylor & Taylor (2012) define as paradigms for cement kilns (Rotary kiln, Hurry-Seaman process; Edison long kiln; Dundee kiln, Process control), mixture of paradigms (turbine and jet propulsion; narrow body and wide body) and generations (for DC-2, DC-3, Boeings 247, 707 and 747) for airplanes, and paradigms for CPUs (transistors, integrated circuits, and semiconductor memory). One would have a major difficulty deriving technological life cycles from these data sets, as their performance measures are aggregates of numerous technologies and for which the nature, stage of development, and science-based limits would be impossible to determine.

Table 1: TLC conceptualizations: Science-based versus diffusion of innovation and PLC

Attribute of conceptual framework	Science-based		Diffusion of innovation/PLC	
	Title	**Logic**	**Title**	**Logic**
X-axis	*Expenditure of engineering effort* or *R&D expenditures*	Technical effort or input required for technological progress	*Time*	Time since product introduction
Y-axis	*Performance*	Measures of technical performance on relevant level of aggregation	*Cumulative sales* or *Cumulative product applications*	Volume of sales, either in units or income
Phases				
• 1st	*Embryonic*, *Emerging* or *New technology*	Slow progress, overcoming technical challenges, with the new technology being superior to previous generation of technology	*Introduction*	Early sales are low as dictated by proportion of early adopters in the relevant market
• 2nd	*Rapid progress* or *Pacing technology*	Major technical obstacles are overcome and outcomes outpace inputs	*Growth*	Rapid growth of sales dictated by the two-stage transfer of information and emergence of dominant design
• 3rd	*Slower progress* or *Key technology*	Decline in output with similar and even increased inputs, with search for substitution begins	*Maturity*	Sales slowing down with transition to cost based competition and emergence of competing new product
• 4th	*Reaching technological limits* or *Base technology*	Technology is reaching scientific-technical limits, with search for substitution accelerates	*Saturation* or *decline*	Market saturation and product becoming obsolete in comparison with new products

Notes: a**)** Phase titles "New technology", "Pacing technology", "Key technology", and "Base technology" from Anderson (1999), used by Dubarić et al (2011), Gao et al (2013: 399) and Islam et al (2013); b) The logic of "Science-based" phases is adapted from Foster (1986).

In contrast, Dubarić et al. (2011) study of patents was conducted on the level of sub-systems of wind turbines and it showed different levels of maturity and engineering effort/innovation intensity, as measured by patenting activities. Clearly, identifying the comparative progress, maturity and limits of the specific technologies would be instrumental in making decisions about the timing and scale of R&D investments in these or alternative technologies. Similarly, Gao et al. (2013) followed a component level of aggregation of patenting activities for their analysis, which enabled a more reliable derivation of the TLC (for Cathode Ray Tube and Thin Film Transistor Liquid Crystal Display, with comparison to Nano-biosensors). Furthermore, they went into the details of Nano-biosensors technology to deal with fabrication and the limits of detection, pinpointing for investment the pacing technologies that are still facing major developmental challenges.

The application of the *Bill of Technologies* analytical framework described below was informed by previous research. First, we were motivated by Taylor & Taylor (2012: 545) contention that "… for all but the *most simple* [authors' italics, rephrasing: *simplest*] products, it is impossible to envisage one single TLC that represents all technology progression which is relevant to a particular artifact…" Second, Murmann & Frenken (2006) propose that nested hierarchies of TLCs are interacting at any point in time in defining the technology upon which any complex product is based, similarly to a bill of materials. It should also be noted that the best practices of roadmapping, as described by Phaal et al (2001), must heavily rely on technological life cycles as they must connect technological milestones to the evolutionary trajectory of the analyzed applications. Finally, similar principles were applied to a modular complex system by Cebon et al (2008, Figure 3: 381), depicting the various stages of maturity of technological evolution for system's modules and architectures.

4. *Bill of Technologies* as a Framework for System Disaggregation

4.1 From Bill of Materials to Bill of Technologies

The Bill of Materials is a well-established Operations Management concept dealing with the hierarchy of components that a complex product or system consists of (e.g., Hegge & Watmann, 1991). Delivery of these components at the right amount and in the right time to the production floor enables the assembly of the product or system. The planning and execution of this process, originally embodied in the Material Requirements Planning (MRP) system, is by now part of the digitally integrated Enterprise Resource Planning system or ERP. Its structure is visually represented by a "product structure tree" (see Figure 3 below for an example of a bicycle).

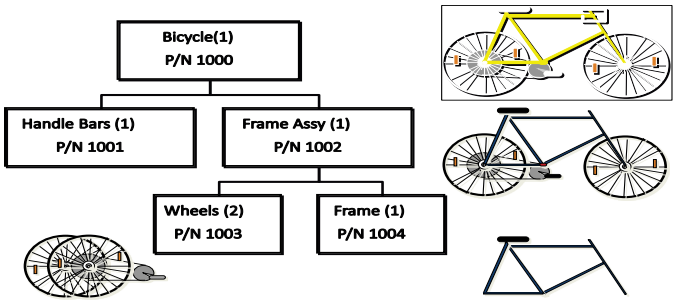


Figure 3: Example of Bill-of-Materials product structure tree for a bicycle

Although technological logic determines the structure of the product structure tree, such as different technologies of production and functionality of the components, the domain of MRP and ERP does not naturally connect with technological innovation or the technology life cycle. The connection between the Bill-of-Materials and the TLC is alluded to by Murmann & Frenken (2006: p.938), who attempt to derive the technological characteristics of an artifact as a structure of nested technologies of its parts. They describe the first level sub-systems of an airplane in terms of a product structure tree, namely as fuselage, wings, propelling device, and landing gear.

4.2 The Principles of the Bill of Technologies

We take these concepts further to derive the Bill-of-Technologies or *BOT* as a similar hierarchy (see Figure 4 below for a generic BOT). This hierarchic structure facilitates the disaggregation of a system or product into their components or modules, which can be meaningfully described in terms of core technologies they embody and the performance characteristics they deliver to the overall product or systems. The meaningful level of disaggregation is dependent on the complexity of the product and requires expert knowledge of the overall product and the technologies it embodies. On the other hand, the basic sub-systems can be derived with limited knowledge, almost purely from the Bill-of-Materials and the Product Structure Tree.

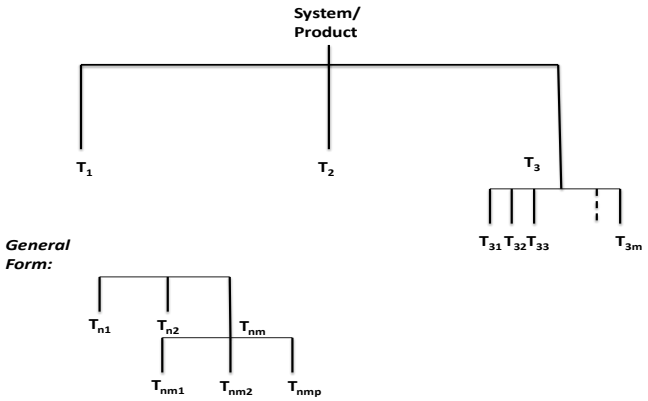


Figure 4: Generic *Bill-of-Technologies* (*BOM*)

We propose several principles to guide the disaggregation process. First, the lowest level in the hierarchy of a product does not have to be uniform across the various sub-systems. For instance, using the airplane example from

Murmann and Frenken (2006), the more complex propulsion sub-system may have more levels than the less intricate landing gear. Second, it is critical that the lowest level in the hierarchy enables technology life cycle analysis and measurement. For instance, Dubarić et al (2011) take the overall aggregated patent class F03D of the European Classification (ECLA) for wind motors and disaggregate it into sub-system level of rotor form (F03D1/06B), regulation (F03D7/04) and adjusting pitch (F03D7/02D). They find different levels of innovation intensity for the three selected sub-systems, as measured by comparative patenting frequency.

Third, a system's or product's definition has to be as complete as possible. For instance, Islam et al. (2013) identify similar elements of wind motor systems to the Dubarić et al (2011) study, but then they realize that due to the "stochastic nature of wind" (p.462), they add a whole section about power storage technologies because they critically impact the performance of the overall wind motor system. The logic that determines the inclusion of a component in the product or system definition has to do with the question whether the technology embodied in this component is critically limiting at least a function of the system or product. Boutellier and Löffler (2006) dubbed it *bottleneck technology*. In this sense, the technologies identified by Dubarić et al (2011) are also *bottleneck technologies*.

Fourth, a *BOT* hierarchy significantly differs from *BOM*'s product structure tree. Primarily, the bill-of-materials (*BOM*) is a production database used to coordinate the scheduling of final assembly of a product or system with other departments and suppliers and is driven by demand from distributors and wholesalers. The final assembler of the product or system must see the *first level* of the "tree", while the subsequent levels are relevant only if the sub-systems' production and assembly, and the relevant fabrication, are coordinated by the same MRP/ERP system. *BOT*'s hierarchy of nested technologies, on the other hand, when applied for analysis of relevant technological imperatives of the product or system to generate a technology life cycle, includes *all relevant levels of the hierarchy*, down to the lowest meaningful level technology embodying components. As an example, Dubarić et al (2011, Table 2: 145) attempt to go beyond the ECLA classes and list the most frequently index words in each of their subclasses, identifying for F03D1/06B (rotor form) these are wind, blade, turbine, rotor, power, generator, axis, rotating, generate and hub. In a formal *BOT* structure of wind motors, the analyst would be expected to go into the specific technologies of the components, including alternative technological options for the same functionality (see Islam et al., 2013: 462) for the list of technologies for storage media relevant for wind motors.

There is also a critical difference in the application of *BOM* and *BOT*, with the former being purely a *tactical* tool of coordinating a stable product, produced by well-defined technologies, while the latter is a *technology planning and forecasting framework*, to be used for *strategic* decisions such as investments and acquisitions of IP, licenses and companies.

4.3 The Bill of Technologies and Technological Forecasting

How does the BOT-based disaggregation model facilitate more effective technological forecasting process and outcomes? Although most of the data is derived from the same well-established sources of patent studies and experts-based judgment, the disaggregation of a system or product into its key or bottleneck technologies facilitates systematic analysis of technological, science-based limits, which could be derived from technology life cycles that are constructed on the level of technologies driving system level performance.

Another critical aspect of dealing with technological forecasting on the level of technologies rather than applications or products is the possibility to make the connection with the underlying natural and life sciences. This should facilitate a clearer analysis of technological limits independently from its diffusion phase or estimates of economic value, with the possibility of adding both at a later stage for refining the forecasts. Finally, this approach avoids the fallacies associated with system or product level aggregation, which are not useful for deriving a technology life cycle.

5. Applying the *Bill of Technologies*

We offer a brief illustration of how the proposed *BOT* framework can be applied to advanced and complex systems. Taking the Boeing 787 *Dreamliner* and using public sources of information, such as http://www.newairplane.com/787/ and Boeing's in-house publication (Hale, 2006), we are able to identify the key technologies that drive end customer's experience, namely, reduced noise and better air quality, and operator's benefits in fuel efficiency, ease of maintenance and reliability. These technologies are embodied in several key sub-systems, namely the composite-dominant fuselage, new versions of General Electric and Rolls-Royce engines with

higher bypass ratios(10 versus 7 for previous version), reducing noise and fuel consumption, and substituting numerous pneumatic and mechanical sub-systems with electric architecture. The latter, if taken to its lowest meaningful level of the *BOT*, would have identified higher reliance on electrical power storage systems, and possibly identified bottleneck technologies in the domain of electrical batteries. It is impossible to ascertain after the fact whether such analysis could have pin-pointed the problem waiting to happen, which grounded the whole fleet of delivered Boeing 787 *Dreamliner* by 17th of January 2013 and a day later Boeing halted new deliveries.

For MRI systems, we relied on Scampini (2010) commercial tutorial and Hauptman & Pope (1992). The key sub-systems identified were static magnetic field (by now almost exclusively based on a superconducting magnet), 3D gradient coils, transmit/receive coils, RF receiver, transmitter, and image signal processing. Here is an example of how bottleneck technologies could shift over time, with the role of the image signal processing sub-system as a bottleneck technology being reduced by the tremendous advances in computer technologies, while the magnet is still a bottleneck technology in view of its dependence on superconducting material cooled to between 1.8 and 20 Kelvin. The requirements for producing such sub-systems are extremely demanding, consequently making the forecasting of the highest possible and effective critical temperature very important for technology planning.

6. Conclusions and Future Research

The purpose of this paper is to reintroduce technology life cycle of technologically advanced systems by using connections between the overall system and its sub-technologies. The authors offer a disaggregation model of *BOT* (bill-of-technologies) that facilitates the analysis of a complex system for more accurate technological forecasting. This method links key/bottleneck technologies to overall system's performance, thus enabling the forecasting of system's technological limits. This work has also highlighted the gaps in technology forecasting studies that arise from mismeasuring technological progress on the product or system level.

Further research should focus on developing methods for identifying bottleneck technologies that drive system level performance. In addition, there is a need for understanding the impact of modularization of systems and products on the application of the BOT method for technological forecasting.

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Biography

Oscar Hauptman is Professor of Innovation Management at the University of Western Sydney. He holds a PhD from MIT, and BEng and MSc from the Technion. His academic appointments include Harvard Business School, Carleton University (Ottawa), and Melbourne Business School. He held visiting positions in Singapore Management University, the Technion and KIMEP Kazakhstan. His research focus is on management of technological innovation. Dr. Hauptman served on editorial boards of international journals, including Organization Science, *IEEE Transaction on EM*, and *Technological Forecasting and Social Change*, and was chair of the TIM Division, Academy of Management. His non-academic positions include managing director of a high-technology incubator and president of boutique consulting firms. He conducted professional training seminars and consulting projects, including UNIDO (Thailand), National Cheng-Chi University (Taiwan), Polaroid, Intel, Port of Singapore Authority, Tata Motors, Tenix Defence Systems, International Wool Secretariat, ICI Explosives, MARDI (Malaysia), Intel and MedSim (Israel), and Schmidt Vietnam.

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Modeling a National Policy Making in the Areas of Superconducting Technology Development Based on Technology Foresight

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Keywords
Superconductor, foresight, tree of technology

1. Introduction
Application developing of the superconductor science needs national policy making. The present research investigates the draft of national document of Superconductor science & technology.

2. Methods
Conducting some foresight methods and qualitative methods, researchers have collected micro and macro data about the situation of the technology of superconductor in Iran and in the other countries. Some methods have use in this document are interview, survey, Delphi and experts panel. These methods cause shaping a network of experts in this field

3. Results
During the research identified the strengths and weakness of the superconductor field in Iran. Also this research presents the application superconductor-tree that classifies industrial and technological applications of superconductor in major fields. Using experts panel this essay presents the list of strategies base on the Comprehensive Scientific Map of the Country.

4. Conclusions
The main results of this research are the draft of national plan of superconductor technology and science, and also the application superconductor-tree, but there is need for install a post-foresight process to implement the results.

Significant Factors Affecting the Selection of the Appropriate Project Delivery Method in Electricity Company's Projects

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Abstract

Project delivery method refers to the owners' approach in organizing the project team that will manage the entire design and construction process. There are mainly three categories of delivery methods: traditional design-bid-build, design-build and construction management. The choice of the appropriate delivery method is a key decision that has to be made by owners early in the project lifecycle. This decision has a great impact on project success. However, the decision is not easy as there are many factors that affect the project delivery method decision. Through literature review, a comprehensive list of (15) selection factors was determined. These factors are Schedule, Cost, Flexibility, Project Scope, Size and Complexity, Level Of Quality, Risk Allocation, Price Competition, Responsibility, Project Management Resource, Number Of Contract, Contract Type, Funding Cycle and Political Issues factors. A questionnaire survey was then developed and distributed to construction experts associated with The General Electricity company (GECOL) construction industry to get their perception as to the importance of these factors. The data was analyzed using SPSS software and the factors ranked according to their average mean (M). The result illustrates that the selection factors :Level of Quality, Cost, and Size and Complexity are the most top important selection factors for Project Delivery method.

Keywords
Project delivery methods, Construction Management, GECOL Construction Industry, Mean.

1. Introduction
Owners are faced with an important question at the start of any construction project. This is related to organization of the project team that will manage the design and construction process or the project delivery method. This decision is important as it affects achieving project objectives such as time, cost, quality and safety. Project delivery method deals with the arrangement of contracting parties such as designers, contractors and construction management companies. It answers the questions of what organization gets hired first and how the parties are related contractually to the owner and themselves. There is a number of project delivery methods that can be used on construction projects (Gould,2005). These can be grouped into three distinct categories: the traditional design-bid-build, construction management, and design-build. The last two categories are commonly referred to as alternative delivery methods (Alebarkos, 2013).The use of alternative delivery method has increased in recent years due to many factors including the increase in complexity and size of projects, increased owner sophistication and requirements, demand for shorter delivery period and others. The traditional delivery method has many drawbacks when it comes to meeting the new owner requirements. The drawbacks include longer delivery time, lack of early estimating and potential for disputes (Alebarkos, 2013))(El-Sayegh,2007). Using the traditional arrangement often

results in adversarial relationships among project participants (Kumaraswamy et al., 2002). Due to the obvious drawbacks of the traditional approach, owners started to use alternative methods such as construction management and design-build. Their use had proved to be successful. Design-build delivery method was shown to be faster than other delivery methods . Also, design-build was better in controlling time and cost growth (Gransberg et al., 2003).

The General Electricity company (GECOL) construction is booming. There are a lot of new projects that are executed every year. Some of these new projects include the biggest project in the north of Africa (Golf Power Plant Combined Cycle), West Tripoli Power plant and others. This rapid expansion and the increase in projects' size and complexity has made GECOL looking for new methods to deliver their unique projects. However, the decision is not easy as there are many factors that affect the project delivery method decision (Alebarkos, 2013).It is important that GECOL understands these factors as it will assist them in making the right choice for their projects. This paper discusses the different project delivery methods, determines and ranks the significant factors that affect the selection of the appropriate project delivery methods (Alebarkos, 2013) .

2. Project Delivery Methods

There is a number of delivery methods that are used on construction projects. Each has advantages and disadvantages. The delivery methods can be grouped into three distinct categories. These are traditional design bid-build, construction management and design build. There exists a number of variations in each category.

2.1 Traditional Delivery Methods

In the traditional design-bid-build arrangement, the owner has two separate contracts: one with the designer and one with the contractors as shown in Figure (1). The design company is hired first to provide design services and develop the contract drawings and specifications. At the end of the design phase, the designer assists the owner in the bidding phase and selecting the contractor. Then, the owner signs a contract with the construction company to deliver the project. The designer assists in supervising the project during the construction phase. This is a familiar delivery method to most owners and requires a defined scope prior to bidding. The main disadvantages are the lack of involvement of construction professional during the design phase, longer delivery time (sequential), less flexible for changes and it often results in adversarial relationships among the parties involved (Alebarkos, 2013)(El-Sayegh,2007).

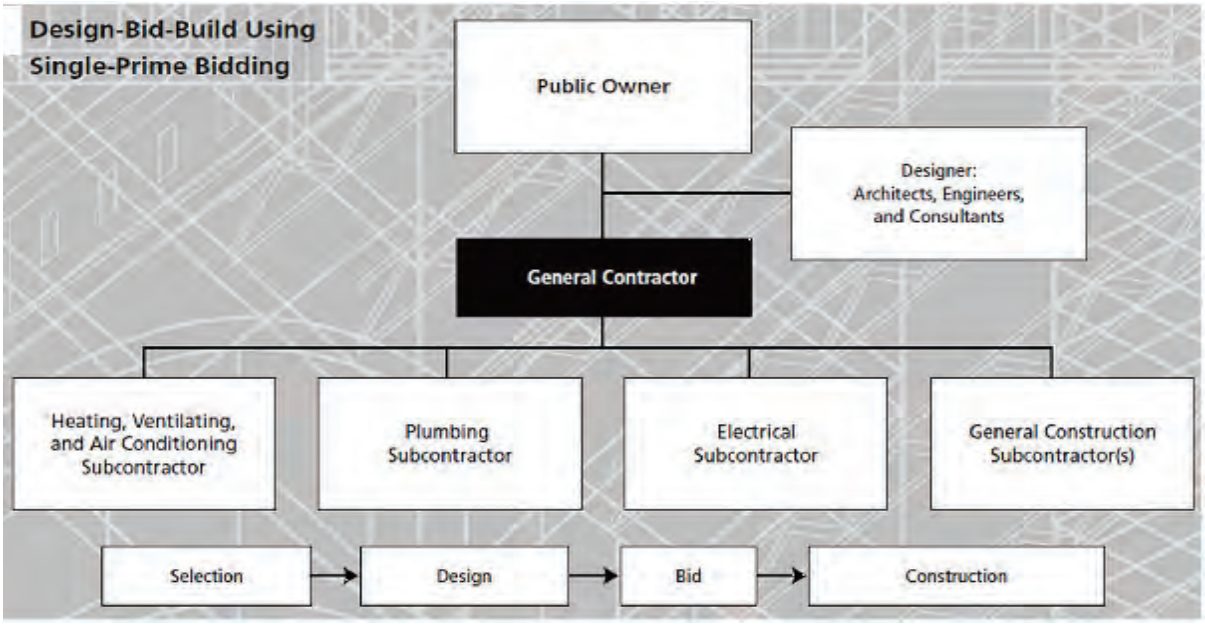


Figure 1: Design-bid-build using single –prime bidding

2.2 Construction Management

This method is similar to the traditional DBB method except for a major addition that is the construction management company. In this method, the owner hires a construction management company at the start of the project. The construction management company assists the owner in selecting the design company, manages the design process and then assists in hiring the prime contractors and later manage the construction process, as showing in Figure (2). This method offers the advantages of professional construction input during the design phase which allows for constructability and value engineering studies. This method allows for more control on project cost, time, quality and safety. The main disadvantage is the lack of overall cost guarantee (Alebarkos, 2013).

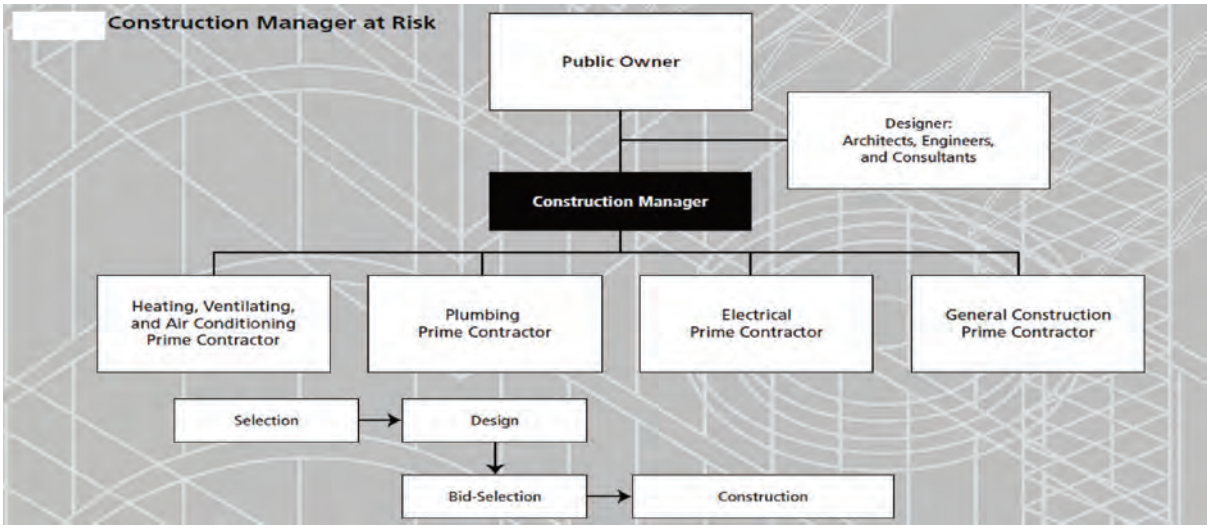


Figure 2: Construction management –prime bidding

2.3 Design-Build

In this method, the owner hires one company for both the design and the construction of the project as shown in Figure (3). The design build company may perform the work itself or hire consultants for the design and subcontractors for the construction work. The advantages of this method include single point of responsibility for design and construction, faster delivery and design and construction integration. The main disadvantages are the lack of check and balances by the owner and the lack of direct contract with the construction contractor (Alebarkos, 2013) (El-Sayegh,2007).

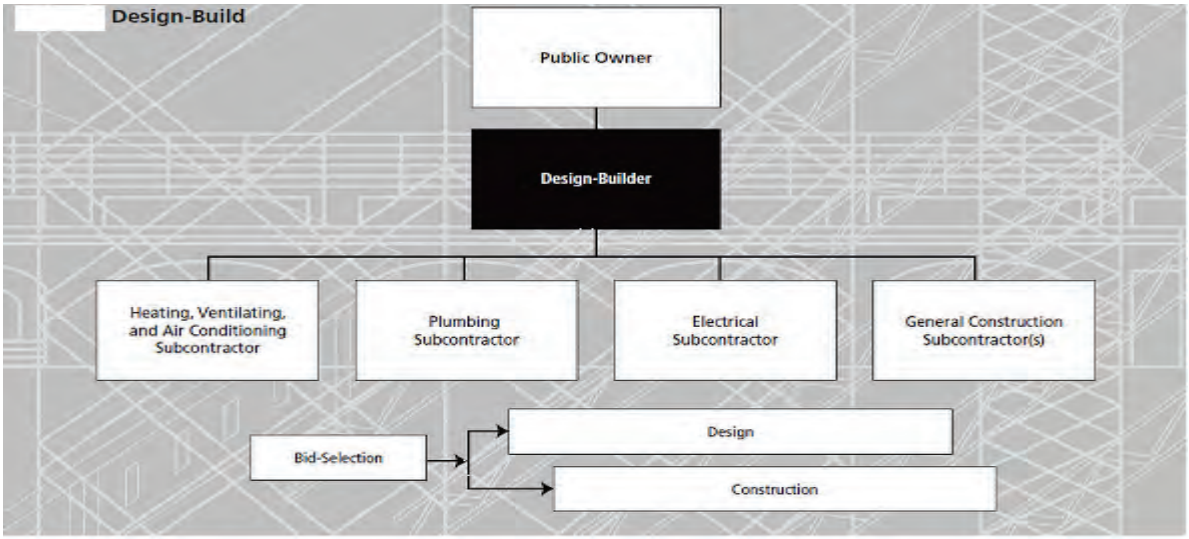


Figure 3: Design-build using single – prime bidding

2.4 The Existing Project Delivery Methods.

Continuous changes in technology and the increasing complexity and development in facilities introduced innovations in project delivery methods. Therefore GECOL policy is planned to develop the project delivery methods to complete the projects within budget, on Schedule and according the required specification. So there are several variations of project delivery methods in GECO construction industry which are (Alebarkos, 2013) :

- Design-Bid –Build Single Primer Contractor.
- Design –Build Contractor or EPC contractor.
- Design-Bid –Build Multiple Primer Contractors.

Table (1) presents results of data that collected about the current project delivery methods used in GECOL from a sample of 67 construction projects issued between 2000 and 2010.

Table 1: Project Delivery Method

Project Delivery Methods	Frequency	Percentage
Design- Bid- Build Single	40	56.70%
Design – Build	12	16.40%
Design-Bid-Build Multiply	15	20.90%
Total	67	100%

According to the Table 1, three primary methods that are used in GECOL to design and build infrastructure projects, where the DBB-S method is 56.7 % of projects, the second most common method is design –bid –build multiply contractors and it is 21 % of projects and the design – build is 16.4 % .

3. Data Collection

The first step in this research was to determine the factors affecting the choice of the appropriate delivery method in construction projects. A literature survey is conducted to identify the major selection factors influencing in the selection of Project Delivery Methods. Table (2) shows the frequency of the selection factors that influencing in the selection of project delivery methods. These factors are related to time, cost, scope, quality, owner organization, cash flow, project characteristics, risk and relationships, then a Questionnaire survey was developed to evaluated on the significant factors affecting the choice of delivery method on GECOL projects. The respondents were asked to evaluate each factor on a scale of 1 to 5 (extremely important is 5, important is 4, normal is 3, slightly important is 2 and not important is 1). The Relative average mean (M) was then calculated as an average of the responses. Fifty – four Questionnaires survey were completed by construction experts working in the General Electricity company (GECOL) construction industry. The respondents profile is shown in Figure (4) and it included 6 Distribution Projects Engineers , 30 Transmission Projects Engineers, 6 Generation Projects Engineers industrial and 5 Contact Projects Engineers.

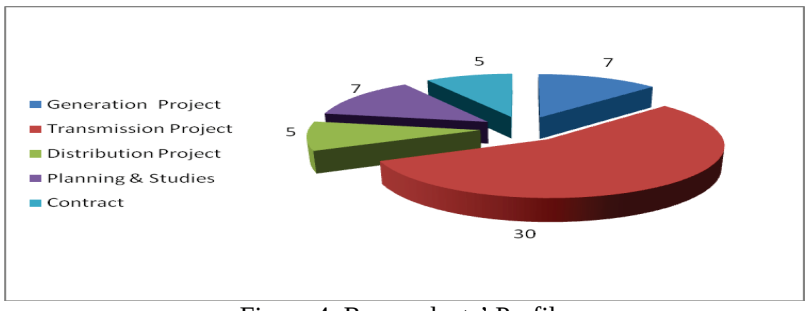


Figure 4: Respondents' Profile

Table 2: Summary of literature reviews on factors influencing the selection of project delivery method

SN	Factor	Description	Frequency
1	Schedule	Time is a major constraint in most projects. The owner must determine if a fast track schedule is necessary. In the traditional DBB method, the project duration is lengthy because of the serial sequencing of phases.	12
2	Cost certainty	Price and the stipulated time and knowledge of how much the client has to pay at each period during the construction phase. A reduction in unanticipated extra cost over-run	11
3	Flexibility	Ability to accommodate design changes during both design and construction periods	8
4	Project Scope	The clarity of the project scope and requirements of the owner can affect the decision to select a PDM. Generally a DB approach requires a well-defined scope . Other methods are more appropriate if the scope is vague and its definition is evolving.	2
5	Size and Complexity	Whether a project is a standard, repetitive design or a complex unique design is also a factor in selecting a preferred PDM. . In the case of a complex design DBB may be used. If the owner also requires additional services such as a fast track schedule, the CM method may be the preferred approach. Constructability analysis	11
6	Quality Level	Contractor's reputation, aesthetics and confidence in design. A building which reflects the clients activities and image	11
7	Risk Allocation	A wish to identify risks and uncertainties during the procuring process	5
8	Price Competition	Covering such issues as value for money, maintenance, costs and competitive tendering.	4
9	Minimizing adversarial relationships	Owners prefer methods that minimizes the disputes and adversarial relationships	6
10	Responsibility	Some owners may prefer the characteristic of DB contracts of a single point responsibility. In a DB system, the contractor is responsible for both design and construction errors. However, in such a situation there may be a tendency to cover some of the errors. Hence, other owners may prefer other types of systems which provide for checks and balances between design and construction.	7
11	Project management Resource	The level of in-house management experience or utilizing various specialty consultants.	2
12	Number of contract	The owner's desire for single project contract or number of contracting parties	2
13	Contract type or Pricing	Contracts may be priced as lump sum, or cost plus. The DBB and the DB methods may be more suitable under a lump-sum contract, while the CM is generally the preferred method for cost-plus contracts.	2
14	Funding cycle	Is the project's funding available for construction at initiation of the design	2
15	Political Issues	Do laws rules , regulations, regulatory and statutory requirements etc ,permit the use of an alternative project delivery method?	2

4. Result

The ranking of selection factors effecting in selection of Project delivery method is calculated based on the mean rank score. Data collected through questionnaire survey was analyzed with SPSS to identify and rank the significant factors affecting in selection of Project delivery method. Results are presented in Table 3. The mean rank score for the Level of quality is extremely high important compared with the other factors where as the other significant factors include as discussed below.

Table 3: Ranking of significant factors affecting the delivery method selection

Factor	Mean	Rank	
Level Of Quality	4.444	1	Strongly Important
Cost	4.2037	2	Strongly Important
Size and Complexity	4.1852	3	Important
On Schedule	4.1667	4	Important
Flexibility	4.1481	5	Important
Responsibility	4.0741	6	Important
Disputes	4.0185	7	Important
Availability of Funding	3.8148	8	Important
Risk Avoid	3.8	9	Important
Project management	3.64	10	Important
Contractor Experience	3.63	11	Important
Issues Political	3.5926	12	Important
Project Scope	3.4815	13	Important
Single Construction Contract	3.2593	14	Normal
Price Competition	2.3889	15	slightly important

4.1 Level Of Quality

The Table 3 indicates that the factor “Level of Quality ", the respondents said that the “Level of Quality” is strongly important factor that influence in selection project delivery method, the weighted mean is (4.444) and ranked 1st. This shows the desire to deliver quality products. Although quality must be ensured in all delivery methods, some delivery methods such as construction management help in achieving this objective. Consequently the study finding shows that “Level of Quality” factor is influenced in the selection of the project delivery method.

4.2 Cost

The Table 3 indicates that the factor “Cost ", the respondents said that the “Cost” is strongly important factor that influence in selection project delivery method, the weighted mean is (4.20) and ranked 2nd. This means that GECOL's Experts prefer the delivery method that complete the project within the budget such as design-build and construction management. as decision makers are worried about controlling cost growth rather than achieving the cheapest cost. Consequently the study finding shows that “Cost” factor is influenced in the selection of the project delivery method.

4.3 Size and Complexity

The Table 3 indicates that the factor “Size and Complexity ", the respondents said that the “Size and Complexity” is important factor that influence in selection project delivery method, the weighted mean is (4.18) and is ranked 3th. This means that GECOL's Experts prefer the delivery method that manage the size and complexity of huge of activates of the project such as design-build. Consequently the study finding shows that “Size and Complexity” factor is influenced in the selection of the project delivery method.

4.4 On Schedule

The Table 3 indicates that the factor “On Schedule ", the respondents said that the “On Schedule” is important factor that influence in selection project delivery method, the weighted mean is (4.16)and is ranked 4th . GECOL's Experts are more worried about ensuring the on-time completion (M is 4.16) and is. This shows the importance of construction management delivery methods that are not necessarily the fastest method but help maintain the schedule and ensure timely completion. Consequently the study finding shows that “On Schedule” factor is influenced in the selection of the project delivery method.

5.5 Flexibility

The Table 3 indicates that the factor “ Flexibility ", the respondents said that the “ Flexibility” is important factor that influence in selection project delivery method, the weighted mean is (4.14) and ranked 5th. This shows that the GECOL's Experts desire for flexibility to make changes during construction and this factor is important in deciding the appropriate delivery method. Consequently the study finding shows that “ Flexibility” factor is influenced in the selection of the project delivery method.

4.6 Responsibility

The Table 3 indicates that the factor “Responsibility ", the respondents said that the “Responsibility” is important factor that influence in selection project delivery method, the weighted mean is (4.07) and ranked 6th. This means that GECOL's Experts prefer the delivery method that to control of the project during construction such as design-bid-build. Consequently the study finding shows that “Responsibility” factor is influenced in the selection of the project delivery method.

4.7 Disputes

The Table 3 indicates that the factor “Disputes ", the respondents said that the “Disputes” is important factor that influence in selection project delivery method, the weighted mean is (4.01) and ranked 7th. This means that GECOL's Experts prefer the delivery method that minimizes the disputes and adversarial relationships for changes during construction of the such as design-bid-build. Consequently the study finding shows that “Disputes” factor is influenced in the selection of the project delivery method.

4.8 Availability of Funding

The Table 3 indicates that the factor “Availability of Funding ", the respondents said that the “Availability of Funding ” is important factor that influence in selection project delivery method, the weighted mean is (3.81) and is ranked 8th. The "Availability of Funding (M is 3.81) which indicates that GECOL's Experts are not worried about financing or cash flow issues. and Is the project's funding available for construction at initiation of the design. Consequently the study finding shows that “Availability of Funding ” factor is influenced in the selection of the project delivery method.

4.9 Risk Avoid

The Table 3 indicates that the factor “Risk Avoid ", the respondents said that the “Risk Avoid” is important factor that influence in selection project delivery method, the weighted mean is (3.8) and is ranked 9t^{h}. This factor is important in choosing the method that properly allocated the risk among contractual parties. GECOL's experts’ prefer methods that transfer risk to minimize the disputes and adversarial relationships that are common in the design-build and construction management delivery method. Consequently the study finding shows that “Risk Avoid” factor is influenced in the selection of the project delivery method.

4.10 Project management

The Table 3 indicates that the factor “In house Project Management ", the respondents said that the “In house Project Management” is important factor that influence in selection project delivery method, the weighted mean is (3.64). Consequently the study finding shows that “In house Project Management” factor is influenced in the selection of the project delivery method. The "In house Project Management" (M is 3.64) is ranked 10th

4.11 Contractor Experience

The Table 3 indicates that the factor “Contractor Experience ", the respondents said that the “Contractor Experience” is important factor that influence in selection project delivery method, the weighted mean is (3.63) and is ranked 11th. This is surprising, as professional construction experience is really needed during the design phase for

constructability and value engineering studies. Consequently the study finding shows that “Contractor Experience” factor is influenced in the selection of the project delivery method.

4.12 Issues Political

The Table 3 indicates that the factor “Issues Political ", the respondents said that the “Issues Political” is important factor that influence in selection project delivery method, the weighted mean is (3.59) and is ranked 12th . Consequently the study finding shows that “Issues Political” factor is influenced in the selection of the project delivery method.

4.13 Project Scope

The Table 3 indicates that the factor “Project Scope ", the respondents said that the “Project Scope” is important factor that influence in selection project delivery method, the weighted mean is (3.48). Consequently the study finding shows that “Project Scope” factor is influenced in the selection of the project delivery method.

4.14 Single Construction Contract

The Table 3 indicates that the factor “Single Construction Contract ", the respondents said that the “Single Construction Contract” is normal factor that influence in selection project delivery method, the weighted mean is (3.25) and is ranked 14th . The selection of the appropriate delivery method depends largely on the owner’s organization. Also, the desire for single construction contract which means that owners still prefer to stay in control of the construction project.

4.15 Price Competition

The Table 3 indicates that the factor “Price Competition ", the respondents said that the “Price Competition” is slightly important factor that influence in selection project delivery method, the weighted mean is (2.38) and is ranked 15th. Consequently the study finding shows that “Price Competition ” factor is influenced in the selection of the project delivery method.

5. Summary and Conclusion

There are several project delivery methods that owners can select from in order to deliver their construction projects and achieve their objectives. There are three main categories and a number of variations. The traditional delivery methods take longer time to complete and result in adversarial relationships. The construction management methods offer more control over time, cost, safety and quality. Design-build methods minimize the number of contracts and allows for good design-construction integration.

To assist GECOL in choosing the appropriate delivery method, a number of factors should be considered. This research indicated that Level Of Quality, completed within budget , Size and Complexity and On Schedule are the main factors to help the GECOL to select the appropriate project delivery method . It is clear that the traditional delivery methods have shoe comings when it comes to meeting these factors and objectives. This paper has presented the characteristics of the common project delivery methods and ranking of the factors affecting the selection process. GECOL's Experts need to evaluate their objectives carefully and choose the method that maximizes their chances of meeting these objectives.

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Sales Quotation and Order Process Value Stream Mapping: A Case Study

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Abstract

Lean thinking has a widespread impact on manufacturing operations. Order-to-delivery lead time can significantly be reduced by eliminating wastes and creating flow. Academic literature and implementation case studies often focus on lean transformation of manufacturing processes. On the other hand, publications on knowledge processing are scarce. However, support functions such as sales, planning, procurement etc. play a critical role on the overall success of lean transformation. Also, the root causes of many wastes in manufacturing can be found in office operations.This study acknowledges the potential benefits of implementing lean principles of office operations and provides a real life case study to present the value stream analysis. Sale quotation value stream and order value stream of an industrial goods manufacturer is analyzed. Current state value stream maps are formed by collaboration of the staff and the management. Total process time and lead time are compared. A novel approach for a dual assessment of lead time is presented and implications are discussed and actions for waste reduction is proposed.

Keywords
Lean, value stream mapping, sales, case study

1. Introduction
Origins of lean thinking stems from manufacturing, specifically manufacturing of motor vehicles (Womack, Jones, & Roos, 1990). Nevertheless today, lean thinking is well expanded from the limits of manufacturing and supply chain operations to cognitive domain of office work. Sales quotation and order process has a major contribution on firm performance and also the lean thinking commends to focus improvement efforts on the point closest to customer. Yet, this area often neglected in both lean thinking and operations management literature.

The lean principles stress the importance of visualization and visual management of value streams. Value stream mapping (VSM) is the visualization tool of lean thinking (Jones & Womack, 2002; Rother & Shook, 2003). VSM applications on the academic literature is dominated by examples of manufacturing system analysis (Braglia, Carmignani, & Zammori, 2006; Dotoli, Fanti, Member, Iacobellis, & Rotunno, 2012; Nash & Poling, 2008; Rahani & al-Ashraf, 2012; Vinodh, Arvind, & Somanaathan, 2010). In terms of office operations, VSM of new product development processes also exist (Fritzell & Göransson, 2012; Locher, 2008; McManus & Millard, 2002; McManus, 2005; Oppenheim, 2004; Schulze et al., 2011). VSM application on sales quotation and order process, on the other hand, is scarce and limited to simple educational examples provided in the books (Martin & Osterling, 2013; Nash & Poling, 2008).

This study aims to fill the gap in Lean Management, more specifically VSM literature and also contribute to sales operations management field by demonstrating an actual implementation of VSM technique in real life setting. Sale

quotation and order value streams of an industrial equipment manufacturer are analyzed. Current state value stream maps are formed by collaboration of the staff and also by direct observation of work-in-process. Total process time and lead time are compared and wastes are presented.

2. Value Stream Mapping

Lean can be defined as continuous elimination of non-value added activities through the value stream to facilitate flow of value synchronized to customer demand (Womack & Jones, 2003). The reference model of Lean Thinking is Toyota Production System (TPS) and the founder of TPS, Taichi Ohno, summarized the focus of TPS as the elimination waste through the point where an order is received to the point of payment (Ohno, 1988). Also, The Lean Enterprise Institute formalizes the second principle of lean thinking as follows; "Identify all the steps in the value stream for each product family, eliminating whenever possible those steps that do not create value" (LEI, 2012). Managing value streams, therefore is the focal point of Lean improvement efforts. Value stream mapping facilitates easy visualization for this purpose. The main distinction between VSM and other visualization tools is that VSM allows us to differentiate between value added and non-value added (waste) activities.

VSM technique requires data collection the following parameters:

- *Lead Time*: The total time spent between the time a job is received and the time it is delivered. Lead time includes the time spent at the queue, waiting due to shortage of resources, outages, delays, failures. Hence lead time involves time spent by non-value added activities as well as value added activities. Lead time may either be derived from interviews with staff and administration or may be calculated by Little's Law (Hopp & Spearman, 2011).
- *Process time*: Process time can be defined as the time a job takes from start to finish in an ideal state; all resources are idle and ready, all the equipment and information are available, there are no failures and work is performed continuously. In other words, process time emphasizes a waste free time. Yet depending on the process, differentiating the exact duration of value added portion of the process may require further analysis and it may possibly be smaller than process time. Nevertheless, the ratio of process time to lead time demonstrate the potential for improvement that can be realized by waste reduction.
- *Ratio accurate and complete (%):* Error and inaccuracy may cause iterations or rework, therefore contributes to non-value added activities. This parameter is delivered by the stand point of the customer of the process.
- *Reliability (%):* This is a parameter concerning the resource used for the process and emphasis the ratio of uptime to total available time
- *Number of staff:* This parameter is the number of people readily available for the process.

3. Case Study

The sales quotation and order value stream mapping will be illustrated through a case study. The firm under observation manufactures industrial products. The sales organization is divided as local and foreign sales teams as these two has many distinct work flows and interactions. Table 1 summarizes the current demand parameters for each value stream for both local and foreign sales operations. Takt time can be defined as the rhythm imposed by the customer demand and for example for local orders, to completely respond to current demand, the sales team should have a cycle time of 3 hours for each order.

Table 1: Takt time for individual value streams

	Sales Quotation VS		Order VS	
	Local	Foreign	Local	Foreign
Total (number per year)	3556	1000	711	200
Takt Time (hours)	0.6	2.1	3	10.5

Following sections demonstrates value stream maps and discusses implication in detail. The dimensions of the maps require an A2 paper type for easy reading, yet for practical purposes first a scaled down version and then parts of the maps are provided. Both value streams applies to both local and foreign sales, yet parameters may differ and some processes may be necessary for only local or for only foreign sales.

3.1 Sales Quotation Value Stream

Before customer places an order, first a series of activities are performed for sales quotation. Complete VSM is given in Figure 1. The whole value stream can be analyzed in five sections; 1) Initial trigger, 2) Demand evaluation and analysis 3) Customer approval 4) Information handoff between planning, manufacturing and procurement, and 5) Delivery of sale quotation.

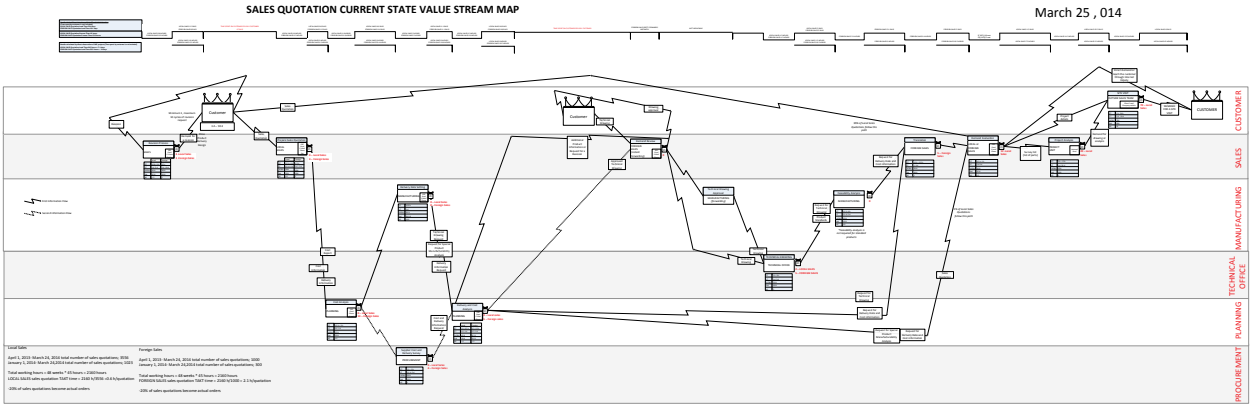


Figure 1: Sales quotation value stream

The value stream commences with either direct customer demand or a demand for a site visit (Figure 2). In the case of site visit, there is an additional process for project analysis and this only applies to local sales. For foreign sales demand is received with a complimentary survey list. For the foreign sales, a sales quotation may be generated just after the demand evaluation process. On the other hand, for the local sales a series of other activities are performed.

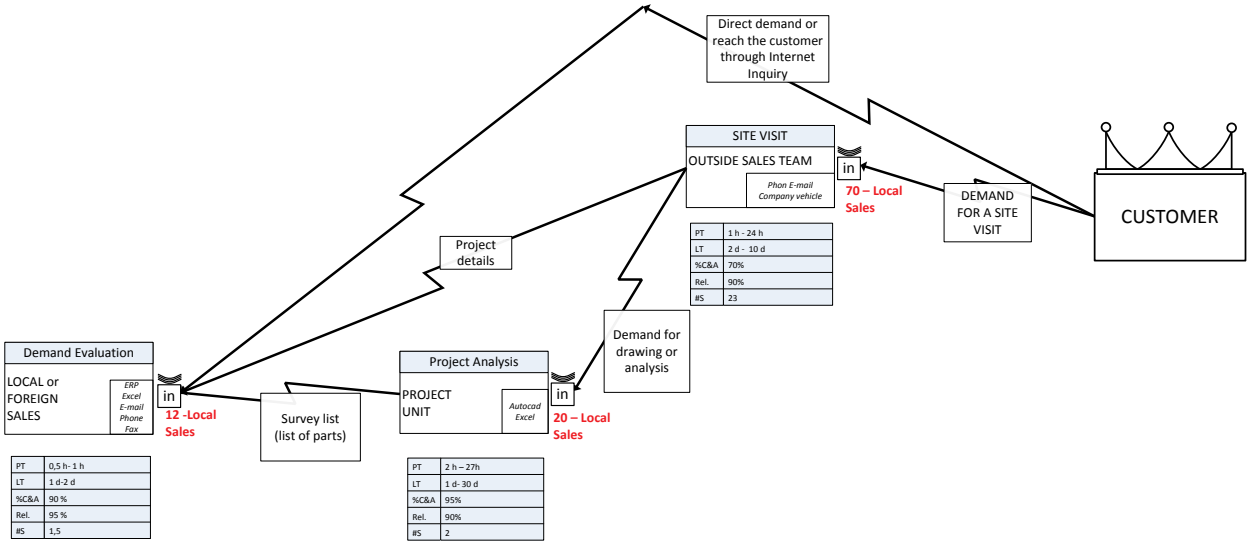


Figure 2: Sales quotation initial trigger

For foreign sales, translation is required before circulating the survey list. Also as seen in Figure 3, both local and foreign sales requires feasibility analysis by manufacturing department and also a technical drawing prepared by the technical office.

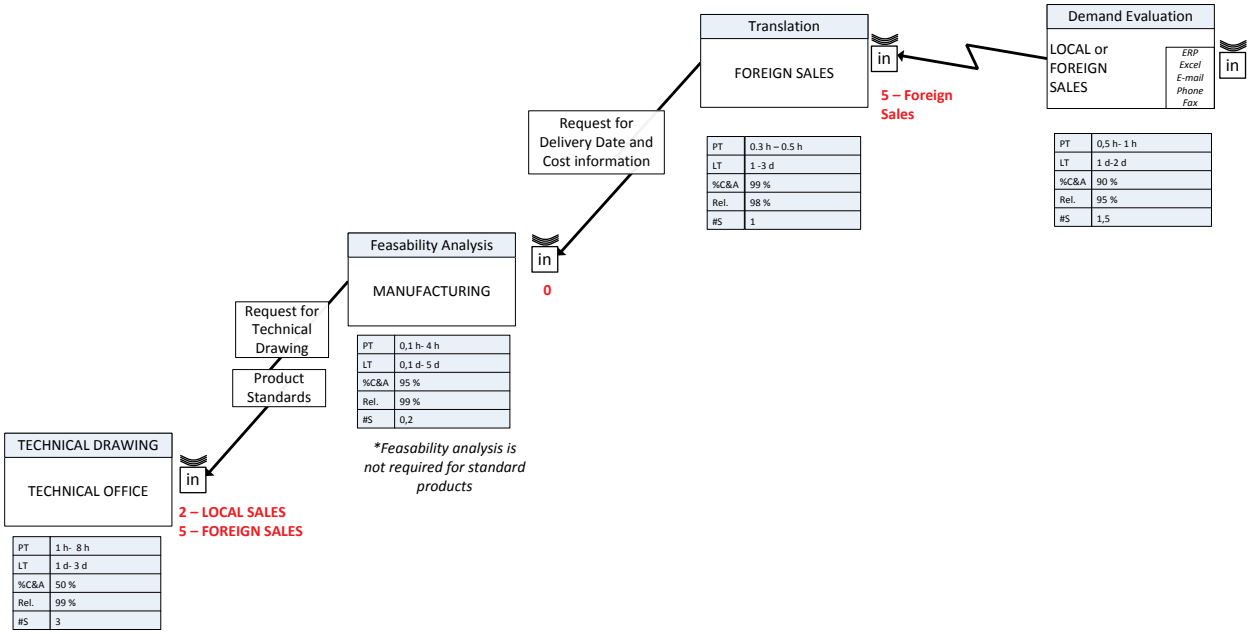


Figure 3: Demand evaluation and analysis

Technical drawing is later send to manufacturing department for approval as seen in Figure 4. Yet, no parameters are stated for manufacturing approval because this is an instantaneous action and it doesn't require any resources. Manufacturing forwards the technical drawing to sales and before moving any further, sales department demands customer approval on the technical drawing. Although this cycle may happen more than once, in the majority of the cases, the technical drawing is approved on the first time.

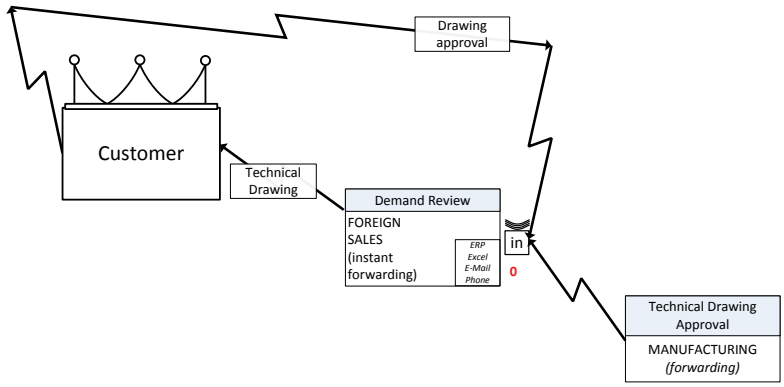


Figure 4: Customer approval

Approved technical drawing and specific demand information later send to planning and procurement departments as seen in Figure 5. At this point there is no direct interaction between sales and manufacturing but planning department coordinate the information between them by requesting a delivery information. In parallel procurement contact suppliers if necessary. Information from manufacturing and procurement departments are gathered by planning and a cost analysis is performed. The dotted line symbolizes a second order information flow. In this case, it means that the planning department first contacts manufacturing and then later contacts procurement.

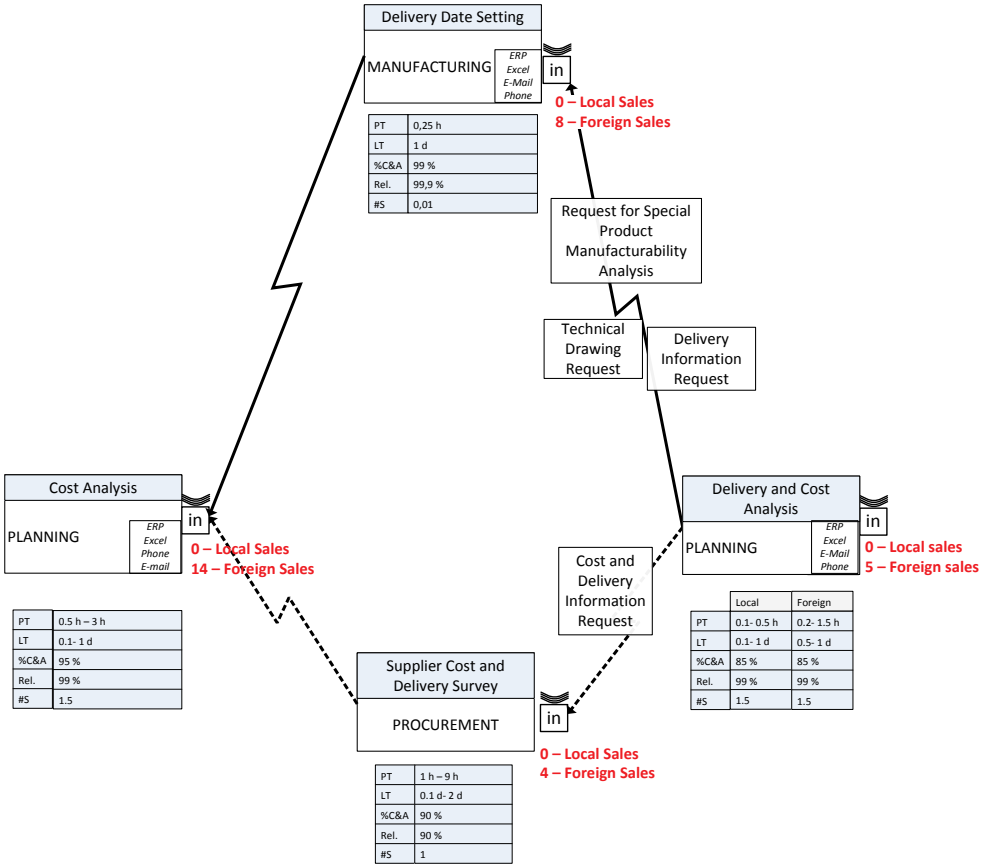


Figure 5: Interdepartmental hand-off of information

Figure 6 illustrates the final stages of the value stream. There is one more approval cycle at this point, between customer and sales if revision is required. This cycle may happen up to 10 times and each time the quotation spend 3 to 90 days at the customer. The revision may be about price, product, delivery, design or a combination of these attributes.

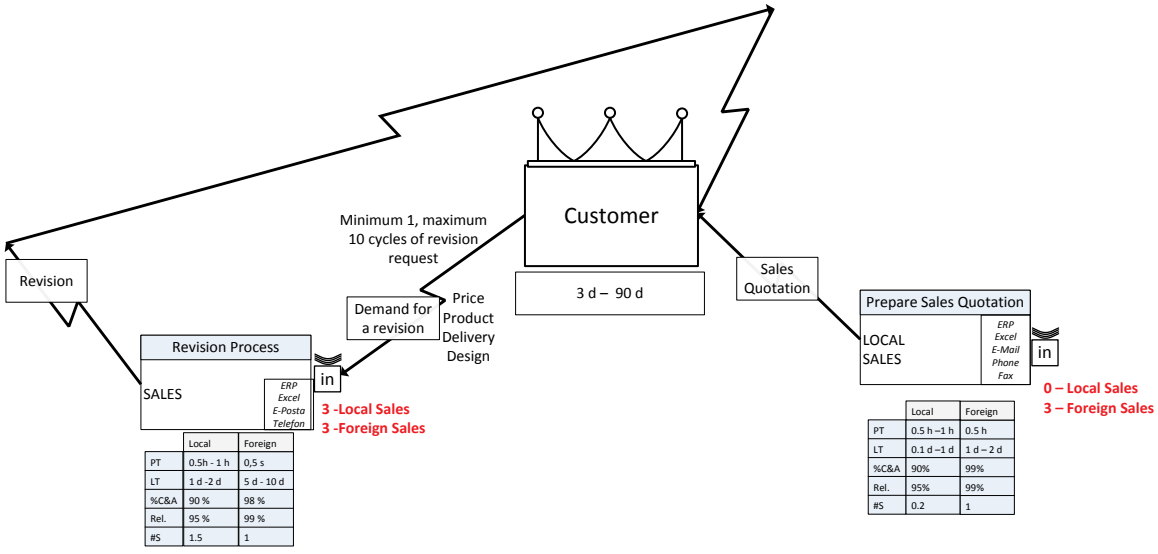


Figure 6: Final steps and revision

Table 2 provides a list of interaction between departments for sales quotation value stream. Values are given in terms of interaction/quotation. The flow of information/material is from the department given in column heading to department given in the row heading. For example total interaction from Sales to Planning is 3 and from Planning to Sales is 1.

Table 2: Sales quotation current state value stream - interaction between departments

	Customer	Sales	Manufacturing	Technical Office	Planning	Procurement
Customer	X	6	0	0	0	0
Sales	5	X	1	1	1	0
Manufacturing	0	1	X	1	1	0
Technical Office	0	0	1	X	0	0
Planning	0	3	1	0	X	1
Procurement	0	0	0	0	1	X

3.2 Order Value Stream

Order VSM is much simpler than sales quotation VSM as given in Figure 7. At this point customer has already received the sales quotation and decided to buy the product on the previously agreed conditions. Still, there is a series of processes concerning the update and approval of this information before actually placing a work order. This value stream also begins with customer trigger but ends when the manufacturing department places a work order.

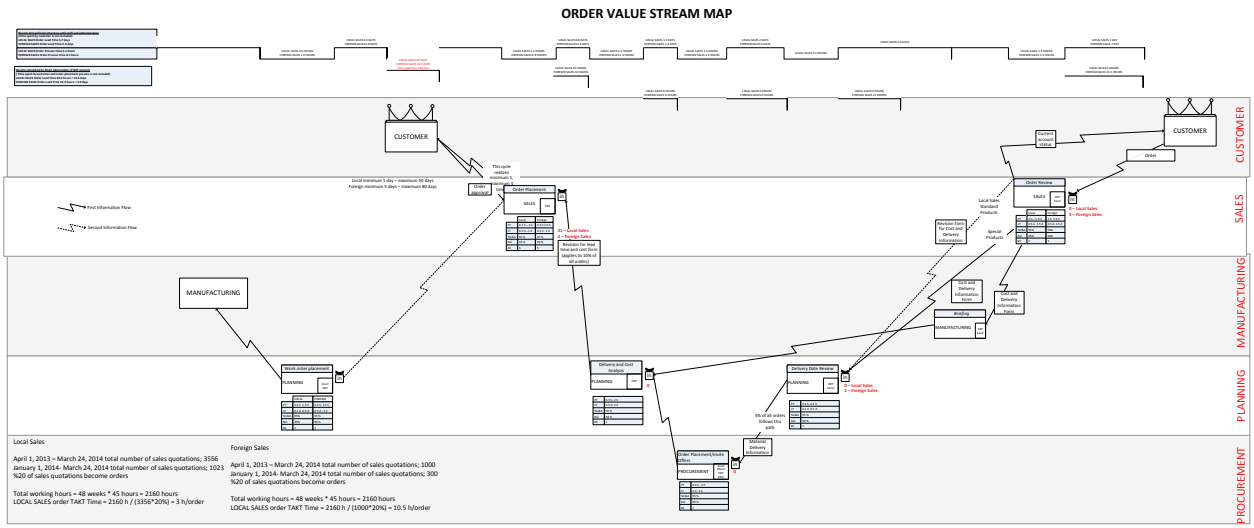


Figure 7: Order value stream

At the beginning of the order value stream there is a cycle between customer and the sales department concerning the account status as given in Figure 8. The sales department may prefer to halt the process depending on the outstanding debt of the customer.

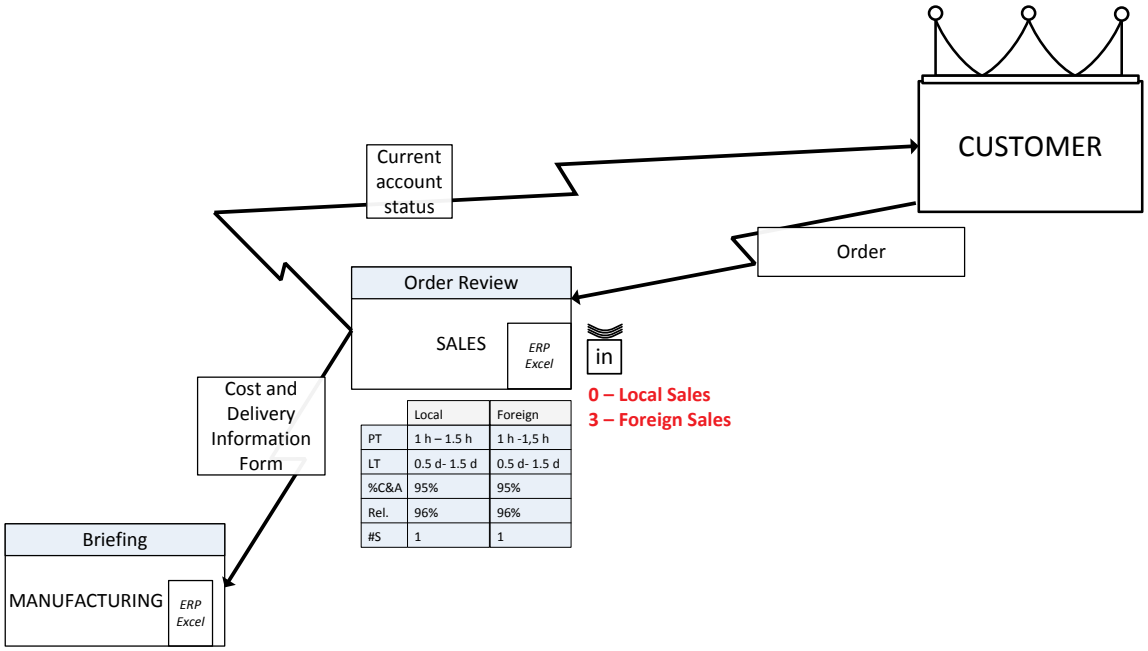


Figure 8: Order value stream trigger

Delivery date is set and agreed upon on the sales quotation value stream. But after the actual order is received, delivery and cost analysis is performed again by planning department as seen on Figure 9. On the 5% of the cases, procurement department is informed and supplier order is placed.

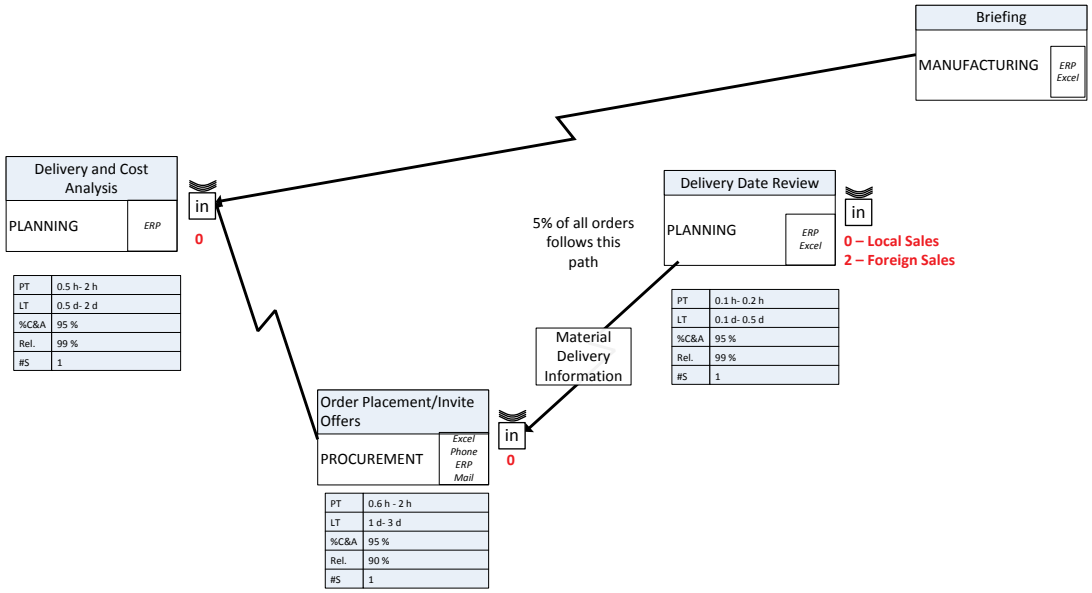


Figure 9: Order value stream delivery planning

Before the manufacturing department receives work orders from planning department, there is a cycle of order approval between sales and customer. This cycle may repeat up to three times. For local sales each review spent up to 50 days and for foreign sales each review spends up to 80 days on customer as given in Figure 10.

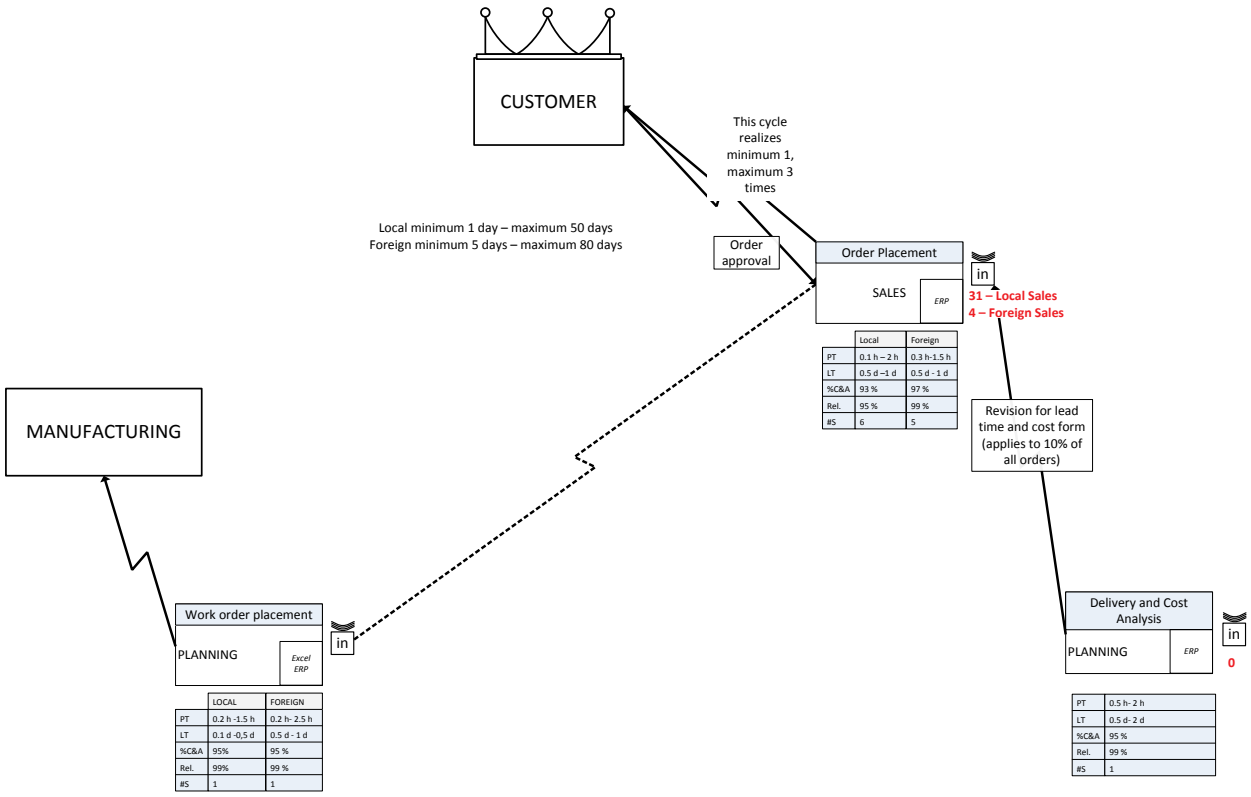


Figure 10: Order value stream final phase

Table 2 summarizes interaction between departments for order value stream. Values are given in terms of interaction/order. The flow of information/material is from the department given in column heading to department given in the row heading. For example total interaction from Sales to Planning is 4 and from Planning to Sales is 1.

Table 2: Order current state value stream - interaction between departments

	Customer	Sales	Manufacturing	Planning	Procurement
Customer	X	2	0	0	0
Sales	3	X	0	1	0
Manufacturing	0	1	X	0	0
Planning	0	4	1	X	1
Procurement	0	0	0	1	X

3.3 Results and Discussion

The lead time is determined in two ways. First, by the interviews with the staff and administration, lead time parameter values are collected for each process. Total lead time derived by this approach is given as “Declared Lead Time” in Table 3. Second, for each process, total number of work-in-process values is collected either by direct observation, or through a query on ERP system. Work-in-process values are transformed into lead time parameter by Little’s equation that is WIP * Takt Time = Lead Time. Total lead time calculated by this approach is given as “Observed Lead Time” in Table 3.

Table 3: Lead time, process time and activity ratio for each value stream

	Sales Quotation VSM		Order VSM	
	Local	Foreign	Local	Foreign
Observed Lead Time (days)	7.1	19	10.4	5.9
Declared Lead Time (days)	29.4	18.1	5.7	5.9
Process Time (hours)	41	15.6	5.1	6.1
Observed activity ratio	0.64	0.09	0.05	0.11
Declared activity ratio	0.15	0.10	0.10	0.11

This type of dual assessment of lead time may lead to following points.

- If the observed lead time is higher than the declared lead time, one or both of these following statements holds
    - Due to variability or unusual peak in the demand trend, system goes through a stage of overburden or excessive demand
    - Due to planning bias or Hawthorne effect, interviewees tend to respond in an optimistic manner for process lead times.
- If the observed lead time is lower than the declared lead time, either one or both of these following statements holds.
    - Due to variability or decline in the demand trend, system goes through a stage of low utilization
    - Due to a misplaced concern that confuses conducted interviews as performance assessment, the interviewees attempt to set higher levels of lead time for future reference.

Apart from the difference between observed and declared lead time, the activity ratio in either case is low. Following actions may be considered to eliminate waste, hence shorten the lead time.

- The system can be reorganized around value streams to avoid hand-offs between departments. Planning and procurement functions can be linked to manufacturing based on the value stream. This would create a multi-functional team that serves a specific value stream. Sales function may still be represented by a different department as the customer demand often involves multiple value streams.
- A further process analysis may be reveal a distinction standard and non-standard work for planning department operations. Standard work such as updating bill of materials may still be a separate function apart from value stream centered organization.

4. Conclusion

The primary focus of lean thinking is often manufacturing Knowledge work is a neglected area of lean thinking and of operations management in general. Yet, office operations, in this case sales operations, propose an improvement potential and may effect overall business performance. This study demonstrated the use of Value Stream Mapping on sales quotation and order processes. Maps are provided and results are explained. A dual assessment of lead time is performed for both value streams and also branched for local and foreign sales. A new notion of observed and declared is first introduced in this study and implications are discussed.

Future study will focus on future state design for the same value streams. A pull framework will be provided to lower the lead time and to set up an environment for continuous development.

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The Evaluation of Implementation Levels for RFID Applications using Fuzzy Information Axiom

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Abstract

Radio Frequency Identification (RFID) systems is regarded as key to the success in supply chain management, no matter which product or industry is considered. Therefore RFID systems gained popularity and implemented for distribution, manufacturing, warehousing processes, even in industries such as defence and healthcare. The advantage of RFID tags is that they use a memory storage device to store a data such as the product identification number, price, cost, manufacture date and location. In addition, determining tagging level can be regarded as a critical stage for RFID projects due to the fact that each system has different expectations and requirements as for RFID integration aspect. Thereby, Information Axiom, the second axiom of axiomatic design (AD), provides the basis for decision making. The utilization of linguistic terms are suitable during the evaluation of RFID tagging level alternatives, since the alternatives do not have precise and crisp ratings with respect to each criteria. That being the case, fuzzy logic is integrated to the proposed information axiom oriented methodology. In this paper, fuzzy Information Axiom based model is proposed for determining the most appropriate tagging level for RFID projects. The related evaluation is made for the alternatives of item, box and pallet levels with respect to cost, benefit and implementation aspects in a hierarchical manner.

Keywords
RFID tagging level, information axiom, axiomatic design, fuzzy logic

1. Introduction
Radio Frequency Identification (RFID) technology is one of the straightforward technologies that are being used by a number of both manufacturing and service systems. Investments in RFID technologies are expected not only to reduce costs as well as to increase business value. The level of tagging has a greater influence on total RFID related costs. Tags can be applied at item level, case level or pallet level. Denser the level of tagging more would be information gathered and higher would the associated costs (Url-1). However, for all type of applications it is not the scenario where denser the level of tagging higher would be the benefits attained. It is important to select appropriate level of tagging for a particular type of application. Tags can be applied at pallet level for less valued items such as auto spares parts. Case level tagging would be appropriate for perishable items in which expiry date for all items in a case is same. Pallet and case level tagging would be useful for warehouse management. The tags could be applied to individual items for tracking of high valued items, for example, gold ornaments, baggage tracking (Gaukler et al., 2007). This paper presents an information axiom model with the aim of determining the most effective RFID implementation level among the alternatives of item, box and pallet levels. The developed model considers cost, benefit and implementation aspect related criteria.

On the other hand, effective decision is regarded as a critical success factor for businesses due to the fact that it presents the best course of action in terms of performing a given task, resource utilization and managing conflicts. Multi-Criteria Decision Making (MCDM) is the most well known branch of decision making. It is a branch of a general class of Operations Research (OR) models which deal with decision problems under the presence of a number of decision criteria (Triantaphyllou, 1998). What is more, the information axiom, the second axiom of axiomatic design (AD), provides the basis for decision making when there are many choices. Information axiom is required to minimize information content of the design and it is used to select the best alternative when there are more than one design that satisfy independence axiom. Guiding decision makers to define decision parameters via functional requirements, information axiom has been widely used and mostly preferred for the solution of decision making problems. The underlying reason of using information axiom (IA) is that it is the most effective decision making method in terms of considering the changing satisfaction level of functional requirements for decision makers.

Fuzzy logic provides an inference morphology that enables approximate human reasoning capabilities to be applied to knowledge-based systems. The theory of fuzzy logic provides a mathematical strength to capture the uncertainties associated with human cognitive processes, such as thinking and reasoning. A rise in the fuzzy evaluation based research studies using the information axiom for multi-attribute decision making problems has been stated in the comprehensive literature survey of Kulak et al. (2010). Kulak (2005) developed a decision support system that was utilized for material handling equipment selection under fuzzy environment based on classical information axiom. Huang and Jiang (2002) extended the independence axiom oriented design framework into the fuzzy set theory. Celik et al. (2009) proposed a hybrid approach ensuring the competitiveness requirements for major Turkish container ports based on fuzzy information axiom and fuzzy technique for order performance by similarity to ideal solution methodologies (TOPSIS). Kulak et al. (2005) developed unweighted and weighted multi-attribute axiomatic design approach include both crisp and fuzzy functional requirements and applied the methodology to equipment selection problem. Celik et al. (2009) addressed shipping investment decisions by developing a model, namely ship of quality framework. The methodology integrates quality function deployment, fuzzy analytic hierarchy process and fuzzy axiomatic design principles. Cebi & Kahraman (2010) proposed a new product development algorithm based on axiomatic design principles. The independence axiom of axiomatic design is extended to fuzzy environment.

When considering the large body of literature, it can be concluded that this paper has the originality of presenting the first decision making model for determining the most appropriate RFID implementation level by means of fuzzy information axiom. The rest of this paper is organized as follows. The developed decision making approach is explained in Section 2. Problem description is given in Section 3. Section 4 describes the functional requirements for the proposed model. In Section 5, application study of the proposed approach is expressed. Finally in Section 6, conclusions are provided.

2. Fuzzy Axiomatic Design

The information axiom states that among those designs that satisfy the independence axiom, the design that has the smallest information content is the best design. Information is defined in terms of the information content, that is related in its simplest form to the probability of satisfying the given FRs. Information content of alternative i for functional requirement j (I_{ij}) determines that the design with the highest probability of success is the best design. I_{ij} is defined as follows:

$$I_{ij} = \log\left(\frac{1}{p_{ij}}\right) \qquad i = 1,\ldots, m \quad j = 1,\ldots, n \tag{1}$$

where m is the number of alternatives, n is the number of functional requirements (FRs), p_{ij} is the probability of achieving the FR j for alternative i and log is either the logarithm in base 2 (with the unit of bits).

If the fuzzy data are expressed in linguistic terms, they are transformed into fuzzy numbers first. Then all the fuzzy numbers (or fuzzy sets) are assigned crisp scores. The following numerical approximation systems are proposed to systematically convert linguistic terms to their corresponding fuzzy numbers. An example for a conversion scale is given in Figure 1.

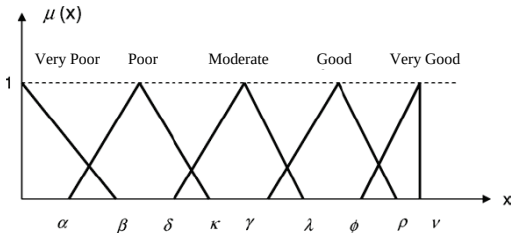


Figure 1: A conversion scale for functional requirements

In any design situation, the probability of success is given by what designer wishes to achieve in terms of tolerance (i.e., design range) and what the system is capable of (i.e. system range). As it is illustrated in Figure 2, the overlap between the designer-specified "design range" and the system capability range "system range" is the region where the acceptable solution exists. Each alternative is evaluated with respect to decision area of each functional requirement. Intersection of the decision range, belonging to functional requirement and the system range, belonging to alternative, called as common area. A ratio called as information content is calculated by using common range and system range. A membership function of triangular fuzzy numbers (TFNs) or trapezoidal fuzzy numbers (TrFNs) exist whereas we have a probability density function in the crisp case. The common area is the intersection area of triangular or trapezoidal fuzzy numbers. The common area between design range and system range is shown in Figure 2. Thus, information content is calculated by Equation 2.

$$I_{ij} = \log_2 \frac{TFN\ of\ System\ Range_{ij}}{Common\ Area_{ij}} \quad i = 1,\ldots, m \quad j=1,\ldots, n \tag{2}$$

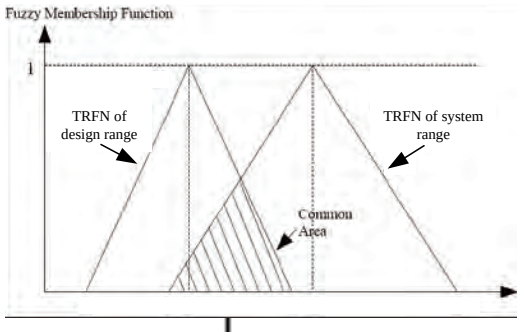


Figure 2: The common area of system and design ranges

Total information content (TI_i) is calculated via the following equation:

$$TI_i = \sum_{i=1}^{n} I_{ij} \qquad i = 1,\ldots, m \tag{3}$$

Finally, the alternative with the minimum TI_i is determeined as the most appropriate alternative. However, FAD does not give permission to rank alternatives in two cases; 1) more than one alternative never satisfies the decision goal, 2) more than one alternative satisfy the FRs for all functional requirements completely. In the both two cases, there come into being more than one alternative having the same result. Therefore, fuzzy functional requirements are defined as presented in Figure 3 with the aim of ranking the alternatives. x_{max} denotes the maximum upper value of TFN scale.

