Eurasian Academy of Sciences Social Science Journal (International Refereed & Indexed)
Eurasian Academy of Sciences Social Sciences Journal
2016 Volume:8 S: 135 - 148
Published Online March 2016 (http://socialsciences.eurasianacademy.org)
http://doi.org/10.17740/eas.soc.2016.V8-07

COMPARISON OF CLEAN GROWTH OF COUNTRIES IN TERMS OF SUSTAINABLE DEVELOPMENT

Suna Özyüksel*, Ünal H. Özden**, Özlem Deniz Başar ***

* İstanbul Ticaret Üniversitesi, **İstanbul Ticaret Üniversitesi, ***İstanbul Ticaret Üniversitesi
E-mail: sozyuksel@ticaret.edu.tr, uozden@ticaret.edu.tr

Copyright © 2016 Suna Özyüksel, Ünal H. Özden, Özlem Deniz Başar. This is an open access article distributed under the Eurasian Academy of Sciences License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

ABSTRACT

The irreversible type of consumption of the natural resources after Industrial Revolution and the rapid growth after World War 2 have had negative effects on environment; and the counter-relation between development and environment was clearly revealed. Today, one of the most primary problems that prevent the success of sustainable development is the climate change. Excessive climate events directly affect the socio-economic factors; and they have a negative impact on the productivity of labor force, GDP and sustainable development. The aim of this study is to measure and analyze the relative total activities in terms of greenhouse gas emission during the countries' economic activities; which is one of the most important factors for the realization of climate events. This study begins by explaining the concepts used in one of the methods used in measuring the efficiency of countries, data enveloping analysis (DEA); then detailed information is provided about the CCR models used in DEA. Finally, the efficiency of top 50 economies in the world in terms of greenhouse gas emissions are ranked by using input oriented CCR models.

Keywords: climate change; data enveloping analysis; economic system; greenhouse gas emission; sustainable development.

JEL-Clasification:

ÜLKELERİN SÜRDÜRÜLEBİLİR KALKINMA AÇISINDAN TEMİZ BÜYÜMELERİNİN KARŞILAŞTIRILMASI

ÖZET

Sanayi Devrimi ile birlikte doğal kaynakların geri dönüşü mümkün olmayan bir şekilde tüketilmeye başlanması ve 2. Dünya Savaşı sonrasındaki hızlı büyümenin çevre üzerinde yarattığı olumsuz etkiler, kalkınma ile çevre arasındaki o güne kadar görülen ters yönlü ilişkiyi açıkca göstermiştir. Günümüzde sürdürülebilir kalkınmanın başarılmasının karşısındaki en

öncelikli sorun, iklim değişikliğidir. Aşırı iklim olayları, sosyo-ekonomik faktörleri doğrudan etkilemekte, işgücünün verimliliğini, üretimi, GSYH'yı ve sürdürülebilir kalkınmayı olumsuz etkilemektedir. Bu çalışmanın amacı, ülkelerin ekonomik faaliyette bulunurken iklim olaylarının gerçekleşmesinde en önemli faktörlerden olan sera salınımı açısından görece toplam etkinliklerinin ölçülerek analiz edilmesidir. Çalışmada ilk olarak, sistemlerin etkinliklerinin ölçülmesinde kullanılan yöntemlerden biri olan Veri Zarflama Analizi'nde (VZA) kullanılan kavramlar açıklanmış ikinci olarak VZA'da kullanılan CCR modelleri ile ilgili ayrıntılı bilgi verilmiştir. Son olarak da en büyük ekonomiye sahip 50 ülkenin ekonomik faaliyette bulunurken sera gazı salınımı açısından ne kadar etkin oldukları girdi yönelimli CCR modelleri kullanılarak hesaplanıp incelenip sıralanmıştır.

Anahtar Kelimeler: İklim Değişikliği, Veri Zarflama Analizi, Ekonomik Sistem, Sera Gazı Salınımı, Sürdürülebilir Kalkınma

1. Introduction

Since 1970s, as the developing technology and development has accelerated; the question raised was what to do in order to pass the natural resources to the next generations; and the concept of sustainable development started to be argued for the first time. First definition of sustainable development was made in Brundtland Report published by UN World Environment and Development Commission (Brundtland Commission) in 1987 as "to meet the current requirements without compromising from the ability of next generations to meet their own requirements in the future".

One of the primary problems that prevent successful sustainable development is the climate change. As it is known, as a result of greenhouse effect created by man-made gases' release into the atmosphere; there is an increase in world atmosphere and in oceans, which is named as global warming. The greenhouse effect mentioned in here stems from an increase of the accumulation of carbon dioxide, methane and diasod monoxide gases in the atmosphere. Before the Industrial Revolution, the carbon dioxide accumulation in atmosphere was approximately 280 parts per million (ppm); and in 2012, this has reached to 390,5 ppm. It is assumed that this amount will be around 500 ppm in 2050 (Erim, 2005: 2). Excessive situations about the climate prevent the achievement process of sustainable development. Excessive climate situations directly affect the socio-economic factors. For instance flood will pollute the water resources and destroy the agricultural products; and it causes poor nutrition and illnesses. As a result; climate changes have negative effects on the productivity of labor force, on GDP and on sustainable development.

Several international meetings and protocols were arranged in order to emphasize the negative effects of climate change and to struggle with it. As a result of First Evaluation Report of Intergovernmental Panel on Climate Change (IPCC) (Houghton et al., 1990); 1992 United Nations Framework Agreement on Climate Change (UNFACC) was agreed on in Rio De Janeiro and came into force in 1994 in order to set the ground for a global reaction against the problem of climate change. 194 countries have signed the agreement. Although the agreement has no legal binding; it has encouraged the UN member countries to reduce the greenhouse gas emissions, to collaborate on research and technology and to protect the greenhouse gas reserves. Following this agreement, the infrastructure of Kyoto Protocol was prepared through annual "Conferences of the Parties- COP" and the protocol was signed in 1997.

