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Prioritizing of Risk Components in the perishable goods supply chain and Supplier selection in supply chain risk management

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Abstract

Presently, the topics of supply chain risk management and supplier selection have become one of the most important issues in the world and many studies have been done on such topic. The members of a supply chain are trying to respond to the market demand by choosing the best supplier. On the other hand, there is undeniable risk in the supply chain, and members of a chain tend to identify and prioritize these risks in order to be able to react quickly to prevent potential risks. The issue of identifying risk and choosing the best supplier in a perishable goods supply chain is important due to the short life of these and choosing an incorrect strategy for selecting supplier may impose irreparable damage to organizations.

As a result, the main objective of this research is to prioritize the risk factors of the supply chain of perishable goods supply chain and selecting the appropriate supplier by using the Shannon entropy and COPRAS. In this study, firstly by applying literatures and expert's viewpoint on supply chain management, the criteria were identified. Then, to reduce the number of variables, the factor analysis method was used. In addition, the entropy method has been used to calculate the weight of the variables. Finally, multiple suppliers were ranked by Cooper's method. Based on the results of this study, there are 9 risk factors of high priority, most important of which is demand risk.

Keywords: *perishable goods supply chain, SCRM, Shannon Entropy, COPRAS.*

1. Introduction

Supply chain management is usually defined as managing a nexus of organizations responsible for all levels of production of goods and their respective services intended for end customers (Christopher and Peck, 2004). This includes the entire cycle of supply change from transportation and storage of raw materials to all the operational processes in between, up to the point of consumption (Le et al., 2019). In other words, supply chain management involves an all-inclusive strategy aimed at different actors in the supply chain scenario: demand, operational procedures, obtaining the raw material, and finally getting through the intricate supplier processes through top-notch management (Forozandeh et al., 2018).

The existence of a proper planning in the perishable goods is necessary. Perishable goods, such as dairy products, have a very limited life span. On the other hand, due to unstable and variable storage conditions, they are exposed to degradation of quality or even complete corruption. The risk of perishable goods is very significant in the supply chain (Surya et al., 2017). For this reason, providing a comprehensive model for evaluating and prioritizing the most important risk factors in the perishable goods supply chain is very important (Abdollahi et al., 2015).

Due to increased uncertainty in the supply chain and the presence of factors such as political issues, demand fluctuations, technological changes, financial risk, natural disasters and etc., organizations have to spend more time for identify and reduce the risk and their effects on the supply chain management (zand hessami et al., 2012)

With these uncertainties and risk factors, the issue of risk management in the supply chain has become very important (Wagner et al., 2008). Existence of the risk and failure in the supply

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chain can have a significant effect on short-run performance as well as a negative long-run effect on financial performance of the organization (Sutthibutr & Chiadamrong, 2019).
Risk management involves identifying, evaluating and rating various risks. Risk assessment is one of the pillars of risk management and its purpose is to measure the risks based on different indicators such as the degree of impact and the probability of occurrence(Saeedi et al., 2018)
Risk management is a routine case in logistics and resource management. Risk reduction allows the company to outperform its competitors and reduce estimated lengthy damages to its businesses. Main factors of the supply chain profit are efficiency, accountability, and reliability (Sutthibutr & Chiadamrong, 2019).
The incidence of risk episodes at various phases of the supply chain negatively affects the function of supply chain. It was turned that managing the risk events about SCRM is a major element of the business strategy. SCRM, by moving towards the universal supply chain and increasing domestic and foreign risk events that disrupt chain operations has attracted more attention (Petrudi et al., 2018)

To choose an appropriate supplier, several criteria should be considered and evaluated according to the characteristics of different sources. Hence, this issue may be viewed as a multiple criterion decision-making (MCDM). When the supply chain encounters risk events, to choose an appropriate supplier will be more essential for businesses. Numerous variables, including immeasurable, insufficient, and inaccessible data, as well as partial errors, reduce the accuracy of decision-making (Punniyamoorthy et al., 2013). As the common MADM techniques with such vague information cannot solve the problems effectively, consequently multiple decision-making methods according to the inaccuracy in the evaluation and importance in order will be developed with rankings characteristics and performance (Faez et al., 2009).
Ranking the Risk is a key part of this process. Because by rating, the superiority of each risk is identified against other risks, and as a result, the decision maker can plan on the amount of resources allocated to deal with each risk (Mohamadi and Shojaei, 2016). Given the diversity and the high number of risks that affect the supply chain, effective and efficient risk management is not possible without identifying and providing a risk-failure structure. Also, some of these factors are much less important for the supply chain, so that the existence of these factors is not a problem for the supply chain, and can even be neglected, and devote time and energy to addressing the underlying risks. As the common MADM techniques with such vague information cannot solve the problems effectively (Aqlan and Lam, 2015). Consequently multiple decision-making methods and Compilation models will be developed according to the inaccuracy in the evaluation and importance (Ginevicius, 2008).
One of the best methods for identifying important criteria is the entropy method. For this purpose, in this research, by first studying the literature, the criteria for determining the risk of supply chain in perishable goods are identified and then we use the Shannon entropy method to weigh and prioritize these criteria. In the next phase of the problem, using the copras method, suppliers will be selected and ranked based on the supply chain risk management for perishable goods.