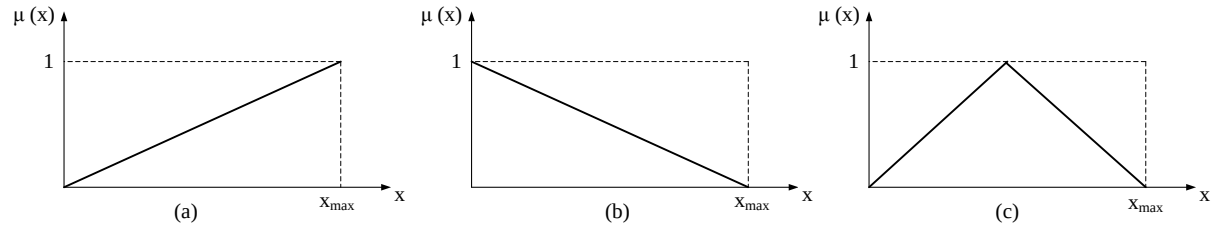


Figure 3: Ideal design ranges for (a) benefit, (b) cost, (c) non-monotonic functional requirement

3. Problem Definition

The information technology (IT) department of a firm plans to integrate an RFID System in its business processes. The alternatives are item,box and pallete level. The goal is considered as selecting the most appropriate implementation level with respect to the judgements of an experienced information system (IS) expert of the firm.

4. The Proposed Fuzzy Information Axiom Model

The criteria presented by Ustundag et al. (2007) for RFID implementation level determination problem were modified by information system (IS) expert of the firm to determine functional requirements of the information axiom model. The functional requirements can be expressed as follows:

FR1-Hardware cost: The readers, antennas, computers, printers and cables etc. constitute hardware cost.

FR2-Software cost: Middleware and application software are either developed inhouse or outsourced. This cost component is reflected into infrastructure cost as software cost.

FR3-Tagging cost: Tagging is performed at one of the levels of item, box or pallet.

FR4-System integration cost: System integrator combines the components of the system and provides the implementation.

FR5-Consultancy and training cost: Consultancy is given to the employees by system integrator or RFID experts. Training programs are arranged so as to improve capability related to RFID technology

FR6-Maintenance cost: RFID hardware and other equipments are maintained periodically.

FR7-Decrease in labour cost: Increasing the process efficiency, RFID integration leads to lower labour cost. Furthermore, since the accuracy of the process is increased, the process requires lower labour.

FR8-Decrease in inventory cost: Since the safety inventory appears to be lower with higher process accuracy, total inventory cost is reduced.

FR9-Decrease in shrinkage cost: The higher security level provides lower shrinkage cost. What is more, RFID causes the tracking of product life time effectively.

FR10-Decrease in lost sales: This subcriterion considers the fact that higher product visibility prevents occurring stockouts.

FR11-Increase in sales: This attribute expresses the improved performance in terms of sales as a result of customer satisfaction.

FR12-Implementation time: This attribute indicates project duration with respect to the roll-out plan.

FR13-Organizational learning: It indicates the required effort of the employees to adapt RFID-enabled processes.

FR14-Process re-engineering: It is related with process restructuring as a result of RFID integration.

FR15-Upgrade ability: It reflects the capability of expanding the RFID utilization to different implementation levels.

FR16-Compatibility with existing IT/IS system: It states the degree of accordance between current IT/IS system and RFID technology.

FR17-Experience about technology: Different implementation levels of RFID require varied levels of technological experience.

Properties of functional requirements, such as type, assessment and triangular fuzzy number (TRFN) for design range are summarized in Table 1.

Table 1: Properties of functional requirements

FR	Type	Assessment	TRFN for Design Range	FR	Type	Assessment	TRFN for Design Range
FR1	Cost	Tangible	(0,0,1)	FR10	Benefit	Tangible	(0,1,1)
FR2	Cost	Tangible	(0,0,1)	FR11	Benefit	Tangible	(0,1,1)
FR3	Cost	Tangible	(0,0,1)	FR12	Cost	Tangible	(0,0,1)
FR4	Cost	Tangible	(0,0,1)	FR13	Benefit	Intangible	(0,1,1)
FR5	Cost	Tangible	(0,0,1)	FR14	Benefit	Intangible	(0,1,1)
FR6	Cost	Tangible	(0,0,1)	FR15	Benefit	Intangible	(0,1,1)
FR7	Benefit	Tangible	(0,1,1)	FR16	Benefit	Intangible	(0,1,1)
FR8	Benefit	Tangible	(0,1,1)	FR17	Benefit	Intangible	(0,1,1)
FR9	Benefit	Tangible	(0,1,1)				

When alternatives are concerned, item level, box level and pallet level are determined as the potential RFID tagging level alternatives.

The linguistic terms, their abbreviations and fuzzy membership functions are given in Table 2.
Then, the judgments of IS expert on alternatives are presented. The linguistic assessments of alternatives (system ranges) are given in Table 3.

Table 2: Linguistic scales

Scale 1 (for tangible FRs)	Scale 2 (for intangible FRs)	Fuzzy Number
Very High (VH)	Very Good (VG)	(0.6, 1, 1)
High (H)	Good (G)	(0.5, 0.7, 0.9)
Medium (ME)	Moderate (MO)	(0.3, 0.5, 0.7)
Low (L)	Poor (P)	(0.1, 0.3, 0.5)
Very Low (VL)	Very Poor (VP)	(0, 0, 0.4)

Table 3: Linguistic assessment of alternatives

	Item level	**Box level**	**Pallet level**
FR1	H	ME	L
FR2	H	ME	L
FR3	VH	ME	L
FR4	H	ME	ME
FR5	H	ME	ME
FR6	H	ME	ME
FR7	VH	H	ME
FR8	VH	H	ME
FR9	H	L	VL
FR10	ME	L	VL
FR11	M	L	L
FR12	H	ME	L
FR13	P	MO	MO
FR14	G	MO	MO
FR15	P	MO	G
FR16	P	MO	G
FR17	P	MO	MO

The information content of each alternative is computed with respect to each functional requirement and given in Table 4.

Table 4: Information contents (I_{ij})

	FR1	**FR2**	**FR3**	**FR4**	**FR5**	**FR6**	**FR7**	**FR8**	**FR9**
A1	1.030	1.030	1.807	1.030	1.030	1.030	0.000	0.000	0.142
A2	0.435	0.435	0.435	0.435	0.435	0.435	0.142	0.142	1.030
A3	0.142	0.142	0.142	0.435	0.435	0.435	0.435	0.435	1.807
	FR10	**FR11**	**FR12**	**FR13**	**FR14**	**FR15**	**FR16**	**FR17**	
A1	0.435	0.435	1.030	1.030	0.142	1.030	1.030	1.030	
A2	1.030	1.030	0.435	0.435	0.435	0.435	0.435	0.435	
A3	1.807	1.030	0.142	0.435	0.435	0.142	0.142	0.435	

The final ranking is also given in Table 5. Final results demonstrate that box level has the minimum information content overall, followed by pallet level and item level, respectively. In other word this tagging level meets functional requirements of the system at the highest level.

Table 5: Total information content (TI_j) and ranking of each alternative

	TI_i	Rank
Item level	**13.266**	3
Box level	**8.598**	1
Pallet level	**8.979**	2

6. Conclusion

Deploying RFID technology in an enterprise is considered as a strategic business decision. Moreover, determining the tagging level which provides the highest effectiveness is one of the most important key components for RFID projects. To solve this multi-criteria decision making (MCDM) problem, costs as well as the business-and customer-related benefits should be included comprehensively. On the other hand, fuzzy information axiom, a quantitative method that can be used to integrate qualitative information and quantitative values and analysis, has been effectively used for decision making applications. In this study, a fuzzy information axiom model is presented to evaluate the RFID implementation level alternatives. The model contributes the decision makers to understand the complex relationships among cost, benefit factors and implementation aspects of RFID applications.

There are several related work to be pursued in future. Different MCDM methods will be applied for the same problem, so that a comparison study can be made. The number of decision makers can be increased so as to conduct group decision making. Moreover, the proposed model can be improved by weighting functional requirements.

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Biography

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A Research on Measuring Computer Network System Productivity and Efficiency with Simulation Modeling

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Abstract

Computer networks are the most prevalent systems with many applications-especially internet sales. Internet commands are working with complex algorithms; therefore, it can cause communication troubles. With this study, it is proposed to demonstrate the usage efficiency of the computer network systems by describing system topology with ARENA simulation model. First, web system working principle was analyzed; the related data about web commands was gathered and suited to the probability distributions. After that, system variables, attributes, performance variables were defined and model results came. According to the results, existing system resource usage ratios were criticized to make suggestions. Hopefully, this study would be a good example for constructing similar network systems.

Keywords
Computer network system, productivity, discrete event simulation, ARENA.

1. Introduction

Communication productivity has become a significant issue for enterprises due to the increasing global trading, information sharing etc. In this dynamic changing economic and social environment, computer network systems provide an increasing level of communication and connection between companies and units in the firms. Therefore, an increasing amount of investments are planned and resources are assigned for the development and deployment of computer networks in order to make quick responses and supply customer demand –both internal and external customer-on time.

Although network systems seem simple structured type of systems for many people, actually that are not. Behind the system, links and pop-ups are working with different complex algorithms. The problems could occur due to the connection faults on commands and affect most of the job processes.

In this study, it is aimed to investigate the efficient and effective working ways of client-server structure in a network topology, to carry out productivity studies and decide what kind of network topology will be convenient for different systems with simulation modeling. First, the working principle of the web systems are explained, deeply analyzed and the former data about different buttons are gathered from an e-business web system. Second, data is suited with a known probability distribution. Thereafter, system variables, system criteria, attributes, performance variables, parameters and processes are all defined. Afterwards, ARENA simulation model was effectuated by entering entity and assigning values for attributes. Additionally, processes and conditional situations are assigned with their properties. After run parameters are entered and simulation results are acquired, existing system resource usage ratios, queues, performance criteria are evaluated and different scenarios are discussed in order to make suggestions for the improvement of network system.

The reminder of this paper organized as follows: In Section 2, a brief literature review is given and after that, problem generally occurred in computer networks is explained in Section 3. Proposed simulation model related to the considered current network situation is presented and simulation results are attained in Section 4. Paper ends with model verification and conclusions.

In conclusion, this study proposes to demonstrate the usage efficiency and system productivity of the computer networks for making developments in the system by putting forward the system topology working with discrete event simulation model. Hopefully, this study would be a good example for similar computer network systems.

2. Literature review

Previous studies appeared from 1995 with Giokas and Pentzaropoulos. They evaluated "queue" problem in computer networks with a queuing model named (M/M/I/K) and they utilized data envelopment analysis for measuring computer network efficiency. In recent years, studies related to computer network efficiency have been increased. For instance, Lin and Yeh (2012) integrated genetic algorithm, minimal paths and recursive sum of disjoint products methodology and they observed several computer networks in order to demonstrate the efficiency of this combined algorithm. They also compared this approach with different algorithms. Lin and Huang (2013) emphasized delivery reliability of the computer networks using minimal path method for demonstrating quality of network services. Lin and Huang (2013) also investigated service level agreement and quality of services in order to specify the system reliability. Li et al. (2014) searched wireless sensor networks resource allocation problem and proposed an algorithm based on heuristics. Chen (2014) suggested a nonlinear programming model for monitoring system reliability. Pióro et al. (2014) utilized mixed integer programming formulations for maximum-minimum fair flow optimization in wireless mesh networks.

From the literature review reflections, mathematical illustration is appearing one of the most complicated ways for the efficiency determination of computer networks. With simulation modeling, analyzers could easily realize the network efficiency and resource allocation problems before implementing a new system. In this study, simulation modeling is preferred because of the mathematical formulations complexity in applications.

3. Stated Problem

The productivity measurement with simulation modeling is implemented for an e- business web site. This web site is working with four commands named Add, Delete, Find and Search. Requests coming in milliseconds expect "Search" button. In this web site, four types of clients could appear. The firm wants to renew the client-server process in order to reply customer demands as quickly as possible.

The process is working as follows: Requests are coming to the client nodes and evaluated in network infrastructure. After that, system distributes the requests according to the types and requests are classified and assigned in server node for the appropriate replies for the clients waiting in the website. Finally, responses are prepared and given to the network in order to send the reply to the customers. Although the firm could forecast the intervals between coming requests, the overloading in this system could block quick responses given to the customers. Time between requests, computer network system, and descriptive statistics of the observations coming from four clients and independencies between observations are given in Figure 1, Figure 2 and Figure 3.

Table 1: Interval between messages and expected request types.

Client node	**Intervals between coming messages and probability distributions (message/second)**	**Request type (expected)**
1	EXPO(10 s.)/current system NORMAL(0.031,0.0072) hour/new system	%20 1st,%15 2nd,%40 3rd,%25 4th client type
2	EXPO(20 s)/current system NORMAL(0.062, 0.013) hour/new system	%40 1st, %60 2nd client type
3	EXPO(25 s)/current system NORMAL(0.093,0.012) hour/new system	%60 3rd, %40 4th client type
4	EXPO(28 s)/ current system NORMAL(0.064,0.0001) hour/new system	%20 1st,%20 2nd,%40 3rd,%20 4th client type

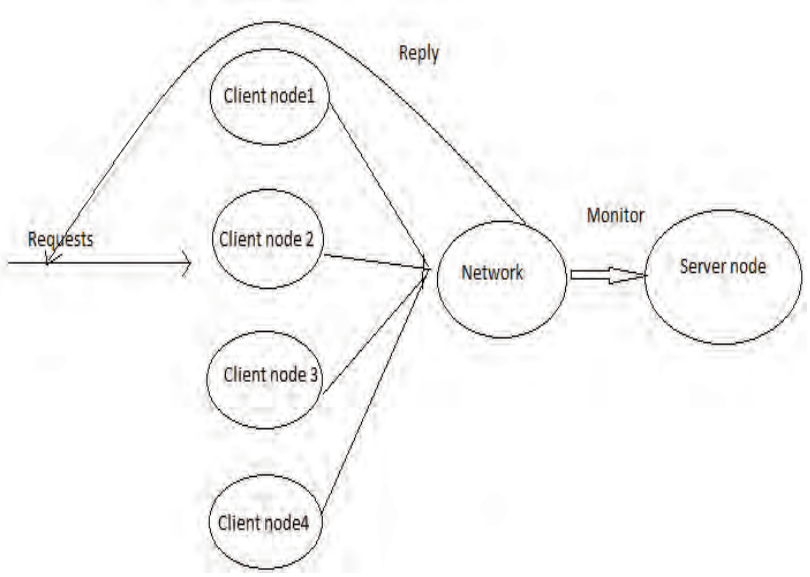


Figure 1: Computer network system

Table 2: Request types and time between requests.

Request number	Request type	Time between requests (milisecond)
1	Add	20
2	Delete	18
3	Find	15
4	Search	DISC{(0.2 10, 0.3 25, 0.3 32, 0.2 45)}

Descriptive Statistics (Spreadsheet1)

Variable	Valid N	Mean	Median	Mode	Frequency of Mode	Minimum	Maximum	Lower Quartile	Upper Quartile	Range	Quartile Range	Variance	Std.Dev.	Skewness	Kurtosi
Var1	50	0,031080	0,032000	Multiple	5	0,012000	0,043000	0,026000	0,036000	0,031000	0,010000	0,000052	0,007225	-0,521088	0,0096

Descriptive Statistics (Spreadsheet1)

Variable	Valid N	Mean	Median	Mode	Frequency of Mode	Minimum	Maximum	Lower Quartile	Upper Quartile	Range	Quartile Range	Variance	Std.Dev.	Skewness	Kurtosis
Var1	50	0,063940	0,064500	Multiple	3	0,034000	0,090000	0,053000	0,074000	0,056000	0,021000	0,000189	0,013743	-0,086379	-0,652955

Descriptive Statistics (Spreadsheet1)

Variable	Valid N	Mean	Median	Mode	Frequency of Mode	Minimum	Maximum	Lower Quartile	Upper Quartile	Range	Quartile Range	Variance	Std.Dev.	Skewness	Kurtosis
Var1	50	0,094520	0,095000	Multiple	3	0,071000	0,117000	0,084000	0,104000	0,046000	0,020000	0,000150	0,012228	-0,063676	-0,931646

Descriptive Statistics (Spreadsheet1)

Variable	Valid N	Mean	Median	Mode	Frequency of Mode	Minimum	Maximum	Lower Quartile	Upper Quartile	Range	Quartile Range	Variance	Std.Dev.	Skewness	Kurtosis
Var1	50	0,064060	0,064000	,0730000	4	0,042000	0,080000	0,056000	0,073000	0,038000	0,017000	0,000090	0,009477	-0,179158	-0,650732

Figure 2: Descriptive statistics of four clients.

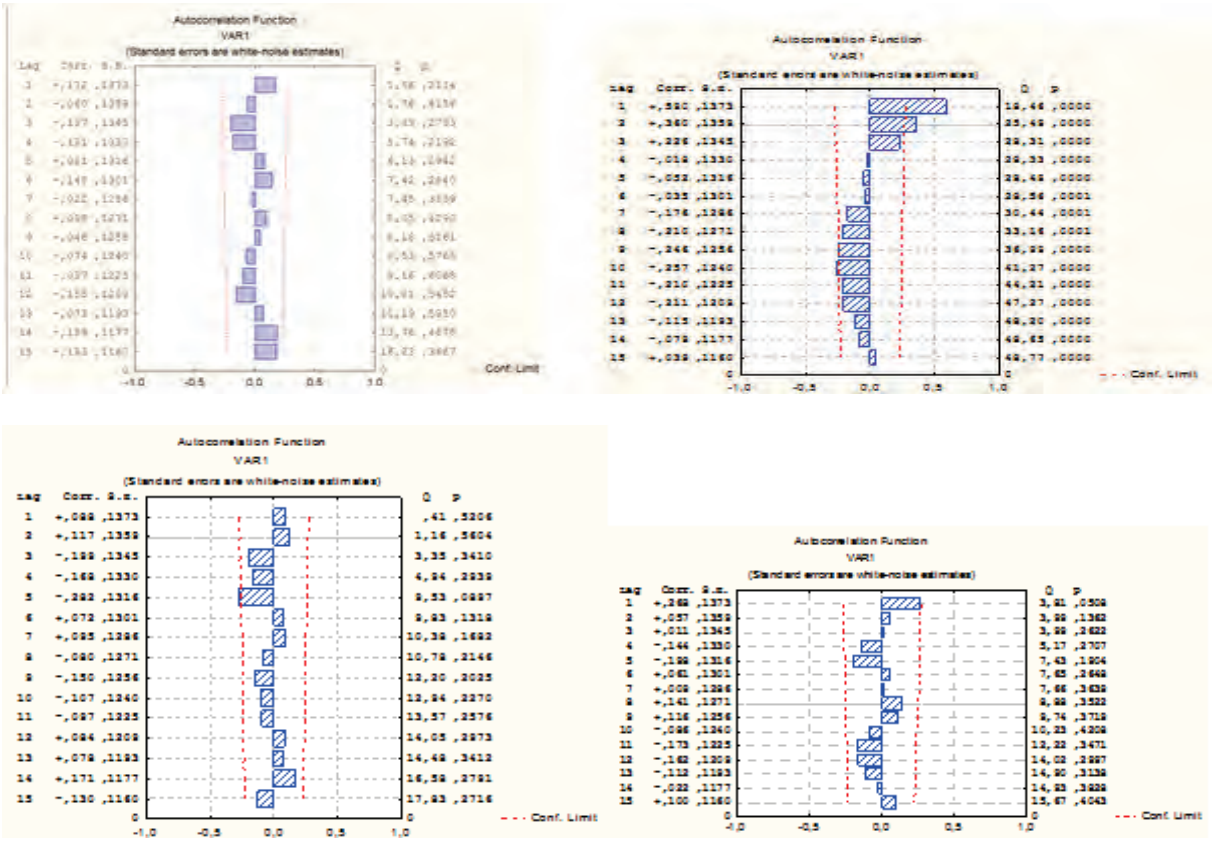


Figure 3: Autocorrelation graphs for the clients.

4. Proposed simulation model and simulation results

A discrete event simulation model is offered for monitoring the agglomerations appeared in the previous system. The model is structured in accordance with the computer network system by utilizing ARENA 10. As seen from Figure 4, requests coming from clients are assigned as a "request" and counted. After, requests are classified and network system determines priorities of these requests. In accordance with the priorities, requests are sent to the related servers. Performance variables could be listed as follows:

- The amount of coming requests
- Average flow times of the works.
- Average queue length of the servers.
- The amount of coming requests in accordance with request types and average flow times of the requests
- Server usage ratio
- Average response times of the network.

System attributes are determined as:

- Distribution of incoming message time intervals of the clients.
- Server service type and service time
- Client message size and response message size
- Priority number

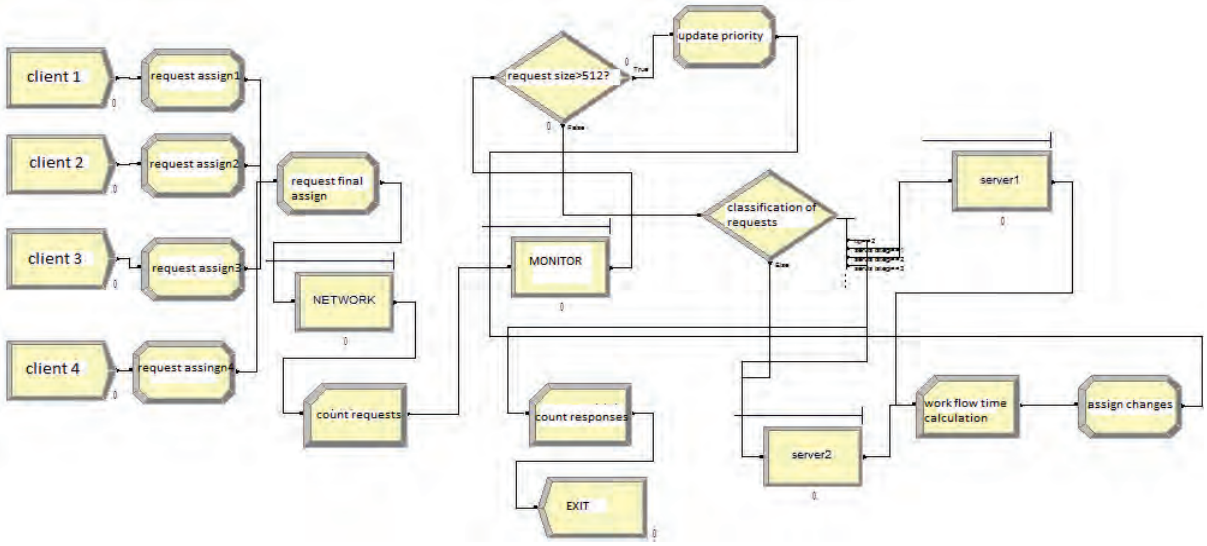


Figure 4: Proposed simulation model.

ARENA simulation model is run with 40 seconds warm-up time and 1000 replications. Process accumulated times, process per entity, queues and resource usage ratios could be realized in Figure 5, Figure 6, Figure 7 and Figure 8.

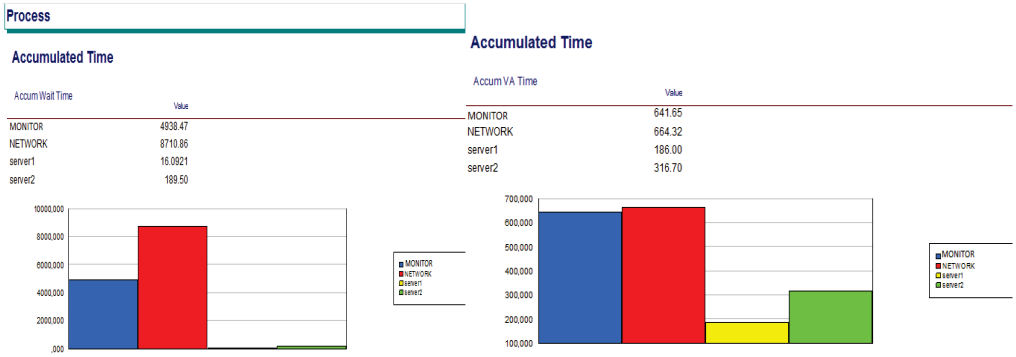


Figure 5: Process accumulations.

From simulation results, Server 2 has long waiting times when compared with Server 1. The accumulations would occur in classification section and one could conclude that Server 2 needs improvements. Network queue also supports this improvement, especially in reply-classification process. In addition, rules needed for the determination of the priorities of coming requests could be rearranged.

Process

Time per Entity

VA Time Per Entity

	Average	Half Width	Minimum Value	Maximum Value
MONITOR	3.9365	(Insufficient)	1.0085	6.9651
NETWORK	16.2029	(Insufficient)	7.2533	20.0533
server1	18.6000	(Insufficient)	18.0000	20.0000
server2	21.1133	(Insufficient)	15.0000	28.1000

Wait Time Per Entity

	Average	Half Width	Minimum Value	Maximum Value
MONITOR	30.2974	(Insufficient)	0.00	244.73
NETWORK	212.46	(Insufficient)	20.0533	452.17
server1	1.6092	(Insufficient)	0.00	16.0921
server2	12.6333	(Insufficient)	0.00	44.7459

Total Time Per Entity

	Average	Half Width	Minimum Value	Maximum Value
MONITOR	34.2339	(Insufficient)	1.1076	249.51
NETWORK	228.66	(Insufficient)	40.1067	472.22
server1	20.2092	(Insufficient)	18.0000	34.0921
server2	33.7466	(Insufficient)	15.0000	59.7459

Figure 6: Entities in computer network process.

Queue

Time

Waiting Time

	Average	Half Width	Minimum Value	Maximum Value
MONITOR	31.5445	(Insufficient)	0.00	244.73
NETWORK	223.48	(Insufficient)	40.1067	471.86
server1	1.4629	(Insufficient)	0.00	16.0921
server2	11.8437	(Insufficient)	0.00	44.7459

Other

Number Waiting

	Average	Half Width	Minimum Value	Maximum Value
MONITOR	10.2636	(Insufficient)	0.00	22.0000
NETWORK	60.1102	(Insufficient)	6.0000	123.00
server1	0.02472194	(Insufficient)	0.00	1.0000
server2	0.3193	(Insufficient)	0.00	2.0000

Figure 7: Queue occurred in computer network process.

Resource

Usage

Instantaneous Utilization

	Average	Half Width	Minimum Value	Maximum Value
monitor	0.9890	(Insufficient)	0.00	1.0000
network1	0.6000	(Insufficient)	0.00	0.6000
SRV1	0.3016	(Insufficient)	0.00	1.0000
SRV2	0.5275	(Insufficient)	0.00	1.0000

Number Busy

	Average	Half Width	Minimum Value	Maximum Value
monitor	0.9890	(Insufficient)	0.00	1.0000
network1	6.0000	(Insufficient)	0.00	6.0000
SRV1	0.3016	(Insufficient)	0.00	1.0000
SRV2	0.5275	(Insufficient)	0.00	1.0000

Number Scheduled

	Average	Half Width	Minimum Value	Maximum Value
monitor	1.0000	(Insufficient)	1.0000	1.0000
network1	10.0000	(Insufficient)	10.0000	10.0000
SRV1	1.0000	(Insufficient)	1.0000	1.0000
SRV2	1.0000	(Insufficient)	1.0000	1.0000

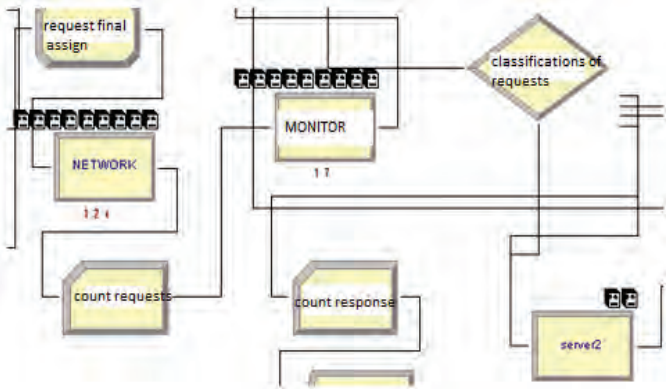
Figure 8: Resource usage in computer network process.

5. Model verification

Model verification includes the monitoring aspects whether model really reflects the major processes and model results are consistent or not. Therefore, analyzer should control the model by using extreme values of the real system. The model results are coherent with the real computer network system because;

- One could measure performance variables with the system.
- Model worked with different warm-up times and replications gives different performance values.
- Model indicates the agglomerations in Server 2 and network processes. Additional monitoring infrastructure is needed for preventing these accumulations.

When simulation runs with these situations, Server 2 and monitoring processes become relieved as seen in Figure 8.



Scheduled Utilization	Value
monitor	0.9890
network1	0.6000
SRV1	0.3016
SRV2	0.5275

Figure 9: Adding new monitoring resources to the system and simulation results.

6. Conclusion

In this study, it is aimed to demonstrate the computer network system efficiency and productivity by utilizing discrete event simulation. Model is structured in ARENA 10 including essential processes, attributes and system performance variables. According to the results, existing system resource usage ratios were criticized to make suggestions and model verification is implemented for different conditions. This model helps analyzer for the detection of the faults and agglomerations in computer network systems and provides different trials before establishing varied network systems. Future researches could focus on diversified client-server structures utilizing both agent based simulation and discrete event simulation.

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Approximations to Aggregated Orders Bullwhip Effect Variance in Two-Echelon Supply Chains

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Abstract

This paper develops two approximations to estimate the variance of aggregated retailer orders which is a form of the widely recognized Bullwhip effect, using the renewal theory and available Markov chain models for the two-echelon supply chain. These approximations are used to develop several managerial insights on (S, s) inventory policies used by retailers who make replenishment orders to a supplier that uses a periodic review inventory policy where market demand is assumed to be based on Poisson market orders.

Keywords

Supply chain management, bullwhip effect, variance estimation.

1. Introduction

The Bullwhip Effect in Supply Chain management has been widely investigated and has lead many researchers through various approaches to study its circumstances and understand its implications. The earliest of works conducted on this phenomenon dates back to (Caplin 1985) who developed a Markov chain model for the aggregated demand of retailers that use (S, s) inventory policies and derived an explicit expression for the replenishment order variance for each retailer as well as the variance of the aggregated orders received by the supplier. In the same paper Caplin proved the statistical independence among retailers' orders to the supplier.

An optimization approach by (Kahn 1987) attempted to derive the optimal production decisions under demand uncertainty, and (Lee et al 1997) were the first to call the variance distortion of the supplier production by its current name: "The Bullwhip Effect". They based their findings on empirical data and provided few factors that lead to such destabilizating effect in the order variance. (Baganha and Cohen 1998) suggested an optimization model that help stabilizing this phenomenon. Approximation tools were proposed by (Kelle and Milne 1999) in order to analyze the effect of changes in various parameters of the (S, s) inventory policies on the variability in aggregated orders upstream the supply chain.

More recently, the work by (Buchmeister 2008) focused on using simulation models for multi-echelon supply chain to test various inventory policies on reducing the bullwhip effect. Some researchers attempted to look into ways to reduce the Bullwhip effect. (Lin and Lin 2006) used a portfolio theory that adjusts the order quantities based on their order variance. In their paper, (Jakšič and Rusjan 2008) argued that certain replenishment policies can stimulate the Bullwhip effect while other may actually reduce it, and suggested few rules to select the appropriate policy to prevent it from occurrence. (Duc et al 2010) examined the impact of third-party warehousing on three-echelon supply chain order variance using several scenarios concerning lead times between warehousing and retailers. Further, (Chen and Lee work 2012) showed that aggregating over long periods can hide the size of the Bullwhip phenomenon and emphasized the need to choose appropriate times to identify its existence.

The purpose of this paper is to use the renewal process approach and other existing results based on Markov chain models to analyze the Bullwhip effect and to provide approximate estimates of the variance of aggregated retailer orders in two-echelon supply chain. The exact derivation of this aggregated variance proved to be very hard. The paper considers the simple Poisson market demand process for items that are ordered in units and assumes that the market is partitioned among a number of independent retailers.

Two approximations are considered which can be applicable in two different conditions in the market demand process. The first assumes low demand rate and uses the results of (Caplin 1985), while the second is used when the first approximation is no longer applicable where a second-order approximation for the variance of a renewal process as derived by (Brown and Solomon 1975) and further elaborated by (Aydoğlu and Öztürk 1998) is applied. The findings of this paper are direct results of these two approximations and the aim is to provide managerial insights and suggest policies that can be dwelled on in practice.

2. The Renewal Model for a Two Echelon Supply Chain

Consider a simple two-echelon supply chain that consists of a single supplier and few retailers where the market demand process happens according to a Poisson process with fixed occurrence rate equal to λ.

Consider also m retailers who share the market according to a probability distribution p_i for $i = 1,2, \dots, m$. The fact that the market demand follows a homogeneous Poisson distribution leads to the result that each retailer will entertain his shared demand in the market independently from the other retailers and with fixed rate equal to $p_i\lambda$.

Assume that the (S, s) inventory policy is common for all retailers with different order quantities Q_i, $i = 1,2, \dots, m$, and which are independently set by them. Obviously all Q_i's are constant according to the (S, s) policy, and zero lead times are assumed so that the focus will remain on the impact of these order quantities on the total variance of all retailers' orders as seen by the supplier.

For the supplier, the aim is to estimate the variance of the total of all orders made by his customers, i.e the retailers, within a fixed period equals to R. This can be considered to be the review period in a periodic review policy used by the supplier.

Under these assumption, let $\{Y_t, t > 0\}$ be the market demand process that follows a Poisson process. Therefore, the mean demand during period R is λR. Similarly each retailer market demand will follow a Poisson process with individual mean demand during period R equals to $p_i\lambda R$ since their shares in the market form a partition.

The fact that the shares of the suppliers in the market demand follow Poisson distribution means that the times between two subsequent sales at a retailer are randomly independent and exponentially distributed. Since the retailer will wait to sell Q_i units before setting the next order to the supplier, this means that the times between his replenishment orders, say T_i, is the sum of a number of Q_i independent exponential times. Therefore, T_i has Gamma distribution with parameters Q_i and $p_i\lambda R$, and this is the same for every retailer i.

While all the times between retailer's orders are independent, then the ordering process by each retailer i is a renewal process, say $\{N_i(t), t > 0\}$, that counts the number of orders he makes during the supplier's review period R. The total quantity of such retailer's orders during R is then defined by $X_i(R) = Q_i N_i(R)$, and consequently, the aggregated orders to the supplier from all retailers is therefore $X(R) = \sum_{i=1}^{m} X_i(R)$. The goal now is to estimate the mean and variance of the aggregated total of all retailers' orders $X(R)$

By the renewal theorem, the mean of $N_i(t)$ is

$$E[N_i(R)] = \frac{p_i\lambda R}{Q_i} \ . \tag{1}$$

Using (1) to estimate the mean of $X(R)$ to get the mean of the whole market demand, it follows that

$$E[X(R)] = \sum_{i=1}^{m} E[X_i(R)] = \sum_{i=1}^{m} Q_i \, E[N_i(R)] = \sum_{i=1}^{m} Q_i \frac{p_i\lambda R}{Q_i} = \lambda R \sum_{i=1}^{m} p_i = \lambda R \tag{2}$$

Which is an obvious result. But on the other hand,

$$VAR[X(R)] = \sum_{i=1}^{m} VAR[X_i(R)] = \sum_{i=1}^{m} Q_i^2 \, VAR[N_i(R)]. \tag{3}$$

Since $\{N_i(t), t > 0\}$ is a renewal process, the computation of its variance is essentially hard even for the simple Poisson process. This paper's approach is to consider two approximations to the variance of $X_i(R)$: The first approximation considers a Markov chain model for the retailers inventories developed by (Caplin 1985) and uses it

for low market demand rates. While the other approximation makes use of a second-order approximation for the variance of a renewal process as derived by (Brown and Solomon 1975) and investigated further by (Aydoğlu and Öztürk 1998), and can be applied for large supplier's review period R or high market demand λ.

3. The Low Market Demand Rate Approximation Scheme

In (Caplin 1985), the variance of the sales for retailer i was derived by a Markov chain approach under the assumption that $\sum_{y=0}^{Q_i-1} f_i(y) = 1$, where $f_i(\cdot)$ is the probability distribution of the market sales at retailer i. This can be used as an approximation when the market demand rate λ is low. The lemma below shows that the tail probabilities of the Poisson distribution for small λ are approximately zero, and subsequently the number of orders as set by retailer i during the supplier's review period R will be either 0 or 1. Hence, $E[N_i(R)] = E[N_i^2(R)]$ and this in turns leads to

$$Var[N_i(R)] = E[N_i^2(R)] - (E[N_i(R)])^2 = \frac{p_i\lambda R}{Q_i} - \left(\frac{p_i\lambda R}{Q_i}\right)^2 = \left(\frac{p_i\lambda R}{Q_i}\right)\left[1 - \left(\frac{p_i\lambda R}{Q_i}\right).\right] \quad (4)$$

Therefore,

$$Var[X_i(R)] = Q_i^2 Var[N_i(R)] = p_i Q_i \lambda R\left[1 - \left(\frac{p_i\lambda R}{Q_i}\right)\right]. \quad (5)$$

Since all retailers' sales are mutually independent as they make an independent partition of the total Poisson market demand process, then

$$Var[X(R)] = \lambda R \sum_{i=1}^{m} p_i Q_i\left[1 - \left(\frac{p_i\lambda R}{Q_i}\right)\right]. \quad (6)$$

Knowing that the market demand variance is λR, then the Bullwhip effect variance ratio, say γ_1, is

$$\gamma_1 = \frac{Var[X(R)]}{Var[Y(R)]} = \sum_{i=1}^{m} p_i Q_i\left[1 - \left(\frac{p_i\lambda R}{Q_i}\right)\right]. \quad (7)$$

Recall however, that this result requires (Caplin 1985) condition $\sum_{y=0}^{Q_i-1} f_i(y) = 1$, which is not exact in the case of Poisson market demand and this is the reason why the above result is not exact and should be considered as an approximation. Based on the fact that the above ratio $\gamma_1$cannot be negative, then for it to be valid, it requires $Q_i \geq p_i\lambda R$. The following Lemma shows that this condition approximately meet the requirements of (Caplin 1985)'s simply because in this case $f_i(y) \approx 0\ for\ \ y \geq Q_i$.

Lemma: *Given large enough positive integers α and M*,

$$M \geq \alpha \Rightarrow f_i(y) = e^{-\alpha}\frac{\alpha^y}{y!} \approx 0 \quad for\ any\ \ y \geq M \quad (8)$$

Proof: Take $\alpha \geq 1$ an integer,

$$\frac{f_i(\alpha+1)}{f_i(\alpha)} = e^{-1}\left(\frac{\alpha+1}{\alpha}\right)^{\alpha} = e^{-1}\left(1+\frac{1}{\alpha}\right)^{\alpha} \quad (9)$$

Knowing that $lim_{\alpha\to\infty}\left(1+\frac{1}{\alpha}\right)^{\alpha} = e$, it is enough to prove that $\left(1+\frac{1}{\alpha}\right)^{\alpha}$is monotically increasing to deduce that $\left(1+\frac{1}{\alpha}\right)^{\alpha} < e$ for every finite α.

For this purpose, the first derivative for the function $g(x) = \left(1+\frac{1}{x}\right)^{x}$ is

$$g'(x) = \left(1+\frac{1}{x}\right)^{x-1}\left[\left(1+\frac{1}{x}\right)Ln\left(1+\frac{1}{x}\right) + \frac{1}{x}\right]. \quad (10)$$

It is then clear that $g'(x) > 0$ for $x \geq 0$. Thus the function $g(x)$ is increasing for $x \geq 0$. This is especially true for integer numbers.

The above result also means that $f_i(\alpha+1) < f_i(\alpha)$ for every finite integer α, and since each $f_i(\alpha) \geq 0$, being probability terms, then consequently $\lim_{\alpha\to\infty} f_i(\alpha) = 0$ and therefore $f_i(\alpha) = e^{-\alpha}\frac{\alpha^{\alpha}}{\alpha!} \approx 0$ for large α. Furthermore, for even a bigger integer M where $M > \alpha$ it is becomes clear that $f_i(y) = e^{-\alpha}\frac{\alpha^{y}}{y!} \approx 0$ when $y \geq M \geq \alpha$.

The result of the above lemma leads to the fact that for every retailer who orders the same quantity $Q_i \geq p_i\lambda R$, the probability terms for orders bigger than or equal to Q_i will be almost zero, and thus the above approximation becomes applicable.

4. The Second-Order Renewal Theory Approximation

(Brown and Solomon 1975) as well as (Aydoğlu and Öztürk 1998) worked out a second-order linear approximation to the variance of the counting process for a renewal process to be

$$Var[N_i(t)] \approx at + b \tag{11}$$

as $t \to \infty$, where

$$a = \mu_1^{-3}(\mu_2 - \mu_1^{-2}) = \mu_1^{-3}\sigma^2, \tag{12}$$

and

$$b = \frac{5}{4}\mu_1^{-4}\mu_2^2 - \frac{2}{3}\mu_1^{-3}\mu_3 + 2\mu_1^{-2}\mu_2 - 3\mu_1^{-3}\mu_2\mu_1 + \frac{1}{2}\mu_1^{-2}\mu_2\,. \tag{13}$$

Here, μ_r is the r^{th} moment and σ^2 is the variance of the renewal function for which the counting process $N_i(t)$ is defined.

By computing these moments and the variance for the Gamma process whose scale parameter is the retailer order quantity Q_i, and shape parameter is equal to the Poisson market demand rate $p_i\lambda$, we obtain

$$\mu_r = \frac{Q_i(Q_i+1)(Q_i+2)\cdots(Q_i+r)}{(p_i\lambda)^r}\,. \tag{14}$$

When substituted in the approximation of the variance of the number of a retailer orders, we get

$$a = \frac{p_i\lambda}{Q_i^2} \qquad \text{and} \qquad b = \frac{1}{12}\left(1 - \frac{1}{Q_i^2}\right). \tag{15}$$

Therefore,

$$Var[N_i(t)] \approx \frac{p_i\lambda}{Q_i^2}\,t + \frac{1}{12}\left(1 - \frac{1}{Q_i^2}\right). \tag{16}$$

So, the variance of the order quantity during a review period R for the supplier will be

$$Var[X_i(R)] = Q_i^2\,Var[N_i(R)] \approx p_i\lambda R + \frac{1}{12}(Q_i^2 - 1). \tag{17}$$

The variance of the total orders received by the supplier from all retailers during the supplier's review period is

$$Var[X(R)] = \sum_{i=1}^{m} Var[X_i(R)] \approx \sum_{i=1}^{m} p_i\lambda R + \frac{1}{12}(Q_i^2 - 1), \tag{18}$$

that is,

$$Var[X(R)] \approx \lambda R + \sum_{i=1}^{m}\frac{(Q_i^2 - 1)}{12}. \tag{19}$$

When dividing the supplier order variance above by the Poisson market demand variance λR we obtain the second approximation for the Bullwhip effect ratio as

$$\gamma_2 = 1 + \frac{1}{\lambda R}\sum_{i=1}^{m}\frac{1}{12}(Q_i^2 - 1)\ . \tag{20}$$

This result is useful when the review cycle is large. It is also useful when the market demand rate λ is high where the assumption of (Caplin 1985) is no longer valid. In either case, multiple retailer orders to the supplier is possible during the supplier review period.

5. Managerial Insights Relevant to the Bullwhip Effect Ratios

The following discuss the practical implications for special cases regarding the bullwhip effect ratios obtained in (7) and (20).

5.1 Dominating Retailer

When one retailer dominates a given market over other competitors, then it is assumed that market sales partition is reduced into a single retailer while all other shares are practically zero. This is reflected in

$$\gamma_1 = Q\left(1 - \frac{\lambda R}{Q}\right) = Q - \lambda R, \tag{21}$$

where Q is the order quantity for this retailer. Obviously, as it was assumed that $Q > \lambda R$, then γ_1 is obviously larger than one and gets bigger as Q increases. It is therefore recommended in this case that the supplier should consider the acquisition of this retailer or attempts to interfere in the retailer operations through policies such as Vendor Managed Inventory systems in order to have better control on the order variance amplification due to the Bullwhip effect.

5.2 Equal retailer market shares

Another extreme situation concerning retailers competition is realized when all retailers' shares in the market are equal. In this case, $p_i = \frac{1}{m}$, where m is the number of retailers. Here the bullwhip effect ratio becomes

$$\gamma_1 = \frac{1}{m}\left(\sum_{i=1}^{m} Q_i - \lambda R\right). \tag{22}$$

Define $\bar{Q} = \frac{\sum_{i=1}^{m} Q_i}{m}$ to be the average of all retailers order quantities, then $\gamma_1 = \bar{Q} - \frac{\lambda R}{m}$. It is clear then that the number of retailers m increases the bullwhip ratio obviously increases unless the supplier management work on lowering the retailers order quantities in order to reduce $\bar{Q}$ at the same time.

5.3 Increase in the market demand rate

As λ increases, the first approximation of the Bullwhip effect ratio will no longer be appropriate since (Caplin 1985) condition is no longer applicable. Therefore, we resort to the second second-order renewal approximation of the bullwhip effect variance ratio, i.e. γ_2, where it is clear that it asymptotically approaches to 1. It is assumed in this case that the review period R is constant and that the retailers' order quantities Q_i, for $i = 1, \cdots, m$ are finite.

It can also be argued that when the market demand rate increases, it will lead to an increasing number of retailers in the market and thus, the order quantities by these retailers will remain finite. It is hence more beneficial to the supplier to increase the number of retailers in the market when the market demand increases.

5.4 Long Supplier Review Periods

Similar result to Case 3 above is also true when the supplier review period is long enough to have multiple single retailer orders during one review cycle. However, this policy is not preferred as it increases the warehousing costs to the supplier in order to meet adequate service levels to the retailers. The following section actually supports the argument that longer review periods are not adequate in common practice.

6. Optimum Review Period to Minimize the Approximated Bullwhip Effect Variance

In an extension to the above analysis, if one can assume as mostly common that each retailer order is proportional to the square root of the market sales mean rate, that is $Q_i = C_i\sqrt{p_i \lambda R}$, where C_i is a constant, then the derivative of γ_1 with respect to R is

$$\frac{\partial \gamma_1}{\partial R} = \sum_{i=1}^{m} \frac{C_i p_i}{2\sqrt{p_i \lambda R}} - \lambda R \sum_{i=1}^{m} p_i^2 . \tag{23}$$

Setting (23) to zero to get the optimal review period as

$$R^* = \frac{\sum_{i=1}^{m} \frac{C_i}{2\lambda} \sqrt{\frac{p_i}{\lambda}}}{\sum_{i=1}^{m} p_i^2} . \tag{24}$$

As it shows, R^* is inversely proportional to the market demand rate λ. That means that products with higher market demand rate require smaller inventory review period. This will ultimately lead to a continuous review policy which will be better than the periodic review policy in such case.

7. Conclusion

The paper proposed two approximations for the Bullwhip Effect variance ratio of the aggregated independent retail orders to the market demand. The first approximation considers low market demand rate situation while the second uses renewal theory approximation to the retailers' orders variance to provide approximation to the bullwhip effect variance ratio. Some useful managerial insights were discussed in each situation. Further work need to take place to extend these results to correlated retailer orders to the supplier. Bounds on the variance ratios may also be the aim of future research.

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Bibliography

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Modeling a Stochastic Multi-Objective Order Allocation Problem in Uncertain Supply Environment

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Abstract

One of the routine but significant subjects in supply chain management is purchasing and supplying management, in which supplier selection and order allocation occupy the critical position. Recently, it has been shown that supply uncertainty is of great concern to supply chain managers and practitioners. In this paper, by taking the constraints of minimum purchasing quota and minimum production batch into account, a multi-objective mixed-integer stochastic programming model considering uncertainty in both timing and quantity of supply is presented. By means of transforming the stochastic and fuzzy constraints into deterministic equivalents, the model is converted into a linear programming model. An improved two-phase heuristic approach is proposed and its feasibility and efficiency is illustrated through a numerical example. Further, another numerical instance is conducted to evaluate the effects of the weight of each objective and uncertainty level on the optimal order policy and to obtain some managerial insights for the decision-making of the manufacturers.

Keywords

Supply chain management, supply uncertainty, order allocation, mixed-integer stochastic programming

1. Introduction

Supply chains are subject to the operational risk and natural risk and most manufacturers have to deal with the supplier uncertainty, which might be due to capacity, quality or even strategic problems at the supplier. Discrete manufacturing has a high demand for the punctuality and accuracy of the supply process of the components. Selecting the right suppliers from candidate suppliers and allocating purchasing order among the suppliers significantly reduces the total cost and improves comprehensive competitiveness of the company.

Recent years have seen a growing attention given in the literature to decisions on the appropriate selection of suppliers with different capacities, price, service and quality level, and on assigning order quantities to these suppliers. Academics very early consider the optimal order policies with both stochastic demand and uncertain delivery and then present two heuristic strategies. They show that the optimal inventory policy is order-up-to with identical order-up-to levels and if the inventory level is below a critical threshold, it is optimal to diversify and order from the joint supplier (Gurnani et al., 1996). In the case of multiple sourcing, given multiple criteria and suppliers' capacity constraints, academics construct a mixed-integer non-linear programming model, which takes into account the total cost of logistics and then propose an algorithm to solve it (Ghodsypour et al., 2001). An EOQ model with numerous suppliers with random capacities in a continuous-review system was presented by some academics and computational results show that when the optimal policy is applied, the number of unfulfilled order units from all suppliers must all be the same. They further obtain some characterization and properties for the uniform and exponential capacity cases (Erdem et al., 2005). Based on Ghodsypour's research, researcher points two issues with their assumptions and discusses two different capacitated supplier settings. Then, the researcher proposes a model that provides the same or a better solution than Ghodsypour's model (Ali, 2012). However, above literatures only considered the order policy in the case of single-material. Some researchers model the procurement problem as a Nash game where the buyer has to allocate his purchases between two suppliers with different price and deliver

ratio. They further model the case in an asymmetric scenario and show that the buyer benefits from information asymmetry (Haresh et al., 2012). Considering a supply chain with one supplier and one retailer with random yield and uncertain demand, academics propose several risk sharing contracts and compare the results of these contracts, finally, the numerical experiments show that yield uncertainty might enhance the supply chain performance and decrease the double marginalization effect (He et al., 2007). A decentralized assembly system under uncertain demand and random supply yield is considered, the researchers propose two contracts and show that suppliers coordinate the chain under forced compliance (Guler et al., 2008). Further, academic propose a single-period ordering and uncertain delivery planning model and find a coordination mechanism that allows the producer-supplier system to perform as a centralized one(Kristin, 2002). A multi-objective supplier allocation model proposed to help in supplier selection under uncertainty environment and to provide proactive mitigation strategies against disruptions is proposed (Bilsel et al., 2011). However, the literature focus more on the coordination of the supply chain without considering the issue of the kitting of the materials and maximize the profit of the manufacturer. Some academics study the supplier selection and order quantity allocation problem under uncertain demand, quantity discounts and fixed selection costs conditions. They propose an optimal algorithm based on Bender's decomposition and conduct numerical experiments to show its efficiency and obtain some managerial insights (Zhang et al., 2013). The optimal allocation problem across the suppliers given the risk of supplier failures and contingency planning in the decision process is considered by some researchers (Alex et al., 2013). A multi-objective model in which cost, quality and tardiness is minimized under stochastic demand and price-dependent demand conditions is considered (Nima, 2013). Recently, an integrated approach including fuzzy technique for order priority and a mixed-integer programming model for supplier selection under multi-item/multi-supplier conditions is presented (Huseyin, 2013). In this paper, we discuss issues related to random capacity, multiple suppliers, single-product with multiple materials or components. Our problem is similar to that of Ghodsypour and O'Brien (2001) since we both discuss multiple sourcing with multiple criteria and with suppliers' capacity constraints, but the suppliers' capacity is stochastic in our model and the number of materials is not limited to one. Another closely related study is by Bilsel and Ravindran. A multi-objective chance constrained programming model is presented for supplier allocation under uncertainty, but we consider the shortage cost and tardiness time, which is a fuzzy value. Finally, we illustrate the effect of uncertainty degree and weight of each objective on optimal order allocation solution using a numerical example.

The paper is organized as follows. In Section 2, we present the basic assumptions of the model and develop the multi-objective order allocation model with random capacity, multiple materials, multiple suppliers and chance constraints. Section 3 is devoted to transferring the model into a mixed-integer linear programming model and to finding the optimal order assigning solution. Section 4 illustrates the model and analyzes the effect of the degree of supply uncertainty and the level of weight of each objective on the optimal order allocation quantities using numerical examples. Section 5 concludes the paper and discusses extensions.

2. Model Formulation

2.1 Model Assumptions and Notation Description

The manufacturer produces single product that processed and assembled by multiple materials or components:

- Each material could be obtained from multiple suppliers with different price, capacity and quality level
- The manufacturer has some information about the uncertain capacity
- The quantity of materials purchased from the suppliers just meet the production demand for once
- Manufacturer's demand for materials, which consists of the quantity constraints, quality constraints and type constraints, must be fulfilled before regular production
- Without considering the secondary purchasing cost if materials meet any delay, and the tardiness time is a fuzzy value that relative to suppliers' capacity and order quantity.

Table 1: Model variables and parameters

Notations	Description	Notations	Description
M	Number of material type	m	The m th material
D	Demand quantity for each material	T_0	Length of purchasing leadtime
N_m	Supplier number of m th material	n	The n th supplier
p_{mn}	Price of n th supplier for m th material	r_{mn}	Perfect rate at supplier n for material m
U_{mn}	Capacity at supplier n for material m	K_{mn}	Minimum accepted order quantity for n
A_{mn}	Available quantity at supplier n for material m	η	Minimum accepted perfect rate
ε	Minimum accepted production number	H_m	Unit inventory holding cost for material m
S_m	Unit shortage cost of material m	q_{mn}	Order quantity to supplier n at material m
x_{mn}	1 if q_{mn} more than 0 and 0 otherwise	P_m	Purchase budget for material m
P	Total purchase budget for all materials	α_{mn}	Percent of available to promise materials
Q_m^H	Inventory quantity for material m	y_m	1 if material m meet the requirement of ε
t_{mn}	Tardiness time at supplier n for material m	t_m	Maximum tardiness time for material m
t_{mn}^+	Inventory time for material m	Q_m^L	Tardiness quantity for material m

2.2 Formulating the Multiple Objective Model

In this model, it is considered that the manufacturer would like to choose the best suppliers and allocate appropriate order quantities among those suppliers with different price, perfect rate and random capacity. It is a multiple objective model and the first objective is to minimize the sum of purchasing cost, which consists of material cost, holding cost and shortage cost, the second objective is to maximize the perfect rate of all materials while the last objective is to minimize the tardiness time of the whole materials. The material cost can be formulated as: $C_{material} = \sum_{m=1}^{M}\sum_{n=1}^{N_m} p_{mn}q_{mn}x_{mn}$, inventory quantities is composed of two terms due to manufacturer's requirement of minimum production lot-sizing, that is,

$$\mathrm{Q}_m^H = y_m\left[\sum_{n=1}^{N_m}(q_{mn}\alpha_{mn}) + \sum_{n=1}^{N_m} q_{mn}(1-\alpha_{mn})\right] + (1-y_m)\sum_{n=1}^{N_m} q_{mn}(1-\alpha_{mn}) \quad (1)$$

tardiness time t_{mn} is a triangular fuzzy number, whose value is related to the tardiness quantity and supplier's capacity, and $t_{mn} = (Q_{mn}^{min}, Q_{mn}^{mid}, Q_{mn}^{max}),$, where $Q_{mn}^{min} = K_{mn}$, $Q_{mn}^{max} = q_{mn}$, and $Q_{mn}^{mid} = (K_{mn} + q_{mn})/2$ the membership function of t_{mn} is

$$\mu(t_{mn}) = \begin{Bmatrix} \lfloor T_0(A_{mn} - Q_{mn}^{min})/(Q_{mn}^{mid} - Q_{mn}^{min})\rfloor, & Q_{mn}^{min} \le A_{mn} \le Q_{mn}^{mid}; \\ \lfloor T_0(Q_{mn}^{max} - A_{mn})/(Q_{mn}^{max} - Q_{mn}^{mid})\rfloor, & Q_{mn}^{mid} \le A_{mn} \le Q_{mn}^{max}; \\ 0, & others \end{Bmatrix} \quad (2)$$

Where $\mathrm{A}_{mn} = \min\{q_{mn}\alpha_{mn}, q_{mn}\}$. Let $t_{mn} = max\{t_{m1}, t_{m2}, \dots, t_{mn}\}$, indicates the maximum tardiness time of material m, and holding time $t_{mn}^+ = t_m - t_{mn}$, thus, holding cost:

$$C_{holding} = \sum_{m=1}^{M} H_m\{y_m[t_m\sum_{n=1}^{N_m}(q_{mn}\alpha_{mn})] + t_{mn}^+\sum_{n=1}^{N_m}[q_{mn}(1-\alpha_{mn})] + (1-y_m)t_{mn}^+\sum_{n=1}^{N_m}[q_{mn}(1-\alpha_{mn})\} \quad (3)$$

The backordering quantities:

$$\mathrm{Q}_m^L = \sum_{n=1}^{N_m} q_{mn}(1-\alpha_{mn}) \quad (4)$$

and shortage cost:

$$C_{shortage} = \sum_{m=1}^{M} S_m\{t_{mn}[\sum_{n=1}^{N_m}[q_{mn}(1-\alpha_{mn})]\} \quad (5)$$

The supplier selection and order quantity allocation model formulation is as follows:

$$\min z_1 = C_{material} + C_{holding} + C_{shortage} \quad (6)$$

$$\min z_2 = \sum_{m=1}^{M}\sum_{n=1}^{N_m}(q_{mn}\alpha_{mn}) \quad (7)$$

$$\min z_3 = \sum_{m=1}^{M}\sum_{n=1}^{N_m}(q_{mn}t_{mn}) \quad (8)$$

$$s.t. \sum_{n=1}^{N_m}(p_{mn}q_{mn}) \le P_m, \sum_{m=1}^{M} P_m \le P \quad (9)$$

$$\sum_{n=1}^{N_m} q_{mn} = D, \forall m \quad (10)$$

$$\sum_{n=1}^{\mathrm{N_m}} \mathrm{U_{mn}} \ge \mathrm{D}, \forall \mathrm{m} \quad (11)$$

$$U_{mn} \ge q_{mn} \ge K_{mn}, \forall m, n \quad (12)$$

$$\sum_{n=1}^{N_m}(q_{mn}r_{mn}) \ge r, \forall m \quad (13)$$

$$Pr\{\sum_{n=1}^{N_m} C_{mn} \ge D\varepsilon\} \ge \theta, \forall m \quad (14)$$

$$Pr\{\sum_{n=1}^{N_m}(q_{mn}r_{mn}) \le \eta D\} \ge \varphi, \forall m \quad (15)$$

$$\sum_{n=1}^{N_m} x_{mn} = 1, \forall n \quad (16)$$

$$\varepsilon, \eta, \theta, \varphi, \alpha_{mn} \in [0,1] \quad (17)$$

$$x_{mn}, y_m, y \in \{0,1\}, \forall m, n \quad (18)$$

$$q_{mn}, U_{mn}, C_{mn} \in Z^+, \forall m, n \quad (19)$$

The first objective function in Eq.(6) minimizes total purchasing cost of manufacturers. The second objective function in (7) maximizes the total quality of purchased products. The third objective function in (8) minimizes the total tardiness time of purchased products. Constraints in (9) limit the capital budget of the material. Constraints in (10) ensure that the total purchase quantity assigned to each supplier equal to the demand of the material. Constraints in (11) restrict the amount of demand of each material less than each the supplier's largest supply capacity. Constraints in (12) ensure the capacity of each supplier cover the ordered quantity. Constraints in (13) represent manufacturers' quality requirements for the materials supplied. Constraints in (14) mean the chance constraints that suppliers meet the demand of some materials. Constraints in (15) represent the chance constraints that suppliers meet the quality demand of some materials. Constraints (16) prohibit assigning the same supplier to more than one type of material. Constraints in (17), (18) and (19) force decimal, binary, non-negative and integral requirements on the variables.

3. Linearization of the Constraints in the Model and Solution Algorithm

3.1 Linearization of the Model

This section addresses the linearization of the constraints in the model. Constraints in (14) and (15) contain the random variable α_{mn}, denoting the uncertain actual capacity at supplier n can provide material m. We assume α_{mn} follows the normal distribution $N(\mu_{mn}^{\alpha}, {\sigma_{mn}^{\alpha}}^2)$.Traditional method that deals with chance constraints is to transform them into deterministic equivalents (Liu, 1998). Firstly, constraints (14) can be transformed into:

$$Pr\{\sum_{n=1}^{N_m}(q_{mn}r_{mn}x_{mn}) \ge \varepsilon D\} \ge \theta, \forall m \quad (20)$$

Let $g(\alpha_{mn}) = \varepsilon D - \sum_{n=1}^{N_m}(q_{mn}r_{mn}x_{mn})$, $\lambda = \frac{\{D_c - \sum_{n=1}^{N_m}(b_{mn}\beta_{mn}) - [E(D_c)] - \sum_{n=1}^{N_m}[b_{mn}E(\beta_{mn})]\}}{\sqrt{V(D_c) + \sum_{n=1}^{N_m}[b_{mn}^2 V(\beta_{mn})}}$ then, we can obtain the expectation and variance: $E\big(g(\alpha_{mn})\big) = E(\varepsilon D) - \sum_{n=1}^{N_m}(q_{mn}x_{mn})E(\alpha_{mn})$, $V\big(g(\alpha_{mn})\big) = V(\varepsilon D) - \sum_{n=1}^{N_m} q_{mn}^2 x_{mn}^2 V(\alpha_{mn})$, and formula (20) becomes:

$$\frac{\varepsilon D - \sum_{n=1}^{N_m}(q_{mn}r_{mn}x_{mn}) - [E(\varepsilon D) - \sum_{n=1}^{N_m}(q_{mn}x_{mn})E(\alpha_{mn})]}{\sqrt{V(\varepsilon D) + \sum_{n=1}^{N_m}[q_{mn}^2 x_{mn}^2 V(\alpha_{mn})]}} \ge -\frac{E(\varepsilon D) - \sum_{n=1}^{N_m}(q_{mn}x_{mn})E(\alpha_{mn})}{\sqrt{V(\varepsilon D) + \sum_{n=1}^{N_m}[q_{mn}^2 x_{mn}^2 V(\alpha_{mn})]}} \quad (21)$$

thus, equivalent (20) is equal to

$$Pr\{\lambda \ge -\{E(\varepsilon D) - \sum_{n=1}^{N_m}[q_{mn}x_{mn}E(\alpha_{mn})]\}/\sqrt{V(\varepsilon D) + \sum_{n=1}^{N_m}[q_{mn}^2 x_{mn}^2 V(\alpha_{mn})]} \ge \theta \quad (22)$$

Where λ follows standard normalization distribution, and the probability density function of λ is $\phi(\lambda) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\lambda} e^{-\frac{t^2}{2}}dt$, then, we have

$$\phi^{-1}(\theta) \le -\frac{E(\varepsilon D) - \sum_{n=1}^{N_m}(q_{mn}x_{mn})E(\alpha_{mn})}{\sqrt{V(\varepsilon D) + \sum_{n=1}^{N_m}[q_{mn}^2 x_{mn}^2 V(\alpha_{mn})]}} \quad (23)$$

then, deterministic equivalent to the chance constraints in (14) is

$$\sum_{n=1}^{N_m}[q_{mn}x_{mn}E(\alpha_{mn})] - \phi^{-1}(\theta)\sqrt{V(\varepsilon D) + \sum_{n=1}^{N_m}[q_{mn}^2 x_{mn}^2 V(\alpha_{mn})} \ge E(\varepsilon D) \quad (24)$$

However, Eq.(24) is non-linear. Let $D' = \varepsilon D$, $E(q_{mn}r_{mn}) = \mu_{mn}$, we have:

$$[\sum_{n=1}^{N_m}(\mu_{mn}x_{mn})]^2 - 2D'\sum_{n=1}^{N_m}(\mu_{mn}x_{mn}) + D'^2 \ge (\phi^{-1}(\theta))^2 \sum_{n=1}^{N_m}(\sigma_{mn}x_{mn}) \quad (25)$$

By using the method of linearization (Bilsel, 2011), the Eq.(25) can be formulated as:

$$\mu_{mn}^2 x_{mn} - \mu_{mn}\sum_{l=0}^{l_{mn}}(2^l s_{mn}) + \sum_{l=0}^{l_{mn}}(2^{2l}w_{mn}) + \sum_{a=l}^{l_{mn}}\big[\sum_{v=a}^{l_{mn}}(2^{2v-a+l}y_{m,n,(v-a),v})\big] - [\phi^{-1}(\theta)]^2\sum_{n=1}^{N_m}(\sigma_{mn}x_{mn}) \ge 0 \quad (26)$$

Where $x_{mn} \ge s_{mn} \ge 0$, $s_{mn} \le w_{mn}$, $x_{mn} + w_{mn} - s_{mn} \le 1, \forall m, n$, $y_{(v-a),v} \in \{0,1\}$, $y_{(v-a),v} \le w_{v-a}$, $y_{(v-a),v} \le y_{(v-a),v} \le w_v$,and$w_{v-a} + w_v - y_{(v-a),v} \le 1, \forall v, a$. The transformation of Eq.(15) is the same as Eq.(14). After that, the model above is transformed into a deterministic multiple objective linear mixed integer programming model.

3.2 Two-phase Approach

Lingo or other mathematical programming software can be used to solve small-scale problems directly. However, it may take too much time for large-scale problems. There exists several approaches to solve multi-objective linear programming problem (Masud & Ravindran). Some academics further points out that the result of the non-preemptive goal programming is the best (Bilsel, 2011). Based their research, we develop a heuristic algorithm for the model. The algorithm can be described as two stages, the first stage is to reduce the scale of feasible solution space; the second stage is to search the optimal solution in the feasible solution space. The specific steps are as follows:

- First Stage: Reduce the scale of the feasible solution according to the characteristic of the model.
  - Step 1: Find all initial feasible solutions that meet the constraints in Eq.(10) and the initial feasible solution space is denoted by I^0. Every feasible solution can be formalized as $S_i=(s_{i1},s_{i2},s_{i3})$, where s_{i1} represents the order allocation solution in the i th solution, namely $s_{i1}=(q_{i11},q_{i12},q_{i13})$
  - Step 2 : Set the minimum procurement lot size of each type of material, which is denoted by ls_1,ls_2 and ls_3 respectively. The value of ls_i is related to specific material. Let μ_{U_i} denote the average supply capacity of each type of material, $\sigma_{U_i}^2$ denotes the corresponding variance and p_i denotes the average price of material i. Let $ml=p_i\sigma_{U_i}^2/\mu_{U_i}$, who indicates the availability and supply stability of material i, and the smaller this value is, the smaller the corresponding procurement lot size. Then, we have feasible solution space I^1
  - Step 3: Sort the model objectives according to decision maker's preference, denote by l_j, $j=1,2,3$. The priority of the objective is associated with the weight of each objective that we will discuss in stage 2. Perform the constraints in turn that correspond to the turn of the objective, we have new and smaller-scale feasible solution space I.
  - Step 4: Conduct the constraints that correspond to the chance constraints in Eq.(14) and (15) and we might have new feasible solution space and further denoted by I^3. Then, we recognize it as the final feasible solution space which satisfies all constraints in the model
- Stage 2: Find the optimal solution in the feasible solution space using the improved non-preemptive goal programming method. The specific steps are as follows
  - Step 1 Consider each objective function as the optimization goal and ignore other objectives under space I^1 and work out the corresponding optimal value, denoted as the ideal value of z_1^{ideal}, $z_2^{ideal}$and z_3^{ideal}respectively
  - Step 2: Assign the weight for each objective that denoted by w_1, w_2, and w_3,. The value of each weight is consistent with the order of each objective in step 3 of stage 1
  - Step 3: Let $z = \frac{w_1(z_1-z_1^{ideal})}{(z_1^{max}-z_1^{ideal})} + \frac{w_2(z_2^{ideal}-z_2)}{(z_2^{ideal}-z_2^{min})} + \frac{w_3(z_3-z_3^{ideal})}{(z_3^{max}-z_3^{ideal})}$ and find the best solution that keeps the value of z the smallest in space I^2 and denote it as $S^* = (s_1^*, s_2^*, s_3^*)$.Then, $S^*$is the optimal solution that we are searching for.

4. Computational Study

4.1 Computational Example

To evaluate the performance of proposed model and the effect of the degree of uncertainty and the value of weight of each objective, the following computational experiment is conducted on randomly generated instances. Assume that the manufacturer would purchase 3 types of materials and each type of material owns 3 candidate suppliers. We consider three different settings for the three kinds of materials with different price level, quality level and capacity level. For convenience, we set the same level of available rate for the same material and denote them by α_1, α_2 and α_3 and they follow *N(0.9,0.4), N(0.7,0.12)* and *N(0.8,0.08)* respectively. The basic data of the model is shown in Table 2.

Follow the steps of the algorithm indicated in Section 3.2, we reduce the scale of the feasible solution space from the initial 60 million to 7 million and finally to 300 thousands. Then, the ideal values illustrated in step 1 of the stage 2, that is $z_1^{ideal} = 4184.81$, $z_2^{ideal} = 432.91$ and $z_3^{ideal} = 650.22$. We consider different kinds of weight combination settings and find corresponding solutions as shown in Table 3.

Table 2: Stochastic capacity data of each supplier

M	N_m	p_{mn}	U_{mn}	r_{mn}	K_{mn}	H_m	S_m	α_{mn}	ls_m
1	1	1.08	70	0.93	0.4	0.2	0.24	1.00	5
	2	1.12	80	0.94	0.4	0.2	0.24	0.70	5
	3	1.20	90	0.94	0.4	0.2	0.24	0.81	5
2	1	7.13	40	0.98	0.2	1.6	6.56	0.30	1
	2	8.20	50	0.98	0.2	1.6	6.56	0.62	1
	3	9.08	100	0.99	0.2	1.6	6.56	0.44	1
3	1	4.45	50	0.94	0.3	0.9	1.84	0.55	2
	2	4.56	60	0.96	0.3	0.9	1.84	1.00	2
	3	4.78	70	0.97	0.3	0.9	1.84	0.46	2

Table 3: Optimal order quantity allocation solution under different weight of each objective

(w_1,w_2,w_3)	(s_1^*, s_2^*, s_3^*)		
	$(q_{11}^*, q_{12}^*, q_{13}^*)$	$(q_{21}^*, q_{22}^*, q_{23}^*)$	$(q_{31}^*, q_{32}^*, q_{33}^*)$
(1.0,0.0,0.0)	(70,40,40)	(20,50,80)	(40,60,50)
(0.0,1.0,0.0)	(0,60,90)	(0,50,100)	(20,60,70)
(0.0,0.0,1.0)	(30,50,70)	(25,50,75)	(45,60,45)
(0.8,0.1,0.1)	(30,55,65)	(21,50,79)	(42,60,48)
(0.2,0.7,0.1)	(0,65,85)	(21,50,79)	(28,60,62)
(0.3,0.1,0.6)	(30,55,65)	(20,50,80)	(42,60,48)

The first three lines in table 3 show the optimal solutions only considering the single objective respectively in turn. For example, if the decision-maker only care about purchasing cost, the optimal order allocation solution of material 1 is(70,40,40), which means buy 70 units material 1 from supplier 1, 40 units from supplier 2 and 40 units from supplier 3, the optimal solution for material 2 is(20,50,80) while (40,60,50) for material 3. Obviously, there is a big difference between material 1 and material 2 in price and shortage cost, which lead to the order solution for these materials that material 1 gives preference to suppliers with low price and material 2 gives priority to suppliers with high available capacity. Line 4 to 6 respectively assigns greater weight to objective 1, 2, and 3 and it shows that the solution shown in line 4 is closely to the solution in line 1 and so as the line 5 and 6. It reveals that the optimal solution for different weight level at the same uncertain degree is different and the greater the objective weight is, the closer the corresponding order allocation solution to the solution regarding the objective as the single objective in the model.

4.2 Computational Analysis

In this section, we will evaluate the effect of the degree of uncertainty and different weight level for each objective on the optimal solution. We consider two different settings as shown in Table 4, the two kinds of materials has quite different characteristic, as we can see in the table, the difference of price level, quality level, and capacity distribution between respective two suppliers is big, besides, we give the procurement lot-sizing a fixed and minimum value, that is, 1, which could provide distinct results for us. The optimal order allocation solutions under different conditions are shown in Table 5.

Table 4: Stochastic supplier capacity data

M	N_m	p_{mn}	U_{mn}	r_{mn}	K_{mn}	H_m	S_m	ls_m
M_1	1	1.08	90	0.93	0.4	0.2	0.24	1
	2	1.20	110	0.94	0.4	0.2	0.24	1
M_2	1	7.13	60	0.98	0.2	1.6	6.56	1
	2	9.08	120	0.99	0.2	1.6	6.56	1

Let $W=\{W_1,W_2,\ldots W_n\}$represent the set of different weights combinations, where $W_i=(w_{i1},w_{i2},w_{i3})$, and let $S_{i,j,k}=(Q_1,Q_2)_{i,j,k}=(q11_{ijk},q12_{ijk},q21_{ijk},q22_{ijk})$, who represents the material allocation solution under the level of W_i and the "available to deliver" proportions for Material 1 and Material 2 are $\alpha_1=j$ and $\alpha_2=k$ respectively. From the data analysis of Table 5, we can obtain:

- When $\alpha_1=\alpha_2=1.0,\forall W_i(i=1,2,\ldots,n)$, we have $S_{ijk}=S_{i+1,j,k}(i=1,2,\ldots n-1)$. That is to say, when the availability of all the materials can be guaranteed, the material allocation solution is always fixed no matter what level of the weight of each objective is, and the specific material allocation solution is connected with its price and quality level. It reveals that the order allocation solution of the manufacture is fixed and has nothing to do with the weights combination when the ordered material can be delivered on time
- When $\alpha_1=\alpha_2\neq1.0$, if $W_i\neq W_{i'}(i,i'=1,2,\ldots n)$, then $S_{ijk}\neq S_{i'jk}(i,i'=1,2,\ldots n)$. That is to say, when the available to deliver proportions of materials are same but not equal to 1, the allocation solutions under different weight combinations are different. However, as shown in Figure 1, order allocation solutions under different weight combinations have similar features: the product quotas of the suppliers with a lower price who are matched with material 1 which has a low price but also a low quality level increase at first and then decrease with the increase of the degree of uncertainty; the product quotas of the suppliers with a lower price in material 2 which has a high price but also a high quality level decrease gradually and tend to be stable. It reveals that the subjective decisions of decision maker can affect the order allocation solution when the level of the uncertainty degree is fixed

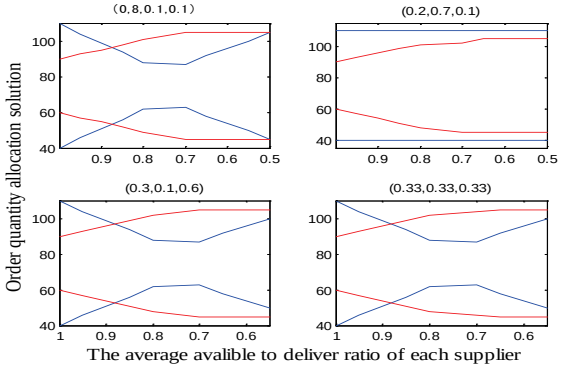


Figure 1: The optimal solution under different conditions

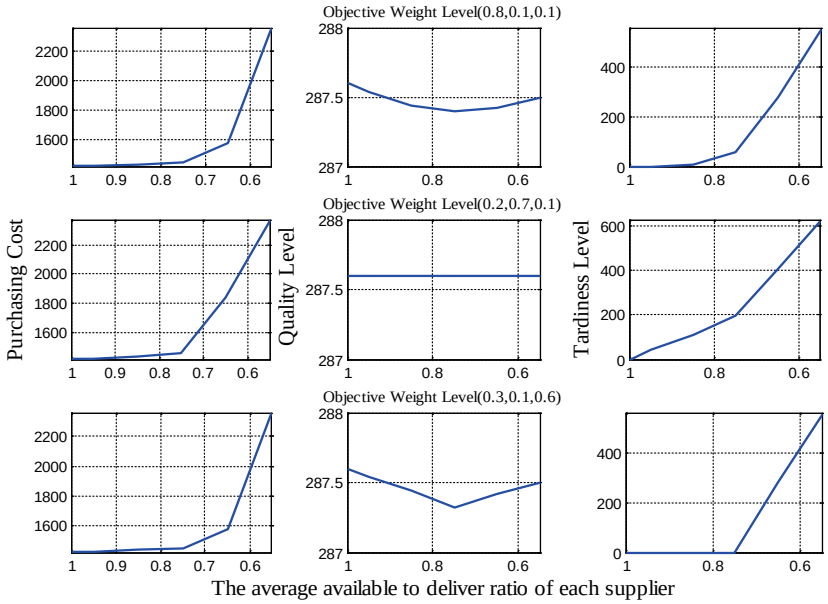


Figure 2: The impact of uncertainty and weight on different objective

Table 5: Comparison of solutions under different conditions

(w_1,w_2,w_3)	α_1 vs α_2	α_1	α_2	(q_{11}^*, q_{12}^*)	(q_{21}^*, q_{22}^*)	O_{cost}	$O_{quality}$	$O_{shortage}$
(0.8,0.1,0.1)	$\alpha_1 = \alpha_2$	1.00	1.00	(40,110)	(60,90)	1420.20	287.60	0
		0.95	0.95	(46,104)	(57, 93)	1425.33	287.54	0
		0.85	0.85	(56,94)	(52, 98)	1434.73	287.44	6.76
		0.75	0.75	(60,90)	(45,105)	1448.24	287.40	55.80
		0.65	0.65	(58,92)	(45,105)	1576.60	287.42	279.34
	$\alpha_1 > \alpha_2$	0.95	0.85	(46,104)	(52, 98)	1435.93	287.54	6.76
		0.85	0.75	(56,94)	(45,105)	1447.53	287.44	0
		0.75	0.65	(68,82)	(45,105)	1568.11	287.32	139.50
		0.65	0.55	(58,92)	(45,105)	2313.91	287.42	420.34
	$\alpha_1 < \alpha_2$	0.85	0.95	(56,94)	(58,92)	1422.97	287.44	6.96
		0.75	0.85	(68,82)	(52,98)	1433.29	287.32	6.76
		0.65	0.75	(58,92)	(45,105)	1454.59	287.42	139.84
		0.55	0.65	(50,100)	(45,105)	1849.86	287.50	412.50
(0.2,0.7,0.1)	$\alpha_1 = \alpha_2$	0.95	0.95	(40,110)	(57,93)	1426.60	287.60	41.80
		0.85	0.85	(40,110)	(51,99)	1441.67	287.60	112.20
		0.75	0.75	(40,110)	(45,105)	1461.41	287.60	195.80
		0.65	0.65	(40,110)	(45,105)	1841.18	287.60	405.70
	$\alpha_1 > \alpha_2$	0.95	0.85	(40,110)	(51,99)	1438.30	287.60	41.80
		0.85	0.75	(40,110)	(45,105)	1453.37	287.60	112.20
		0.75	0.65	(40,110)	(45,105)	1595.33	287.60	335.30
		0.65	0.55	(40,110)	(45,105)	2345.54	287.60	546.70
	$\alpha_1 < \alpha_2$	0.85	0.95	(40,110)	(57,93)	1429.97	287.60	112.20
		0.75	0.85	(40,110)	(51,99)	1449.71	287.60	195.80
		0.65	0.75	(40,110)	(45,105)	1525.73	287.60	266.20
		0.55	0.65	(40,110)	(45,105)	1864.62	287.60	482.70
(0.3,0.1,0.6)	$\alpha_1 = \alpha_2$	0.95	0.95	(46,104)	(57,93)	1425.33	287.54	0
		0.85	0.85	(56,94)	(51,99)	1435.83	287.44	0
		0.75	0.75	(68,82)	(45,105)	1446.09	287.32	0
		0.65	0.65	(58,92)	(45,105)	1576.60	287.42	279.34
	$\alpha_1 > \alpha_2$	0.95	0.85	(46,104)	(51,99)	1437.03	287.54	0
		0.85	0.75	(56,94)	(45,105)	1447.53	287.44	0
		0.75	0.65	(68,82)	(45,105)	1568.11	287.32	139.50
		0.65	0.55	(58,92)	(45,105)	2313.91	287.42	420.34
	$\alpha_1 < \alpha_2$	0.85	0.95	(56,94)	(57,93)	1424.13	287.44	0
		0.75	0.85	(68,82)	(51,99)	1434.39	287.32	0
		0.65	0.75	(58,92)	(45,105)	1454.59	287.42	139.84
		0.55	0.65	(50,100)	(45,105)	1849.86	287.50	412.50

- $\forall W_i (i = 1,2, \dots, n)$, fix α_1, $\alpha_1 \neq 1.0$, then the order allocation solution of Material 1 is fixed, and when $\alpha_2 \leq \alpha_1$,the allocation solution of Material 2 tend to give large quota to the supplier with a high supply capacity gradually with the increasing of α_2; when $\alpha_2 > \alpha_1$,the allocation solutions of Material 2 gradually tend to give large quota to the supplier with small supply capacity but a low price; similarly, fix α_2 and $\alpha_2 \neq 1.0$, ditto for the allocation solution law of Material 1. It reveals that when the uncertainty degree of a material is fixed, its allocation solution is fixed and unaffected by the uncertainty degree of other materials and the weight of objective
- Generally, as the uncertainty degree increases, the allocation solutions with different weight combinations show the same characteristics. As shown in Figure 2, with the increasing of the uncertainty degree, the procurement cost increase gradually, and the rate of increasing changes from weak to strong, the level of material quality decreases at first and then increases, but the level of materials tardiness increase gradually

- With different weight combinations, as the degree of materials' uncertainty increase, the allocation solutions of different materials gradually tend to be stable. Define that material tends to be stable after the uncertainty degree α_i, and the rate of material tending to be stable is associated with the weight level. For example, when the decision-maker thinks a lot of procurement cost, the materials with a higher price achieve stability first; the materials with a lower price and a lower quality achieve stability first, while the decision-maker thinks highly of quality level. It reveals that under different level of weight combination, each kind of material has a fixed allocation solution with small risk and the solution can be adopted when the uncertainty degree of materials is almost impossible to estimate.

