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Türkiye ile AB Ülkelerinin katı atık yönetimi performanslarının malmquist endeksi ile karşılaştırılması

Comparison of solid waste management performances of Turkey and EU countries associated with Malmquist Index

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Comparison of Solid Waste Management Performances of Turkey and EU countries associated with Malmquist Index

Araştırma Makalesi / Research Article

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ABSTRACT

In this study, it's aimed to determine the solid waste management performances of Turkey and EU countries with DEA. Waste and environmental data of the countries has been evaluated in this study for a period of seven years and performance changes of the countries has been examined by years through Malmquist Total Factor Productivity by establishing two different models. In first model, performance of the countries has been examined in terms of environment. Benefiting from the variables of waste management according to the waste categories (domestic and industrial) of the countries, waste generation excluding the important mineral wastes and municipal waste generation, it's aimed to achieve maximum of municipal waste recycle ratio, packaging wastes recycle ratio and packaging waste recovery ratios. In the second model, performance of the countries has been examined in economic terms. Benefiting from the public sector environmental investment amount (as GDP percentage) and environmental protection expenditures (million Euros) variables, it's aimed to achieve maximum of municipal waste recycle ratio, packaging wastes recycle ratio and packaging waste recovery ratios.

Keywords: Data envelopment analysis, solid waste management, Malmquist Index.

Türkiye ile AB Ülkelerinin Katı Atık Yönetimi Performanslarının Malmquist Endeksi ile Karşılaştırılması

ÖZ

Bu çalışmada iki farklı model kurularak, VZA ile AB ülkeleri ve Türkiye'nin katı atık yönetimi performanslarını belirlenmesi amaçlanmaktadır. Ülkelerin yedi yıllık atık ve çevresel verilerinin değerlendirildiği çalışmada, iki farklı model kurularak Malmquist Toplam Faktör Verimliliği yöntemi ile ülkelerin yıllara göre performans değişimleri incelenmiştir. Birinci modelde; ülkelerin performansı çevresel yönden incelenmiştir. Ülkelerin atık kategorisine göre (ev ve iş yerleri) atık üretimi, önemli mineral atıklar hariç atık üretimi ve kentsel atık üretimi değişkenlerinden yararlanarak, kentsel atık geri dönüşüm oranı, ambalaj atıkları geri dönüşüm oranı ve ambalaj atıkları geri kazanım oranlarının maksimum olması amaçlanmıştır. İkinci modelde; ülkelerin performansı ekonomik yönden incelenmiştir. Kamu sektörü çevresel yatırım miktarı (GSYH yüzdesi olarak) ve çevre koruma harcamaları (milyon Euro) değişkenlerinden faydalanarak, , kentsel atık geri dönüşüm oranı, ambalaj atıkları geri dönüşüm oranı ve ambalaj atıkları geri kazanım oranlarının maksimum olması amaçlanmıştır.

Anahtar Kelimeler: Veri zarflama analizi, katı atık yönetimi, Malmquist indeksi.

1. INTRODUCTION

Environmental problems not only bear a global qualification but also vary according to the development levels of the communities in recent years. Wastes that originate as a natural result of life and waste management are the primary issues to which the communities have been approaching with an understanding of keeping out of sight. Solid wastes emerging from population growth, technological development, industrialization, urbanization, rapidly increasing and differentiating and differentiating consumption are one of the important environmental problems due to their negative effects on environment and human health.

These problems have required the approach of evaluating the solid wastes in terms of environment and human health. Today, solid wastes became an issue needed to be managed while they were resources needed to be re-evaluated.

Solid waste management that is one of the approaches brought to solve the problems arising from the solid wastes is defined as a system developed for supporting a production with less wastes, recovery of solid wastes for raw materials or other purposes and application of

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disposal principles as not to damage earth, air, water environment and living creatures.

In this study, solid waste management and related concepts are generally included and it's tried to present what the issue is and it's evaluated how solid wastes are managed in Turkey and EU countries and what the problems are using the data from EU countries.