2. Literature Review

2.1. Perishable goods Supply chain management

Perishable goods are products in which certain conditions for their transportation must be taken into account and the absence of special conditions would spoil such goods. Therefore, for the carriage of such cargoes, it is essential that the necessary coordination be carried out in advance so that, depending on the type the packing weight, the temperature of the goods and

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the appropriate means of transportation shall be considered according to the requirements of the goods (Surya et al., 2017)

There are two types of Perishable goods based on decomposition and corruption. The first item includes items whose value has not changed for a certain date, and then suddenly reaches zero. This is true of products that their customer desirability, such as calendars, anniversaries, maps, and electronic tools that quickly become obsolete after a certain date (Le et al., 2019). However, these talents may be in perfect condition, however, are no longer useful. In a similar category, expired products such as medicine, yogurt and bottle milk are found. These goods can be consumed freshly and in a few days later, but after expiration date they are not suitable for consumption. The second is the products whose quality and perceived value gradually decrease with time. Examples of these include fruits, vegetables and flowers. In this research, Perishable goods were investigated (Surya et al., 2017).

2.2. Supply chain risk management (SCRM)

Nowadays, global speedy transformations have forced organizations to investigate risk management in supply chain in order to overcome their insecure conditions. Suppliers should produce materials and parts with of high quality and low costs. Identifying and ranking of the effective risks in supply chain is necessary in order to achieve this goal.(zand hessami and savoji, 2012).

SCRM is identified as a vital issue in the supply chain. SCRM is characterized as the identification and management risks in the supply chain via the right attitude among supply chain members for declining the overall vulnerability of the supply chain (Lemghari et al., 2019).

According to Bogataj, SCRM means to develop and implement strategies for managing daily risks in the supply chain to reduce vulnerability and ensure business continuity [6]. SCRM plays a crucial role in the excellent management of business processes. Most researchers believe that SCRM consists of five successive stages: risk identification, evaluation, analysis, elimination, and monitoring (Bai, and Sarkis., 2010).

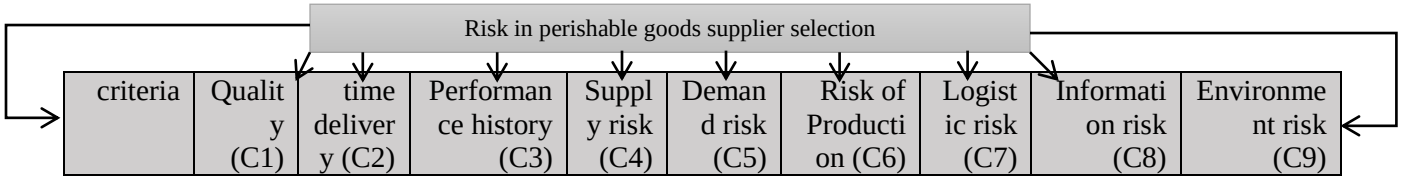
Supply chain risk consists of any chance regarding information, material, and products flow from the supplier's resource to delivering the final product to the ultimate consumer (Banaeian et al., 2016). Reducing uncertainty in the supply chain leads to its efficiency. Aglan argues that there are 2 kinds of risks in the supply chain; operating and disruptive risks. Operating risks address intrinsic un-certainties, including product demand, supply, and cost (Aqlan, and Lam, 2015). Disruptive risks relate to the natural catastrophes, including earthquake, storm, and so forth.