Kyoto Protocol (1997) is a legally binding document of UNFACC in terms of reducing or limiting the

greenhouse gas emissions. With this feature, Kyoto Protocol is the single framework document in order to provide struggle on global warming and climate change (Özyüksel and Oksay, 2014:95). Countries that have signed this Protocol have accepted to reduce the emission of gases that cause greenhouse effect and to increase their rights by emission trade, as indicated in the annex of Protocol. A total of 169 countries and state-bound organizations have signed the agreement since December 2006. Some of the countries which have not signed the agreement are; developed countries such as USA and Australia, and developing countries such as Turkey (Turkey has signed Kyoto Protocol in February 2009 and by the decision of Parliament on condition that it is included to the countries listed in Protocol, Annex-2 and without any reduction in carbon emission). Although the required number of signatures is reached for its validation; the non-signature by USA, that produces the highest amount of greenhouse gas emissions with 23-24 %, has made the applicability of Kyoto Protocol impossible. Countries with high emission rates such as USA and China have joined the Protocol in 2014. USA and China have been hesitant about stopping climate change and they are responsible for 45 % of carbon emissions worldwide. And, they have undertaken for the first time that they will reduce greenhouse gas emissions, providing a due date. USA has undertaken that greenhouse gas emissions will be reduced by 26-28 % in 2025 when compared with 2005 figures; and China has declared that the emissions will be reduced from 2030 onwards. Countries which signed the protocol have accepted that the historical and current global greenhouse gas emission was mainly done by developed countries; that the gas emissions per person in developing countries is still very low and that the global emissions of developing countries will increase according to social and developmental needs.

Annex-A of the Protocol includes the names of greenhouses gases caused by human activities and equivalent to carbon dioxide. These gases are Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydro fluorocarbons (HFCs), Per fluorocarbons (PFCs) and Sulphure hexafluoride (SF_6). In Annex-1 at Protocol Annex-B, emissions limitations and decrease obligations were indicated. A common goal of reducing the greenhouse gas emissions by 5 % when compared with 1990 data was set for all countries in the Protocol. Net changes in the greenhouse gas emissions as a result of utilization of field and deforestation since 1990 with direct human effect were indicated in the protocol. Along with this, protocol has made it possible for the countries to purchase carbon credits from other countries (to make emissions trade) in order to reach their greenhouse gas emissions targets.

The aim of this study is to analyze and determine those countries among the top 50 economies in the world in terms of the ones that pollute the nature least (by doing the least amount of greenhouse gas emission), thereby producing in the most efficient way. As there are multiple input and output variables in the analysis, input oriented CCR models in Data Enveloping Analysis is used in order to calculate the relative total efficiencies of countries. In addition to this, the target values and potential enhancement rates that need to be realized in order for the non-efficient countries to be efficient.

2. Methodology

Each system has its unique goals. These goals are generally expressed by performance indicators such as high productivity, efficiency, profit maximization, minimization of costs, served satisfactions, growth and respectability (Barutçugil, 2002:13). One of the methods used in measuring the efficiency of systems is the data enveloping analysis. In data enveloping analysis, how efficient and productive the system resources (inputs) are used while producing goods and services (outputs) will be determined.

Data envelopment analysis (DEA) was first developed by Charnes, Cooper and Rhodes (1978) with the aim of measuring the relative efficiency of systems that produce similar goods or services and named

as Unit of Decision-Making (UDM). This method is a Linear Programming (LP) based approach that provides the chance to measure the relative total factor efficiency of UDMs in cases where there are too many input and output variables with different measuring units and they cannot be downgraded to a common scale (Aydemir, 2002:45). Efficiency measurement will be done under the assumption that production function is known (production limit, also known as efficiency limit) and the efficiency of systems are relatively measured by comparing with production limit (Yolalan, 1993:65). The efficiency measures used in DEA are "total", "technical" and "scale" efficiency measures. By using the input compound about the system in the most appropriate way, generating the most possible outputs is named as "technical efficiency"; whereas the efficiency calculated by multiplying the technical efficiency and scale efficiency is named as "total efficiency" (Cıngı and Armagan, 2000:3).

DEA compares each UDM only with the best UDMs. UDMs determined as the best ones establish the efficiency limit; and the efficiency of any UDM is measured according to this limit. Method evaluates the best UDMs above the efficiency limit as relative efficient and these units are stated as the reference cluster. Other UDMs which are not above the efficiency limit are the units that are relatively not efficient. DEA is a method that guides the managers and decision-makers about what to do for the enhancement of relative inefficient decision making units' efficiencies (Reisman, 2004:3-4).

There are several models used in DEA that assume each system will choose the weight of inputs and outputs in a way that will multiply its own efficiency grade most. The way to determine which way to be used in general depends on the scope of research and the assumptions to be used. If it is assumed that UDMs have the fixed asset according to the scale and is the total efficiencies of the units are needed to be determined; CCR or unidirectional models can be used. If the variable input assumption is valid for UDMs according to scale and if only the technical efficiencies of the units is to be calculated; BCC or additive models would be sufficient to utilize.

Also, CCR and BCC models used in DEA can be installed in two different ways as input-oriented and output-oriented. If the control on inputs is low (or absent) an output-oriented model; and if the control on outputs is low (or absent) an input-oriented model should be established. In input oriented models, least amount of input should be used to generate the existing output and in output oriented models, it is aimed to generate the most output with the existing input (Dinç and Haynes, 1999:470). The study will measure the total efficiency of countries with CCR models. Whether the CCR models are input or output oriented have no impact on efficiency values. In other words, both input and output oriented total efficiency values provide the same result. Therefore, as the countries' controls on inputs are higher while producing; input oriented CCR models are used.