Two models are proposed in the study where waste and environmental data of the countries for seven years (2006-2012) are evaluated: In first model, performance of the countries has been examined in terms of environment. In this model, waste management according to the waste categories, waste generation excluding the important mineral wastes and municipal waste generation are used as inputs and municipal waste recycle ratio, packaging wastes recycle ratio and packaging waste recovery ratios are used as outputs. In the second model, performance of the countries has been examined in economic terms. In this model, public sector environmental investment amount and environmental protection expenditures are used as inputs and municipal waste recycle ratio, packaging wastes recycle ratio and packaging waste recovery ratios are used as outputs.

2. EUROPEAN UNION AND SOLID WASTE MANAGEMENT

EU policies regarding the conservation of environment and natural sources gained increasingly importance after 1980s. While protection of the environment is brought to European and international level, particularly pollution problems became significant in environment policy during the expansion process of EU. 6 principles are determined to make the sustainable development one of the objectives of European Community in Amsterdam Treaty. These are, complementarity, high level protection, reserve, prevention, prevention at the source and polluter pays principles.

Solid waste management is a sustainable factor based on recovery and efficient usage of the sources. It became necessary to follow the goals of reduction of waste generation, re-use and increase of recycle, controlled storage of non-utilizable wastes, establishment of a good relationship between solid waste management industries and ensuring environmental efficiency for the continuity of solid waste management in line with the sustainable progress.

3. MATERIAL and METHOD

Study data has been obtained from EUROSTAT. In this study, input and output variables selected for performance assessment are presented in Table 1. Package program DEAP Version 2.1 (Coelli, 1996) developed by Tim Coelli is used to determine the efficiency in the study. Statistical values for input and output variables are as shown in Table 2:

4. DATA ENVELOPMENT ANALYSIS

Data Envelopment Analysis (DEA) is a nonparametric linear programming technique used commonly for comparison of homogeneous decision making units. DEA is a linear programming process that can be defined as frontier analysis of many inputs and many outputs. From the point of the sectional-convex enveloping approach of Farrell (1957) to efficient frontier estimation, Charnes, Cooper and Rhodes gave DEA technique to the literature.

DEA compares the input and output levels of DMUs (Decision Making Units) and defines the efficient frontier by determining the best DMU. Converting the inputs into the outputs in the most effective way, DMU forms a part of the efficient frontier. Achieved performance measure is defined as efficiency.

In CCR model developed by Charnes Cooper and Rhodes, analysis is performed under the assumption of constant return to scale. In BCC model developed by Banker, Charnes and Cooper, analysis is performed under the assumption of variable return to scale (Banker et al, 1984).

CCR and BCC models can be classified in two groups; input-oriented and output-oriented. Input-oriented CCR model is expressed as follows:

$$\max \mathrm{y_k} = \sum_{\mathrm{r=1}}^{\mathrm{s}} \mathrm{u_r y_{rk}}$$

Subject to:

$$\sum_{\mathrm{i=1}}^{\mathrm{m}} \mathrm{v_i x_{ik}} = 1$$

$$\sum_{\mathrm{r=1}}^{\mathrm{s}} \mathrm{u_r y_{rj}} - \sum_{\mathrm{i=1}}^{\mathrm{m}} \mathrm{v_i x_{ij}} \leq 0 \qquad (\mathrm{j=1,...,n})$$

$$\mathrm{u_1, u_2, ..., u_s} \geq 0, \ \mathrm{v_1, v_2, ..., v_m} \geq 0$$

Output-oriented CCR model is expressed as follows:

$$\min x_k = \sum_{i=1}^{m} v_i x_{ik}$$

Subject to:

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0$$

$$\sum_{r=1}^{s} u_r y_{rk} = 1$$

$$u_1, u_2, ..., u_s \geq 0$$

$$v_1, v_2, ..., v_m \geq 0$$

Input-oriented BCC model is expressed as follows:

$$\max y_k = \sum_{r=1}^{s} u_r y_{rk} - u_0$$

Subject to:

$$\sum_{i=1}^{m} v_i x_{ik} = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} - u_0 \le 0 \quad ,j=1,...,n$$

$$u_1, u_2, ..., u_s \ge 0$$

$$v_1, v_2, ..., v_m \ge 0$$

u_0, free

Output-oriented BCC model is expressed as follows:

$$\min x_k = \sum_{i=1}^{m} v_i x_{ik} - v_0$$

Subject to:

$$\sum_{r=1}^{s} u_r y_{rk} = 1$$

$$\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} u_r y_{rj} - v_0 \ge 0 \text{ , } j=1,...,n$$

$$u_1, u_2, ..., u_s \ge 0$$

$$v_1, v_2, ..., v_m \ge 0$$

v_0, free

5. MALMQUIST TOTAL FACTOR PRODUCTIVITY INDEX

When performance of a production unit is measured with CCR model in a given year, frontier deviation in time can not be calculated with DEA as this measured efficiency remains constant. After Sten Malmquist (1953) created amount indexes like ratios of distance functions, Malmquist Productivity Index (MPI) introduced by Caves, Christensen and Diewart (1982) and developed by Fare, Grosskopf, Norris and Zhang (1994) calculates the movement in the frontier.

Malmquist productivity index indicates the distance of the inputs under constant technology to the outputs to be obtained in a different time. Without putting any limitation on production technology, it makes efficiency measurement via linear programming method for inputs and outputs. Production curve is created for each input and output and production technologies are determined. Determined technology level gives the efficiency ratio. Malmquist productivity index can be defined as follows in graphics:

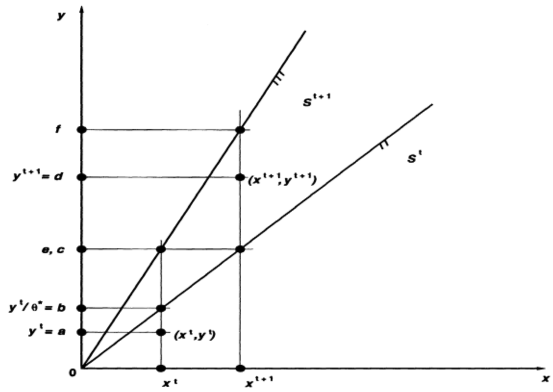

Figure 1. Output way Malmquist TFP index (Fare et al 1994:70)

S^t and S^{t+1} are production technologies belonging respectively to t and subsequent t+1. Distance function aims the highest output proportional increase that is possible in the outputs with a certain input amount. In graphic, where x^t is data, the highest output amount for y^t is y^t/Θ point on the production frontier. Distance function of observation in (x^t, y^t) point based on the output is expressed with (0a/0b) ratio with a value below 1 with regards to distances in y axis. This ratio is the proportionately opposite of Farrell output-oriented technique efficiency criterion measuring how far an observation is away from the efficient production frontier.

$$D_0^{t+1}(x^{t+1}, y^{t+1}) = \frac{0d}{0f}$$

$$D_0^{t}(x^{t}, y^{t}) = \frac{0a}{0b}$$

$$\frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^{t}(x^{t}, y^{t})} = \frac{(0d/0f)}{(0a/0b)}$$

x^t input can produce the most efficient output in t time for 0b but more input in (t +1) period up to 0e.

Therefore, (0b / 0e) ratio expresses technological change measurement. If this ratio is greater than one unit, this expresses the technological development.

$$D_0^{t}(x^{t}, y^{t}) = \frac{0a}{0b}$$

$$D_0^{t+1}(x^{t}, y^{t}) = \frac{0a}{0c}$$

$$\frac{D^{t}(x^{t}, y^{t})}{D^{t+1}(x^{t}, y^{t})} = \frac{0c}{0b}$$

Thus, technological change:

$$\left[\frac{D^t(x^{t+1}, y^{t+1})}{D^{t+1}(x^{t+1}, y^{t+1})} x \frac{D^t(x^t, y^t)}{D^{t+1}(x^t, y^t)}\right]^{1/2} = \left[\left(\frac{0d/0e}{0d/0f}\right)\left(\frac{0a/0b}{0a/0c}\right)\right]^{1/2} = \left[\frac{0f}{0e} x \frac{0c}{0b}\right]^{1/2}$$

is expressed with its equality. An important advantage of distance function is that it provides a suitable way to define more than one input and more than one output production technology without the necessity of stating the functional forms like cost minimization and profit maximization (Kaneko and Managi, 2004).