According to Bai, supply change falls into two distinct categories namely, inherent risks (risks related to the supply, demand, and business credit) and their external counterparts (caused by the interaction between supply change and environment) (Bai and Sarkis, 2010). Another major factor involved in supply change is a resource, which is put into five categories by Wagner. These include demand side, supply side, regulatory, legal, administrative, infrastructure, and events. Li et al. offers a different classification for risk management in a 2-phase outlook in which the first stage distinguishes between 6 risk groups and 25 risks related to the green supply chain and the second phase analyzes the risks identified in the first stage using a quantitative/qualitative analysis known as the hierarchical process (Li et al., 2015)

The criteria for supplier selection in the perishable goods supplier selection in SCRM are given in table (Saeedi et al., 2018; Surya et al., 2017; Aqlan, and Lam, 2015; Banaeian et al., 2016; Le et al., 2019; Mohamadi and Shojaei, 2016 and etc.):

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Figure1. Criteria and their References for perishable goods supplier selection in SCRM



2.3. Supplier selection

One of the essential activities for many organizations and producers is choosing a supplier and service provider via a competitive bidding process. In modern competitive market, the firms perceive the significance of choosing the right suppliers that may meet their needs on time and at with desired quality (Saeedi et al., 2018). Therefore, to select the best available candidates in their supply chains, the businesses have been trying to evaluate the surplus performance of their suppliers. Subsequently, supplier selection will be one of the major factors in procurement processes. The choice of an appropriate supplier is viewed as an uncertain job (Aqlan, and Lam, 2015). For achieving this aim, most decision-makers have empirically assessed and selected the suppliers. The choice of suppliers is a decision-making attitude toward eliminating initial prospective supplier groups to make the final choice the supplier is described as a significant issue for organizations to maintain a competitive situation because of immediate effects on the cash flow and profitability (Le et al., 2019). The supplier's selection is a decision-making procedure to assess the supplier to make a contract. The choice of supplier is significant, because the cost of new materials and parts forms the price of the product, and companies need to spend a substantial amount on revenues and purchases (Saeedi et al., 2018).

Supplier selection is, without a doubt at the zenith of issues associated with decision-making. The aim is to identify, study, and finally choose the supplier with the finest raw material and the most reasonable price. For fulfilling the customers' demands and declining costs and risks, the firms select the right supplier to create products with higher competitiveness, and disperse them better among consumers and cover all kinds of their needs (Le et al., 2019). To maintain a strategic and competitive chain, some issues should be dealt with in the supplier selection. For example:

- Which suppliers should be selected for partnership?
- Which supplier should be part of supplier development?
- Which supplier should be eliminated from distribution?
- How suppliers enhance their performance?
- How the companies assign their resources to supplier development plans?

3. Research methodology

The present study is conducted using descriptive and analytical methods with a focus on the target type. Use of interviews and relevant documentation were the methods of choice for data collecting and evaluation in the analysis section was conducted via and Shannon entropy and copras combination technique rendering the research at three levels of objective, criteria, and criteria. Twelve people that

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function as the statistical population of the study were picked randomly from a long list of suppliers and professionals from the field of decision-making management. The adopted tool for data collection is a questionnaire used to establish the validity of the criteria and to assess the performance of the statistical population on the selected criteria. Here respondents were asked to determine the priority they attach to values of each different criterion using numerical and linguistic variables (Table 1) (Zavadskas et al., 2008b).

The initial phase of the research process in the present study was meticulous literature reviewing in the course of which essential material for the study was identified. Next using the relevant methods of choice, the main indicators of the supplier's choice were identified and ultimately finalized by conducting polls. Shannon entropy technique was applied to determine the indicators significance and the criteria weights. As shown below the copras approach was employed in EXCEL to determine the significance of supply selectors.

Table 1. Linguistic variables for significant values of all criteria

numbers	Linguistic variables
(1)	Very low (VL)
(2)	Low (L)
(3)	Medium (M)
(4)	high (H)
(5)	very high (VH)

3-3-Shannon entropy

As mentioned earlier, one of the popular methods to obtain weight for an MADM problem, particularly for achieving appropriate weights on the basis of the preferences and DM tests won't be feasible, is Shannon's entropy. The main process of Shannon's entropy may be written in the following steps:

S_1**:** Normalization of the decision matrix.
Set $p_y=\frac{x_y}{\sum_{j-1}^{m} x_y}$, j=1,……., m, i=1,……,n

S_2: Computation of entropy h_i as $h_i = -h_0\sum_{j=1}^{m} p_y$.In p_y i=1,…..,n where h_0 represents the entropy constant and equals to (in m)$^{-1,}$ and p_y.in p_y is described as 0 if p_y =0.