If there is m amount of inputs and s amount of outputs in DEA that belong to n number of decision making unit; and the i input amount for j decision making unit $X_{ij} \geq 0$; and for r output amount produced by j decision making unit $Y_{rj} \geq 0$; then the input oriented fractional DEA model is shown as

$$Max \frac{u_1.Y_{1k} + u_2.Y_{2k} + \ldots + u_s.Y_{sk}}{v_1.X_{1k} + v_2.X_{2k} + \ldots + v_m X_{mk}} = Max \frac{\sum_{r=1}^{s} u_r Y_{rk}}{\sum_{i=1}^{m} v_i X_{ik}} \quad (1)$$

$$\frac{u_1.Y_{1j}+u_2.Y_{2j}+...+u_s.Y_{sj}}{v_1.X_{1j}+v_2X_{2j}+...+v_mX_{mj}} \le 1 \Rightarrow \frac{\sum_{r=1}^{s} u_r Y_{rj}}{\sum_{i=1}^{m} v_i X_{ij}} \le 1 \quad ; \quad j=1,...,n \tag{2}$$

$$u_r \ge \varepsilon > 0 \quad ; \quad r=1,...,s$$
$$v_i \ge \varepsilon > 0 \quad ; \quad i=1,...,m \tag{3}$$

form. In the model:

Max : Maximization

u_r : weight given to output r by k decision unit,

v_i : weight given to input i by k decision unit,

Y_{rk} : r output generated by k decision unit,

X_{ik} : i input used by k decision unit,

Y_{rj} : r output generated by j UDM,

X_{ij} : i input used by j UDM,

ε : A positive and very small value

as it is. If there are *n* number of UDMs in DEA; then the models to be generated will be *n* number and in order to measure the relative efficiency of each UDM; *n* number of best models need to be solved. The goal function of models is the maximization of the ratio of total weighted outputs (virtual outputs) for k decision making unit to total weighted inputs (virtual inputs) (Cooper et al., 2004:8-21). Charnes et al. have made the transformation of the fractional model defined above in order to solve it with linear programming (LM) solution methods in 1962 $\sum_{i=1}^{m} v_i X_{ik} = 1$ and they have mentioned the model as

$$Max\ u_1Y_{1k}+u_2Y_{2k}+...+u_sY_{sk} = Max\sum_{r=1}^{s} u_rY_{rk}$$

$$v_1X_{1k}+v_2X_{2k}+...+v_mX_{mk}=1 \Rightarrow \sum_{i=1}^{m} v_iX_{ik}=1$$

$$u_1Y_{1j}+u_2Y_{2j}+...+u_sY_{sj} \le v_1X_{1j}+v_2X_{2j}+...+v_mX_{mj} \Rightarrow \sum_{r=1}^{s} u_rY_{rj} - \sum_{i=1}^{m} v_iX_{ij} \le 0$$

$$u_1,u_2,...,u_s \ge 0 \quad ; \quad v_1,v_2,...,v_m \ge 0 \Rightarrow u_r \ge 0 \; ; \; v_i \ge 0 \tag{4}$$

thereby developing the LP model. This model is also named as input-oriented CCR model and it measures the total efficiency with the assumption of fixed income to the scale and provides the best solution with the fractional model.

Dual model in data enveloping analysis requires less mathematical transactions than the primal model to reach the best solutions; and it also provides important administrative information; therefore it is used widely. The dual version of input-oriented primal CCR model in Model 4 is given in Model 5.

$$Min\ \theta_k$$
$$\sum_{j=1}^{n} \lambda_{jk} X_{ij} \le \theta_k X_{ik}$$
$$\sum_{j=1}^{n} \lambda_{jk} Y_{rj} \ge Y_{rk}$$
$$\lambda_{jk} \ge 0 \qquad (5)$$

If we assume that the dual model indicates (θ_k*) as the best model; in order to say that a decision making unit in data enveloping analysis is relative total efficient;

i. θ_k*=1

ii. S_i^-=0 ve S_r^+=0 (6)

conditions must be met together. S_i^- indicates the idle variables related with over-used inputs in order to transform the inequalities in LP models to equalities; and S_r^+ indicates the idle variables related with deficient produced outputs. If the value of a goal function related with a UDM is less than 1 (θ_k*<1) and/or the idle variables have different values than zero (S_i≠0 and/or S_r≠0); then the result will be to say that UDM is not relative total efficient. In the literature, fulfilling the first condition only is defined as "weak" relative efficiency; and if the second condition where the idle variable values are equal with zero along with the first condition is met, it is defined as "strong" relative efficiency (Cooper et al., 2007:43-128).

To determine the possible input excessiveness and output lack of UDMs of which the relative total efficiency is investigated and whether the propositions provided in Equation 6 have been realized together or not; require the two-phase solution of Model 7 (Cooper et al., 2004:8-21).

$$Min\ \theta_k - \varepsilon \sum_{i=1}^{m} S_i^- - \varepsilon \sum_{r=1}^{s} S_r^+$$
$$S_i^- = \theta_k X_{ik} - \sum_{j_1}^{n} X_{ij} \lambda_j$$
$$S_r^+ = \sum_{j=1}^{n} Y_{rj} \lambda_{jk} - Y_{rk}$$
$$\lambda_{jk}, S_i^-, S_r^+ \ge 0 \qquad (7)$$

At the first phase of the solution of this model, Model 5 will be solved and the best value of goal function θ_k* will be reached. In the second phase; θ_k* value reached with the solution of Model 5 at first phase will be put to its place in Model 7 and the values of dual variable will be found as λ*, S_i^-* and S_r^+*.