For productivity change between t and t+1 periods, Malmquist Productivity Index is defined as follows for relative technology level in t period (Caves, Christensen, Diewert, 1982).

$$M_{CCD}^{\ t}=\frac{D_0^{\ t}(x^{t+1},y^{t+1})}{D_0^{\ t}(x^t,y^t)}$$

Relative productivity change in technology in t+1 period can be formed as follows:

$$M_{CCD}^{\ t+1}=\frac{D_0^{\ t+1}(x^{t+1},y^{t+1})}{D_0^{\ t+1}(x^t,y^t)}$$

Fare et al (1994) proposed Malmquist Productivity Index for output-oriented productivity change from t period until t+1 period by taking the average of geometric average of these models.

$$M_0(x^{t+1},y^{t+1},x^t,y^t)=\left[\left(\frac{D_0^{\ t}(x^{t+1},y^{t+1})}{D_0^{\ t}(x^t,y^t)}\right)\left(\frac{D_0^{\ t+1}(x^{t+1},y^{t+1})}{D_0^{\ t+1}(x^t,y^t)}\right)\right]^{1/2}$$

This index can also be defined as follows:

$$M_0(x^{t+1},y^{t+1},x^t,y^t)=\left(\frac{D_0^{\ t+1}(x^{t+1},y^{t+1})}{D_0^{\ t}(x^t,y^t)}\right)x\left[\left(\frac{D_0^{\ t}(x^{t+1},y^{t+1})}{D_0^{\ t+1}(x^{t+1},y^{t+1})}\right)\left(\frac{D_0^{\ t}(x^t,y^t)}{D_0^{\ t+1}(x^t,y^t)}\right)\right]^{1/2}$$

Ratio in brackets measures the technological change (TECHCH). Between t and t+1 periods, measures the change in production frontier. If TECHCH>1, production technology advanced between t and t+1 periods. If TECHCH<1, production technology degraded between t and t+1 periods. Ratio out of the bracket is called as efficiency change (EFFCH).

It gives the amount capturing the efficiency between t and t+1 periods. EFFCH>1 indicates that there is an increase in the efficiency of DMU concerned and EFFCH<1 indicates that there is a decrease in the efficiency of DMU concerned.

EFFCH calculated under the assumption of variable return to scale can be separated into pure efficiency change index (PECH) and scale efficiency change index (SECH).

Here, $D^t_{VRS}(x^t,y^t)$ and $D^{t+1}_{VRS}(x^{t+1},y^{t+1})$ distance functions are calculated under the assumption of variable return to scale in t and t+1 periods. PECH defined as distance function of its own period under variable return to scale indicates the proximity of each production unit to the best unit in its own period. SECH is the ratio of the distance function under the assumption of constant return to scale to the distance function under the assumption of variable return to scale.

$$PECH_t^{\ t+1}=\left(\frac{D_{VRS}^{\ t+1}(x^{t+1},y^{t+1})}{D_{VRS}^{\ t}(x^t,y^t)}\right)$$

$$SECH_t^{\ t+1}=\frac{D_{CRS}^{\ t+1}(x^{t+1},y^{t+1})}{D_{CRS}^{\ t}(x^t,y^t)}\ x\ \frac{D_{VRS}^{\ t}(x^t,y^t)}{D_{VRS}^{\ t+1}(x^{t+1},y^{t+1})}$$

The most important feature of Malmquist productivity index is that it explains the efficiency change and technological change for further decomposition of total factor productivity.

6. APPLICATION

Table 1. Input and output variables used in the study

Model 1	
Input Variables	Output Variables
According to the waste category waste production (1000 tones)	Recycling rate of municipal waste
Important mineral waste except waste production (per kg)	Recycling rates for packaging waste
Municipal waste production (per kg)	Recovery rates for packaging waste
Model 2	
Environmental investment by the public sector(GDP%)	Recycling rate of municipal waste
Environmental protection expenditure(100 million euros)	Recycling rates for packaging waste
	Recovery rates for packaging waste

Table 2. Input and output variables of descriptive statistics

Variable	Mean	Standard deviation	Min	Max
According to the waste category waste production (1000 tones)	102,1	14,99	1,54	603,42
Important mineral waste except waste production (per kg)	218,7	156,863	67,82	849,47
Municipal waste production (per kg)	485,47	114,74	293,86	698,5
Environmental investment by the public sector (GDP%)	0,19	0,16	0,02	0,66
Environmental protection expenditure(100 million euros)	30,84	47,59	0,38	176,04
Recycling rate of municipal waste	28,17	18,74	0,67	63,17
Recycling rates for packaging waste	56,63	12,39	28,3	80,97
Recovery rates for packaging waste	68,13	19,7	28,49	99,87

Figure 2 and Figure 3 shows the average amount of the input variables used in the models.