S_3: set $d_i = 1-h_i$, i=1… n as the diversification degree.

S_4: set $w_i= \frac{d_i}{\sum_{i=1}^{n} d_s}$, i=1,…,n refers to the degree of the significance of attribute I (Shannon, 1948).

The raw data normalization was done for eliminating anomalies with various measurement scales and units. The above procedure converts distinct units and scales amongst different criteria into usual gauge able units for allowing for comparing various criteria (Shannon, 1948)

3-4-COPRAS method

Zavadskas and Kaklauskas provided the complex proportional assessment (COPRAS) method (Zavadskas et al., 1994). Several studies described COPRAS techniques and chances of its uses (Zavadskas et al., 2008b). Ranking options by COPRAS technique assume direct and relative dependence of the importance and priorities of the examined alternatives on a system of criteria. Determining the importance and priorities of alternatives via COPRAS may be expressed briefly using four stages (Viteikiene & Zavadskas, 2007):

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***Stage* 1. Construction of the normalized decision-making matrix D**.
In general, criteria in the MCDM procedure possess various units of measures. For transforming function of the examined alternatives into computable dimension-less values, the normalization process was employed. Ginevicius overviewed a number of of the most prominent multicriteria techniques and the respective normalization processes (2007). Moreover, Zavadskas ET. Al. comprehensively overviewed the most significant normalization processes (2008a).

The formula below was applied to normalize in COPRAS method.

$$\tilde{x}_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}, \quad (1)$$

where x_{ij} represents the *i*-th alternative performance concerning the *j*-th criterion $\tilde{x}_{ij}$ refers to its normalized value. *m* represents the numbers of alternative.

***Stage* 2. Calculation of the sum of the weighed normalized criteria, which describe the *i*-th alternative**.
All alternatives in the COPRAS procedure will be defined with its sums of maximizing attributes S_{+i},; that is, optimization direction is maximization, and minimizing criteria S_{-i},; that is, optimization direction is minimization.

For simplifying the S_{+i} and S_{-i} compution in the decision-making matrix columns, the maximizing criteria are initially included, and afterwards, the minimizing criteria will be placed. Under this conditions, S_{+i} and S_{-i} are computed:

$$S_{+i} = \sum_{j=1}^{k} \tilde{x}_{ij} \cdot q_j, \quad (2)$$

$$S_{-i} = \sum_{j=k+1}^{n} \tilde{x}_{ij} \cdot q_j \quad (3)$$

where *k* refers to several maximizing criteria. *n* represents total numbers of criteria. q_j indicates *the* significance of the *j*-the criterion.

***Stage* 3.Calculation of the relative weight of all alternatives**.

Calculation of the relative weight Q_i of *i*-th alternative is presented here:

$$Q_i = S_{+i} + \frac{\min_i S_{-i} \sum_{i=1}^{m} S_{-i}}{S_{-i} \sum_{i=1}^{m} \frac{\min_i S_{-i}}{S_{-i}}} \quad (4)$$

In addition, formula (10) can be expressed in a simple form:

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$$Q_i = S_{+i} + \frac{\sum_{i=1}^{m} S_{-i}}{S_{-i} \sum_{i=1}^{m} \frac{1}{S_{-i}}} \quad (5)$$

***Stage* 4. Determination of the priority order of alternatives**.

The priority orders of the compared alternatives will be specified according to their relative weight. The alternative with greater relative weight will have greater priority (rank). An alternative with the greatest relative weight will be the best alternative.

$$A^* = \left\{ A_i \middle| \max_i Q_i \right\} \quad (6)$$

The proposed process of the COPRAS technique suggests its easy application to evaluate the alternatives and choose the most effective alternative so that decision-makers will fully know the physical concept of the procedure.

Nevertheless, several decisions would be made in the real-world circumstances where there are not precise knowledge of the criterion values. Afterwards, criterion values may be written as intervals (Zavadskas et al., 2008b). Therefore, a novel technique of the multiple criteria complex proportional assessment with the values, which have been estimated in intervals – COPRAS-G would be designed (Zavadskas et al., 2008b).

2. Data analysis and Numerical example

7 supply chain specialists with more than ten years of experience participated in this research. The present study examined 4 of the suppliers who supplied accessories for car manufacturers. According to the experts, 9 criteria have been determined for evaluation of the suppliers, which include quality (C1), delivery time (C2), performance history (C3), supply risk (C4), demand risk (C5), production risk (C6), setting risk (C7), information risk (C8), and environmental risk (C9).