5. Conclusion

Risk management is an inherent part of the procurement process, especially those products with complicated structure and assembled by large amount of components. Effect of disruptions on supply chains can be crucial. This paper studies a stochastic multi-objective supplier selection and order quantity allocation problem with random supply capacity and uncertain tardiness time. We derive the deterministic equivalents for capacity and demand chance constraints under the normality assumption. After linearization of the nonlinear deterministic equivalents, a two phase algorithm is proposed to solve the problem. The model presented in this paper is of value for manufacturers in the supply chains. Since the numerical results show that specific material allocation solution is related to multiple factors, such as objective weight, uncertainty degree of supply, price of each kind of material and so on, which can be used as guidelines in industrial implementations.

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Biography

Xiaobing Liu is a professor and doctoral advisor of Dalian University of Technology, the dean of College of business administration of Dalian University of Technology, the member of experts of CIMS from the National 863 Plan of China and the committee members of robotics from China Association of Automation. He graduated with a B.E. and a M.E. from Dalian University of Technology in 1982 and 1984, and a D.E. from Dortmund University in 1992. His current research interests include advanced manufacturing and management mode, mass customization, ERP and so on. He has published over 100 research papers in Chinese and overseas journals, including EI and SCI papers. And he also has published 5 works about his research. He has presided and completed over 90 national, provincial and enterprise projects and achieved excellent research results and outstanding application effects.

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Identifying the Need for Innovation Risk Management

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Abstract

In this paper we show the importance of carefully managing risk in innovation with an effective innovation risk management process. The innovation risk management process is presented as a composite theory. By looking at historical cases we highlight the effects of not using innovation risk management and discuss these effects. Innovation is inherently risky and companies continue to pursue innovation evaluation and selection techniques which inhibited their processes and diminish innovation output. We found that extensive research on innovation risk strategies is lacking both in academia and industry; this conclusion comes from examining the literature and real world cases related to innovation management that there is a general absence of an innovation risk strategy. This paper will improve success to failure balance in favour of innovators wanting to maximize opportunities and mitigate threats. We propose three levels of analysis derived from risk management and applied to innovation management, which provides a basis for an innovation risk management framework. Finally, we identify open research questions that need to be addressed to improve our understanding of innovation risk management.

Keywords
Innovation management, risk management, innovation risk management.

1. Introduction
Innovation is risky and failure to innovate is costly. We examine the literature and best practices in innovation and risk management and propose a basis for an innovation risk management framework. The need to reduce costs and limit the failures in innovation motivates the development of a composite theory for innovation risk management strategy.

There are five types of risks that we consider in association with innovation: Technological risks, defined as all those risks which lead to non-completion, under-performance or false performance of the requirements, inputs, or of the procured good and service use to support the innovation process. As a result of the more innovative nature of technology (as opposed to other areas where innovation is found), often the risk lies in the technical characteristics of the service or product or in the process that results in their production. This risk often originates on the suppliers' side, customer side or with external stakeholders; thus making procurement management, requirements gathering, and stakeholder management important skills in mitigating innovation risks.

Second, there are dimensions of Organizational and Societal risks which include all those risks of the procurement failing or under-performing for internal rather than external reasons. Further, Societal risks are those related to non-adoption of the innovation by the intended innovation user.

Third, Market risks which include the demand and supply side with the former occurring whenever innovations in public procurement are intended to spill over to private markets and those private markets are not large or responsive enough or do not built up quickly enough to justify capacity investment (EU Commission, 2010).

The EU Research Policy Commission defines the latter as those that potentially disrupt or delay operations such as political instability and volatile labor market; potential threats that a competitor will take over a supplier and potentially lock out supplies, risks related to delays and insufficient quality.

A fourth type of innovation risk is financial risks; this opens up a slew of evaluation methods already common in the financial sector. These evaluation methods include Earn Value Management, and various simulation and modelling techniques that lead to decision making.

Finally there are Turbulence Risks. Turbulence or Force Major represents those uncertainties that are hard to predict and measure. These fall under the type Insurable Risks and ought to be transferred when possible. They are associated with large scale innovation projects and often emerge from natural phenomena.

The risk management theory that we consider originates from project risk management. Within this theory, risk management has a range of response strategies that can be applied to Innovation Management and thus reduce the cost of innovation and reduce the probability of failure. Risk Management can reflect the business value on innovation risks and help managers make more informed decisions through its various tools and techniques. A risk management process consists of the following steps: Planning, Identification, Analysis (also known as Qualification and Quantification), Risk Response, and Monitoring and Control (PMI, PMBOK, 2012). This paper address primarily three of the process steps: Identification, where effort is made in listing all the threats or opportunities the innovation activity may face; Analysis, which focuses on subjective or objective-numerical valuation of the threats or opportunities identified; Risk Response, which shows how negative and positive risk in innovation can be treated by selecting from the various response strategies that project risk management offers.

Each of these steps contributes to the risk management process and should play an important role during the innovation process. There is no overwhelming proof in literature that innovators generally qualify and quantify the innovation risks faced in their innovation process. Not applying an effective innovation risk management strategy can impact company profit and reduce management credibility, both of which have profound negative impact on the company's innovation and performance (Mollick, 2013).

Joining the two theories of Innovation Management and Risk Management provides a composite theory for Innovation Risk Management. Innovation is defined broadly and, according to Schumpeter's Organisation for Economic Co-operation and Development (OECD) model includes innovation products, services and processes (Ina, 2004). It is important that the proposed theory is compatible with the fast pace of innovation and the need to have early return on investment (ROI) (MII, 2010). There exist at least three advantages to applying risk management to innovation management. First, the ability to identify innovation risks early helps to facilitate discussion. Second, planning responses such as contingencies allow the innovator to leverage opportunities and mitigate threats early. Third, monitoring and control builds up the knowledge gained in previous innovation processes, it helps us to understand the process and it allows transfer of that knowledge to new innovation activities.

Innovation processes often change in order to facilitate further innovation. It is possible to feasibly apply risk management to such process change. Innovation risk management provides relevant tools and techniques that can be applied to changing innovation management processes; these tools are applied in finance, workplace safety, health and other areas (Morris, 2008). In these areas these tools are standardized and widely applied. Innovation management needs its own set of tools adopted from these areas and standardized specifically for innovation management.

The remainder of this paper is organized as follows. In Section 2, we highlight the effects of not using innovation risk management and discuss these effects by looking at several historical cases. Section 3, provides a basis for innovation risk management and identifies open research questions that need to be addressed to improve our understanding of innovation risk management.

2. Results of Not Using Innovation Risk Management

Failing at innovation is likely and costly. There are many examples of failures in innovations for various reasons. In this section we look at some of the consequences of failing at innovation when not using risk management. Risk management can play a positive role at every stage of the innovation management process. We discuss the stages of the risk management process in tandem with methods of innovation selection, cost of innovation, and organizational management in relation to innovation risk management. Furthermore, we study several historical cases and explain how risk management could have helped getting a better outcome.

Innovation managers rely on tools and techniques to select and pursue innovation projects. If innovation managers were to rely on tools and techniques solely outside of risk management, such as ROI or other financial measures, then weaknesses in these measures bring failure (Stulz, 2008). The flaw of using only ROI as a measure of innovation success is that it excludes, among other things, the potential for market adoption (Group, 2000), (Perrin B. e., 2013). ROI may be a gratuitous example of an innovation measurement because its flaws are so painfully evident (Morris, 2008); it weeds out the potential and impact of truly innovative ideas because the measure of success is purely financially driven. Instead these measures should be used together with risk management process steps. For example, the identification and qualification of potential risks and opportunities help to give a holistic management view on the innovation potential.

We see holistic management as a complete monitoring of all major actors and actions in an organization. Holistic management is complex, but within this complexity can be found the potential for increased synergy in the organization. Seen also as only a partial remedy to the problems in innovation management, adding risk management to holistic innovation management is likely to bring more success to technology management and technology adoption. This is where (holistic) innovation risk management as a composite theory can be used as an innovation manager's process for understanding the risks involved in technical areas and support validation of their many business assumptions.

The next stage we consider is the cost of innovation. The pharmaceutical industry has extensive records on the amount of money lost in innovation failures (Horrobin, 2000), (DiMasi, W., Henry, & Louis, 1991). However, the industry has weathered these failures by introducing 70 to 100 products per year leveraging profit earned on these innovation successes. The pharmaceutical industry has had to introduce each year one new product which will sell 355 million Euros per year for every 1-1.5% of the market in which they compete (Horrobin, 2000). A company of the size of GlaxoWellcome/SmithKline Beechman needs to introduce 3-7 successful products every year in order to remain viable. In this kind of competitive environment, the pharmaceutical industry is seeing an increase in costs of innovation (DiMasi J. A., 1991), an increase known to be present in other industries. The total number of worldwide new chemical entities launched yearly have fallen from between 80 -100 entities in the 1950-60s to a number between 30 and 40 entities, in the late 1990s. Pharmaceutical companies, partly based on their profit potential, have higher risk tolerances that IT companies. We see the profit margins of top IT companies, for example in Europe, decrease from 30% to 21% over the last ten years due to failures in innovation (Benveniste, 2013). Meanwhile pharmaceutical companies with all their perceived advantages have been merging and streamlining and commercializing their research processes – a clear sign that investment in R&D is falling (Horrobin, 2000), (Ansell, 1997). IT companies who cannot be adequately differentiated in their service offers cannot leverage this kind of collaboration in innovation. Risk management provides us with a way of reducing costs through techniques such as earn value management (EVM). EMV takes into account uncertainty and potential earning to determine which innovation to pursue eliminating more costly innovation decisions in favor of those that bring better business value. Further examples like this prove difficult to come by outside of product organizations as the direct impact of innovation is not often seen.

Innovation Risk Management can be used with old and new management strategies especially holistic management approaches. Holistic management is conducive to innovation risk management because of the way it inclusively manages stakeholders within the organization (Kolter & Keller, 2014). Innovation Risk Management can also be used with Agile Management methods. Agile management has process points in which risk management can be embedded. Agile management is recursive and self-improving, perfect for applying a risk management operational process. Agile coaches and experts would argue that risk management is facilitated inherently in their process, but we have seen that this is only at the operational level. Risk management proposes an abstract end-to-end view of the entire innovation process and can be accommodative to self–organizing operational agile processes that will ultimately deal with issues, not risks with high strategic business impact.

2.1 Historical Innovators

Upcoming innovators would benefit from reading about previous innovators like Ford, Da Vinci, Thomas Edison, Newton and other great innovators even outside of the fields of science and technology in order to understand their innovation processes, and to understand how they thought about what they did. They had no innovation risk management strategy. None of the established or contemporary innovators we know held a Degree in innovation management, neither did they read books on how innovation happens or took creative thinking classes. They certainly did not hire expensive consultants to come and tell them how to think like an innovator. However they all believed in their ideas and followed it with a passion despite the inherent risks.

Certainly innovation risk management was not at the forethought of the contemporary innovator. What has changed, and why is innovation risk management important now? There are at least three answers to follow that explain why we cannot manage innovation the way prior innovators did, the existence of Pure Risks, the increase cost in Prototyping, and collaboration in innovation.

We present our first answer and point to it being found in examining what risk management refers to as Pure Risks. Pure Risks have no positive outcome and often result in loss of life and or limb. Pure Risks have led to an increase in government and industry regulation and affects innovation management in ways never seen by prior innovators. Risk management will alleviate the impacts of Pure Risk in innovation through a response strategy of avoidance. Avoidance is the only acceptable response strategy for Pure Risk. Hence with government regulation curtailing the number of Pure Risk events in major industries such as pharmaceutical, manufacturing and aviation, the side effect is that it has also impacted the potential to innovate. Innovation Risk Management can help innovation managers to positively navigate regulatory requirements, to remain compliant and to maximize on their innovation potential.

The second answer, the increased cost of prototyping, highlights further dissimilarities between historical and current innovators. In the past, the ability to provide capital investment for your innovation pursuit was a very important factor. Today, you see persons with great ideas unable to convert their idea into its final innovation-form and fund deployment to market due to the cost of prototyping. Prototyping in today's world is often an expensive activity that risk management can reduce the cost of through earned value management and similar quantitative techniques (DiMasi J. A., 1991). Generally we can see the trend of research and development (R&D) spending and capital investment costs in innovation tend towards increases that small innovators cannot afford (Hall & Lerner, 2009).

Third, collaboration in innovation through such techniques as the famed Open Innovation method often reveals how mismatched some innovation management techniques can be. We are confident that innovation risk management can realign these techniques and prevent them from limiting potential innovation opportunities (Koetzier, Wouter; Alon, Adi; Hooper, Kenneth, 2011). Often this approach needs to be modified or completely replaced by approaches that bring flexibility in the company's innovations portfolio or strategic focus – referred to as 'opportunity grabbing'; leveraging speed in selection processing, with advantageous time to market, and a level of control and forward planning for contingencies that only innovation risk management can provide.

Looking at the chronology of any one innovation is not a useful thing to do in understanding the risk involved. Often, retrospectively looking at innovation reveals the obvious; it reveals things that the innovator had not the luxury of knowing. Had the innovator known what he knew at the point of break through then various risks would have been avoided. Taking risk is not about committing to failure but committing to seeking alternatives and prototyping. Reference the Google 20% rule (originating from Richard Drew's 15% rule) – project related to Google work and geared at seeking out alternatives as well as new innovations. Innovators have to allow themselves to make mistakes and be able to accept the fact that they may fail. Innovation has a personal responsibility to break rules. Risk Management prepares for the consequences.

Innovation risk management's post-mortem feature of lessons learned comes in the monitoring and control phase of the risk management process. Risk management also does pre-mortems which is a forward look at potential failure. These techniques would be especially useful across innovation projects within the same company and same technology context.

The next section expands on innovation examples but aligns each in the context to a risk management process.

3. Recommended Ways to Perform Innovation Risk Management

This final section outlines how innovation management can be combined with risk management as a new value adding composite process. The section will show that process steps in risk management can easily be adapted to old and new management processes. Failures of innovation play a role both on a macro and on a micro level. On a macro level, the consequence of not using innovation risk management can be so great that nation states cannot afford environmental, economic, and social uncertainty that innovation risks will bring. The future and sustainability of a nation may be tied to innovation. However the micro and macro levels show that the problem is multi-fold, bearing many perspectives. Schumpeter saw innovation, together with all its effects, and the response to innovation by the economic system as the primary generator of growth in the economy. A failure to innovate on the macro level would mean the absence of economic growth (Schumpeter J. , 1939).

Recommended steps for innovation risk management: it must be domain specific, process fitting and market reaching. It must be able to be applicable to all the phases of innovation management being pursued by the company. The risks in innovation risk management depend in great measure on the management choices made in pursuing innovation, the more informed the choices are during the decision making process, the more likely the risk in innovation will be minimized and the opportunities maximized (Merton, 2013). There are tools and techniques, processes and models in other risk areas that can be applied to innovation; they require a fundamental understanding of the risks involved in order to produce good results. The purpose of innovation is to satisfy a customer need or to create opportunities with industry push. Innovation often comes in times of need; in addition, it must be adopted by an audience in order to be deemed successful (Rogers, 1995). Therefore innovation risk management must extend towards the market to deal with dynamic impacting market issues on innovation success. Also innovators can derive their purposes from problems related to their disciplines, and therefore, innovation risk management must be domain specific.

Innovation risks are often driven by the innovation need or problem complexity originating from the customer side or via technology push. In order to satisfy customer pull, it is not sufficient to see cost and time to market as the only risk at stake. The innovation manager must be involved in risk management activities beginning from idea to output. A Risk management plan is most effective if it includes a measurable process, in addition industry best practices state that the status of innovation risk in an organization should be presented across domains. One of the first standard frameworks that can be adapted to suit innovation risk management originates from project risk management. This framework has six parts: risk planning, risk identification, qualitative assessment, quantitative evaluation, risk response planning and risk monitor and controlling. If these six steps were to be adopted to uniquely fit the technology/product innovation process then this would be a workable starting point.

The recommended way of performing innovation risk management should examine what effective innovation risk strategies are available to innovation companies and how can innovation risk management be strategically aligned within innovation companies. The goal is to formulate and implement a strategy for delivering value. Successful technology innovation often requires coverage of multiple categories, for example, a combination of product, market and customer – taking the shape of holistic innovation management in order to be more successful (Collinson & Wilson, 2006).

Discover driven planning (McGrath & Macillan, 1999) presents as a proposed approach used by managers seeking to address significant amounts of uncertainty. As this paper seeks to string together an innovation risk management theory, it is important to identify those overlapping theories that have not yet been articulated into a streamlined theory for innovation risk. Discovery driven planning can therefore serve as the starting point in developing an innovation risk strategy. The underlying components in this planning phase will involve Framing (scope definition), Benchmarking, Implement TRMs, Documenting Assumptions, Specifying and checking stage-gates. McGrarth *et al* further points out that, in a conventional world, managers are held to the key performance indicators (KPI) of meeting the numbers." For innovation managers this is not directly applicable. Innovation managers must plan for failure because innovation is inherently risky and failure happens. The question is therefore, how should innovation managers be measured? Question: Can new knowledge and insight created be valued if the source of knowledge is failure?

Risk planning in innovation positions all the variables required for effective risk management. This includes stakeholder analysis and assessment, positioning of organizational assets and environmental factors.

3.1 Strategies for Innovation Risk Management

Some form of guidance is required for increasing the viability of innovation activities. This paper recommends that effective innovation risk management should bear levels of analysis and be very specific about the dimensions of innovation and the corresponding innovation risk to which innovation risk management is being applied.

Organizational studies focused on innovation have shown that management strategies ill-applied do as much to kill organizational growth; even more so with innovation which is inherently risky (Collinson & Wilson, 2006).

With the careful focus on dimensions and levels of analysis in justifying the need for innovation risk management this paper is also focused on the specific risk that can be identified from these dimensions and levels; for example strategic versus operational, internal versus external, pure risks versus business innovation risks.

3.2 Risk Identification

Risk innovation planning asks the question: “what could go wrong?" having a healthy contact with an understanding of stakeholder needs is one of the most effective steps to be taken in planning for any type of risk. It is worthwhile to note the difference between traditional risk identification and innovation risk identification. Traditional risk identification is often tied to bodies of knowledge or an area of expertise that is well established; for example finance, workplace safety, and pharmaceutical. Whereas innovation risk identification would be characterized by the nature of the innovation being pursued.

3.3 Analyze (Qualitative & Quantitative Analysis of Innovation Threats and Opportunities)

The analysis phase of the innovation risk management process applies qualitative and quantitative measures upon the risks identified in the identification phase. Its output is ranked, prioritized and quantified through measures of the innovation risks. Innovation risk analysis must be based on the simple premise of accounting for uncertainty among discrete innovation risk events. The goal of the innovation risk analysis is to provide insight into the potential impact that the innovation may have during implementation or execution. Other fields have had some success with mapping and measuring its critical success factors.

The technology field should not abandon tried and tested financial models for subjectively and quantitatively evaluating threats and opportunities. These financial aspects of the conventional models of risk management should be brought forward and applied in the technology context. Currently it is the stage-gated selection model from the theory of Open innovation (Enkel, Gassmann, & Chesbrough, 2009) that has permeated the technology industry.

Qualitative analysis of innovation and innovation risk is a subjective effort to be carried out holistically. Innovation subject matter experts and human enablers of the innovation effort take center-stage in this analysis. Quantitative analysis currently involves numerical methods applied predominantly in the financial sector. Just as with financial controlling, inaccurate or incomplete information at the quantitative step in the framework will render an innovation risk model useless. Because innovation is not just a clear cut decision- tree situation, meaning it is not readily a discrete situation but, as Basic Research will show, is an on-going activity- there needs to be a constant validation of assumptions and justification of the numeric values applied.

Innovation is defined within this paper as both a process and an output; both of which are characterized by novelty and acceptance from the innovation audience. The opportunities and threats surrounding the design and ultimate roll-out of the innovation to the innovation audience is where the risk lies. Innovation risk is the threat of a loss or a potential unforeseen gain in an innovation process or with the adoption of an innovation artefact. So innovation is both the method by which firms leverage or master their business models or put into practice product designs and manufacturing processes that are new to them, (Nelson, 1993); it is also a collision between technological opportunities and user need, (Lundvall, 1998).

The questions upon which the problem of formulating an innovation risk strategy is built are: can a framework for developing the innovation process or a template be generated to support risk identification in innovation? Can a tool be developed to aid in idea selection and checklist the key success factors that may guarantee innovation success? Which level of analysis should this tool be focused at, who are the targeted users?

Ideation, which is another starting point for innovation is idea generation. Ideation is the process of creating new ideas and successful ideation (innovation) is defined and assigned types under the categories of product, service, technology platform, channel and branding, and financial/business model innovations.

The biggest innovation that has been seen in risk management in recent years has been fuelled by the financial sector. Vishal Kapoor, Regional Practice lead for APAC expresses his view that risk management should not be limited to quantitative finance but (thanks in part to the global crisis and the regulation that followed) risk in innovation has become a focal point for board members. Within the last five years risk management has seen a lot of investment in terms of training and research; Peter Deans, Chief Risk Officer at the Bank of Queensland express that innovation risk management is being talked about more and being given higher credence at the board level, but risk management especially in innovation is lacking at the practical level. Furthermore, Gilbert Kohnke, CRO and executive VP of OCBC Bank states that Data analytics and data mining can play a foundation role in the category of technology that's supports innovation risk management. A composite theory of innovation risk management would have the required data to make it a variable approach or process.

Literature that comprehensively deals with risk in innovation is lacking. A cross-referencing of the selected levels of analysis, the topics of innovation and risk, against the literature shows that gaps and room for research exist.

4. Conclusion

There is no guarantee that emulating the innovators of old will yield success; but repeating their mistakes will for sure bring failure. Innovation risk management takes the best industry lessons in avoiding failure and applies them to the innovation context. Innovators have the advantage of the persistent documentation that accompanies today's fast paced technology, the innovation manager can decipher those lessons learned that can be applied to the innovation process and make for surer innovation output; thus avoiding the same kinds of failures seen before.

Innovation risk management strongly recommends having failures properly documented so that they can be avoided or mitigated. With so much at stake in modern day companies it is the prudent way forward. Innovation management has a body of knowledge that focuses on how to innovate. Risk management, especially in more mature industries as finance, work place safety, and health/pharmaceuticals, all have very mature documentation of lessons learned. All used to avoid major pitfalls in doing business in these areas. What innovation risk management lacks is the analysis and response planning component. The first lacking component, analysis, comprises of qualification and quantification. These approaches are not clearly seen in the innovation management effort; Analysis and with Risk response were adopted from the project-risk management area.

Because innovation risk management strategies are lacking both in academia and industry the proposed method of building a composite theory in Innovation and Risk Management for an innovating company holds much relevance for improving the success to failure balance in favor of innovators. Open research questions that need to be addressed were identified as we all seek to add value to the effort of maximizing opportunity and minimizing threats in innovation.

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A Literature Based Model to Measure Innovation Capability

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Abstract

Innovation capability has been one of the most prominent concepts in engineering and technology management literature, yet there is not any consensus on defining innovation capability. Thus, innovation capability and related concepts have been used interchangeably in the literature such as innovation performance, innovation capacity, innovative capability, innovativeness, organizational innovation, and innovation. Usage of these concepts interchangeably has caused confusion in measuring innovation capability. The main aim of this study is to generate a solution for this confusion by proposing a literature based model. For this purpose, key words related to innovation capability cross-searched in well-known databases. The articles gathered from this search were investigated deeply to shed light on this confusion. In the meantime, conceptual and measurement models related to innovation capability were examined. Furthermore, measurement questions collected from these articles were scrutinized carefully by taking these models into consideration. As a result of this systematic research, a literature based model to measure innovation capability is proposed.

Keywords
Innovation capability, measurement models, conceptual models, confusion

1. Introduction

Innovation capability is one of the most referred concepts in technology management literature; besides the importance and necessity of innovation capability in private and public sectors have been increasing day by day. However not having a consensus on defining innovation has reflected on defining innovation capability. Various definitons of innovation and innovativeness from wide variety disciplines such as economics, entrepreneurship, business and management, technology, science and engineering are seen in the literature (Michna, Meczynska, & Kmieciak, 2011). However there is not any unique accepted interdisciplinary definition of innovation, hence the identification of innovation is difficult (Eggink, 2012). With regard to variability in definition of innovation, the developing literature on the definition of innovation capability is spread through with incongruity (Suping & Xu). Innovation capability and related concepts have been used interchangeably in the literature such as innovation performance, innovation capacity, innovative capability, innovativeness, organizational innovation, and innovation (Hogan, Soutar, Kennedy, & Sweeney, 2011). Usage of these concepts interchangeably has caused confusion in measuring innovation capability. While measurement of innovation is hardly difficult by its nature (Rogers, 1998),

(Tohidi & Jabbari, 2012), adding confusion to this difficulty creates a blur environment to measure innovation capability. Nowadays especially in developing economies, researchers have been studying on measurement of innovation capabilities. Confusion on measurements might play a drastic role for future success of the organizations (Saunila & Ukko, 2012). Moreover, the confusion not only affect firm level, but also affect government level, since measurements of innovation capability are used to determine several kinds of strategies from firm level strategies to government policies. Furthermore, the confusion in the literature starts with concept confusion, and reaches measurement confusion. Since penetration of the confusion is high and multidimensional, there has been a need of a reliable and valid model for measurement of innovation capability.

In this study, the main purpose is to generate a solution for the confusion in the literature, and propose a literature-based model for measurement of innovation capability. With this purpose, concepts, conceptual models, measurement models and scales related to the topic are investigated. It is expected to terminate the confusion and fulfill the gap in the literature by this model.

2. Method

In order to determine a reliable structure to measure innovation capability, literature review has been done. As a result of this literature an article pool has been created. Methodology of gathering process is derived from the study of Edison, Bin Ali, and Torkar (2013). Firstly, well-known databases were chosen according to their reputations; these databases are ABI Inform Complete, Academic Research Complete, Business Source Complete, Emerald Journals, Expanded Academic ASAP, Knovel Library, Science Direct, and Wiley-Blackwell. In these databases, pre-determined words have been individually and inter-crossly searched. The search was conducted in the first half of 2013, and covered the articles between 1950 and 2013 that includes pre-determined key words for instance “innovat*”, “measure*”, “innovation capability”, “scale development”. This article pool was classified into three distinctive subgroups as concept research, innovation measurement models and innovation measurement scales. Each subgroup has addressed different aspects of the study. Based on this literature research, it can be seen from Figure 1 more precisely.

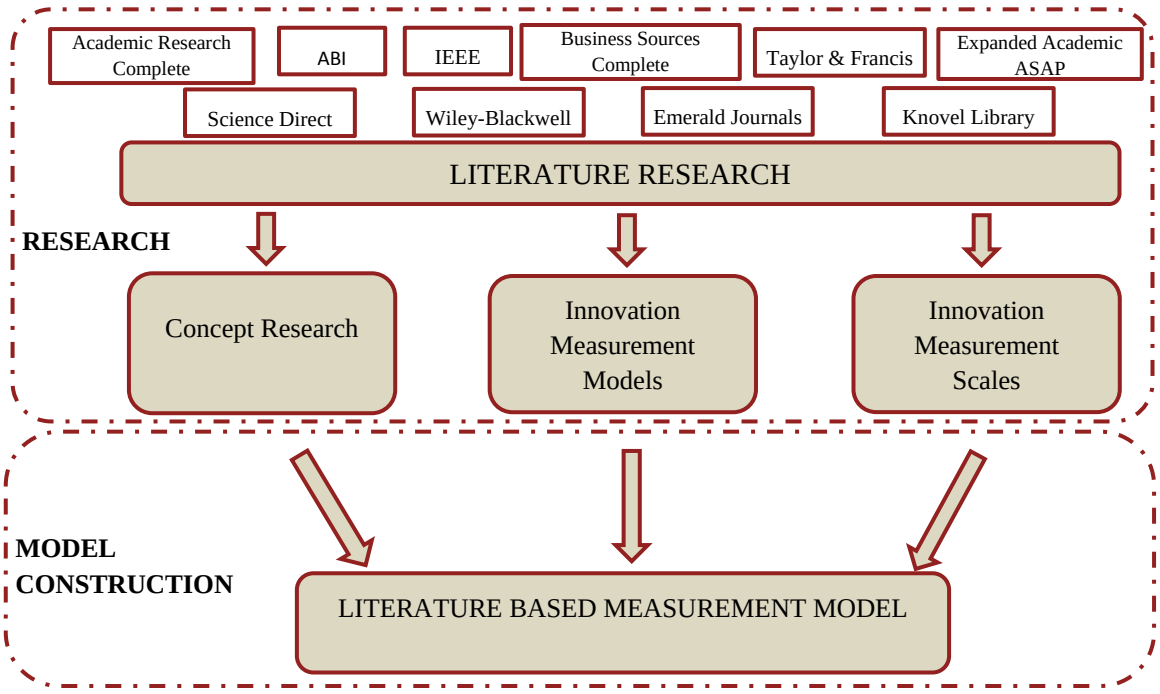


Figure 1: Methodology

2.1 Concept Research

First of all, the definitions of the concepts related to innovation capability are gathered from literature as noted above.

2.1.1 Definitions of Innovation Capability

Different authors from various disciplines have defined innovation capability. It is crucial to investigate how innovation capability delineated in the literature. For instance, Lawson and Danny, (2001) define innovation capability as "the ability to continuously transform knowledge and ideas into new products, processes and systems for the benefit of the firm and its stakeholders". Guan and Ma (2003) define it as "the capacity of developing new products satisfying market needs; the capacity of applying appropriate process technologies to produce these new products; the capacity of developing and adopting new product and processing technologies to satisfy the future needs; and the capacity of responding to accidental activities and unexpected opportunities created by competitors." Whereas Romijn and Albaladejo (2002) states innovation capability as "the skills and knowledge needed to effectively absorb, master, and improve existing technologies, and to create new ones". In 2009, Suping and Xu summarized innovation capability in one small sentence as "the ability to integrate scarce resources to implement innovating."

2.1.2 Concept Confusion

As noted before, not having any concurrence on defining innovation caused confusion in the literature. It is seen that authors have defined "innovativeness" as "innovation capability"; for instance "an organization's overall innovative capability of introducing new products to the market, or opening up new markets, through combining strategic orientation with innovative behavior and process" is the definition of Wang and Ahmed (2004) for organizational innovativeness. They used the terms related to their definition of innovativeness as innovation capability in their article published in 2007. Similarly, Panayides (2006) state the sameness of these terms in his article. Moreover, Keskin's (2006) topic includes innovation capability in SMEs, yet innovation capability does not appear as words in the whole text; the author has used innovativeness as the same meaning of innovation capability without addressing it. Similarly, Buganza and Verganti's (2006) topic includes "innovative capability", yet the whole text does not contain these words, and innovation has been used as them. On the other hand, Akgun, Keskin, and Byrne (2009) include "innovation" in their topic but in the text they have used "innovativeness". Additionally, Martinez-Roman, Gamero, and Tamayo (2011) propose that innovation capability-innovative capability-innovation capacity concepts are interchangeable. Controversially, Eggink (2012) state that the distinction between innovation capacity and innovation capability should be made. Last but not least, Calantone, Cavusgil, and Zhao (2002), Lin (2007) and Mehrabani and Shajari (2012) exemplify of the extension of confusion. Calantone et al. (2002) have used firm innovation capability and firm innovativeness interchangeability without stating that both concepts have the same meaning, and Lin (2007) cited Calantone et al.'s "firm innovativeness" as "firm innovation capability" in his work. Mehrabani and Shajari (2012) cite Lin's "firm innovation capability" as "firm innovation capacity". This example summarizes how confusion precedes step by step in the literature.

2.2.1 Measurement Confusion

There is a vast need of reliable and valid scale of measurement of innovation capability in the literature (Deshpande & Farley, 2004), (Crespell, Knowles, & Hansen, 2006). Concept confusion mentioned above has caused measurement confusion. Regarding to using concepts interchangeably, not being able to distinct the borders of potential, process and outcome-focused measurements have been the main reasons of the measurement confusion. It is seen that innovation capacity that addresses innovation potential has used interchangeable with innovation capability consisting of potential and process. For instance, Liao, Wu, Hu, and Tsui (2010) measured innovation capability by classifying into three groups as input, support and outcome. Moreover, it is observed that innovation capability has been used instead of innovation performance where the measurements focused on concepts that could be measure only long term such as number of patents, number of projects (Bao, 2010), (Wang, Fan, & C, 2010). Additionally, it is observed that there is another distinction between quantitative measurements and qualitative measurements in some studies (García-Moralesa, Lloréns-Montesa, & Verdú-Joverb, 2007), (Chen & Huang, 2009). Furthermore, in the literature outcome-focused and qualitative measurements refer to innovation capability.

2.3 Model Research

In this phase, the main purpose is to capture the models that explain how innovation capability should be measured, yet all the articles proposed measurement models related to innovation is also gathered to examine. It is encountered that predominantly measurements of innovation capability and innovation performance have been studied, and have

followed approaches as potential, process and outcome (Guan, Yam, Tang, & Lau, 2009), (Roma´n, Gamero, & Tamayo, 2011), (Saunila & Ukko, 2012), (Edison, Bin Ali, & Torkar, 2013).

Edison et. al. (2013) suggested that innovation measurement should consist of measurement of innovation capability, innovation output, and innovation performance. In their study, innovation capability is composed of innovation inputs, determinants, and activities, also as measurement of innovation output, measurements of innovation types is addressed. Additionally, they suggested that measuring of innovation impact as innovation performance as seen in Figure 2.

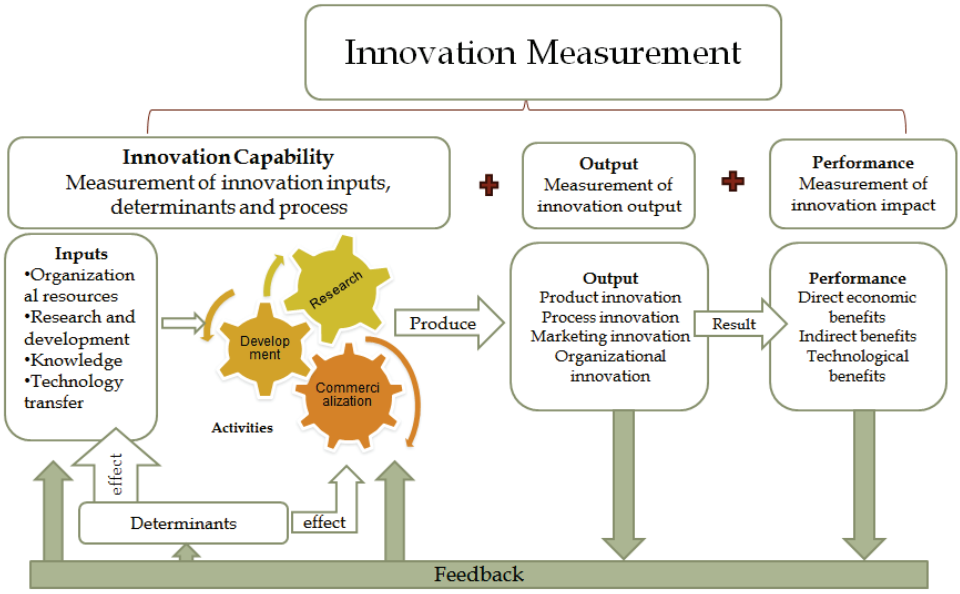


Figure 2: Innovation measurement model (Edison et. al., 2013)

Similar to Edison et. al. (2013), Roma´n, et. al. (2011) distinguishes concepts as innovation capability and output whereas Kruglianskas and Gomes (2007) measure innovation capability as measurement of innovation impacts.

Furthermore, Saunila and Ukko (2012), and consider all the elements influence an organizations capability to manage innovation, and include also results of innovation activities in innovation capability as seen in Figure 3.

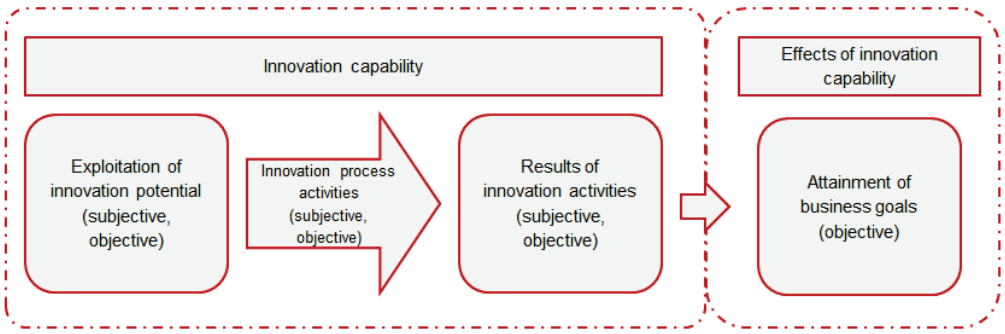


Figure 3: Innovation capability model (Saunila & Ukko, 2012)

Correspondingly, Vermeulen, O'Shaughnessy, and Jong (2003) measure innovation to analyze financial performance of the organization via considering innovation input, innovation throughput and innovation output. There are various approaches that models embraces, for instance Neely, Filippini, Forza, and Hii (2001) investigates innovation capability under capacity to innovate in their model.

Moreover, Carayannis and Provance (2008) define innovation and draw borders of performance and capabilities with a different approach. They distinguished innovation into three phases: propensity, posture and performance. Posture clarifies where the organization stands in the big picture of the system and consists culture, competition, and knowledge. Propensity explains the ability of the organization to capitalize the posture and contains processes, routines and capabilities. Finally, performance includes output, outcome and impacts of the system. Innovation capability takes place under propensity in this model.

2.4 Measurement Scales Research

As mentioned in model research, while examining models, measurement of innovation and close meaning concepts were investigated. Gathered measurement scales were scrutinized carefully by taking pre-mentioned models into consideration. A substructure was prepared based on research on measurement scales from related databases. The questions in the scales and aspects of the models were compared. The reason behind this is to gain a measurement scale and to provide harmony between models and measurements in the literature. It is procured that the purpose of asking the questions and promises of the models to be unanimous.

For instance, some authors have used qualitative questions to measure innovation performance, but if address of the questions points out innovation capability, the questions would be able to transform if necesseray to innovation capability questions (Chen & Huang, 2009), (Inauen & Schenker-Wicki, 2011).

3. Model Development

In the literature, innovation capability is mentioned in a good number of studies, however proposed innovation capability measurement scales and measurement models are limited. In this study, measurement models, measurement scales and related concepts were investigated. After investigating the models cited above (Saunila & Ukko, 2012), (Edison et al. 2013) and (Vermeulen et al., 2003), based on their structure, borders between innovation capability and innovation performance were drawn. In this study, it is proposed that innovation capability should be measured by potential and process focused (Edison et al., 2013), (Vermeulen et al., 2003).

Assumptions of the Model:

- Potential and process focused measurements should be conducted.

Not outcome focused approach: The reason behind is that the tendency move to innovation performance while focusing on outcome. Basis of measurement confusion is formed by not distinguishing innovation capability and innovation performance in the literature. Capabilities of the system are qualifications that enable innovation (Eggink, 2012). Additionally, measuring outputs of the system is appropriate for just few types of innovations (Saunila & Ukko, 2012). For small or service organizations, measuring outputs of the system is not recommended (Albaladejo & Romijn, 2000)

Not only potential (input) focused approach: Not every type of organizations has equal opportunities to invest in R&D, also it does not mean that innovation capability and R&D investments directly proportional (Albaladejo & Romijn, 2000).

- The model shall include more than one dimension

Inconsistency also occurs in defining and distinguishing dimensions of innovation (Hogan et al. 2012) that reflects dimensions of innovation capability. There are one-dimensional and multidimensional typologies of innovation in the literature. For instance, Wang and Ahmed (2004) proposed five dimensions of innovativeness as product innovativeness, market innovativeness, process innovativeness, behavioral innovativeness, and strategic innovativeness. In a similar vein, four different types of innovations are included in OSLO Manual (OECD/Eurostat, 2005): product innovation, process innovation, organizational innovation and marketing innovation. Innovation capability by its nature supports multidimensional construct (Hogan et al. 2012) since measurement of it cannot be conceivable directly (Saunila & Ukko, 2012). In this study, OSLO Manual's dimensions are adopted to measure innovation capability related to process phase of the system.

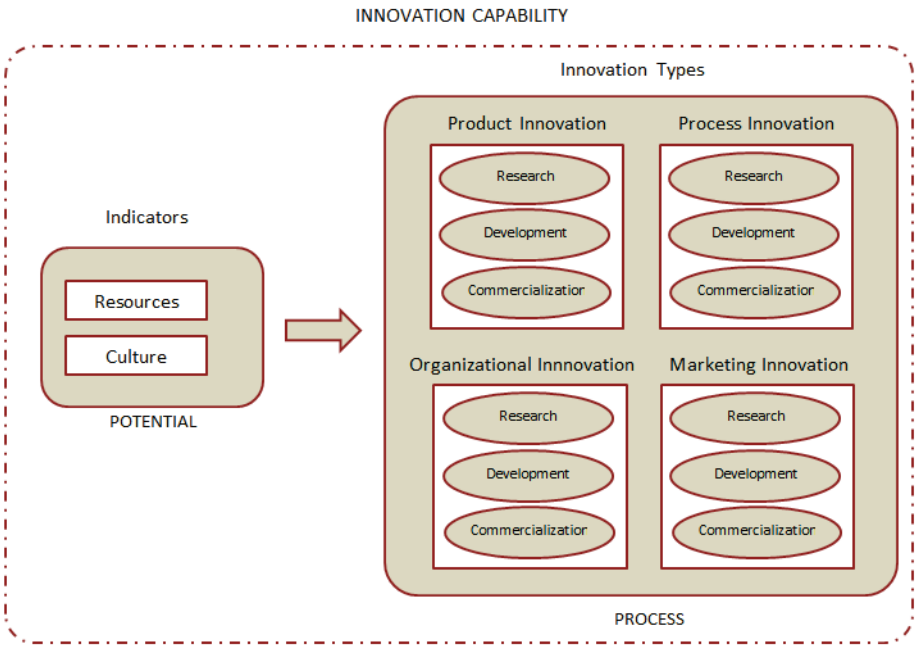


Figure 3: The proposed literature based measurement model

Hence, while measuring innovation capability, potential and process are considered. Potential includes innovation sources and culture. Process includes four innovation types proposed by OECD. Proposed literature based model, addition to inspiration from Edison et al. (2013), Vermeulen et al. (2003), and Carayannis and Provance (2008) models, includes innovation types and indicators. This model that can be seen in Figure 4 enables organizations to measure their innovation capabilities individually according to innovation types.

4. Conclusion

By the nature of innovation, it is a multidisciplinary and broad subject. These disciplines, based on their objectives, concentrate on different aspects of innovation, thus innovation does not have a universal definition. Related concepts have used interchangeably due to not having a consensus on defining innovation, and this usage have caused concept and measurement confusion in the literature. Primary focus of this study was to address the confusion and propose a literature-based measurement model for innovation capability. In order to do that articles from respected databases collected and classified in three groups. Concepts were investigated to point out confusions; models were examined to clarify how innovation capability is measured in the literature, and measurement scales were analyzed to notice what kind of questions have chosen to measure innovation capability and to discover what is missing between models and scales. By absorbing all the gathered data from the literature, a literature based measurement model for innovation is proposed. It is expected that this model will shed light on the concept and measurement confusion also be a reliable and valid model for innovation capability.

For further research, it is important to test the validity and applicability of this model. It is recommended to test and compare the results with the existing models. Additionally, a measurement scale consisting of qualitative questions based on literature might be generated.

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A Study to Evaluate the Familiarity and Usage of Theories of Motivation

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Abstract

This study explored the use of various motivational theories and principles used by Engineering Managers across organizations and evaluated the well-known and most used motivational theories by industry, number of employees supervised and the position by which they are used. The study was conducted based on the industry, nature of work, position of the manager and the number of employees supervised. The study identified the theories of motivation most commonly known by Engineering Managers and those that were being used by them. Individual responses of the study were analyzed to determine if there was any dependency between the familiarity and use of a particular theory of motivation. The study was developed based on a similar survey conducted by Dawn R. Utley and Jerry D. Westbrook (1988) to study the current practice. Judgment sampling technique was used to analyze the results. The results of the study showed that Maslow's hierarchy of needs was the most well-known theory and also most used motivation theory by Engineering Managers.

Keywords

Theory of Motivation, Maslow's hierarchy of needs, management by objectives, Herzberg's two-factor theory of motivation.

1. Introduction

Motivation is an inner state that energizes people. Motivation is defined as the desire to achieve a goal at a certain performance level, leading to goal-directed behavior. According to Hughes (2003), from an organizational perspective, maintaining a highly motivated team is the key to a company's success. A lack of employee enthusiasm can significantly affect a firm's productivity. Pouchová (2011) states that in the time of worldwide economic crisis it

is necessary for companies to realize the importance of human capital and particularly the significance of work motivation and satisfaction of employees in relation to the performance and competitiveness of a company.

There is no one-size-fits-all approach to motivation. A combination of techniques that matches the unique needs and personalities of employees can bring the most effective results.

There are many theories of motivation of which Maslow's hierarchy of needs and Herzberg's two factor theory are most commonly used. Maslow's Hierarchy of needs (Maslow, 1943) states that people have 5 different hierarchical needs which they try to satisfy starting from the base need. Those needs are satisfied in the order of physiological, safety, membership, esteem and self-actualization.

Herzberg's two factor theory states that there are certain factors which, when improved, only bring the employee to a neutral position, but, when there is a deficiency among them, can be a great source of dissatisfaction. These are called hygiene factors and they include such things as organizational policy, working conditions, relationship with supervisor, and even salary. There are, however, factors which, when provided, can be a great source of job satisfaction and help motivate the employee. These factors include achievement, recognition, responsibility, and chance for advancement. (Herzberg, 1968)

Neff, T. M. (2002) described an instance when legendary business icon and General Electric CEO Jack Welch was once asked which was more rewarding to people: money or recognition. Welch responded that it was just not enough if companies paid their employees well and expected great work in return. He said companies must also empower their employees and provide incentives for them to perform at high levels. Motivating employees and understanding the psychology behind employee motivation are essential to any successful organization.

Motivated employees are needed in rapidly changing workplaces. Motivated employees are more amenable to change. Motivated employees are also more productive. To be effective, managers need to understand what motivates employees within the context of the roles they perform. Of all the functions a manager performs, motivating employees is arguably the most complex. The importance of motivation in the workplace is straightforward theoretically, but difficult to measure empirically. Ascertaining the level in which high motivation results in higher productivity is difficult to pinpoint, as an individual's drive is difficult to measure through metrics. The management of motivation is therefore a critical element of success in any business, allowing the input of human resources to be maximized in regard to fulfilling the potential output expected.

Reiger and Stang (2000) concluded that employee satisfaction and productivity are goals that administrators should stress in order to accomplish the objectives of an organization, whether those decisions are made through a traditional or non-traditional approach. Knowing and using the apt motivational tool, specific to the company and the employees is very crucial for the success of the company. This study in a whole investigated to find the commonly known motivational theories and principles used in the present day's workplace.

2. Methodology

For the purpose of this study, a manager is defined as any professional who directly or indirectly manages employees. The questions of this survey were developed by using a similar survey conducted by Dawn R. Utley and Jerry D. Westbrook in 1988.

Each participant was informed about the purpose of the study, explaining the survey instrument, and assuring the anonymity of the participant. Each participant was also given an opportunity to exit the survey anytime during his/her participation. The survey responses were collected and stored using the online survey monkey tool. The survey data was analyzed and the results were tabulated.

The sampling procedure used was judgment sampling. Judgmental sampling design is usually used when a limited number of individuals possess the trait of interest. It is the only viable sampling technique in obtaining information from a very specific group of people.
The data was obtained by posting the survey in certain group pages of LinkedIn.com. The group pages of LinkedIn that were used to post the link to the survey were as follows:

- ASEM (American Society for Engineering Management)
- ASME (American Society of Mechanical Engineers)
- Medtronic
- The Project Manager Network

3. Data Analysis

The sample size of this survey was 53. Out of the 49 respondents, 18 (36.7%) identified themselves as working in Manufacturing and Production industry, 9 (18.3%) identified themselves as working in Healthcare-medical industry, 11 (22.4%) identified themselves as working in Engineering firm. The remaining 11 (22.4%) identified themselves as working in various other industries.

The majority of the sample, 28 (57.1%), supervised 0 to 5 employees, 10 (20.4%) supervised 16 or more employees, 8 (16.3%) supervised 6 to 10 employees and the remaining of the sample, 3 (6.1%), supervised 11 to 15 employees.

The majority of the sample, 25 (51.0%), held position as Senior/Principal Engineer, 12 (24.5%) held position as Engineer, 9 (18.4%) held position as manager, 1 (2%) each of Vice President of Engineering, consultant and Chief Executive Officer. For the analysis purpose, two of the respondents who identified their position as managing firm principal and Senior Project engineer were added to Senior/Principal engineer position response count because of their similarity.

Familiarity: In terms of familiarity, Maslow's hierarchy of needs topped the list with 28 (65.1%). Management by objectives (MBO) was the next most familiar motivational principle among the respondents with 24 (55.8%) respondents familiar with this theory. Herzberg's two factor theory made the list in third place in terms of familiarity. Quality Circles and Reinforcement theory were tied in fourth place. McGregor's Theory X and Theory Y and McClelland's Theory were tied in fifth place with 20 (46.5%) respondent's familiarity. The findings are tabulated in Table 1.

Usage: In terms of usage and application of theories, Maslow's hierarchy of needs topped the list with 16 (37.2 %) respondents. Management by objectives was the second most used theory by the respondents. Herzberg's two factor theory made the list in third place in terms of usage. McGregor's Theory X and Theory was 4th in the list. McClelland's theory and Reinforcement theory were tied in the fifth place while managerial grid was next. The findings are shown in Table 1.

Vroom’s valence theory was the most unfamiliar theory among the respondents. Vroom’s valance theory and Drucker’s survival principle were tied for the least used theory by the respondents. The findings are tabulated in Table 1.

Table 1: Theories and principles familiarity and use

Theory/Principle	Familiar	Use
Maslow’s hierarchy of needs	28	16
Herzberg’s two factor theory	22	14
McGregor’s theory X and theory Y	20	12
Managerial grid	13	9
Likert’s system IV	14	7
In search of excellence	16	8
McClelland’s theory	20	10
Vroom’s valence theory	5	1
Management by objective(MBO)	24	15
Quality circles	21	8
Ouchi’s theory Z	12	2
Drucker’s survival principles	18	1
J. Stacey Adam’s equity theory	16	3
Reinforcement theory	21	10

Of the 25 Senior/Principal Engineers who responded to this survey, 8 (32%) worked in Manufacturing and Production industry, 5 (20%) worked in healthcare-medical industry, 5 (20%) worked in Engineering firms, 4 (16%) worked in Consulting firm and 2 (8%) worked in Aerospace, Aviation and Defense industries.

Seventeen (68%) of the 25 Senior/Principal Engineers who responded to this survey managed/supervised 0 to 5 employees, 4 (16%) managed/supervised 6 to 10 employees and 4 (16%) managed 16 or more employees.

Five (41.7%) of the 12 engineers who responded to this survey worked in Manufacturing and Production industry, 4 (33.3%) worked in Engineering firm and 1 (8.3%) each worked in Aerospace, Aviation and Defense industry, Consultancy firm and Healthcare-medical industry.

Eight (66.7%) of the 12 engineers managed/supervised 0 to 5 employees, 3 (25%) managed/supervised 16 or more employees and 1 (8.3%) managed/supervised 6 to 10 employees.

Four (44.4%) of the 9 managers who responded to this survey worked in Manufacturing and Production industry, 3 (33.3%) worked in Healthcare-Medical industry and 1 (11.1%) each worked in Aerospace, Aviation and Defense industry and Engineering firm. 3 (33.3%) each of the managers managed/supervised 6 to 10 and 11 to 15 employees, 2 (22.2%) managed 0 to 5 employees and 1 (11.1%) managed 16 or more employees.

3.1 Familiarity and Usage by the Number of Employees Supervised

Twenty one (75%) of the respondents who supervised 0 to 5 employees were familiar with Maslow's hierarchy of needs. 18 (64%) were familiar with Management by objective, 15 (53.5%) were familiar with Quality Circles, 14 (50%) were familiar with Reinforcement theory.

The most used theory among this group of respondents was management by objectives with 7 (25%). Maslow's hierarchy of needs, Herzberg's two factor theory and reinforcement theory came in second place, 6 (21.4%), in terms of use among this group. The findings are tabulated in Table 2.

J. Stacy Adam's Equity Theory was most familiar among the respondents who supervised 6 to 10 employees. 4 (50%) of the respondents in this group responded that they are familiar with J. Stacy Adam's Equity Theory.

In terms of use, Management by Objective with 4 (50%) was the most used theory among this group of respondents. The findings are tabulated in Table 2.

For the group of respondents who supervised 11 to 15 employees, In search of Excellence, was the most familiar motivational theory/principle with 3 (100%) responses. Maslow's hierarchy of needs was the most used theory with 3(100%) respondents in this group responding as they use this theory. The findings are tabulated in Table 2.

For the group of respondents who supervised 16 plus employees, Herzberg's Two Factor Theory, McClelland's Theory and Ouchi's Theory Z were the most familiar with 7 (43.7%) responses.

Maslow's hierarchy of needs was the most used theory with 5(31.2%) respondents in this group responding as they use this theory. 4 (25%) of the respondents answered that they use Herzberg's Two Factor Theory, McGregor's Theory X and Theory Y, Managerial Grid, In Search of Excellence and Quality Circles.

The findings are shown in Table 2.

Table 2: Responses by the number of employees supervised

Theory/Principle	Number of employees supervised							
	0 to 5(n=28)		16 plus(n=10)		6 to 10(n=8)		11 to 15(n=3)	
	Familiar	Use	Familiar	Use	Familiar	Use	Familiar	Use
Maslow's hierarchy of needs	21	6	5	5	2	2	0	3
Herzberg's two factor theory	13	6	7	4	1	2	1	2
McGregor's theory X and theory Y	13	5	4	4	1	2	2	1
Managerial Grid	8	3	2	4	1	1	2	1
Likert's system IV	8	1	5	2	0	3	1	1
In search of excellence	9	3	2	4	2	1	3	0
McClelland's theory	11	5	7	1	2	2	0	2
Vroom's valence theory	2	0	2	1	0	0	1	0
Management by objectives(MBO)	18	7	4	2	2	4	0	2
Quality circles	15	3	4	4	2	0	0	1
Ouch's theory Z	3	0	7	2	1	0	1	0
Drucker's survival principle	8	0	5	1	2	0	2	0
J Stacey Adam's equity theory	8	1	3	2	4	0	1	0
Reinforcement theory	14	6	4	2	2	1	1	1

3.2 Familiarity and Usage by Industry

Out of 18 respondents working in manufacturing and production industry, 12(66.7%) were familiar with Quality Circles, 11 (61.1%) were familiar with Management by objectives, 10 (55.5%) were familiar with both Maslow's hierarchy of needs and Herzberg's Two Factor Theory, and 9 (50%) were familiar with McGregor's Theory X and Theory Y and Reinforcement Theory. 8 (44.4%) used Management by objectives, 5 (27.7%) used Quality Circles, 4 (22.2%) used Maslow's hierarchy of needs and McClelland's Theory as motivational tools at work. The findings are tabulated in Table 3.

Out of 11 respondents working in engineering firm, 6 (54.5%) were familiar with Maslow's hierarchy of needs, 5 (45.4%) were familiar with McGregor's Theory X and Theory Y, Management by objectives, Ouchi's Theory Z, Drucker's Principles and Reinforcement Theory. 4 (36.3%) were familiar with Herzberg's Two Factor Theory, Likert's System IV, In Search of Excellence, McClelland's Theory and J. Stacy Adam's Survival Theory. 5(45.4%) used Managerial Grid, 4 (36.3%) used Maslow's hierarchy of needs and Reinforcement Theory, 3 (27.2%) used Herzberg's Two factor theory, McGregor's Theory X and Theory Y, and Quality Circles as motivational tools at work. The findings are tabulated in Table 3.

Out of 9 respondents working in healthcare-medical industry, 4 (44.4%) were familiar with Maslow's Hierarchy of needs and In Search of Excellence. 3 (33.3%) were familiar with Drucker's Survival Principles, J. Stacy Adam's Equity Theory and Reinforcement Theory. 3 (33.3%) used Management by objectives, 2 (22.2 %) used Maslow's Hierarchy of needs, Herzberg's two factor theory and Likert's System IV as motivational tool at work. The findings are tabulated in Table 3.

Out of 6 respondents working in consulting firm industry, 4 (66.7%) were familiar with Herzberg's Two factor theory and McClelland's Theory. 3 (50%) were familiar with Maslow's Hierarchy of needs, Managerial Grid, Management by objectives and Quality Circles. 2 (33.3%) were familiar with McGregor's Theory X and Y, Likert's System IV, Ouchi's Theory Z and Drucker's Survival Principles. 4 (66.7%) used Maslow's hierarchy of needs and Herzberg's Two Factor Theory, 3 (50%) used In Search of Excellence and 2 (33.3%) used McGregor's Theory X and Theory Y and McClelland's Theory as motivational tool at work. The findings are tabulated in Table 3.

Table 3: Responses by industry

Theory/Principle	Industry							
	Manufacturing and Production(n=18)		Engineering Firm (n=11)		Healthcare-Medical(n=9)		Consulting(n=6)	
	Familiar	Use	Familiar	Use	Familiar	Use	Familiar	Use
Maslow's Hierarchy of needs	10	4	6	4	4	2	3	4
Herzberg's two factor theory	10	2	4	3	2	2	4	4
McGregor's theory X and theory Y	9	3	5	3	1	1	2	2
Managerial Grid	6	2	3	5	0	1	3	1
Likert's system IV	5	1	4	1	1	2	2	0
In search of excellence	6	3	4	2	4	0	1	3
McClelland's theory	6	4	4	2	2	1	4	2
Vroom's valence theory	2	0	3	1	0	0	0	0
Management by objectives(MBO)	11	8	5	1	2	3	3	1
Quality circles	12	5	3	3	2	0	3	0
Ouchi's theory Z	3	0	5	1	0	0	2	1
Drucker's survival principle	6	0	5	1	3	0	2	0
J Stacey Adam's equity theory	6	0	4	1	3	0	0	1
Reinforcement theory	9	3	5	2	3	1	1	0

3.3 Familiarity and Usage by Position

The most familiar theory/principle among the engineers (n=12) were Maslow's Hierarchy or Needs, Herzberg's Two factor theory and Reinforcement Theory with 7 (58.3%) responses. 6 (50%) of the engineers were familiar with McGregor's Theory X and Theory Y, Likert's System IV, Management by objectives and Quality Circles. 5 (41.6%) of them were familiar with J. Stacy Adam's Equity Theory. 5 (41.6%) of the engineers used Reinforcement Theory, while 4 (33.3%) used McGregor's Theory X and Theory Y and Managerial Grid. 3 (25%) used Maslow's Hierarchy of needs and Quality Circles. The findings are tabulated in Table 4.

The most familiar theory/principle in descending order among 4senior/principal engineers (n=25) was Maslow's Hierarchy of needs with 17 (68%) responses, Management by objectives with 14 (56%) responses, Quality Circles with 12 (48%) responses, McClelland's Theory with 11 (44%) and Herzberg's Two factor theory with 9 (36%) responses. Herzberg's two factor theory was used the most by this group with 8 (32%) responses. 5 (20%) of the respondents in this group used Maslow's Hierarchy of needs and Management by objectives. 4 (16%) of the respondents used McGregor's Theory X and Theory Y, and McClelland's Theory as the motivational tool at work. The findings are tabulated in Table 4.

The most familiar theory/Principle among the managers (n=8) was In Search of Excellence with 5 (62.5%) responses. 4 (50%) of the managers were familiar with McGregor's Theory X and Theory Y, Drucker's survival principles and Reinforcement theory. Herzberg's two factor theory, Managerial Grid, Likert's System IV and J. Stacy Adam's Equity Theory were familiar to 3 (37.5%) of the managers. Maslow's Hierarchy of needs and Management by objectives were used by 5 (62.5%) managers. Herzberg's Two Factor Theory, McGregor's Theory X and Theory Y, Likert's System IV and McClelland's Theory were used by 3 (37.5%) managers as motivational tool at work. The findings are tabulated in Table 4.

Table 4: Responses by position

Theory/Principle	Position					
	Engineer(n=12)		Senior Engineer(n=25)		Manager(n=8)	
	Familiar	Use	Familiar	Use	Familiar	Use
Maslow's Hierarchy of needs	7	3	17	5	2	5
Herzberg's two factor theory	7	1	9	8	3	3
McGregor's theory X and theory Y	6	4	7	4	4	3
Managerial Grid	2	4	5	2	3	2
Likert's system IV	6	0	3	3	3	3
In search of excellence	4	2	5	2	5	1
McClelland's theory	4	1	11	4	2	3
Vroom's valence theory	1	0	1	0	2	0
Management by objectives(MBO)	6	2	14	5	2	5
Quality circles	6	3	12	2	1	1
Ouchi's theory Z	3	0	6	1	1	0
Drucker's survival principle	3	0	8	0	4	0
J Stacey Adam's equity theory	5	2	6	0	3	0
Reinforcement theory	7	5	7	1	4	2

4. Results

The main objective of this survey was to evaluate the most commonly used motivational theories and principles used by managers.

- Maslow's Hierarchy of needs was the most familiar and used motivational theory among managers.
- 45% of respondents who worked in Manufacturing and Production industry used Management by objectives. Around 45% of respondents who worked in an Engineering firm used managerial grid and around 33% of respondents who worked in healthcare-medical industry used Management by objectives.
- 43% of the engineers used reinforcement theory, thirty two percent of the senior/principal engineers used Herzberg's two-factor theory and little over sixty two percent of the managers used both Maslow's Hierarchy of needs and management by objectives.
- 25% of the respondents who supervised 0 to 5 employees used Management by objectives. 50% of the respondents who supervised 6 to 10 employees used Management by objectives and about thirty one percent of the respondents who supervised 16 or more employees used Maslow's hierarchy of needs.
- Likert's System IV had the most familiarity and use dependency among the respondents who supervised 6 to 10 employees. All the other motivational theories and principles for all the categories were dependent ranging from slightly dependent to extremely dependent.
- Utley and Westbrook's survey found that Management by objectives, Quality Circles and In Search of Excellence were the most familiar (in descending order) theories and principles. Management by Objective, Maslow's Hierarchy of needs and Quality Circles were the top three (in descending order) theories and principles used.
- Maslow's Hierarchy of needs, Management by objectives and Herzberg's two factor theory are the top three (in descending order) familiar and used (in the same order) theories and principles among engineering professionals.

5. Conclusion

From this survey and the subsequent data analysis, it is concluded that Maslow's hierarchy of needs was the most familiar and used theory among managers. Management by objectives and Herzberg's two factor theory also rated high in familiarity and were used by about 50% of managers. Data analysis for individual responses yielded dependency between familiarity and use ranging from very weak to very strong. Likert's System IV's familiarity and usage had a full dependency for respondents managing 6 to 10 employees.

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Biography

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Effects of CIOs' Positive Characteristics and Competencies on their Perceived Management Effectiveness in a Transformed IS Organization

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Abstract

The CIO role has become a very important position in all kinds of businesses from the task of leading the way to drive the business goal achievement and support all parts of the organization with ICT. Information systems are changing rapidly. The core remaining processes of IS organization are resulting in a significantly transformed organization, which according to (McNurlin et al., 2009) is characterized by Driving Innovation, Managing Supplier and User Relationship, and Supporting the Infrastructure. This study aims to investigate the effect of the CIOs' crucial positive leadership characteristics and competencies on the perceived management effectiveness in a transformed IS organization. The response from 63 CIOs/IT Managers of organizations in Thailand revealed that information technology competency and management competency played a significant role on perceived management effectiveness in a transformed IS organization. While the data shows that positive leadership has no significant perceived effect in terms of a direct factor, its correlation with information technology competency and management competency can be confirmed. Positive leadership should therefore be considered as an important indirect factor in the future. The findings are seen as helpful for the executive team regarding factors they should consider in CIO hiring decisions and for the CIO and CIO-to-be in preparing to be effective in this role.

Keywords
CIO, positive leadership characteristic, competency, perceived management effectiveness

1. Introduction
Information Technology (IT) is embedded widely through all kinds of business (McNurlin et al., 2009; Chun & Mooney, 2009). Evidently, IT is one of the significant factors that have impacted on the organization performance (Sobol & Klein, 2009; Bhardwaj, 2000; Tanriverdi, 2006). Thus, Chief Information Officer (CIO) who is the highest-ranking executive with primary responsibility for information management (Synnott, 1987) has become a very important person in the organization. To confirm a significance of CIO, previous studies stated that a CIO is a key person in driving the transformation and innovation in the business and has been mentioned as an essential factor of organization performance (Li & Tan, 2013; Peppard, 2010; Sobol & Klein, 2009).

The current trend of information technology transformation results in Information System (IS) organization being reformed into a transformed organization with the three main processes: Driving Innovation, Managing Supplier and User Relationship and Supporting the Infrastructure (McNurlin et al., 2009). Since the trend towards a transformed organization is global, CIOs have to change their management role to be effective in the new paradigm of IS organization.

From a power distance score of cultural dimensions in Hofstede's theory (Hofstede, 2001), Thailand was described as a country in which inequalities are accepted; a strict chain of command and protocol are observed. Each rank has its privileges and subordinates show loyalty, respect and deference for their superiors in return for protection and guidance. This may lead to paternalistic management approach. Consequently, an attitude towards managers is more formal, an information flow is hierarchical and controlled (Hofstede, 2014). Therefore, CIOs in Thailand are very important in the perception of the employees and organizations in this country.

However, the interesting question is why some CIOs are effective in their roles but others are not, although they worked in the same circumstance likes a similar organization size, government IT policy, type of organization. When eliminate those environment factors, the remaining differentiating factors of an effective CIO are positive personality characteristics and competencies.

Prior research found that some CIOs or Chief Executive Officers (CEOs)' competencies that can be gained by learning, studying or practicing (e.g. information technology competency and management competency) related to the CIOs' performance (Chen & Wu, 2011; Synnott, 1987; Smaltz et al., 2006).

On the other hand, some personal factors (e.g., positive personality traits and work engagement) that are embedded inside the personality also have been shown to have positive relationships with the CIOs' performance (Li & Tan, 2013; Cho et al., 2011).

Thus, this research aims to examine two research questions:

(1) What are the positive characteristics and competencies that relate with effective CIOs?
(2) Which of a CIOs' positive characteristics and competencies have significant effect on perceived management effectiveness in a transformed IS organization?

2. Literature Review

2.1 The Role of the CIO

The best known definition of Chief Information Officer (CIO) was introduced by Synnott (1987) as the highest-ranking executive with primary responsibility for information management. Later, Boyle & Burbridge (Boyle & Burbridge, 1991) stated the CIO as an executive with broad responsibility for information technology (e.g., data processing, telecommunications and office automation) who reports to a high-level corporate officer (e.g., president or CEO).

2.2 IT Management Competency

The Oxford Dictionary (2014) gives a meaning of "competency" as the ability to do something successfully or efficiently. As a C-Level of the organization, the CIO is related with all critical processes of the firm. Thereby, to succeed as a CIO, IT management competency, that is the ability to manage the effective IT should be concerned. Chen & Wu (2011) gathered the taxonomy of IT management competency from prior research (Bassellier & Benbasat, 2004; Bassllier et al., 2003; Gorgone et al., 2002; Reich & Bendasat, 2000; Willcocks et al., 2006) and summarized it into 2 major categories:

- IT competency is the skills or knowledge that let a CIO establish an effective IT-Infrastructure and implement IT with the crucial business processes effectively (Weill et.al., 2002 ; Chen & Wu. 2011). This competency composted of 3 domains as follows:
  - IT infrastructure skills/knowledge including the ability of the CIO to configure, implement, apply, and evaluate an existing and expanding information and communication technologies for creating an integrated and reliable IT infrastructure.
  - Business applications skills/knowledge was defined as the ability of a CIO to apply an integrated set of available and reliable IT infrastructure components, services, or functions to accomplish the goals of the organization.

- Business – Technology integration skills/knowledge refers to the ability of CIO to conceptualize the solutions from the plenty of technologies to empower the firm performance, and help to provide concurrences between IT and business performance.

- Management competency refers to the CIOs' skills or knowledge of fundamental business that useful for carrying the mission of IS organization to meet the goal of business. Chen & Wu (2011) deduced three domains of this category as:
  - Business domain knowledge refers to a CIO's understanding of the overall organizational features that correlated with IT and of the association between IT and the organization in order to deploy the proper IT for the highest organizational benefit.
  - Interpersonal skills represent the ability of a CIO to motivate other people, articulate visions and preferences and communicate them to others, handle negotiations, and manage conflicts. Moreover, as the top leader of IS organization and agent of change, team building and jargon-free communication also were added to this domain.
  - Business management practice skills/knowledge is related with the ability to execute business management practices. This domain refers to the CIO's action as a leader in manipulates the renovation and risk management of the firm.

In addition, the research result (Chen & Wu, 2011) revealed that both a CIOs' IT competency and management competency positively associated with management activity effectiveness.

2.3 Positive Leadership Characteristics

Characteristic was defined as a feature or quality belonging typically to a person, place, or thing and serving to identify them (Oxford Dictionary, 2012). "Leadership characteristics" is related with the positive characteristics belonging to the leaders that can identify their personal or thinking. Previous studies (Li & Tan, 2013; Cavazotte et al., 2012; Zaccaro et al., 2004) evidently examined that personal characteristics like personality traits effected on the leaders effectiveness. Furthermore, work engagement that is the state of mind also has been focused on its positive influence on individual and firm performance.

- Positive personality traits

The well-known taxonomy of personality traits was referred to 5 personality characteristics as extraversion, agreeableness, conscientiousness, openness to experiences and neuroticism (Costa & McCrae,1992; Goldberg, 1990). However, from the studies on the effect of leaders' personality traits on leadership performance (Salgado, 1998; Zaccaro et al., 2004; Envick & Langford, 2000; Bartone et al., 2002; Cavazotte et al., 2012), it is clear that only four traits have positively effected on the leader performance and agreeableness is the weakest one that no significant impact has been found in some previous research. Therefore, this study focuses on three positive personality traits as follows (Costa & McCrae, 1992; Li & Tan, 2013):

- Openness is the characteristics of being imaginative, curious, creative, unconventional, broad-minded, and adventurous.
- Extraversion includes sociability, positive emotionality, ambition and excitement-seeking.
- Conscientiousness is the characteristic of a person who has a responsibility, persistence, reliability, organizing ability especially in working.

- Work Engagement

Work engagement was defined as a work-related state of mind which is positive, consisting of three characteristics; vigor, dedication and absorption (Schaufeli et al., 2002). Vigor represents high levels of energy and mental resilience while working, the willingness to invest effort in one's work, and persistence in the face of difficulties. Dedication is described as a sense of significance, enthusiasm, inspiration, pride, and challenge. Absorption is the characteristic of being fully concentrated and deeply engrossed in one's work, and is characterized by time passing quickly and difficulties in detaching oneself from work.

It has been proven that work engagement is positively associated, for instance, with mental and psychosomatic health, intrinsic motivation, efficacy beliefs, positive attitudes towards work and the organization, and high performance and has been analyzed in different languages and different occupations (Schaufeli & Salanova 2007).

According both of positive personality traits and work engagement are the outstanding positive characteristics of the leader that directly impact on the CIOs' Effectiveness. Hence, in this empirical study, we referred to them as positive leadership characteristics.

2.4 Transformed IS Organization

IT is a very crucial technology in an organization. (McNurlin et al., 2009) The appropriate IT can lead the way of a firm's direction, growth, structure and sustainability. Information System (IS) organization that supervises IT has become one of the most important parts of the business in the same time. The traditional view of "waves of innovation" described the 6 proposes of IT use in an organization. The waves are: reducing the cost, leveraging investment, enhancing products and services, enhancing executive decision making, reaching the consumer and leveraging partnerships through supply-chain management or other forms of collaboration (Primozic et al.,1991; McNurlin et al.,2009).

However, the present rapidly changing trend of IT causes some responsibilities of IS organization are shifting into the other components of the organization or expanding the responsibility of IS. For examples: Distributed systems move the application to the area of user or customer. Ever more knowledgeable users make IS has to provide the more efficiency software and pay more effort to support the requirement of users. Better application packages need lesser number of in-house programmers and analysts and change the task of IS organization from system development to system integration. Outsourcing has been popular and consequently some missions are transfer to outsourcing companies.

Although some tasks of IS organization are migrated to other parts, the responsibility of IS spreads thorough the organization indistinguishably. According to this evolution, IS organizations have been transformed into IS- Lite organizations (McNurlin et at., 2009 citing Roger Woolfe, 2000). At first, the three major processes of managing IS organizations were defined as driving innovation, delivering change and supporting the infrastructure, but an idea of IS – Lite looks forward to the processes in the future.

The managing processes of IS-Lite organizations would be split with the policy of an organization in order to integrate IT with all departments of the business and to be outsourced. Thus driving innovation does not belong to only IS anymore, it is embedded in all parts of the business. The remaining issue of driving innovation in transformed organizations are driving the innovation in information, driving the innovation in system architecture and supporting system integration in the organization.

Delivering change is the most changed process in IS organization. After transforming, more than half of the jobs are embedded with the whole organization and some are outsourced. Managing supplier and user relationships is placed instead of delivering change by the processes of approaching supply-chain management, establishing e-commerce centers and providing helpdesk support for suppliers and users.

Furthermore, supporting infrastructure is outsourced in the main part and some is embedded to the business. The important roles of transformed organization in this dimension are establishing information technology policies and standards, providing networks, database and processing and providing helpdesk support for the organization (McNurlin et at., 2009).

3. A Conceptual Model Aimed at Explaining CIO Effectiveness

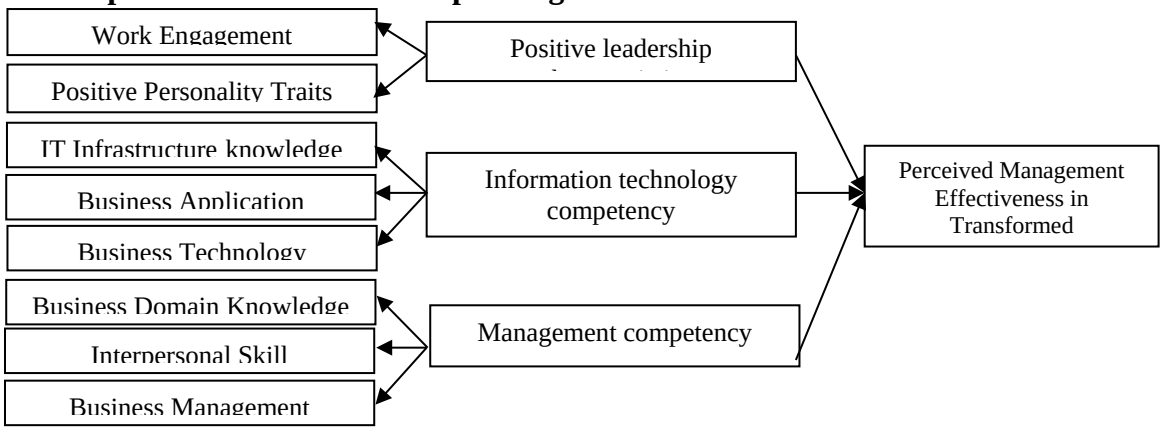


Figure 1: Conceptual model

This research aims to identify the relationship between CIOs' positive characteristic and competencies in three major perspectives: positive leadership characteristic, information technology competency and management

competency on perceived management effectiveness in a transformed IS organization. The conceptual model is displayed in Figure 1.

Some hypotheses that need to be tested against real world data to answer the research questions were proposed as follows:
H1: Positive leadership characteristic has a significant direct and positive significant effect on perceived management effectiveness in a transformed IS organization.
H2: Information technology competency has a significant direct and positive effect on perceived management effectiveness in a transformed IS organization.
H3: Management competency has a significant direct and positive effect on perceived management effectiveness in a transformed IS organization.

4. Data Collection and Analysis

The survey was conducted test via an electronic questionnaire in order to gather proper data for statistical analysis. The electronic questionnaires were sent to CIOs and IS/IT Managers by selecting the type of organization, amount of employees and control the similar respondents with selecting only organization that have IT outsourcing.

4.1 Measures

There were 4 main parts in the questionnaire as follows:

- Respondents demographic; 14 questions about subjects' demographic are used for the purpose of significant data identification.
- IT management competency is composed of 2 factors: information technology competency and management competency. In this research we used thirty components with a 5-point Likert scale that were developed by Chen & Wu (2011) to determine CIOs'competencies.
- Positive leadership characteristic is the combinated part of positive personality traits and work engagement.
  - Positive personality traits scale anchored 1-to-7 Likert scale (1=strongly disagree; 7=strongly agree) from (Li& Tan, 2013) with the lesser questions than the original version (http:ipipori.org/ipip/) but already has been analised a reliability and it was reliable.
  - Work engagement is obtained from a 9-item version of the UWES (UWES-9) that also has been developed from the original 17 items (UWES-17) (Schaufeli et. al., 2006). This shorter version still has 3 dimentions: vigor, dedication and absorption, but was reduced to three items per dimension.
- Perceived management effectiveness in a transformed IS organization is adapted from the description of IS-Lite characteristics (McNurlin et at, 2009 citing Roger Woolfe, 2000). To conduct this part, the questions were examined by the factor analysis method. To test the correlations between variables, KMO and Bartlett's test was analyzed with 86 subjects who are working in IT fields. The KMO value is .903 which greater than a recommended at .60. In addition, for each variable in each factor, the factor loading values were higher than the reccommended value for the 85 person – sample size (>0.60). Likewise, Cronbach's α of each factor is greater than 0.70 meaning that they were reliable (Hair et al., 2009). The result of the factor anaysis is shown in Table 1:

Table 1: Factor analysis of perceived management effectiveness in a transformed IS organization

	Factor Loading	Cronbach's α
Factor 1: Driving Innovation		.868
To Drive the innovative in information	.855	
To drive the innovation in system architecture	.714	
To support system integration in the organization	.693	
Factor 2 : Managing Supplier and user Relationships		.819
To approach supply-chain management	.643	
To provide the e-commerce center	.787	
To provide help desk support for supplier and users	.700	
Factor 3 : Supporting Infrastructure		.876
To establish Information technology policies and standards	.841	
To provide networks, database and processing	.789	
To provide help desk support for the organization	.654	

4.2 The Sample

Considering the demographics of the respondents, there were 63 significant respondents left. According to the samples, they were specifically selected by a type of an organization, amount of employee and the outsourcing deployment, then the returned data is included various representatives of CIOs/ IT Managers. The respondents' demographic detail is shown in Table 2.