When we assume that there is a relative inefficient decision making unit and the reference cluster of this UDM is indicated with R_k ; the efficient UDMs at R_k will constitute an example for inefficient UDMs; and the theoretical (reference) UDM represents a single point that inefficient UDM has to imitate. More clearly, in order to become as efficient as the UDMs in reference cluster; the UDMs that are not relative

efficient should aim for the input and output levels of theoretical UDM. In order to reach the targeted input and output levels, the potential enhancements (PE) about the relative inefficient UDM's input and outputs can be calculated as percentage by the following formula.

$$PE\ (\%) = \frac{Target - Observed}{Observed}.100 \quad (8)$$

In order to make the relative inefficient UDM efficient; the value of the variable which had negative PE percentage should be reduced as much as PE, and the positive value should be increased as much as PI. If it is zero, then there is no need to make any kind of enhancement (Babacan et al., 2007:103).

3. Data

The aim of the countries in the world is to utilize the existing resources in order to provide the economic welfare and to increase the life quality of their citizens. As most of the economic activities necessitate utilization of energy, this increases the greenhouse gas emission. Therefore, in order to provide the homogeneity of UDMs, only top 50 economy countries were included to the study. For the determined countries; 1990, 2005 and 2010 were considered as set by Kyoto Protocol , implemented and when the reports were crated. But, as the 1990 data for Belgium, Russia and Ukraine were missing; it was thought that the efficiency results that rely on relativity would be arguable, these countries were excluded from the scope of analysis in 1990.

It was not possible to use all input and output variables used in the literature. Because, as efficiency is measured by DEA; using too many input and output variables would make it harder to separate relative efficient and inefficient UDMs. The number of UDMs that could be analyzed in the study is 47 for 1990; and 50 for 2005 and 2010. Total of input and output variable numbers is 6. In this analysis, 5 input and 1 output variables were used from which accurate data could be obtained and those that do not have high correlation within themselves. The data and the descriptions about these variables were received from the official website of World Bank. The descriptions about the variables used in research can be found below.

Input variables

a) Energy Use per Person (EUPP): The definition of energy as used in here means the primary energy used before transforming into other fuels. This value was reached by adding import and stock changes to local production, and by excluding the exported fuel and the fuel provided to planes and ships that conduct international transportation. The variable used in this study was generated by proportioning this value with the population values of countries. Lozano and Gutierrez (2008) have determined the economic growth and energy utilization as the factors with the most impact on carbon dioxide emission. Altıntaş (2013), in the study on Turkey, has says that energy generation and investments are effective on economic growth; but energy generation causes over pollution. Therefore, the EUPP variable was used as an input variable in this study.

b) Non-Forest Area (%) (NFA): The naturally existing or planted trees which have the height of 5 mt. or more consist the "forest". Fruit trees, agricultural forestry systems, parks and gardens are not within this scope. As the variable used in this study is generated; the forest field rate that was rationed according to the fields of the countries were subtracted from 100 % and the non-forest area percentage for the related countries was obtained. According to the report published by Food and Agriculture Organization (FAO) (2010); it has been stated that carbon emissions stem from deforestation is an important issue that should be handled within the climate change policies. Therefore, deforestation or

increasing the non-forest field will cause changes in carbon emissions.

c) Agricultural Area (%) (AA): The variable of agricultural field that is used in this study states the percentage of cultivable and cultivated field, when the surface of the related countries is considered. Agricultural lands are used as input variable as it is a factor that increases the greenhouse gas emission.

d) Methane Emission Per Person (MEPP): Methane emission is calculated by values obtained from human activities such as agriculture and from industrial methane production. The variable used in this study was obtained by rationing the methane emission value to the population of related countries.

e) Carbon dioxide Emission Per Person (CEPP): Carbon dioxide emission stems from the burning of fossil fuel and from cement production. These are the carbon dioxide values that appear as a result of burning of solid, fluid and gas fuel. The variable used in this study was obtained by dividing the carbon dioxide values acquired for countries to the populations of related countries. Jebli and Youssef (2015) have determined in their study that carbon dioxide emission has a positive and statistically significant impact on GDP.

Output variable

f) Gross Domestic Product Per Capita (GDPPC): This value is obtained by dividing the GDP value to the middle of the year population of the related country. The data used in this study were calculated as Dollar in order to have a common meaning.

Within the framework of determined variables, CCR models were used in order to calculate the relative total efficiencies of countries on clean growth. To do this, DEA Solver 3.0 package program, which is an add-on to MS Excel was used.

4. Results

Kyoto Protocol has set a common goal that presumes the countries to reduce their greenhouse gas emissions 5 % less than 1990 level. In order to achieve this, member countries should make these arrangements and also prevent the GDP and sustainable development to be negatively affected from this. In short, the most important goal of the countries is to increase their production volume and to keep their greenhouse gas emissions at a minimum. The aim of this study is to measure and analyze the relative total activities in terms of greenhouse gas emission during the countries' economic activities; in other words, their amount of efficiency was determined by data enveloping analysis.

As a result of calculations done by CCR models, countries that are relatively total efficient are Brazil, Canada, Finland, France, Italy, Japan, Norway, Sweden, Switzerland, United States of America and England. Relative efficient countries are the same for 2005 and 2010. These are; Finland, Japan, Norway, Singapore, Sweden and Switzerland. 6 countries (USA, Brazil, France, England, Italy, Canada) were relative efficient in 1990; but they have lost their relative efficiency in 2005 and 2010, becoming inefficient countries. On the other hand, one country (Singapore) was not relative effective in 1990; and it became relative efficient in 2005 and 2010. Countries which are relative total inefficient are those which have efficiency scores below Table 1.