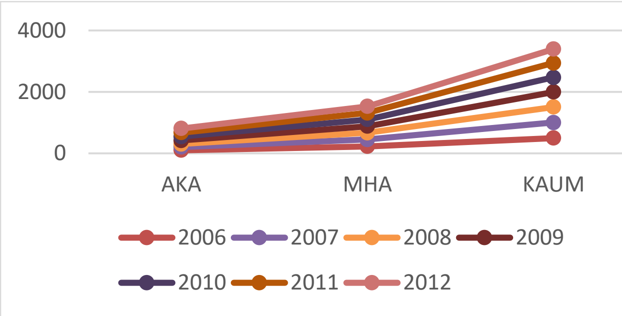

Figure 2. The average on the input variables used in the first model

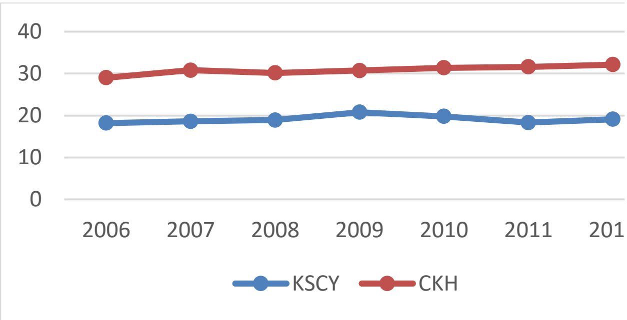

Figure 3. The average on the input variables used in the second model

Figure 4, it shows the average values of the variables used in the model output.

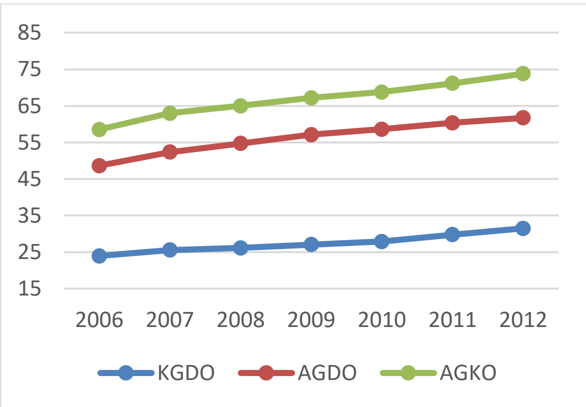

Figure 4. The average change of the output variables used in the model

According to the solid waste management performance model based on environment, total factor productivity (TFP) changes of the countries by years are as given in Table 3.

In 2007, Slovakia is the best country with an increase of 70,9% in TFP. Considering the output variables of the country in 2007, it's seen that these variables increased for an average of 1.5 times compared to 2006. Malta is the country with the lowest performance with a decrease of 56.9% in TFP. It's seen that Turkey had an increase of 4,5% in TFP.

In 2008, Malta is the best country in terms of solid waste performance with an increase of 37,4% in TFP contrary to 2007. Considering the output variables of Malta in 2008, it's remarkable that there is an increase for approximately 4 times compared to 2007. Slovakia is the country with the lowest performance with a decrease of 20,2% in TFP. Average 20% decrease in output variables may be shown as a reason for that case. A decrease of 08,7% in TFP is observed in that period in Turkey.

Considering the changes in 2009, Estonia is the best country with an increase of 34,9% in TFP change. With a decrease of 11,9% in TFP change in that period, Turkey is the country with the lowest solid waste management performance.

Compared to 2009, Slovenia is the best country in 2010 among Turkey and other EU countries with an increase of 22,9% in TFP. A decrease of 20,9% in TFP in Slovakia made the worst solid waste management performance of the country. Turkey showed a slight decrease in TFP in that period.

In 2011, the best change belongs to Malta in TFP compared to 2010. Denmark, on the other hand, is the country with the lowest performance. Turkey increased its TFP with a ratio of 19,3% in that year compared to 2010.