Table 2: Demographics of respondents

Factor	Frequency (n)	% with in Sample
Education		
Bachelor degree	17	26.98
Master Degree	35	55.56
Doctoral Degree	11	17.46
Position		
CIO	10	15.87
IT/IS Manager	16	25.40
MIS/IT director	11	17.46
Senior IT Manager	22	34.92
Other	4	6.35
Organization Type		
Public Organization	28	44.44
Private Organization	35	55.56
Amount of employees		
1 – 50	11	17.46
51 – 100	13	20.63
101 – 500	11	17.46
501 – 1000	13	20.63
>= 1001	15	23.82

4.3 Analysis of Data

To analyze the reliability of all items in the questionnaire, a reliability analysis was conducted. Cronbach's α for the whole questionnaire = .979 which confirms that set of questions has a high reliability. When focus on each factor, each Cronbach's α was calculated separately and found that all three factors also have a value greater than recommended (> 0.70).

Although all three factors are adopted from previous work that already have been determined and confirmed the availability of those factors, this study also recalculated the factor loadings to reconfirm their results. The result stated that for each variable, there were factor loadings results higher than 0.5.

Table 3: Confirmatory factor analysis and validity test result

Construct	Sub-construct	Scale -item	Factor Loadings	Cronbach's α
Positive leadership characteristics	Openness	Opn 1 - 4	0.530 – 0.781	0.943
	Extraversion	Ext 1-4	0.536 – 0.608	
	Conscientiousness	Con 1-4	0.577 – 0.755	
	Dedication	Ded 1-3	0.673 – 0.798	
	Absorption	Abs 1-3	0.720 – 0.834	
	Vigor	Vig 1-3	0.556 – 0.642	
Information technology competency	IT Infrastructures	Iik 1-6	0.575 – 0.765	0.951
	Business Application	Bap 1-4	0.716 – 0.833	
	Business-technology integration	Bti 1-5	0.840 – 0.866	
Management Competency	Business domain knowledge	Bdk 1-5	0.736 – 0.853	0.952
	Interpersonal skills	Isk 1-5	0.649 – 0.785	
	Business management practice	Bmp 1-5	0.782 – 0.859	

To estimate the model structure, Structural equation modeling procedure (SEM) was used. The result is found that it is a reasonable model as Chi-square Probability Level (CMIN_p) = 0.223 (recommended >0.05), Relative Chi-

square (CMIN/df) = 1.166 (recommended < 3), Goodness of fit Index (GFI) = 0.887 (recommended >0.90), and Root Mean Square Error of Approximation (RMSEA) = 0.052 (recommended < 0.08).

However, since the sample size is less than 100 which is argued that it was a very small sample size for SEM, the multiple regression analysis was conducted to determine the reasonability of the model in another method. The result is R^2 Value = 0.525. Likewise, Multiple Regression Analysis also was used to determine the significant regression coefficient of positive leadership characteristic, information technology competency, and management competency on perceived management effectiveness in a transformed IS organization.

Furthermore, the correlation matrix, mean, and SD were calculated. The result indicated that there is no highly correlated factor more than 0.70 as displays in table 4.

Table 4: Mean, SD, and inter-construct correlations

	Mean	SD	(1)	(2)	(3)	(4)
Perceived Management Effectiveness in a Transformed IS Organization (1)	3.565	0.759	1.000			
Positive leadership characteristics (2)	5.146	0.861	0.364	1.000		
Information technology competency (3)	3.621	0.701	0.680	0.468	1.000	
Management Competency (4)	3.734	0.636	0.688	0.375	0.690	1.000

5. Results

According to the hypotheses of this research aimed to identify the relation between CIOs' positive characteristics and competencies, multiple regression analysis was conducted. The result is shown in Figure 2.

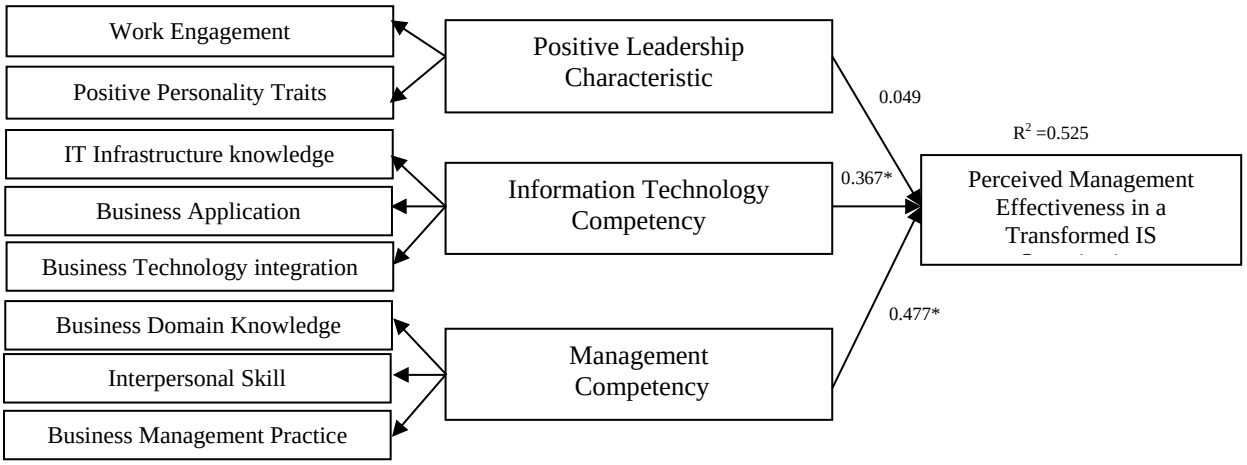


Figure 2: Results of the model

The R^2 Value of 0.525 indicates that the construction of three factors is correct: positive leadership characteristics, information technology competency and management competency explained 52.5% of the total variance of perceived management effectiveness in a transformed IS organization.

H1: Positive leadership characteristic has a direct and positive significant effect on perceived management effectiveness in a transformed IS organization. Although it has a regression coefficient in the positive way, its *p* value > 0.05; thus, this hypothesis was rejected.

H2: Information technology competency has a direct and positive significant effect on perceived management effectiveness in a transformed IS organization. Form the *p* value < 0.05, this factor has a direct and positive significant effect on perceived management effectiveness in a transformed IS organization. In addition, its regression coefficient is 0.367 in the positive direction; therefore this hypothesis was accepted.

H3: Management competency has a direct and positive significant effect on perceived management effectiveness in a transformed IS organization. In the same direction with H2, this factor also has a *p* value < 0.05 and the regression coefficient is 0.477 in the positive way; so this hypothesis was also accepted.

6. Discussion

From the evident result of this research, the related personal factors of effective CIOs were referred into 3 domains: positive leadership characteristic, information technology competency and management competency. When focused on the statistical analysis, we found that management competency has a quite high regression coefficient on perceived management effectiveness in a transformed IS organization. Accordingly, an IS organization was embedded into the organization and transformed, so the core processes that still remain in the responsibility of IS are close to the management process. That is why the person who has the higher management competency could be perceived easier as an effective CIO in a transformed IS organization.

Likewise, information technology competency also has positive significant effect on perceived management effectiveness in a transformed IS organization because the core processes of IS still related with IT unavoidably.

In addition, as this research monitored the effectiveness by the actions of CIOs not by the characteristic like presented in previous study (Andersen, 2006), we got the result in the way that positive leadership characteristic has no direct and positive significant effect on perceived management effectiveness in a transformed IS organization. However, when we considered the correlations between those three factors, we noticed that there are positive correlations between positive leadership characteristic and both, IT competency and management competency.

Consequently, to prove that positive leadership characteristic still relates to the CIOs' effectiveness, we proposed the second model, but set positive leadership characteristic as an indirect factor. As a result, the second model remained the available model with $R^2 = 0.523$; that means information technology competency and management competency explained 52.3% of the total variance of perceived management effectiveness in a transformed IS organization.

Furthermore, both information technology competency and management competency have a direct and positive effect on perceived management effectiveness in a transformed IS organization as regression coefficient at 0.394 and 0.478 sequentially.

For the positive leadership characteristic result it revealed that positive leadership characteristics can explain 21.9% of the total variance of information technology competency and 14.1% of the total variance of management competency. And it also has a positive significant effect on both competencies in the positive way as shown in Figure 3.

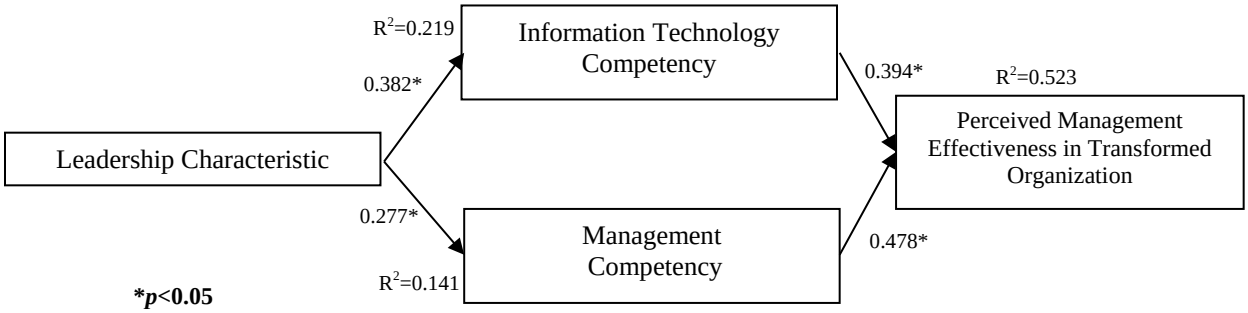


Figure 3: The second model

This implies that the critical personal factors of the CIOs or IT managers are a combination of information technology competency and management competency, while positive leadership characteristic is an indirect factor that supports the development of both competencies. Therefore in the CIO hiring decisions, CIO candidates should have both, competencies and positive leadership characteristics in order to lead the IS organization.

For the CIO-to-be, in-formation technology and management competencies can be gained by learning and doing, while leadership characteristic is the guideline of being. To prepare for being a CIO candidate, skills/knowledge in these two domains and positive leadership characteristics that can help to be perceived as an effective CIO in the future, should be focused on.

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Enhancing Health & Safety Management in Construction Sites by Using Mobile Computing in Saudi Arabia

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Abstract

This paper is a part of research project which about improving the health and Safety practice in Saudi construction projects by identifying the Key Performance Indicators and develop measure it to investigates the relevance of mobile computing to improve Health and Safety (H&S) in onsite construction projects. Even though the construction sector in Saudi Arabia has been rapidly expanding, the health and safety record of this industry remains considerably poor given the rising figures of injuries and mortalities. The literature review identifies and highlights the current status of H&S practice in Saudi construction projects and the reasons behind it. Moreover, the review also indicates and discusses the proposed scenario of using mobile computing technology to improve H&S. From this, the paper discusses the relevance of mobile computing for better information provisioning, information flow and decision making. Conclusions are drawn about the future impact of emerging mobile computing technologies to enhance H&S in construction site.

Keywords
Health and Safety, Construction Management, Communication, Mobile computing.

1. Introduction
In recent years, new demands have been put in place on construction projects because of increasing complexity of design, productivity and other increasingly stringent regulations. Besides that, construction industry has come under increasing pressure to improve its health and safety practice and to address coordination and communication challenges that often resulted in accidents, injuries and deaths. Also, industry needs to develop a capable workforce to "deliver transformational change in the next decade" (Construction 2025, 2013). Rapid uptake of Information and communications technology (ICT) has results in major changes in organisational structure, processes and technology uptake within construction organisations. In recent years, there has been tremendous development in technologies such as information systems cloud computing, wireless networking and mobile technologies, that can assist to "support the collaborative creation, management, dissemination, and use of information through the entire product and project life cycle" (Shen et al, 2009). There is also rapid growth in new applications, equipment, materials, methods, processes, etc. These developments in technologies enable potential improvements in construction methods and processes spatially in the practice of H&S in on site construction.

2. Health and Safety in Saudi Construction Projects
On a global note, as stated by Fewings (2013), the construction industry has experienced a poor safety record in both developed and developing states, with construction undertakings still lead to deadly injuries and the rise in mortalities among the workforce (HSE 2009). According to the UK's HSE (2013), an average of over 60 deaths per year in the last decade has been recorded in the construction sector. One of the major reasons behind the high number of incidents and accidents recorded all over the world is the absence of health and safety management in

construction (Chaudhry et al., 2007). In addition, there is a good deal of statistics evidencing the fact that the construction industry is the most hazardous industries in a number of countries, as shown in a study conducted by Ritzel, Fontaneda, & González (2008). According to Zhang et al. (2013), in the Unites States, the last two decades have seen more than 26,000 employees lose their lives in construction projects, which is equivalent to five people per day.

On the other hand, there had been approximately 350 fatalities every year between 2000 and 2006 taking place in the Spanish construction sector (Ministry of Labour and Immigration, Under Secretary of the Ministry of Labour and Social Affairs, 2006). Similarly, in developing countries, such Saudi Arabia, and as recorded by the General Organization for Social Insurance (2010, 2011), incidents in all sectors from 2004 to 2010 accounted for 261,076 injuries, with an average ratio of 3,413.9 per 100,000 workers annually. In addition, the number of fatalities reached a total of 2,176 with an average rate of 28.3 per 100,000 workers per year. It has been suggested in some research studies that there are several different factors for these figures; including the fact that the majority of these incidents taking place were brought about by a considerable lack of governmental health and safety management, while most of the work (95%) is carried out by migrants and expatriates (Alassmri et al., 2012; Jannadi et al., 1998; and Al haadir et al., 2011).

Despite Saudi Arabia economical progress and financial growth which reflected on the tremendous growth of construction industry, health and safety in construction remains considerably poor (Al haadir et al, 2011). As evidenced by Alasamri (2012), when it comes to construction safety, the sector has recorded the highest number of injuries and fatalities in a comparative study involving eight developed and Arab countries. Besides, many construction sites have been built without the least form of protecting perimeters, which provide no security for the pedestrians within proximity of the site. Berger (2008), for instance reported that, in 2006, 25 people lost their lives while a building was being demolished in Makkah city. On the other hand, in 2011, the General Organization for Social Insurance in Saudi Arabia published one of the most revealing figures with the number of injured workers totalling 75,825, a shocking 48% of which taking place within the construction sector. While the number of those who recovered without incurring any incapacities was 61,633, those incapacitated accounted for 3,677 employees, with 575 of whom dying as a result of the lack of health and safety measures and precautions (GOS, 2012).

As reported by Berger (2008), in the construction business ventures across Saudi Arabia, 25% of contractors did not provide new recruits with on-site rudimentary safety gear or training, and hardly any first aid, while 38% of the contractors had no mandatory training courses in place in terms of health and safety. As such, enhancing health and safety has remained as one of the most pressing needs in Saudi Arabia over the past 20 years. Furthermore, the issue of applying a successful health and safety program lies in the fact that the government has failed to acknowledge the human aspect of the situation (Hinze, 1997). Moreover, the several causes of accidents are linked to human performance, poor working environment, the exceptional nature of sites and a lack of health and safety laws in place (Janndi et al., 2001). Similarly, the research findings of Janndi (1995) showed that construction workforce would be influenced by the rapport between the senior managers and the ordinary employees. In addition, Cooper (2003) stated that the three key features to ascertain health and safety policies include behaviour, people and a work setting.

2.1. The work setting

The work setting in general includes the actual setting and physical presence of the employees on-site. As for the construction site, it involves a set of a complex milieu since it necessitates a sizable quantity of information for the site managers to successfully carry out the safety procedures. Furthermore, the setting is directly associated with the quality of the safety management system (SMS) within the construction place (Choudhry et al., 2007). Additionally, reports and analyses of a site's safety performance are essential to the successful upgrading of general on-site health and safety practices for the business. For the health and safety in business to be effective, support is needed from the top level of management in the form of a robust pledge and commitment to safety at the workplace (Jaselskis et al., 1996; Cooper, 2000).

There is a myriad of factors for appreciating and adhering to successful safety management systems. In addition, as part of their overall policy, the management should pay attention to health and safety measures by handing out safety packs, gear, as well as appointing a well-qualified safety representative at the workplace (Teo et al., 2005; Sawacha et al., 1999). Likewise, the relationship between the management and other members of the workforce on site should be enhanced (Fang et al., 2004), not to mention the absence of safety awareness among the senior managers and project managers (Tam et al., 2004). All these managers should work together to maintain the

appropriate access and traffic to the site, as well as providing material and all services and facilities to ensure an effective and safe working environment (Mattila et al., 1994). In the Saudi context, the temperatures can easily hit the 50 degrees mark and the 80 per cent humidity rate; thus, health and safety management can be one of toughest challenges to have the system implemented.

2.2. Behaviour

According to Phillips (2005), behaviour can be defined as the approach people take in situations when they are exposed to the effects of the outer environment. In the case of the construction industry, Lunt et al. (2008) reported that to alter people's behaviour, barriers should be overcome, including complex work settings and the diversified aspects of the construction site, which can be home to a mixture of cultures and tongues. Despite this diversity, the senior members of the management team can be extremely influential and inspirational in terms of maintaining a positive attitude about the health and safety behaviour the lack of which can lead to adverse effects. In fact, unsafe work behaviour can result in around 80 to 90 per cent of accidents (Phillips, 2005). As such, a behavioural approach has become of a particular importance in dealing with safety issues as it sheds light on the psyche of the workforce at the workplace.

3. Key Performance Indicators

In addition, as suggested by Sawacha et al. (1999), the poor safety performance of the construction industry can be ascribed to lack of knowledge and absence of training, lack of supervision, lack of resources to follow through the task safely, misjudgement, nonchalant behaviour, lapses of attention, thoughtlessness, type of the construction work carried out, the uncontrolled working atmosphere, the complex and diverse nature of the workplace, hazardous and irresponsible risk taking, uninformed personnel about safety culture, poor management response and complacent behavior. Key Performance Indicators (KPIs) are those major activity areas, where constructive and effective performance is potentially required for a particular manager. According to Keegan &Turner (2002), CSFs can be defined as those factors in which success is paramount so that each of the main actors in the project has a maximum level of opportunities to achieve their aims.

3.1 Good Communications

One can define communication as the process of sharing thoughts, information, and messages with other people in a given time and place. According to Hamer (2005), communication involves not only writing and talking, but also nonverbal communication, including facial expressions, body language, or gestures; visual communication in the form of images or pictures, such as painting, pictures, video clips or movies; and electronic communication, including telephone conversation, email messages, cable TV, or satellite transmissions.

Poor communication, low level of knowledge and poor site awareness have been shown as some of the key reasons behind the occurrence of accidents within construction sites (Tyler and Lamont, 2008; Donaghy, 2009). On the other hand, communication can pose a serious challenge for managers since they are in charge of delivering information; thus, meeting these communication challenges professionally can eventually yield efficient and effective collective and individual performance in their organisations (Kristina *et al*., 2005).

If there is a communication issue inside an organisation, there could normally be a failure in the manner information has been transmitted from the sender to the receiver, which is standard norm in institutions that have a top down hierarchical approach. In this kind of hierarchy, it is not usually easy for bottom level workers to gain access to information concerning changes and developments taking place within the company.

Being able to communicate effectively is of paramount importance in all walks of the construction industry, but it is even more important when one takes into account health and safety issues, especially when it can expose an employee's health and safety to several hazards. With the majority of the workforce in Saudi Arabian construction industry coming into the country from various ethnic backgrounds and with communication and language difficulties in what is known as a universal language; i.e. English, the communicative process can be even more crucial in such circumstances. In addition, many expatriates and employees come from a wide variety of cultures and hold different perspectives in terms of their construction experience and education, which can also lead to countless problems, adding to the already vague knowledge of the health and safety issues and regulations (Ghaemi, 2006).

3.2 Regular Safety Inspections

The major aim of the project was to provide a method to be utilised by inspectors within the construction industry to assess health and safety performance/improvement over a period of time within a specific sector.

In any given working environment, safety inspection teams in the organisation should identify a number of hazards that have to be tackled. In addition, the chief contractor/construction manager should carry out and note down regular daily and weekly safety inspections that can be either formal or informal of the work site to ascertain the legality and consistency of the practices, and those of their subcontractors/trade contractors employed by the organisation. For inspectors to make the most of these benefits, and to maximise their potential for them, a methodology has been introduced to address the current inspection practices and operations from an organisational point of view. The tool is intended to offer a structure for full utilisation of the current inspectors' skills, knowledge and experience. Through an approach grounded on present skills and experience, one can rest assured that the measures chosen will be not only significant but also wide-ranging.

4. The Key Challenges of Health and Safety Management in Saudi Arabia

Saudi construction industry suffers from many different issues that directly or indirectly affect H&S practice in KSA. Al-Kharashi el at (2009) outlined some causes that related to the contractor that affect the delivery of the project which included ineffective scheduling of project by contractor, poor qualification of contractors' technical staff, poor site management and supervision by contractor, contractor experience and ineffective control of the project progress by the contractor. The reason behind it may embodied in that the construction sector within KSA still follows a document centric communication model, heavily reliant on traditional management methods supplemented by basic communication tools. Sidawi (2012) conducted a survey within Saudi construction companies which showed that majority of (89%) used traditional communication systems and tools such as fax machines, mobile phones, site visits, weekly/monthly reports and face-to-face meetings.

Communication can pose a serious challenge for managers since they are in charge of delivering information; thus, meeting these communication challenges professionally can eventually yield efficient and effective collective and individual performance in their organisations (Kristina et al., 2005). Tyler and Lamont (2008) indicated that poor communication, low level of knowledge and poor site awareness have been shown as some of the key reasons behind the occurrence of accidents within construction sites. In Saudi Arabia, a number of unique challenges are offered through the distinctive socio-cultural environment. Identified number of factors make Saudi construction sites unique when compared to Western sites, including heavy dependence multi-cultural, multi-language, low and semi-skilled labor and very low adoption of technology coupled with heavily subsidized the AEC sector, fuelling various process inefficiencies. Sidawi (2012) identified that barriers that obstruct the implementation of advanced electronic management and communications systems include management system such as the organizational structure and practices; concerns over technical issues such as cost, maintenance and support; difficulty in making changes to the organization's structure, internal influences, external pressures and the level of staff IT skills.

This should be seen in the backdrop of the fact that total population of construction workforce in the private sector is 3.5 million in 2011 (Saudi Arabian Monetary Agency, 2013). With the majority of the workforce in Saudi Arabian construction industry coming into the country from various ethnic backgrounds and with communication and language difficulties in what is known as a universal language; i.e. English, the communicative process can be even more crucial in such circumstances. In addition, many expatriates and employees come from a wide variety of cultures and hold different perspectives in terms of their construction experience and education, which can also lead to countless problems, adding to the already vague knowledge of the health and safety issues and regulations (Ghaemi, 2006).

5. Relevance of Mobile Computing to Support H&S On-site

This section discusses the relevance of mobile computing with a focus on construction phase particularly in health and safety practice. As known, construction projects are relatively different and complex in terms of their nature and produce large amount of information. "The emergence of mobile computing has the potential to extend the boundary of information systems from site offices to actual work sites and ensure real-time data flow to and from construction work sites" Chen et al, (2011). Mobile Computing also plays a key role in management of information generated during a construction project. Wilkinson (2005) defines 'construction collaboration technology' as a combination of technologies that together create a single shared interface between two or more interested individuals (people), enabling them to participate in a creative process in which they share their collective skills, expertise, understanding

and knowledge (information) in an atmosphere of openness, honesty, trust and mutual respect, and thereby jointly delivering the best solution that meets their common goal. Using mobile computing it is possible to create such a collaborative platform bringing together site-based and office based personnel. Mobile computing technologies provide engineers unprecedented opportunities to innovate the existing processes of construction projects (Kim et al, 2011).

Construction sites are hazardous and dynamic by their nature. Mainly, the key advantage of utilize mobile computing in construction projects include real time information sharing, decrease time and cost in construction operation, decline in faults, accidents, increase in productivity, better decision-making, quality control, etc. However, with regards to this paper, mobile computing can improve H&S practice on-site by having reliable and updated information that regards to the current states of the conditions of the site, records and measures the safety commitment of the site-based workers as will as reporting the possible hazards in which may affect the workers' safety in real time communications either by texts, photos or videos by the site managers which provides the projects manager with fast reaction and better decision-making.

Despite that this technology has potential advantages, it has some barriers and challenges which embedded with the "skepticism from the industry because of the relative lack of supporting data and a lack of understanding of mobile computing devices" (Son et al, 2012). In his landmark report, Egan (1998) advised construction industry, stating that, "New technologies can simply reinforce outdated and wasteful processes. The change should be approached by first sorting out the culture, then defining and improving processes and finally applying technology as a tool to support these cultural and process improvements" Egan (1998). Several studies have investigated and discussed the emerging technology barriers and challenges which may affect the data exchanges. These barriers and challenges can be categorised into technical, organisational, cultural and usability barriers. Moreover, Saidi et al (2002) found two barriers to the use of mobile computing in construction which are:

Limitations of Mobile Computer: The limitations of mobile computers include screen size, screen visibility, processing capability, and input method.

Construction Industry's Characteristics: The barriers relating to the construction industry's characteristics have been recognised as the physical jobsite conditions (such as temperature, humidity, dust, etc.) and organisational issues such as the industry's fragmentation and low risk tolerance.

6. The Scenario - Regular Safety Inspections

This paper propose a scenario that discuss the potential advantage of mobile computing that will aid in the future to improve H&S on-site construction practice which can be gained through the enhance of information provisioning support between the project participants. In the beginning, site managers in the project are obligate to report and identify a number of hazards that have to be tackled to enhance the safety of the site. In addition, construction site manager should carry out and note down regular daily checklist in the morning that regards to the workers' safety commitment such as the helmet and the safety boot as well as inspect the site environment for any possible hazard with some photos or short videos to support the findings. In the other way, these reports are forwarded to the project manager which provide him with fast, updated and reliable information to take better decisions.

7. Conclusion

The improvement of Information Communication Technologies has made it possible for increasing safety in construction areas. For example, when a site permanently change one or some of its details, such as workers, activities, work place, etc., it has to assume full responsibility for health and safety issues by constantly updating its information about the existing and planned activities and the qualifications gained by employees and safety conditions that are required to ensure their wellbeing. As such, mobile computing solutions allow this information to be easily accessible without affecting or unsettling the flexibility and agility of those responsible for health and safety procedures.

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Lean Manufacturing Principles Applied to University Library: A Lean Library

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Abstract

The purpose of the paper is to address the challenges, understand the critical success factors (CSFs) and assess the role of relevant tools and techniques for the successful introduction and deployment of lean principles in university library. Lean thinking is one of the initiatives that many major industries in the world have been trying to adopt in order to remain competitive in an increasingly global market. The objective of the lean approach is to reduce cost by identifying and eliminating non-value added activities from the product and service provided. Traditionally lean concept is applied to manufacturing only, where as lean principles can also be applied to the educational institutes. The lean principles used in the university library case of this paper are adopted from the University of Central Oklahoma, United States.

Key Words
Lean thinking, library design, non-value added activities.

1. Introduction

Lean philosophy was introduced by Toyota Production System in the 50^{ies} of the nineteenth century after the 2nd world war when Japan had to utilize its limited resources. The concept is to stop over production to achieve quality and instead focus on improving the production process and building quality into the product in the first place (Liker, 1998) (Pavnaskar, 2003).

Lean describes a method of doing more with fewer people, fewer equipment, less time, less effort and space to provide customers exactly what they want (Marselli, 2004). Lean manufacturing is a philosophy rather than a new management method in which the upper management has a key role during the implementation process. From the very beginning until the near past, lean thinking had been practiced only in the manufacturing sector to reduce non-value added processes in the production flow. Actually lean thinking cannot be restricted only to the manufacturing sector. It is a sophisticated philosophy that can be applied to every field of life to eliminate “waste”.

The importance of service sector can be imagined by the PPP GDP (Purchase Power Parity-Gross domestic Product) sector comparison of the main worldwide economies.

Table 1: PPP GDP sector comparison (Laureani, 2012)

PPP GDP 2010	Agriculture	Industry	Service
European Union	5.7%	30.7%	63.6%
United States	1.2%	22.2%	76.7%
China	9.6%	46.8%	43.6%
India	16.1%	28.6%	55.3%

So far lean is being implemented in many areas of service sector like hospitals, call centers, restaurants etc. The latest application areas of lean thinking in service sector are universities. Education has experienced different pressures in recent years, especially in the fields of on-line programs, distance-learning, workshop-type training and global executive education. In this way the constant improvement in educational programs has become necessary for the educational institutions (AACSB, 2002). In addition to the education, students and parents search for high quality of safe and up-to-date residence halls, state-of-the-art facilities and the latest offering of the technology (Clare L. Comm, 2005). Library, being the heart of a university, has more importance as compared to the other departments of a university because every student is connected to it. With the limited resources, library has to cope with the increasing number of students and services to be provided. This pressure on educational organizations to continuously improve their quality of service is a mounting and relentless challenge. To handle these challenges universities and educational institutes need to adopt the lean philosophy.

2. Lean Tools

From the very beginning until the near past, lean thinking had been practiced only in the manufacturing sector to reduce non-value added processes in the production flow. Actually lean thinking cannot be restricted only to the manufacturing sector. It is a sophisticated philosophy that can be applied to every field of life to eliminate “waste”. Nowadays, lean approach is also implemented in service organizations both in public and private sectors in order to improve customer service, quality, efficiency, staff morale, internal cooperation and communication (Andrews, 2012).

2.1 5S

5S is one of the most important and easiest applicable lean tools. Very simply, 5S can be described as “a place for everything and everything in its place”. 5S is a workplace housekeeping technique which is recognized as both a problem solving tool and environmental improvement tool. It is based on five Japanese acronyms; *seiri* (sort), *seiton* (set in order), *seiso* (shine), *seiketsu* (standardize) and *shitsuke* (sustain) (Machado, 2010).

2.2 Spaghetti Diagram

A Spaghetti map is a visual lean tool which shows the movement of one item, service or employee by drawing on a layout plan. Generally the movement is counted as a waste and needs to be reduced as much as possible. Spaghetti diagram makes it easier to find out the extra movement and eliminate it by redesigning the work space (Machado, 2010).

2.3 KANBAN

Kanban is the best known visual tool of lean which means “card” or “sign board”. Kanban is a visual communication system displaying the necessary items with necessary amount and at necessary time through all process. Kanban is a component planning and control system. In this system, a Kanban card is assigned for each component. The most frequently used Kanban form is a card, where as any kind of signal can be used as a Kanban. It could be a card, an alarm, a light, a square on the floor or a bin. Thus it is a perfect basement tool for applying some other lean tools like 5S, Jidoka or JIT(Just-In-Time). Kanban is a very efficient, easy and low cost technique (Machado, 2010).

2.4 Conducting Time Measurement

Conducting time measurement is a useful tool often connected to the value stream map which allows measuring the duration of each step in the process. It helps to catch the wasted time and non-value adding steps of the whole process. Also, by setting the relation of value-added and non-value added time, the efficiency and productivity can be calculated. Furthermore at the end, the success of an implemented lean tool can be seen perfectly by comparing time before and after implementation (Machado, 2010).

2.5 JIDOKA

Another important lean principle to understand automation is Jidoka. It is a Japanese term which means “react at the first defect”. The main approach of Jidoka is “automation with a human touch” which ensures that the mistakes will be fixed at the previous steps before going on (Hickley, 2006).

3. Implementation Of Lean Principles Into A University Library

3.1 The Model

The University of Central Oklahoma was transformed into a Lean University by implemented lean principles successfully. The reason behind the implementation of lean was to overcome some challenges like; decrease in budget, overcome increasing costs, low productivity, job satisfaction and old methods of administration. In the beginning lean thinking was introduced at administration level with the main objective of elimination of waste from the service being provided. Before implementing lean, The University of Central Oklahoma made surveys to figure out the core issues. The surveys concluded that major problems were complaint based and non value added activities. To create a common understanding among the staff, administration was involved to give trainings and make an environment of lean thinking. A 4-step model was used to implement lean thinking in the university. The 4-step model is given below:

Step 1: Identify the Opportunities - Complete an organization-wide diagnostic search for issues, problems and opportunities.
Step 2: Solution Design - Create a draft for success that involves all employees: training, mapping, and planning.
Step 3: Implementation – Use kaizen events, core teams, and metrics to implement and illustrate change.
Step 4: Continuous Improvement – Monitor performance after projects are completed.

In the beginning lean specialized consultant was outsourced. The priority list was created in the first step by doing university wide surveys. In the second step value stream mapping workshops and trainings were given. On the basis of maps created at step two, departments made changes in their processes. In this way third step was finished. The fourth step is still under process and kaizen (continuous improvement) is being followed. The result of implementing lean in The University of Central Oklahoma was a positive change with better service quality and employee empowerment. The flow of process and student satisfaction level was also improved (Moore, 2007).

3.2 Case Study in University Library

The library of a university supports education and research to provide, arrange and put into service all kind of information and service needed. The main library of a university in Istanbul, Turkey is selected as the case study of this research. With the turnstiles entrance, main library consists of 2 floors and 2500 square meter closed area. The main library can contain 140 thousand volumes with the seating capacity of 450. Apart from two general study halls, there are 13 individual, 6 group study rooms and one computer laboratory with 15 computers for photocopy and print. The library offers services from 08:00 to 19:00 in weekdays and 09:00 to 16:00 on weekends except Sunday.

The main library provides following type of services;

- Membership – Loaning
- Interlibrary Loan
- Article Provision
- Private Study Rooms
- Computer and Wireless
- Daily Newspaper
- Photocopy and Printer
- Purchasing - Work Request
- Service for Users with Disabilities

One of the key steps in lean manufacturing is to find out what operation is value adding and what is not. 7 types of wastes are well known in lean manufacturing and Toyota Production System (TPS). There can be many types of wastes according to facility in addition to the 7 wastes. 10 types of wastes are identified with respect to the services provided by the main library.

Table 2: 10 Wastes of main library

Defects	Defects can be in the form of damaged books or furniture, lost files or data entry errors
Duplication	Multiple signatures, data re-entering, multiple queries, unnecessary procedures create duplication and wastage of time
Inventory	Wasting time finding what was needed, limited stock, unnecessary copies increase inventory level
Lack of customer's attention	Poor attention to the customer and rudeness towards the customer
Overproduction	Processing paperwork before time and books or journals no ones will ever read are forms of overproduction
Unclear communication	Lack of standard data format creates ambiguity
Motion/Transportation	Poor ergonomics and poor facility layout enhances transportation and costs
Underused Employees	Limited authority given to the employees and excessive bureaucracy undermines the workers
Variation	Variation comes when lead time is defined very poorly
Waiting/Delay	Waiting for order fulfillment, waiting for issuance and malfunctioning of the system are the types of delays in a service organization

The time wasted during the book finding process in library is the main problem of the case. To find solution for the above mentioned ten types of wastes, especially reducing the time consumed while finding a book, 4-step model of University of Central Oklahoma was used.

Step 1. Identify the Opportunities

The main library contains about 136,000 books which are divided into different sections with respect to the category of books. Numbers and names are given to each section. Current procedure being followed by students to find a book is stated below;

1. Student searches online library catalog by the name of book
2. Goes and gets the book by the "call number" with respect to its department
3. Goes to librarian desk to issue the book for a maximum period of one month
4. After one month the student returns the book to the librarian

After returning to the librarian, the book has to be placed back to its corresponding shelf. Also the librarian has to collect those books which are left behind by the students within the library desks and study rooms. Librarian follows the following steps;

1. Librarian enters the data of student and the book into the library system when a book is returned
2. Books are collected on the librarian desk
3. At the end of the day, librarian classifies the books
4. Librarian finds the corresponding shelf by matching the code written on book and shelf.

In the current procedure that is being followed in library, takes a lot of time and effort both of student and librarian. Being a human, the librarian or student may place the book in a wrong shelf (Poka Yoke). Sometimes it is difficult to find a pen and paper placed near the computer for catalog search. When a book is searched on a computer placed in library, the system gives the shelf number where book is placed but it does not give any information about the floor of the shelf. There are different types of irregularities, like some books are too big to fit in the shelves, some are too old to read and others are placed in wrong order.

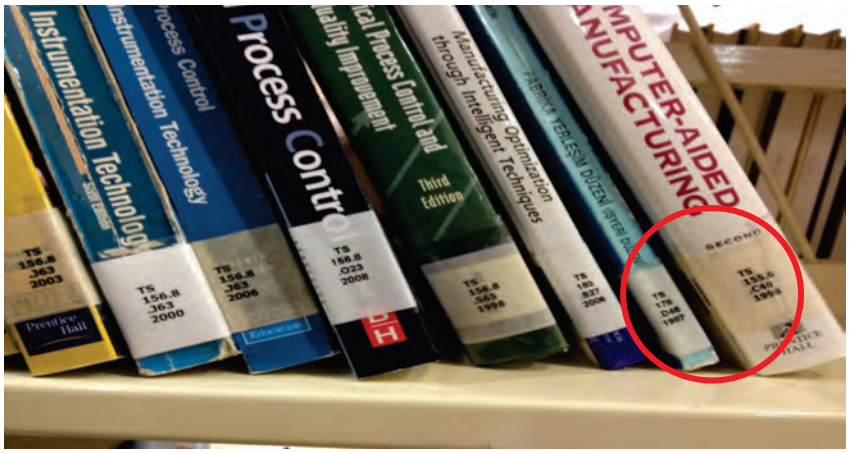


Figure 1: Example of wrong ordering

Step 2. Solution Design

A solution using different lean tools was proposed in order to fix the problems mentioned above and make a lean library. Solution contains a bar code reader connected to the computers placed in library to search the books. Each book will have a bar code. The bar code will contain all the information like name, author, edition, type, publisher, place and shelf number of the book. Books must be placed in the shelves and there will be a moving bar code scanner/reader on each shelf. There will also be two more bar code system and student card reader that will be placed at the exit point of the library and the librarian desk close to entrance in order to issue and return the book respectively. There will be a specific number of boxes nearby the scanner where books will be placed by students after returning to library according to their categories. New procedure that will be followed by students to find a book is stated below;

1. Search online for the book
2. At the same time scanners start moving and reading the bar codes written on books
3. When a scanner finds the searched book, it gives signal to the computer by showing the exact place of the book.
4. Student goes and gets the books.
5. At the exit point student shows the required book and student card at the same time to the scanner.
6. Scanner feeds the information of student and the book and stores in the library system.

Return of the book

The returning process of the issued book follows the following steps,

1. At the librarian desk student shows the book to be returned and the identity card to the scanner
2. After the scanner gets information of the book, student places the book in the respective box and leaves
3. At the end of the day, librarian classifies the books
4. Librarian finds the corresponding shelf by matching the code written on book and shelf number and places it.

Step 3. Implementation / Simulation using lean tools

The proposed solution will bring the current library system into a lean service system. For the application of the proposed lean system, following lean tools need to be applied;

1. Time Measurement

The value-added and non-value-added activities were measured in the current system of searching, issuing and returning back for the book.

Before

- Enter Library
- Walk to computer: 0.1 minute

- Searching the book on computer: 1.01 minute
- Walking to shelf: 0.66 minute
- Searching for the book: 1.5 minutes
- Walking to the librarian desk: 0.33 minutes
- Issuing the book: 3 minute
- Walking to exit: 0.66 minute

Total cycle time of issuing a book: 7.66 minutes

- Enter Library
- Walking to the librarian desk:0.58 minute
- Issuing the book:0.3 minute
- Walking to exit:1.28 minute

Total cycle time of returning a book: 2.16 minute

After

- Enter Library
- Walk to computer: 0.1 minute
- Searching the book on computer: 1.01 minute
- Walking to shelf: 0.66 minute
- Searching for the book: 1.5 minutes
- Walking to exit: 0.56 minute
- Scanner: 0.06 minute

Total cycle time of issuing a book: 2.89 minutes

- Enter Library
- Walking to the librarian desk:0.1 minute
- Scanner:0.11 minute
- Walking to exit:0.11 minute

Total cycle time of returning a book: 0.33 minute

2. 5S

- Seri (Sort): Elimination of old and worn books those are not useful anymore.
- Seiton (Set in Order): Removing old labels from all the books and replacing with new labels with the bar code that will be readable to the scanners.
- Seiso (Shine): Cleaning all the shelves. Modifying shelves for the book sizes.
- Seiketsu (Standardize): Defining a fixed place for each book on shelves.
- Shitsuke (Sustain): Permanently application of the defined rules.

3. JIDOKA

The bar code readers mounted on every shelf will be run twice a day by the librarian to check either every book is on its place or not. If a book is misplaced, the bar code reader will give an error in the system.

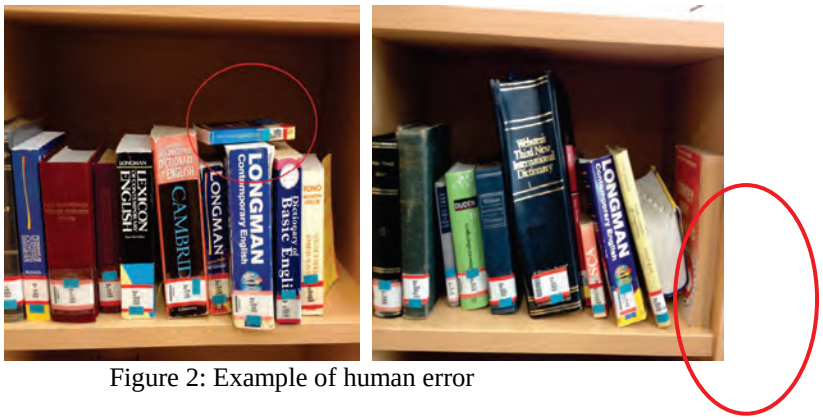


Figure 2: Example of human error

4. Spaghetti Diagram

The spaghetti diagram given below shows the walking ways of a student in the current system while searching, issuing and returning back the book. Also second spaghetti diagram shows the predicted walking ways after the simulation of new system.



Figure 3: Spaghetti diagram of main library

5. KANBAN

The codes written at the back side of the each book present in library will serve as KANBAN. Also the category name written on the boxes placed near to the return scanner will also serve as a KANBAN.

Step 4: Continuous Improvements

By implementing lean manufacturing principles to the main library;

- Around **6.5 minutes** of a student can be saved on a single trip to the library. **(Time Measurement)**
- The work load of the librarian can be reduced as a result there will be less chances of the human error like data entry errors, placing the books on wrong shelves or in wrong order. **(KANBAN, JIDOKA)**
- Walking ways can be shortened **(Spaghetti)**
- Book finding process can be easier **(Scanner)**
- Old books or journals no ones will ever read can be discarded to make space for the important books. **(5S)**
- Excessive bureaucracy can be eliminated completely. **(Scanner)**
- The new system will give more clear information about the location of the book. **(Scanner)**
- Shelves will be arranged according to the size of the books.**(5S)**

4. Conclusion

It is known that lean works quite well in the manufacturing sector. It helps to identify lead time, bottlenecks and downtime within the production system. Bottlenecks, downtime and lead times also exist in service industry. Even the manufacturing and service sectors are differentiated from each other in respect to the things that they produce or provide, they face more or less with the same problems and also, in both industries, the main goals are same which are customer satisfaction, increasing productivity, speed and quality while decreasing cost. That means lean principles can also be implemented to a service industry. Universities are one of the most dynamic service organizations within the service industry and in this sense every university is a good candidate for the implementation of lean principles. Most of the time, a university is considered as a single organization, but actually there are several different organizational structures that form a university like administration, teaching, security, etc., and they all have different dynamics which are connected to each other at the top level to constitute the whole university. The main library of a university is one of these dynamics, maybe the most interactive one. In this paper one of the university structures, the main library was selected as a case study of implementing lean principles. Because the proposed solution is a long term approach which required a technological infrastructure, it is just

simulated in order to see the results in advanced and to decide if this technology is going to help the library to become more lean, coordinated and qualified. This case study ensures to identify several particularities for lean implementation in the educational environment.

First of all, the main difference in this case is that the entity which generates the continuous flow is a totally living property, a human. The human in the system is both in the role of customer and provider who creates the whole cycle. Therefore the human has the biggest role in this system, and needs to be considered in every point of view like her/his various whishes, the different ways of thinking or human errors. In this library case, as a customer, the wish of the student is certain that is finding easily what he/she wants and leaving the system as soon as possible without unnecessary waiting. In order to satisfy these wishes, lean philosophy is the best and the easiest way both for the student and librarian.

In conclusion, as in the library case, there are many improvement areas that need lean implementation in a university. While establishing lean philosophy in a service institute, human-induced problems may appear in understanding the need of lean, because generally humans are unwilling to change, but overcoming this kind of problems is also a part of lean philosophy. As it is stated before, lean is actually a life philosophy, and understanding it well and establishing an adequate strategy can contribute to the success of lean, and also increase the quality in every field of life.

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Alliance Management Process Design with Design for Six Sigma

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Abstract

Nowadays, it has become inevitable for companies to develop mutually beneficial well- organized alliances in order to ensure sustainability and to achieve their strategies. Particularly, companies necessitate to build alliances with their suppliers, customers, society and shareholders to achieve their short and long term strategies. Therefore; alliance management is approved to be an administrative process due to the great significance for companies' strategies. IDOV is a frequently used Six Sigma methodology which refers to Identify, Define, Optimize and Verify. It is a variant of Design For Six Sigma (DFSS), which is used for designing a completely new product or business process to meet customer needs and specifications. In this study, the techniques defined in IDOV methodology is applied for Alliance Management Process (AMP) design. Throughout the paper, the term "alliance" is used instead of "customer" in order to represent all the members of the value chain; like suppliers, customers, society and shareholders for process design. Furthermore, Business Process Management (BPM) principles are used in IDOV phases. Finally, a portal application is developed in order to ensure the validation phase in IDOV.

Keywords
Alliance management, process design, DFSS, BPM, IDOV, CTQ

1. Introduction

In today's world, the capabilities of the enterprises to achieve various goals are becoming inadequate and they need cooperations. Therefore, today's organizations developing mutually beneficial cooperations to ensure sustainability and to develop strategies. As well determining the necessities such as how cooperations should be or to which purposes would it serve, some main issues such as finding and choosing the most appropriate partner candidate which appropriately suits company's strategies, managing and developing successful cooperations are also particularly important.The general definition of cooperation is the process of groups of organisms working or acting together for their common/mutual benefit. An alliance is a pact, coalition or friendship between two or more parties, made in order to advance common goals and to secure common interests (Tuna & Behret, 2013).

Alliance management enables companies to provide high quality products and services with lower costs, to reach the resources such as expertice, technology and raw materials easily, to direct a wider geography or new segments of an established market. In the literature, alliance management is mostly examined in terms of strategic or as a supplier selection process; however social and operational dimensions are rarely considered in this process which we should define all together to make multi-dimensional analysis indeed. It is obvious for the global companies that they should consider their partnership in social and operational dimensions to maintain sustainability and support their strategies through operational excellence (Tuna & Behret, 2013).

The aim of this study is, to design alliance management process as a management process by integrating Business Process Management (BPM) and Design For Six Sigma (DFSS) principles. In the business world, Six Sigma is defined as a 'business strategy used to improve business profitability, to improve the effectiveness and efficiency of all operations to meet or exceed customer's needs and expectations (Antony & Banuelas, 2001). Six Sigma is one of the powerful business strategies that improve quality initiatives in many industries around the world. It is a company-wide systematic approach in order to achieve continuous process improvements. Design for Six Sigma(DFSS) is a data-driven quality strategy for designing or re-design a product or service from the ground up (Patil et al., 2013). The Design for Six Sigma (DFSS) approach offers a wide range of methodologies which aids the design and construction process and which may be implemented depending on the nature of the project (Brue & Launsby, 2003; Kiemele, 2003; Stamatis, 2003; Yang & Haik, 2003). DFSS employs the IDOV (identify, design, optimise and verify) methodology, during the design/redesign of processes or products (Antony & Banuelas, 2002). IDOV consists of four different phases; the identification phase deals with identifying specific customer needs, based on which a product or business process will be designed. The design phase deals with various issues such as functional requirements, development of alternate business processes ,evaluation of available options, and selection of the most appropriate business process, based on Critical to Quality (CTQs) that were identified during the first phase. The optimization phase utilizes CTQs for assessing the tolerance level of a selected business process, with the help of advanced simulation tools. The last phase of IDOV methodology deals with testing and validating the selected design.

In this study, the techniques defined in IDOV methodology will be applied for Alliance Management Process (AMP) design. We'll use the term "alliance" instead of "customer" which represents all the members of the value chain; like suppliers, customers, society and shareholders for process design. Furthermore, Business Process Management (BPM) principles will be used in IDOV phases. Finally, risk analysis will be examined to determine severity and probability values at the fourth phase in IDOV.

2. Alliance and Alliance Management

According to Association of Strategic Alliance Proffessionals (A.S.A.P., 2002), the definition of an alliance is a close, collaborative relationship between two or more entities that share complementary assets and strengths to create increased value for their customers and their own organizations that could not be accomplished independently.

According to many researchers, alliances can be defined as; a voluntary, evolutionary and flexible organization forms (Osborn & Hagendoorn, 1997), between two or more organizations (Duysters, 2001), to realize both collective and individual goals (Varadarajan and Cunningham, 1995). The main part of the collaborative relationships maintained in the companies include the alliances for value chains. Value chain alliances are the type of long-term alliances between companies and suppliers or customers for mutually beneficial goals. Alliance management enables companies to provide high quality products and services with lower costs, to reach the resources such as expertice, technology and raw materials easily, to direct a wider geography or new segments of an established market. In the literature, alliance management is mostly examined in terms of strategic or as a supplier selection process; however social and operational dimensions are rarely considered in this process which we should define all together to make multi-dimensional analysis indeed. It is obvious for the global companies that they should consider their partnership in social and operational dimensions to maintain sustainability and support their strategies through operational excellence (Tuna & Behret, 2013).

The studies in the current literature show that, alliance management has strategic importance for companies. Therefore, alliance management should be designed and conducted as an Business Process Management concept. Hoffman & Schlosse (2001) considered alliance management as a process and collected alliance management processes under five topics. These are; Strategic analysis and decision to co-operate, Search for a partner, Designing the partnership, Implementation and management of the partnership and Termination of the partnership. In another study, Kale & Singh (2009) determined process steps of alliance management as; Alliance formation and partner selection, Alliance governance and design and Postformation alliance management.

3. Design for Six Sigma, IDOV Methodology

The traditional quality management approaches, such as statistical quality control, zero defects and Total Quality Management have been key actors for many years, while Six Sigma is one of the more recent quality improvement

initiatives to gain popularity and acceptance in many industries across the world (Patil et al., 2013). Six Sigma is one of the powerful business strategies that improve quality initiatives in many industries around the world. . It is a company-wide systematic approach to achieving continuous process improvements.

Design for Six Sigma (DFSS) is a systematic methodology utilizing tools, training and measurements to enable the organization to design products and processes that meet customer expectations and can be produced at Six Sigma quality levels (Mader, 2002). DFSS is an approach that improves quality by redesign the product/process or developed the product/process as per "Voice of Customer" (VOC) or customer requirement (Patil et al., 2013). DFSS is driven by "Critical to Quality" (CTQ) factors, the quality characteristics critical to the customer. DFSS has various problem solving methods that are used worldwide. The following table illustrates different approaches used as DFSS problem solving cycle (Table 1).

Table1: DFSS cycles

DFSS cycle	***Phases***					
DMADOV	Define	Measure	Analyse	Design	Optimize	Verify
DMAIC	Define	Measure	Analyse		Improve	Control
DMADV	Define	Measure	Analyse	Design		Verify
IDOV		Identify		Design	Optimize	Verify
ICOV		Identify	Characterize		Optimize	Verify
DMEDI	Define	Measure	Explore	Develop	Implement	
CDOV			Concept	Design	Optimize	Verify
DCCDI	Define	Customer	Concept	Design	Implement	
DCOV	Define		Characterize		Optimize	Verify
DIDOV	Define	Identify		Design	Optimize	Verify
DMADIC	Define	Measure	Analyse	Design	Implement	Control

Design for Six Sigma (DFSS) focuses on the development of a new process, product or service. IDOV is a common methodology used in DFSS especially in the manufacturing world. The IDOV acronym is defined as Identify, Design, Optimize and Validate. The first step of IDOV, the Identify phase is driven by the "Voice of the Customer" (VOC), identifying customer requirements and performing a competitive analysis to establish the business case for the new design. This phase involves developing a team and team charter, gathering VOC, performing competitive analysis, and developing CTQs. The design phase emphasizes "CTQ Deployment", identifying functional requirements and developing and evaluating alternative concepts and ultimately selecting the "best fit" concept. In the optimize phase, detailed design element are developed and the design is optimized. In the verify phase the design is tested and validated.

4. Business Process Management

Process management is the management of the processes in a systematic way (Aras, 2005). Process management aims to provide the definitions of all the activities in the process manner, to modify and integrate operations in order to achieve corporate goals and improvement of the process in a sustainable system.

Business Process Management (BPM) is based on the necessity of the value added tasks to be performed in the administrative processes. Jeston and Nelis (2006) stated that BPM focuses on the management of business processes in an efficient and effective way. Alexieva (2012) emphasised that BPM is a management approach to achieve efficiency by integrating the business process and to improve the process in accordance with the corporate strategies. Davenport and Short (1990) defined the business process as a set of logically related tasks to perform the desired business outcome.

American Productivity and Quality Center (APQC) classified the process in to two groups; operational, administrative and support processes. In this manner, alliance management can be considered as a business process. Hence, the related process design should be performed based on business process management (BPM) principles

and the requirements of the company should be taken into consideration while designing the process. In a general approach; the phases of the process design are; preparation; defining the objectives, items, owner, relations with other process; determining the performance indicators; pilot implementation and documentation of the process (Aras, 2005).

In this study, alliance management is considered as an administrative business process and the process design steps are determined according to BPM principles as following;

1. Realization of the need for cooperation ;
2. Decision of the alliance type according to the needs;
3. Building and managing the inventory structure for the potential partners in order to select the feasible alliance to meet the needs of the company;
4. Selection of the appropriate partners among the alternatives;
5. Managing and conclusion the coopereation;
6. Performance and risk evaluation;
7. Inventory updating and final documentation.

5. Alliance Management Process Design with DFSS

In this study, IDOV cycle which is a common methodology used in DFSS is applied for Alliance Management Process (AMP) design. The term "alliance" is used instead of "customer" who represents all the members of the value chain; like suppliers, customers, society and shareholders for process design. In the phases of IDOV, Business Process Management (BPM) principles are used. The main steps and contents of the IDOV for AMP design is represented in Table 2.

Table 2: IDOV for AMP design

IDOV cyle	**Content**
Identification	Design requirements (BPM) Process main steps Process Identification Card
Design	Voice of Alliance (VOA) performing works SIPOC Diagram CTQ Diagram
Optimization	AMP main structure (BPM) Alliance aims Partnerships Expert Committees Decision Committees
Validation	Risk analyses (Failure Modes and Effects Analysis-FMEA) Process Management Portal

5.1 Identification Phase

The identification phase deals with identifying specific customer needs, based on which a product or business process will be designed. In this study, this phase includes the determination of the design requirements, determination of the main steps of the process and finally formation of the process identification card. The main steps of the process and process the identification card are structured based on the fundamentals of BPM.

Considering the base studies in the literature; it is obvious that the first step of AMP begins with the realization of the need for cooperation. The decision of the alliance type among the predetermined types will provide good communication skills. It is thought to be a requirement for the process structure to manage the cooperations in a collective and integrated structure in order to keep the inventory records of the potaential partners. Building and managing the inventory structure of the potential partners enables the companies to select the feasible alliance to meet the needs of the company. The cooperation is made with the best-fit candidate among the alternatives; next it is developed and finally ended. Having ended the cooperation, the evaluation of the performance of the cooperation and risk assessment should be made. Recording all the information in each step of cooperation stated above may enable the company to have a strong feedback system and to make a better decision during the selection of the alliance for the next cooperation. The basic flowchart of the alliance managemet process is represented in Figure 1.

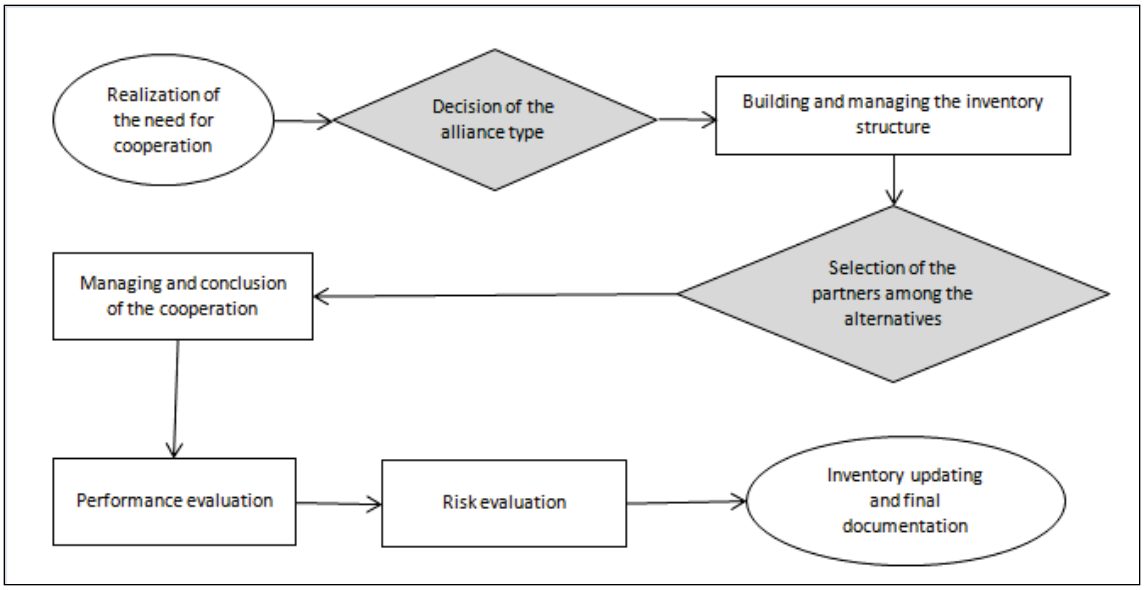


Figure 1: Alliance management process steps

The identification of the processes is one of the main steps of process management. Hence, the firs step of of process documentation is to form the process identification card. The process identification card includes the basic information of the process such as the ID number, the full name, the content, the owner and the basic explanation of the sub-processes of the related process. The process Identification card enables to define the objective and the borders of the process in the beginning of the process design. The process identification card of the AMP is given in Table 3.

Tablo 3: AMP process identification card

ALLIANCE MANAGEMENT PROCESS IDENTIFICATION FORM			
Process Number **:** Management Process-1			
Process Name **:** Alliance Management Process			
Process Leader **:** General Manager			
Process Aim **:** The observance and managementof mutual cooperation to achieve a win-win relationship			
Scope Of Process (Limits): Between "the realization fo the need for cooperation" and "inventory updating and final documentation" including all sub-processes			
Process Relations: All Processes are in relation			
Sub-Process No	**Sub-Process Leader**	**Sub-Process Name**	**Sub-Process Limits**
1.1	All Process Leaders	The realization fo the need for cooperation	
1.2		Decision of the alliance type	
…		…..	……

5.2 Design Phase

In this study, during the process design of the alliance management process; the voice of customer is adapted as the voice of alliance (VOA). Afterward, the SIPOC and CTQ (Critical to Quality) methods are used to identify the expectations of the alliance.

SIPOC diagram is a tool to identify the contents of the Supplier, Input, Process, Output and Customer that belongs to the process. It is also used to define the boundaries of the process. SIPOC diagram is one of the lean six sigma

tool preffered in shaping the business process and in defining the possible measures. This method is used to handle the entire process and to identify the subprocesses and the basic tasks. SIPOC is a powerfull tool to see the whole system and to visualize it in a wider manner. SIPOC diagram shows process activities, components, roles and relationships. It is used to define the process, its limits and stakeholders. It also provides the "cause and effect vision"for to problems to arise. (Madenli, 2006). The SIPOC diagram for the alliance management process is given in the Table 4. This diagram is made for the entire process. This study may be carried on for the subprocesses depending on the requirements.

CTQ Diagram (Critical to Quality) is a lean six sigma tool to identify the expectation of the customer that is necessary for a product, project or a process. CTQs are used to decompose broad customer requirements into more easily quantified elements. CTQ trees are often used as a part of six sigma methodology to help prioritize such requirements. In this study, The CTQ diagram is used to identify the expectations of the partners and the indicators to measure in a concrete way. The CTQ diagram for the alliance management process is shown in Table 5.

Table 5: CTQ Diagram for AMP

Critical to Quality Characteristics					
Process Outputs	***Expectation***	***Importance***	***Indicator***	***Formula***	***Index***
Collaboration	On Time	To establish an alliance when it is necessary	Alliances compliance rate	Collaboration made at the scheduled time / Total collabration number	%
	With the correct institutions / persons	To make cooperate with the best candidate	Work rate (to make cooperate with the best candidates)	Number of cooperations made with the best candidates / Total collabration number	%
	Compatible with the principle of win-win strategy	To ensure winning in all sides	Target realization rate	Number of successful indicators / Total number of indicators	%
Potential Collaborations	Sufficient number	Effective alternative candidate collection	Candidates performance rate in the alternative pool for all branches	Candidate rate in the alternative pool for all branches (supply, customer)	Unit
	Registered	All candidates to register			
Collaboration Risks	Continuously decreasing	Minimum error	Risk reduction rate	Decreasing risk score / Total risk score	%
Collaboration Performances	Maximum efficiency	To obtain maximum efficiency from the alliances	Alliances success rate	Number of successfully completed collaboration / The number of completed collaborations	%

5.3 Optimization Phase

The optimization phase first assesses the process to ensure that all the critical design parameters are being met. The establishment of the basic structure of the alliance managent process is provided in this phase. In particular, types of the cooperations, the goal of the cooperation, the contents and the requirements of the cooperations are identified. Then the required structures are formed to operate the process. The basic concept of alliance within the scope of this study; is the partnership between the institutions which considers and adopts the same goals and interests in accordance with the principle of mutual win-win. Types of alliances are to be determined under three main headings; strategic, operational and social. Strategic alliance covers all of the collaborations related with strategies directly associated with stakeholders including customers and competitors that affect the direction of the company. Operational alliance covers the collaborations in order to improve and to manage operational excellence having the

smaller scopes that do not directly affect the strategies. Social alliance covers all the collaborations to strengthen the image and reputation of the company and to implement the core values.

Types of collaborations are classified according to the purposes such as procurement, sales, training, awareness raising, product development and social requirements, and then each has been described separately in the Table 6.

Table 6: Alliance types

Alliance Type	**Alliance Aim**	**Information**
Strategic Operational Social	Supply	The alliances with suppliers
	Sale	The alliances with customers
	Training	The alliances with trainers and consultants
	Product Development	The alliances with all partners for product development
	Social Necessity	The alliances with universities, civil society and government organizations etc.

Establishing the stable alliances requires finding the proper candidates and then collecting them in a pool with all the significant information. The expositions, benchmarks, visits to companies, internet, advice, training and seminars are the resources of finding the candidates for the alliance necessary for the organisations. Under the objective of each alliance; organizations should find, choose and manage the cooperation with the skilled staff and carry on the cooperations with a professional board. Partnership expert committees are structured according to the different alliance aims (see Table 7).

Table 7: Partnership expert committees

Alliance Aim	**Decision Committees**
Supply	Supply-Quality Management Process
Sale	Sales&Marketing-Customer Relationship- Research&Development –Financial processes
Training	Human Resources- Continuous improvement process
Product Development	Research&Development -Qality- Customer Relationship Process
Social Necessity	All Processes

5.4 Validation Phase

This phase focuses on verifying the final design. This is where the design and processes are tested, analyzed, and changed where necessary. During this phase; a portal structure is configured in order to collect all the related information and to record corporate database. In the portal structure, all of the necessary documents regarding the design process are stored and multi-selective interfaces are used for easy reporting. Next, FMEA study is performed to minimize all the possible risks and to eliminate the potential causes.

Failure Modes and Effects Analysis (FMEA) is most widely used to identify the process risks in the lean six sigma methodology. Chen & Ko (2009) stated in their study that FMEA is a systematic approach to identify and to prioritize potential failures before they occur. In the literature there are a large number of studies related to the FMEA. The traditional FMEA uses risk priority number (RPN) to evaluate the risk level of a component or product/process which is determined by the severity (S), occurrence (O) and detection (D) indexes (Narayanagounder & Palanikumar, 2013). The S - O - D scales used in the this study is originated by Sellepan & Palanikumar (2013). The severity scale represented by (1 – None , 10 – Hazardous), occurrence scale is represented by (1-extremely remote,10-extremely high) and detection scale is represented by (1-almost certain, 10-absolutely uncertainty) during this study.

Table 4: SIPOC diagram for AMP

SIPOC

Who are the suppliers for our product or service?		What do the suppliers provide to my process?		What are the start and end points of the process associated with the problem and the major steps in the process.		What product or service does the process deliver to the customer?		Who are the customers for our product or service? What are their requirements for performance?	
Suppliers (4)		***Input (3)***		***Process (5)***		***Output (1)***		***Customers (2)***	
A-B-C-D	Company internal Process	A (1-2-3).	Strategy meeting results	Start Point:		1	Collaboration	1-4	Suppliers
E-D	Suppliers	B (1-2-3-4).	Revision meeting results	Realization of the need for coopertaion		2	Potential Collaborations	1-4	Customers
F-H	Customers	C (1-2-3-4).	Research results (trades, travels, benchmarking, internet etc.)	Operation or Activity:		3	Collaboration Risks	1-2-3-4	Company internal Process
D-G-H	Society	D (1-2-3-4).	Introducing Presentations	1	Decision of the alliance type	4	Collaboration Performances	2-3-4	SteakHolders
A-C-D-G	Government	E (1-2-3-4).	Supplier Informations	2	Building and managing the inventory structure			1-4	Society
A-B-C	SteakHolders	F (1-2-3-4).	Customers Informations	2	Selection of the partners among the alternatives			1-4	Government
A-B-C	Process Leaders	G (1-2-3-4).	Society Informations	1	Managing the Alliances			1-2-3-4	Holding
C-D-E-F-G-H	Specialist Consultancies	H (1-2-3-4).	Competitor Information	3	Conclusion of the Alliance			1-2-3-4	General Manager
A-B-C	Holding			4	Performance evaluation of the Alliance Risk evaluation of the Alliance				
				End Point:					
				Inventory updating and final documantation					

In the study of Chen and Ko (2009) a conventional form of FMEA includes the following steps; the design function of parts/process, the potential failure mode (categories of failure), the potential effects of failure (measured by the severity index), the potential causes of failure (measured by the occurrence (frequency) index), the detection method (measured by the detectability index), the risk priority number (RPN). Based on the explained steps; the determination of the potential risks of the alliance management process is represented in Table 8.

Table 8: FMEA for AMP

PROCESS	Process Steps / Function	Potential Failure Mode	Potential Effect(s) of Failure	Severity-S-	Potential Cause(s) of Failure	Occurence-O-	Control	Detection-D-	RPN
ALLIANCE MANAGEMENT PROCESS	Realization of the need for cooperation	Unable to create the environment in order to determine the requirement of alliance	Unable to establish stable alliance	8	The absence of institutional approach in alliances	9	None	9	648
	Deciding alliance	Not enough alternative partner candidate	None of the candidate partners provide maximum utility	10	Inefficient working of alliance process leaders and decision committees	8	Yes	9	720
		No standart for the selection process of best-fit alliances	Not able to select the best candidate	8	Absence of communication between process leaders and teams	7	None	8	448
	Implementation of cooperation	Ignorance of the win- win principle	No mutual gain at alliance	9	Absence of systematic approach that provides win-win principle	10	Yes	7	630

After this stage; action plans are prepeared beginning with the process which has the highest value of RPN and the study is conducted regularly. By this method, the risks can be minimized to the negligible values.

6. Conclusion and Future Research

It is inevitable to manage the Alliance Management Process in a systematic and efficient manner for today's companies. For this reason, it must have a well-designed structure and clearly defined standarts. In this study, Alliance Management Process is designed as a as a management process by integrating Business Process Management (BPM) and Design For Six Sigma (DFSS) principles.

IDOV is a frequently used Six Sigma methodology which refers to Identify, Define, Optimize and Verify. It is a variant of Design For Six Sigma (DFSS), which is used for designing a completely new product or business process to meet customer needs and specifications. Throughout the paper, the term "alliance" is used instead of "customer" in order to represent all the members of the value chain; like suppliers, customers, society and shareholders and Voice of Alliance (VOA) is adapted instead of Voice of Customer (VOC) during the process design. In identification phase of IDOV, process requirements and process main steps are determined. In the design phase, SIPOC and CTQ analysis are presented based on Voice of Alliance (VOA). In the optimization phase, process structure is configured and finally in the validation phase, process portal structure is designed and FMEA is applied for the risk analysis.

This study is mainly focus on the overall process design, hence the requirements of the sub – processes are not considered in detail. Selection of the best alliance candidate in the decision step by using multi-criteria decision

making methods and implementation of performance evaluation methods such as balance score card in the performance evaluation step may be considered in the future studies.

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Biography

Banu Tuna, has a double degree from Erciyes University Electrical / Electronic Engineering Depatment and Industrial Engineering Department. She is graduated from Erciyes University Industrial Engineering Master Program in 2014. She has been working as a business development specialist for seven years. She has proffesion at alliance and strategic management, business management and project management.

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A Review of Small Scale Distributed Power Generation Technologies Using Solar Energy

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Abstract

Traditionally, off-grid power generation and supply in remote and inaccessible areas is provided by fossil fuelled technologies such as diesel gensets. Currently the emphasis however has shifted towards deploying renewable energy technologies which are becoming increasingly an important part of many countries power generation infrastructure. Small scale solar energy projects are mainly dominated by PV technology whereas large schemes use Concentrated Solar Power (CSP). This paper gives an insight into current solar energy technologies that can be deployed for power generation either as stand-alone or connected to the main power grid. Then an alternative technology using Stirling Cycle will be described giving its potential application and limitation. A conceived new design of Free Piston Stirling Engine is under research will be discussed and introduced.

Keywords
Power generation, small scale renewable energy technologies, PV, CSP, Stirling engine

1. Introduction
Recent studies found that 90% of CO2 emissions is a result of burning fossil fuel for power generation and transportations [1]. it is projected that oil prices could increase to $225/barrel by 2035 [1]. However, fossil fuels are the main energy source in the world and currently represent more than 75% of the overall energy consumption with a projection to remain the leading energy source to 2035 [2, 3] On the other hand, the global demand for primary energy grows by approximately 1.2% per year on average, that would represent about 36% of the world energy demand between 2008 and 2035 [2]. Meanwhile, demand for electricity worldwide stands at about 20,000 TWh and increases at a rate of 2.3% per year , the largest rise of any other final energy form, accounting for around 80% of today's demand, by 2040 [3, 4]. The demand for electricity per year increases by 2.3% worldwide and it is expected to continue to rise rapidly and more than any other final energy form as it will account for around 80% of today's demand, which stands at about 20,000 TWh by 2040 [3, 4]. Furthermore, other estimations project global demand for electricity to continue the upward trend by around 2.2% per year until 2035, with about 80% of this growth is expected to be in developing countries [2]. In order to meet the demand growth for electric energy, additional generation capacity of about 5,900 GW will be required by 2035 [5]. Hence, growth in power generation will account for about 40% of the all energy production by 2030 [3].

This paper presents a review of electrical power generation using solar energy technologies with a particular focus on Concentrating Solar Power (CSP) technologies.

2. Power Generation Technologies
Fossil fuels such as coal, oil and natural gas remain the main fuels for electricity generation nowadays, and are expected to continue to be the predominant sources of energy in the world up to 2035 [6]. Power plants which are fuelled by fossil fuels, such as gas-turbine (GT), steam-cycle and combined-cycles power stations (CC) generate

approximately 66% of world electrical power[7]. However, about 80% of this power generation around the world is produced by the conventional Rankine cycle (steam turbine cycle) [8]. Moreover, current research works focus on improving the efficiency of the power generation plants using. Combined Heat and Power (CHP), and supercritical steam cycle where the power plant operates at supercritical pressure (greater than 22.06 MPa) [9]. Concerns over energy security because of the rapid increase in the fuel prices and the negative environmental impact of the greenhouse gases emission have led many countries to invest heavily in renewable and low carbon energy technologies. These include solar, wind, hydro, geothermal and biomass as well as clean coal technologies such as carbon capture and storage. Solar power particularly, photovoltaic (PV) technologies as well as wind power have seen an extraordinary growth, and yet hundreds of Gigawatts of new capacities have been installed in recent few years because of the drop in costs and the new policies that address market developments. The current share of electricity generated from renewables, mainly from hydropower, is about 19.3% of the global electricity generation capacity and the growth in renewables increased on average by 2.8% in the last decade [10]. As consequence, renewable energy technologies are growing rapidly, particularly those for electricity generation, which is projected to increase by 3.1% per year in the period between 2008 and 2035 [6]. The global power generation based on renewable resources has been affected by the global financial crisis in 2008. However, the recent estimations indicate that the contribution of renewable electricity generation share will exceed 30% of the total power generation by 2035 [11]. Moreover, the analysis of International Energy Agency (IEA) indicates that up to 1/3 of the global final energy demand may be provided by solar energy after 2060 [12].

Electricity produced from hydro and wind energy is also projected to increase by more than 82% in between 2008 and 2035 [6]. However, the non-hydro renewable energy such as solar, wind, geothermal and bio-energy grows fast as a result of the increase in power demand. The contribution of power generated from non-hydro renewable energy is expected rise from 2.5% in 2007 to 8.6% in 2030 [13], whereas the share of power generated from hydro energy is projected to drop from 16% to 14% at the same period [13]. Renewable sources are alternative sustainable energy sources though their initial cost is relatively high. However, in the long run, they can prove to be cost-effective as the operation and maintenance costs for some renewable technologies, such as PV system, solar thermal and wind turbine are very low and close to zero. Renewable energy technologies are suitable for stand-alone and in hybrid mini-grid applications.

3. Renewable Power Generation Technologies

Renewable sources are alternative sustainable energy sources though their initial cost is relatively high. However, in the long run, they can prove to be cost-effective as the operation and maintenance costs for some renewable technologies, such as PV system, solar thermal and wind turbine are very low and close to zero. Renewable energy technologies are suitable for stand-alone and in hybrid mini-grid applications. Figure 1 highlights the future of renewable generation according to the analysis of International Energy Agency. A percentage above bars represents the contribution of renewable energy technologies over the total electricity generation.

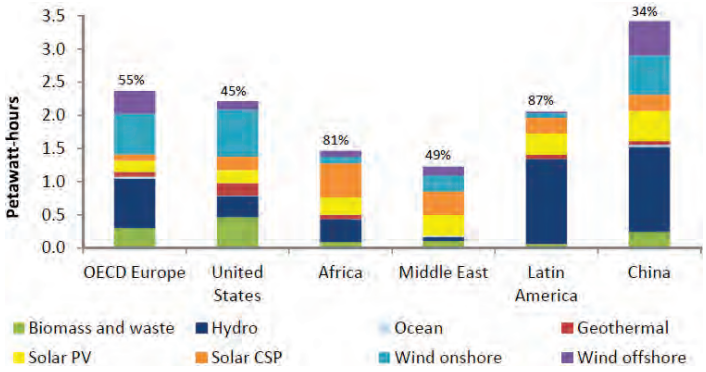


Figure 1: The projection of renewable generation production by regions in 2050 [6]

3.1. Organic Rankine Cycle (ORC)

It is similar to the conventional power plant in its operation principle although the working medium used is an organic fluid instead of water-steam. That result in lower operational temperature (below 300°C), which can be achieved at solar radiation intensity. The mechanism of tracking the sunlight may be eliminate in the ORC, and

cheap materials and relatively inexpensive solar collectors are used in the ORC which reduces capital and O&M costs[14-16].

The Organic Rankine Cycle (ORC) shown in Figure 2 operates on the same principle as Rankine Cycle with the working fluid being of low boiling temperature organic medium. The working medium is the key point in organic Rankine cycle since it influences the ORC power plant performance and cost. Research of ORC has started in early 1970s when an Organic Rankine Cycle System (ORCS) was installed on a diesel engine in order to use the engine coolant as working fluid [17]. The results of the lab test showed that the fuel consumption decreased by about 10-12.7%[18], however, a wide-ranging of advanced organic fluid such as n-pentane, benzene, ammonia, trichlorofluromethane and dichlorodifluoro-methane are currently implemented in the ORC technology still in development [19]. The organic working fluids have characteristics of thermal and chemical stability, high latent heat, high density, high specific heat, low condensing and evaporating pressure and low environmental impacts, which accepts a wide temperature range and increases the cycle efficiency.

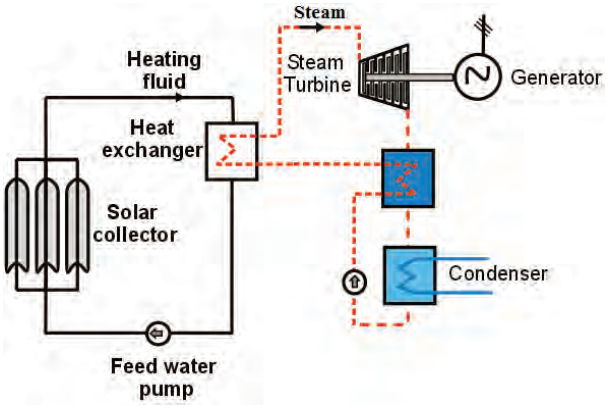


Figure 2: Organic Rankine cycle (ORC)

The increasing requirement for a small efficient sustainable power for economic growth in remote and isolated areas influences the advances and development in the small power plants. ORC be can use with heat from different thermal sources such as solar, geothermal, biomass and industrial waste heat; hence it is an appropriate technology small scale electrical power generation applications [14, 20]. The ORC power plants requires less heat for the evaporation of the working fluid as the evaporation process occurs at low pressure and temperature in compared to the heat required by the conventional steam Rankine power plants. Simple single stage turbine can be used with the ORC plant since the differential in temperature and hence in pressure between the evaporation and condensation is small. The other advantage of the organic Rankine cycle plant over the conventional one is that the need for superheating stage is limited and can be avoided and the blade erosion is not applicable because the expansion process for the most organic working fluids conducts and ends at the vapour state[21].

There are various applications of the organic Rankine cycle utilizing different heat sources, the most common types are:

- ORC biomass power plants, in which biomass fuel is burned and used as heat transfer medium.
- Binary geothermal power plants, which use the geothermal energy.
- ORC in waste heat recovery application, which use the generated heat during the industrial processes, from thermal engines and combustion processes and chemical reactions as heat source.

3.2. Solar Thermal Power Plants

Some references referred to as Solar Thermal Electricity (STE). Currently, even though some parts of the world enjoy high solar radiation and CSP is considered among the most cost-effective renewable energy technologies, it accounts for only 0.5% of total primary energy needs world-wide [22]. However, CSP technologies are progressing and improving and candidate to participate in the greatest share of renewable power generation; therefore, it became a promising and economically competitive technology for countries with abundant sunshine and clear skies like Middle East and North Africa region and. The solar thermal power stations become more reliable when combined with a conventional heat source such as electrical generator or. Fissure 3 in below illustrates the general layout of a combined solar thermal power plant

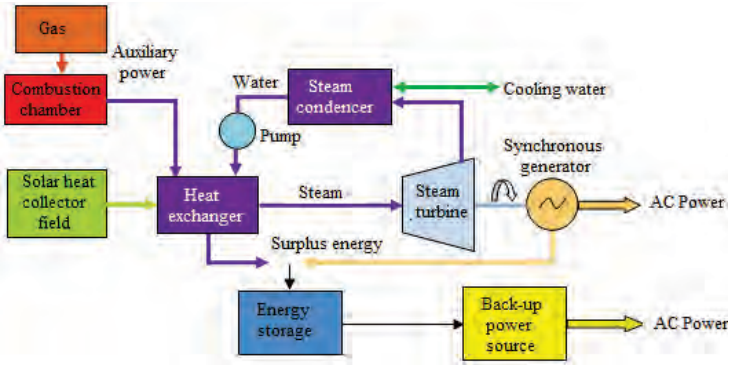


Figure 3: The general layout of CSP power plant combined with conventional heat source and energy storage

4. Concentrating Solar Power (CSP)

Conversion of solar energy to electrical power is mainly accomplished by two distinct technologies: (i) direct solar energy conversion to electricity is performed by photovoltaic (PV) cells, which are made of semiconductor materials. (ii) indirect solar energy conversion to electricity technologies such as Concentrating Solar Power (CSP) where thermal energy is produced by mean of concentrating solar radiation in the focus of the system. CSP power plants use an intermediate working agent (fluid) that undergoes a thermodynamic cycle (such as Rankine cycle) and converts the thermal energy collected from the solar radiation to mechanical energy by rotating the shaft of a heat engine such as steam turbine, micro gas turbine or Stirling engine to produce electricity

Energy produced from CSP can either be used directly for generating electricity or stored in storage systems to be used at peak time. This represents an advantage that is lacking in other technologies such as PV plants where their electrical energy storages on large scale are not economically and environmentally practical.