Table 1: Five Countries with Lowest Efficiency on Year Basis

1990		2005		2010	
Country	**Value**	**Country**	**Value**	**Country**	**Value**
Romania	0.081	Ukraine	0.038	Ukraine	0.046
Poland	0.116	Iran	0.071	Iran	0.093
Hungary	0.139	China	0.081	China	0.106
Venezuela	0.143	India	0.098	India	0.106
South Africa	0.161	Indonesia	0.101	South Africa	0.116

As it is seen on Table 1, the countries with the lowest efficiency value among those relative total inefficient in 1990 are Romania, Poland, Hungary, Venezuela and South Africa, in consecutive order. In 2005, these countries were Ukraine, Iran, China, India and Indonesia. In 2010, relative most inefficient five countries are Ukraine, Iran, China, India and South Africa.

Greatest economy in the world, United States of America, was relative total efficient in 1990; in 2005, it moved back to 13th rank in relative efficiency and 16th rank in 2010. Turkey was 31st in 1990, 27th in 2005 and 29th in 2010; in terms of relative total efficiency ranking. China was 41st in 1990, and 48th both in 2005 and 2010. Results about other countries are indicated in detail at Table 2.

When the reference clusters that indicate the countries which should be considered as an example by relative inefficient countries are examined; Switzerland appears to be the country that should be considered as a reference in 1990, 2005 and 2010. When it is examined regionally, countries with developed democracies such as north European ones appear to be those that should be referred to. Norway, Japan and Sweden are in 2005 reference cluster for USA and in 2010, Switzerland and Sweden are in reference cluster for USA. In addition, at reference cluster for Turkey; there are Switzerland, France and Italy in 1990, and Switzerland in 2005 and in 2010. In the reference cluster of China, there is USA in 1990; and Switzerland in 2005 and 2010.

Table 2: Relative Total Efficiency Values of Countries, Ranking by Efficiency and Reference Clusters

Countries (DMUs)	1990			2005			2010		
	Total Relative Efficiency	Total Relative Efficiency Ranking	Reference Cluster	Total Relative Efficiency	Total Relative Efficiency Ranking	Reference Cluster	Total Relative Efficiency	Total Relative Efficiency Ranking	Reference Cluster
1-USA	1	1		0,607	13	28-37-25	0,537	16	26-25
2Germany	0,964	12	20-28-1	0,612	12	26-28-37	0,546	14	26-28-25
3-Angola	0,476	25	26-16	0,192	36	26	0,278	31	26
4-Argentina	0,554	22	10-28-1	0,212	33	26	0,267	32	26
5-Australia	0,69	17	20-28-1	0,479	23	26-37	0,549	13	26-25
6-Austria	0,737	16	26-27-28	0,789	9	26-28-37	0,726	8	26-25
7-United Arab Emirates	0,793	14	37	0,45	26	15-37	0,389	26	28-37-39
8-Bangladesh	0,595	19	26-16	0,163	39	26	0,169	41	26
9-Belgium	-	-		0,537	18	26-28-37-	0,487	22	26-28-25

						25			
10-Brazil	1	1		0,261	31	26	0,363	27	26
11-Algeria	0,344	32	26-27-28	0,203	35	26	0,181	40	26
12-China	0,21	41	1	0,081	48	26	0,106	48	26
13-Denmark	0,81	13	26-27	0,892	8	26	0,747	7	26
14-Indonesia	0,291	37	10-16	0,101	46	26	0,151	44	26
15-Finland	1	1		1	1		1	1	
16-France	1	1		0,591	14	26-25	0,516	18	26-25
17-South Africa	0,161	43	27-28	0,123	42	26	0,116	46	26
18-India	0,332	34	10-1	0,098	47	26	0,106	47	26
19-Netherlands	0,621	18	26-16-27-28	0,572	16	26-28-37	0,507	19	26-25
20-England	1	1		0,69	10	26	0,538	15	26
21-Iran	0,224	40	27-28	0,071	49	26	0,093	49	26-37
22-Ireland	0,56	21	26-27	0,934	7	26	0,692	9	26
23-Spain	0,791	15	26-16-27	0,519	20	26	0,505	20	26
24-Israel	0,44	27	26-37	0,541	17	26-28-37	0,578	11	26-28-37
25-Sweden	1	1		1	1		1	1	
26-Switzerland	1	1		1	1		1	1	
27-Italy	1	1		0,642	11	26	0,563	12	26
28-Japan	1	1		1	1		1	1	
29-Canada	1	1		0,5	21	26-37-25	0,535	17	28-37-39-25
30-Qatar	0,387	29	15-37	0,588	15	15-37	0,58	10	37-25
31-Korea Rep.	0,398	28	26-27	0,474	25	26-28-37-25	0,423	24	28-25
32-Kuwait	0,327	35	26-37	0,341	29	15-37-25	0,312	30	28-37-39-25
33-Hungary	0,139	45	26-16-27	0,258	32	26	0,228	35	26
34-Malaysia	0,248	38	26-16-27-28	0,174	37	26-37	0,199	38	26-25
35-Mexico	0,379	30	20-28-1	0,324	30	26	0,265	33	26
36-Egypt	0,184	42	26-28-37	0,112	44	26-37	0,187	39	26-37
37-Norway	1	1		1	1		1	1	
38-Peru	0,316	36	26-16-27	0,35	28	26	0,349	28	26
39-Poland	0,116	46	20-28	0,21	34	26	0,212	37	26
40-Portugal	0,5	24	26-28	0,474	24	26	0,456	23	26
41-Romania	0,081	47	26-16-27	0,163	38	26	0,212	36	26
42-Russia	-	-		0,107	45	37-25	0,164	43	26-37-25
43-Singapore	0,591	20	26-37	1	1		1	1	39
44-Saudi Arabia	0,245	39	26-27-28	0,16	40	26-28-37	0,165	42	26-25
45-Thailand	0,335	33	10-28-1	0,113	43	26	0,122	45	26
46-Turkey	0,361	31	26-16-27	0,364	27	26	0,313	29	26
47-Ukraine	-	-		0,038	50	26	0,046	50	26
48-Venezuela	0,143	44	26-27-28	0,147	41	26-37	0,259	34	26-37-25
49-New Zealand	0,534	23	26-16-28	0,481	22	26-37	0,422	25	26-25
50-Greece	0,464	26	26-27	0,521	19	26	0,489	21	26-25-25