In 2012, Turkey is the best country in terms of solid waste management performance in that period with an increase of 34,7% in TFP. Lithuania is the country with the lowest solid waste management performance with a decrease of 9,6% in TFP.

Table 3. Environment based on changes in total factor productivity compared to solid waste management in the country according to the performance of the model

Countries	2007	2008	2009	2010	2011	2012
Turkey	1,009	0,913	0,881	0,931	1,193	1,347
Slovakia	1,709	0,798	1,286	0,791	1,385	1,098
Bulgaria	1,252	0,849	1,286	1,087	1,118	1,075
Slovenia	1,208	1,027	1,004	1,229	1,359	1,141
Poland	1,244	0,878	1,067	1,102	0,976	1,037
Hungary	1,125	1,235	1,037	1,228	1,075	0,952
Spain	1,060	1,251	0,961	1,023	0,996	1,008
England	1,091	1,102	1,067	1,047	1,069	1,109
Lithuanian	1,166	1,177	1,224	1,022	1,006	0,904
Estonia	1,099	0,957	1,349	1,02	1,154	1,095
Finland	1,052	1,023	1,073	0,978	0,982	1,027
France	1,034	0,98	1,018	1,057	1,019	1,053
Belgium	1,055	1,082	0,961	0,988	0,999	0,993
Czech Republic	1,076	1,026	1,017	1,048	0,987	1,055
Denmark	0,858	1,236	0,965	0,986	0,847	1,003
Germany	1,003	0,991	0,975	0,966	0,981	0,996
Latvia	1,064	1,374	1,05	1,128	0,881	0,984
Luxembourg	1,023	1,056	0,948	0,969	1,078	1,077
Austria	0,998	1,048	1,088	1,11	1,765	0,725
Romania	1,038	1,058	1,238	1,216	1,377	1,3
Italy	1,027	1,008	1,121	1,022	1,063	1,054
Portugal	1,074	0,992	1,122	1,093	1,132	1,163
Netherlands	1,012	1,004	1,023	1,023	0,994	1,016
Sweden	0,995	0,997	1,088	1,054	1,014	0,996
Malta	0,431	1,374	0,965	1,132	1,695	1,019
Average	1,068	1,057	1,072	1,05	1,125	1,049

According to the solid waste management performance model based on economy, total factor productivity (TFP) changes of the countries by years are as given in Table 4.

Compared to 2006, Hungary is the country with the best change ratio with an increase of 142,3% in TFP in 2007. Significant increase of input variables used in the analyses compared to the previous year may be shown as the reason for the great increase in TFP change. The lowest performance in TFP change belongs to Malta compared to 2006. Compared to 2006, Turkey showed an increase of 27% in TFP in 2007.

Compared to 2007, Malta showed an increase of 200,16% in TFP in 2008. This important change was caused by the great changes in input variables used in the analysis compared to the previous year. Bulgaria is the country with the lowest performance in 2008. Turkey showed an increase of 16,7% in TFP index.

Romania is the best country in terms of TFP change in 2009. Slovenia is the country with the lowest TFP change performance in 2009. TFP change of Turkey made a slight positive progress.

Estonia increased its TFP change with a ratio of 98,1% in 2010 compared to the previous year. Hungary showed a decrease of 43,9% in TFP index change compared to 2009. Turkey's TFP change remained constant.

Spain had the best TFP change in 2001 with an increase of 326,1%. The lowest TFP change performance belongs to Estonia with a decrease of 49,7%. In that period, Turkey had a decrease of 7,9% in TFP change.

Romania became the best country with an increase of 162,7% in TFP in 2012. TFP change of Spain showed a decrease of 71,9% and thus it became the country with the lowest performance. Turkey had an increase of 3,5% in TFP.