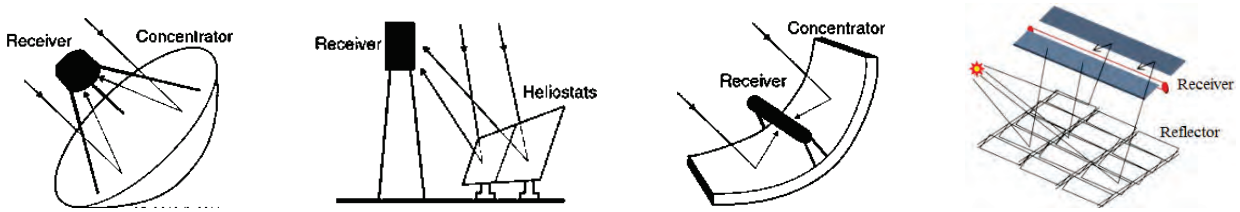
Parabolic trough solar concentrating power plants are the most mature technology among the solar electric generation technologies, as there are several solar electric power plants either operating or under construction. For instance, the American solar thermal plant (SEGS) with a capacity of 354 MW which was installed in 1980s is still operating. Other examples of CSPs include a 1 GW installed in US and 500 MW installed in Spain [12] and there are more under construction or development in different countries in which the total capacity expected to reach 15 GW [23].

Solar thermal concentrating (CSP) can be categorized according the geometry of their focus into: line-focus concentrators (linear Fresnel and parabolic trough), and point-focus concentrators (solar dish or engine dish and power tower) [24]. Additionally, The CSPs can be classified into three main types according to operating temperature; low temperature CSP, generally it operates at lower than 120 °C; medium temperature CSP that operates between approximately 400-500 °C and CSP operates at high temperatures which is more than 1000 °C [25]. The low temperature applications generally used for producing hot water by means of solar flat collectors. The medium and high temperature applications are mainly for electric power generation. In order to reach such a high temperatures, reflecting mirrors or lens configurations receive the sun's radiation, concentrate and reflect it onto thermal receivers. There are various solar thermal receivers (collectors) used to capture the concentrated solar radiations for power generation technologies. Table 1 shows the various categories of the solar thermal collectors (concentrators/reflectors) according to their operational temperature and tracking mechanism.

Table 1: Types of solar thermal collector [12]

Technology	Temperature range (°C)	Tracking mechanism
Flat plate collector	30-100	-
Advanced flat plate collector	80-150	-
Evacuated tube collector	90-200	-
Parabolic trough	70-400	One-axis
Fresnel reflector	100-400	One-axis
Solar dish	500-1200	Two-axis
solar tower	500-800	Two-axis

Although there are different reflect systems and sun-tracking techniques to produce useful energy, the CSP technologies are similar in their principle work. Basically, all of the CSP generators utilize direct solar radiation (Direct Normal Irradiation, DNI) and reflected incident components. Figure 4 shows the most common types of solar concentrating technologies.



(a) Solar dish (b) Solar tower (c) Parabolic trough (d) Linear Fresnel

Figure 4: CSP technologies

Solar concentrating power plants are usually supplemented onsite thermal storage to store solar energy during periods of sunshine and hence extend the number of running hours of the plant. These power plants are also combined with conventional boiler fuelled by fossil fuel when necessary.

CSP plant usually operate according to a thermodynamic cycle as in thermal power plant with the conventional boiler being substituted by solar field composed of concentrators (mirrors or optical devices) receiving the direct solar energy. The solar radiation is reflected onto a special receiver in which a working fluid, such as water/steam, molten salt or synthetic thermal oil, is heated up to high temperature in order to produce steam. The rest of the components of CSP plant are similar to the conventional power plant including a steam turbine, condenser, electrical generator and a water-circulating pump. These power plants are generally grid connected and either used for peak power generation or base load demand. Moreover, recent research shows that the CSP technologies can be used for producing concentrating solar fuel (CSF) such as hydrogen. Table 2 illuminates the operating CSP plants and that in construction in the world.

Table 2: Operational and in construction CSP power plant around the world [26]

Type of CSP plant	Operating	Under construction
Parabolic trough	20	27
Linear Fresnel	3	1
Solar tower	5	2
Solar dish	1	1
Total	29	31

4.1. Parabolic Trough CSP Technology

Parabolic trough collector (PTC) is the most mature technology and lowest cost among the CSP technologies that attracts the greatest interest. The PTCs widely used for power generation with geometrical concentrating ratio is between 20 to 30 and temperature from 300 to 400° C [24], and recently has been developed up to 500 C° [26] or even up to 580 °C [27] are available today. the other application is the industrial process heat (hot water, air conditioning and swimming pool heating) with a geometrical concentrating ration of 15 to 20 and temperature between 100 to 250° C [24]. The main disadvantage of power plant based on parabolic trough field is the low performance of the Rankine cycle since the operating temperature of the solar field is limited to less than 400°C (750 K)[27, 28]. However, the vast majority of existing thermal solar plants, particularly in commercial size use the parabolic trough for thermal energy supply. The first CSP plant at industrial scale in capacity of about 350 MW [26, 28] was built in 1980s in California based on parabolic trough field. The CSP plant mainly consists of two parts as it is shown in figure 5:

- Solar field: it consists of parabolic reflectors or parabolic mirrors concentrate solar energy onto a receiver positioned in the focal line. The receiver trough is a stainless steel pipe with selective coating absorbing solar heat energy and generating high temperature, which can either be used to produce steam directly or to

be stored in a storage tank for a while. The concentrator (reflector) and the receiver (absorber) both of them move and track sun light as it moves from east to west.

- Power generation block: it is similar to Rankine cycle and consists of a steam turbine, a condenser and a pump.

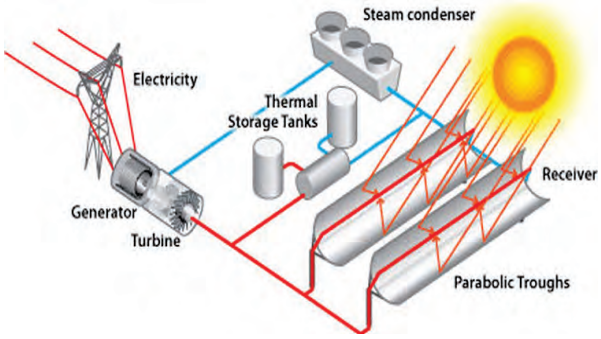


Figure 5: General layout for parabolic trough CSP plant [29]

The parabolic trough provided by one-axis solar tracker and designed to track and collect direct solar irradiation (DNI) then reflect and concentrate the heat energy onto a focal line at its axis. A receiver (tube with selective coating) positioned at the focal line containing a working fluid of, generally, synthetic mineral oil, water or molten salt. PTCs solar field can be integrated with a steam power station in two ways; Indirect Steam Generation (IDSG) in which the molten salt or the mineral oil is used as working fluid that heated in the solar field up to around 400°C. the heat is then used to generate steam through a heat exchanger, which in turn is used to drive a steam turbine for generating electricity [30]. Synthetic oil (thermal oil) is most common use in the parabolic trough commercial solar power plants that connected to the electricity grid [31], with the maximum temperature for thermal storage salts can be as much as 600 °C [27].

The other arrangement for power generation is called Direct Steam Generation (DSG) in which the working fluid is water which is converted to steam (superheated steam) directly in the solar field and then transported to drive the steam turbine [23]. The efficiency of parabolic trough with direct steam generation potentially is higher as a result of higher temperature that can be achieved in the collector receivers. Moreover, they are simpler in terms of design and more economical in terms of cost than IDSG since the stage of heat exchanger is not required. For these advantages DSG has become a promising option for CSP power generation. The drawbacks of DSG are the storage difficulties and the high volumetric flow in the solar field. Projects of pre-commercial systems with a capacity of 3 and 5 MW are under development in Spain [31]. Moreover, there are new working fluid types still under testing, such as pressurized gas and new liquid fluids. The pressurized gas is under testing at the Plataforma Solar de Almeria, thermal solar plant in Spain [23].

4.2. Linear Fresnel CSP Technology

Linear Fresnel reflectors (LFRs) are flat or slightly curved mirrors in their shape but they are similar to parabolic troughs in their operation concept. The optical system (mirrors) concentrates the solar radiation onto receivers of cylindrical parabolic tube at their focus line. Consequently, the working fluid, which is water, is heated up to 285 °C and hence converted to saturated steam which is transferred under pressure of around 70 bar to the steam turbine that drives electrical generator in order to produce electricity [32]. An advanced design known as compact linear Fresnel reflectors (CLFRs) has the advantage of using two parallel receivers for each one row of mirrors, and hence they occupy less land than parabolic troughs and producing the equivalent output.

LFRs are simpler and cheaper than PTC due to the flat shape mirrors and the structural advantages; nevertheless their optical efficiency is lower so their thermal efficiency is only about 26% only [33]. On the other hand, solar field density of LFRs is around 35% [26] which is higher than PTCs (26%) [26], since LFRs consist of small heliostats units based on sharing tracking units that is reduces solar field layout as well as, decreases blocking and shading.

A LFC solar collector shown in Figure 6 is used as a thermal source for CSP power plant instead. LFCs are direct solar power generation power plants (DSG).

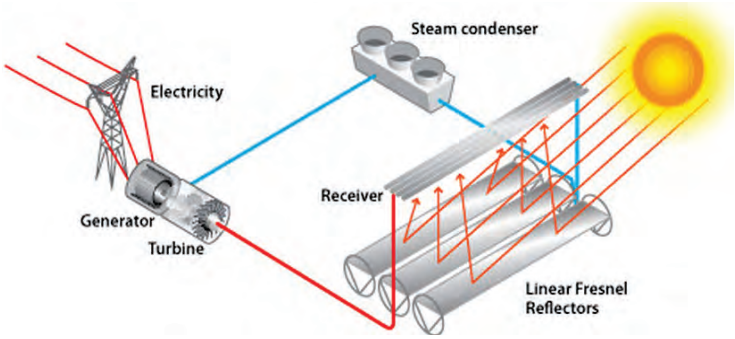


Figure 6: Scheme of CSP plant with Linear Fresnel reflectors [29]

4.3. Solar Tower

It is a central receiver system (CRS) in which a solar field of Fresnel reflectors (flat heliostats) with two tracking axes concentrate the sun rays onto a receiver at the top of tower that is located in the centre of the field. A higher operating temperature and higher thermal conversion efficiency and hence greater power conversion efficiency than the line focus concentrates technologies due to the two-axes tracking mechanism enables a large concentrated solar radiation. Solar tower produces directly a superheated steam as a result of the high temperature that can be achieved in the receiver that can be up to 1000 °C [34]. Recent developments increased the receiver temperature to above 1200 °C[35]. However, air is used as heat transfer fluid in the receiver where it is heated and transferred to a steam boiled to produce steam; and other types of heat transfer fluid may be used such as molten salt or liquid sodium. The receiver is usually made of ceramic or a metal that can withstand the high temperature and energy density. Solar tower can also be used for concentrated solar chemical applications to produce solar fuel such as hydrogen and melting of metals that require high temperature. Figure 7 illustrates a schematic view of the largest solar tower power plant in the world, with a capacity of 377 MW located in the Mojave Desert, USA. The plant has undergone successfully first functional trials and is almost ready for full operation [33].

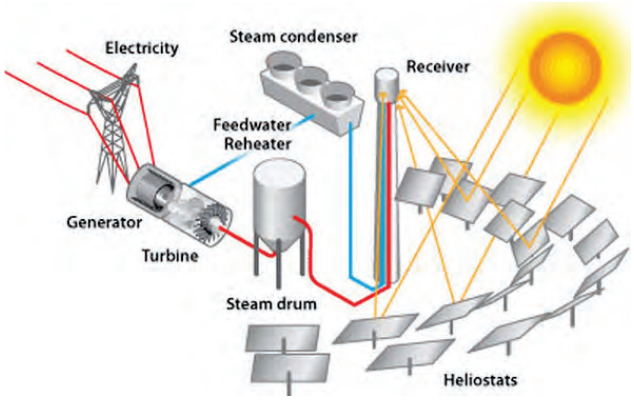


Figure 7: Schematic view of solar tower power plant [29]

5. Stirling Engine

Stirling engine is not a new technology, its invention dates back to 1816. However, there is currently a renewed interest in its application for small scale power generation using both fossil-fuels and renewable sources of energy including solar and biomass. The market of Stirling engine however is still very limited to specific applications. Theoretically Stirling engine operates on the most efficient thermodynamic cycle. However, in practice the typical efficiency is limited between 30 to 40% depending on the temperature range which could be as high as 1073 °K and with typical rotation speed range of 2000 -4000 rpm [36, 37]. Being an external combustion heat engine, Stirling engine lends itself well to using solar energy in its concentrated form.

5.1. Solar Dish

A parabolic dish solar uses two axes to track the sun and concentrate incident solar radiation onto a single focal point above its center where a receiver is mounted. Using a Stirling engine as an active thermal receiver to convert

incident solar radiation into electrical power is very effective in that the entire system (the parabolic dish and the engine) tracks the sun and there is no need for a heat transfer fluid and associated heat exchanging equipment.

Dish concentrating solar energy also uses a central receiver systems and known as an on-axis tracking system. Parabolic dish concentrates solar radiation into a receiver at focal point above the centre of the dish as it is shown in Figure 8. The vast majority of the solar dishes have a Stirling engine as a generator at their focus. For that reason, the design reduces the need for heat transfer fluid (HTF) and cooling water. The entire system (the parabolic dish and the engine) tracks the sun as they rotating in two axes in order to achieve the highest levels of the solar radiation. The Stirling engine-dish combination is considered to be the efficient technology in terms of energy conversion among the CSP systems. Single units are usually of small scale systems with a typical power output capacity of around 25 kW [33]. However, multiple units can be used in the form of a solar farm for large power generation. Currently there are only two solar dish plants, one is active with capacity of 1.5 MW in the USA and the other is under construction in Spain [30].

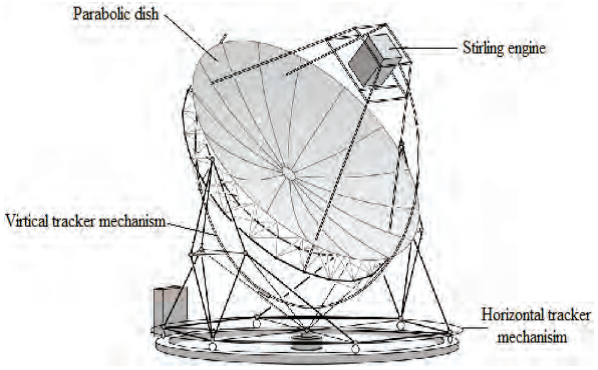


Figure 8: Parabolic dish

The geographical location of Libya which lies in the so called “sun belt” region is a huge potential for solar energy technologies. The incident solar radiation averages 5 kWh/m2/day and a daily sun shine of 9 hours resulting from a yearly harvestable solar energy of 140,000 TWh [38]. This huge energy resource could be exploited for powering remote communities which are not economical to be connected to the national grid as well as for water pumping and irrigation. Hence, a Stirling engine-solar concentrating dish system could be a feasible solution among the CSP technologies for the Libyan hot climate.

6. Photovoltaic Technology

Solar cells or Photovoltaic cells (PV) convert the sunlight into electricity directly without need for heat engine to interfere. PV panel (PV module) compose of a sum of PV cells and rated in peak Watts (Wp). The peak watt (Wp) is the electrical power produced by the PV module when it is hit directly by sunlight on a clear day or illuminated by any light source. However, the peak watt is measured under certain conditions, which is known the standard conditions, of 1000 W/m2 intensity at 25 °C ambient temperature and 1.5 air mass (AM) [28]. Air mass (AM) is the sunlight (the spectrum) passes through the atmosphere when the sun is at 42° elevation from the horizon [28]. However, PV cell in average produces only about 20% of its Wp rating in the year, because of the variations in insolation over the day time and cloud cover [28].

Solar cell is recently becoming a mature technology for power generation, yet solar PV generators only produce 0.1% of the total electricity worldwide [39, 40]. On the other hand, it is investigated that PV installation is the fastest growing technology of renewable power technologies around the world in the last decade as it has grown from only 1.5 GW in 2000 to reach 65 GW in 2011 [10]. Moreover, some reports indicated that solar PV is growing annually in the average of 40% [39] and projected to continue growing due to the ongoing R&D to improve the efficiency of the solar cell and technical advances [39]. In addition, the PV unit cost has decreased to approximately one third of its cost 5 years ago [39, 40] which will identify PV generators as one of the major power generation infrastructure in the world. Furthermore, some reports claim that, according to future prediction, solar PV generators will produce around 345 GW that is about 4% of the global electricity by 2020 and rising to 1081 GW in 2030 [39].

PV power generation system can be either connected to the national grid such as that shown in Figure 9 or operates as a stand-alone system in remote and rural areas in which its general layout similar to that in figure 10.

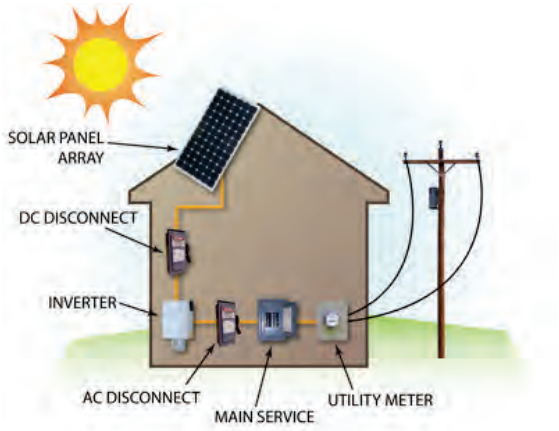


Figure 9: Grid connected solar system [41]

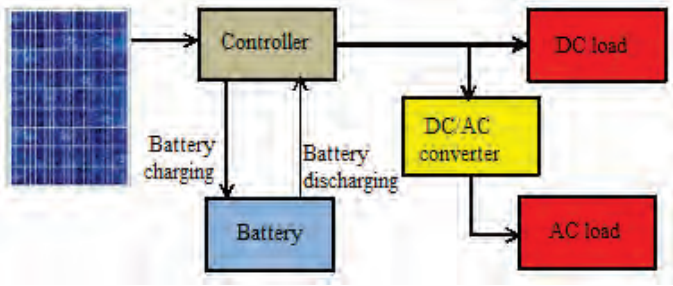


Figure 10: Stand-alone PV system

Standalone PV generators have been used in Libya since 1976, but it become even successful after 2008 when Al-madar Al-jadid for mobile phone network has established and set up more than 100 GSM (Global System for Mobile communications) sites supplied by PV generators with average capacity of 10 kWp/site and a total installed capacity of 1.25 MWp. Currently there a planned project in Libya for a 14 MWp grid connected PV station to be sited in Aljufrah and is estimated to generated about 27 GWh per year [42].

8. Conclusion

An overview of solar energy technologies for small and large scale power generation using both solar radiation concentrating and harvesting technologies and direct conversion have been presented. The focus was on technical properties, advantages and limitations and examples from current practice. Although, standalone PV systems have had generally good success in the Libyan climate and more compact solar technology sung SCP in combination with Stirling engine could be a viable alternative power supplier for small scale loads in the remote and rural areas of Libya.

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A Model Suggestion for Measuring Dynamic Capabilities

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Abstract

Dynamic capabilities approach is a very challenging issue in resource-based view literature which is based on firms' resources and the effects of these resources that provide competitive advantage to firms. According to this approach, firms that have dynamic capabilities can extend and/or modify their operational capabilities and update their skills and competences which is required to be able to survive in today's ever-changing environment. The literature on dynamic capabilities has expanded continuously in recent years and the emphasis has ranged from researching the impacts and contributions of dynamic capabilities on firm performance to determining their relationships with organizational learning culture, intellectual capital, etc. Some of the studies available in this field suggest measurement models to operationalize dynamic capability concept for specific issues or departments, but there is not any proposed general model that can be used by whole industries. In this study, we focus on determining the constituents of dynamic capabilities which are available for general usage and how they can be measured, extending the existing measurement models in the literature. Firstly, the studies that operationalized dynamic capabilities were researched and then a dynamic capabilities measurement model that can be used within overall industries was suggested. Finally, model's constituents were given in detail.

Keywords
Competitive advantage, operational capabilities, dynamic capabilities, environmental turbulence.

1. Introduction
A central concern of a firm's overall strategy and management is to maintain a dynamic fit between what a firm offers and what the environment dictates. As such, a firm must possess dynamic capabilities so as to constantly reconfigure, renew and redeploy its resources and capabilities to better capture the changing opportunities (Teece et al. 1997). Precondition for a dynamic capability to integrate and reorganize a firm's resources is that, the firm has enough resources; otherwise, it must search and absorb resources from external environment. If the organization boundary is regarded as a cut-off point, dynamic capabilities include not only the integration and reorganization of internal resources and knowledge, but also, the absorption and coordination of external resources and knowledge (Xin, 2010) as well.

Teece (2007) proposes a dynamic capabilities understanding consisting of three dimensions, such as, sensing, seizing and reconfiguring capabilities, in order to transform the resources and processes to newer, firm-specific, difficult-to-imitate and difficult-to-replicate resources and assets. Teece (2007) aims to develop a model for measuring a firm's dynamic capability level. There are numerous studies in the literature suggesting dynamic capability measurement models for some specific issues, industries or departments, but none of these models is appropriate for making measurements in all industries. To fulfill this gap in the literature, subcomponents of dynamic capabilities are determined and explained, i.e., a general measurement model is proposed in this study, in order to perform the measurement process manageable easily.

The paper proceeds as follows: First, the literature survey on dynamic capabilities, especially the studies proposing a measurement model for dynamic capabilities, is summarized. Secondly, the suggested measurement model is presented. Finally, explanations concerning the contribution of this paper to the dynamic capabilities literature, the method suggestion for evaluating the results of the survey data, and future research directions are given. This paper's content is confined by suggesting a measurement model; but, the application of the suggested model is being carried out in the manufacturing industry of Turkey.

2. Dynamic Capabilities View

Resource based view regards the firm as a bundle of resources and emphasizes that competing firms possess heterogeneous resource bases (Grant, 1991). Resources are defined as assets that are useful in the production process (Amit and Schoemaker, 1993) and cannot be purchased or acquired from the market. Moreover, even if they could be purchased, these capabilities generally have a relatively short life; therefore, any advantage that can be gained, must be through the organization's distinctive routines or evolutionary process (Barney, 1986).

According to the resource based view, a firm's resources, particularly the intangible ones (such as, intellectual capital, patents, etc.) enable that firm to attain and sustain superior performance (Eisenhardt and Schoonhoven, 1996). Although, dynamic capabilities approach follows the resource based view, Pavlou and El Sawy (2011) claim that resource based view emphasizes resource picking (selecting resource combinations), while dynamic capabilities emphasize resource renewal (reconfiguring resources into new combinations of operational capabilities).

Teece et al. (1997) point out the terms "dynamic" and "capabilities" separately. The term "dynamism" refers to the capacity to renew competences, so as to achieve congruence with changing business environment, while the term "capabilities" emphasizes the key role of strategic management in appropriately adapting, integrating, and reconfiguring internal and external organizational skills, resources, and functional competences to match the requirements of a changing environment. Teece (2007) customizes the dynamic capabilities as sensing the environment to seize opportunities and to reconfigure assets. In detail, sensing activity includes scanning and monitoring changes in the operating environment and identifying new ideas; seizing activity focuses on linking the innovativeness to products and markets; and reconfiguring activity deals with aligning the firm's resources and capabilities (Jantunen et al., 2012).

Dynamic capabilities may be seen as the processes where resources are acquired, integrated, transformed or reconfigured to generate new value-creating firm-based activities (Eisenhardt and Martin, 2000). According to another excessively referred definition, dynamic capability can be described as the capacity of an organization to purposefully create, extend or modify its resource base (Helfat et al., 2007). This approach emphasizes that dynamic capabilities reflect how organizations develop firm-specific capabilities and competences in environmental dynamism (Teece et al., 1997). Here, there is an issue that needs a brief explanation regarding the difference between the terms "competence" and "capability". Capabilities represent a system's separate components, while competences represent its realized proficiencies, or briefly, it can be stated that capabilities are the "building blocks" of competences. While a company can have as many as 30 or more capabilities, it may have less than 5 or 6 competences (Prahalad and Hamel, 1990).

Dynamic capabilities are viewed as tools that enable the reconfiguration of existing operational capabilities. Operational capabilities are "zero-order" capabilities which aims "earning a living by producing and selling the same product, on the same scale and the same customer population" (Winter, 2003). Thus, dynamic capabilities would correspond to the exploration of new opportunities, whereas operational capabilities would correspond to the efficient exploitation of existing resources (Pavlou and El Sawy, 2011). In a similar vein, Zollo and Winter (2002)

define the dynamic capabilities as a learned and stable pattern of collective activity through which the organization systematically generates and modifies its operating routines in pursuit of improved effectiveness.

In the literature, number of studies about dynamic capabilities has extended too much in recent years. Although, Teece et al. (1997) has developed this strategic management frame, their study takes Schumpeter's (1934) innovation-based competition as a basis, in which competitive advantage was based on the "creative destruction" understanding. In the literature, different authors and researchers treat the dynamic capabilities concept differently. Their treatments vary in terms of the focus and the aim of the study, or the acknowledged description. Some studies aim to develop an explanatory model in order to clarify the direct, indirect or moderating affect of dynamic capabilities on a firm's performance; some intend to determine the subcomponents of dynamic capabilities, and others scrutinize the relationship between dynamic capabilities and learning, or human capital, process alignment, etc. Most of them suggest measurement models for specific issues so as to operationalize dynamic capability concept, but, a general measurement model has not been developed yet.

This paper exploits the studies suggesting measurement models in the literature. These models can be divided into two groups: First group tries to determine the subcomponents of dynamic capabilities and use them in measurement; second group focuses on measuring the dynamic capabilities directly, not exhibiting the relevant components. Studies that can be classified into these two different groups, examine the dynamic capability concept in terms of their relations with some specific organizational issues, such as, "organizational learning".

First group of papers have an explanatory approach in terms of explaining dynamic capabilities and decompose the concept into its components. Pavlou and El Sawy (2011) explored the constituents of dynamic capabilities and defined them as an "elusive black box". They proposed a measurable model including sensing, learning, integrating and coordinating capabilities. Their model is limited and suitable to assess new product development activities of the firms. Therefore, the modified versions of these constituents are used in the measurement model proposed in this study. McKelvie and Davidsson (2009) measured four dynamic capabilities (i.e., idea generation capability, market disruptiveness capability, new product development capability and new process development capability) in new firms. These constituents are not usable in all industries, the focus is on new firms, and there are some difficulties in determining the level of dynamic capabilities.

Second group of papers have direct focus on dynamic capabilities and do not determine their subcomponents. Hsu and Wang (2012) developed and tested a theoretical model explaining how dynamic capability mediates the impact of intellectual capital on performance. Dynamic capability measure includes, only the change percent of expenditures about the improvements regarding the activities of two specific departments: R&D and marketing. Dynamic capability concept is measured only with financial data, so, their approach is limited. Arend (2012) aimed to explore a different type of dynamic capability, ethics-focused dynamic capability and have distinct measures for both types of capabilities. Drenevich and Kriauciunas (2011) aimed to exhibit the link between the environment and usage of operational and dynamic capabilities. Their study has a general view and does not try to determine the constituents of dynamic capabilities. It focuses on general dynamic capabilities and their heterogeneity.

Marcus and Anderson (2006) studied the firms' general dynamic capabilities in relation to its potential for breeding competences, while the firm achieves its business and social goals. The paper defines two types of capabilities. The first one is the firm's general dynamic capability and the second one is the firm's environmental capabilities which include four subcomponents: employee training and education, technical analysis, and advanced recycling & basic recycling. In this study, the focus is on environmental capabilities, and dynamic capability is measured simply in order to be able to use the model in different industries. Zott's (2003) study explored how the dynamic capabilities of firms may affect differential firm performances within the same industry, by using a simulation method. The paper has a great contribution to the literature, as it introduces a conceptual model but the model does not have any chance to be applied with real industry data.

The strategic management literature has a greater extent regarding researches which investigate learning of organizations. Also, an important research area including learning studies takes a part in literature in relation to dynamic capabilities approach. Lichtenthaler and Muethel (2012) argued what the role of deliberate and experiential learning in developing dynamic capabilities may be. They mentioned three different types of capabilities which could be referred to Teece (2007)'s study: sensing capacity, seizing capacity and transforming capacity. The study takes part in first group which contains subcomponents of dynamic capabilities but doesn't have a general dynamic

capabilities view. Similarly, Lee et al. (2011) elaborated that the firm's learning intent and embedding learning, influence the emergence of dynamic capabilities. The study focuses on market and hierarchy governance structures and does not introduce any subcomponent of dynamic capabilities. Similarly, Hung et al. (2010) tried to clarify whether dynamic capability is created via organizational learning and focuses on learning culture and process alignment or not. They approach dynamic capability with three different types: organizational strategic capability, R&D innovative capability, and organizational management capability. These constituents are directly related with management of organizations and don't have any general usability.

Thus far, we summarized some of the studies consisting dynamic capability measurement models, and our measurement model is given in detail in the following section.

3. Dynamic Capabilities Measurement Model

As mentioned above, Teece's dynamic capabilities approach includes three stages/steps/constituents, which a firm has to possess, in order to change itself and conform to the changing business environment: (i) sensing capability, (ii) seizing capability and (iii) reconfiguring capability. Each stage has its own constituents and measures which will be used to operationalize these stages, for the purpose of measuring dynamic capabilities which a firm possesses actually.

We define each measure, i.e., the groups of questions representing the stages of dynamic capabilities. The questions are organized as expressions to be answered by the top managers of the firms, using a 5-point interval scale, ranging from strongly disagree to strongly agree. The main question of the assessment is stated as "Considering your firm, please mark the most appropriate expression among five-point scale for each question below". Figure 1 demonstrates the components of suggested measurement model of dynamic capabilities.

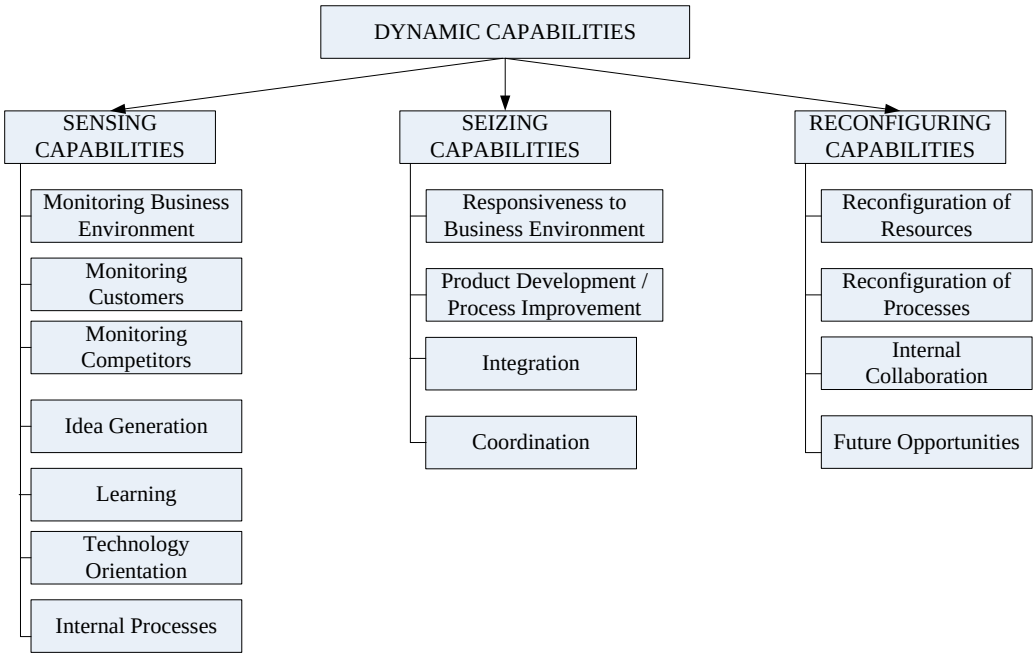


Figure 1: Constituents of the dynamic capabilities measurement model

3.1 Sensing Capability

Sensing capability is defined as the ability to spot, interpret, and pursue opportunities in the business environment (Pavlou and El Sawy, 2011). Additionally, this capability can be accepted as the capacity of effectively monitoring the opportunities on time and determining the trends or change needs of firm's operational capabilities. Our measurement model has seven subcomponents in order to evaluate a firm's sensing capability.

3.1.1 Monitoring Business Environment

This constituent has two questions that assess directly the firm's capability to monitor its business environment. Main purpose of these questions is to determine a firm's capability of identifying new business opportunities and threat possibilities frequently and quickly. Questions are derived from Hung et al. (2010) and Pavlou and El Sawy (2011).

- We frequently scan the environment to identify new business opportunities.
- We own ability that can fast aware new business opportunity or threat possibility.

While monitoring the business environment has direct questions about general business environment, we have two main ingredients for monitoring the external environment additionally: monitoring customers and monitoring competitors.

3.1.2 Monitoring Customers

Customers might be changing the trends or their treatments. Therefore, firms aspiring to conform to these variations about customers, must have to determine them primarily. We add four questions to the model. First two questions are about the change in customers and market segments. Third one is about matching the product development efforts to the customer needs and the last one searches information about competitors' customers. Questions are derived from Hung et al. (2010), Lee et al. (2011), Pavlou and El Sawy (2011), and Janssen et al. (2012).

- We periodically review the likely effect of changes in our business environment on customers.
- The firm is strong in distinguishing different groups of users and market segments.
- We often review our product development efforts to ensure that we are in line with what the customers want.
- We periodically search for information about that which customers our competitors supply.

3.1.2 Monitoring Competitors

The latter of business environment components, is competitors. Competitive scanning capabilities are critical to firm competitiveness; because a firm formulating its strategies needs to scan the external environment for gathering information about its competitors and identify strategic opportunities or threats that can be originated from competitors. We define 4 questions for this constituent. First two questions are about strategies, tactics and market shares of firm's competitors, identifying a firm's competitors' positions against it. Third one is about a firm's responsiveness to strategic moves of competitors and the fourth one is about a firm's pressure about creating changes in the market. Questions are adapted from Marcus and Anderson (2006), McKelvie and Davidsson (2009), Hung et al. (2010) and Protogerou et al. (2011).

- We regularly monitor our competitors' strategies and tactics.
- We periodically collect information about our competitors' market share.
- We can succeed to response timely to competitive strategic moves.
- Our firm generally initiates changes that our competitors are forced to thereafter react to.

3.1.3 Idea Generation

It has its roots in the entrepreneurship and innovation. The ability of a firm to develop new ideas for future entrepreneurial action is generally accepted as being a precursor for firm-level innovative behavior and may be a source of competitive advantage, if firms are able to capitalize on their ideas. The three questions given below are taken directly from Marcus and Anderson (2006) and McKelvie and Davidsson (2009).

- We constantly search for new ideas and methods.
- We have more promising ideas than we have time and the resources to pursue.
- We never experience a lack of ideas that we can convert into profitable products/services.

3.1.4 Learning

Teece et al. (1997) defines learning as a process by which repetition and experimentation enable tasks to be performed better and quicker and it also enables new production opportunities to be identified. Thus, once a market opportunity is identified, it must be addressed with new products, which requires a decision to revamp existing operational capabilities with learning, and new knowledge and skills (Teece, 2007). Learning activities also help groups become more proactive by enhancing their creative capacity. We have 4 measures to measure the knowledge assessment of a firm. First three questions are about gathering information, producing knowledge, and utilizing knowledge. Fourth question is about learning by using information gathered from other organizations and it may be

also seen as a specific way of collecting information. Pavlou and El Sawy (2011), Arend (2012) and Janssen et al. (2012) are adopted for these expressions.

- We have effective routines to identify, value, and import new information and knowledge.
- We have adequate routines to assimilate new information and knowledge.
- We are effective in utilizing knowledge into new products.
- We think that collaboration with other organizations helps us in improving or introducing new services.

3.1.4 Technology Orientation

This measure relates to keeping up-to-date of market developments. Being familiar with the latest technologies can be useful inspiration for modifying the services or products a company provides. Also knowledge about modern technologies is often essential for adaptation and renewal of the interaction-process. We use Janssen et al. (2012)'s approach to assess a firm's technology orientation capacity. First two questions search for technology monitoring activities of firm and the third question is about the source of information, regarding technology usage for identifying possibilities.

- We think that staying up to date when promising new products, services and technologies is important for our organization.
- We follow which technologies our competitors use.
- In order to identify possibilities for new products or services, we use different information sources.

3.1.5 Internal Processes

Internal processes include data collection about a firm's internal processes. Specifically, we focus on two dimensions: first one is about a firm's quality and continuous improvements understanding for the purpose of better firm performance (Lee et al., 2011). It includes analyzing variability in operational processes and outcomes through systematic data collection. Promoting trial and error experimentation is an example for this type of data collection (Marcus and Anderson, 2006). Second dimension is about a firm's strengths and weaknesses. It can also be related to R&D innovative capability, because of novelty creating nature of R&D operations in pursuance of strategic decisions (Hung et al., 2010).

- We routinely collect data regarding our company's production or management process variations.
- We have the ability to evaluate our own organization's strength and weakness.

3.2 Seizing Capability

Once a new technological or market opportunity is sensed, it must be addressed through new products, processes, or services. This almost always requires investments in development and commercialization activity (Teece, 2007). In particular, it involves the transfer of knowledge to the implementation. Therefore, it refers to the realization of the opportunities that have been identified, based on a firm's sensing capability (Lichtenthaler and Muethel, 2012). Our measurement model has five subcomponents so as to measure a firm's seizing capability.

3.2.1 Responsiveness to Business Environment

This dimension has several questions measuring general responsiveness level of the firm to the business environment. First three questions are introduced by Arendt (2012) and they are added to this model suggestion for assessing a firm's level in terms of the ability of lessening market uncertainty and responding to opportunities on time. The last two questions are about creating new relationships in accordance with the knowledge handed by the firm about creating operations for, and augmenting, the responsiveness level by means of other organizations and customers. They are derived from Drnevich and Kriauciunas (2011) and Cao (2011)'s studies.

- We have enhanced our ability to reduce market uncertainty.
- We have enhanced our ability to respond to market opportunities in time.
- We have enhanced our responsiveness.
- We can thoroughly create effective relationship with our stakeholders.
- We can successfully create new customer relationships.

3.2.2 Product Development / Process Improvement

Product innovation and improvements on methods and processes are major components of dynamic capability concept because of their nature of creating innovation. Seizing opportunities means changing itself and taking actions in convenience with the unstable customer needs and exceeding the competitors by appealing the customers' attention firstly.

We have 4 questions to measure a firm's product development capability. First three expressions are about developing new products, using new ideas, and investing. The last question measures a firm's product/service innovation performance, and the quality and quantity of new products/services relative to its competitors. These questions are derived from McKelvie and Davidsson (2009), Hung et al. (2010), Drnevich and Kriauciunas (2011), Pavlou and El Sawy (2011) and Arend (2012).

- We devote a lot of time to implementing ideas for new products or services and improving our existing products or services.
- We heavily invest in innovation and development of new products or services.
- Over the past few years, our firm has released very many new products or services to the market.
- Relative to our two most important competitors, we have a good position in terms of our firm's performance over the past few years, concerning the development of new products or services.

The suggested model has two expressions measuring process improvement level or capability of a firm. The first question is introduced for detecting the process innovation position of the firm relative to its industrial competitors and the second one is about the timing and direction (which innovation alternative will be chosen and how this innovation will be realized) of R&D operations. We utilize McKelvie and Davidsson (2009) and Hung et al. (2010) in order to put the questions in our model for measuring process improvement capability of a firm.

- Our firm is often the first firm to introduce new systems, production methods etc.
- We have the ability to know the direction and timing for R&D.

3.2.3 Integration

Reconfiguration capability relies on integrating new resources and assets, because the reconfiguration of existing operational capabilities requires a collective logic and shared interaction patterns (Pavlou and El Sawy, 2011). The knowledge, which a firm needs, is created by learning, and integration capability conveys this knowledge to reconfiguring capability, so as to provide the coherence of the firm to the turbulent environment. Because new knowledge is mostly owned by individuals, it must be integrated to a collective level in order to make it operationalized. We have two questions measuring the firm's integration capability and these questions consider integrating individual's knowledge to the group.

- We are forthcoming in contributing our individual input to the group.
- We have a global understanding of each other's tasks and responsibilities.

3.2.4 Coordination

Coordinating capability is defined as the ability to orchestrate and deploy tasks, resources and activities in the new operational capabilities (Pavlou and El Sawy, 2011). Teece et al. (1997) alleged that dynamic capabilities are embedded in distinct ways of coordinating. Thus, coordination activities have gained significance in terms of assessing the seizing capability of a firm. We have four appropriate items to value the coordination capability of a firm. First two expressions are related to the synchronization of individuals' merited tasks and the outputs of their works while "working as group" activities. The model includes third expression, because of its allocation focus about sharing resources among individuals and/or groups fairly. The last one is about the coordination with community and it has a social meaning regarding gaining the same or the similar benefits for both the firm and the community. The questions below are derived from Pavlou and El Sawy (2011), Hung et al. (2010) and Arend (2012).

- We ensure that the output of our each department/team is synchronized with the work of others.
- Group members are assigned to tasks commensurate with their task relevant knowledge and skills.
- We ensure an appropriate allocation of resources (e.g., information, time, reports) within each department.
- We succeed to coordinate with community to fulfill mutual needs.

3.3 Reconfiguring Capability

In rapidly changing environments, there is obviously value in the ability to sense the need to reconfigure the firm's asset structure and to accomplish the necessary internal and external transformation. This requires constant surveillance of markets, technologies and the willingness to adopt best practices (Teece et al., 1997). Briefly, reconfiguring capability refers to maintaining competitiveness by redirecting a firm's processes. It is corresponded with the ability to recombine and to transform assets and organizational structures, as markets and technologies change. Therefore, a firm has to reconfigure their interfaces with other processes (Lichtenthaler and Muethel, 2012). We define 4 measures to assess the occasion of a firm whether it has possessed reconfiguring capability or not.

3.3.1 Reconfiguration of Resources

Teece et al. (1997) argued that the strategic posture of a firm is determined not only by its learning processes and by the coherence of its internal or external processes and incentives, but also by its specific assets. Therefore, a firm has to transform its resources to distinctive assets which are not easily imitated or replicated by other firms. These assets can be classified into seven different categories: technological, complementary, financial, reputational, structural, institutional and market (structure) assets. Such assets determine a firm's competitive advantage at any point in time. We have three questions for reconfiguration given below. First two questions measure the transformation capacity of a firm as explained above. The last question assesses the reconfiguration capability of a firm's resources, in terms fair and suitable resource deployment. Pavlou and El Sawy (2011) and Arend (2012) are adapted for these measures.

- We can successfully reconfigure our resources to come up with new productive assets.
- We often engage in resource recombination to better match our product-market areas and our assets.
- We have enhanced capabilities of resource deployment.

3.3.2 Reconfiguration of Processes

The firm's processes and positions (assets and organizational boundaries) collectively encompass its competences and capabilities. By this transformation or reconfiguration activity from processes to capabilities are expected to create firm-specific routines. We determine 5 different expressions in order to assess a firm's reconfiguration capability of processes. First three expressions are derived for determining the transformation capacity of a firm directly. The fourth expression has a focus on the importance of experimentation and learning-by-doing activities. Finally, the last question assesses the firm's position against its competitors, regarding the newness of product development methods.

- We can successfully reconfigure our processes to come up with new productive assets.
- Over the past few years, changes to our product lines have been radical.
- We often engage in process recombination to better match our product-market areas and our assets.
- We choose to implement new business processes which are determined by our experimentations.
- Relative to our two most important competitors, we have a good position in terms of our firm's performance over the past few years concerning the development of new product development methods.

3.3.3 Internal Collaboration

Several researchers have identified collaboration as a means of reducing inter-functional and inter-organizational conflict and promoting the development of a distinctive relational advantage. Allred et al. (2011) argued that several theories implicitly or explicitly inform the importance, development and impact of collaboration as a dynamic capability. Thus, we have five questions to assess internal collaboration capability of a firm.

- Information applications are highly integrated within our firm.
- Our firm's middle managers are more empowered to make operating decisions than five years ago.
- More process-oriented performance measures are tracked today than five years ago.
- Our firm's organizational culture promotes collaboration across functional areas.
- Our employees are more empowered to make operating decisions than five years ago.

3.3.4 Future Opportunities

Dynamic capabilities understanding include a direction for the future perception. This issue is related with the willingness and persistency of a firm, in terms of its assessment about the flexibility of pursuing competitive opportunities in the future, as same as now. The question is adopted from Hung et al. (2010).

- We own future competitive flexibility in industry.

4. Conclusion

Dynamic capabilities can be seen as a newer approach which had been originated from the resource-based view of strategic management. While resource-based view emphasizes resource picking (selecting resource combination), dynamic capabilities stress resource renewal (reconfiguring resources into new combinations of operational capabilities) and transformation of resources to rival better against the savage competition in rapidly changing and turbulent business environment.

The literature has many studies that proposed a measurement model for assessing a firm's dynamic capability level and relating dynamic capabilities with other important aspects of the firms, such as, performance, collaboration, intellectual capital, etc. or with specific capabilities of the firms, such as, dynamic licensing capability, ethics-

focused dynamic capabilities, etc. With this study, we make contribution to the literature by determining and using the foundations of dynamic capabilities for the firms operating in various industries.

Following Teece (2007), dynamic capabilities are divided into three stages in this study. Sensing capability includes seven different components/activities. Firstly, a firm which desires to compete successfully in turbulent environments has to monitor its external environment (business environment, customers and competitors) and internal processes in order to capture the opportunities. By utilizing these data, it learns what can be or have to be changed. Idea generation process begins after learning process. The firm has to orient its technological base with the new information, by keeping up with the novelty in technologies. After sensing the opportunities, these opportunities should be seized by the firm. This item has four different activities. The firm has to develop more effective integration and coordination activities between individuals, groups, tasks and sources, so as to take actions in pursuance of the sensed opportunities. Coordination and integration ease developing new products or processes and/or improving existing products or processes. This change enables the firm to effectively and productively respond to the changes occurring in the business environment. Reconfiguring capability has four activities. To capture opportunities and take necessary actions, a firm has to reconfigure or transform its processes or resources appropriately. Reconfiguring resources and processes necessitates internal collaboration. Sustaining to possess future opportunities is directly related to the flexibility of the firm.

To demonstrate the applicability of our measurement model and suitability of the questions to the relevant constituents, the survey will be applied to the firms in the manufacturing industry of Turkey. After collecting sufficient number of responses, firstly a reliability analysis followed by a factor analysis will be performed. By means of these analyses, we will have the chance to learn and show the applicability and suitability of our measurement model.

According to the literature research, there exist no studies examining Turkish firm's dynamic capabilities and the effect of dynamic capabilities on financial performance. In the future researches, a structural model for analyzing the direct or indirect impacts of dynamic capabilities on performance, or any other constructs, such as, organizational learning, intellectual capital, joint ventures, etc. can be developed. There are many gaps that need to be fulfilled in dynamic capabilities literature, especially in terms of measuring them and demonstrating the conceptual models in industries.

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Biography

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Conceptualization of Organizational Modularity

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Abstract

Organizational modularity is a common but not well-defined term in organizational research literature. There is no consensus or a common model in the literature for identifying and measuring organizational modularity. Properties of organizational modularity and its relationship with organizational design parameters have not been researched yet. In this research, observed properties of an organization related to organizational modularity are tried to be defined and classified under intra-organizational and inter-organizational aspects. In this context, this paper can be considered as an attempt to conceptualize the organizational modularity by utilizing the Baldwin and Clark's 'visible design rules' and Mintzberg's 'organizational design parameters'.

Keywords

Organizational modularity, conceptualization, visible design rules, organizational design parameters, measurement model

1. Introduction

Over the last decades, improvements in technology and communication channels increased the level of competition and facilitated to enter new and overseas markets. Additionally, advancements in technology create new opportunities to produce advance products and therefore, establish a strong potential to gain competitive advantage in different market settings. On the other hand, these advance technologies increase the complexity within the product development process, which, in turn, increase the product development cycle times. In order to overcome these kind of complexities, modular design emerged as a design principle. Modular design, basically, drives organizations to design the group of components in their products by considering interdependencies among them. Grouping the components having more interdependencies with the ones in different modules let organizations manage the changes and innovations in a module by limiting and predicting the impact of change on the whole system.

These changes in the environment also affect the organizational designs. Growing competition drives organizations to respond effectively to the changing demands of the customers. In order to adapt to new customer requirements and advance technologies, and respond quickly to the new opportunities in the market, organizations are trying to review and reconfigure their organization structures. This requires the organizations to identify and manage the interdependencies and interactions between their business units. Organizational modularity emerged as a response to these dynamic changing environmental conditions and market demands.

Although there are several studies dealing with organizational modularity or modular organizations in the literature, current definitions of the terms are limited and consider only specific aspects of the concept. Additionally, methods for measuring the level of organizational modularity is missing, and the existing ones rely on a variety of restrictive assumptions. Most of the literature attempts to evaluate the organizational modularity among organizations but ignores the relationships within organizations.

This paper aims to identify the properties of an organization which can be considered to have high level of (organizational) modularity and conceptualize the organizational modularity term by utilizing Baldwin and Clark's 'visible design rules' (Baldwin and Clark, 2000) and Mintzberg's 'organizational design parameters' (Mintzberg, 1979).

2. The Concept of Organizational Modularity

2.1. Literature Review

Modularity term is not directly used, but mentioned in the seminal work of Simon (1962). In his paper, Simon investigated the complexity of architecture in biological, physical and social systems and proposed a matrix approach to manage the interdependencies between units of the systems. Later on, the modularity concept was investigated for products by several researchers, especially, as an initiative in the computer industry (Baldwin and Clark, 2000).

In order to define the modularity concept, it would be better to give the definition of the module concept firstly. Baldwin and Clark (2000) defined a module as "a unit whose elements are highly connected among themselves and relatively weakly connected to the other units' elements". Thus, modularity can be defined as a system property that is obtained by minimizing the interdependencies among modules and maximizing the interdependencies within modules, which, in turn, provides opportunities to create new configurations by means of mixing and matching, and without losing performance and functionality (Campangolo and Camuffo, 2009; Baldwin and Clark, 2000).

Nelson and Byers (2005) considered organizational modularity as a property concerning the relationships within an organization. In contrast with this view, Shilling and Steensma (2001) measured the modular organizational forms of an organization by considering the inter-organizational relationships, such as alliances. According to Nelson and Byers (2005) a modular organization is an organization, in which administrative interdependencies and hierarchical structures are minimized, while cross-unit awareness and bottom-up processes are maximized.

There are only a few studies in the literature that attempted to measure organizational modularity directly (Nelson and Byers 2005) or by simply measuring certain aspects of organizational modularity (Worren et al., 2002; Todorova and Durisin, 2009). For example, Nelson and Byers (2005) measured the organizational modularity of 'Standford's technology transfer and entrepreneurship education programs', using 'cross-unit dependence (independence in recognition of the differences)' and 'awareness (to obtain the synergy)' constructs. They used a questionnaire in order to measure the effects of these constructs. Schilling and Steensma (2001) focused on the external relationships of organizations in order to measure the organizational modularity. They explored the modular organizational forms like contract manufacturing, alternative work arrangements and alliance formation to calculate the overall modularity of the organizations. They utilized several US Nation wide statistics for their measurement variables. Worren et al. (2002) measured the effect of modular product architecture over strategic flexibility and firm performance. They considered the modular structure and modular processes as mediating variables, which increase the strategic flexibility and performance. Hoetker (2006) claimed that firms organizing for modular products prefer internal supplier usage, and value past relationship with suppliers less than firms organizing for systemic products. He utilized several databases and journals for the construct measurement. He concluded that, although modular products help to create a more reconfigurable organization, which is an expected property for a modular organization, they do not have any effect on shifting activities out of hierarchy. Benassi (2009) investigated the modular organizations and reached some valuable findings about the properties of modular organizations in his study. Some of the properties mentioned in this study include, autonomy in decision making, flatter hierarchies, managing suppliers directly, etc. Campognolo and Camuffo (2009) made a literature review where they classified the modularity in management studies and emphasized that the drivers of modularization have not been investigated in the studies dealing with modularity in organization design. They also emphasized that literature is missing on how and when a modular organizational structure is suitable.

Most of the researchers in the organizational modularity field either underline the lack of conceptualization of the term or clarification of distinctive properties of an organization with high level of modularity. Therefore, the aim of this paper is to investigate the properties of an organization with high level of modularity and conceptualize the organizational modularity concept. First, and differently from the literature, relationship between organizational modularity, organizational design parameters of Mintzberg (1979) and visible organizational design rules of Baldwin and Clark (2000) would be established, and a measurement model for organizational modularity will be constructed.

2.2. Organizational Modularity

Shifting from a general systems perspective to the organization specific perspective, neither definition of organizational modularity nor measurement methodology is clear. Based on the design rules of Baldwin and Clark

(2000) and considering the autonomous decisions and reconfiguration capability of organizational modularity, organizational modularity is high for an organization if:

- the units in an organization can take their decisions independently and these decisions do not substantially affect other organizational units,
- creating a new unit or maintaining the operations of an existing unit is compatible with the system architecture and standards,
- interfaces maintaining the communication among units, are clearly defined and standardized,
- organizations can easily reconfigure themselves so as to adapt to the changing environmental conditions and market demands.

Based on the measurement models found in the literature (which is very few in number) and the properties of organizational modularity discussed in a number of papers, the properties of organizational modularity have been identified considering the internal and external properties of an organization.

2.2.1. Internal Properties of Organizational Modularity

2.2.1.1. Self-Containedness

Miller and Elgard's (1998) paper, which explains the module and modularity concepts, mentioned that a design template could only be evaluated as a module when it includes an essential and self-contained functionality. Each system consists of many individual parts that constitute the overall system. Typically, each organization has discrete business units in which there are individuals who perform the work. A distinctive property of an organization having a modular design is consisting of units, which are self-contained. These units should maintain their own activities without necessitating other units' activities.

2.2.1.2. Reconfigurability

In his paper, Hoetker (2006) mentioned some of the advantages of organizational modularity, where one of these advantages is easily reconfigurability. When organizational units, which contribute to the design or production of a component, are easily reconfigurable, organizations are more capable to select the best supplier for a given component.

Waard and Kramer (2008) investigated Dutch Armed forces and found that, with their organizational structure, Dutch Armed forces can reconfigure ninety different functional components into a variety of constellations. Their modularly designed parent organization can create different types of temporary modular organizations, by reconfiguring its organizational units. In this context, organizations can enhance their flexibility by changing their organizational structures and reconfiguring themselves in order to respond to the changing market conditions.

2.2.1.3. Less Hierarchical Level

Less hierarchical level corresponds to relatively short command chain between top-level managers and employees. On the other hand, long command chain corresponds to more managerial workload and more complexity and interaction. When organizational modularity is high, autonomous decisions take place in modular designed units. Autonomous decisions are related to the organization structure and characteristics of the tasks. Units are expressed as flat hierarchies in organizational modularity. This flat structure not only includes low level of hierarchy but also participation of organizational units to the decision mechanisms (Benassi, 2009).

Mintzberg (1979) had stated two fundamental assumptions describing the effects of unit size to the organization structure: (i) increasing standardization for coordination will cause bigger working groups (ii) more reciprocal communications required organizations (where interactions between complex tasks are high) have smaller unit size. In a modular designed organization, coordination activities are more standardized. Thus, interdependencies are grouped into modular designed units and decisions are taken independently. Unit sizes are bigger, so, the hierarchical levels are less.

2.2.1.4. Autonomous Decisions

In organizational modularity, units corresponds to a specific product, subsystem or process. Each unit has its own domain, takes its own decisions in many situations, manage its suppliers directly, and has a flat structure (Benassi, 2009). Nelson and Byers (2005) mentioned that low level of dependency between units (i.e., the effect of a unit on

other units is low during decision making (independent decision making)), increases organizational modularity. Decentralization of decision making in organizations provides organizational units to take autonomous managerial decisions.

2.2.1.5. Defined Process Standards

Interactions between functional groups in organizational process design, includes how a component is placed as per others, how work-in-process components are transferred between groups, what kind of information will be exchanged and how they will be transferred between groups (Sanchez, 1997). Miozzo and Grimmsha (2006) underlined that process standardization is a crucial property for determining the organizational modularity. The reason for SAP (which is an Enterprise Resource Planning Software) emerging as a modular software in Germany, is the prevailing methodological and standardization effect of German culture, which also caused the standardization of business processes. Thus, this type of software can be used by several firms with low level of customization.

From the organizational modularity perspective, standardization requires not standardizing the process details, rather it requires, defining and standardizing the rules that should be used during the preparation of processes (Langlois, 2003).

Standardizing the processes decompose the key activities to special routines and interfaces (Worren et al., 2002). Standard preparations give a roadmap for the organizational units and employees to how to behave during different processes, which in turn increase the modularity of the processes. Thus, increased modularity of processes also shapes the behavior formalization, which is compatible with modularity, and hence increases the organizational modularity.

2.2.1.6. Defined Output Standards

Organization design literature recognizes two means for controlling the output: (i) action planning and (ii) performance control (Mintzberg, 1979). In a modular designed organization, different units should transfer related outputs to the other units using standard interfaces. Correspondingly, organizations with high level of organizational modularity, rely less on control processes. Here, it is important to ensure that defined outputs are prepared based on the pre-determined standards and expected performance levels.

2.2.1.7. Awareness

In the literature, it is mentioned that low level of coordination (i.e., embedded coordination into architecture) could be accepted as a property, in order to identify the organizational modularity (Wolters, 2002). When interactions between components increase, processes become more complex and a managerial coordination requirement is emerged in order to manage the processes. It is provided by placing operational authority hierarchies in the organization structure. However, standard interfaces would be designed between components using modular design, and hierarchy requirements would be eliminated. In this type of organizations, embedded coordination into architecture can be used (Sanchez, 1995).

In addition to this, most of the studies showed that although interactions between modules are tried to be eliminated in modular design, it is not always perfectly accomplished. Instead of this, decreased and manageable interactions should be tried to be designed (Staundenmayer et al., 2005).

An important point underlined in most of the studies is that, modularity helps organizational units to advance in their own operations. However, because the knowledge of a module is limited to its own operations, modular design is suitable for incremental innovations than radical innovations. Hiding knowledge is mentioned as a property of modularity by some researchers (Hahn ve Turowski, 2005). Brusoni et al. (2007) suggested using integrator firms in order to resolve this problem. Brusoni and Prencipe (2006) suggested sharing the changes within and among units with all other units in the organization, to be able to make radical innovations. Additionally, sharing general architecture knowledge and operation knowledge can be considered as a requirement for innovation (Baldwin and Henkel, 2012). Modules should communicate directly to each other in order to manage the dependencies related to the interactions among modules and should create an awareness about the changes in the other modules concerning the general architecture and operations.

One of the studies emphasizing the importance of awareness is Colfer and Baldwin's (2008) study. In the ideal case, action transparency of all modules over the system is very important. By doing this, every module can be informed

about each other without a separate, special communication initiative. However in an organization with high level of organizational modularity, independent units pursue independent goals, but synergy between these units is still expected (Nelson and Byers, 2005).

2.2.1.8. Low Level of Interaction

Defining the social hierarchies, Simon (1962) underlined that it is important to highlight who interacts with whom instead of who locates closer to whom. Ethiraj and Levinthal (2004) depicted cross dependencies and interactions in different types of matrices, which represents the relationships between organizational departments and expressed that departments with less dependency and interaction are loosely coupled. For a modular organizational design, it is expected to group the individuals in the same unit with more interaction, and to have less interaction among units during unit creation and/or reconfiguration. It is also expected to manage these interactions by using clearly defined interfaces. Correspondingly, in a high level of organizational modularity environment, interactions among the units should be much more than interactions within the units. Given the above mentioned organizational modularity properties, Table 1 depicts the relationship between these properties and how they correspond to the Baldwin and Clark's (2000) visible design rules and Mintzberg's (1979) organizational design parameters.

Table 1: Organizational design parameters, modular design rules and organizational modularity properties relationship

Baldwin and Clark's (2000) modular design rules	**Mintzberg's (1979) organizational design parameters**	**Organizational modularity properties**
Architectures	Unit Grouping	- Self-containedness - Reconfigurability
	Unit Size	- Less hierarchical level
	Horizontal Decentralization	- Independent decisions
Standards	Behavior Formalization	- Defined Process standards
	Planning and Control Systems	- Defined Output standards
Interfaces	Liaison devices	- Awareness - Low level of interaction

2.2.2. External Properties of Organizational Modularity

2.2.2.1. Dependency to the Supplier

This property can help to measure the effect of past relationships with the suppliers for a new deal. Organizational culture can play a role as a facilitator for communication and decision making, in order to increase collaboration and coordination. Studies related to the effect of culture on the supply chain show that understanding the culture deeply helps to develop more successful supply chain development strategies (Whitfield and Landeros, 2006). A supplier with a long-term relationship gains the communication advantage. A common language is developed in order to discuss the technical details. This type of language is especially important for implicit knowledge transfer. However, increased standardization and communication using interfaces, decreases the importance of implicit knowledge transfer and using common language. So, it is expected to consider past relationships less for higher level of organizational modularity (Hoetker, 2006).

2.2.2.2. Outsource Usage Capacity

In order to be able to use outsourcing for some activities or units, there should be "thin crossing points" between the related activities/units and other activities/units (Hoetker, 2006). When crossing points become thicker, the level of affection from the changed activity/unit and vulnerability level increases for the remaining activities/units. Thus, an organization, which is ready to use outsourcing, can be said to be more modular.

Schilling and Steensma (2001) used outsource usage as a variable to measure overall modularity of the organization. However, there is an important underlying assumption in this approach. Baldwin and Clark (2003) stated that modular design was an "option-type" property. It was not an obligation but was a right; therefore, increasing modularity also increases the options of an organization. So an organization with more outsource usage could be less modular than an organization with more internal supplier. In some cases, organizations that use outsourcing are not capable of changing their supplier because of their non-modular design. If organizations could not change their decisions according to the new conditions, then it is not possible to mention about the options they have. Therefore, it is important to measure the capacity of outsource usage instead of actual outsource usage. Capacity could tell us

whether it is possible to take an action and the ability to give up when it is necessary. Same approach is also applicable for alternative work arrangements and alliance formation. The alternative work usage capacity and alliance formation capacity should be considered instead of actual usages, in order to understand whether an organization is flexible to adapt to the changing environmental conditions and able to change the decisions when required.

2.2.2.3. Alternative Work Arrangement Usage Capacity

Alternative work arrangements are recruiting contract based or temporary employees in organizations in order to increase or decrease the scope and capacity of the organizations in different situations (Schilling and Steensma, 2001).

Using temporary workers is an advantage, in terms of cost and flexibility. However, employee loyalty and hands on experience is low when compared to the permanent workers (Sinha and Van de Ven, 2005). It is important to define the processes and skills required for the tasks and standardize the activities in order to utilize alternative work arrangements. Capacity of alternative work arrangement usage is an important indicator in order to understand the capability of responding to the demand changes of the market.

2.2.2.4. Alliance Formation Capacity

Organizations can use alliances to access to the critical capabilities that they do not have and/or they cannot create them quickly. Usually, these critical capabilities have the potential to provide flexibility to adapt to the changing environmental conditions (Schilling and Steensma, 2001). Tiwana (2008) researched the effects of modularity, process control and output control on the alliance performance, and found a positive relationship between organizational modularity and outsource performance. Alliance formation capacity is an important indicator for an organization whether its processes and units are designed in modular fashion or not. Easily and quickly forming an alliance with other parties is critical to respond to the new opportunities in the environment; especially, when internal reconfiguration is not economically feasible and/or not capable of satisfying all the necessary requirements.

3. Organizational Modularity Measurement Model

As mentioned above, the properties of organizational modularity should be classified into two categories. These categories include internal and external properties. Internal properties of organizational modularity are mostly related to the internal relationship between organization units. However, external properties of organizational modularity are related to the relationship of overall organization with other organizations.

In order to measure the internal organizational modularity construct, internal properties of organizational modularity are taken as a basis: (i) self-containedness, (ii) reconfigurability, (iii) less hierarchical level, (iv) independent decisions, (v) defined process standards, (vi) defined output standards, (vii) awareness, and (viii) low level interaction. Additionally, in order to measure external organizational modularity construct, external properties of organizational modularity are taken as a basis: (i) dependency to suppliers, (ii) outsource usage capacity, (iii) alternative work usage capacity, and (iv) alliance formation. The measurement model for “Organizational Modularity” construct is given in Figure 1.

4. Conclusion

In this study, in order to conceptualize the organizational modularity concept, a literature review about organizational modularity was conducted. According to the results of the literature review, it is concluded that there is no consensus or a common model in the literature for identifying and measuring organizational modularity. Therefore, properties of organizational modularity are tried to be defined and classified under intra-organizational and inter-organizational aspects in this study. Identifying the properties of organizational modularity was crucial in order to conceptualize it, because there are only a few studies in the literature that attempted to measure organizational modularity directly or by simply measuring certain aspects of the concept.

Organizational design literature was also reviewed in order to establish the relationship between organizational design parameters and organizational modularity. In the past studies, properties of organizational modularity and its relationship with organizational design parameters have not been researched yet. Differently from the past studies, this study aimed to explain the properties of organizational modularity in terms of organizational design parameters. Therefore, organizational modularity was conceptualized by utilizing the Baldwin and Clark’s ‘visible design rules’ (2000) and Mintzberg’s ‘organizational design parameters’ (1979).

After defining and classifying the properties of organizational modularity in two categories (i.e., internal and external. properties of organizational modularity), a measurement model was constructed (See Figure 1) to measure the organizational modularity concept.

Literature review shows that different researchers focused on the different aspects of organizational modularity, so, existing measurements ignore some of the important aspects. Some of these studies also ignore the option like property of modularity. That is why this study had focused on the capacity of the organizations about the external properties of organizational modularity, which ensures the organizations to preserve their options to respond to the changing environmental conditions.

This paper is part of a dissertation thesis. As a future research, a questionnaire for measuring the internal organizational modularity and external organizational modularity constructs will be designed and applied to the target groups that will be determined later, in terms of sector and geography. Confirmatory factor analysis technique will be applied to determine the factor loadings and evaluate the developed measurement model.

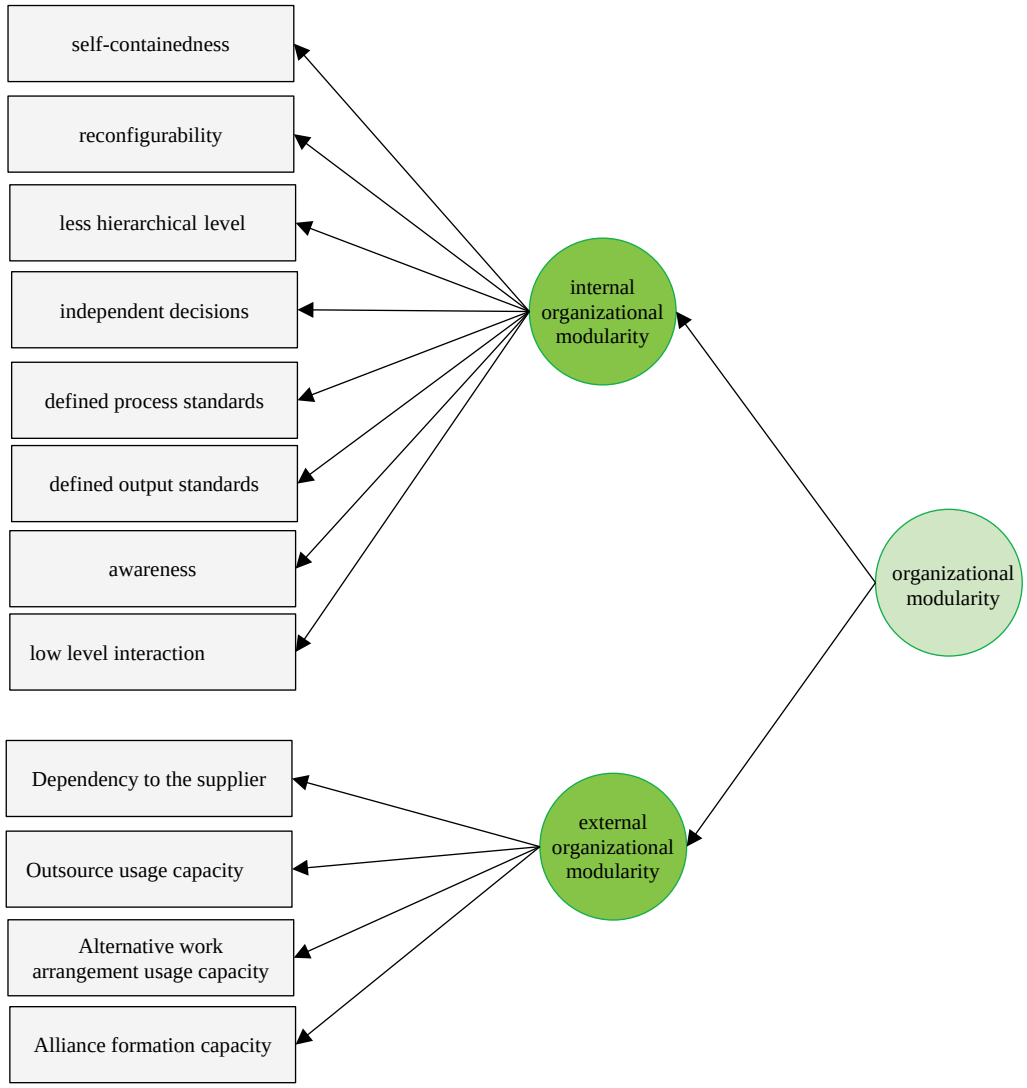


Figure 1: Organizational modularity measurement model

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Developing Strategic Plan for Manufacturing Companies Located in Developing Countries

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Abstract

Strategy plan development is the first step and a vital element that companies should have to withstand fierce market competition and to improve its business performance. This study provides detailed procedure for a strategic plan development for the companies located in developing country using both quantitative and qualitative analyses at various levels. A chemical household cleaning company located in Jordan is taken as a case study in this paper. The Porter model is used to identify the competitive environment of companies. PEST analysis is used to analyze the external environment of companies. EFEM is used to visualize and prioritize the external threats and opportunities of companies. To overcome the shortcomings of previous tools, Quantified SWOT analysis combined with GSM is used to identify strategies of manufacturing companies located in developing countries. Based on the results, the external (opportunities and threats) and the internal (strengths and weaknesses) factors that affect the situation of the company were evaluated. Finally, Quantitative Strategic Planning Matrix (QSPM) is used to evaluate possible strategies.

Keywords

Engineering management, internal and external analyses, Porter's competitiveness model, PEST analysis, SWOT

1. Introduction

Jordanian companies have tried many different management methods during the last three decades to improve their business performance. Unfortunately, most of the companies have failed to achieve their objectives. Examples of these methods are: Kaizen, Quality Circles, ISO 9000, Total Quality Management, JIT, Business Process Reengineering, Business Excellence Mode. The reasons for high failure rates can be attributed to factors that have delayed or influenced effective implementation of these approaches. Furthermore, most of the mentioned approaches have been implemented as separate initiatives and in separation of a complete framework to manage and adapt to changes (Rawabdeh, 2005). In addition, these approaches are largely descriptive with little or no emphasis on the logical links between their components.

Strategic management has been widely used by all enterprises to survive aggressive market competition. The strategic planning process is considered objective, logical, systematic approach for making major decisions in an organization (Breene et al. 2007, Brews et al., 2007). It allows effective decisions to be made under conditions of uncertainty. The strategic management process has three stages: strategy formulation, strategy implementation, and strategy evaluation (David, 1998). It is found that Jordanian companies need a focus on formal strategy, structure and work activities so as to be able to compete in the current competitive environment (Rawabdeh, 2005). The concept of strategic planning is not yet fully accepted and implemented in Jordanian companies. Currently, the Jordanian industrial sector is considered the driving force for growth in Jordan. Many Jordanian companies are thriving to have a clear picture of their future road map. This can be achieved by careful identification of their priorities, focusing in developing their internal capabilities, and providing the necessary willingness to compete externally.

Most manufacturing companies in Jordan are facing aggressive local, regional and international competition. Strategic management process equips the companies with set of capabilities that allow the companies surviving in such environment. Because of this, Jordanian companies are forced to adopt strategic planning concepts. This will

help them set their vision, mission, and build strength. In addition, adopting strategic planning will serve in resolving their weaknesses, exploiting opportunities, and avoiding threats.

The chemical cleaning household industry is experiencing a very competitive era like many others, thus it is curial to find methods to reduce manufacturing costs, improve quality etc. Dima Company for Chemical Industries is taken as a case study in this study. The company was founded in 2003. It is located in Irbid industrial city. It specializes in the production of household cleaning chemicals such as dishwashing detergents, bleaching liquid, liquid laundry detergent, floor detergents, shampoo, body wash, and hairstyle gel. Currently, they supply their products to the local market.

The main objective of this project is to develop a strategic plan for The Dima chemical cleaning household company. An effective strategic planning process is achieved by developing an EFEM and IFEM followed by a SWOT and then finally a QSPM (Meredith et al., 2009). For achieving the project's objectives, the following methodologies were utilized and can be summarized as follows; setting the mission and vision of the company, perform external assessment, conduct Porter competitiveness Model, conduct Political-Economical-Social-Technological (PEST) analysis, develop External Factor Evaluation Matrix (EFE), perform Internal assessment, and develop Threats-Opportunities-Weaknesses-Strengths Matrix (TOWS Matrix) and combine it with GSP. Finally, construct Quantitative Strategic Planning Matrix (QSPM) to evaluate possible strategies. Riston (2008) pointed out the benefits of external and internal analyses which can be summarized as follows;

- Increasing managerial awareness of environmental changes,
- improving resources allocation decisions,
- facilitating risk management,
- acting as an early warning system,
- focusing attention on the primary influences on strategic change.

It has been concluded that the result of SWOT analysis is often artificial and rough listing or an incomplete qualitative examination of internal and external factors (Kurttila et al, 2000). Quantified SWOT in this case study not only improves the previously mentioned methods, but also advances them on the basis of the Grand Strategy Matrix (GSM) (Christensen et al, 1976).

2. Company Information

The current status of the company can be summarized as follows; The company has 18 employees, its market share around 12% with average profit around 15.5%, it ranks 7 out of 25 among local competitors, it does not have strategic plan vision, mission statement, organization structure, or marketing techniques. It relies on labor – intensive manual processes, it does not have R&D activities, a moderate productivity is estimated with traditional inventory control, it has skilled labors with low turnover. The total sales of the company for the four three years are presented in Table 1.

Table 1: Total sales and profit during the period 2010-2012

	2009 (JD)	2010(JD)	2011 (JD)	2012 (JD)
Sales	189184	192785	206725	204896
Profit	36142	37506	38726	37562
Net profit	29049	31941	32268	31759
Net profit as % of sales	15.35%	16.5%	15.6%	15.5%

3. Analysis and Discussion

Several management analysis tools are implemented to analyze the current company position and develop strategic plan. The following subsections present detailed analyses and discussion of these methods.

3.1 Porter's Competitiveness Model

The porter model is a tool used to identify the competitive environment of the company. It is a matrix that takes into consideration 5 competitive forces which are: threat of new entrants; intensity of rivals; threat of substitute products; bargaining power of buyers; and bargaining power of suppliers (Porter 2008). The data of the competitive forces is presented in Table 2 followed by the analysis. The analysis of the competitive environment shows that the company

is facing 3 types of competitive forces: a) bargaining power of consumers (4.00/5.0), b) the potential entry of new competitors (3.2/5.0), and Rivalry among competing firms (3.33/5.0). Bargaining power of consumers has a huge impact on the company's competitive force since the number of buyer is large but a large portion of them is cultured toward low cost products. The power of negotiation is weak due to the existence of different manufacturers in the market related to chemical cleaning agents even though the size of market segment is large.

It can be seen from the analysis results that the company should pay careful attention to its competitors in order to maintain its market share. The causes for such fear are mainly due to: large number of competitor companies and cost of starting similar business is relatively low. Another competitive force that the company needs to pay attention to is Rivalry among competing firms. This is due to the large number of regional and local competitors who have the capability of introducing new products, meeting customer demands, managing price sensitivity issues, and work with easiness of brand switching at low cost factor.

Table 2: Porter's Competitiveness model

	Low Presence			High Presence	
Rivalry Among Competing Firms (Average = 3.33)					
High number of competitors	1	2	3	4	5
Competitors are relatively equal in size and capabilities.	1	2	3	4	5
Demand is declining.	1	2	3	4	5
Price cutting is common.	1	2	3	4	5
Brand switching is easy	1	2	3	4	5
Barriers to leave the market are high	1	2	3	4	5
Fixed costs are high	1	2	3	4	5
Products are perishable	1	2	3	4	5
Rival firms are diverse in strategies, origins and culture	1	2	3	4	5
Mergers and acquisitions are common	1	2	3	4	5
Potential Entry of New Competitors (Average = 3.2)					
Easiness of gaining economies of scales.	1	2	3	4	5
Easiness of gaining technologies and specialized Know-How	1	2	3	4	5
Easiness of obtaining required experience	1	2	3	4	5
Customer lack of loyalty	1	2	3	4	5
Brand preferences are negligible	1	2	3	4	5
Capital requirements are low	1	2	3	4	5
Presence of adequate distribution channels	1	2	3	4	5
Convenience of government regulatory policies	1	2	3	4	5
Easiness of access to raw materials	1	2	3	4	5
Easiness of patents possession	1	2	3	4	5
Potential saturation of the market	1	2	3	4	5
Potential Development of Substitute Products (Average = 1.50)					
Decline of relative price of substitute products	1	2	3	4	5
Consumers' switching cost are decreasing	1	2	3	4	5
Inroads into the market by these products	1	2	3	4	5
Strong plans of those firms for market penetration	1	2	3	4	5
Bargaining Power of Suppliers (Average = 2.25)					
Relatively low number of suppliers	1	2	3	4	5
Rareness of substitute raw materials	1	2	3	4	5
High switching cost of raw materials	1	2	3	4	5
Backward integration is rarely used.	1	2	3	4	5
Bargaining Power of Consumers (Average = 4.00)					
Customers are concentrated or large	1	2	3	4	5
Customers buy in volumes	1	2	3	4	5
Products are standards	1	2	3	4	5

3.2 PEST Analysis

The PEST analysis is a useful tool for understanding market growth or decline, the position, potential, and direction for a business. PEST includes Political, Economic, Social and Technological factors, which are used to assess the market for a business or organizational unit. Since PEST factors are essentially external, completing a PEST analysis is helpful prior to completing a SWOT analysis. The political factor forms one of the external environment factors of the company and it includes: Political stability, foreign policies, legal system, import-export regulations and stability of governments. The Dima is influenced by the negative and positive changes in this matter. The political changes seem to be in favor of a potential growth for the company.

Jordan is witnessing significant growth in industrial sector. This growth is attributed to increase of international investment, strong GDP growth, reduction in both interest rates and price fluctuation. However, the manufacturing Jordanian companies are suffering from the raise of the fuel cost and the changes in the value of dollar compared to the Euro especially if the raw materials are imported from Europe. Jordan has signed the World Trade Organization (WTO) with Europe, signed a free trade agreement with the USA, and many Arab countries. The impact of such agreements on the manufacturing companies can have positive and negative impact. The Jordan companies can take this opportunity by benefiting from the newly opened markets. On the other hand, Jordanian market is open for foreign products.

The social parameters have a significant impact on the performance of the industrial sector in Jordan (Rawabdeh, 2005). For example, the average annual growth rate of the Jordanian population is 2.8%. The population is young, with approximately 41% under the age of 15 and 73% under the age of 30 (Rawabdeh, 2005). The social impact on the household cleaning agents is large since the individuals are the direct customers beside large companies, stores, government military and civil trade establishment, large restaurants, bakery shops and factories. Finally, the technological factor is of moderate impact on such industry. The factors of the spending for R&D, patent protection, technology transfer activities are of moderate impact on the company.

Table 3: External factor evaluation matrix

	Factor	Weight %	rating	Weighted score
	Opportunities			
1.	Customers culture effect	13	2	0.15
2.	Employees culture effect	9	4	0.4
3.	Small Market Size	32	2	0.6
4.	Household cleaning industry growth trend	12	3	0.3
5.	WTO, EC and Arab free trade agreements	0	4	0
6.	Import/Export factors	8	3	0.3
7.	Unemployment rate in the country is declined	10	2	0.5
8.	Government regulator and authority	5	3	0.15
9.	Small business growth in area	7	1	0.14
	Threats			
10.	Taxes increase	10	3	0.3
11.	Availability of acceptable loans/credit forms	15	3	0.2
12.	New technology trends in Plastics industry	5	3	0.15
13.	Availability of RM sources	5	4	0.2
14.	Distribution effect	13	1	0.15
Total				3.99

3.3 External Factor Evaluation Matrix

External Factor Evaluation Matrix (EFEM) is a matrix that analyzes the current business conditions. EFEM is excellent tool to visualize and prioritize the external threats and opportunities of a company. It summarizes and evaluates all economic, political, social, technological, and competitive information surrounding a company. The first step in obtaining the EFEM is identifying a list of key external factors, then assign a weight to each factor, ranging from 0 (not important) to 1.0 (very important), after that, assign a 1-4 rating to each factor to indicate how effectively the firm's current strategies respond to the factor. (1 = response is poor, 4 = response is extremely good), then , multiply each factor's weight by its rating to determine a weighted score, finally, sum the weighted scores. For

the present case study, 14 factors are identified. The factors, their weights and rating are presented in the external factor evaluation matrix as can be seen in Table 3. The analysis of the results shows that customer and employees culture effects are among the least effective external factors that affect the performance of the Dima Company. Also the impact of the different economic bilateral agreements with Jordan does not bring a serious impact on this type of industry yet. On the other side, we can see that the small market is the main external factor that may limit the development of the company.