Potential enhancement percentages for 1990, 2005 and 2010 of inefficient countries are provided in Table 3. The total inefficiency of USA when compared with countries in its reference cluster (Sweden and Switzerland) is rooted in percentage in agricultural area, methane emissions per person and carbon

dioxide emissions Per Person; and deficiency in Gross Domestic Product per capita. As such, if USA could decrease agricultural area rate by 39,5 %, methane emissions per person by 12,9 % and carbon dioxide emission per person by 53,8 %; and if it increases the Gross Domestic Product per capita by 86,3 %; then it will become total efficient as Sweden and Switzerland in its reference cluster.

Table 3: Potential Enhancement (PE) Rates Related with Input and Output Variables of Relative Total Inefficient Countries

Countries	EUPP	NFA	AA	MEPP	CEPP	GDPPC	YEARS	EUPP	NFA	AA	MEPP	CEPP	GDPPC	Countries
	0	0	0	0	0	0	**1990**	0	0	0	0	0	0	
USA	0	0	-59	0	-18	64,8	**2005**	0	0	0	0	0	0	**Switzerland**
	0	0	-40	-13	-54	86,3	**2010**	0	0	0	0	0	0	
	0	-1,4	0	0	-4,6	3,8	**1990**	0	0	0	0	0	0	
Germany	0	0	-28	0	-26	63,4	**2005**	0	-9,9	-31	-12	-38	55,9	**Italy**
	0	0	-25	0	-30	83,3	**2010**	0	-14	-33	-14	-38	77,6	
	-57	-91	-93	0	0	110	**1990**	0	0	0	0	0	0	
Angola	0	-79	-87	-89	-22	421	**2005**	0	0	0	0	0	0	**Japan**
	0	-73	-83	-86	-35	260	**2010**	0	0	0	0	0	0	
	0	-84	-81	0	0	80,4	**1990**	0	0	0	0	0	0	
Argentina	0	-61	-62	-87	-34	372	**2005**	-9	0	0	0	-42	100	**Canada**
	0	-55	-59	-83	-36	275	**2010**	0	0	0	0	-17	87	
	0	-0,5	0	0	-22	44,9	**1990**	-47	0	0	-82	-54	159	
Australia	0	0	-63	-54	-50	109	**2005**	-58	0	0	-78	-79	70	**Qatar**
	0	0	-22	-80	-58	82,3	**2010**	-41	0	0	-79	-59	72,5	
	0	0	-24	0	-13	35,7	**1990**	0	0	-2,2	0	-4,9	151	
Austria	0	0	-46	0	-13	26,7	**2005**	0	0	-37	0	0	111	**Korea Republic**
	0	0	-34	-18	-36	37,7	**2010**	-1	0	-31	0	-19	136	
United	-44	-1,4	0	-47	-67	26,1	**1990**	0	-31	0	-56	-71	206	
Arab	-8,8	0	0	-1,5	-46	123	**2005**	-5,9	0	0	0	-45	194	**Kuwait**
Emirates	0	-16	0	0	-42	157	**2010**	0	0	0	0	-50	220	
	-32	-98	-99	0	0	68	**1990**	0	-20	-39	0	0	617	
Bangladesh	-1,4	-96	-98	-95	0	514	**2005**	0	-30	-54	-33	-24	287	**Hungary**
	0	-95	-97	-94	-19	492	**2010**	0	-32	-51	-53	-25	339	
	-	-	-	-	-	-	**1990**	0	-11	0	0	0	304	
Belgium	0	0	-16	0	0	86,3	**2005**	0	0	-54	-19	-43	474	**Malaysia**
	0	0	-13	0	-5,9	105	**2010**	0	0	-21	-57	-57	403	
	0	0	0	0	0	0	**1990**	0	-71	-76	0	0	164	
Brazil	0	-38	-61	-92	-1,1	284	**2005**	0	-54	-68	-71	-38	209	**Mexico**
	0	-27	-52	-89	-6,3	175	**2010**	0	-53	-67	-71	-40	278	
	0	-78	0	0	-24	190	**1990**	0	-94	0	0	-2	444	
Algeria	0	-81	-40	-87	-52	392	**2005**	0	-87	0	-37	-40	797	**Egypt**
	0	-78	-29	-84	-52	452	**2010**	0	-87	0	-39	-40	434	
	-38	-95	-95	0	-45	376	**1990**	0	0	0	0	0	0	
China	0	-66	-74	-75	-51	1000	**2005**	0	0	0	0	0	0	**Norway**
	0	-50	-62	-71	-55	842	**2010**	0	0	0	0	0	0	
	0	-16	-26	0	-27	23,4	**1990**	0	-77	-58	0	0	217	
Denmark	0	-21	-40	-55	-36	12,2	**2005**	0	-79	-68	-84	-41	186	**Peru**
	0	-18	-36	-53	-38	33,9	**2010**	0	-71	-56	-81	-51	187	
Indonesia	-5,2	-58	-48	0	0	243	**1990**	0	-13	-17	0	-23	761	**Poland**