Table 4. Economics based on total factor productivity changes over the years the country according to the solid waste management performance model

Countries	2007	2008	2009	2010	2011	2012
Turkey	1,270	1,167	1,12	1	0,921	1,035
Hungary	2,423	1,593	1,092	0,561	1,699	0,779
Slovakia	1,834	0,754	1,4	0,617	1,008	0,934
Czech Republic	1,773	1,007	0,888	0,793	1,008	1,051
Poland	1,285	0,998	1,261	1,042	0,871	1,262
Germany	1,175	1,009	0,879	1,114	1,063	1,176
Belgium	1,161	0,972	0,97	1,899	0,784	0,935
Sweden	1,135	0,999	1,033	1,194	1,502	0,65
Italy	1,130	0,906	1,075	1,23	0,995	1,027
Finland	1,103	0,884	1,158	0,731	1,37	1,386
France	1,040	0,83	1,022	1,083	0,878	0,941
Slovenia	1,017	0,867	0,747	1,444	1,482	1,201
Estonia	0,970	0,959	0,612	1,981	0,503	0,685
Spain	0,952	1,172	0,799	1,386	4,261	0,281
England	0,945	0,957	1,005	0,983	1,002	0,911
Denmark	0,938	0,977	1,066	1,004	0,804	1,022
Netherlands	0,936	1,01	1,104	1,012	1	0,999
Luxembourg	0,927	0,918	0,812	1,379	0,919	0,727
Portugal	0,906	1,008	1,007	1,119	1,19	1,192
Bulgaria	0,888	0,716	1	1,778	1,044	0,903
Latvia	0,886	1,76	1,126	1,577	0,559	0,756
Lithuanian	0,856	1,251	0,779	0,876	1,683	1,05
Austria	0,812	0,945	0,924	1,158	1,298	0,958
Romania	0,525	1,022	1,288	0,799	0,892	2,627
Malta	0,309	3,16	1,216	0,712	2,616	0,621
Average	1,016	1,054	0,998	1,081	1,121	0,937

7. CONCLUSION and DISCUSSION

Amount and characteristics of the wastes thrown by the people as a result of domestic use vary depending on the factors such as socioeconomic level of the city they live in, type of the fuel used, food habits etc. Depending on the development levels of the countries, food wastes and inorganic wastes like ash in low-income countries are more and recyclable wastes are less. As the income level increases, amount of food waste decreases and amount of packaging wastes increases. The reason for that is the increase of the consumption of the packaged products in high-income countries. First goal in waste management is the prevention of the waste formation. If it's not possible to prevent, waste minimization should be ensured. If possible, occurring wastes should be used again and if it's not possible, recycling methods should be implemented to minimize the amount of wastes to be disposed. In case it's not possible to implement all these methods, wastes should be subjected first to the energy recovery and then to the disposal process. Through the solid waste management projects that are carefully planned and ensuring contribution, management of the solid wastes, one of the important problems, is a significant tool for elimination of the urban poverty as well as the environmental, economic and social efficiency. There isn't a management model that is valid for all communities and will give the same successful result in solid waste management. Each community needs to develop the best method that is applicable within its own capacity in compliance with the nature of the problem. Development level is related with the economic level, social structure, cultural structure of the country. As the social and cultural structure increases, environmental consciousness of the people will also increase and therefore, damage given to the environment will decrease.

In this study, solid waste management performance of Turkey and EU countries is put forward by establishing two different models. When average values are examined by years, according to the solid waste management performance model based on the environment, it's seen that total factor productivity index is greater than 1. When the TFP index of Turkey by years is compared to the average values, it can be concluded that generally Turkey is ahead of other EU countries on this subject. Same comment may be made also for the solid waste management performance model based on the economy. For two models, the best year is in 2011 in terms of the average of solid waste management performance. In solid waste management performance model based on environment, an increase with a ratio of 5,9% occurred in TFP of EU countries. In other words, countries increased their production capabilities in time and increased the level of efficient production frontier and generated more outputs with the same input amount. Turkey showed an increase with a ratio of 3,3% in total factor productivity. In the solid waste management, this means that when waste management according to the waste categories, waste generation excluding the important mineral wastes and municipal waste generation remains the same, an increase occurs in municipal waste recycle ratio, packaging wastes recycle ratio and packaging waste recovery ratios. Technological progress made by Turkey can also be evaluated as the success to reach the efficient frontier. In solid waste management performance model based on economy, an increase with a ratio of 3,3% occurred in TFP of EU countries. Turkey showed an increase with a ratio of 7,9% in total factor productivity. In other words, when the public sector environmental investment and environmental protection expenditures remains the same, an increase occurs in municipal waste recycle ratio, packaging wastes recycle ratio and packaging waste recovery ratios.

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