3.4 Internal Audit Checklist

In order to identify the strengths and weaknesses of the company management system, internal audit checklist is executed (not shown). The internal audit executed in the company involves topics such as, management, marketing, production/Operation, management information system, and information system. As for management audit, it was found that Dima company has no clear stated goals, objectives, strategies, allocated resources, and mission or vision statements. It does not have any formal organization structure, job descriptions, job specifications, rewarding system, or authority delegation systems. The employees' moral is moderate. There is no human resources department, no training programs, no administrative system. There are no effective financial, sales, and inventory control systems. Also, there are no effective management, quality, computer-assisted, and production control systems.

The production audit reveal that the there is not space for business growing. Furthermore, the factory layout is not efficient. The company adopted both production systems, i.e. Make-to-Order and Make-to-stock. However, the factory, warehouse, and stores are not arranged correctly. The existing equipment and machines are adequate for the expected output. The flow system of products and materials is poor. The products demand is not effectively forecasted, and there is no plan for dealing with non-uniform demands. For inventory, there is no effective inventory control system. There is no statistical quality control system. The company lacks any efficient information technology system.

3.5 The SWOT Analysis and the TOWS Matrix

SWOT analysis of external opportunities and threats as well as the internal strengths and weaknesses of the enterprises is the first step for strategy formulation and development. By matching these threats and opportunities with the existing strengths and weaknesses of the company, strategies can be suggested. Such a matrix is called the SWOT matrix. Table 4 lists the identified Strengths, Weaknesses, Opportunities and Threats of Dima Company. The Threats-Opportunities-Weaknesses-Strengths (TWOS) Matrix (Table 4) is an important matching tool that helps managers develop four types of strategies: SO (strengths-opportunities), WO (Weaknesses-Opportunities) Strategies, ST (strength-threats) strategies and WT (weaknesses-threats) strategies. For the company, the following matrix shows the suggested set of strategies to enhance the strengths of the company, reduce the effect of weaknesses, grasp the opportunities, and avoid threats. Table 4 lists summery of the identified strengths, weaknesses, opportunities and threats for the company.

Table 4: The TOWS Matrix

OS Strategies 	**Strengths** S1: good reputation in the Jordanian market. S2: High quality product S3: Skilled workforce S5: Ahead on experience curve S6: Adequate financially resources S7: Cost advantages S8: Location advantages

Opportunities O1: Growing market in Jordan O2: Enter new market O3: Potential in export markets O4: Introduce new product O5: Access to economic of scale O6: Serve additional customer groups O7: Diversify into related products O8: Complacency among rival companies O9: Faster market growth O10: ability to move to better strategic group	OS1: Establish new links with new markets in (Market Development Strategy- Exporting) OS2: Seeking increased sales by developing new products (Product development) OS3: joint Venture OS4: Hire qualified person as a deputy manager with industrial background. OS5: Develop and implement a quality system (ISO9000) OS6: Develop and implement a production planning and control system
WT strategies 	**Weaknesses** W1: No clear strategic direction W2: Weak internal organization, management structure, coordination and reporting. W3: Below average marketing skills. W4: Obsolete facilities W5: Falling behind in R & D W6: Too narrow ranges of products W7: Weak distribution network W8: Below average marketing skills W9: Weak track record
Threats T1: Entry of low cost foreign competitors T2: Growing competitive pressure) T3: Cheaper products from small factories T4: Costly regulatory environment T5: Growing bargaining power of customers T6: Unstable region T7: Adverse government policy	WT1: Target a segmented market for Low-cost chemical cleaning agents
ST Strategies 	**Strengths** S1: good reputation in the Jordanian market. S2: High quality product S3: Skilled workforce S5: Ahead on experience curve S6: Adequate financially resources S7: Cost advantages S8: Location advantages
Threats T1: Entry of low cost foreign competitors T2: Growing competitive pressure) T3: Cheaper products from small factories T4: Costly regulatory environment T5: Growing bargaining power of customers T6: Unstable region T7: Adverse government policy	ST1:Target a segmented market A-level stores (segmentation strategy) ST2: Participate in activities related to the plastics

OW strategies 	**Weaknesses** W1: No clear strategic direction W2: Weak internal organization, management structure, coordination and reporting. W3: Below average marketing skills. W4: Obsolete facilities W5: Falling behind in R & D W6: Too narrow ranges of products W7: Weak distribution network W8: Below average marketing skills W9: Weak track record
Opportunities O1: Growing market in Jordan O2: Enter new market O3: Potential in export markets O4: Introduce new product O5: Access to economic of scale O6: Serve additional customer groups O7: Diversify into related products O8: Complacency among rival companies O9: Faster market growth O10: Ability to move to better strategic group	OW1: Apply extensive promotion and advertising plan (Market penetration Strategy) OW2: Introduce new products based on R & D for new materials/processes (Product development) OW3: Concentric Diversification OW4: Develop and implement a strategic /business plan(s) OW5: Hire qualified personnel in marketing OW6: Develop an organization structure with jobs descriptions. OW7: Increase the company capacity by buying new machines

3.6 The Grand Strategy Matrix

The Grand Strategy Matrix offer reference for the enterprises to develop strategies based on the competitive position of a company versus its market share. Figure 1 shows four distinctive quadrants with a set of strategies for each quadrant. The first quadrant stands for the enterprises' strengths and market opportunities. Enterprises in this quadrant can use their strengths to adopt market penetration, market development, and product development strategies. This will increase the competitive strength of the company. Enterprises in the second quadrant have market developing opportunities but have weak competition. Enterprises fallen in the third quadrant have competitive strength and facing threats from other competitors. Defensive strategies should be implemented to avoid threats. Furthermore, in case of previous strategies fail, divestiture or liquidation should be adopted. Enterprises in the fourth quadrant have competition strength but are exposing to greater threats than opportunities. To reduce this large threat, diversification or joint venture strategies can be suggested.

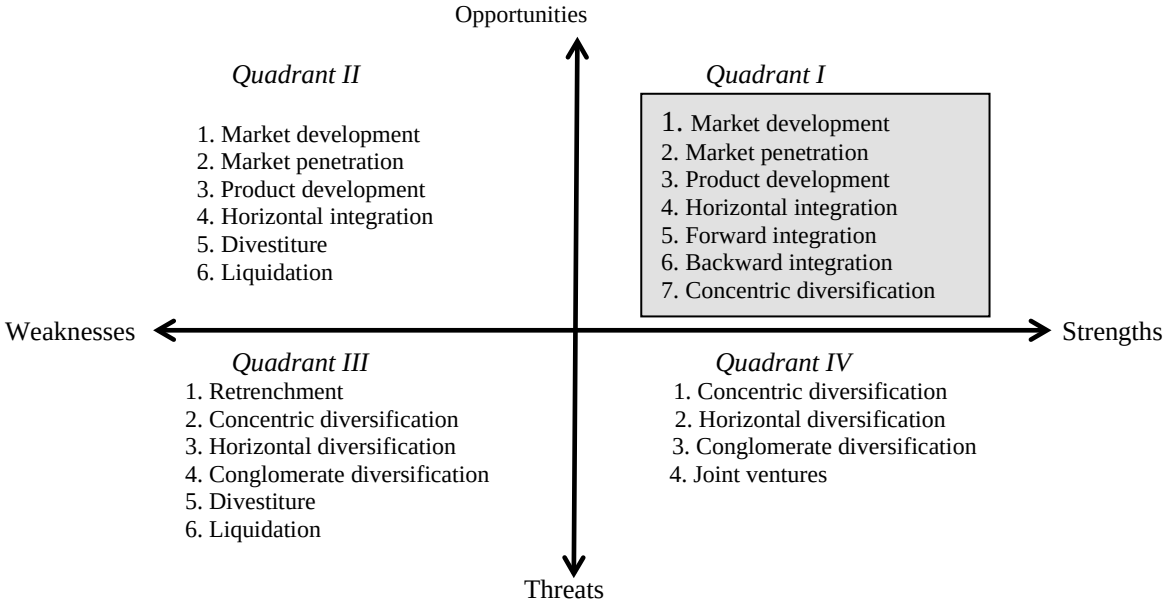


Figure 1: Quantified SWOT analysis and the strategic matrix (Christensen et al., 1976)

Having both Quantified SWOT analysis and knowing the coordinates serve enterprises in realizing their position in the competition and having a reference for developing their strategies. To identify position of the company establishment in the Grand Strategy Matrix, it is agreed that the competitive position of the company is considerably moderate in a moderate market growth. Based on that, the location could be between Quadratic I and IV. Quadrant I is selected with its 7 generic strategies as shown in the Figure 1.

4. Developing Strategies

In order to develop a set of general strategies for the company based on the collected information through different matrices, Quantitative Strategic Planning Matrix (QSPM) is built. QSPM is a high-level strategic management approach for evaluating possible strategies. Furthermore, QSPM provides an analytical method for comparing feasible alternative actions. With QSPM, it less likely that key external/internal factors will be ignored or weighted inappropriately in deciding which alternative strategies to pursue (Meredith et al, 2009).The following steps is executed to construct QSPM; 1) identify a set off strategies that can be selected; 2) identify the criteria that can be used to differentiate among these strategies; 3) grade was assigned for each strategy, 4) rank each strategy based on the total grades of each strategy. The selected applicable business strategies and the selected criteria for evaluation are listed in table 5.

Table 5: QSPM for business strategies

Criteria/Importance	High Profitability	Large size of investment	Ease of Control	High Organization Capability	High Market Potential	Factory Adaptability	low number of workers	Total	Rank
1. Market Development	4	4	4	1	5	5	4	27	2
2. Market Penetration	4	4	4	1	5	4	3	26	3
3. Product Development	2	2	3	1	4	2	3	17	6
4. Market Segmentation	5	5	5	4	5	4	4	32	1
5. Market Segmentation	3	4	3	2	4	3	4	23	4
6. Concentric diversification	4	3	2	1	2	4	3	19	5
7. Joint Venture	2	2	2	1	1	1	2	11	7

5. Conclusions

This paper provides guidelines and procedures to show how the enterprise located in developing countries can develop strategic plan. In this study, several methodologies were utilized to develop strategic plan for manufacturing companies located in Jordan. External and internal assessments were performed. These analyses includes; Porter competitiveness Model, Political-Economical-Social-Technological (PEST) analysis, External Factor Evaluation Matrix (EFE), Threats-Opportunities-Weaknesses-Strengths Matrix (TOWS Matrix). From SWOT analysis,the company can realize its position in the competition and this helps the company learn about itself and its competitors. To overcome the shortcomings of previous methods, Quantified SWOT analysis combined with GSM is used for is used to suggest adoptable competing strategies for the company (Chang et al., 2006). It was found that the company has market developing opportunities but have weak competition. Finally, Quantitative Strategic Planning Matrix (QSPM) is constructed to evaluate possible feasible strategies.

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Biography

Khaled Bataineh serves as associate professor of Mechanical Engineering at Jordan University of Science and Technology. He is active in Renewable energy resources and energy management in Developing country. He received a B.S. from Jordan University of Science and Technology in 1999, and an M.S. from Carnegie Mellon. He received his Ph.D. in Mechanical Engineering from the University of Pittsburgh in 2005. He is the author of about 24 reviewed journal articles and other technical publications. He has been a consultant to several companies where he made contributions to the solving problems and offering possibility of launching new products. He is a member of numerous professional societies.

Total Quality Management of Projects in the Saudi Construction Industry: A Critical Review

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Abstract

Attaining acceptable levels of quality in construction has long been a challenge. Valuable time, financial and other resources are wasted each year because of inefficient or non-existent quality management procedures. Quality management in construction projects should therefore ensure the maintenance of the quality of construction works at the required standard so as to obtain customer satisfaction that would bring competitiveness and business advantage. The role of quality management for a construction company is therefore not an isolated activity, but intertwined with all the operational and strategic processes. The total quality management (TQM) concept developed in manufacturing and first applied in Japan helped to improve efficiency. Although construction is uniquely creative usually involving one-off products, the Japanese construction industry embraced the TQM philosophy that was arguably thought of as solely applicable to mass production. The concept has since been tested in construction extensively where the use of this tool has been adopted in the management of construction projects for the benefits it brings. Therefore, this paper aims to critically review available literature and practices on the implementation of TQM concepts in the construction industry of the Kingdom of Saudi Arabia (KSA) in order to address the persistent management problems from initiating to the commissioning of projects in the sector. In this way it is believed that the reduction in costs, time overruns, risks as well as other efficient measures could bring improved benefits to all stakeholders.

Keywords

Client satisfaction, Construction industry, KSA and TQM.

1. Introduction

Achieving the desired quality has always been a worrying phenomenon in the execution of construction projects. The rampant incidence of dissatisfactory performance in the industry has led to the belief that construction projects can hardly be completed on time and within budget to clients' assigned brief (Abdul-Rahman, 1996). The implementation of quality management by several construction companies has failed to ensure that the persistence of serious problems on construction projects are permanently addressed. This is attributable to the lack of an effective quality-cost system in place, which makes performance improvements very difficult to identify and measure (Lee et al, 2013). Duncan et al, (1990) introduced two sets of problems that they ascribed as mainly responsible for costly errors that lead to client dissatisfaction in construction as follows:

- Inadequate training and management of designers i.e. the results of low quality design are variation orders and claims due to frequent changes in the detailed information during the construction process;
- Inadequate or incorrect specifications in the tender i.e. how much organizations should invest in a particular activity.

In addition, El-Rayes and Kandil (2005), based on performance measures tracked with the dimensions of quality, cost and schedule, argue that current management practices are not effective predictors of project success. Consequently, a project team cannot consistently rely on performance to identify deficiencies in the management process. They specifically observed three weaknesses faced by project execution teams in respect of performance monitoring in current construction practice. For empirical demonstration, the authors conducted a four-month case study on an American hospital project using three performance metrics to evaluate existing management practices. These covered the management of process deficiencies that could not be readily identified as some performance

measures are hardly ever tracked and included the overall quality performance, flexibility in aligning with client priorities, and responsiveness to efficiency and effectiveness. Upon introducing client satisfaction based on the criteria tested, it was ascertained that project teams could not tactically align to project deficiencies and client priorities because performance monitoring was less frequent and hardly publicised. Additionally, performance measures that were tracked were found incapable of effectively predicting client satisfaction even though managers tracked the latency of Requests for Information (RFIs) which was seen to be quite high on average. Therefore, insights into team activity and overall performance were seen to be diminutive and led to less input into the process at the construction stage and could only be assessed against client satisfaction when the product was finished

2. Quality Management

The preceding section has identified the lack of involving client concerns throughout the various stages in the construction process until the completion and has stressed quality as the hallmark for project success and customer satisfaction. In order to assess projects requirements for quality, the initiation stage is critical and begins at project inception. Also essential, is a careful balance between client's requirements of the project costs and schedule, desired operating characteristics, materials for construction, and professional design criteria for adequate time and budget to meet those set requirements during the design process. This stage is seen as extremely essential if client satisfaction is to remain a priority (Arditi et al. 1997). It is worth noting that project managers must be preoccupied with satisfying client requirements. As such, project teams must endeavour to establish good relationships with key stakeholders on a project in order to bring about a thorough appreciation of the concept of quality and its definition as well as the targets set to achieve it. For, the ultimate decision with regard to the level of quality standard acceptable always rests the client. Many projects technically fail as project teams usually focus on meeting prescribed specifications in clients' briefs and ignoring other stakeholder needs and expectations from the project which may not have been evident at the inception stages no matter how trivial these may be.

The ultimate aim of quality management should be to ensure that, projects meet set requirements upon completion not ignoring other factors, particularly upon consultation, that could lead to clients feeling involved (Schwalbe, 2006). With regard to the implementation of quality management on projects, Tan & Abdul-Rahman (2011) delineate the concepts of quality planning (identification of quality standards), quality assurance (evaluation of overall project performance) and quality control (monitoring of specific project results) in the quality management processes as defined by the Project Management Institute [PMI] (2013). They further identified tools and techniques which form part of implementing the process to include, benefit/cost analysis, benchmarking, flow-charts, design of experiments, cost of quality, quality audits, inspection, control charts, pareto diagrams, statistical sampling, flow-charting and trend analysis. Mathews et al. (2001) in their study also grouped quality tools and techniques that aid quality programmes into three main types as, hard quality tools, mixing methods and soft methods. They proceeded to describe hard quality tools as formal quality systems, documented quality systems, quality costs, control charts, and statistical sampling standards; mixing methods were seen to involve strategy and action plans review, flexibility of organization structure, control charts, quality circles, and quality planning tools and finally soft methods were classed as training, customer satisfaction surveys, regular contact with clients and other bodies, actions to optimize environmental impact, empowerment, self-assessment, and benchmarking (Tan & Abdul-Rahman, 2011). However, such diversity in tools of measurements does no more than clutter the process and hampers any attempts at standardisation which only leads to less involvement of stakeholders and impacts negatively on the ultimate organisational goal somewhat alienating the client ultimately.

2.1 The Significance of Quality Management

The importance of quality management and the role it plays in construction companies is enormous (Harris and McCaffer, 2004). During the process of production, quality management is critical to the quality standard of the final product. Quality, therefore, must be on an equal level with project scope, time and cost (Schwalbe, 2006). As a result, project teams are obligated to adjust scope, time and cost in order to satisfy stakeholder needs and expectations should they not be satisfied with the quality standards of management or the final product. Hence, meeting only written requirements for scope, time and cost, according to the specified brief is simply not sufficient. The concept of quality management ensures aiming efforts at achieving the required level of satisfaction from a product and must be well planned and organized. Quality management in construction projects should therefore maintain the quality of construction works at a level commensurate with quality assurance standards in order to

achieve a level of client satisfaction (Toor, & Ogunlana, 2010) that would bring competitiveness and business advantage to ensure long-term survival (Tan & Abdul-Rahman, 2011).

Consequently, quality management in the industry cannot be done in isolation, but in conjunction with the various operational and managerial processes in any business concern. In their study on high quality expressway construction, Lee et al. (2013), note that given the situation of ensuring total client satisfaction and in order to ensure high quality construction, there is the need to highlight the importance of quality control environment objective and performance-based quality control for construction structures, rather than monitoring based quality control during the process of construction. This therefore implies that the process stages of actual construction, in their view, are of less significance and thus they lay more emphasis rather on the finished product. They went further to assess the quality of construction based on two quality assessment items of durability and functionality considering the different construction site conditions and work processes. By establishing detailed assessment criteria for each item to permit the performance of quantitative assessment, an analysis of the status of defects, and the combined opinions of construction experts could aid the process of assessment (ibid). However, this finding was based on an investigation of an outline of the types of construction works that have a high possibility of defects occurring in their structural performance like expressways and speed rails which requires further research for generalisation.

Also, El-Rayes and Kandil (2005) state that in the early and mid-2000s, the application of new contracting methods, particularly in the highway sector, had been adopted by many departments of transportation (DOTs) in several American states of which they note the following characteristics which are also captured in figure 1:

- Bidding on cost/time to encourage competition among contractors to minimize project duration (Herbsman 1995);
- Incentive/disincentive contract clauses that provide financial incentives to reduce construction duration (Jaraiedi et al. 1995);
- Night-time construction that seeks to cut service disruption and project time by requiring contractors to work during off-peak night-time hours (Ellis & Amos 1996; El-Rayes & Hyari, 2004);
- Warranty contracting that attempts to improve construction quality by making contractors liable for the performance of the facility after project completion (Anderson and Russell 2001; ENR 2002);
- Multi-parameter contracts that provide incentives to contractors to improve quality performance (Anderson and Russell 2001).

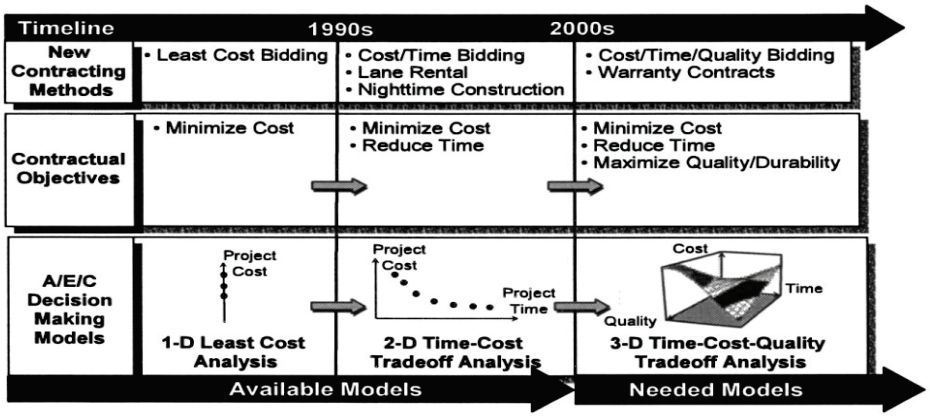


Figure 1: Impact of new contracting methods on decision making in construction (Source: El-Rayes & Kandil, 2005)

As outlined, new and emerging contracts place an increasing pressure on decision makers in the construction industry to search for an optimal resource utilization plan that minimizes construction cost and time while maximizing quality and client satisfaction (El-Rayes and Kandil, 2005). This process initiated innovative and pressing needs for advanced resource utilization models capable of optimizing the multiple and conflicting objectives of construction time, cost, and quality dimensions, as captured in figure 1 where the various dimensions have been factored in the models in later models to achieve better decision making and management, models which lend themselves to better quality management.

2.2 Intrinsic Quality Management Challenges

Basing the argument on observation of project management practice for a large-scale commercial general contracting firm in California, Li (2011) posited that management is predominantly ad-hoc and project execution is based on reference frameworks that are usually intuitive and gathered from professional experience and judgment. To this effect, it is undeniable that initial project planning involves mental models of risks and challenges for this particular contract and the stakeholders concerned. Therefore, project managers mostly rely on analytical skills for required adjustments in order to achieve project outcomes; this ad-hoc process is usually not formally documented as it is almost always based on informal deduction. As these processes are generally informed by intuition, the motivating factors necessitate a client-based, tactical-driven project management reliant on real-time measurement of meaningful metrics. This is done to permit a tactical alignment of teams with project requirements for the execution of projects for a sustained customer satisfaction. The alignment has to be efficient and effective and not only be based on the perception of satisfaction but controllable performance deficiencies (ibid). These deficiencies can be identified by the implementation of performance metrics involving tracking and reporting and the relevant metrics must be explicitly defined by the client. They may be used as evidence to determine their affect on client perception and as indicated earlier, the frequency of measurement should be in real-time so as to initiate fast response to deficiencies.

In practice, the inherent characteristics of construction projects form the basis for the majority of the complexities that management teams encounter (Kreiner & Winch, 2009). Instances such as the separation of teams from the origins of formal authority resulting in autonomous execution of project tasks in relatively different environments that are mutually interdependent have been noted as highly problematic (Hartmann, 2008). Also, the heterogeneity of firms constituting management, who are made up of design and construction teams as well as other stakeholders, creates a fragmentation originating from the numerous firms that are spread over several locations. This tends to have a negative impact on the effectiveness of traditional management practices and as El-Rayes and Kandil, (2005) caution, management practices like Integrated Project Delivery (IPD) have generated very little empirical research to support their effectiveness beyond anecdotal evidence. Again, El-Rayes and Kandil (2005) outline the fields to be explored for limitations that primarily lie in organizational effectiveness on key performance indicators in evaluating project success. Secondly, in strategic management research Total Quality Management (TQM) stresses on the need for continuous improvement and the setting of objectives that are customer-oriented. Lastly, the application of microeconomics establishes a relationship that is realistically based on monitoring performance and practising good management. It is in the second area that this paper examines client satisfaction although Chan and Chan's (2004) consolidated framework for evaluating construction success based on Key Performance Indicators (Figure 2) also comes into focus.

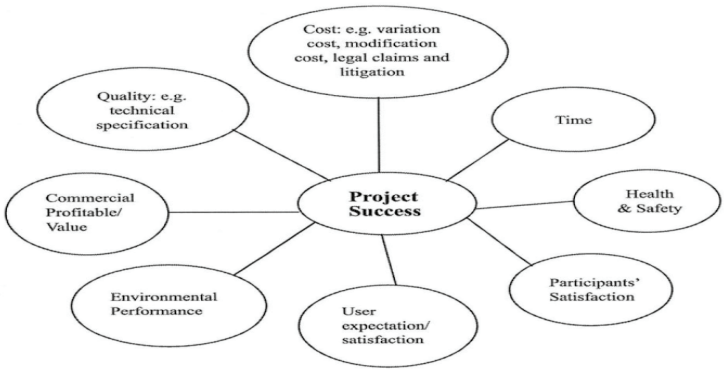


Figure 2: Consolidated model for project success (adapted from Chan & Chan, 2004)

Encapsulated in the KPIs laid out in figure 2, Chan and Chan (2004) derived the definition of project success as the set of principles or standards by which favourable outcomes can be completed within set specifications. Nevertheless, the emphasis is on TQM and the focus will be strengthened in that direction although successfully achieving project goals lie in the factors given.

3. Total Quality Management (TQM) in Construction

TQM has been defined as a complete management philosophy that permeates every aspect of a company and place quality as a strategic issue which is achieved through a concerted effort by all the various levels of the company for enhanced clients' satisfaction (Tan, 2011; Ledbetter and Lemer, 1991). Its realisation is contingent on the continuous improvement of prevailing performance in an organisation. In their review of the literature on quality and safety management in the construction industry, Loushine et al. (2006) examined several definitions of quality performance by various authors as shown in table 1.

Table 1: Definitions of quality performance (source: Loushine et al, 2006)

Definition	Authors
'Meeting expectations of the customer'	Chase, 1998; Kanji & Wong, 1998; McKim & Kiani,1995; Torbica & Stroh, 1999
'Reduced rework or defects'	Atkinson, 1998; Love et al., 1999; McKim & Kiani, 1995; Pheng & Wee, 2001; Sypsomos, 1997
'Repeat business'	Sommerville, 1994; Sypsomos, 1997
'Conformance to ISO 9000 criteria'	Bubshait & Al-Atiq, 1999; Sun, 1999
'Completion on-time and within budget'	Courtice & Herrero, 1991; Gransberg et al., 1999; Jaafari, 1996; Kiwus & Williams, 2001; Love et al., 1999; McKim & Kiani, 1995; Ripley, 1996; Sypsomos, 1997; Wong & Fung, 1999

It is evident from table 1 that a precise definition of quality in the construction industry is farfetched. Furthermore, there is little empirical data on quality measurement in construction. To examine how contractors define quality, how they measure it, how they think it can be improved, and what the barriers are to quality in the construction industry, Hoonakker et al. (2010) surveyed contractors views and arrived at the finding that quality is most often measured through customer satisfaction and is best improved by means of education and training. They further found the biggest barrier to quality to be personnel related.

Consequently, the adoption of TQM in the construction industry has been extensively promoted in several studies (Low & Teo, 2004; Haupt & Whiteman, 2004). The International Organisation for Standardisation (ISO) certification has been the trend for measuring quality in most industries including construction since its introduction. There are many standards in the ISO 9000 family (ISO, 2012) as outlined in table 2.

Table 2: ISO Standards and description

ISO Standard	Description	Year
ISO 9000	covers the basic concepts and language	2005
ISO 9001	sets out the requirements of a quality management system	2008
ISO 9004	focuses on how to make a quality management system more efficient and effective	2009
ISO 19011	sets out guidance on internal and external audits of quality management systems	2011

Also, standardized recommended principles as they appear in ISO 9000:2005 and ISO 9004:2009 that managers apply to improve their organizations' performance and the benefits derived from their use and of actions that managers typically take in applying them cover the following: Principle 1 – Customer focus; Principle 2 – Leadership; Principle 3 – Involvement of people; Principle 4 – Process approach; Principle 5 – System approach to management; Principle 6 – Continual improvement; Principle 7 – Factual approach to decision making; Principle 8 – Mutually beneficial supplier relationships (ibid). This standardisation has characterised construction activities in many forms although the industry is still said to be ineffective and inefficient (Khaled & Shehata, 2011; Xue, 2007)

In a study on Life Cycle Management (LCM), Guo et al. (2010) acknowledged the use of this tool in the management of construction projects for many years in order to reduce whole life cost, time, risk and improvement of service to owners. However, they bemoaned the lack of an effective information sharing platform which currently impinges on the effective use of LCM of construction projects as it is not effectively used in the construction industry, a practice comparable to TQM. Although construction has the uniqueness of being a creative and mainly involving one-off processes, the Japanese construction industry embraced the TQM concept that some argued could only be applied to mass production through prefabricated construction; a method that has been regarded by many as

an effective and efficient approach to improving construction processes and productivity, ensuring construction quality and reducing time and cost in the construction industry (Li et al, 2011).

The increasing significance of TQM in the construction industry has been stressed in several countries as an improved strategic management tool, irrespective of the many barriers impeding its effectiveness in implementation. The manifestation of this is borne by the levels of increased quality and performance in other industries like manufacturing which has practices that have been recommended as lessons for the construction industry. In the light of this however, the construction industry is still characterized by low productivity, cost overruns, and poor quality (Khaled & Shehata, 2011; Xue et al, 2007). TQM, among a variety of techniques has recently emerged as very significant in operations management and has certainly impacted on several industries. Therefore, it is not surprising that it has increasingly been introduced into the construction industry to improve project performance and delivery (Loushine, et al.. 2006; McIntyre & Kirschenman, 2000; Torbica & Stroh, 1999; Sommerville, 1994).

3.1 The European Foundation for Quality Management (EFQM) Model

EFQM defines TQM as all the various ways in which an organisation meets the needs and expectations of its customers, personnel, financial stakeholders and society in general (EFQM, 2012). This definition is fairly abstract since TQM can be considered a philosophy rather than a model which has numerous definitions (Loushine et al., 2006). Its widely accepted definition is however based on three principles: customer focus - decisions are mainly based on the needs of the clientele; continuous improvement - efforts continually aimed at improving the organisation, its products and services; integral approach –TQM's preoccupation with the overall performance of the organisation. Many tools, methods and models have been developed to substantiate the TQM concept and have been widely adapted across the world. The EFQM Model for Business Excellence made up of nine distinctive areas of an organisation aids in the assessment of their progress in achieving Total Quality. These nine areas are subdivided into areas concerned with achieved results (Results) and the process adopted to achieve these results (Enablers). Figure 3 shows the nine areas and their relationships within, and outside the model. Here, customer and people satisfaction are seen as critical to the ultimate organisational goal.

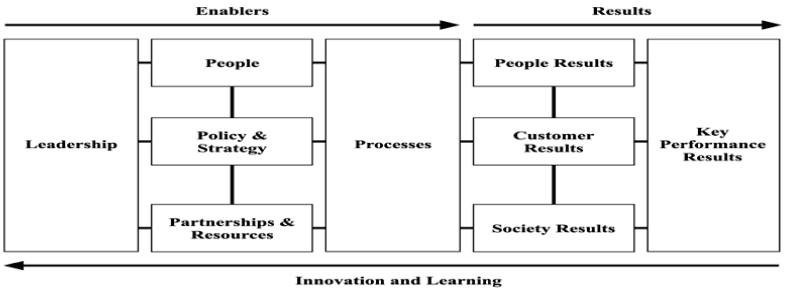


Figure 3: The EFQM model for business excellence (adapted from EFQM, 2012)

The Model for Business Excellence (figure 3) serves as a useful framework for quality management based on an integrated cycle for continuous improvement. The need for developing and improving people, partnerships and processes in order to deliver value-added products and services to clients is rendered as the basis for achieving sustained success the foundations of which lie in strong organisational leadership and clear strategic direction. The EFQM Excellence Model classifies these as the Enablers and where the right Enablers are effectively implemented, an organisation is most likely to achieve expected Results for all the stakeholders concerned. For example, in attempting to improve employee satisfaction, People Management needs to be strengthened alongside Leadership, Policy and Strategy by targeting improved actions to these particular areas. After such improvement has been implemented, the organisation must again carry out a self-assessment in order to see if the improvement actions have resulted in a better overall performance. Based on this second assessment, new 'Result' areas can be selected for improvement, thus beginning a new cycle. The process of TQM results in continuous process management through which deficiencies, problems and defects can be easily detected and addressed hence the wide acceptance of the model and its application in several industries.

3.2 Limitations to TQM

The limitation of TQM is that it does not explore the specific characteristics of customer demands for which reason Li (2011) proposed a benchmark of the perceived factors that influence client satisfaction in the construction

domain. Therefore, one main principle in the implementation of TQM should be the focus on work processes and management should have the ultimate goal of guiding organizations to measure, analyze, and improve work processes. This is the concept of continuous quality improvement which underscores success for organisations that commit to constant examination of technical and administrative processes in search of better procedures and processes. Opportunities to develop better methods for carrying out work always exist, and a commitment for continuous improvement ensures that people never stop learning about the work they do (Karuki and Mburu, 2013).

The main barrier to TQM in construction has been noted as the absence of high quality and standardised data across firms, as projects are markedly heterogeneous (Li, 2011) which makes the implementation of tested and beneficial practices across firms difficult or even unlikely. Bloom and Van Reenen (2007) developed an innovative tool to systematically measure management practices across manufacturing firms. They also explored why firms do not all adopt certain management practices they know are beneficial for them and why there is variation across firms and industries within national boundaries. Reasons detected included industry heterogeneity, costly investment, contractual restrictions, managerial entrenchment and learning effects. The problems have led to clients' dissatisfaction in the main, most of which usually leads to rework. To this effect, Fayek et al. (2004) carried out a comprehensive study on the causes and costs of rework on behalf of the Construction Owner's Association of Alberta (COAA) in Canada. They found that almost all companies have a rework tracking system, although there are variations with no apparent industry-wide standard which they categorised as being: Engineering driven - mostly due to drawing changes, design errors, constructability issues, changes in scope; Customer driven - mostly due to changes requested by operators; i.e. after construction is completed; Manufacturing and supply - mostly due to poor quality of manufactured equipment and construction errors in the field. Upon determining that 97% of rework on the Syncrude Aurora 2 project in Alberta, was as a result of root causes in Human Resource Capabilities, Engineering and Reviews, and Material & Equipment Supply, they updated the COAA's root cause diagram accordingly (figure 4):

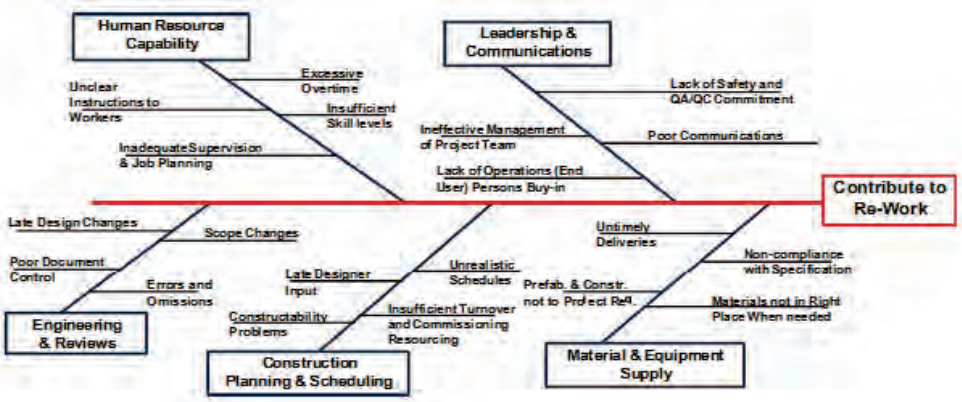


Figure 4: COAA's Fishbone rework cause classification diagram (adapted from Fayek, 2004)

The combination of the factors outlined in figure 4 and in other sections of this paper form the basis of the desired impact on TQM practices in the Saudi construction sector, albeit in recognition of its unique characteristics like *Saudization* of the industry and its local organisational and occupational cultures. It is in view of the foregoing then, that it can be affirmed that TQM should focus on creating a culture of improvement to form the basis of its adoption in the construction industry in KSA to enhance client satisfaction.

4. The Uptake of TQM on Construction Projects in KSA

The Saudi construction industry is one of the largest in the GCC and is set to be the main engine of growth in the sector (Gulf Investment Corporation, 2012). According to Falqi (2004), like any other construction industry elsewhere, the Saudi construction industry suffers from poor performance and faces several difficult challenges which warrant multiple local studies into its improvement. However, studies of this nature are few and dominated by authors who are generally outside the Saudi culture. Notwithstanding, some academic treatise have look into this and attempted to address the issue. These will form the basis for review in this section in respect of the foregoing quality management practices in other parts of the world already considered. TQM has been recognized by many countries as one of the keys to competitiveness. Organizations in other industries are increasingly using self-assessment instrument to drive continuous improvement and direct the TQM journey in moving the organizations

towards business excellence. In Saudi Arabia, many organizations implementing TQM are in need of a self-assessment instrument to assist in implementing TQM properly. It is clearly necessary, as a result, to evaluate TQM practices as a key part of the TQM implementation strategy within construction industry organizations using the appropriate assessment instruments.

4.1 The KSA Construction Industry

Construction is one of the mainstays of KSA's economy and was responsible for 11.7% of her GDP in 2011 accounting for over 45% of the labour force in the private sector (SAMA, 2012). Like anywhere else, economic cycles of boom and bust dictate the behaviour of construction in Saudi Arabia. As the economy is mainly dependent on public financing for the injection of capital, which is in turn controlled by world oil pricing, it must be noted that economic activity in the sector is very much centralised. The country has therefore witnessed unprecedented growth since the early 1970s from oil price hikes. Huge oil revenues, as a result grants the opportunity for the government to invest heavily in the infrastructure of the country. According to the Construct Arabia News (2014) the Kingdom's construction market is slated to undergo a dramatic revitalization with a projected growth rate of 35%, to see the sector become the fastest-growing in the Kingdom's economy by 2015. A staggering USD 76 billion of the national budget has been allocated to construction projects, a figure expected to exceed $3 trillion by 2020. The construction of ambitious projects including a $160 billion six major economic cities, the $40 billion Sudair Industrial City, $15 billion King Faisal University and the iconic $16 billion Jeddah Kingdom Tower expected to unseat Dubai's Burj Khalifa as the world's tallest building mean that the sector is set to drive growth in the economy.

However, the Saudi construction sector has been known to rely on foreign labour both skilled and unskilled with the latter constituting a bigger share. Originating from high-unemployment countries such as Pakistan, Indian, Korea and Egypt, they are paid low wages (Mahbashi, 2007). Consequently, the indigenous population do not find the industry attractive leaving it to be dominated by foreign and transient labour. Training therefore is bespoke and targeted, and as turnover is high for the migrant employees, management problems are likely to abound in the sector.

4.2 Challenges Facing the Saudi Construction Industry

Being a major sector in the country comes with numerous challenges which have been foreseen by the Fourth Saudi Businessmen's Conference under the theme "*The Progress of the Construction Industry in the Kingdom: Obstacles and Solutions*". In his treatise on the subject, Mahbashi (2007) enumerated the following problems as persistently facing the industry: Fluctuation of demand for construction; foreign competition and the illegal conduct of foreign businesses that are apparently thought of as necessary to survive in the KSA; the existing debts and accumulated interest of Saudi market; the cumbersome procedures involved in the transfer of foreign labour sponsorship for various professionals across construction companies, among others. In addition, there is a lack of dedicated agencies responsible for dealing with contractors' issues as no funding allocation is made for solving Saudi contractors' financial problems other than from commercial banks, just like other non-petroleum sectors like manufacturing and agriculture. Other challenges result from the non-compliance of foreign companies operating on projects in the Saudi construction industry against government rules requiring foreign companies to subcontract 30% of their business to local contractors. Small firms also embark on cover-ups for illegal workers and are characteristically responsible mainly for false contractor classification and last but not least the lack of clarity and legalities of terminologies used in contract documents.

Table 3: The existing classical Saudi culture and quality culture (Source: Bubshait, 2003)

Existing Classical approach	Quality Culture approach
Product oriented.	Process oriented.
Little interest in training.	More concentration on education and training.
Corrective attitude.	Preventive attitude.
Blaming attitude.	Problem solving.
Cost reduction.	More market share.
Focus on standards or Continuous improvement.	Specifications.
Hierarchical structure.	Flattened structure
External control	Internalized control to individuals.

Organisations aiming to adopt TQM need to consider an overhaul of its dominant culture to accommodate the 'supportive culture' of this style of management to avail of its benefits. Also, businesses need to assess periodically their prevailing organisational culture and monitor the developing trends over a rating scale using a suitable instrument to identify the actual gaps that must be filled for an appropriate corrective action (Bubshait, 2000; 1999). Table 3 illustrates some existing classical management approaches in Saudi organizations, which need corrective measures to match TQM approach.

From the foregoing, it is envisaged that a successful transformation to TQM to address these problems requires a change in the organizational culture of companies in the sector. These problems still persist and lack solution as a result of the nonexistence of a governmental body mandated to deal with them. This said however, there is a dominance of private construction companies in operation as well as a lot of external western influence in the business environment. Therefore, local cultural practices and government regulation in major sectors of the economy may be blamed for the lack of solution based on the common belief that many of the above problems could have been resolved through direct government intervention although its involvement is ubiquitous.

4.3 TQM in KSA Construction

Construction has been established as a very strong industry in KSA but its lack of emphasis on strategic planning for project tenders responsible for suspended projects, lengthy delays causing underachievement performance and financial loss is bemoaned by several authors (Assaf and Al-Hejji 2005; 2006; Abdul-Raman et al, 2006). It is justifiable to believe that the heavy presence of foreign companies could have aided the adoption of TQM in helping to address most of the problems outlined in section 4.2. However, Al-Sedairy's (2001) research findings revealed that the practice of project management in the industry varies widely among stakeholders. Owners appear to take the lead in setting standards for the industry because of their authority and their acquired expertise through the use of sophisticated tools for project control. It is also found that owners place a high value on the control of design quality. The research found that consultants usually have project management methods in place as a result of the pressure exerted by owners to develop well-defined routines for the logistics and scheduling and so on (Mahbashi, 2007). However, the research found that contractors, although sufficiently matured to adopt the state-of-art managerial techniques such as Total Quality Management, they are impeded by the general setup in the country.

Albayou (2003) recommends as a priority the promotion of TQM principles and its applications and transferability to create efficiency for the benefit of advancing management practices in the construction sector as TQM has been recognized by many countries as key to competitiveness. Several companies in KSA construction industry have made attempts to adopt TQM to create a quality culture (table 3) in their management system using TQM consultants. Notwithstanding, some of the TQM models introduced are not developed specifically for the construction industry nor for adoption in KSA culture and as a result usually fail to reap the benefits. Therefore, there is a need for a TQM model with an appropriate self-assessment instrument designed for the Saudi construction industry organizations (Al-Harkan, 2007). For example, Mahbahi (2007) cites the case of owners in KSA using sophisticated tools for project management, such as Saudi Aramco, a company that is financially well positioned, in addition to its advanced management style, which makes its way of conducting business exceptional. In fact, it sets an example for other organizations who strive for excellence and state-of-the-art strategy implementation for solutions leaving the practice of TQM philosophy out of the status quo in the sector in KSA. It is acknowledged that Saudi Aramco is mainly influenced by global trends, especially of the United States and always strives to adopt comparable managerial and technical innovations. In fact, it is a symbol of American presence in the industry and can be considered as a gateway for management and technology transfer from the West.

Considering design in Saudi construction, Arain *et al.* (2006) stress the inconsistencies in this area and their negative impact on performance in the industry. They enumerate further factors deemed responsible among which are: the involvement of the designer as a consultant; communication gaps occurring between the contractor and the designer; insufficient details in the work drawings; lack of coordination between the parties as well as the lack of qualified personnel in the design firms which usually result in knowledge deficits of available materials, equipment and specifications. In a separate study, Arain *et al.* (2007) deplored the lack of client experience leading to amendments in design specifications and contract terms that affect project performance and hence failure also confirmed by other studies (Assaf and Al-Hejji 2006; Al-Musallami, 1992; Al-Dubaisi, 2000). Such actions have always culminate in variation order mistakes and discrepancies in design documents; faulty drawings; very complex project designs;

insufficient data; misunderstanding of client's requirements; lack of access to advanced engineering design software and requisite experience. These ultimately result in cost and time overruns and client dissatisfaction. Also, Al-Otaibi et al. (2013) singled out Saudi procurement methods as responsible for underachievement of projects performance as it is based on the lowest price irrespective of the prevailing conditions. This is without regard for Egan's (1998) practical strategy of replacing competitive tendering with long term relationships reliant on clear measurement of performance and sustained improvements in quality and efficiency for the industry to redress the debilitating cycle of competitive tendering, conflict, low margins and dissatisfied clients. Indeed, official government statistics indicated tender inadequacies and shortcomings of over 3000 public projects in 2011 alone (Al-Hammadi et al, 2013). In fact, with such concerns leading to the need for The Council of Ministers' Resolution on addressing barriers facing construction works and the *Saudization* of projects in 2007 at a meeting on compensation issues in Washington DC with His Royal Highness himself present (Al-Hammadi, et al., 2009), the seriousness of this matter could never have been well emphasised.

Therefore, several indigenous authors have recorded considerably poor performance of Saudi construction projects and indicated that since Al-Sultan's (1987) and Al-Khalil & Al-Ghafly (1999) treatises on poor performance of construction projects in KSA, with 70% of projects suffering costs and time overruns, little has changed (Alsuliman et al., 2012; Al-Kharashi & Skitmore, 2009; Sweis et al., 2007). This therefore has created a negative image for the industry with clients expressing varying worrying concerns. This negative image has motivated many researchers (Assaf & Al-Hejji, 2006; Sweis et al., 2007; Al-Kharashi & Skitmore, 2009) to investigate the problem in studies in the KSA industry context. In an interview, the chairman of the Contractor's Committee made the shocking revelation that KSA's delayed public projects were estimated to cost $147billion (Staff, 2012). Notwithstanding, there has hardly been any conscious effort to find lasting solutions to the numerous problems. Consequently, it is not surprising that The MOEP (2007) recommended the need to apply several innovative approaches to enhance performance that required developing effective regulations and management, and the technical qualification of staff through specialisation.

5. Conclusions

Therefore, the construction industry in the KSA needs to tread the extra mile and implement TQM principles to the letter albeit cognizant of the need to adopt these to local and organizational cultural practices and appropriate technologies. It is also worth noting that the construction industries of many countries generally suffer problems of varying dimensions, however the characteristics of each is peculiar and need home grown solutions hence the need for comparison. While, Cannon (2008), for example, found the causes of delay in the building projects in the UK as being the shortage of project management skills, the large volume of temporary workers, health and safety, insolvency, and litigation, Tucker et al. (1999) outlined critical factors causing delays in the US as the approval for building authorization, changes in client orders and designs, the lack of complete documentations, and inspection pressures which were mainly attributed to unskilled workforce. These problems have also been known to characterize the KSA construction industry and also cut across other domains. This said, the need to concentrate on training a local and appropriate workforce to handle local problems of the industry by adopting and applying TQM principles to local cultural practices is paramount if the industry is expected to succeed in managing its projects successfully to reduce client dissatisfaction to the barest minimum. An example of a strategic quality improvement programme could be done by empowering installation workers to undertake inspection and conformance controls themselves where operatives are not blamed for conformance problems or suffer pay cuts for stopping tasks as a result of problems but by incentivizing a 'right first time' policy reward system rather than the volume of output, practices which are currently uncharacteristic of the SKA industry. Another point worth stressing is that while KSA construction jointly encounters problems with other nations, what is worrying is the lack of concerted effort and the required actions from the designated authorities towards ameliorating the situation to ensure client satisfaction. The construction industry in the SKA in adopting TQM aught to comprehensively address these management concerns from all quarters.

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Current Status of Offsite Construction in Saudi Arabia

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Abstract

Offsite construction is considered a new method of building in Saudi Arabia compared to other developed countries. The aim of this paper is to investigate the current status of offsite construction in Saudi Arabia, to achieve these aims the researcher adopted mixed methods combining Semi-Structured interview and Questionnaires. The interviews were administered amongst 6 expert participants in the field of construction in Saudi Arabia while the questionnaire was filled in by 140 participants from the construction industry. All the data was gathered and analysed based on scientific methods of analysis. This research extends the previous studies achieved by Lu (2007) and Shahzad (2011) on the offsite construction techniques (OCT). These studies have investigated offsite construction and its perception in the USA and New Zealand respectively, however in a different context this study will examine the use of offsite construction and in Saudi Arabia and how participants are satisfied with it while studying factors related to its implementation.

Keywords

Offsite construction, modern method of construction, Saudi Arabia

1. Introduction

There is no doubt that offsite construction has been played a very vital and significant role in the field of construction. As well as developing countries are concern, it is one of the rapid and effective methods to be used now days. Offsite construction has been proven to be very cost effective as there is an effective use of material; it minimizes the waste of material. This helps to reduce the overall cost and increases the profit margin. As in offsite construction, most of the products are manufactured and produced in factories with a strict environmental control which includes moisture; this increases the life cycle as well as quality of product. Offsite construction also contributes to create a safer environment for the workers as in factories environment and surroundings are regulated according to required health and safety condition defined by local authorities as compare to onsite conditions.As well as Offsite construction is concern in Saudi Arabia, Its trend has been increased dramatically in last few years. As it proves itself to be an effective method in Saudi Arabia conditions; that the reason it is selected and proffered to many construction companies as compare to onsite construction. By following the current trend, it is predicted that, Offsite construction has a very bright and stable future in Saudi Arabia.

2. Literature Review

2.1 The Saudi Construction Industry

Saudi Arabia has the biggest construction market in the whole region of the Middle East, with multi-billion dollar projects in the process of being completed and several others in the planning stage. It is experiencing nowadays a boom in both the public and private sectors (Middle East Finance and Economy, 2005).The construction industry plays a fundamental role in the physical as well as the economic development of Saudi Arabia. It contributes with approximately 9% to the GDP, employs more workers than any other sector (3.5 million workers) and is a big

consumer of manufacturing and service commodities (MOP, 1997; NCB Economist, 2003). For this reason, the condition and efficiency of this industry are significant to the Saudi economy. The initiatives for a large infrastructure development during the last decade have provided the construction industry with a unique opportunity to launch a number of large projects. For instance, Figure 2.1 shows that a budget of 65 billion Saudi riyal (SR) was allocated and spent in 2009 alone (MOP, 2009).

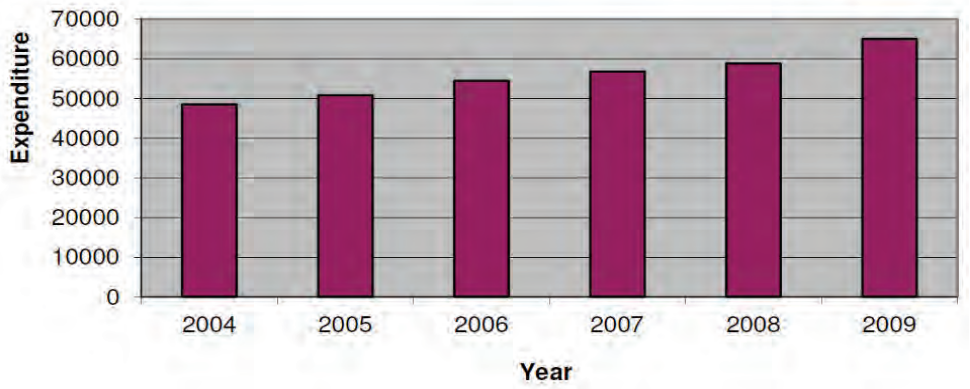


Figure 1: Saudi Government expenditure on construction (MOP,2009)

In the conditions of such boom in the field of construction, demand is high in Saudi Arabia for construction materials, equipment, technology and efficient construction management and operation techniques and methods. Construction has often been a driving force of growth, responding to the needs in housing, which is related to demographic increase and through the government subsidies, makes efforts to build a modern infrastructure. In this regard, the government has taken a number of initiatives to enhance the performance of the existing departments within public bodies in order to enable them, so that they will be able to monitor various construction projects especially those financed by the government in the fields of infrastructure education, health, state buildings, and public services. In order to promote quality in such services, the government has also given it order to expand certain bodies and to establish new specialised construction control units.

The construction industry in Saudi Arabia faces a set of real challenges; some are related to the environment, whereas others are inherently part of any construction business. Three primary concerns are common to owners: time necessary for completion, cost and quality. The traditional 'sequential' approach to construction is another compounding challenge. As a matter of fact, several studies in the past report that the industry encounters persisting problems such as delay, waste, poor quality, low productivity, mistakes and later rework. One of the most serious problems in the public sector is the recurring and delays of considerable length in the completion of projects (Zain Al-Abidien, 1983; Al-Sultan, 1989; Al-Khalil and Al-Ghafly, 1999; Falqi, 2004; Assaf and Al-Hejji, 2006).

One of the distinctive features of the Saudi construction industry is its heavy dependence on low skilled foreign workers. Several contractors employ workers employed who, in many cases, have a little or no experience in construction. Although they have skills in construction, the standards practised in Saudi Arabia are different to some extent to those in their home countries (Saudi Council of Chambers of Commerce and Industry, 1998). Besides this, in Arab countries and the Middle East, including Saudi Arabia, people are not usually committed to time, which means that their punctuality is poor. Such attitudes to time, which are related to culture, will impact the performance of the industry.

2.2 Offsite Construction

Arif and Egbu (2010) define Offsite construction as the type of construction where the purpose is to transfer some of the effort that goes into construction from the construction site to the supervised setting of a manufacturing facility

2.3 Comparison of Offsite Construction and Traditional Construction Methods

Goodier and Gibb (2007) observe that the choice between the use of OCT and the traditional construction methods is usually made on the basis of development cost rather than the life cycle value of the project. However, the speed of construction remains the most appreciated advantage of using OCT over other methods of construction. Another advantage is the fact that OCT is more eco-friendly. Barret and Weidmann (2007) argue, in the course of their

comparison of OCT to traditional construction methods, that OST definitely outperforms the traditional construction approach when it comes to greenhouse gas emissions.

The MBI (2010a) Report makes the following comparison between OCT and the traditional construction methods:

- OCT has the potential to optimise the use of construction material, to minimise waste and to offer clients a high quality product to the clients.
- The changes of moisture being trapped in fabric of the new construction after installation are eliminated given that the materials are kept and manufactured in factory-controlled environment.
- As most of the modules or components are manufactured offsite, congestion on site is reduced. Likewise, the requirement of equipment and machinery is reduced on site.
- At a site of conventionally built project, construction workers are exposed to extreme weather conditions; high temperature, wind and rain. Besides this, they may be injured due to falls and other site risks. In factory conditions, however, the workers are provided a safer workplace as they are fully equipped with the required materials and tools.
- An Australian study (CRC, 2007a) indicated that modular construction schedule results in new buildings being open 30 – 50% sooner than the conventional construction schedule; this is possible thanks to the ability to achieve simultaneous site development and building construction in the factory environment with the modular system.

2.4 Summary of Offsite Construction Application Worldwide

The reason for choosing offsite construction in the countries specified earlier is that they have successfully implemented OCT with years of experience. For example Offsite construction techniques have been implemented mainly by large UK construction companies. The use of offsite construction techniques are more largely implemented in the commercial sector than the residential and industrial sectors. The main re the reluctance of clientstoadopt innovated building techniques because they failed to ascertain the benefits that offsite construction techniques added to their projects. Also for many of those who were involved in the construction process, the benefits of using offsite construction techniques were not fully grasped. Furthermore the unclear impact of the construction costs was another big challenge to the use of offsite construction techniques in the UK. There was also a shortage of skilled assembling workers is another contributing obstacle and research found that home buyers are partially resistant to new building materials but are not resistant to new forms of offsite construction techniques.

In the context of USA the OCT have been implemented for many years, however there aredemands on the part of owners (buyers of construction) that projects to be completed faster, be less expensive, and be completed without sacrificing quality and safety performance are reported. The Offsite construction techniques adopted include offsite preassembly, hybrid building systems, panelised systems and modular buildings.OCTs have not been implemented at a large scale in the United States construction industry even if current automation technology and modes of transportation provide great opportunities for implementing techniques to optimise overall project performance.

In the late 1950s, the housing market in Japan started to utilise the techniques of offsite construction because there were a rapid economic growth not enough skilled carpenters, and at present, offsite construction techniques are mainly used in the building sectors in Japan, especially in the residential sector (Matsumura, 1994). In the Netherlands the Smooth-faced gypsum blocks are utilised in the building for non-load-bearing internal walls, which provide flexibility in the layout design, and better sound and resistance to fire. Also research found that Offsite construction approaches; compared to conventional construction technology in the Netherlands, bring construction time from 21 months to 12 months, with 33% more usable floor area. They also decrease the cost of the building to 17%. Most contractors are taking advantage of these materials and methods. They have been implemented with success in the industry for more than 25 years (Waskett, 2001).

The implementation of OCT extends to other Asian countries such as Singapore and Korea. In Singapore construction depends heavily on foreign labour. In the system of HDB's semi-precast reinforced concrete, the principal building components, beams and columns, among others, are all made cast-in-place. All other reinforce concrete components are pre-cast in factory environment; these include staircases, parapets as well as internal non-load-bearing partition walls. In the context of Korea Construction typically has set up a prefabricating facility on the

project site. Given that the preassembly is carried out onsite, the construction company does not deal with the transportation issues. All of the precast concrete modules are manufactured onsite and a crane lifts them into position at the rate of one floor per day. Like most of the other Asian countries, Korea's large population offers a great opportunity for using offsite construction techniques which have been widely implemented in constructing high-rise buildings with more fifteen floors.

2.5 Benefits of Offsite Construction

Offsite construction technology offers several benefits such as shorter project duration, reduced cost, better quality control, improved onsite safety, less environmental degradation for the environment; reduced cost helps improve productivity of the construction process (Gibb, 1999; Lu, 2009; Lusby-Taylor *et al*., 2004).

Gibb and Isack, 2003 provide benefits of offsite construction. The following table presents some of the benefits:

Table 1: Benefits

Benefits	Description
Time	• Less time on-site—speed of construction • Speed of delivery of product • Less time spent on commissioning • Guaranteed delivery, more certainty over the • programme, reduced management time
Quality	• Higher quality—on-site and from factory • Product tried and tested in factory • Greater consistency—more reproducible • More control of quality, consistent standards
Cost	• Lower cost • Lower preliminary costs • Increased certainty, less risk • Increases added value • Lower overheads, less on-site damage, • less wastage
Productivity	• Includes less snagging • More success at interfaces • Less site disruption • Reducing the use of wet trades • Removing difficult operations off-site • Products work first time • Work continues on-site independent • of off-site production
People	• Fewer people on-site • People know how to use products • Lack of skilled labour • Production off-site is independent of local • labour issues
Process	• Programme driven centrally • Simplifies construction process • Allows systems to be measured

2.6 Challenges of Using Offsite Construction

Table 2: Challenges

Challenges	Description
Project Planning and Coordination	• The increase of pre-project planning stage. • There is a need for more engineering effort made beforehand. • The planning and design should be conducted with precision to incorporate the construction work needs. • Coordination of design, transportation, and onsite installation are critical components for the implementation to be successful.
Transportation Restraints and logistic challenges	• Transportation logistics plays a fundamental role in determining whether offsite construction is feasible or not. • The method and route of transportation impose size and weight as well as width and height restrictions during transit. • Manufactured building components have to be overly designed to minimise possible damage during transit.
Design challenges	• The lack of flexibility which makes any design modifications at a later stage impossible.
Negative Perceptions	• The general negative perceptions of offsite construction. • There has always confusion between prefabricated buildings and manufactured houses.
Flexibility to make changes onsite	• The inability to make changes onsite during construction may lead a decrease in the use of offsite construction. • Require a well-defined scope in the early stages of the project planning.
Process and Programme	• A process which requires integration of planning, design, manufacturing, supply and installation. • Design takes longer than usual and this is due to proper management of interfaces during design. • Extensive coordination on the part of clients, architects, management consultants and contractors is required.
Cost, value and productivity	• The higher cost of using offsite construction is related to the steel moulds utilised for offsite construction being more expensive than the traditional timber formworks used. • This cost is dependent on the distance that separates the factory location from the construction site; accordingly, long distances are likely to be more expensive, thereby increasing the entire cost of the project.
Regulations	• The legal frameworks are not structured to encourage the use of Offsite construction. • The lack of knowledge about Offsite construction in policies and code of practice for construction industry. • There are safety compliance issues in the use of cranes to handle heavy prefabricated components which are not only expensive to meet, but also consumes time and discourage contractors.
Market culture	• The construction industry is a sector which is labour intensive and labour has its own stakes against the newly emerging technologies. • Resistance of labour market to accept offsite construction is likely to hold back its uptake. • Clients have their own stakes based on the perceptions they have.
Supply chain procurement	• The limited capacity of suppliers as a supply chain obstacle to the adoption of Offsite construction. • Market control by traditional suppliers and loss of project control during activities on-site also obstructs the adoption of Offsite construction. • The difference between Offsite construction cash flows and routine cash flows of the construction projects.
Skill and knowledge	

3. Research Methodology

This paper is a part of a doctorate research that for developing an implementation strategy of offsite construction in Saudi Arabia which has seven objectives. One of its important goals is to investigate the current status of offsite construction in Saudi Arabia. There for, designing a good methodology was needed to meet the research objectives. The research methodology has three stages which are pilot study for the first stage; the second one is survey questionnaire and semi-interviews that investigated the current status of offsite construction; and finally, developing a strategy to implement offsite construction in Saudi Arabia which will be validated by case studies.

In other words, the researcher will firstly rely on secondary data generated from the literature review followed by primary data which are generated through the adoption of mixed methods of research strategies namely Semi-structured interviews and Questionnaire. The interviews aim to provide the researcher with an initial understanding of the OC practice in Saudi Arabia and help in designing the self-administered questionnaire. Following that the researcher aims to develop the OC implementation strategy which will be tested and validated using a Case-Study methodology.

4. The Status of Saudi Offsite Construction

4.1 Original Field of Study

The graph below demonstrates the valid percentage of participants based on their original field of study. In answering that it was very evident that the majority of participants (72.5%) studies engineering, while only 17.6% studied management, architecture was studied by 6.% of the participants while 3.8% of them highlighted other fields of study

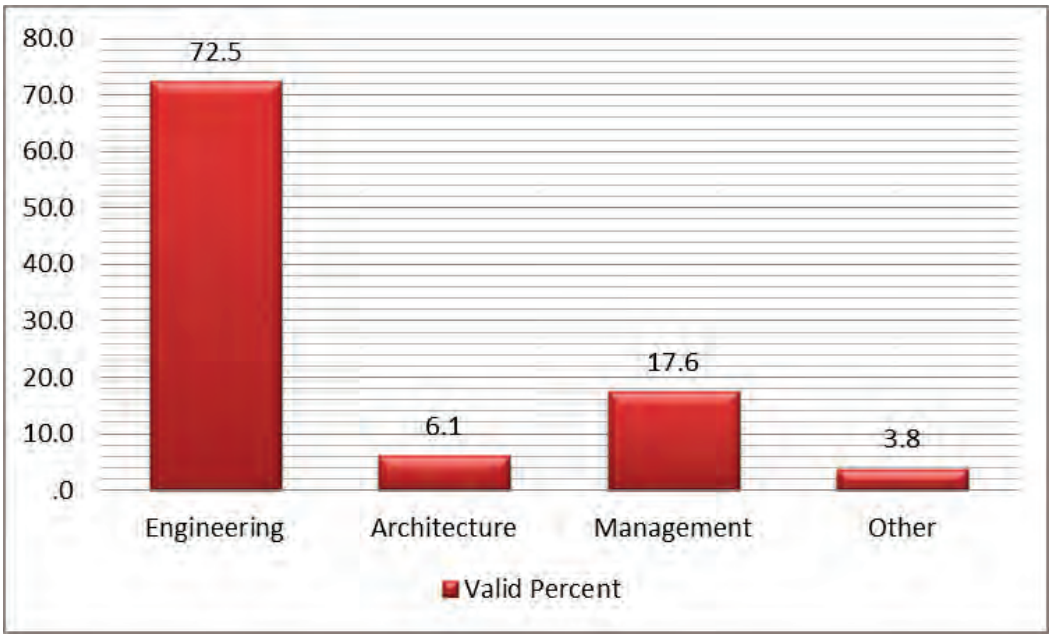


Figure 2: Shows the frequency of answers in percentages concerning the original field of study

4.2 Experience of Off-site Construction

Further description explained that the experience of off-site construction varies between the participants, however almost half of them, 47.1%, have an experience of less than 5 years followed by 24.3% who have a 5-10 years of experience; 11.8% had experience of 11-15 years; 9.6% had more than 20 years of experience and lastly 7.4% stated an experience of 16-20 years.

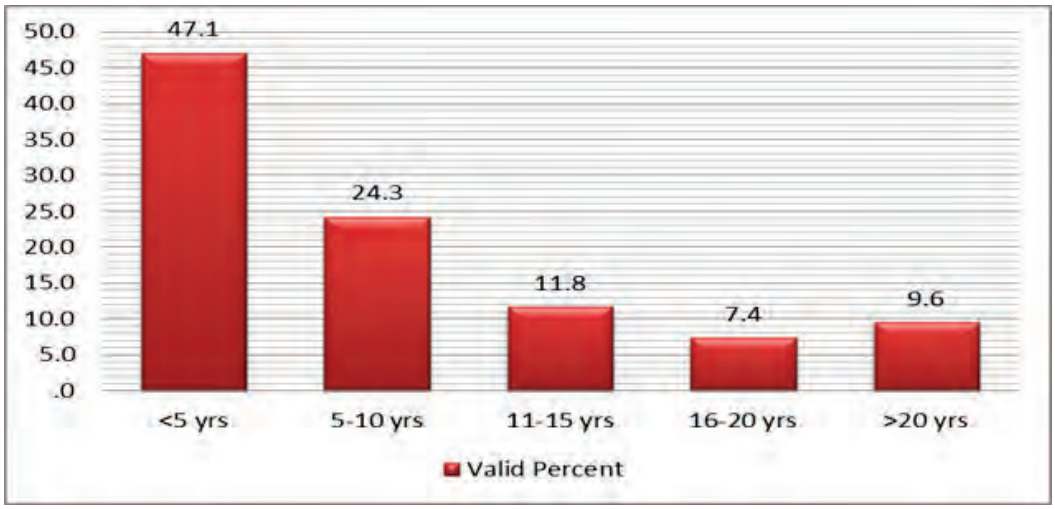


Figure 3: Shows participants' experience of off-site construction in percentages

4.3 The Techniques of Off-Site Construction & Satisfaction

This part describes the techniques of off-site construction and participants' satisfaction regarding techniques. The first part asked participants to rate the four off-site construction techniques (Off-site preassembly, Hybirdsystem, Panelised system and Modular building) from 1=most used to 4=least used. However by looking at their answers many of the participants ticked one of the four without providing the rank, therefore all four techniques were ranked based on the number of ticks/agreement they received. When looking at the technique techniques it was found that 74.6% of the participants use "off-site preassembly, followed by 63.8% who showed the use of "Panelised system"; thirdly that rated the "modular building", receiving 37.7% and finally the "Hybrid system" which received 55.1% of the agreements.

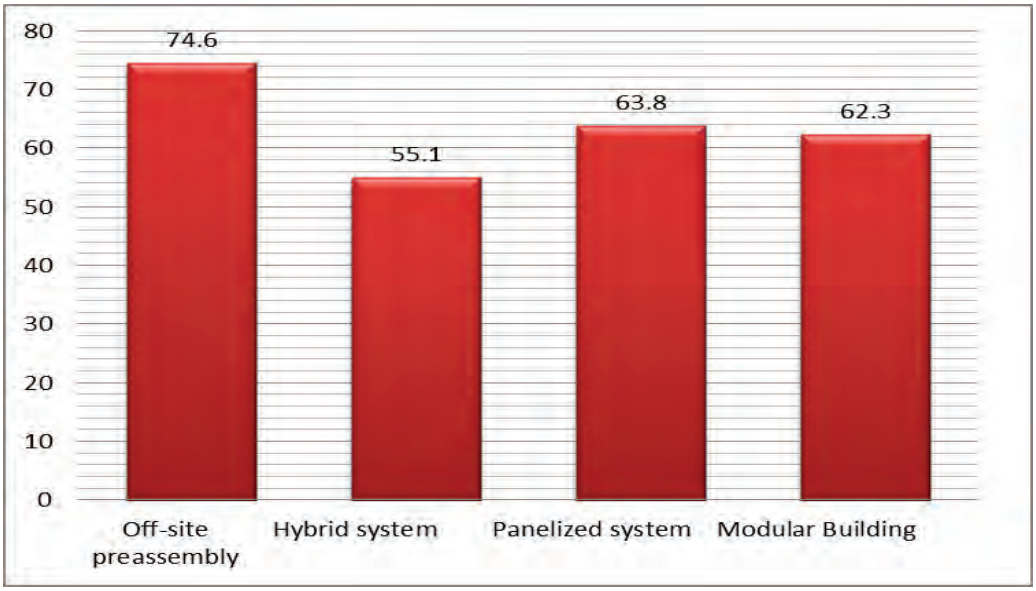


Figure 4: Shows the off-site techniques used by participants

4.4 Reasons of Using Off-site Construction Techniques

Table 3: Shows the frequency of the most common reasons for the use of off-site techniques

Reasons	No	Yes	Rank
Project owners require using off-site construction techniques	110	28	5
	79.7%	20.3%	
To reward for the shortage of skilled craft workers	111	27	6
	80.4%	19.6%	
To reward for the local weather conditions	134	4	11
	97.1%	2.9%	
To reduce design duration	110	28	5
	79.7%	20.3%	
To reduce construction duration	50	88	1
	36.2%	63.8%	
To reduce project overall schedule	87	51	3
	63.0%	37.0%	
To reduce overall project cost	74	64	2
	53.6%	46.4%	
To increase product quality	97	41	4
	70.3%	29.7%	
To increase overall labour productivity	110	28	5
	79.7%	20.3%	
To reward for the restricted working space onsite	131	7	9
	94.9%	5.1%	
To reduce environmental impact	133	5	10
	96.4%	3.6%	
To improve project safety performance	134	4	11
	97.1%	2.9%	
To increase your company's profit margin	128	10	7
	92.8%	7.2%	
To enhance your company's reputation	129	9	8
	93.5%	6.5%	

4.5 Challenges of Using Off-site Construction Techniques

Table 4: Shows the frequency of challenges of using off-site construction techniques

Challenges	No	Yes	Rank
The project owners do not allow using off-site construction techniques.	90	48	2
	65.2%	34.8%	
General contractors do not have expertise of assembling prefabricated building components onsite.	87	51	1
	63.0%	37.0%	
The local zoning ordinance restricts the use of off-site construction techniques.	130	8	11
	94.2%	5.8%	
The local building regulation restricts the use of off-site construction techniques.	115	23	7
	83.3%	16.7%	
The financial institution restricts the use of off-site construction techniques.	119	19	10
	86.2%	13.8%	
Designing off-site construction components requires special computer Software.	117	21	8
	84.8%	15.2%	
Lack of skilled assembly craft works locally.	103	35	5
	74.6%	25.4%	
Using off-site construction techniques will increase the design cost.	101	37	4
	73.2%	26.8%	
Using off-site construction techniques will increase the construction cost.	96	42	3
	69.6%	30.4%	
Transportation restraints	118	20	9
	85.5%	14.5%	
Limited design options of using off-site construction techniques.	106	32	6
	76.8%	23.2%	
Inability to make changes in the field by using off-site construction techniques.	87	51	1
	63.0%	37.0%	

5. Conclusion

There are four techniques that are being utilized now days in Saudi Arabia such as Offsite Preassembly, Hybird System, Panelised System, Modular Building. These techniques are being used frequently and preferred as Offsite construction methods. There are some reason for the utilization of these techniques which are described as: To reduce construction duration, To reduce overall project cost, To reduce project overall schedule, To increase product quality, To increase overall labour productivity. In addition to these reasons, there are some challenges for the implementation of these techniques which are described as: General contractors do not have expertise of assembling prefabricated building components onsite, The project owners do not allow using off-site construction techniques, Using off-site construction techniques will increase the construction cost, Using off-site construction techniques will increase the design cost, Lack of skilled assembly craft works locally. It is very crucial to overcome these challenges as they are the obstacles in the implementation of Offsite construction more frequently. Further studies will be done to answer these challenges and overcome the obstacles so that offsite construction will become more practical and operational in construction industry.

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An Application of MCDM in Competence Sourcing

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Abstract

The main issue of this article is to propose a framework by which competence sourcing mode the goal of optimal operations strategy and management will be carried out and achieved in the OMDs. Our integrated model incorporates the decision making trial and evaluation laboratory method (DEMATEL), integrating these relation weights along with the analytical network process (ANP) and zero-one goal programming (ZOGP) to find an optimal sourcing portfolio for task execution and to achieve objectives using limited resources. The ultimate objective was to devise a method to help practitioners/OMDs managers to evaluate how well aligned each competence sourcing decision is with the company's strategic direction, and to reap the optimal benefits from competence sourcing decisions regarding task arrangement. In order to adequately evaluate the competence sourcing decision, we considered critical criteria from various points of view on the basis of reviews of literature regarding optimal operations strategy and management. We also considered available strategies from capability assessment, competence alignment and operations management to validate the meaning of sustainable competence sourcing management.

Keywords

Strategic capability sourcing, competence sourcing, ANP, DEMATEL, ZOGP

1. Introduction

1.1. Optimal Allocation Strategy and Management

Operations Management Departments (OMDs) are experiencing significant changes triggered by market and regulatory drivers. The recent years have shown that OMDs need to be flexible and agile in adapting their operating models based on maximizing the use of all their resources – human, financial, and physical-technological. OMDs need to acquire the right capabilities/competences from the right source, at the right time and, at the right cost to improve and sustain their competitive position. Competence sourcing is an organizing process to gain access to best-in-class capabilities/competences for all activities in a company's value chain to ensure long-term competitive advantage. Different sourcing strategies are the most common way to increase the operational flexibility of an OMD. The foundation for ensuring that all resources are leveraged to the fullest is making sure that the right work is being done by the right people and that the processes they engage in to complete their work are the most efficient and effective. Unfortunately, in many OMDs, work is not prioritized and allocated systematically in respect to competences and capabilities of their resources. Perhaps the organization has grown over time, either through mergers and acquisitions or adding personnel on an as-needed basis, and personnel continue doing the work they did before the changes. Or perhaps the physical-technological and human size has remained static with individuals taking on additional responsibilities as requested by management side. While there exist several studies and modeling applications for capability arrangements, competence distribution and allocation for OMD's, these models are limited to qualitative suggestions such as threshold capabilities in respect of an integrated organizational improvement view. However, most OMDs efforts are characterized by significant complexity and dependency amongst three major perspectives, thus preventing the identification of the type of the sourcing mode. When work is allocated in this somewhat ad hoc manner, the result can be over- or under-utilization of resources and disproportionate effort focused on matters that are not the companies or department's priorities and strategy. These are situations that no OMDs can afford anymore. OMDs require an optimal competence sourcing strategy which enables it to take good advantage of its resources efficiently, so that it can concentrate on its core competences and

capabilities, to identify what comprises strategic capabilities in terms of organizational resources and competences and how these relate to the strategies of organizations. The solution is to systematically assess, prioritize, and allocate both the work and competencies based on its actual value to the company. A methodical prioritization and allocation of work will allow to the OMD to more clearly communicate work parameters and competencies to its resources, enhancing their value contributions as well. Internally, this will improve performance and generate positive results at all levels of the organization and individually each members' job satisfaction, -either white or blue collar- will increase because they have a clear understanding of their roles and responsibilities and know that the work they do is meaningful to the company and for themselves. The corporation as a whole will benefit because the OMDs will focus its priorities on mitigating the company's risk and on furthering the strategic goals of the company and will maximize the use of its time and human/physical resources, performing services in the most efficient and cost effective manner.

In facing the problem of how to decide the priorities of OMDs task arrangement and which competence mode to operate with a proper sourcing mode, it's proposed a novel hybrid model to optimize the operations strategy for a white goods manufacturing company in Turkey. The proposed hybrid model is not only because OMDs stays in the era of turbulent marketplaces, global competition, and volatile technology, but also because past allocation decisions in regarding competencies used an entire OMD department as a unit of analysis rather than treating individual competence arrangement of OMD tasks separately. On the basis of factors for evaluating resource alternatives, i.e., optimal operations strategy and management of OMD in this study, here, the author illustrate several factors with respect to the aspects in achieving its setting goal in higher level of hierarchical system and combine a wide range of criteria. The ultimate objective was to devise a method to help practitioners/OMD managers to evaluate how well aligned each competence sourcing decision is with the company's strategic direction, and to reap the optimal benefits from competence sourcing decisions regarding task arrangement. In order to adequately evaluate the competence sourcing decision, we considered critical criteria from various points of view on the basis of reviews of literature regarding optimal operations strategy and management. We also considered available strategies from capability assessment, competence alignment and operations management to validate the meaning of sustainable competence sourcing management.

1.2. The Research Problems and Goals

The main issue of this article is to propose a framework by which competence sourcing mode the goal of optimal operations strategy and management will be carried out and achieved in the OMDs. Our integrated model incorporates the decision making trial and evaluation laboratory method (DEMATEL), integrating these relation weights along with the analytical network process (ANP) and zero-one goal programming (ZOGP) to find an optimal competence sourcing portfolio for task execution and to achieve objectives using limited resources. Our ultimate objective was to devise a method to help practitioners evaluate how well aligned each competence sourcing decision is with the company's strategic direction, and to reap the optimal benefits from competence sourcing decisions regarding task arrangement. The Management of the OMD**s** therefore requires sophisticated tools and techniques to ensure that corrective action can be taken proactively and that the tasks involved are exactly assigned and executed with a proper competence sourcing mode to manage OMD capabilities.

This paper is organized into four sections. A theoretical background of strategic competence sourcing and competitive advantage is explained in the next section. In the third section, the three generalized potential competence sourcing alternatives and evaluation criteria based on BSC are introduced as an approach to improve the firm's competitive position. Finally, in the last section, conceptualization as a solution is proposed for competence sourcing modeling.

2. Literature Review

2.1. Components of OMD Strategic Capabilities

The resource-based view (RBV) of strategy asserts that the competitive advantage and superior performance of an organization is explained by the distinctiveness of its capabilities and competencies, which means strategic capabilities/competences. Strategic capability is the ability to perform at the level required to survive and prosper. It is underpinned by the resources and the competences of the organization. Threshold resources are the resources that needed to meet customers' minimum requirements and therefore to continue to exist. Threshold competences are

activities and processes needed to meet customers' minimum requirements and therefore to continue to exist (Johnson and Scholes, 2005).

Competence sourcing decisions are strategic decisions at the management level of organization. These decisions formulate corporate strategies how to achieve competitive advantage through arranging the firm's resources and configuring the firm's capabilities within a changing environment. Strategic competence sourcing decisions are made about choosing the right sourcing solutions like outsourcing, insourcing or co-sourcing. At the strategic management level in an organization, decision makers need to share a common ground or a common language to facilitate their discussions (Clark, H., Brennan, 1991). A common language is needed to define and articulate concepts that facilitate the description of objects of strategic interest and that improve the strategic discussions and enhance related decision making (Osterwalder, A., Pigneur, Y. 2013).
The firm's resources, capabilities and competencies are the main factors driving the strategic sourcing.

- Resources are the assets that organizations has or can call upon (e.g. from partners or suppliers), that is, 'What the firm has'. Two categories of resources are tangible resources and intangible resources.
- The concept of capability represents the firm's capacity or ability to integrate the firm's tangible and intangible resources to achieve a desired objective that is "What the firm does". So, capabilities can be considered as the firm's capacity and ability to capture the value of resources (Cardeal, N., António, N. (2012).
- The concept of capability/competency captures the essence of what makes an organization unique in its ability to provide value to customers. Competences are the ways those assets are used or deployed effectively, that is what we do well' e.g. Competencies are "What a firm does that is strategically valuable" (e.g. product design skills, cooperative relationships). Distinctive competency is something that an organization does particularly well relative to its competitors.

A methodical prioritization and allocation of capability/competence will allow to the OMDs to more clearly communicate work parameters and competencies to its employees, enhancing their value contributions as well. The solution is to systematically assess, prioritize, and allocate both the resources and competencies based on its actual value to the company.

2.2. The Factors of Capability/Competence Sourcing

Strategic sourcing is rooted in the idea that a business must have a set of explicitly defined capabilities in order to execute its strategy successfully (Loftin, R., Lynch, R., Calhoun J., 2011). "Leaders often mistake the course of action and pursue a wrong path diverting attention from the intended strategy. A root cause is often that strategic intent and objectives are not articulated in clear operating language for better execution. A written strategy does not ensure strategic action" (Loftin, R., Lynch, R., Calhoun J., 2011).