	0	-65	-68	-87	-16	886	**2005**	0	-31	-49	-75	-52	377	
	0	-62	-67	-82	-28	561	**2010**	0	-21	-37	-70	-53	373	
Finland	0	0	0	0	0	0	**1990**	0	-37	-37	0	-10	100	**Portugal**
	0	0	0	0	0	0	**2005**	0	-20	-34	-63	-35	111	
	0	0	0	0	0	0	**2010**	0	-26	-37	-64	-34	119	
France	0	0	0	0	0	0	**1990**	0	-3,1	-17	0	0	1000	**Romania**
	-1,4	0	-30	-36	0	69,3	**2005**	0	-50	-68	-72	-36	513	
	-0,6	0	-29	-40	0	93,7	**2010**	0	-50	-68	-75	-34	372	
South Africa	0	-42	-50	0	-26	521	**1990**	-	-	-	-	-	-	**Russia**
	0	-42	-63	-63	-48	715	**2005**	0	0	-77	-22	-39	835	
	0	-38	-60	-59	-54	764	**2010**	0	0	0	-53	-42	511	
India	-2	-93	-93	0	0	201	**1990**	0	-40	0	-93	-63	69,2	**Singapore**
	0	-88	-91	-82	-39	916	**2005**	0	0	0	0	0	0	
	0	-84	-89	-78	-47	840	**2010**	0	0	0	0	0	0	
Holland	0	-5,7	0	0	0	61,2	**1990**	0	-20	0	0	-28	308	**Saudi Arabia**
	0	0	-24	0	-27	74,9	**2005**	0	0	-48	0	-42	524	
	0	0	-16	-20	-36	97,1	**2010**	0	0	-39	-37	-47	508	
England	0	0	0	0	0	0	**1990**	0	-83	-82	0	0	198	**Thailand**
	0	-17	-43	-34	-35	45	**2005**	0	-52	-57	-79	-38	783	
	0	-25	-49	-37	-40	86	**2010**	0	-42	-51	-79	-41	717	
Iran	0	-77	-61	0	-13	347	**1990**	0	-69	-59	0	0	177	**Turkey**
	0	-47	-8,2	-67	-41	1000	**2005**	0	-71	-75	-75	-43	175	
	0	-40	0	-61	-45	973	**2010**	0	-65	-67	-74	-48	219	
Ireland	0	-23	-37	0	-22	78,4	**1990**	-	-	-	-	-	-	**Ukraine**
	0	-24	-40	-82	-48	7	**2005**	0	-28	-54	-62	-32	1000	
	0	-28	-47	-81	-47	44,4	**2010**	0	-29	-54	-63	-36	1000	
Spain	0	-20	-28	0	0	26,4	**1990**	0	-11	0	0	-7,4	599	**Venezuela**
	0	-0,8	-39	-25	-36	92,7	**2005**	0	0	-7,3	-69	-42	582	
	0	-11	-44	-34	-30	98	**2010**	0	0	0	-68	-44	287	
Israel	0	-49	0	-68	-40	128	**1990**	-0,1	0	-17	0	0	87,2	**New Zealand**
	0	-51	0	0	-46	84,8	**2005**	0	0	-36	-78	-21	108	
	0	-50	0	0	-39	73,1	**2010**	0	0	-18	-87	-22	137	
Sweden	0	0	0	0	0	0	**1990**	0	-38	-58	0	-39	116	**Greece**
	0	0	0	0	0	0	**2005**	0	-23	-3,3	-30	-51	91,9	
	0	0	0	0	0	0	**2010**	0	-27	-56	-38	-53	105	

Switzerland is in 2010 reference cluster for China. If China could decrease non-forest area rate by 50,20 %, agricultural area rate by 61,50 %, methane emissions per person by 70,80 % and carbon dioxide emission per person by 55,10 %; and if it increases the Gross Domestic Product per capita by 814,5 %, then it will become total efficient as Switzerland in its reference cluster.

On the other hand, Switzerland is in 2010 reference cluster for Turkey. If Turkey could decrease non-forest area rate by 64,8 %, agricultural area rate by 67,3 %, methane emissions per person by 74,1 % and carbon dioxide emission per person by 47,8 %; and if it increases the Gross Domestic Product per capita by 219 %, then it will become total efficient as Switzerland in its reference cluster.

4. Conclusions

The most important reason of climate change today is the greenhouse gas emissions released in the atmosphere that increase by the production increase. Therefore, the countries have to determine policies that will minimize the emissions, abide by several protocols arranged and to realize "clean" growth.

This study was conducted in order to determine the level of clean growth for countries, and DEA method was used. The variables of energy usage per person, non-forest area, agricultural area, methane emission per person and carbon dioxide emission per person were taken as input; and the variable of gross domestic product per capita was taken as output.

As a result of analysis; it was seen that countries such as Brazil, Canada, Finland, France, Italy, Japan, Norway, Sweden, Switzerland, United States of America and England were the countries that have used the input variables most appropriately, efficiently in 1990. In 2005 and 2010; Finland, Japan, Norway, Singapore, Sweden and Switzerland were determined as relative efficient countries.

Greatest economy in the world, United States of America, was relative total efficient in 1990; in 2005, it moved back to 13th rank in relative efficiency and 16th rank in 2010. Another great economy in the world, China, is one of the countries with less relative efficiency in terms of 2005 and 2010 measurements. This indicates that greenhouse gas emissions in China have increased along with its growth.

In total efficiency ranking; Turkey was at 31st place in 1990, 27th place in 2005 and 29th place in 2010. Greenhouse gas emissions of Turkey have increased by 133,4 % since 1990.

From the data used by Bosetti and Frankel in their study dated 2014; it is seen that China has the first place in greenhouse gas emissions according to 2010 data with 10702 mton CO_2 . USA follows China with 6802 mton CO_2. Although Turkey does not emit the same amount of greenhouse gas as China or USA; the per person emission amount (5,9 tons annually) is above the world average.

USA, China and Turkey will be able to achieve efficient and clean growth like the countries in their reference clusters if they can make the necessary potential enhancements. When we examine other countries, we see that countries with developed democracies such as the north European ones are being referenced.