The linguistic variables for ranking and numbers are shown in Table 1. Table 2 presents the decision matrix that represents the average of the experts' views of the options in all criteria.

Table 2.Decision Matrix

	Quality (C1)	time delivery (C2)	Performance history (C3)	Supply risk (C4)	Demand risk (C5)	Risk of Production (C6)	Logistic risk (C7)	Information risk (C8)	Environment risk (C9)
A1	3.1	2.9	3.3	3.1	4.1	2.1	2.2	2.5	3.9
A2	2.67	2.4	2.56	4.12	3.87	2.7	3.4	2.56	4.25
A3	3.21	2.1	3.5	2.43	1.9	1.6	2.3	2.1	3.5
A4	3.5	1.2	3.72	2.28	2.1	1.5	1.7	2.8	3.1
sum	12.48	8.6	13.08	11.93	11.97	7.9	9.6	9.96	14.75

For each computational criterion, the evaluation was conducted by Shannon entropy, and data were converted to new data with a focus on regional method.

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Therefore, Table 3 reports the decision matrix for Shannon entropy. The steps of the following entropy lead to the achievement of the Values of supplier selection criteria in the last row of the table.

Table 3. Normalized decision Matrix and Values of supplier selection criteria

	Quality (C1)	time delivery (C2)	Performance history (C3)	Supply risk (C4)	Demand risk (C5)	Risk of Production (C6)	Logistic risk (C7)	Information risk (C8)	Environment risk (C9)
A1	0.248	0.337	0.252	0.259	0.342	0.265	0.229	0.251	0.264
A2	0.213	0.279	0.195	0.345	0.323	0.341	0.354	0.257	0.288
A3	0.257	0.244	0.267	0.203	0.158	0.202	0.239	0.210	0.237
A4	0.280	0.139	0.284	0.191	0.175	0.189	0.177	0.281	0.210
Ej	0.996	0.967	0.992	0.978	0.958	0.979	0.976	0.995	0.994
DJ	0.003	0.032	0.007	0.021	0.41	0.020	0.023	0.004	0.005
Wj	0.023	**0.**203	0.044	**0.**131	**0.**258	**0.**130	**0.**147	0.026	0.033

Clearly, demand risk is an essential criterion in the choice of supplier. The order priority of the supplier selection criteria is as follows:

$$C_5 > C_2 > C_7 > C_4 > C_6 > C_3 > C_9 > C_8 > C_1$$

In step 2, the copras method has been used to rank suppliers. On the basis of the decision matrix (Table 1) and the benchmark values of suppliers' selection (Table 3), the decision matrix values were normalized, and the supplier rankings will be listed in the order in Tables 4 and 5.

Tables 4: normalized matrix

	Quality (C1)	time delivery (C2)	Performance history (C3)	Supply risk (C4)	Demand risk (C5)	Risk of Production (C6)	Logistic risk (C7)	Information risk (C8)	Environment risk (C9)
A1	0.059	0.0067	0.0111	0.0337	0./0856	0.0345	0.0320	0.0065	0.0087
A2	0.0051	0.0055	0.0086	0.0448	0.0808	0.0444	0.0495	0.0066	0.0095
A3	0.0061	0.0048	0.0117	0.0264	0.0396	0.0263	0.0335	0.0054	0.0078
A4	0.0067	0.0027	0.0125	0.0248	0.0438	0.0246	0.0247	0.0073	0.0069

Tables 5: R +, R-value, R-reverse and final prioritize

Sj+	Sj-	1/Sj-	final prioritize
0.017	0.208	4.80	0.167
0.013	0.241	4.14	0.143
0.017	0.144	6.93	0.35
0.019	0.135	7.39	0.250
	0.729	23.27	

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The findings showed that the final ranking of the suppliers is as follows:

$$A_3 > A_4 > A_1 > A_2$$

3. Conclusion

Supplier selection is an essential and deliberate operation to develop cooperation in the field of the supply chain. Part of this procedure involves evaluating suppliers and ranking them across numerous dimensions. The focus on outsourcing plans has caused the organizations more and more become dependent on suppliers. Therefore, performance evaluation and supplier selection are very important.

Several objectives and multi-criteria decision-making methods should be taken into consideration to evaluate and select suppliers. In the present paper, the supplier of spare parts was evaluated in the field of SCRM.

It was found that the demand and environmental risks respectively would have the highest and lowest value in the supplier selection problem. Further research may address Shannon entropy.

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