Sourcing decisions are strategic decisions at the management level of organization. These decisions are related to the organizing process of an organization. Organizing is defined as the process of arranging resources to work together to accomplish a goal (Schermerhorn, J.R., 2012). The organizing process formulates corporate strategies to achieve competitive advantage through arranging the firm's resources and configuring the firm's capabilities/competencies within a changing environment. In the organizing process, strategic decisions are made about choosing the right capability/competence sourcing solutions like outsourcing, insourcing or co-sourcing.

This paper express the firm's capabilities/competences as 1) Insourced capabilities/competences that are assigned to an internal (but 'stand-alone') entity that specializes in that operation. 2) Out-sourced capabilities/competences that are assigned to a third party to per-form on its behalf. 3) Co-sourced capabilities/competences that are assigned to a partnership as a long-term cooperation between two (or more) business partners. As regards the different components of sourcing capabilities/competences, are the three main sourcing modes in the distribution of capability and competence arrangement.

At the strategic management level in an organization, decision makers need to share a common ground or a common language to facilitate their discussions (Clark, H., Brennan, 1991). A common language is needed to define and articulate concepts that facilitate the description of objects of strategic interest and that improve the strategic discussions and enhance related decision making (Osterwalder, A., Pigneur, Y. 2013). We introduce a novel hybrid model of competence sourcing to prioritize and allocated systematically of competence sourcing alternatives.

Competence sourcing models can facilitate strategic sourcing decision making to choose the right sourcing solution for the organization.

A list of evaluation criteria considered influential in the competence resource allocation has been summed up using a detailed literature review (Erensal, Y.C., Gürbüz T., Albayrak Y.E., 2010) and consultation with company managers. While interview with executive managers of white goods manufacturer, the competence sourcing alternatives and criteria have been discussed and made known in academic and management publications. Finally, the questionnaire is formed from the integration of three sourcing alternatives with 27 criteria as shown in Fig. 1. Simple cost/benefit and financial analysis criteria may be inadequate for such strategic analysis. Performance metrics are used to measure and estimate the impacts of sourcing alternatives. One of the features of the methodology is that does not rely entirely on financial measures. Rather, it takes an approach where financial measures are integrated with non-financial, strategic measures. The strategic nature of this justification methodology requires that the analysis team gain an understanding of the strategic direction of the firm. This understanding is accomplished by completing documentation for the enterprise's vision, mission, objectives, and strategies. For the purpose of this discussion, several generic criteria identified as being critical in making a strategic capability/competence sourcing decision in respect of an integrated organizational improvement view. In summary, the preliminary evaluation criteria based on the balanced scorecard can be categorized as four criteria and twenty-seven sub-criteria. The four main criteria for evaluating key capabilities and core competence are finance, customer, internal business process, and learning and growth, respectively. Twenty-seven evaluation sub-criteria are embedded in the four evaluation criteria.

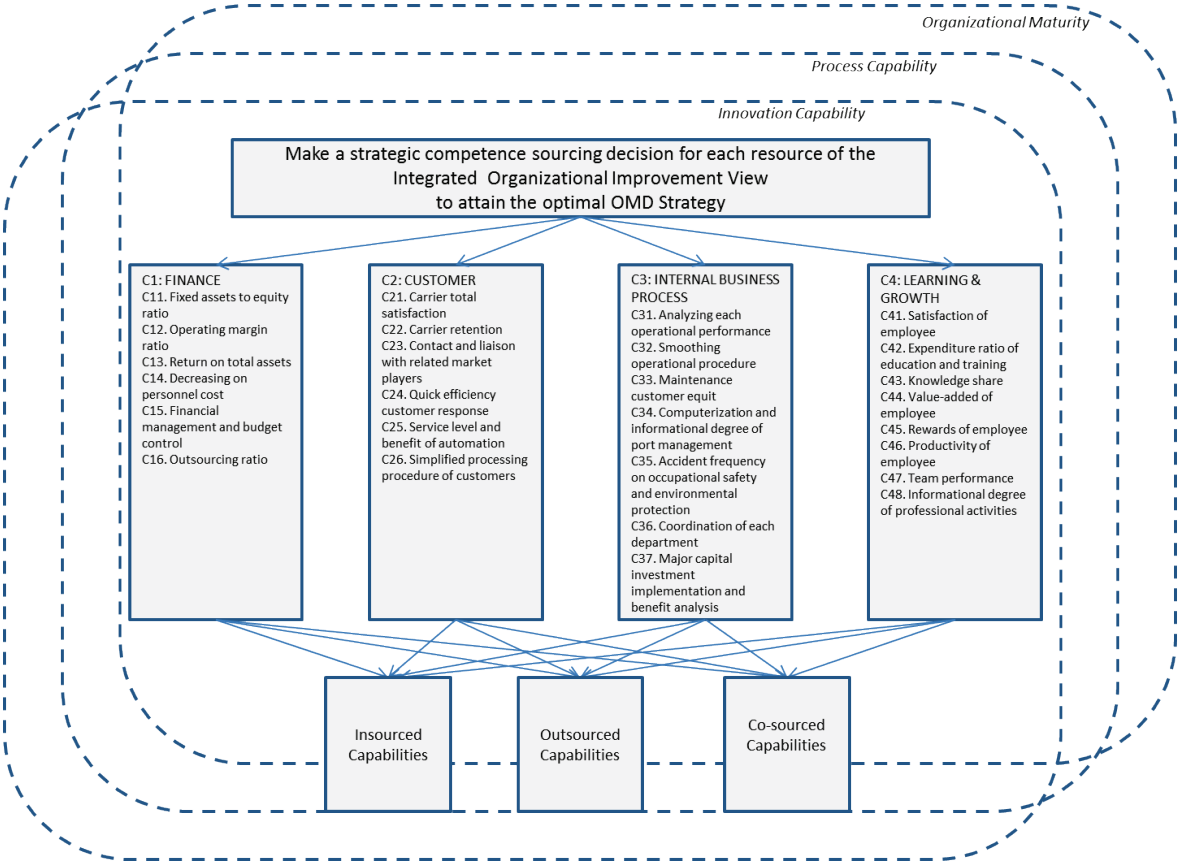


Figure 1: The overview of the ANP structure

To attain the optimal OMDs strategy in respect of an integrated organizational improvement involves at least three main perspectives/tasks: Innovation Capability; Process Capability and Organizational Maturity. An enterprise may

feel that certain sourcing strategy have a greater effect on meeting the OMDs objectives. Similarly, not all metrics are equally applicable in measuring the impact for a particular competence sourcing strategy.

In this paper, a methodology is introduced in which the conceptualization can serve as a common language to facilitate discussions about capability/competence sourcing at the strategic management level of OMDs.

3. The Methodology of the Research

The main issue of this study is to decide the priority of capability/competence sourcing mode to execute OMDs task by which sourcing mode the goal of optimal operations strategy and management will be carried out and achieved. Our integrated model incorporates the decision making trial and evaluation laboratory method (DEMATEL), integrating these relation weights along with the analytical network process (ANP) and zero-one goal programming (ZOGP) to find an optimal sourcing portfolio for task execution and to achieve objectives using limited resources. Our ultimate objective was to devise a method to help practitioners evaluate how well aligned each sourcing decision is with the company's strategic direction, and to reap the optimal benefits from sourcing decisions regarding task arrangement. The ZOGP model results, thus, provide an optimal recommendation that can help managers to decide the most appropriate capability/competence sourcing mode to execute to each task of the OMDs responsibilities.

3.1. Constructing Decision Making Structure of Competence Sourcing

A typical ANP hierarchy consists of at least three levels: the goal, the evaluation criteria and the alternatives. The highest level with only one element is the ultimate goal of the decision maker(s). In this study, the goal of the ANP model is to make sourcing decisions for each OMDs tasks to attain the optimal operations strategy and management, and is placed at the first level of the hierarchy. The second level of the ANP model is the factors of the perspectives and criteria for achieving the goal. In the competence sourcing consideration, perspectives and criteria mean those factors of evaluation principles that conform to of operations strategy and management are built up by the expert panel as mentioned in Section 2. Lastly, the final level of the structure is the sourcing alternatives. We consider three aspects of potential capability/competence sourcing modes as the alternatives of capability/competence arrangement, including Insourced, Outsourced and Co-soured. That is, the expert panel will evaluate and assign the weights to each potential alternative for the execution of the competence allocations individually, in accordance with the perspectives and criteria of the operations strategy and management. The overview of the ANP structure is shown in Figure 1.

In particular, such well-constructed evaluation process of capability/competence sourcing decision model could be extended and applied to any existing or future tasks, projects or systems that need access to both internal and external resources and fit in with the goals of operations strategy and management simultaneously. This proposed decision model to the capability/competence sourcing mode could therefore be a MCDM decision model of sourcing arrangement and will conform more close to the decision need for the practitioners in reality.

3.2. Evaluating relationships between perspectives by DEMATEL

Before the capability/competence sourcing decision hierarchy of ANP is applied to obtain the weights of each potential sourcing alternative for each OMDs tasks, the causal relationships of the perspectives and criteria involved should be analyzed and evaluated for further application of ANP in order to identify their direct, indirect and total influences among the cause and effect groups. Following the procedure of the DEMATEL method, the expert panel will be asked to determine the intensity of the influence between each perspective and criterion through the use of scale and pairwise comparisons. Once the relationships between those factors have been measured by the expert panel, the initial direct-relation and the normalized direct-relation matrix can be produced. Here, the expert panel has to choose an appropriate value as a threshold in order to focus on those perspectives and criteria that provide great influence, and not to blur in the network structure of the whole system because of too many factors. Subsequently, the expert panel deploys both of the well-formalized relations of the perspectives and criteria into ANP model to construct a complete OMD sourcing decision model.

3.3. Set priority weight by ANP

After the relationship structure systems of the perspectives and the criteria have been formulated and set in the OMDs sourcing decision hierarchy, the ANP approach is applied to derive the weights of each potential sourcing alternative for each task of the OMDs.

3.4. Find an optimal sourcing portfolio of OMD tasks by using the Goal Programming Model

Although the expert panel suggested and provided a set of priority of the sourcing modes for each task on the phase of the ANP, white goods manufacturing company still has to make an optimal selection decision under the authority of department budget and related resource constraints of the organization. Moreover, with limited resources, in the process of ranking the competence source will make the relative OMD activities to improve, and then, the results of that appraisal can be applied to OMD strategy formulation. Thus, when the priority weights of sourcing alternatives of each task of the OMD have been ascertained, these ANP weights will not only be thought of as preferences for OMD task arrangement but also be deployed as a constrained condition of goal programming in the ZOGP model.

Generally speaking, the competence sourcing mode with the highest weights represented the most important degree to achieve organizational objectives and would be best adopted to execute the task in advance. After considering the obligatory and mandated limitations, it is not necessary that the sourcing mode with the highest weights should be adopted in advance by the task in every instance. The different ANP weights and limitations result in the different optimal solutions. Finally, the results will show that this integrated MCDM support model can not only fully utilize the available resources of the organization but also find an optimal task sourcing portfolio for executing each task of the OMD in building an integrated organizational improvement view.

4. Conclusions

To deal with future planning and strategic competence sourcing management for maintaining long-term sustainable competetive advantage, the most important task for the authorities/managers is the optimization of the use of strategic competence sourcing alternatives. Competence/capability sourcing decision making models are in nature MCDM of sourcing alternatives based on organization's capabilities. These type of hybrid MCDM's help decision makers to choose the right sourcing alternatives for capabilities such as insourcing forms, outsourcing forms and sharing forms. It provides a frame to define a more specific decision making framework and for modeling strategic competence sourcing alternatives and elaborating analytical techniques to explore, compare, and evaluate alternatives and make the right decision. This may be essential for authorities, managers to research and understand the portfolio of their resources, capability or key capability, as well as competence or core competence in order to achieve sustainable competitive advantage. To facilitate the concepts identifying the unique core competences, a hybrid MCDM integrating three approaches – DEMATEL, ANP and ZOGP – is employed to evaluate those important factors. It was the main objective of this paper to utilize these techniques to achieve better resources allocation and improve various activities in order to form an effective OMDs strategy.

As a further investigation of this study an illustrative real case application will be published next. The following evaluation process shows how the white goods manufacturing company utilized our proposed method to decide logically on an optimal competence sourcing portfolio for each task execution of the OMDs.

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Biography

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Potentials of Laser Technologies in Processing Panel Display Glass

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Abstract

Displays are all around us. Using our cell-phone, computer or navigation system, we became accustomed to them and our expectations have risen dramatically. Therefore, the requirements rose simultaneously. Every display contains multiple glass layers that contribute to the characteristics of the final display. This is why the processing of display glass becomes more and more decisive. Machining processes of glass vary from mechanical up to thermal procedures. Traditional glass processing like milling or scribe and break are confined to a few geometries and provoke offcuts and waste. The application of laser technologies in this field is not prevalent yet however, it is successfully applied in manufacturing procedures of various other materials. In order to identify and evaluate the potentials of laser technologies in the processing of panel display glass, first the state of the art of common mechanical and laser procedures are presented in this paper. Potentials and limitations of the presented procedures are derived from the target specifications of display glass. In general they cannot be thin or light enough and their geometries have to fit into the final electronic devices. The evaluation is executed as a utility analysis and follows the strategic success factors quality, cost and time as well as the aspect of sustainability. Requirements for the display glass such as thickness of the glass blanks can be adjusted before evaluating. The objective of this elaboration is to present opportunities of manufacturing display glasses with lasers compared to prevalent machining processes.

Keywords

Laser technology, panel display glass, technology evaluation, potentials, processing

1. Introduction

A life without cell-phones, computers and navigation systems is unimaginable. But for all these technical devices we need displays. The requirements rose simultaneously with the occurrence of new or improved products. Touch screens, excellent picture quality, robustness and being light and thin are usual needs. Traditional glass processing is being stretched to its limits. The application of laser technologies in this field is not prevalent yet, however, it becomes more and more common.

In the following chapters the properties of the most common display technologies will be given, evaluated and compared with each other. In the conclusion the potentials of the different technologies in processing panel display glass will be presented.

2. State of the Art

2.1.1 Overview and Classification

Nisar et al. (2013) gives a thorough overview about all different class cutting procedures. They divide the distinct procedures into conventional and unconventional processes. The conventional processes constitute of milling and scribe and break. The scribe and break process can be executed using a standard metal cutting wheel or one made out of diamond. The unconventional processes consist of water jet cutting with or without abrasive material, laser cutting processes and hot air jet. A further distinguishing feature regarding the type of processing glass is whether the process can be regarded as a mechanical process or a laser-based process. For this paper the procedures are separated into mechanical processes (hot air jet, water jet cutting, milling, scribe and break) and laser processes (stress-induced laser cutting, ultra-short pulsed laser, laser scribe and break, laser cutting).

2.1.2 Mechanical Machining Processes

Milling of glass can be considered as the most common and conventional industrial procedures to cut glass. Due to glass being a brittle and fragile ceramic, milling it is a complex and challenging procedure (Westkämper et al., 2010). Moreover, the lack of ductility of glass contributes to the difficulties in milling it what results in an insufficient surface quality and reduced resistance to break, triggered by micro-cracks induced through the milling process (Westkämper et al., 2010). Nonetheless, milling glass is used mainly to cut display panels because it is a cheap and quick procedure and post-processing may compensate for any minor cutting edge quality.

Scribe and break is yet another conventional glass cutting process. It might be executed using either a cutting wheel made of metal or one made of diamond, as already stated above. Certain manufacturers also offer cutting wheels with special teeth (MDI Schott, 2014). Those toothed cutting wheels are less prone to wearing but, most importantly, they are able to produce a longer vertical crack up to 90% of the glass thickness (MDI Schott, 2014). Furthermore, using the toothed cutting wheels, less lateral micro-cracks occur (MDI Schott, 2014).

According the classification of Nisar et al. (2013) presented above, the hot air jet is an unconventional glass cutting process. Moreover, it is also a relatively new glass cutting process which still is not entirely studied (Prakash et al., 2000). With the hot air jet glass cutting process, a stream of hot air out of a nozzle is used to propagate a previously initiated crack throughout the entire glass panel. Here, the induction of non-uniform heating generates thermal stress along the impact zone of hot air. For the initiation of the crack a scribing tool, for instance a cutting wheel like described above, has to be used. This makes the hot air jet process a two stage process. Nisar et al. (2013) list significant parameters of the hot air jet process which determine edge quality of the cut glass, cutting speed and hence efficiency. The hot air jet process is a relatively cheap process because it does neither require high pressure nor very high temperatures (Nisar et al., 2013).

The increasing importance among cutting technologies of the water jet cutting technology is based, according Fritz et al. (2006), upon many advantages. This is partially due to the use of abrasive material whereby even cutting of hard, brittle and compact materials as well as composites became feasible. The so-called "cold cut" might be the most decisive advantage of the water jet cutting process (Fritz et al., 2006). This process free of any thermal stress leads to an ameliorated surface quality. Given a frictionless nozzle, an axially symmetrical current and a constant velocity, the water power at the nozzle discharge is given by formula (1) (Fritz et al., 2006):

$$P = \rho \cdot A \frac{v^3}{2} \qquad (1)$$

P	Power of water jet in W,	(1)
ρ	Density of the fluid in kg/m³,	
A	Cross-section surface in m²,	
v	Velocity of water jet in m/s.	

With the sole-water jet cutting, pressures between 1000 and 4000 bar are used and the nozzles' hole vary between 0.1 and 0.35mm (Fritz et al., 2006). Commonly, quartz sand is used as an abrasive material due to its crystalline structure and hardness.

2.1.3 Laser Technologies

As well as the mechanical scribe and break process of glass, the laser-based scribe and break process also is a two- or more-step process (Nisar et al., 2013). The first step consists of scribing a line or many holes into the glass with the laser. The second step is to mechanically break along the previously defined line. Hence, this process requires a high degree of automation and a lot of time. For scribing different lasers, such as CO_2-laser or solid state lasers, can be used (Nisar et al., 2013). Pulsed lasers are very convenient for cutting glass panels due to their high peak

performance which evaporates the glass immediately and hence little heat damage results (Nisar et al., 2013; Tsai et al, 2007).

Laser cutting of different materials has proven its value in industrial processes. Here, the glass panel is entirely cut by the laser without the uses of additional means for mechanically break it. However, through melting of the glass during the laser cutting process, tensions in the glass are provoked which negatively influence the material's properties. For instance, the bending strength is significantly reduced as well as a lower edge quality results. These negative ramifications can be mitigated using water as a coolant during the laser cutting process. Nevertheless, post-processing is required (Nisar et al., 2013). In order to avoid heat damage, an ultra-short pulsed laser might be used. The thermal stress induced into the glass during cutting is minimized through the reduced interaction between laser and the processed material. The UV radiation beams in nanoseconds of the excimer laser produces less melt. Hence, more passes of the excimer laser over the glass panel are necessary what, in turn, increases processing time (innovationundtechnik.de, 2014). The active material of the excimer laser is highly reactive and hence has to be replaced frequently what results in more downtime and higher costs due to safety requirements (innovationundtechnik.de, 2014).

Ultra-short pulsed lasers are very convenient for cutting glass panels due to their superior properties such as little induction of thermal stress, as mentioned above. The duration of pulse is smaller than ten picoseconds. Therefore, material can be removed before heat is able to induce thermal stress (Bonse, 2001). The high photon energy of the ultra-short pulsed laser is sufficient to raise electrons into the conduction band. Hence, glass is not transparent to the wave length and its intrinsic energy of the ultra-short pulsed laser. Conversely, the solid state laser cannot produce enough energy in order to circumvent the transparency of glass to the wave length of the solid state laser. Similar to the excimer laser, the ultra-short pulsed laser only removes very little material at one pass. This makes repeated passes compulsory in order to cut a glass panel entirely, particularly when the glass panel is very thick. Thus, this approach enlarges the kerf and prolongs processing time (Russ et al., 2012).

For the stress-induced laser cutting process mostly a CO_2-laser is used (Nisar et al., 2013). With this process, less laser power is needed. The laser passes once over the material which heats up. This also causes cracks. After that, the material cools down again what leads to local tension. Once this local tension is greater than the tension of defect, the initial crack can propagate throughout the material (Nisar et al., 2013). With the stress-induced laser cutting process the crack deviates from the passing lane of the laser. This causes imprecise cuts. An improvement of this deficit can be achieved using a focus directed into the direction of cutting (Nisar et al., 2013). Nisar et al. (2013) also name a process with dual laser beams. In this process first a defocused laser beam passes over the material in order to heat it up. The second laser beam is focused and splits the material. Through this process less stress is induced and hence less micro-cracks occur. On the other hand, high temperatures require more post-processing. A further enhancement of the stress-induced laser cutting process is using a laser beam to heat up the material, followed by an abrupt cooling out of a cooling nozzle which uses water as coolant due to its good thermal conductivity.

2.2 Comparison

Regarding simplicity of the production process, mechanical processes outrun the laser-based processes. This rests upon the fact that most mechanical processes are well studied and a lot of research has been done in their respective fields. Laser processes are relatively new and not all their potentials can be exploited yet due to a lack of research on how to operate the laser beam properly and how the processed material reacts. Eventually, it depends upon a trade-off between quality, machining rate and costs. This will be further elaborated in the following chapters.

3. Potential Analysis

3.1 Requirements for Panel Display Glass Processing

There are several display technologies on the market (Chen et al., 2012). Even though displays were further developed from an electro-technological view, all the solutions contain glass layers. One example of a technology that is on the rise is the Projected Capacitive Touch Screen with a one glass solution: sensor on lens. One layer can be eliminated compared to Projected Capacitive Touch Screen Separate Module Configuration (Poor, 2012). However, three glass layers are still necessary.

Users are mainly interested in the optical and haptic characteristics of displays. These are influenced by the display technology, the type of glass and the machining processes of glass (Schott AG, 1999). In order to debunk the potentials of laser technology in processing panel display glass, the impact of machining processes to the requirements of display glass are analyzed.

Regarding quality requirements, machining processes influence significantly the resistance to damages of the final display. The machining process causes damages to the glass that affect the flexural strength. Flexural strength is defined as the ability of the material to resist deformation under load (Arbeitsgruppe Vollkeramik, 2014). The dimension of micro-cracks after the machining process, reduce resistance to deformation of brittle materials like glass (Schicker et al., 2001). The measurement of flexural strength is usually carried out by the standardized four point flexural test method (DIN EN 843-1). As an example display glass with polished edges has a flexural strength of ~ 600 MPa (Stute, 2013). Flexural strength can also be calculated by (Alderink, 2012; Stute, 2013), as shown in formula (2):

$$\sigma_B = \frac{3\,F_p\,(L_2 - L_1)}{2\,b\,h^2}. \qquad (2)$$

F is the load (force) at the fracture point (N)
L_i is the length of the loading (inner) span
b is width (mm)
d is thickness (mm) (2)

A further requirement is the ability of the machining process to achieve desired geometries of the edges. Moreover most devices with displays have equipment like cameras, microphones or speakers. In order to build in such devices recesses in the display glass are necessary. The required thickness of the display glass depends on the final application. In general the motto is “Thin is In”, what is also connected to desired weight reduction (Gaebler, 2008). The thinnest doable panel glass starts at 0.1 mm at the moment (Hitech, 2011). The thickest panel glass depends on the requirements of the final device. As an example, standard for a big screen television is 2.8 mm (Gaebler, 2008).

The selection of the considered machining processes in the evaluation is due to the qualification of them to achieve the requirements of panel display glass.

3.2 Application

The feasibility of different geometries is given when milling glass panels. However, a very good dynamic interaction between the component, tool and machine is required due to many altering environment variables (e.g. feed rate, ankle, cutting force) (Fritz et al., 2006). Speaker holes, for example in the display glass of smart phones, cannot be cut with this process. The milling process is limited to a minimal diameter of 4 up to 130mm what is not small enough for today's requirements for display glasses and their holes. The cutting range of the milling process varies between 3 and 10mm glass thickness (Schollglas, 2014; Glass-expert, 2014). The feasibility of different geometries also is given using a mechanical scribe and break process. However, it is possible that several steps are required (Nisar et al., 2013) and radiuses are limited by the thickness of the glass panel. This makes speaker holes impossible. The range of processing thickness is limited between 0.03 and 20mm (Gaebler, 2008). Due to thermal stress and the lack of an initial scribing, the hot air jet process is not able to cut speaker holes, albeit other geometries are feasible (Prakash et al., 2001). Glass thick as 2 up to 20mm can be processed using a hot air jet (Prakash et al., 2001). Both observed water jet cutting processes are able to cut different geometries into glass. However, this strongly depends on the water flow-rate, where required the flow-rate of abrasive material, diameter of particles of abrasive material, distance between the work piece and nozzle and the water pressure (Momber et al., 1998). It is feasible to cut speaker holes (Serralaser, 2014). With this process the glass thickness which can be cut varies between 0.08 and 70mm using abrasive material (Park et al., 2004; Maximator-jet, 2014) and is limited to 0.635 up to 25.4mm without abrasive material (Serralaser, 2014).

The laser-based scribe and break process can cut glass panels from 0.2 up to 10mm (Gaebler, 2008). Limitations regarding radiuses of speaker holes are given. With the laser cutting process a glass thickness of 0.05 up to 8mm is feasible to cut. There are no constraints regarding any geometries of cutting. The same holds for ultra-short pulsed lasers which are very flexible and arbitrary geometries are feasible to cut. Glass panels from 0.1 up to 1mm can be cut with this process. The upper boundary is defined with an increasing inaccuracy of the kerf the thicker the glass becomes. The stress-induced laser cutting process can handle 0.1 up to 2mm of glass thickness (Nisar et al, 2013). Here speaker holes are not feasible to cut.

3.3 Quality

The properties of glass mentioned above result in radial and lateral micro-cracks due to the cutting force when using a milling process. Arif et al. (2011) show that the feed-rate of the milling head is crucial for the resulting surface quality. With a low feed-rate only in the material which will be cut off later occur cracks. Conversely, with a high feed-rate there also occur cracks in the material which remains (Arif et al., 2010). Nisar et al. (2013) state that this process results in an inferior surface quality as well as in micro-cracks and material deformation. The bending strength is reduced to 60 % compared to its initial value. Therefore a high need for post-processing results (Nisar et al. 2013). The hot air jet process is compared to the other mechanical processes in the middle to upper range of quality. Occurring micro-cracks and a reduced bending strength can be mitigated by post-processing and are less frequent as with the water jet process but more frequent as with any laser process. When water jet cutting brittle material like glass, there occur many cracks and following ablation of parts of the material (Henning, 2007, S. 38). Cracks are more common when using no abrasive material compared to when using some, what reduces bending strength (Prakash et al., 2001; Yuan et al., 1995). This results in post-processing and hence additional costs (Nisar et al., 2013).

Despite contactless processing using laser scribing, the final quality also depends on the later mechanical breaking process. This leads to a lower edge quality and required post-processing. The CO_2-laser damages wide parts of the material what significantly reduces overall quality. This makes post-processing mandatory. Short-pulsed lasers like the excimer laser reduce material damage. Nevertheless, post-processing is still required (Nisar et al., 2013). Bending strength is best and almost comparable to its initial value using the ultra-short pulsed laser. In order to ameliorate edge quality, post-processing might be used. While using the stress-induced laser cutting process no chipping occurs and post-processing like cleaning and polishing are not often required. The achieved edge quality is much better compared to the one achieved with mechanical processes. This becomes obvious in a higher bending strength, but depends on the use of a coolant. The quality also depends on the process strategy and if speed or quality is demanded. In general it can be said that laser processes have the advantage of contactless processing. Hence, there is little wearing and the processing quality remains more or less equal.

3.4 Cost

The complications mentioned above, milling glass results in high post-processing costs in order to accomplish the desired work piece and edge quality. Operating supplies, such as for the milling head (ca. € 30 to 100), are situated in the middle range, as well as energy consumption. The initial investment amounts to € 40,000 to 100,000 (Alienxpress, 2014). Metal cutting wheels cost, depending on size and model, between € 0.3 and 40 up to € 250 for diamond cutting wheels, respectively (Alibaba, 2014). Cutting wheel machines cost on the market ca. € 150,000 to 1,000,000, whereas energy costs are relatively low compared to other processes. Post-processing cost can be considered moderately high for the hot air jet process compared to the other processes in order to achieve a given display panel glass quality. The sole operating supply for the hot air jet process is a tool to initiate the crack. Hence, those costs are relatively low. On the other hand, energy consumption and its costs vary with the size of the hot air jet machine and range in the middle sector. The initial investment for such a machine is between € 5,000 and 150,000 (Alibaba, 2014). Nisar et al. (2013) argue that the high operating supply and wear part costs of the water jet process is a huge disadvantage of this process compared to others. The abrasive material sums up to ca. € 0.2 per hour. However, if recycled, the abrasive material only costs around € 0.02 each hour. Reinforced nozzles, for water jet cutting with abrasive material, amount up to € 1,500, whereas the non-reinforced nozzles cost up to € 750 (Waterjets, 2014). The mixer unit, where water and abrasive material mix, are also exposed to augmented wearing and cost between € 75 and 150 (Waterjets, 2014; Thefabricator, 2014). Moreover, high initial investment of around € 100,000 is disadvantageous, too (Nisar et al., 2013; Alibaba, 2014). A compressor to produce the high water pressure increases energy consumption.

Investment costs for a laser machine are higher than those for mechanical machines by the factor 1.5 to 2.

3.5 Processing Time

The machining rate of glass milling is between 33 and 83 mm/s (Sodick, 2014). Total processing time is prolonged by intensive post-processing like polishing and grinding. Setup times for a milling head are low but frequent. Scribing and breaking of glass using cutting wheels has a machining rate of 5 to 65 mm/s. A high post-processing requirement extends total processing time. Setup times for cutting wheels are very short but due every day. The hot air jet process has the major disadvantage of a very slow machining rate of maximal 2.33 mm/s with very thin glass; with thick glass even slower (Prakash et al., 2001, Nisar et al., 2013). Instead, post-processing time with the hot air

jet is less than mechanical scribe and break. Setup times are limited to changes of the cutting wheel which initiates the crack. Water jet cutting of glass with abrasive material has a machining rate of 0.2 to 211 mm/s, without abrasive material maximal 66.6 mm/s (Wardjet, 2014, Schneideforum, 2014). Durabilities of nozzles vary between 40 and 800 hours, depending on whether the nozzle is reinforced or not (Wardjet, 2014; Thefabricator, 2014). Setup times for nozzles vary between 5 and 15 minutes and 5 to 10 minutes for the mixer unit (Thefabricator, 2014). With a smaller glass thickness of up to 10 mm, cutting speed of water jets is inferior compared to those of lasers (Fritz et al., 2006).

The machining rate of laser-based scribe and break is ranged around 2000 mm/s (Nisar et al., 2013). The laser cutting process depends on the glass thickness and which laser source is used and can cut as fast as around 500 mm/s. Machining rates of the ultra-short pulsed laser also depend on the glass thickness. Between 0.1 and 1 mm, ultra-short pulsed lasers can cut ca. 2 to 5 mm/s. Because lasers have a life span of around 10,000 hours, except the excimer laser, setup times are relatively low compared to the above mentioned processes.

3.6 Sustainability

The sustainability of milling, separated into energy consumption and emissions (e.g. coolant with glass particles), can be located in a middle range. The energy consumption of the mechanical scribe and break process compared to other processes can be classified as low, whereas emissions like a coolant contaminated with glass particles are situated in an intermediate sector. The hot air jet process uses relatively little up to medium energy. There are no direct emissions connected to the hot air jet process. Due to the only partially recyclable abrasive material what results in a significant amount of mud and waste water, water jet cutting with abrasive material yields high emissions. The water jet cutting process without abrasive material accordingly yields fewer emissions. Moreover, compressors for water pressure cannot be neglected regarding emissions.

Energy consumption of all laser processes is significantly above all mechanical processes due to cooling systems and a high thirst for energy.

4. Evaluation

4.1 Evaluation Method

The evaluation of different machining processes shall demonstrate their potential in processing display glass. The potential mainly results from technical characteristics. This is why the evaluation focusses on technical criteria. From an economic perspective, the cost of processing glass is considered. The evaluation criteria are oriented on the strategic success factors of manufacturing: Quality, cost, and processing time (Gienke/Kämpfer, 2007; Rasch, 2000). Due to the recent development of ecological aspects and the focus of stake holders on sustainable manufacturing, sustainability will accomplish the evaluation criteria (Kraus, 2011).

The evaluation is limited by the application possibilities. Only if the desired final panel display glass can be processed, the machining process will be evaluated.

The evaluation is carried out by a utility analysis. The scoring model contains the above mentioned categories. Subcategories are determined by the characteristics of the machining processes in which they differ and influence quality, cost, processing time or sustainability.

Quality is influenced by damages caused by the process. Subcategories therefore are linked to the dimension of damage, starting with micro cracks up to chips ending with the flexural strength of the final product. All processes cause more or less damage that can be compensated by post-processing. This leads to the next criteria. Cost of the manufacturing process is influenced by the dimension of necessary post-processing in order to achieve the desired quality. The second severe cost drivers are operating supplies such as cutting wheels for mechanical scribe and break. The third subcategory is energy cost of the evaluated process. Initial investment for the necessary machinery builds the last subcategory of the cost criteria. Processing time is as well as cost influenced by the necessary post-processing. Post-processing prolongs the time needed for the final product. Also the possible operating speed of the machining process limits the minimum processing time. Set-up time is the third subcategory influencing processing time. Sustainability as fourth criteria is driven by recent political developments. It is determined by energy and resource consumption of the processes and emissions caused during machining such as glass particles or sewage.

The evaluation process starts with the preferences of the decider. He can elect “yes” or “no” for recesses for build-in devices. The thickness of the final display glass can also be elected in mm with two decimal places. The edge geometry cannot be determined since with post-processing all geometries can be achieved. This first step eliminates all processes from the evaluation that are not able to perform the desired panel display glass. They are marked as “not suitable”. In a second step the decider can indicate his preferences of quality, cost, processing time, and sustainability on a scale from “0 - not relevant” to “10 - highly relevant”. The scoring converts the “0 – 10”- scale into a “0 – 2”-scale where “1” acts as neutral multiplicator for “5 – neutral”. Therefore a symmetric perspective from a mathematical point of view is possible.

We differentiate six data types in the scoring model. Type 1 considers the absolute values given from the analysis. Type 2 contains only “yes” or “no”. Type 3 is used for characteristics that cannot be exactly quantified. This is the case for micro cracks, post-processing, energy consumption, set-up time, and emission. These subcategories are severely affected by the machine type and the level of machine utilization. The effects on the processed products usually do not correlate linear to machine utilization. Also the evaluation shall not give indications for a machine type but for the type of machining process. In order to eliminate these biases from the evaluation a three-point scale is used. “0” means “bad”, “5” “medium”, and “10” “good”. Type 4 compares the values on a scale from one to ten. The difference of the values and the rank are hereby considered. The conversion of the values to a zero-to-ten scale ensures a consistent weighting in the whole evaluation. It is used for operating supplies and flexural strength. Type 5 is only used for initial investment. Investment for the machines differs partly significant. Therefore the average for each machining process is used and converted to a zero-to-ten scale. Zero stands for the highest investment and ten for the lowest. Type 6 is used for the operating speed. It is assumed that the decider prefers the fastest possible operating speed. The machines also differ here. As value the maximum operating speed is taken into account, converted to a zero-to-ten scale, from zero – the slowest to ten – the fastest.

4.2 Case Study

For the case study a decider is assumed that wants to produce flat panel display glass without recesses for in-built devices, with a thickness of 2 mm. Quality, cost, processing time, and sustainability have the same importance to him.

Milling and ultra-short pulsed lasers are not evaluated since they cannot perform the desired thickness. Ultra-short pulse lasers could perform a thickness of more than 1 mm, from a technologic point of view, but it is not economic since processing time prolongs disproportionally.

Taking a closer look at the result for each criteria, we learn the following: Laser techniques dominate from a quality perspective. Only hot air jet from the mechanical machining processes can compete with laser scribe and break. This result is due to less damage caused by lasers. From the cost perspective mechanical machining processes are slightly better. First of all the average initial investment of the considered mechanical machines is significantly lower than for laser machines. High energy consumption of the laser processes further increases their cost. Less post-processing caused by less damage from the laser processes cannot compensate the mentioned higher cost. Hot air jet causes the lowest cost. Concerning processing time laser processes are invincible. Their higher energy consumption de facto can be compensated by their essentially higher processing time. Similar to the other criteria hot air jet follows closely. Its processing time is comparable to laser cutting. The higher energy consumption of lasers on the other hand causes a weak result for the criteria sustainability. Mechanical machining processes lead here with exception of water jet cutting. Hot air jet on rank two overall also convinces in sustainability with its low emissions. Laser machining dominates mechanical processing of display glass from an overall perspective in this case. Hot air jet is the only mechanical technique that is positioned in the top five.

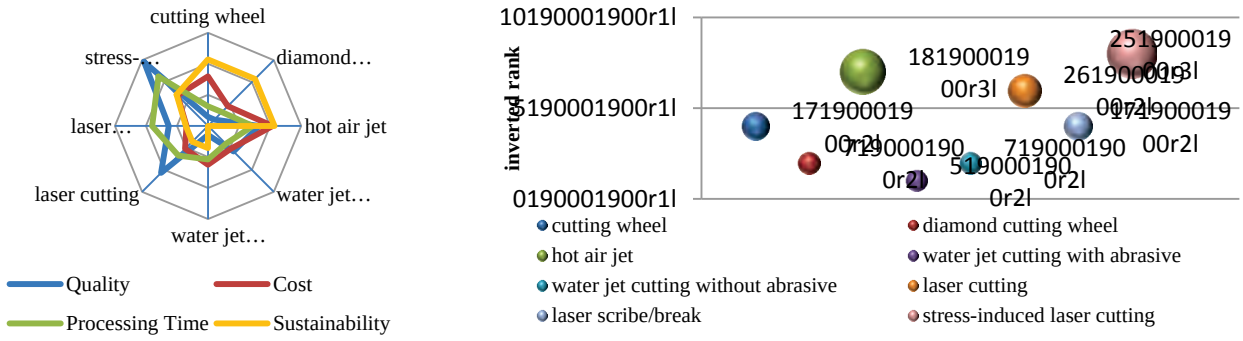


Figure 1: Overall evaluation result

The domination of lasers is not caused by the indications of the decider. Looking at the behavior of the evaluation tool, changes in the ranks of the compared machining processes can be observed. Nevertheless laser processes dominate the overall evaluation. As an example see figure two below that shows the behavior for changing preferences for the criteria quality while other criteria stay constant.

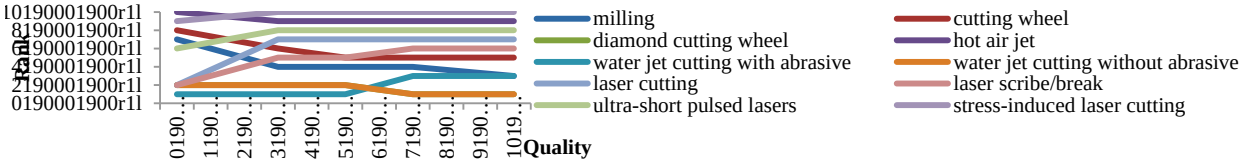


Figure 2: Ranking with changing preferences

5. Potentials of Laser Technologies Panel Display Glass

Laser technologies are clearly at an advantage over mechanical machining processes regarding the increasing requirements for panel display glass. Looking at the processed edges of the glass with a microscope the different dimension of damage from mechanical vs. laser technologies becomes clear. Lower quality, higher need of post-processing and therefore higher cost for mechanical processed display glass accomplish the dominance of laser technologies. Moreover processing very thin display glass is not possible for the regarded mechanical technologies.

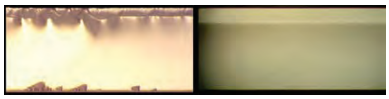


Figure 3: Mechanical vs. laser processed display glass

Summarizing the stated facts in this paper, laser technologies show more potential for panel display glass processing. Especially the strategic success factors quality, cost, and processing time are dominated by lasers.

There are several application possibilities for laser technologies. It is not only qualified for cutting various materials but is also able to mark, skim, engrave inside materials, or to drill for instance (Glastec Messe, 2013). Lasers are not very common for processing glass but show high potential. Recent research shows that especially for ultra-short pulsed lasers several innovative applications in glass processing are on their way. In the past the light spectrum for laser processing was limited to ultraviolet and infrared light (Glastec Messe, 2013). Transparency of glass allows processing in the visible light spectrum. Therefore it is possible to process inside the volume of the work piece as well as starting the process at the reverse side of the blank. Focusing the laser at the reverse side of the glass enables to process chamfers or other radius shapes (Stute, 2012). For mechanical machining this is only possible with high cost and time effort. Round edges of processed panel display glass are required since no damage to the glass or to the electrical contacts is forced compared to sharp edges. Especially laminated display glass can only be directly processed with lasers. Mechanical methods would destroy the lamination. Compared to mechanical manufacturing processes lasers are very young. If we assume a similar development for lasers as for mechanical manufacturing

processes within the last 100 years we expect further application possibilities for lasers. Today lasers are used for various geometries and materials. These possibilities soon might also be applicable to display glass.

6. Conclusion

Lasers definitely show higher potential in processing panel display glass due to their technical characteristics and their enormous potential for further development. The presented evaluation tool offers a base structure for a sound assessment of machining processes for panel display glass. Since it is built for an abstract evaluation of technologies, the state of the art was evaluated on a quantitative base and expectations about their development in the future were integrated qualitatively. It could be easily adapted for a concrete decision problem e.g. the choice of machine that should be purchased. Therefore it can be modified for practical application for several issues concerning panel display glass processing.

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A Web Based Optimization System for Supply Chain Network

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Abstract

With the increasingly competitive nature of industry today, it is very critical for organizations that supply chains continue to work as planned, with smooth and uninterrupted flows of materials from initial suppliers through to final customers. Hence, distribution network design is an important strategic decision for the supply chain managers. In this study, a web-based Decision Support System (DSS) for fuzzy distribution network optimization is proposed. Fuzzy linear programming is used in the DSS to consider the uncertain and imprecise data.

Keywords
Distribution network optimization, fuzzy linear programming, supply chain, web-based decision support system

1.Introduction
A supply chain consists of the series of activities and organizations that materials move through on their journey from initial suppliers to final customers Waters (2012). With the increasingly competitive nature of industry today, it is very critical for organizations that supply chains continue to work as planned, with smooth and uninterrupted flows of materials from initial suppliers through to final customers. In today's world, customers are tightening their requirements in terms of throughput time and perfect-order delivery while demanding continuous reductions in supply chain cost. At this point, distribution network design (DND) emerges as a major problem faced by the supply chain managers. DND problem consists of selecting locations to install factories, warehouses, and distribution centers; assigning customers to serving facilities; and interconnecting facilities by flow assignment Miranda and Garrido (2009).

Decision Support System (DSS) is a useful tool make DND decisions effectively and efficiently. DSSs assist decision makers to obtain data, documents, knowledge or models, increase the number of alternatives examined, achieve better understanding of the business, provide fast response to unexpected situations, offer capability to carry out ad-hoc analysis, facilitate improved communication, achieve cost and time savings, achieve better decisions, facilitate more effective teamwork, achieve better use of data resources, present graphical information Subsorn *et al.*(2008).

Web-based DSS provides benefits to decision makers in terms of wide accessibility, ease of use, portability, effectiveness and time reduction (Shim *et al*.,2002). Furthermore, web-based DSS can eliminate limitations such as poor maintainability, poor flexibility and less reusability (Xie *et al*.,2005).

Uncertain and imprecise data increase the complexity of decision making problems. Fuzzy set theory which has been widely applied in different disciplines, such as operations research, management science, control theory and artificial intelligence is one of the solutions to deal with uncertainty in decision making (Shih, 1999). Fuzzy mathematical programming is one of the most popular decision making approaches based on the fuzzy set theory.
The rest of this paper is organized as follows. In Section 2, literature regarding to the distribution network design is reviewed. In Section 3, fuzzy linear programming method is explained. In Section 4, web-based DSS architecture and fuzzy mixed integer linear programming model (MILP) are described.

2. Literature Survey

The network design mathematical models have been constructed based on the facility location theory. Recent literature reviews on supply chain management and facility location are presented by Arabani and Farahani (2012), Van der Vaart and van Donk (2008), Gebennini *et al*. (2009) and Melo *et al*. (2009). Literature presents a very large number of studies on models and methods for the design and control of complex distribution systems.

Schütz *et al.* (2009) presented a supply chain design problem modeled as a sequence of splitting and combining processes. They formulated the problem as a two-stage stochastic program. The first-stage decisions are strategic location decisions, whereas the second stage consists of operational decisions. The objective is to minimize the sum of investment costs and expected costs of operating the supply chain. Ahumada and Villalobos (2009) reviewed the main contributions in the field of production and distribution planning for agri-foods based on agricultural crops. Through their analysis of the current state of the research, they diagnosed some of the future requirements for modeling the supply chain of agri-foods.

Most of the previous studies focusing on the uncertainty in logistics network design use stochastic programming methods.Liang (2008), developed a fuzzy multi-objective linear programming model with piecewise linear membership function to solve integrated multi-product and multi-time period production/distribution planning decisions problems with fuzzy objectives. Paksoy *et al.* (2012) apply fuzzy sets to integrate the supply chain network of an edible vegetable oils manufacturer. The proposed fuzzy multi-objective linear programming model attempts to simultaneously minimize the total transportation costs. In fuzzy mathematical programming, models have been proposed to incorporate fuzziness of objective and constraint functions. Percin and Min (2013) create a fuzzy decision making methodology for selection of 3PL (third part logistics provider).Creazza *et al*.(2012),proposed a mixed integer linear programming model to solve a real networks with multiple-layer, single location-layer, multiple-commodity and time-constrained logistics.

In this study, imprecise parameters and fuzzy situation in distribution network optimization is addressed. A web-based DSS architecture is presented. Furthermore, as application, distribution network optimization is conducted for a company in ceramics industry with the consideration of vagueness in customer demand, opening costs of distribution centers and production plants.

3. Fuzzy Linear Programming Method

The difference between the fuzzy mathematical programming approach and conventional mathematical programming approach is in the point where a fuzzy model exists between a real world optimization problem and usual mathematical model (Inuiguchi and Ramik,2000).In real world problems, there are usually uncertainties in knowledge on parameters. Additionally, qualitative constraints and objectives are almost difficult to represent in mathematical forms. In such conditions, a fuzzy solution satisfying the given mathematically represented requirements are very useful in a sense of weak focus in the feasible area. The decision maker can select the final solution from the fuzzy solution considering implicit and mathematically weak requirements (Inuiguchi and Ramik,2000).

Fuzzy linear programming can be derived by using fuzzy sets as coefficient values in objective function, constraints or right hand sides of the constraints. There are several methods in the literature to solve fuzzy linear programming models (Verdegay(1982), Chanas(1991), Zimmermann(1991), Julien(1994), Negoita and Sularia (1976) Carlsson

and Korhonen(1986), Werners (1987) , Buckley(1989)). In this study, Julien's method is used in the DSS since it provides computation convenience comparing to other methods.

Julien (1994),transformed the fuzzy linear programming problem with the best and the worst linear programming problem at different α-cut levels, and got the possibility distribution of the optimal objective value. Julien associated the α-cut concept with Buckley's (1989) possibility programming to resolve the maximization problem in Eq. (1) including fuzzy objective and fuzzy right hand side. Therefore, the crisp linear programming problems in Eq. (2) and (3) are solved where the superscript represents an α-cut of the fuzzy parameters, and the subscripts L and U are the corresponding lower and upper cuts (Allahviranloo and Afandizadeh ,2008).

$$\tilde{\text{Max}} \quad cx \tag{1}$$
s.t.
$$a_i x \lesssim b_i \quad i = 1,...,m$$
$$x \geq 0$$

$$\text{Max} \quad c_L^{\alpha} x \tag{2}$$
s.t.
$$A_U^{\alpha} x \leq b_L^{\alpha} \quad i = 1,...,m$$
$$x \geq 0$$

$$\text{Max} \quad c_U^{\alpha} x \tag{3}$$
s.t.
$$A_L^{\alpha} x \leq b_U^{\alpha} \quad i = 1,...,m$$
$$x \geq 0$$

When Julien's method is applied to a minimization problem given in Eq. (4), the Eq. (5) and (6) should be considered to determine the interval of the objective value.

$$\tilde{\text{Min}} \quad cx \tag{4}$$
s.t.
$$a_i x \gtrsim b_i \quad i = 1,...,m$$
$$x \geq 0$$

$$\text{Min} \quad c_U^{\alpha} x \tag{5}$$
s.t.
$$A_L^{\alpha} x \geq b_U^{\alpha} \quad i = 1,...,m$$
$$x \geq 0$$

$$\text{Min} \quad c_L^{\alpha} x \tag{6}$$
s.t.
$$A_U^{\alpha} x \geq b_L^{\alpha} \quad i = 1,...,m$$
$$x \geq 0$$

4. DSS Architecture

The DSS called as “Portneo Optimizer” is based on the distribution operations of a production company that provides raw materials from suppliers and sends the products to customers through distribution centers. Production is achieved at the production plants using raw materials supplied from different suppliers. The products produced in the plants are sent to distribution centers using different transportation means. The supply chain network is described in Fig. 1.

The DSS components involve database, optimization engine, GIS engine and user interface. The architecture for the DSS is shown in Fig. 2. In the web-based DSS, the databases are built using MySQL and the user interfaces are created using Microsoft Silverlight technology. Google Maps is used as GIS Engine, additionally COIN-OR Symphony is used as the open-source optimization solver in the DSS (COIN-OR Symphony Project). The fuzzy mixed integer linear model is constructed using the input data and then converted into an .mps file.

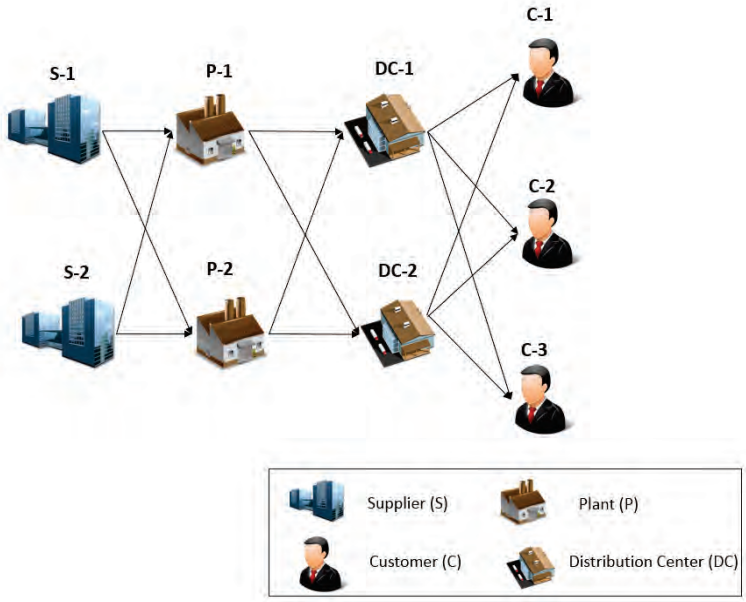


Figure 1: Supply chain network

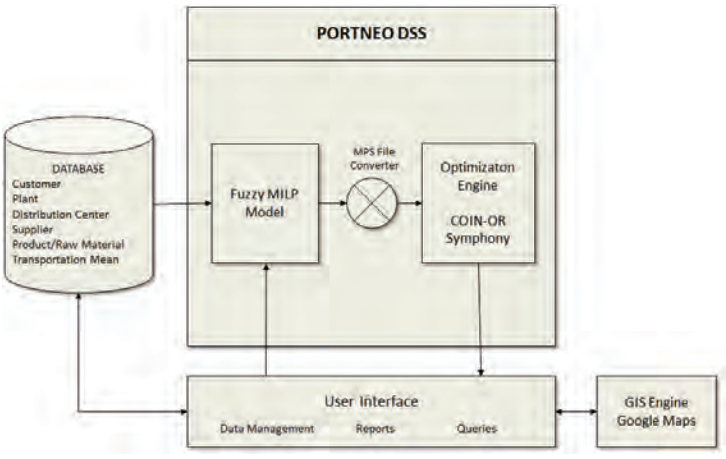


Figure 2: Portneo DSS architecture

The .mps file is used by Symphony and the optimization is conducted. The solutions are obtained and the reports are created on the user interface. In the DSS, different scenarios can be conducted using different parameter values.

Google Maps is used to determine the exact locations of the facilities and customers and also to calculate the road distance between two points on the map in Fig. 3. Additionally it is also used for graphical representation of the supply chain network.



Figure 3: User interface for location determination using Google Maps

4.1 Fuzzy MILP Model

In the DSS, the DND model is described considering a supply chain composed of suppliers, production plants, distribution centers and customers. Raw materials are sent from suppliers to production plants with different types of transportation vehicles such as train, truck, ship or aircraft. Products are transported from the plants to the distribution centers. In this model, location and capacity allocation decisions are made for both production plants and distribution centers. Finally, customer demands are met by the distribution centers. Multiple distribution centers may be used to satisfy demand at a customer and multiple production plants may be used to replenish distribution centers. In the model, it is assumed that units have been appropriately adjusted such that one unit of input from a supply source produces one unit of the finished product. As customer demand, fixed costs of opening plants and distribution centers have fuzzy values, the other parameters have crisp values in the model. The parameters of the model are given below:

m = number of customer demand points
n = number of potential production plants
l = number of suppliers
p = number of transportation vehicle
t = number of potential distribution center locations
$\tilde{D}_j$ = annual demand from customer j
K_i = potential capacity of production plant at site i
S_h = supply capacity at supplier h
R_p = transportation capacity at vehicle p
W_e = potential distribution center capacity at site e
$\tilde{F}_i$ = fixed cost of opening a plant at site i
$\tilde{f}_e$ = fixed cost of opening a distribution center at site e

c_{hip} = cost of shipping one unit from supplier *h* to factory *i* with transportation vehicle *p*

c_{iep} = cost of producing and shipping one unit from production plant *i* to distribution center *e* with transportation vehicle *p*

c_{ejp} = cost of shipping one unit from distribution center *e* to customer *j* with transportation vehicle *p*

The goal of the DND model is to identify locations of production plants and distribution centers as well as transportation vehicles and quantities shipped between various points that minimize the total fixed and variable costs. The decision variables are given below:

y_i = 1 if production plant is located at site *i*, 0 otherwise

y_e = 1 if distribution center is located at site *e*, 0 otherwise

Q_{hip} = quantity shipped from supplier *h* to production plant at site *i* with transportation vehicle *p*

Q_{iep} = quantity shipped from production plant at site i to distribution center *e* with transportation vehicle *p*

Q_{ejp} = quantity shipped from distribution center *e* to customer *j* with transportation vehicle *p*

The problem is formulated as a mixed integer linear program.

$$Min \quad \sum_{i=1}^{n} \tilde{F}_i y_i + \sum_{e=1}^{t} \tilde{f}_e y_e + \sum_{h=1}^{l}\sum_{i=1}^{n}\sum_{p=1}^{s} c_{hip} Q_{hip} + \sum_{i=1}^{n}\sum_{e=1}^{t}\sum_{p=1}^{s} c_{iep} Q_{iep} + \sum_{e=1}^{t}\sum_{j=1}^{m}\sum_{p=1}^{s} c_{ejp} Q_{ejp} \tag{7}$$

st.

$$\sum_{i=1}^{n}\sum_{p=1}^{s} Q_{hip} \le S_h \text{ for } h = 1,.....,l \tag{8}$$

$$\sum_{h=1}^{l}\sum_{p=1}^{s} Q_{hip} - \sum_{e=1}^{t}\sum_{p=1}^{s} Q_{iep} \ge 0 \text{ for } i = 1,.....,n \tag{9}$$

$$\sum_{e=1}^{t}\sum_{p=1}^{s} Q_{iep} \le K_i y_i \text{ for } i = 1,.....,n \tag{10}$$

$$\sum_{i=1}^{n}\sum_{p=1}^{s} Q_{iep} - \sum_{j=1}^{m}\sum_{p=1}^{s} Q_{ejp} \ge 0 \text{ for } e = 1,.....,t \tag{11}$$

$$\sum_{j=1}^{m}\sum_{p=1}^{s} Q_{ejp} \le W_e y_e \text{ for } e = 1,.....,t \tag{12}$$

$$\sum_{h=1}^{l}\sum_{i=1}^{n} Q_{hip} + \sum_{i=1}^{n}\sum_{e=1}^{t} Q_{iep} + \sum_{e=1}^{t}\sum_{j=1}^{m} Q_{ejp} \le R_p \text{ for } p = 1,..,s \tag{13}$$

$$\sum_{e=1}^{t}\sum_{p=1}^{s} Q_{ejp} = \tilde{D}_j \text{ for } j = 1,.....,m \tag{14}$$

$$y_i, y_e \in \{0,1\}, Q_{hip}, Q_{iep}, Q_{ejp} \ge 0 \tag{15}$$

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Creativity in Supply Chain Performance of Eram Sanat Company by Using the ARIZ71 Algorithm

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Abstract

Today organizations need to create new ideas and new opinions for their growth and survival .Generally innovation in products or services is hard and risky work so that to succeed, must be used reliable methods. Using the ARIZ71 algorithm is one of the ways to achieve creativity and innovation.

ARIZ71 algorithm is a systematic instruction to identify solutions for non-standard matters using technological capabilities and creative methods which can be obtain from ARIZ71 algorithm to increase performance of company's supply chain are: First, The solutions to reduce the Lead Time; Second, reducing maintenance costs; Third, Reduce supply risks.

Keywords
Supply chain, ARIZ71 algorithm, creativity, performance improvement

1. Introduction
All organizations need for their growth and survival, to new ideas and new opinions. Thoughts and new ideas have injection new blood to body of organization and saves it from destroy. Supply chain includes all the steps that directly or indirectly provide customer demands. Supply chain encompasses all areas related to logistics network that it is including suppliers, manufacturing centers, warehouses, distribution centers and retail markets and the raw materials, inventories under construction and finished products.

Supply chain management can be a combination of art and science that improves the method to find the raw needed materials for companies manufacturing and service. One of the most important problems in the case study company is incapable from forecasting what kind of products and how many, orders of customers and this increases the cost of the company's supply chain. The purpose of this paper is to introduce the ARIZ71 as a creative technique, to find solutions the problems of companies' supply chain and company can continue to operate in a competitive situation.

2. Solving Approach
In this research, ARIZ 71 algorithm is used which is a systematic instruction to identify solutions for non-standard matters using technological capabilities and creative methods through 6 phases:

- Selection of the problem
- Exact defining of problem
- Analysis
- Preliminary analysis to achieve the concept
- Operation
- Synthetic

First phase: Selection of Problem

1.1 The ultimate goal of solving the problem:

a) What is the technical purpose? (What characteristics of the object should change?)
Change supply chain processes, to minimize the time between receive the customer's order to delivery and reduce supply chain costs.

b) What attributes of the object cannot be changed during problem solving?

- The structure of existing companies in the supply chain
- The policies of competitors supply chain
- Exchange price to buy foreign raw materials
- Tariffs on imports of raw materials and machinery
- Customer tastes

c) What is the economical target with solving problem? (If the problem is resolved which cost will reduce?)
Total costs of the supply chain includes the cost of raw materials, goods maintenance costs, transportation costs, marketing costs, the opportunity cost of lost sales, supply risks, etc.

d) What are the overall acceptable costs?
Personnel costs, costs of materials processing, transport and distribution costs.

e) What are the main technical features / economy that should be corrected?
Supply chain processes

1.2 Find the best status: imagine that the problem cannot be solved substantially. What other more general problem can solve to reach this favorable final result?

It should be improve the following system (process) to improve great system (Supply chain)

1.3 Determine which problem has the main method or the best alternative to solve the problem?

a) Compare the main problem with the same item within the same industry.
KMV Company to reduce maintenance costs of goods uses the push-pull strategy this means that moved maintaining of goods back to suppliers until be kept less finished goods because maintenance of the completed product is more costly.

b) Compare the main problem with the same item within another industry

Dell Company's supply chain: The Company's supply chain strategy based on high diversity and flexibility. The company tries that has the standard part until will be used in most of products. This leads to increases production rate and cuts Cost. The Company also has been deleted Wholesaler from its supply chain and deal directly with consumers. This means that consumers can visit the company site and after reviewing various products, orders product according to their need and taste. Company provides products in the possible shortest time and sends to the customer home. This will lead to customer satisfaction and reduce the cost of delivery because of macro and micro distribution of the supply chain has been deleted. This policy has led to a typical Dell company has been a 3000% increase in market share and become a pole in the computer industry.

c) Compare the best alternative status with the same in another industry.

Dell's supply chain is a suitable method. This company removed the distributors and dealing directly with consumers reduced costs and also it can with the data it collects through its website, predict future market and use the tastes of customers for innovative products. Inform the final customer demand causes that the company reduced the bullwhip effect and avoid its harmful effects.

d) Compare main problem with the problem which has the best similar status and choose one.
Dell's strategy seems to be pretty good at dealing directly with consumers because the product delivered to the consumer price reduced and if Eram Industry Company could be create a site like Dell's site that will collect data could also partly to forecast sales and face With less problems such as the bullwhip effect and swollen demanded.

1.4 Specify the required quantitative features
Factors that affect the cost of the supply chain
(Such as inventory levels, inventory levels of reliability, the number and size of barns),

1.5 Introduce the modification time for quantitative features

- The cost of inventory should reduce.
- LEAD TIME should reduced

Second phase: Define the problem precisely

2.1 Use operations (size, time, and cost).STC

a) Imagine changing in the flow rate time and speed of an object, from the amount of data to zero. Is this problem solvable in this case? How?
Yes, exactly, if it can be lowered to minimize LEAD TIME, a basic problem in the supply chain has been solved. For this, it must be able to anticipate orders until to be acting
towards the purchase of raw materials and semi-manufactured products on time and prepare on time the finished product (final).

b) Imagine changing in the cost and speed of an object, from the amount of data to zero. Is this problem solvable In this case? How?

If they could be removed a wholesaler or retailer from the supply chain and deliver the products directly to consumers, costs and the final price to consumers is reduced.

2.2 Describe the conditions of problem in two sentences like following form

a) The provided system (including components)

- Supplier
- Manufacturer
- Wholesaler
- Retail
- The final customer (consumer)

b) Elements (explaining the elements), in Situations (explained modes) have undesirable effects (effects expression)

- Sometimes suppliers do not deliver raw materials and semi-manufactures.
- The manufacturer cannot predict the amount of sales.
- visit and request size of wholesaler and retailer are not clear

2.3 With inserting elements of 2.2.a, we will have the following table:

Table 1: Elements of 2.2.a

Elements :	Elements describe:
Supplier	If company policy like Belvaves and appropriate contract can be said about a good deal
Manufacturer	With proper planning, the situation can be improved
Wholesaler	A little sizes can be made to interact
Retail	Cannot be much interaction
The final customer (consumer)	must be established Communication with customer to create interaction

2.4 Select from step 2.3:

a) The easiest element to change, redesign or adjustment.
The ease of way: 1- Manufacturer 2- supplier 3- Wholesaler 4- retailer 5- consumer

Third phase: Analysis

3.1. Formulate the ideal final result as following figure: IFR

a)Select element from step 2-4 : Mechanical equipments complement and cooling material (liquid or gas)

Manufacturer

b) Exert the suitable implementation.
Manufacturer reprogramming about sales do in order to reduce LEAD TIME and Consumers can get the product cheaper.

c) Announce its act.
Manufacturing do new design for sales and trade to wholesalers and retailers and also establish direct communication with consumers to deliver products at lower cost to consumers. It also would establish a friendly relationship with the supplier. Especially with a supplier that provides strategic components

d) Announce its operating conditions
Management provide funds to sales planning and redesign, If is needed, backup software and staff trained to work with the software and use the legal adviser to close contracts with suppliers

3.2Drag two image: Initial conditions (before IFR) and ideal conditions (after IFR)



Figure 1: Initial conditions

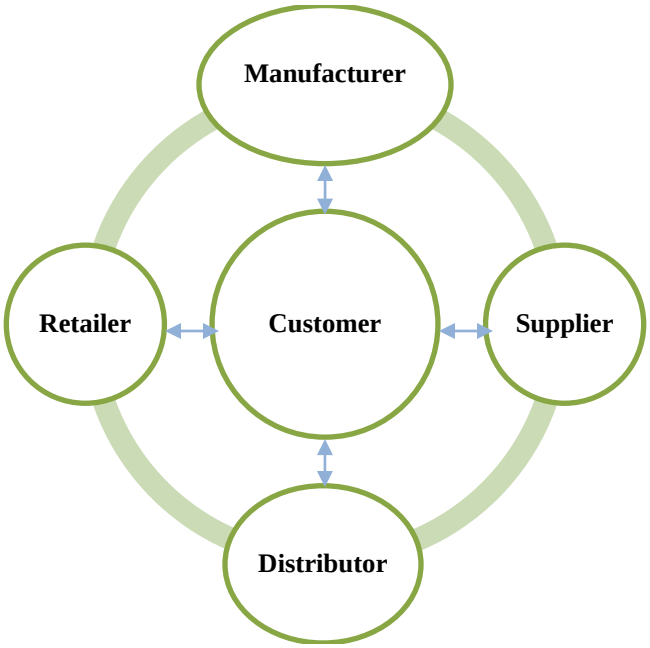


Figure 2: Ideal conditions

3.3 In Ideal conditions find specified Element in 3.1.a (The part that cannot perform necessary functionality under necessary conditions)
Manufacturer is Component that is not adequate planning

3.4 Why cannot it, (by itself) does this function?
It is entirely dependent on refer customer (wholesalers, retailers, consumers) and There is no perfect system for prediction in organization.

3.5 In what circumstances can do the necessary action?
If it has good planning and appropriate method

3.6 Formulated a concept that can be cognition, specifically
As mentioned, if we can reduce LEAD TIME reduced many of the problems in the supply chain. For example, reducing the cost of maintenance and inventory costs LEAD TIME causing to reduced lost sales and damage caused by the bullwhip effect. The proposed model there are several important differences in the way mentioned above, first, should design a website for the company. Products and their details are on the website and the customers can order their desired product through website and get needed information through it. The second is design a proper database until customer information is collected in the database.

Fourth phase: Preliminary analysis to achieve the concept

4.1 Meanwhile the use of theory or new concept, what is better and what is worse?

- Delivery time decreases (gets better).
- Sales of goods increases (we deal directly with the consumer).
- Cost of goods delivery to the customer is reduced.
- Risk of shortage of raw materials is reduced

4.2 Is it possible to prevent worsening of the situation, which has been accrued by changing the used method or program? Plot a sketch of a tool or modified method.

Not apply because the situation does not worsen
• If achievements are more than the losses (even future) go to the sixth **phase** (synthetic Phase)
• If losses are more than achievements back to.3.1. Step.

Sixth Phase: Synthetic

6.1. Determine how much major system that our defined system belongs to it should change.

The studied system is Eram Sanat Company's supply chain. The relations must be improved and better their performance

6.2 Investigate how our defined system might be used otherwise

With create more harmony and unity among suppliers of high levels, with other chains (systems) behind competing in the competition.

3. Conclusions

3.1 Reduction strategies of LEAD TIME:
As mentioned, it can reduce LEAD TIME and many of the problems in the supply chain are reduced. LEAD TIME reduction causes the cost of holding inventory and the cost of lost sales and damage caused by the bullwhip effect is reduced. To reduce LEAD TIME is provided under an innovative model. Before presenting the model of the current methods used are described in the company. The customer by phone or email your order suggests the presence in the company. In agreement with the client application (financially) the order is completed, so that the detailed the order in terms of raw materials and transport facilities are also studied. The next step when the table is ready that in the order to complete each stage, such as manufacturing, transportation, post and delivery schedules are specified.
The proposed model has some important differences with the method described above.

The first should design a website for the company and be prepared products and their details are on the website and the customer can order their desired product through website. The second is a proper database design until customer information is collected in the database. After providing the website and database an important step is added to the former process.

When customers come to the company (via website or telephone or other methods) made of the information his profile, creating customer profiles and keep them in a database which will help the company until to be distinguished from Clients who have been come to several times and they have a loyal customer name and distinguish special facilities for them.

Another important advantage of maintaining customer profiles is that After a client is referred to several times The inquiries and orders him to be predicted and Before future reference Provided the item is ready to be delivered. In this case the time interval between received an order to supply a significant amount will be reduced. So it can communicate with the consumer and Be more feisty supply chain and be less costly.

3.2 Solution reduces maintenance costs
To reduce maintenance costs in the entire supply chain one of the ways is to maintain the balance of the above has led suppliers because the costs of raw materials and semi- finished products is less than the cost of maintaining this will reduce the maintenance cost of the whole supply chain and since each depends on the chain members Reduce the maintenance cost in the whole chain Enhance the chain. To determine where to keep inventory the mathematical calculation should be used provided it does not exist here.

Another method is to reduce the cost of using 3PL. 3 PL s are companies that offer services such as transportation. The benefits that 3PL have, is it can help improve organizational performance in some cases; companies can make use of ERAM Sanat. Another factor that reduces the maintenance cost is reduced, which is in LEAD TIME mentioned above.

Another way to reduce the maintenance costs of goods is use of strategic cooperation between supplier and retailer. In this way, the supplier (manufacturer or distributor for a large) retailers to reach agreement that every time a certain amount of a commodity at retail receipt a certain amount of goods to send to manufacturer to retailer. To do this there is a need for an information system until manufacturer be aware, retailer inventory levels to always and to prepare themselves for producing and shipping VMI model is a special case of this type of cooperation that the Supplier (manufacturer), itself decides when and how much to send goods it is the responsibility of the consequences. So Eram Sanat company can has such collaboration with a number of retailers and distributors.

To reduce transportation costs and improve product sales it, the warehouses and representatives around the country to be built selection. To make the best selection and construction and barn there is a representation to minimize the cost and reduce delivery times to customers and the customer can provide good after-sales service. It is suggested that this facility can be used to determine the location of the computer simulation. Because computer simulation allows to the minimum possible time to review the different aspects and the optimal solution is selected.

3.3 Identify and reduce security risks

The risks are identified in the supply chain and the figure 3 is classified.

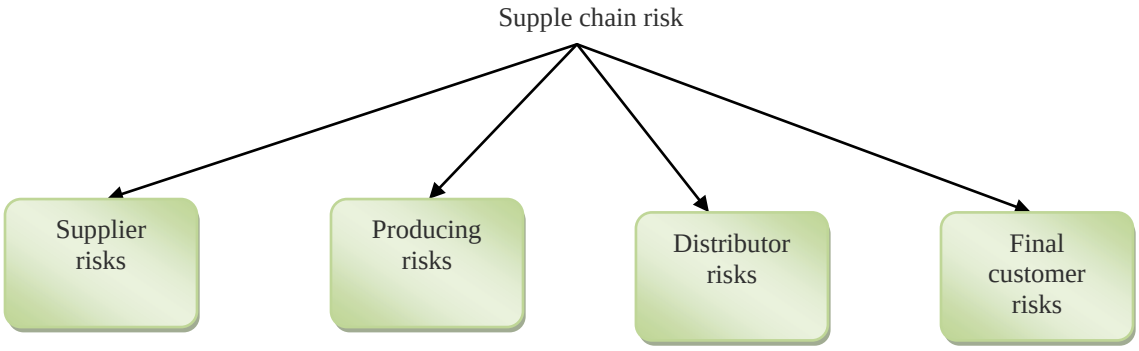


Figure 3: Supple chain risk

Supplier risks:

- Delivery errors
- On time supply of raw materials
- No direct relationship with the customer
- Quality of raw materials
- Increases in raw material prices
- Inability to perform each task
- Falling behind the technology changes
- Competitors conditions
- Inadequate transport materials
- Problems of technology information
- Inadequate stock
- Supplier bankruptcy
- Environmental Factors

Producing risks:

- Quality of raw materials
- Technology transfer
- Changes in product Engineering
- Changes in the product life cycle
- Errors in production planning
- Inadequate control of production
- Inventory of environmental risk

- Reliance on a single supplier
- Lack of flexibility by supplier
- Financial power of customers
- Environmental problems

Distributor risks:

- Wrong forecasting of demand
- Market share
- Product quality
- International regulations
- Product price change
- Received unpaid accounts
- Return product from customers
- Risk of Transportation
- Environmental Factors

Final customer risks:

- good price
- Sales services
- Quality assurance
- Time delivery

After classifying risks, questionnaire should be prepared and use of experts, to identify most important risks until they decision. Reason choice the main risk is that ability to assess and deal directly with all the risk to the organization not exists. In addition, it can be implemented some good foreign policy on supply chain contracts. Also should be created centralized information systems in the supply chain until chain members are aware of the required information and planning to do the right thing and increase supply chain efficiency.

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Biography

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Strategic Evaluation of High Technology Companies Based on Game Theory and Hierarchical Balanced Scorecard

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Abstract

High technology companies play a critical role in creating wealth for nations. On the other hand, high technology companies have faced with rapid growth of science and technology in various areas. In today's world, they should learn how to use a proper performance measurement system (PMS) in their performance evaluation activities. Balanced scorecard (BSC), first introduced by Kaplan and Norton, enables managers and company leaders to evaluate and monitor their performance in both financial and non-financial aspects for achieving determined strategic goals. In addition high technology companies need another form of BSC, which emphasizes on measurement in both technology and business strategy to gain competitive edge. This study aims to exhibit a framework for strategic evaluation of Iranian high technology companies with using game theory and hierarchical balanced scorecard (HBSC) approaches. HBSC is the most repetition model for strategic performance evaluation for high technology companies in the literature is composed by integration of the balanced scorecard (BSC) and analytical hierarchy process (AHP) techniques. This study shows an application of Shapley value that adapted from cooperative game theory concepts for allocating weights to each criterion. Therefore, current study presents a new framework by integration of HBSC and Shapley value approaches, for evaluation and ranking of high technology companies, which participated in the second national management of technology and innovation award.

Keywords

Performance evaluation, balanced scorecard, hierarchical balanced scorecard, game theory, high technology

1. Introduction

In the last decades, the emergence and rapid growth of high technology-based companies has accelerated the need for innovative and validated strategic performance measurement (SPM) models for business, and has provided a suitable context for research on these subjects. Companies in different industries are interested in how they can more effectively manage science, innovation, and technology indices, which are growing rapidly in the organizational context. The complexity, dynamics, and rate of technological innovations change on a global scale at a time of increasing organizational and progressive sectors. Changing technologies, including nanotechnology, biotechnology, information technology (IT), and social technology, require significant opportunities for enforcing sectors, provide growth, and present a potential threat to the existing activities of firms. Strategic management of technology (SMOT) is expanding most rapidly, in terms of both theory and practice, owing to its multi-disciplinary and multifunctional nature. A number of disciplines are relevant to the academic perspective, such as science, engineering, economics, sociology and psychology. In high technology businesses, contributions from the commercial, technological, and strategic functions are critical in order to make correct decisions and deliver successful products and services to the market. Performance measurement consists of rules for assigning a value to objects or events in such a way as to represent quantities, qualities or categories of an attribute. A performance measurement system plays different roles in excellence of organizational procedures. In some way the aim of evaluations is just scoring and showing which sector or firm do own tasks well, but without having any clear objects and goals in their evaluations, such evaluations has no effectiveness (Oleyaei-Motlagh, 2014).

Systematically converting a traditional BSC introduced by Kaplan and Norton into the technology BSC is discussed in this paper. After classifying strategic objects and criteria into four aspects of proposed hierarchical balanced scorecard (HBSC), at the next step we will compute suitable weights for each balanced scorecard (BSC) aspect using Shapley value, which adapted from cooperative game theory concepts. These six Iranian high-tech companies adapted from different industries such as chemical fibres, micro-electronics, precision machinery, civilian aircraft,

biotechnology and energy development that participated in the second national management of technology and innovation award.

2. Literature Review

Khalil (2000) classified technology into the six various ways (high technology, low technology, medium technology and appropriate technology). In his category, advanced or sophisticated technologies are building blocks for a high technology company (Khalil, 2000). Rogers & Larsen (1984) defined attributes of high-tech companies as "an abundance of scientists and engineers in the organization, fast-growing industry, higher R&D expenditure than in any other industry and worldwide market for their products". Wheeler & Shelley (1987) investigated forecasts of demand for innovative high technology products and they found market share to be uniformly optimistic by 50% or more. They attributed this to a lack of forecaster expertise in consumer behavior, overenthusiasm for high technology and poor judgment (Wheeler & Shelley, 1987). On the other hand, high technology start-ups typically aim for future success as the payoff for current activities. These companies need at least an informal and agreed-upon view of their technology delivery system (TDS) to develop and execute a technology-based business plan. For instance, in devising indicators of high technology development among nations, Roessner and Porter (1996) used technology sales as surrogate production measures. This raises some interesting questions about the nature of high technology companies in the developing countries and about their experiences; in particular what factors, especially R&D expenditure, lead to success. High-tech products are the fastest growing segment of international trade and some 25% of exports from developing countries are in high-tech products (Fagerberg et al., 2007; Porter et al., 2011; Roessner & Porter, 1996).

The balanced scorecard (BSC) approach helps organization managers to implement and monitor their strategies. Since 1990s, the balanced scorecard (BSC) introduced by Kaplan and Norton, which emphasized on measurements of company performance in both financial and non-financial aspects, up to now, several expansions for the BSC has provided by researchers in this field (see Table 1). The balanced scorecard has been applied in numerous large organizations resulting in many positive results that have been chronicled in the management literature (Gumbus, 2005; Neely, 2005).

Table 1: Previous studies on BSC

Author / year	Accompanying techniques	Case study
Chen & Chen, 2007	DEA	Performance evaluation of semiconductor industry
Chytas & et al., 2011	Fuzzy cognitive maps (FCM)	-
Huang & et al., 2011	AHP	Evaluate the performance of the biopharmaceutical firm
Huang, 2009	AHP	Performance evaluation of a knowledge-based systems
Tseng, 2010	ANP, DEMATEL	Taiwanese universities' performances evaluation
Wang, 2010	AHP, Non-additive fuzzy integral	Performance evaluation of high technology companies
Wuo & et al., 2011	DEMATEL, ANP, VICOR	Performance of educational centers of Taiwan
Wuo, 2012	DEMATEL	Performance evaluation of banking industry of Taiwan

BSC measures organizational performances from four financial, customer, internal business processes, and learning and growth perspectives. The BSC approach links logically these four perspectives. It means that improvement of learning and growth level causes in improvement of internal business processes, which creates better products and services. Therefore, higher customer satisfaction and higher market share, leading to financial profits for the organization (Kaplan & Norton, 2004; Marr & Schumia, 2003; Norreklit, 2000). Thus, a good balanced scorecard should identify most important priority of each aspect within the business and helps employees and managers appreciate the roles of employee and task as well as the importance of each result to the overall corporate effort. BSC attempts to move businesses from monitoring to measurement, from measurement to management and from management to direction setting (Nair, 2004).

Marr and Schiuma (2003) claimed that "the BSC is the most influential and dominant concept in the field of recent performance measurement research". Neely (2005) noted to the BSC impacts on practices and citied researches and showed that between 30 and 60 percent of firms have adopted the BSC in some form, and on academic researches, in which Kaplan & Norton's writings on the BSC have dominated the citations in articles on performance measurement in the leading academic journals for the last decade. The BSC was first illustrated as a tool for

measuring organizational performances from four key areas. Since then, it has grown into a device for controlling the implementation of strategy by linking the performance measures to organizational strategies and goals (Fink et al., 2005; Kaplan & Norton, 2000). It has become one of the preferred strategic performance management tools in many prominent, public and private organizations. The previous studies on BSC applications commonly ignored the fact that consideration of collations between each aspect of BSC in any reasonable manner. On the other hand, in a high-tech company, emphasizing on measurements of both business strategy and technology strategy is necessary. Thus, for doing studies in the high technology environment, practitioners have to develop and use a modified version of the BSC that enables them to implement, monitor and evaluate their strategies from different viewpoints.