The results of this study indicate that western countries which have signed the Kyoto protocol are generally and relatively clean growing ones; and the countries such as China and USA that have recently agreed on Kyoto Protocol are inefficient countries. Considering the fact that western countries that have caused the climate change problem with greenhouse gas emissions as a result of Industrial revolution, have completed their development; but the level of succeeding clean growth only is not a sufficient achievement. Also, when we consider that world foreign direct investment was around 1.47 trillion dollars in 2014 and more than half of this investment is made to the developing countries; it will be clearly seen that the developed countries did not fulfill all their growth within their land. Therefore, it can be said that these countries have greater responsibilities than the developing ones in terms of decreasing the effects of climate change and adaptation.

REFERENCES

- Altıntaş, H., 2013. Türkiye'de birincil enerji tüketimi, karbondioksit emisyonu ve ekonomik büyüme ilişkisi: Eşbütünleşme ve nedensellik analizi. Eskişehir Osmangazi Üniversitesi İktisadi ve İdari Bilimler Dergisi 8(1), 263-294.
- Aydemir, Z., 2002. Bölgesel Rekabet Edebilirlik Kapsamında İllerin Kaynak Kullanım Göre Verimlilikleri: Veri Zarflama Uygulaması, Devlet Planlama Teşkilatı Uzmanlık Tezi, Ankara.
- Babacan, A., Kartal, M., Bircan, H., 2007. Cumhuriyet Üniversitesi'nin Etkinliğinin Kamu Üniversiteleri ile Karşılaştırılması: Bir VZA Tekniği Uygulaması. C.U. İktisadi ve İdari Bilimler Fakültesi Dergisi 8(2), 97-114.
- Barutçugil, İ., 2002. Bilgi Yönetimi, Kariyer Yayıncılık, İstanbul.
- Bosetti, V., Frankel, J., 2014. Scorecard Online Data. http://www.hks.harvard.edu/fs/jfrankel/ScorecardOnlineDataBosettiFrankel2014.xls , Cited 20 July 2015.
- Charnes, A., Cooper, W., Rhodes, E., 1978. Measuring the Efficiency of Decision Making Units. European Journal of Operations Research 2, 429-444.
- Cıngı, S., Tarım, A., 2000. Türk Banka Sisteminde Performans Ölçümü DEA-Malmquist. TFP Endeksi Uygulaması. Türkiye Bankalar Birliği Araştırma Tebliğleri Serisi 1, 3-21.
- Cooper, W-W., Seiford, L-M., Tone, K., 2007. Data Envelopment Analysis: A Comprehensive Text whith Models, Application, References and DEA-Solver Software. 2nd edt. Springer Science, New York.
- Cooper, W-W., Seiford, L-M., Zhu, J. 2004. Data Envelopment Analysis: History, Models and Interpretations. Handbook on Data Envelopment Analysis. Kluwer Academic Publisher, New York.
- Dinç, M., Haynes, K-E., 1999. Sources of Regional Inefficiency: An Integrated Shift-Share, Data Envelopment Analysis and Input-Output Approach. The Annals of Regional Science 33, 469-489.
- Erim, A., (2005) RIBA İklim Değişikliği Bilgi Notu. http://www.mo.org.tr/UIKDocs/ribaiklimdegisikligi.pdf Cited 20 July 2015.
- Food and Agriculture Organization (2010) Global Forest Resources Assessment 2010. Main Report, Rome.
- Houghton, J-T., Jenkins, G-J., 1990. Climate Change, The IPCC Scientific Assessment. Ephraums, J.J. (ed.) Cambridge University Press, New York.
- Jebli, M-B., Youssef, S-B., 2015. Economic growth, combustible renewables and waste consumption, and CO2 emissions in North Africa. Environmental Science and Pollution Research. DOI 10.1007/s11356-015-4792-0
- Lozano, S., Gutiérrez, E., 2008. Non-parametric frontier approach to modelling the relationships among population, GDP, energy consumption and CO2 emissions. Ecological Economics 66, 687–99.
- Özyüksel, S., Oksay, G., 2014. İklim Değişikliği, Sürdürülebilir Kalkınma ve Sürdürülebilir Sigortacılık. TSEV Yayınları, İstanbul.
- Reisman, A., 2004. What Can OR/MS Academics Learn From and About Data Envelopment Analysis? OH, USA : SSRN, OR/MS.
- The World bank Database (2015) Agricultural data. http://data.worldbank.org/indicator/AG.LND.AGRI.ZS. Cited 20 July 2015.
- The World bank Database (2015) CO2 emissions data. http://data.worldbank.org/indicator/EN.ATM.CO2E.KT. Cited 20 July 2015.
- The World bank Database (2015) Energy use data. http://data.worldbank.org/indicator/EG.USE.PCAP.KG.OE. Cited 20 July 2015.
- The World bank Database (2015) Forest area data. http://data.worldbank.org/indicator/AG.LND.FRST.ZS. Cited 20 July 2015.

- The World bank Database (2015) GDP per capita data. http://data.worldbank.org/indicator/NY.GDP.PCAP.CD . Cited 20 July 2015.
- The World bank Database (2015) Methane emissions data. http://data.worldbank.org/indicator/EN.ATM.METH.KT.CE. Cited 20 July 2015.
- UN Climate Change Newsroom (1992) United Nations Framework Convention on Climate Change. https://unfccc.int/resource/docs/convkp/conveng.pdf. Cited 21 Aug 2013.
- UN Climate Change Newsroom (1997) Kyoto Protocol to The United Nations Framework Convention on Climate Change. http://unfccc.int/resource/docs/convkp/kpeng.pdf. Cited 21 Aug 2013.
- UN Documents: Gathering a Body of Global Agreements Brundtland Report: http://www.un-documents.net/our-common-future.pdf. Cited 21 Aug 2013.
- Yolalan, R., 1993. İşletmeler Arası Göreli Etkinlik Ölçümü. MPM Yayınları, Ankara.