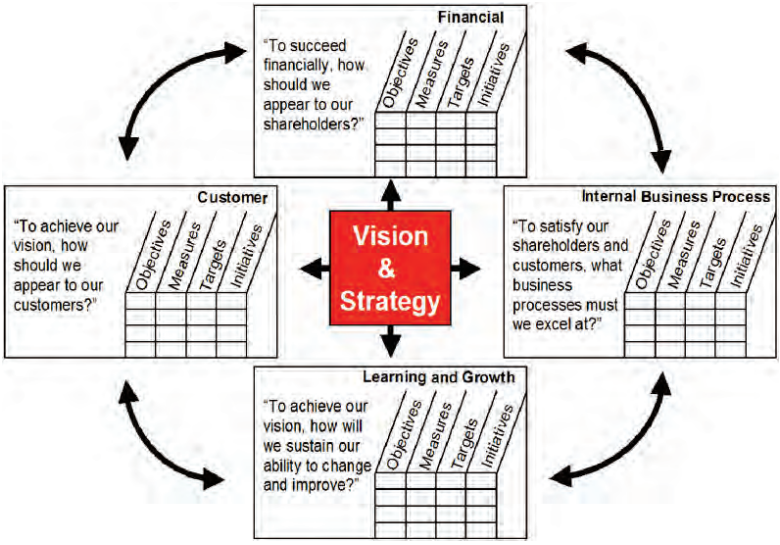


Figure 1: The balanced scorecard and its four aspects

3. Methods of Research

Most of the managers have located in the decisional situation in a business or even in the manufacturing plant, have used business and marketing strategies to gain a competitive edge. On the other side of the issue, the utilizations of technology strategies still is like a broken chain in their operational, mid-term and long-term decisions, which brings substitutions into a stable competitive advantage. Previously only one side of the business is taken into account for the strategy development and balancing, trade-off and linkage between business and technology strategy is not well understood. Gerdsri & et al. (2009) used technology road mapping (TRM) concepts, which integrates technology into business strategy for successful implementation of dynamics of TRM concepts in the initiation, development and integration stages. Many of researchers emphasized on the people, process and data (three critical success factors) in road mapping practice as well (Gerdsri et al., 2007; Gerdsri et al., 2009). In addition, continuation of the enrichments of the BSC has required additional tools and techniques for customizing and facilitating for high technology company's strategic planning practice, which may adapted from road mapping processes by integrated with decision theory modes, technology strategies and technology forecasting techniques.

Table 2: Selected high-tech companies in this study

Name*	Industry	Strategic plan	Employees	Licenses	Joint ventures	TRM	Geographical scope	Technological innovation
Aircom	Aerospace	Y	100	3	1	Y	Local	5
Precom	Defense	Y	500	3	1	Y	Local	7
Enecom	Oil & Gas	Y	2,000	12	5	Y	Global	28
Fibcom	Chemical	Y	120	8	3	Y	Global	5
Elecom	Electrical	N	80	1	-	N	Local	3
Biocom	Medical	Y	120	2	-	N	Global	5

*Because of royalty rights, in this study, we never use real name of high-tech companies.

3.1 Selecting Criteria from Different Perspectives

High technology companies have an undeniable duty to make a credit and wealth for nations and they have direct influence on GDP rate. Even though high-tech companies acquire competitive advantage for countries, there is no comprehensive framework for strategically managing of technology in neither micro nor macro level of strategic planning studies. Absence of equilibrium between strategic management and technology management activities, have caused high-tech companies had not got any advantage from high technology environment. This is a well-known phenomenon, which most of the researchers encountered in both strategic management and technology management studies. Several field studies have done in order to find of strategic planning elements on the six Iranian high-tech companies. The results showed that they have used different cognitive procedures in their strategic management of technology (SMOT) procedures. However, the above-mentioned matter refers to the most cited notions in the literature, but analytical studies seem to be absent. For example, generic process model (Gregory model) does not correctly reflect both technological and business trends. In calculating shareholder value it is customary to make a distinction between the 'planning' period (usually less than 5 years), and the 'continuing period' beyond. A summary of results for different industries are showed in the Table 2. This is another gap which conventional performance evaluation tools could not measure the long-range growth of high-tech companies; therefore we should use an innovative for of PMS for our studies in high-tech environments. With modifying of four traditional BSC perspectives, we are able to compose a new form of PMS, which is emphasizing on measurements of both business and technology strategy. Current study illustrates technology-balanced scorecard (TBSC) as a best solution for traditional PMS problems by application of its four financial, customer, internal and technological processes, and learning and growth aspects (Figure 2).

Table 3: Financial values in different periods (Media & Staff, 2008)

Industry	% of value in the planning period	% of value in the continuing period
Tobacco	40	60
Sporting goods	20	80
Skin care	5	95
High-tech	-20	120

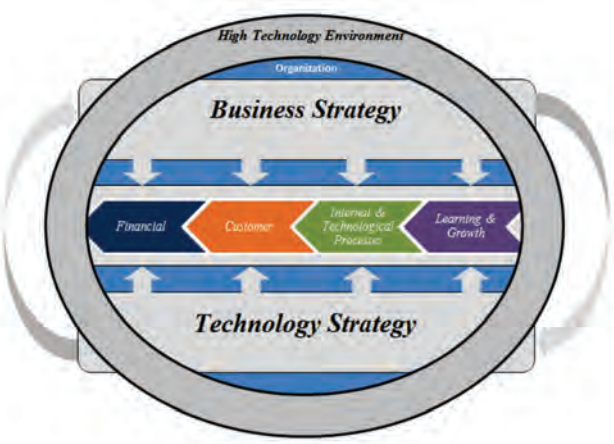


Figure 2: Proposed TBSC for the high-tech companies (Oleyaei-Motlagh, 2014)

3.1.1 Financial Aspect

The financial performance defines the long-run objectives in a high technology company. While most of the industries might emphasize on the profitability objectives, other financial objectives are also possible. High technology companies should look into their financial process beyond the cash flow. Three main strategic financial objects, which a high technology company is facing, are mentioned as follows (Table 4).

Table 4: Financial aspect

Object	Indicators	Mean	SD
Return on investment (ROI)	• Return on technological investments	2.81	0.63
	• Return on capital investment	3.13	0.25
	• Return on product development expense	3.21	0.24
Cost leadership	• Production reduced costs	2.14	0.35
	• General and administration reduced costs	2.23	0.67
Risk management	• Technology ranking of products and process compared to competitors	2.86	0.14

3.1.2 Customer Aspect

Technology customers will typically have strong belief systems underpinning what supplier they do business with and what products/services they purchase (MBA, 2013). On the other hand, they are required mechanism to making coalitions with their suppliers, services organizations, and they might grade their supplier on how successful those interactions are. Headquarters in different industries are interested to the indices that they can use to enhance business strategies respect to the total corporate strategy, such as customer satisfaction and retention indices, and market share index as well. Poor performance from this perspective is thus a leading indicator of future decline, even though the current financial picture may look good. Frequently cited BSC measures for the customer aspect in the high-tech companies are included as below (Table 5).

Table 5: Customer aspect

Object	Indicators	Mean	SD
Market share	• Number of new customers	3.22	0.15
	• Brand price	2.84	0.24
	• Market share (%)	3.17	0.10
Customer satisfaction and retention	• Customer satisfaction index	2.68	0.46
	• Decreased customer's complaints	2.49	0.78
Partnership with suppliers	• Number of suppliers	2.20	0.33
	• Number of outsourced projects	1.89	0.74

3.1.3 Internal and Technological Processes Aspect

Most customers these days need to the innovative vehicles and tools for conformity with technological and social changes, which brings customers satisfaction and enhancement of market share for companies. It forced advanced companies to based research and developments (R&D) and technology transfer strategies respect to their suppliers strategy as well. Objects based on this aspect allow high-tech companies to evaluate how well their business is running, and whether its products and services conform to customer requirements (the mission). These objects and correspondence indicators are as bellow (see Table 6).

3.1.4 Learning and Growth Aspect

Kaplan and Norton (2000) emphasized that learning have included not only training, but also mentoring, ease of communication among workers, and technological tools. Frequently cited BSC measures for the learning and growth aspect have emphasized on the employee capabilities, information systems availability, motivation and empowerment. Number of suggestions per employee, percentage of employee suggestions implemented and percentage of compensation based on individual and team incentives, considered indicators for human capabilities. On the other side of the issue, employee education, employee satisfaction index, and employee turnover rate are considered. Percentage of front-line employees with on-line access to customer information, and percentage of business processes with real-time feedback are considered indicators for learning and grows aspect (see Table 7).

Table 6: Internal and technological processes aspect

Object	Indicators	Mean	SD
Increased responsiveness	• Product delivery reduced time	2.65	0.38
	• Shortage response time	2.17	0.52
	• On-time deliveries	3.23	0.45
Technological innovations	• Number of explored technologies	3.42	0.32
Technology transferability	• Number of licenses	3.58	0.24
	• Number of Joint-ventures	2.47	0.50
Manufacturing processes	• Yields	3.65	0.13
	• Decreased defect rates	3.24	0.25
	• Average time taken to manufacture orders	2.87	0.34
	• Setup time	2.89	0.34
	• Manufacturing down time	3.23	0.21
New Products development	• Number of new products/ services	2.76	0.36
Developed R&D projects and teams	• Number of internal R&D projects	3.25	0.18
	• Number of external R&D projects	2.74	0.64
	• The level of participation in problem definition	2.28	0.75
	• Percentage of projects which based on teamwork	3.20	0.67
Product life cycle managment	• Product/process life cycle time	3.25	0.16
Industry, academic, and institutes collaborations	• Number of new treaties	2.67	0.30
Registered patents	• Number of registered patents	2.28	0.59

Table 7: Learning and growth aspect

Object	Indicators	Mean	SD
Training leading-edge technologies	• Number of scientists	3.24	0.26
	• Leading-edge technology training (Hrs)	2.78	0.45
	• Number of multi-skilled employees	2.93	0.69
Human resource(HR)development	• Employee educational level	2.86	0.53
	• Employee turnover rates	2.27	0.77
Employees satisfaction and motivation	• Employee satisfaction scores	2.35	0.30
	• Number of motivational incentives	2.78	0.55
	• Percentage of employee suggestions implemented	2.91	0.47
Information system capabilities	• Percentage of front-line employees with on-line access to technology information	2.68	0.29
	• Percentage of technological processes with real-time feedback	2.69	0.32
Maintenance project management skills	• Percentage of people involved in decision-making	2.45	0.55
Enhance creativity	• Number of accepted innovative proposal	2.38	0.41
	• Number of new process improvement ideas generated	2.12	0.38
	• Number of suggestions per employee	3.46	0.58
Learning technology leadership	• Technology protection plans	3.76	0.56
	• Number of technology acquainted	2.85	0.66
Improve organizational training effectiveness	• Index of training effectiveness	3.57	0.11

3.2. Integrating Proposed TBSC with AHP

The analytic hierarchy process (AHP), originally developed by Saaty (1981), is a revolutionary breakthrough, which empowers companies and businesses to relate intangibles to tangibles (like a balanced scorecard), the subjective to the objective, and to link both to their purposes. It offers different ways to integrate complexity, set the right objectives, establishes their priorities, and determine the overall value of each alternative solution. The AHP uses

hierarchical decision models (Figure 3) and it has a sound mathematical basis. After allocating criteria equals to the BSC aspects, we have to formed hierarchical process model for all six Iranian high-tech companies, which participated in the second national management of technology and innovation award (Table 2). Respectively six high-tech companies are considered as alternatives for proposed hierarchical balanced scorecard (HBSC) structure.

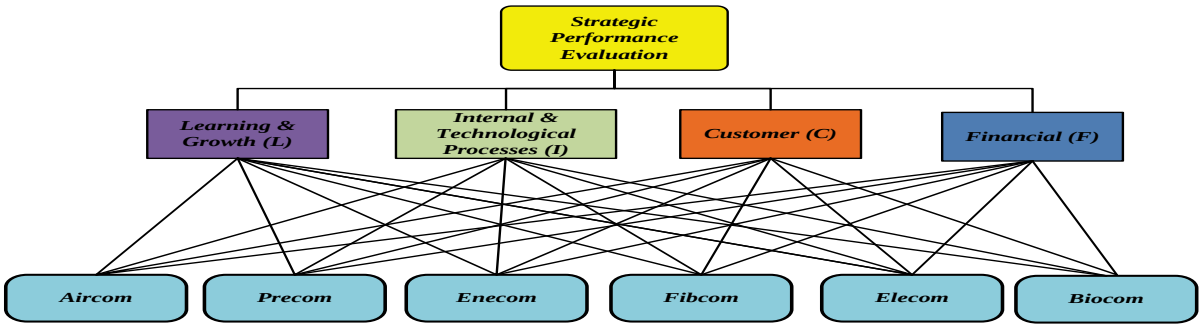


Figure 3: HTBSC framework for evaluation six high-tech companies

The second segment of HBSC structure is doing mathematical computations with respect to the considered criteria and alternatives. The first step begins with composing a comparative matrix respect to a certain criterion. Before composing a comparing matrix, it needed to be defined kind of possible relationships between two notions, and translated it to numerical scale using Likert scale (according to Table 8). After calculating priorities of the alternatives with respect to the criteria (see Table 9), in the next step, we can calculate the priorities of the alternatives with respect to the goal and finally synthesize the final priorities (Salmeron et al., 2005; Wang et al., 2010). Before going to the step three for computing priorities of the alternatives, it needed to be allocated rational weights for each criterion. With using Shapley value in the forthcoming section, this study opens a new perspective for making decision by using cooperative game theory notions.

Table 8: The fundamental scale for making judgment

Judgments about two notions	Numerical equal
Equal	1
Between equal and moderate	2
Moderate	3
Between moderate and strong	4
Strong	5
Between strong and very strong	6
Very strong	7
Between very strong and extreme	8
Extreme	9

Table 9: Comparative matrix respect to the learning and growth criterion

Company	Aircom	Precom	Enecom	Fibcom	Elecom	Biocom	Priority
Aircom	1	1/5	1/9	1	2	1	0.066
Precom	5	1	1/4	2	5	3	0.197
Enecom	9	4	1	8	9	7	0.538
Fibcom	1	1/2	1/8	1	2	1	0.074
Elecom	1/2	1/5	1/9	1/2	1	3	0.067
Biocom	1	1/3	1/7	1	1/3	1	0.058

3.3. Allocation of Shapley Weight for HTBSC Aspects

Game theory is an established and outlined mathematical tool to solve the conflicts of interest quantitatively and can be used to solve the individual benefits with respect to others in a society and can be broadly classified as non-cooperative and cooperative games. A cooperative game is given by specifying a value for every coalition. Formally, the game involves a finite set of players N (number of players), called the grand coalition, and a

characteristic function from $v: 2^N \rightarrow R$ the set of coalitions to a set of payments that satisfies v (Ø) = 0. The players are assumed to choose which coalition to form, according to their estimate of the way the allocation will be divided among coalition members. The main assumption in cooperative game theory is that the grand coalition N will form. The challenge is then to allocate the payoff v(N) among the players in some fair way. But this assumption is not restrictive, because even if players split off and form smaller coalitions, we can apply solution concept to the sub games defined by whatever coalitions actually form. This is advantageous for application in power network as in many a times some players may not be connected to the grids all the time to form the grand coalition. The Shapley value method derives unique payoff vector that is efficient, symmetric, and additive and assigns zero payoff to dummy players (Shapley, 1953). If S and T were disjoint subset of N, i.e., $S \cap T = \phi$ according to cooperative game theory $v(S \cup T) \geq v(S) + v(T)$ that means collation. The Shapley value, which belongs to the Pareto-optimal set, describes one approach to the fair allocation of gains obtained by cooperation among all players. Denoting Φ = (ϕ_1(v), ϕ_2(v), . . . , ϕ_n(v)) as an allocation scheme, the Shapley value is denoted by the condition:

$$\phi_i(v) = \sum_{\substack{S \subseteq N, \\ i \in S}} \frac{(|S| - 1)!(n - |S|)!}{n!} [v(S) - v(S \setminus \{i\})] \quad (1)$$

Where S is any available coalition of N, |S| is the number of the players in the coalition and $v(S \setminus \{i\})$ is the characteristic function of the coalition S except i. The concept of the Shapley value can be explained by one kind of probability explanation. Supposing that all players are arranged in some order and all of the orders are equally likely. Then ϕ_i(v) is the expected marginal contribution over all orders of player i to the set of players who precede him. It can be noticed that the sum of the marginal contributions of all players in any ordering is v(N). The vector $\Phi = (\phi_1(v), \phi_2(v), \ldots, \phi_n(v))$ is an acceptable allocation scheme of v(N) as the payoff each player obtains is not worse than that from one's own efforts (Maaser, 2010; Shapley, 1953).

In this paper, has assumed that none of the TBSC aspects can be an effective criterion, until they take part in the coalitions with other aspects. Therefore, assigned value to each TBSC aspects such as learning and growth, internal and technological processes, customer, and finances are equated with their effectiveness in coalitions for achieving excellence (see Table 10). With considering results of asked questions from four experts and assigned their personal's belief on the values for different aspects in the each subset (coalitions) such as S_i , game weights can obtained by formula (1) obtained as $W = (\Phi(L), \Phi(I), \Phi(C), \Phi(F)) = (0.22, 0.24, 0.26, 0.28)$.

Table 10: Shapley value for each collation in subset S_i

S_i	{I,C,F}	{L,I,C,F}	{C,F}	{L,C,F}	{I,F}	{L,I,F}	{F}	{L,F})
$v(S_i)$	0.75	1	0.50	0.80	0.20	0.85	0	0.15
S_i	{I,C}	{L,I,C}	{C}	{L,C}	{I}	{L,I}	{}	{L}
$v(S_i)$	0.30	0.75	0	0.15	0	0.25	0	0

3.4. Performances Evaluation Using Integrated Method

Comparative matrix for other aspects calculated similar to first comparative matrix and calculations are straightforward. Final priorities obtained by multiplying Shapley weights into the total matrix (see Table 11).

Table 11: The results for choose the best alternative

Company	Learning and growth aspect Φ(L)	Internal and technological processes aspect Φ(I)	Customer aspect Φ(C)	Financial aspect Φ(F)	SHBSC score	Rank
Aircom	0.066	0.168	0.146	0.124	0.128	5
Precom	0.197	0.148	0.247	0.066	0.162	3
Enecom	0.538	0.243	0.258	0.282	0.323	1
Fibcom	0.074	0.232	0.063	0.352	0.187	2
Elecom	0.067	0.083	0.056	0.074	0.070	6
Biocom	0.058	0.126	0.230	0.102	0.130	4
Total	1	1	1	1	1	

4. Sensitivity Analysis

Sensitivity analysis answers the question, "if these weights deviate from expectation weights, what will the effect on the total business performance, and which weights are causing the largest deviations?"

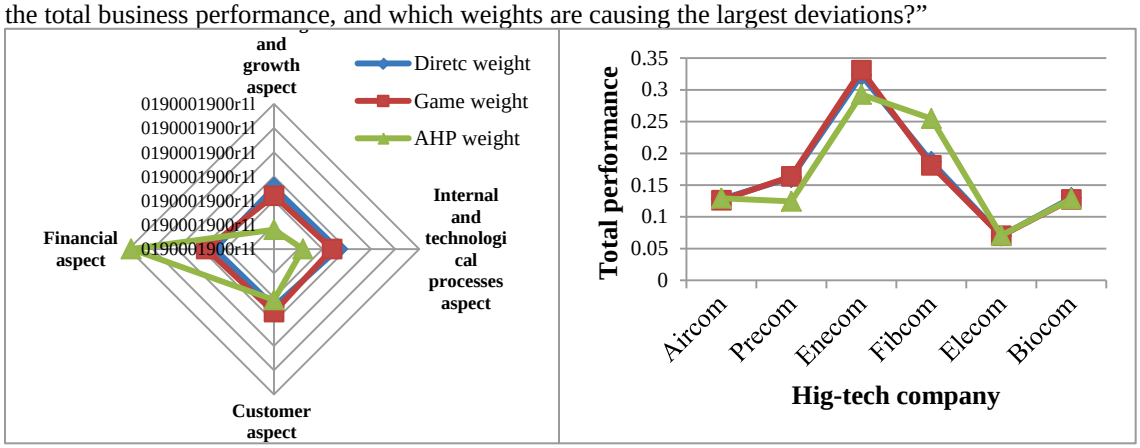


Figure 4: Sensitivity analysis on the criteria

Sensitivity analysis has done on the TBSC aspects with respect to the weights. First weight is direct weight calculated by field-studies on the high-tech companies with contribution of more than 150 informants from different sectors and allocating 1 to 4 score for each indicator as mentioned in Table4 to Table 7. Second weight calculated based on cooperative game theory, and third one has calculated with using AHP technique. Analyzed result illustrates stability of proposed performances measurement model respect to the different weights (Figure 4).

5. Conclusion

In this paper has been demonstrated a new framework for evaluation of high technology companies' performance by integrating of hierarchical balanced scorecard and Shapley value approaches. Six Iranian high-tech companies have been ranked in the second national management of technology and innovation award by using this approach. High technology HBSC similar to BSC has consisted of four aspects. Since the numbers of aspects were less than the numbers of case studies, allocation weights for each aspect in proposed HBSC had a great trace on results. Therefore, allocation of weight for each aspect is a critical activity in performance evaluation studies. Hence, in this study, has been an applied Shapley weight in order to allocating rationality weights for each aspects rather than applying of AHP's paired comparisons matrixes. On the other side of issue, inconsistency in the paired comparisons matrixes in the AHP structures affected on accuracy of previous studies and applying Shapley value for allocation weights is more accordance with the nature of BSC.

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Biography

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Risk Management Efficiency Analysis in Banks using Data Envelopment Analysis (DEA) Approach based on Hedge Accounting: Perspectives and Implications

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Abstract

Risk management is emerging as a major strategic goal of banks. Therefore, risk management efficiency and its measurement are important as these determine the extent to which banks can manage risks. There are several methods for measuring the efficiency of risk management. This paper proposes that Data Envelopment Analysis (DEA) can also be an appropriate method for measuring risk management efficiency. This approach to risk management efficiency measurement is operationalized in this study by applying DEA approach to hedge accounting effectiveness analysis, which is measure of risk management efficiency in hedging using derivatives. Concomitantly, this paper highlights the implications of hedge accounting using a hedge effectiveness test (dollar-offset ratio) integrated with a non-parametric optimization technique on risk management efficiency in commercial banks. The paper introduces DEA and the hedge effectiveness test to provide insight into the quantitative measurement of the dollar-offset approach since DEA and hedge effectiveness test share a fundamental concept with the latter approach. The main contribution to knowledge by this paper is that it is the first study in the literature to apply the DEA with the hedge effectiveness test. A comprehensive analysis of commercial bank's derivatives usage using the DEA method revealed the limitation of the dollar-offset ratio analysis in ensuring that banks are able to integrate derivative elements in their risk management policies. An application of this approach as a performance measurement technique has provided some strategies that can be applied to direct a strategic approach in managing risk and moderating key controls that assist in minimizing potential risks in the banking sector. From the results, several consequences arise which prove that the use of a derivative instrument has important implications in the following areas: (i) derivative measures, (ii) hedging size adjustment, (iii) risk assessment embedded in supporting banking risk management framework, (iv) hedging accounting policies, (v) portfolio management and monitoring, (vi) regulatory reform in cross-country operations, and (vii) methodological implications. These implications are important for both developed and developing markets as banking institutions are exposed to different types of risks and unexpected returns in developed and developing countries.

Keywords

Risk Management, banks, derivatives, data envelopment analysis, hedge accounting

1. Introduction

Risk management is crucial to banks. It became a priority for many firms including banks to be able to reduce the impact to various price fluctuations such as risk related to exchange rates, interest rates, stock market returns, etc. Uncertainty from market risk can hold many significant implications for the operation of an efficient organization. In the banking industry, many firms are still working to fully institute a comprehensive risk management policy, and

most banks are finding it increasingly difficult to mitigate risk especially in the post-global financial crisis scenario. Banks are struggling to ensure that their specific business decisions are consistent with their risk appetite and offer the best solutions to reduce uncertainties (Kupper 2000). Scholars (e.g.Bodnar and Gebhardt 1999; Fratzscher 2006; Abdel-Khalik 2013) believe that financial derivatives have become invaluable tools for risk management.

When new derivative users implement a derivatives strategy, the derivatives function as hedging tools on the firm's assets and reduce financial distress costs. Recommending the use of derivatives for hedging purposes, Guay (1999) found that the taking of a derivatives position is associated with reduction of firm risk. Research on new derivative users shows that they experience a significant impact in reductions in stock return volatility as well as interest rate and foreign exchange exposures from using derivatives. Several authors, such as Smith and Stulz (1985), Nance et al. (1993) and Fok et al. (1997) have argued that hedging can not only reduce the present value of expected tax liabilities but also decrease the expected cost of financial distress and agency cost problems. As derivatives are primarily employed for hedging purposes, they can be used as a means of reducing agency cost arising from wealth transfer from bondholders to shareholders. Since banks can use derivatives as a hedging instrument, they can reduce the volatility of their cash flow and pay out greater level of income in the form of dividends to ensure that bondholders have sufficient cash for debt payments.

In hedge accounting, IAS 39 requires hedging strategies to test the effectiveness of the hedging instrument and the hedged item with a measurement that was originally introduced by Ederington (1979) to measure the risk reduction effect of a futures market. Even though the measurement of risk reduction is often the most challenging part of the whole process (Ramirez 2008), such a measure can test the effectiveness of the hedging item to show how risks are offset by changes in the fair value or cash flows of the hedging instruments. The dollar-offset ratio analysis is given focus in the effectiveness test because of the concept used and its relevance to the data envelopment analysis (DEA) discussion used for efficiency evaluation. In sharp contrast to the limitations of the simple ratio analysis concept applied in the dollar-offset ratio, DEA can accomplish an advanced analysis on the impact of the hedging instrument usage on the hedged item, particularly in the banking sector where risk efficiency takes into account the hedging instrument (interest rate swap) and its effect on the hedged item. Moreover, DEA is also able to make simultaneous comparisons of multiple dependent performance measures, such as outcome, quality and output, with a new principle for determining weights directly from the data.

The primary focus of this paper is to highlight the implications of derivatives usage towards bank's risk management, through integrated approaches of the dollar-offset ratio and the DEA method. In so doing, we contribute to the existing body of knowledge in two ways. First, we provide empirical evidence on the risk management efficiency based on hedge accounting and DEA methods. The results enhance our understanding of the effect of the use of interest rate swap in risk management and hedge accounting. This paper also provides a methodology for integrating the dollar-offset ratio with the DEA approach. Second, we attempt to contribute to banking efficiency studies through the measurement of bank's risk management efficiency based on the use of a derivative instrument as an input. Using the concept of dollar-offset ratio analysis and the DEA approach of non-parametric analysis, this study shows the positive effect of employing financial derivatives to build greater efficiency in bank's risk management. Specifically, derivative usage under IFRS is found to be positively associated with risk management efficiency, particularly in commercial banks in Australia.

The rest of the article proceeds as follows: Section 2 presents a criticism of the simple ratio concept applied in the dollar-offset ratio analysis method. Section 3 compares hedge effectiveness analysis tests with the DEA approach using empirical evidence from both these analyses. The implications of the study are discussed in Section 4. Section 5 concludes the paper with some critical notes on the DEA approach on derivatives advocated in this paper.

2. The Dollar-Offset Ratio Analysis – A Criticism of Simple Ratio Concept Applied

As the dollar-offset ratio implements the concept of ratio in determining hedge effectiveness result, the ratio analysis issue is relevant to the DEA discussion used for efficiency evaluation. Unlike DEA, ratio analysis applied in the dollar-offset ratio does not make use of mathematical programming models to assimilate ratios into a single aggregate measure of efficiency. In particular, it does not take into account interactions over the full range of inputs and outputs simultaneously.[1] As a result, the use of ratio analysis can be considered a very basic technique for

[1] Sherman (1981) and Mante (1997) discuss these same issues.

performance measurement. Mante (1997) has explained this by stating that the performance of the units of analysis cannot be determined by the examination of the simple ratio concept unless the relative importance (weight) of each ratio is specified.

Further, as the amount (number) of output increase is affected by the input usage, the problems of weighting and assimilation grow. Hence, the comparison effect of the changes in fair values of the hedging instrument over the hedged item cannot be determined that well. In the concept of hedge accounting itself, the test may fail if fair value changes are relatively small and reflect ineffective result. Related to the usage of the hedging instrument as a risk management tool, it is not possible to find a simple rule in this approach to determine the impact on the organization's performance of risk management. Apart from lacking the tools for quality assessment and effectiveness (outcomes) measurement, this approach is too complex to collectively discuss the potential impact of derivative instruments usage in enhancing the safety and soundness of financial institutions.

In the literature on hedge (derivatives) accounting methodologies for testing hedge effectiveness, the debate around accounting reporting standards is endless. Panaretou et al. (2011) highlight the effect of accounting for derivatives as prescribed by International Financial Reporting Standards (IFRS) on corporate risk management. Besides the quality of the information regarding derivative instruments, the authors also discussed the ability of corporations to achieve hedge accounting treatment, and reported that under these circumstances, it may provide little information on hedge effectiveness of the firms. The authors provide the clear aim of adopting a more comprehensive International Financial Reporting Standard (IFRS) regime in this area to enhance transparency in the reporting of derivatives. However, the role of dollar-offset ratio which contains the hedging instrument used by the firms are not analyzed for its functions as a tool for risk management, even though Ramirez (2008) revealed that derivatives must show a strong impact on a hedging bank's income statement and are useful for banks in hedging against financial risks occurring from their borrowing and lending businesses. This point of view clearly recognizes that the bank's business is risky, so a reasonable question arises as to whether the dollar-offset ratio evaluating the comparison between the hedging instrument and the hedged item can improve their level of risk management efficiency.

Another argument by Nyhan and Martin (1999) stated that the ratio analysis concept only depends on the preferences of the policy makers in the assignment of weights, which highlights the weakness of the concept used. In a wider scope of assessment using dollar-offset ratio, Nyhan and Martin (1999) are of the opinion that this method is incapable of being used as a performance measurement on the basis of the decision rule. In addition, unlike DEA, they believe that this approach "empirically derives the weights that it assigns to each provider's input variable and performance variables that maximum weights is placed on those variables where a provider compares unfavorably." (1999, p. 11).

In sharp contrast and the limitation of a simple ratio analysis concept applied in the dollar-offset ratio, DEA can accomplish an advanced analysis on the impact of the hedging instrument usage on the hedged item, particularly in the banking sector performance that takes into account the hedging instrument (interest rate swap) and the hedged item implication. Moreover, DEA is also able to make simultaneous comparisons of multiple dependent performance measures, such as outcome, quality and output, with a new principle for determining weights directly from the data. Given the limitation of the ratio analysis, this study proposes to integrate a non-parametric approach (DEA) with hedge accounting effectiveness test (dollar-offset ratio) to address the limitation of the latter method in measuring firm's performance (efficiency). This study believes that a more comprehensive investigation of firm performance can be achieved by enhancing the dollar-offset ratio and hedge accounting measurement with the DEA approach.

3. An Abstract DEA Model

Beginning with the simple concept of a DEA containing a single input and a single output, the efficiency is defined as:

$$efficiency = \frac{output}{input}$$

However, in most cases, managers are often interested to evaluate the efficiency level of various productions or processes with respect to multiple inputs and outputs. This performance measure is extremely important in improving or eliminating inefficient operations as well as avoiding misleading evaluation of the intrinsic productivity of labor (Luptacik 2010). Charnes et al. (1978) measured the relative efficiency of a group of entities or

decision-making units (DMUs) in their use of multiple inputs to produce multiple outputs where the form of the production was not known. Under the ingredients of optimization problems and classification, DEA will identify the best practice performance frontier using a comparable process of transforming inputs to outputs.

A variety of DEA models have been developed for conducting efficiency measurement such as ratio, additive, multiplicative, CCR (Charnes, Cooper, Rhodes) and BCC (Banker, Charnes, Coope) models. This study focuses on the CCR model developed by Charnes et al. (1978). The efficiency of a DMU is defined as the ratio of the sum of its weighted outputs to the sum of its weighted inputs. The CCR model is given, where the ratio measure of relative efficiency for DMU_k is given by the following non-convex, nonlinear, fractional programming (1) and (2). This theoretical DEA model leads to the following fractional programming as given below:

$$Maximize\ h_p = \frac{\sum_{r=1}^{k} w_r y_{rp}}{\sum_{i=1}^{m} v_i x_{ip}},\ p = 1, 2..., n \tag{1}$$

$$Subject\ to: \quad \frac{\sum_{r=1}^{k} w_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1,\ j = 1, 2..., n$$
$$w_r \ge 0,\ r = 1, 2..., k$$
$$v_i \ge 0,\ i = 1, 2..., m \tag{2}$$

In this model, there are two constraints on assigning weights; first, no DMU can get a score of more than 1.000, and, second, the weights must be positive and the sum of weights must add up to one. This is the limitation in weight selection for the inputs and outputs. The weights w_r and v_i are determined by the solution of the problem (4.1) from the x_{ij} and y_{rj} data. The objective function h_p represents the relative efficiency of DMU_j where j ranges from 1 to n. The x_{ij} and y_{rj} (all positive) are known input and output values of $j-th$ DMU. The efficiency of DMU must not exceed unity (100%.) The DMU is efficient if the score is 1 and inefficient if the score is less than 1. The objective function (1) and constraints (2) are composed of fractions and need to be transformed into linear so that the model can be solved using simple linear programming such as simplex. Ragsdale (2010, 113) notes that "an efficiency rating of 100% does not necessarily mean that a unit is operating in the best possible way." He has suggested that linear combination of efficient units is important, which would resulted in a composite unit that produces at least as much output using the same or less input than the inefficient unit (DMU).

4. Comparative Analysis: Hedge Effectiveness Test and a DEA Approach

4.1 An Empirical Analysis on the Dollar-Offset Ratio

The formula of the dollar-offset ratio of hedge effectiveness test can be formulated as:

$$-(\sum_{i=1}^{n} X_i / \sum_{i=1}^{n} Y_i) = 1.0, \tag{3}$$

Where $\sum_{i=1}^{n} X_i$ is the cumulative sum of the periodic changes in derivative instruments value and $\sum_{i=1}^{n} Y_i$ refers to the cumulative sum of the periodic changes in the value of the hedged item. According to the rule, the measurement standard of this method is 80/125 (Swad 1995) and this has become the guideline for assessing the hedge effectiveness of derivative contracts under SFAS 80. This measurement requires the derivative's change in value offset to be at least 80% and not more than 125% of the value change of the hedged item.

In the banking sector, the study found that interest rate swap is the most significant instrument used as this tool is able to mitigate and limit the interest rate risk. The items hedged by this instrument consist of mortgage, and corporate and commercial loans, and customer deposits, and these items have been determined for various reasons when banks are engaged with an interest rate swap. For instance, for gap management reasons, banks have gaps in their balance sheet with long-term loans, such as mortgage loans or any loans for company investment, and liabilities which consist of short-term cash deposits, such as household savings. The gaps are created when banks are exposed to changes in the variable interest rates where these loans are at fixed interest rate (interest received on their loans) and variable rate is paid on customer deposits. The banks may run losses when the variable rate paid is higher than the interest received at fixed rate. Bicksler and Chen (1986) have noted that to solve the gap issue and reduce variable interest exposure, banks and other financial institutions have engaged in interest rate swap that would yield floating-rate liabilities and assets for the customers and fixed-rate liabilities and assets for the banks. To explain this with an example, Table 1 provides empirical evidence consisting of interest rate swap as an instrument and a mortgage, and corporate and commercial loans (hedge item 1) , and customer deposits (hedge item 2), as the items using the dollar-offset method in commercial banks in the year 2007.

Table 1: Empirical illustration of the hedge effectiveness method – Dollar-Offset Ratio for 2007

Banks	Change in Hedging Instrument	Change in the Hedged Item 1	Change in the Hedged Item 2	Dollar-Offset Ratio
COMMBANK	1222.55	38017.8	50391.2	0.013828343
NATIONAL AUSTRALIA	7276.31	35535.5	46638.5	0.088547594
WESTPAC BANKING	2291.72	35477.2	34958.8	0.032536203
BANK OF QUEENSLAND	7682.73	3756.7	2859.9	**1.161129583**
MAYBANK	39026.56	-19262.6	9901.3	4.168925256
CIMB	96584.97	1390.6	6736.2	11.88474799
HONG LEONG BANK	-9634.15	1411.1	4211.7	1.713407911
AMBANK	105273.62	952.5	1929.6	36.52670622

The above table shows the impact of the accounting (asset-liability) management treatment on the bank's asset-liability management. Based on the dollar-offset range of effectiveness, the outcome does not show a huge impact on hedge effectiveness (highly effective) since it is out of the range (80%-125%), except bank four (116%). This scenario indicates that the hedge is deemed ineffective even though the net change is insignificant compared to the change of the item size.

Ramirez (2008, p. 21) provides a solution to eliminate this weakness through "the use of cumulative change since the hedge inception in fair value for both the hedged item and the hedging instrument." However, due to a direct relationship between the instrument and the item, the remedial solution suggested by the author failed to be counted and the direct impact is unresolved. Moreover, in the context of risk management, the author is unable to emphasize

its function as an alternative method or product to manage the interest rate risk. Therefore, to address its role as a risk management tool in the commercial banks, its measurement must go beyond its effective measurement, particularly in showing its performance on yearly basis. The derivative instruments should express its real impact on the level of risk management efficiency, and this will signal its significant role in delivering better risk management function.

4.1.1 Policy and Theoretical Implications

The study believes that the dollar-offset ratio is a significant tool for measuring the efficiency of risk management in banks, and this method can be formulated with non-parametric approach as a powerful and robust technique to measure the efficiency level of the institutions (Grosskopf 1996; Asmild et al. 2007; Casu and Molyneux 2003). These integration approaches can intervene in both accounting and efficiency of risk management in banks. The application of the ratio analysis can clearly measure the direct impact of the derivative instrument usage for risk management efficiency analysis. In addition, it will strengthen the financial and risk management theory with a focus on value creation and risk management effectiveness to increase firm value and shareholder wealth. This assessment is important for banks and other stakeholders who have an interest in banking performance, particularly investors who are concerned that they may experience significant losses if banks are not performing well. The failures of inefficiently managed banks certainly pose grave risks for the financial sector at large and also exert negative external influences on efficient banks. This study also contributes to the practice of risk management professionals to closely consider the evaluation of the hedging instruments and its implications to the hedge item, thus helping them to adequately monitor and control their portfolio, loan and interest rate.

4.2 Descriptive Statistic and DEA Results

4.2.1 Descriptive Statistic

The input and output variables used in this study are reported in Table 1, and before proceeding to the DEA analysis, this study presents the descriptive statistic for the input and output variables employed (Table 1).

Table 1: Descriptive statistic of input and outputs

Variables	Units	Minimum	Maximum	Mean	Std. deviation
Outputs					
Customer deposits	Dollar	85	199137	52346	44422
Mortgage and, Corporate and Commercial Loans	Dollar	425	311537	75982	66345
Input					
Interest rate swap	Dollar	32077	1311117	394472	407799

Source: Authors' calculations

In order to cope with business environment test concept and theories, and the prerequisite condition of the DEA model, Ueda and Hoshiai (1997) have strongly suggested that outputs must have a positive correlation (relationship) with input variables. Hence, the study assesses the relationship between the input and output variables using the Pearson's correlation test (Hair 2009). This test was conducted in eight Australian and Malaysian banks. Table 2 shows the result of the correlation test. Both Customer Deposits *(y1)* and Mortgage and, Corporate and Commercial Loans *(y2)* show a positive correlation to Interest Rate Swap *(x)*, thus, both output variables are appropriate to be included in measuring bank's risk management in the performance evaluation model.

Table 2: Correlation coefficients between input and outputs

Input	Outputs	
	Customer deposits *(y1)*	Mortgage and, Corporate and Commercial Loans *(y2)*
Interest rate swap *(x)*	0.2822**	0.8125*

****p≤0.001, **p≤0.01, *p≤0.05*

4.2.2 Results

In contrast to expectations based on past papers in DEA, this paper first presents a strongly expressed role of derivative instruments through the hedging effectiveness test in banks' risk management efficiency. Using the software package DEAP Version 2.1 by Coelli (1996), the analysis is based on yearly basis, where the first year of the study, 2007, has been used as the baseline for individual banks in the estimated efficiency score (Table 3).

Table 3: Efficiency summary in 2007

Commercial Banks	CRSTE	VRSTE	SE
COMMBANK	1	1	1
NATIONAL ASUTRALIA	0.992	0.994	0.997
WESTPAC BANKING	0.996	0.999	0.998
BANK OF QUEENSLAND	0.941	0.985	0.956
MAYBANK	0.851	0.966	0.881
CIMB	0.889	0.936	0.949
HONG LEONG BANK	0.951	1	0.951
AMBANK	0.885	0.931	0.950
Mean	0.938	0.976	0.960

Notes: CRSTE = Technical Efficiency, VRSTE = Pure Technical Efficiency, SE = Scale Efficiency
Source: Authors' calculations

Based on the input-oriented approach under the constant return to scale (CRS) assumption, the average technical efficiency is 93.8%, which is less than mean efficiency score under the variable return to scale (VRS) assumption with 97.6%. This implies that on an average, the banks could proportionally reduce their input by 6.2% to produce the same amount of output. In the scale efficiency score, the mean is found to be 96%. The result indicates that, on an average, the actual production scale has diverged by 4% of the most productive scale size. Only COMMBANK has achieved the unity SE score, which means the bank operates at the most productive scale size. For this period, the banks were operating in a region of increasing returns to scale (IRS), ranging from 0.851 to 1, implying that it was operating on a scale that was too small.

The extended relative results reported in Table 4 for eight banks range from 0.891 to 1.000. In 2008, COMMBANK and WESTPAC BANKING are operating at the best practice or efficient frontier of technically efficiency (100%), where no wastage of inputs affected the quantity level of outputs. Both banks show better performance and are the most efficient banks. From the result, it is important to recognize that Australian commercial banks experienced advanced risk management strategy with the usage of derivative instruments. Cautious management and continual monitoring improves efficiency and best value for managing interest rate risk (Ahmed et al. 1997; Berkman et al. 1997). As depicted in Table 4, the result of the top four banks in Australia can be set as an example of good operating practices for bottom four banks from Malaysia. Only MAYBANK performs at the best practice in 2011, while the remaining banks have TE score of less than 1, which means that they are technically inefficient. This inefficient risk management highlights the insufficient role played by the instrument in adjusting fair value changes, attributable to the risk being hedged, as well as offsetting the interest rate risk.

Referring to Table 4, the second focus of this analysis is concerned with the fact that commercial banks in a developed country (in this case, Australia), on average achieve a higher efficiency score than those in a developing or emerging country (in this case, Malaysia). In 2008-2012, on average, commercial banks from a developed country have a higher technical efficiency compared to developing country. All Australian banks dominate the risk management efficiency ranking with WESTPAC BANKING as highly efficient. Indeed, this results was expected and it has confirmed findings in other cross-country studies (see, e.g., Eling and Luhnen (2010); Rai (1996)).

Table 4: Technical efficiency score for Australian and Malaysian Commercial Banks (2008-2012)

	2008			2009			2010			2011			2012		
Bank	TE	PTE	SE	TE	PTE	SE	TE	PTE	SE	TE	PTE	SE	TE	PTE	SE
AUSTRALIAN BANKS															
COMMBANK	1	1	1	0.959	0.983	0.976	0.984	0.990	0.994	1	1	1	0.946	0.984	0.962
NATIONAL AUSTRALIA	0.955	0.980	0.974	0.954	0.990	0.964	1	1	1	0.958	0.979	0.979	0.999	1	0.999
WESTPAC BANKING	1	1	1	1	1	1	1	1	1	0.961	0.977	0.984	1	1	1
BANK OF QUEENSLAND	0.967	0.985	0.982	0.947	0.971	0.975	0.770	0.921	0.837	0.939	0.960	0.977	0.949	1	0.949
Mean	**0.981**	**0.991**	**0.989**	**0.965**	**0.986**	**0.979**	**0.939**	**0.978**	**0.958**	**0.965**	**0.979**	**0.985**	**0.974**	**0.996**	**0.978**
MALAYSIAN BANKS															
MAYBANK	0.948	0.969	0.978	0.953	0.975	0.978	0.876	0.899	0.975	1	1	1	0.911	0.944	0.965
CIMB	0.917	0.934	0.983	0.976	1	0.976	0.958	1	0.958	0.929	0.946	0.983	0.895	0.936	0.956
HONG LEONG BANK	0.950	0.972	0.978	0.944	0.970	0.974	0.723	0.924	0.783	0.951	0.968	0.982	0.891	0.937	0.951
AMBANK	0.982	1	0.982	0.942	0.968	0.973	0.829	0.996	0.833	0.935	0.940	0.994	0.925	0.973	0.950
Mean	**0.949**	**0.969**	**0.980**	**0.954**	**0.978**	**0.975**	**0.847**	**0.955**	**0.887**	**0.954**	**0.964**	**0.990**	**0.906**	**0.948**	**0.956**

Notes: TE=Technical Efficiency, PTE=Pure Technical Efficiency, SE=Scale Efficiency
Source: Authors' calculation

5. Discussion of Implications

The result of this study has presented some valuable conclusions. From the result, we can conclude that the use of derivative instrument has significantly affected the measurement of risk management efficiency in banks, where three Australian commercial banks have achieved the top ranking in risk management efficiency. When banks are not efficient, this not only imperils the effectiveness and profitability of their risk management strategy, but also their survival in a highly competitive market. An inefficient organization shows failure in their procedures, policies, strategic framework and decision making. Hence, policy makers and the core team have the responsibility to execute sound risk management, which will boost firm performance to make it more competitive and efficient in the global financial market. In helping banks to integrate derivative elements in their risk management policies, the outcomes of this study address the research problems by providing some strategies that assist in minimizing potential risks in the organization. The implications of this study are important for the following areas:

5.1 Derivative measures

On the basis of the survey and evidence of the empirical results, hedging strategy using interest rate swaps can be a value-enhancing activity that matches the efficiency of risk management in commercial banks. This implication might offer another motivation where derivatives act as a reduction tool in lowering the volatility of taxable income (Smith and Stulz 1985), reducing underinvestment problem (Bessembinder 1991; Myers 1977) and avoiding unnecessary fluctuations either in external funding or investment spending (Froot et al. 1993). In managing access to the company's capital, financial executives are becoming increasingly important for financial derivatives to reduce risk while minimizing the cost of capital. Therefore, the interest rate swap used in this study was tested very carefully using a DEA approach to ensure that its usage meets the goals of risk management and can be used as risk parameters in banks, especially when the funding decision is made in the event of high market interest rates.

The integration of derivative instrument with risk management also helps a bank in planning their amounts of borrowed funds. The profitability of the institutions would be affected if the interest rate rises to result in lesser borrowing and investment. Banks typically have lots of government bonds and other long-term assets (example: loans given to corporate) in their portfolio, while their liabilities are predominantly short-term (example: deposits made by individuals range from one to five years). Hence, in order to address the risk resulting from the asset-liability mismatch, they generally use interest rate financial instruments to hedge their exposure to interest rate volatility. As this study used derivatives as an input of analysis, this study provides an alternative solution and mechanism to investors (banks) that can help them in investment decision making. The results hope to direct hedging decision to ensure that a bank is able to avoid unnecessary fluctuations.

5.2 Hedging Size Adjustment

The results of this study also show that the overall derivative instrument has a huge impact on risk management in banks. In the sample period, four major commercial banks in Australia achieved significant impact of interest rate swap to hedge items. However, the results reveal that all banks have performed under the region of increasing return to scale (IRS). It means that for all periods the operating size of the banks is small, but they have shown efficient economic performance. Therefore, these banks, especially Malaysian commercial banks, are advised to expand their hedging size and also the firm's size to boost their technical efficiency (TE). Lin et al. (2012) and Guay and Kothari (2003) found that the hedging amount has a positive relationship to firm size. With an increase hedging size, the banks will achieve better risk management, and consequently reduce the negative impact of the hedged items. Improving risk management in this manner will increase firm value by reducing the cost of financial distress or under-investment problem (Jin and Jorion 2007).

5.3 Risk Assessment Embedded in Supporting Banking Risk Management Framework

Analysis of the efficiency of risk management based on the use of derivative instruments are designed to assess the extent to which the bank is able to deal with increasing complexity of the external risk environment and effect on the performance of the firm. This study has analyzed the use of derivatives as an option for managing risk although a whole variety of other instruments are available for this. These results are important for performance measurement of how banks manage their risks and implement strategic plans for risk treatment and control action plans. This is important for supporting a more efficient governance structure, enhancing efficiency of the operations carried out by specialist risk groups, and establishing clear reporting and monitoring framework. In fact, the results also provide better mechanisms to monitor the performance of the loan and interest rate movements. The bottom line is that, the banks will have a better assessment mechanism in their ongoing financial security challenges that will improve their revenue management in alignment with their vision and expectation for better performance.

As this study uses intermediation approach, the risk management approaches must be integrated with the tools that which commercial banks use to turn their funds to finance or investments. The result of this study shows that in Australia three commercial banks have achieved the most efficiency, while the others are less efficient in managing their interest rate risk exposure. For Malaysian commercial banks, the technical efficiency level in 2010 reveals the lowest mean value in the sample periods. The results suggest that the banks need to lower their hedging activities as they show less efficiency in mitigating the firm's risk. Instead of developing hedging strategies, other approaches of handling operational risk will also protect the banks from loss, ensure optimization of the process as well as overcome their technical inefficiency.

5.4 Hedge Accounting Policies

The current quantitative prospective and retrospective hedge effectiveness tests (assessment) within the range of 80% to 125% threshold will soon be removed from the new concept proposed and expected to be issued and implemented by the IASB (Li 2012). In this scenario, this study believes that there is an economic relationship between hedging instruments and the hedged item. Hence, in order to evaluate the economic performance of the firms, the result produced by the DEA approach indirectly shows the relationship between both the hedging instrument and the hedged item. In current hedge accounting practice, the effect of interest rate does not dominate the fair value changes in the hedging relationship. For instance, the fair value changes due to interest rate risk tend to be a significant driver of the fair value changes of the hedged item. The hedging ratio, in this study refers to the dollar-offset ratio, this should not only be designated based on the quantities of the hedging instrument and the hedged items but designated for risk management purposes.

As this study uses the intermediation approach to highlight its role in properly and strategically managing risk of interest rate, the management of the hedging instruments to manage the exposure of the interest rate and exchange rate risk must reflect the concept of risk management efficiency. In other words, a bank's hedge accounting policy report should sufficiently consider risk control and monitoring functions, including the administration of interest rate risk management.

5.5 Portfolio Management and Monitoring

Based on the findings of this study, under the intermediation approach, on average, all commercial banks in Australia successfully manage the fluctuation of market risk. Performance efficiency is not threatened by interest rate uncertainty, especially for COMMBANK and WESTPAC BANKING. Almost all TE, PTE and SE achieved an absolute efficiency score (100%). On average, Australian commercial banks are not only scale-efficient but also pure technical as well as holistically efficient. This outstanding result can be attributed to the core principles for effective banking supervision in Australia implemented in 2001 that provided for asset securitizations and derivative instruments effectiveness under its scope.

The involvement of Australian financial institutions in derivative trading with an unknown degree of risk has been a cause of concern for the government as it could cause sudden implosion within the Australian financial sector. For instance, as explained by the government regulations imposed in the Australian Prudential Regulation Authority (APRA) 2010, four main (largest) banks in Australia (National Australia Bank, Commonwealth Bank, Westpac and, Australia and New Zealand Banking Group) have to meet strict criteria of risk governance and risk modeling. APRA has prescribed the criteria for risk weights to assess banks' performances based on direct characteristics observation on each exposure, predominantly in the form of corporate credit commitments, interest rate derivatives and foreign exchange derivatives. As a result, all Australian banks that have been analyzed here in this paper have proven that they have experienced rapid development in their own estimates of the exposure's probability of default and loss given default.

Given the selectivity of hedging activities that may reflect economically insignificant results, a combination of the dynamics of market and innovation in banking, certainly through the usage of derivative instruments, will ensure risk management effectiveness. The results also indicate that there are good structures in place in the Australia banking sector for controlling interest rate risk and effectively dealing with associated risks. The study also finds that appropriate procedures and policies are established to control and limit interest rate risk. The portfolio management and monitoring initiatives are "intended to realize the organization's strategy in order to maximize business benefits, and each is undertaken with a certain level of risks and constraints" .(Rajegopal 2012, p. 67). Here, all main banks in Australia have increased their management's ability to control risk factors, increase their capital and have responded successfully to global changes. As a result, total capital ratio in Australian financial

institutions rose by 1.3% from 2008 to 2010. This study believes that apart from reducing the dependency on government control, the Australian banking sector have achieved high performance and growth by following the guidelines and strict governance criteria. In contrast, Malaysian commercial banks are less efficient in their risk management. The implementation of macro hedging to reduce the impact of market interest rate on its asset and liability of the entire balance sheet are not significantly responsive. Hence, observation on risk management policy and practice in Australian banking sector is needed to maintain the flexibility of financial derivatives and create strong preferences for mitigating the behavior of interest rate risk.

5.6 Regulatory Reform in Cross-Country Operations

The evidence of comparative analysis of this study seems to point to the fact that the roles of derivatives in risk management in banks in a developed country like Australia are more effective compared to a developing country like Malaysia. Regulatory and policy reform has succeeded in making the anticipated impact on successful risk management strategies in Australia, where the banking sector has experienced significant growth with continuing financial innovation and appetite for new financial instruments. The active responses towards trading activity, market conditions and trade execution have contributed to the significant impact of derivatives in the financial landscape in Australia.

This suggests the need for policy review of Malaysian commercial banks to enable them to compete in the global market. Over the past decade, *Bank Negara Malaysia* (Central Bank of Malaysia) is putting monetary and financial policy in place following the government's broader economic plan. There is no issue of lack of independence in Malaysian commercial banks. After 2010, Malaysian financial institutions have experienced robust development of the money market. For instance, financial firms have helped to channel short-term funds between financial institutions to meet their financing needs and portfolio adjustments. However, the development in the derivative contract still depends on the determination of the policy set by the government and the central bank that led to slow growth and reduced sensitivity to the market structure and financial market. Nevertheless, the foreign exchange market has witnessed an increase in transactions, including hedging transactions.

Apart from being used as an instrument for hedging purposes, the financial derivatives are also used by Malaysian commercial banks to further magnify the diversity of investment products. This can be seen from the fact that the notional value of off-balance sheet of interest rate and foreign exchange related financial derivatives contracts amounted to MYR1.1 trillion at the end of 2010. Hence, it would not be wrong to assume that when the regulatory structure has been improved in mitigating interest rate and foreign exchange risks, the bank's performance level will gradually improve, which may also influence their risk management efficiency level. Again, this can be seen from the results generated here in this study which show that all Malaysian commercial banks stand a big chance to achieve an absolute efficiency score by using interest rate swaps in their operations. MAYBANK, CIMB and HONG LEONG BANK have shown good results on the impact of derivative instrument usage and its implication to asset and liability management. The strategy of active involvement in trading activity and market conditions would be very helpful as a further effort to enhance the regulatory framework on their asset and liability management, and this will be able to further manage the exposure on an item-by-item basis.

5.7 Methodological Implications

Based on the literature, more than two decades of research and work with risk measurement in banks have shown that there are a number of common risk factors when one investigates banking efficiency. On this basis, efficiency studies have ignored the role played by the risk management tool and its implication on the efficiency of risk management. Previous researches have focused on the ratio elements and ignored derivative instrument indication. This can lead to confusion and misinterpretation in true measurement of performance level. This methodological implication shows the need to systematically incorporate the measurement approach in the risk management context.

Although the Data Envelopment Analysis (DEA) method used in this study is not new, this approach was synthesized in novel ways that have not been previously attempted. In particular, the analysis started with the identification of relevant sections of risk management efficiency measurement using the DEA model based on hedge accounting. In the context of financial engineering, this study introduces the optimization technique to secure the best possible hedging instrument design for bank's decision making. The DEA model is used to achieve commercial bank's goal of using the interest rate swap to reduce interest rate risk impact on the asset liability burden along with the competing dimensions of market risk. For the establishment of the dollar-offset ratio analysis, the DEA

optimization model used here laid the foundation to support the decision making of risk management in banking institutions.

6. Conclusion

Overall, there is a wide variety of efficiency studies discussed within the context of banking efficiency measurement using the DEA approach. However, the role of derivative instruments as a tool of risk management in the banking sector remains unexplored. Within the scope of efficiency and hedge accounting research, this study expands multi-disciplinary boundaries proposing financial derivatives as a means of risk management. The dollar-offset ratio analysis test method has been chosen as this test shares similar fundamental to the DEA approach involving derivative instruments and the hedged item where asset-liability management is considered as the items. This study contributes to the knowledge, understanding, and development of efficiency and hedge accounting research pointing out some important implications for risk management strategy in both Australian and Malaysian commercial banks.

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Assessment of Sustainability Performance Indicators in Manufacturing

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Abstract

In recent years, sustainable manufacturing becomes center of attraction for production community. Sustainability has a strong relationship with both environmental problems and their threats. Earthquakes, global warming, pollution of natural resources, consumption of energy sources and negative impacts of industrialization reveal importance of public awareness to determine future of the earth. Sustainability develops a roadmap for businesses to reduce energy and natural resource consumption, waste generation and carbon footprint. On the other hand, sustainability encourages all kinds of business to design environmentally friendly product and efficient using of resources. Therefore environmentally supportive design, recycling, remanufacturing, redesign and effective waste management system are important concepts to examine sustainable manufacturing in terms of product life cycle approach. In this context, innovation has risen as a key strategy for sustainable manufacturing. The term of eco-innovation focuses on economic growth and environmental protection for techno-social innovations. The field of eco-innovation and methods for analyzing eco-innovation can provide a decision making mechanism for sustainable manufacturing. Achieving sustainability of manufacturing at the product level depends on evaluation of life cycle steps with social, economic and environmental factors which are components of sustainability. In this study, a framework is developed for sustainable manufacturing on the basis of performance measurement through both life cycle assessment and eco-innovation. The aim of the study is the guidance to determine the decision making strategy for sustainable manufacturing by considering economic, social environmental and technological perspectives.

Keywords

Sustainable Manufacturing, Life Cycle Assessment, Eco-innovation, Sustainability performance indicators

1. Introduction

Industrialization has brought technological development and solution of many problems about communication, transportation, diseases and so on for human beings. Besides all of the desired benefits it has caused fast consumption of resources, generation of hazardous waste, environmental pollution, ozone depletion and global warming. All of the negative effects and unbalance between growing human population and decreasing natural resources are driven force for rise of the sustainability concept. What is more, in the recent decade, there has been

increased pressure on manufacturing companies to think beyond the economic benefits and in our business world they have to consider the sustainability concept in terms of environmental and social effects (Joung et. al., 2012).Sustainability is a key issue for many corporations, in products and in practices ranging from “green” manufacturing to recycling. Brundtland (1987) defines sustainability as “meeting the needs of the present generation without compromising the ability of future generations to meet their own needs”. Many perspectives indicate that sustainability exists at the intersection of strategy, change and culture (Reilly et. al., 2010). In the sense that the term of sustainability spreads over a process or system to create goods or services, sustainable development concept arises. In general sustainable development is defined as a “process through which there is satisfaction of human needs while simultaneously preserving the quality of the natural environment” (Baker, 2008). On the other hand, increasing environmental problems and social awareness draw all attention to industrialization and manufacturing technologies. Modern manufacturing consumes huge amount of natural resources and energy, generates wastes some of which are toxic for water, soil and air. Traditionally, research on manufacturing processes was mainly conducted to improve efficiency and accuracy and to lower cost (Linke et. al., (2013) in press). However, the pressures about support of sustainable production cause partaking of sustainable development into strategic targets of companies. In this context, manufacturing companies need to search new technologies and develop strategic innovation culture that provides design of energy efficient and low waste machinery and processes. Thus sustainable development of industrial enterprises is evaluated on the basis of environmental, economic and social aspects. Sustainable development purposes not only minimization of negative environmental effects but also keeping of efficiency operation of all economic units, coordinative development of industrial enterprises and society (Qinge, et. al., 2009).

Many studies demonstrate that design methods of products, using manufacturing technology and management strategies give significant data to understand perspective of companies on the basis of sustainability concept. On the other view, design selection, use and disposal of products by consumers affect environmental impacts of manufacturing (Gunasekaran, 2012). Sustainable manufacturing intends to achieve waste management, design or production of eco-friendly products, right management of resource and energy consumption and opportunities for satisfying rapidly changing market needs. Hence design of sustainable products include: the application of technological and scientific principles to the design and manufacture of products, with the goal of protecting the environment and conserving resources, while encouraging economic progress, keeping in mind the required criteria to achieve sustainability, and at the same time optimizing the product life cycle and minimizing pollution and waste. Traditionally, reducing resources, reusing materials, and recycling wastes and residuals can be considered as a criterion for sustainability. In the study of Jawahir, et.al, (2006) six main contributing factors are mentioned for sustainability of the products and they emphasized as 6R concept (Reduce, Reuse and Recycle Recover, Redesign, Remanufacture).

Sustainability supports a perspective to understand the interaction between industrial development, innovation, economy and ecological precession. Therefore sustainability has been determined on the basis of three perspectives: economical, societal and environmental. Correlation between these perspectives and sustainability is named as triple bottom line theory. In addition to these three perspectives, ’technology’’ becomes a critical component of sustainability due to emergence of strategic innovation concept. Companies have to find ways to capture and measure their sustainability performance (Linke et. al., (2013) in press). The qualifications of new technologies in manufacturing sectors include the development of efficient techniques for cost reduction, quality, safe and environmentally friendly manufacturing. Innovation involves the implementation of a new technology and development of technology allow to produce green products, minimize waste and perform efficient cost management and reduce risks throughout products’ life cycles. Increasing awareness of ecological balance and adverse effects of human being activities the term of eco-innovation plays a strategic role to take shape of innovation culture of companies.

Eco innovation and conventional innovation are separated from each other with respect to two features. First feature of eco innovation is that reduction of environmental impact emphasizes. Second, eco innovation includes not only innovation in products, process, marketing or organizational methods but also takes notice of institutional and social structure (Rennings 2000). Eco innovation is associated with development of new technology at the process or product levels of manufacturing. In the presence of knowledge it is clear that technological change for provide pollution control, cleaner production, and natural source reduction is requirement to achieve redesign, evolution of manufacturing operations.

Eco innovation admits manufacturing companies to develop alternative solution, redesign products, and earn technical advantage and competitiveness. According to Jovane et al.'s (2008) and Linka et al's studies (2013; in press) product lifecycle has been a tool for strategic decision making in studies of technical innovation. From this point of view, the concept of eco-innovation is a key performance measurement and decision making strategy for sustainable manufacturing by considering product life cycle. In the study of Westkamper et.al (2000) the term of sustainable product design was explained that it provides reduction of environmental impacts throughout the life cycle of products by maintaining the company's position on the market and its place in society. Life cycle of product is a major element for life cycle assessment (LCA). Following LCA means quantifying all physical exchanges with the environment, whether these are inputs (resources, materials, land use and energy), or outputs (emissions to air, water and soil) attributed to different products over their entire life cycle. (Manfredi and Goralczyk, (2013) in press). A product life cycle consists of five phases which are Pre-manufacturing, Product Manufacturing, Product Delivery, Product Use and Refurbishment, and Recycling and Disposal (Labuschagne, et.al, 2005). To obtain innovative approach product life cycle stages should be evaluated on the basis of sustainability criterion for product life, design and manufacturing. Researches intend to develop a framework considering clean technologies, waste minimization, pollution prevention and product management based on the sustainability concept.

2. Research Objective and Methodology

In the direction of literature, studies on sustainable manufacturing propose many indicators or strategic tools by using different perspective to achieve sustainable manufacturing or to asses manufacturing techniques of companies at the product and process level on the basis of sustainability. In this study we observe effect of major drivers for sustainable manufacturing on four perspectives (economical, environmental, social and technological). The other approach of this study is evaluation of sustainable manufacturing performance measurement criteria and explanation of their effects depending upon life cycle phases to suggest a roadmap.

This study involves three main objectives: (i) observation of sustainable manufacturing from all perspectives (ii) identification of sustainable manufacturing drivers and their effects, (iii) evaluation of sustainable manufacturing indicators for life cycle phases. Finally we suggest a framework emphasizing evaluated indicators and drivers to achieve sustainable manufacturing or give an opinion for decision makers or strategists of companies to establish management strategy. The mechanism of this research methodology is that overview of non-conflicting papers written on sustainable manufacturing to explicate and identify selected drivers for sustainable development in manufacturing. Firstly, the main drivers of sustainability in manufacturing from literature are classified considering their effects on technological changes, social awareness, economic growth and environmental regulations. Then life cycle phases are examined on the basis of components of sustainability in manufacturing according to the concept of recycling, reusing, remanufacturing, reducing, redesign and recover. Finally, a framework is developed including performance measurement criteria for sustainable manufacturing to assess valid strategies to achieve sustainable manufacturing.

3. Sustainability in Manufacturing

3.1. Environmental, Economic, Social and Technological Perspectives for Sustainable Business Development

Many believe that "sustainable development" is a solution to balance human activities and nature. Thus, sustainable development affects future government policy, production operations methods of companies, emerge new business models and strategies adopted by both public and private sector (Singh, et.al. 2009). In the study of Dehghanian and Mansour (2009), they discussed objectives of sustainable development and they evaluated three main objectives: (i) maintain a high and stable level of economic growth and employment; (ii) effective protection of the environment; and (iii) provide social progress which recognizes the needs of everyone. Sustainable development in manufacturing sector asses aims for companies to reduce wastes, achieve zero emissions establish management systems considering ecology. In this context, production operation technologies plays a more important role to satisfy social needs, protect environment, adopt economic growth and follow new technological development.

Sustainable development strategies provides effective management of energy consumption, assessment of social needs, prevention of environments from hazardous activities related to industrialization and add eco-innovation to companies strategies. Considered all of these, four main perspectives (environmental, economic, social and technological) should be analyzed with respect to sustainability concept. The manufacturing industry is seeking an open, inclusive, and neutral set of indicators to measure sustainability of manufactured products and manufacturing

processes (Joung et. al., 2012). According to Joung et al. study's (2012), "companies find a large number of stand-alone indicator sets for sustainability in manufacturing and this has caused complications in terms of understanding interrelated terminology and selecting specific indicators for different aspects of sustainability."

3.2. Drivers of Sustainability in Manufacturing

Sustainable production and consumption becomes a new trend to determine future of world. Therefore all attention drags industrialization due to environmental pollution, increasing consumption needs and unhealthy products. All of the factors considered, some drag forces and their interactions with one another begin to shape sustainable manufacturing strategy of companies. Figure 1, explains impact of social, environmental, economic and technological factors on sustainable manufacturing. The relationship between these four factors reveals necessary drag forces for sustainability on manufacturing so these drag forces help to assess sustainability performance indicators in every step of product life cycle.

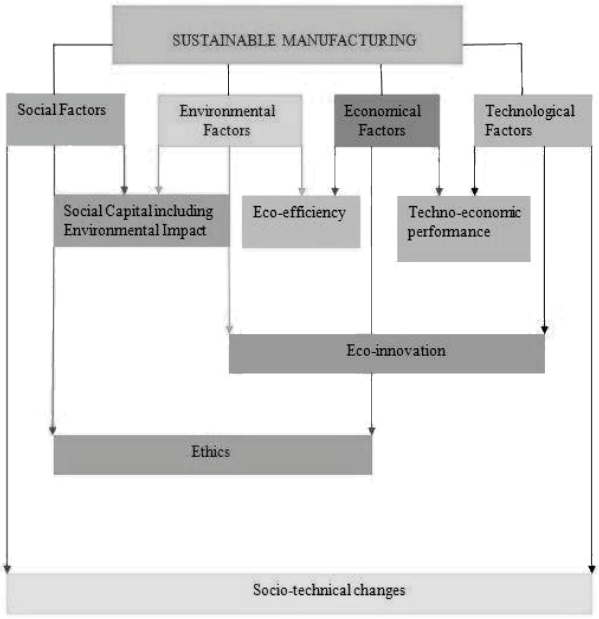


Figure 1: Drag force between components of sustainable manufacturing

Tekelioğlu and Vayvay (2010) emphasize that modern manufacturing consumes large amounts of resources, generates waste, and pollutes the natural environment. Some of the raw materials and energy resources consumed are nonrenewable and often, toxic pollution is vented off into the atmosphere and waste is disposed of indiscriminately. Thus sustainable manufacturing concept emerge to provide waste reduction, recycling of material, remanufacturing and redesign of products or process to manage energy, resource, environmental impact effectively. Social awareness, economic activities, pollution, decrease of natural resources and technological necessities are main drivers of sustainability in manufacturing.

Progression of economic activity depends on efficient natural resource consumption. Decreasing of natural resources against increasing population growth and economic activities result in environmental pollution and waste generation. These demonstrate that all activities relates to each other and any changes in ecological, economical, technological or social dimension effect systems or balance of the world. Social awareness is the most necessary factor to spread sustainability concept in manufacturing sector. In the past studies "social capital" was used for addressing the social component of sustainable development. Generally, social capital includes the networks of social relations described by rules, norms, sanction of trust and reciprocity and exchanges that provides improvement of society efficiency and encourage productive actions (Pretty and Ward, 2001; Lehtonen, 2004). Increasing of social awareness about sustainable development reflects on business as improvement of labor standards and working conditions, creating green products or tending environmentally friendly technologies. Therefore social capital including development of environmental awareness is a bidirectional effect on both environmental and social component of sustainability in manufacturing.

Awareness of consumers constitutes a mechanism to rearrange government policy related to manufacturing industry according to environmental impacts. This condition creates a pressure on companies to reduce negative effect of products and production operations on the ecosystem. Manufacturing companies has begun to add philosophy of sustainability to their growth strategy to achieve sustainable manufacturing. The concept of eco-efficiency can be used to demonstrate the interaction between environmental and economic aspects. Eco-efficiency including both economic and ecological factors provides to achieve environmental friendly production. Thus manufacturing companies aspire to improve their economic and environmental performance through innovative management practices (Zhu, et.al. 2012).Dyllick and Hockerts (2002) mention six criteria to achieve sustainability are derived: eco-efficiency, socio-efficiency, eco-effectiveness, socio effectiveness, sufficiency and ecological equity. "Eco-efficiency means producing goods and delivering services by using lower energy and raw material which together result in lower amount of wastes, pollution and cost." (Heijungset.al, 2010). In fact the main objective of eco-efficiency comprises the combination of ecological and economical goals that are; (i) from the economical perspective, minimization of production cost, raw material cost, labor cost, packaging, transportation, energy cost and, (ii) from the environmental perspectives reduction of environmental impact, pollution and increasing of renewable energy consumption, encourage of recycling, remanufacturing and redesign. The performance of eco-efficiency depends on environmental impacts and economical return. In the study of Hahn et. al. (2010) the combination of environmental and economic conditions were explained for eco-efficiency which are more economic return for a given amount of environmental impacts, less environmental impact for a given amount of economic return, both more economic return and less environmental impact caused.

Technological and industrial revolution drags companies to development of new technologies in competitive market conditions therefore innovation strategies take shape. Technological innovation suggests methods to overcome consumption of extra energy, time and natural resources. Strategic management of technology increase competitiveness of organization and sustainable development is expressed that it has same mechanisms with management performance and competitiveness in terms of productivity, growth, returns and market capitalization (Momoya, 2005). In the study of Cabesaz (2003) efficiency is emphasized a driver for technology development and make technology less expensive to manufacture products, plays a role in sustainability by reducing the amount of resources going into a product. In long term cleaner production technologies obtain advantages to companies due to both environmental and economic reasons (Oltra, 2008).Renewable energy utility at the product manufacturing phase of life cycle and improvement of recycling, disposal and remanufacturing, reuse and redesign technology maximize profit of companies in the long term and provides opportunity to companies against market competitiveness. On the other hand, there can be a limitation to use any of renewable energy in manufacturing and some material cannot be recovered or recycled so economic evaluation should be carried out gingerly with respect to alternative solution. To overcome this limitation all of the operations in manufacturing at the product development level of life cycle must be planned within the bounds of technological and economical possibilities.

Sustainable technology innovation and eco-innovation contain both technological perspective and environmental perspective to create environmentally friendly products by efficient resource consumption. Eco innovation has been driving force to establish sustainable manufacturing systems by using creation of new design, redesign, and procurement of alternative solutions at the product or process level. Many studies in literature demonstrate that some determinants factors are effective on eco innovations to create cleaner technology, establish productive manufacturing systems, and enable cost savings. "Eco-innovation plays a key role for driving manufacturing industries towards sustainable production." (OECD, 2009). Eco-innovation encourages consumers to buy sustainable products, changes market conditions and create market opportunity for companies, adds environmental perspectives to business competitiveness. According to Horbach (2008) studies, four main determinants are defined in the literature for eco innovation which is firm strategies, technology, market and regulations. The major targets of eco-innovation are explained in the literature as energy and material efficiency, improving recycling, reducing water, air soil emissions. (Kammerer, 2009; OECD, 2009). Governments play an important role to be bridge for socio-technical changes. Geels (2010) expressed that governments can address market failures causing environmental problems with policy instruments such as environmental taxes. Therefore environmental cost leads to price changes of products that effect R&D investments and capital investments.

Insights of social transformation in 21st century contain stronger government roles, risk society, ecological modernization, corporate social responsibility, public participation. Technological innovation is the key element to solve environmental problems because of changes in market condition and increasing environmental problems creates socio technical changes so the concept of sustainability begins to evaluate according to both technological

and societal transition. Socio-technical transition fields focuses on function of technological innovation including knowledge development, market formation and entrepreneurial activities (Hekkert, et.al, 2007). In general this mechanism can be explained that "create a new technology on the base of sustainability concept enclosing social networks, government policies, social responsibility and following new technological trends". Besides all of these components and factors, the concept of ethics is another parameter to achieve sustainability. Ethics of companies demonstrates the company's point of view about working conditions, human rights and safety of labor. The concept of ethics covers not only the safe and health of workers but also consider communities and consumers' health (OECD, 2009).

Dyllick and Hockerts (2002) define the interaction between societal and economic factors as a socio-efficiency. In the same study socio efficiency is described the relation between companies' value added and companies' social impacts. The significant role of socio efficiency on the base of sustainability minimizes the negative social impacts. The means of negative effect covers work accidents, violation of health and safety rules, not keeping records for work accidents, injury or death of employees during all activities in production operation. On the other hand social effectiveness of workers is another dimension of socio–efficiency. Social effectiveness of workers includes enhancement of worker efficiency and creativity, their education and supply of security encouragement of their talents and capacities (Jovane et.al, 2008).

3.3. Evaluation of Sustainable Manufacturing Indicators in Product Life Cycle Stages

Development of assessment systems require in order to remove the sustainability concept from narrow point of view for manufacturing sector so sustainability indicators can be evaluated according to operations in steps of product life cycle. Hence, these indicators must integrate social, economic, environmental and technological perspectives on sustainability. Engineering activities for design of sustainable product include: the application of technological and scientific principles to the design and manufacture of products, with the goal of protecting the environment and conserving resources, while encouraging economic progress, keeping in mind the need for sustainability, and at the same time optimizing the product life cycle and minimizing pollution and waste.
According to past studies "Product Life Cycle" theory indicates that it has been a tool for strategic decision making in development of technological innovation. The product life cycle phases which are represented in figure 2 states the period from the product development to end of product life after marketing sales (Hu, 2009).

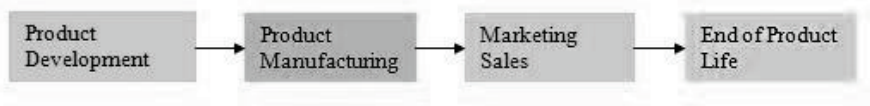


Figure 2: Product lifecycle evolution (Hu, 2009)

The product life cycle is guide for companies to realize the time at which a product introduces a market or withdraws a product from market. This enables comparison the position of companies and market conditions. In addition to this, it gives an opinion success or failure of products in the market (Komnios, 2002). The environmental performance is the one of the main indicator to achieve sustainable manufacturing so it must be evaluated during all product life cycle phases. For that reason, life cycle assessment (LCA) is used as a tool to understand environmental performance and determine sustainability factors. LCA is described as a quantitative analysis and carried out data coming from product life cycle phases. Sustainability elements such as socio-ecological, socio technical or both technological and ecological examining the previous part of this study helps to render LCA from quantitative analysis to qualitative assessment (Andersson, et.al., 1998; Kroser and Vis, 1998).

The indicators of environmental performance contains "competitiveness, new market opportunity, market share, branding, shareholder satisfaction, management satisfaction, worker satisfaction, recruitment and staff retention, short-term profits, long term profits, cost savings, productivity, insurance conditions" (Gunasekaran et.al, 2012). The mechanisms of LCA to determine environmental performance performs by combining main environmental indicators with the "Sustainable Environmental Performance Indicator" so it is possible that many different decision making strategies are improved (Benedetto and Klemes, 2009).In this part, all perspectives and their interaction mechanisms are reflected as a performance indicators to product life cycle phases. The performance indicators are determined from case studies in literature and requirements coming from environmental regulations, health and safety factors, human rights, innovation culture trends, and technological, economic, social transitions in recent years including the concept of sustainability in manufacturing. Table 1which is shown below represents the

sustainability factors separated according to product life cycle phases on the basis of four perspectives. LCA allows the decision makers and companies' managers to measure environmental performance of their products or production operations and identify market opportunity. It reveals whether manufacturing strategies of companies achieve sustainable manufacturing by the help of performance indicators such as reduction of environmental impacts by applying recycling, reusing, re-design remanufacturing technologies; energy efficiency such as utility of renewable energy; and being respect to human rights such as safety and health of employees.

In the past studies many different methods are used to evaluate environmental performance of manufacturing. LCA is the one of the methods to examine the concept of sustainability for every phase of product life cycle using environmental performance indicators. Vinodh and Rathod (2010) suggest using tools of sustainable product development as combining of conscious quality function deployment (ECQFD) and Life Cycle Assessment (LCA) including feedback mechanisms of electronics switches manufacturing organization for material usage, energy consumption, environmental impact and market price so on. In this study environmental performance indicators collating socio-economic conditions socio- technical changes, techno economic performance eco-innovation, eco-efficiency and environmental culture accumulation of society are exposed to complete missing part of LCA. All of the components of sustainability in manufacturing are identified in the light of literature with respect to balance of driving forces of sustainability. Product development and production operations phases play the important role to accomplish sustainability in manufacturing form all perspectives. Many of past studies represent that sustainability of products depends on how to design because design technologies enable recycle, remanufacture reuse and redesign of products. For that reason production cost are determined according to design technologies of product. The fact about product development reflects to markets in terms of competitiveness.

4. Conclusion

In this study sustainability in manufacturing are examined on the basis of social, economic, ecological and technological perspectives. The limitations and empowerment factors about economic, social and technological are discussed to determine performance indicators for sustainable manufacturing. The environmental performance indicators are combined with socio-economical, socio technical and techno-economic transition factors and their effects on sustainability to balance all of the perspectives driving force for sustainable manufacturing.

This study suggests a framework to determine performance indicators of sustainable manufacturing for decision makers, consumers and design engineers considering LCA. The interaction of life cycle assessment procedure and sustainability concept for manufacturing provides a basis for construction of model.

In general, all of the factors driving force to produce environmentally-friendly products are assessed depending on limitations of factors, design criteria, utility of renewable energy, ethics, maximization of profit, reduction of negative environmental impact, environmental regulations, socio economic and techno economic transitions. Especially, technological innovation culture of companies affects achievement of sustainability in production development and design phase. Therefore marketing and production policy of companies should be organized according to R&D studies, examines of production operation on the basis of sustainability and techno economical limitations, driving forces of sustainability, consideration of market failures to obtain an advantage in the competitive market conditions.

5. Further Studies

In this study, an approach for sustainability indicators and their effects on sustainable manufacturing are represented without development of a mathematical model for decision makers. Therefore case studies should be carried out determining effects of performance indicator on sustainable manufacturing. The mathematical model should construct by using data of case studies to evaluate environmental, economic, social and technological performance of production operations or products for companies. Obtaining data from these case studies helps manufacturing companies to understand or notice their failures, their place in market, provide adaptation of technological evaluation to compete in market and enable obtaining market opportunities.

Table 1: Sustainability indicators in product life cycle phases

Product Life Cycle Phases	*Environmental Perspective*	*Social Perspective*	*Economic Perspective*	*Technological Perspective*
Product Development	*Raw Material /Resource consumption *Material processing *Environmental Impact Assessment *Environmental Regulation *Eco-label System *Environmental Legislation	*Occupational Health & Safety *Ergonomics *Human rights *Risk assessment *Sustainable awareness	*Raw material cost *Labor cost	*Environmental friendly design *Eco-design *Eco-redesign/Eco-innovations
Product Manufacturing	*Environmental accidents *Renewable energy consumption *Hazardous emission *Hazardous material/chemical volume *Carbon footprint *Energy Consumption *Soil/Water /Air Contamination *Heat Dissipation *Eco-label system *Environmental Legislation	*Occupational Health & Safety *Ergonomics *Work Ethics *Sustainable awareness	*Production cost *Packaging cost *Transportation cost *Technology transfer/social capital formation *Energy cost	*Sustainable process innovation *Eco-innovation *Quality control *Functionality *Flexibility *Contribution to other versions of the product
Marketing Sales	*Recycling *Carbon footprint *Landfill Contribution *Remanufacturing *Eco-label system	*Human Safety *Complaints *Pricing *Warnings *Accessibility *Integration to the society	*Consumer Injury Cost *Consumer Warranty Cost	*Durability *Upgrade Capability *Produce repairable products
End of Product Life	*Recycling *Remanufacturing *Landfill Contribution *Carbon footprint *Eco-label system *Environmental Legislation	*Recycling *Recovery *Remanufacturing *Reverse Logistics	*Recycling Cost *Disposal Cost *Remanufacturing Cost *Expired product assembling cost	*Recycling Technology *Disposal Technology *Remanufacturing Technique *Recovery Technique *Biodegradability

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