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The production activities of sugar factories in Turkey and Malmquist total factor productivity analysis

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In this study, total factor productivity (TFP) with variance in its components as well as the technical efficiency levels of 25 active sugar factories in Turkey are surveyed via Data Envelopment Analysis (DEA) and Malmquist Total Factor Productivity method using the panel data from Turkish Sugar Factories Corporation's annual activity reports. The aim of the study is to determine the comparative production performances of active sugar factories in Turkey, which would guide both government policies about the sector and the factory managements in the decision making process about issues such as production, growth and profit/cost analysis. It is found that sugar factories in Turkey show increase in TFP stemming from technological improvement in general. Although there is an increase in TFP and technical efficiency, it is nowhere near the one in technological efficiency. Considering the fact that variance in technical efficiency is set by scale efficiency and pure efficiency, the ability of production in optimal scales is found to be low imposing a more congruent use of already possessed production factors. These results put forward the need for increase in competitive capacity and resource management for the sugar factories in Turkey.

Key words: Sugar factories, efficiency, productivity, data envelopmant analysis, Malmquist index.

INTRODUCTION

Acquiring competitive capacity in the production of a critical product such as sugar increases the importance of reorganization of policies in the world and more specifically in Turkey. Commonwealth production lot in Turkey constitutes approximately 70% of sugar industry. The effects of efficiency and productivity criteria are significant for the attempts towards the corporatization of sugar factories in order to reduce commonwealth production lot. Therefore, sugar factories should aim for sustainable competition in an environment in which global competition is steadily increasing. Due to its associated products, its contribution to other sectors and its being indispensable for human health sugar production has been rather important in Turkish economy. Sugar factories generate employment as well as providing economic territories within those specific regions, which is why sugar factories must be grounded on competitive capacity, efficiency and productivity.

Efficiency and productivity index values are accepted as the most reliable units of measure in determining

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Table 1. Public sugar factories.

No	Name of the factory	No	Name of the factory	No	Name of the factory
1	Afyon S.F.	10	Elbistan S.F.	19	Kırşehir S.F.
2	Ağrı S.F.	11	Erciş S.F.	20	Malatya S.F.
3	Alpullu S.F.	12	Ereğli S.F.	21	Muş S.F.
4	Ankara S.F.	13	Erzincan S.F.	22	Susurluk S.F.
5	Bor S.F.	14	Erzurum S.F.	23	Turhal S.F.
6	Burdur S.F.	15	Eskişehir S.F.	24	Uşak S.F.
7	Çarşamba S.F.	16	Ilgın S.F.	25	Yozgat S.F.
8	Çorum S.F.	17	Kars S.F.		
9	Elazığ S.F.	18	Kastamonu S.F.		

production performance of sugar factories. Productivity represents the ratio of output to the input of the production process; on the other hand, efficiency is the ratio of the output acquired in some period to the maximum output acquired using the most ideal techniques. The quality and the amount of the output and input used in performance measurement also affect the decision maker performance. Consequently, it is crucial to deal with decision making units considering all the data. Production performance is accepted to be on the increase as the productivity and efficiency ratios acquired from output and input values. Although there are several ways of measuring efficiency, Data Envelopment Analysis is the most commonly used one. DEA using mathematical programming is used to measure comparative productivity. It classifies companies as “efficient” and “not efficient” according to the already determined production limit of decision making unit which uses the best techniques. As for total factor productivity, it is derived from the multiplication of variance in technology and technical efficiency. The components of variance in technical efficiency consist of the variance in pure efficiency and scale efficiency. Malmquist index is the most commonly used index to measure total factor productivity and variance in its components.

This study in which total factor productivity with its components and technical efficiency levels of 25 public sugar factories in Turkey are measured via Data Envelopment Analysis and Malmquist TFP index firstly focuses on sugar production and sugar factories. Next the study introduces Data Envelopment Analysis and Malmquist TFP index in addition to related data set. Lastly, the production efficiency of sugar factories in Turkey is analyzed with CCR output oriented model, DEA and TFP index.

Sugar factorıes ın Turkey

Approximately 350.000 farmers grow sugar beets in 350.000 – 500.000 hectares of cultivation areas (Konyalı and Gaytancıoğlu, 2012).Technology made use in sugar production in Turkey does not show any particular difference from the developed countries’ except for automation and scale size. Attempts to build a sugar factory in Turkey began in 1923. Uşak Sugar Factory, foundation of which was laid in 1925 was commissioned in 1926 along with Alpullu Sugar Factory in which the first sugar production took place. Reaching the total number of four after the commissioning of Eskişehir (1933) and Turhal (1934), the sugar factories were merged under the title of Turkish Sugar Factories Corporation (TSFC) in 1935. The corporation which has 70% lot in total sugar production has continued to operate with 25 sugar factories ever since. Today, 33 sugar factories operate in Turkey, 25 of which belong to the government, 6 to Pankobirlik and 2 to private organizations (SPO, 2001) Figure 1.

Acting upon the principles of profitability and productivity, TSFC is responsible from sugar production, sales, import/export and pricing out associated products. Aside from that, TSFC also provides necessary tools and means to its factories as well as offering fertilizers, seeds and pesticides to sugar beet farmers (SPO, 2001). Among 25 factories Malatya, Erzincan, Elazığ and Elbistan Sugar factories in Portfolio B and Kastamonu, Kırşehir, Yozgat, Turhal, Çorum ve Çarşamba Sugar Factories in Portfolio C are approved to be corporatized by Republic of Turkey Prime Ministry Privatization Administration on 29.11.2011 for 922.000.000$ fee (http://www.oib.gov.tr/program/ uygulamalar/ 2007_uygulamalar/ihalesi_tamam_imza_asamasindakiler .htm, on 09.07.2012). In this study, production efficiency and total factor productivity comparison of sugar factories in Turkey are made for 25 sugar factories in Table 1 belonging to TSFC (http://www.turkseker.gov.tr/ sekerfabrikalari.aspx on 09.07.2012).

Between 2001 and 2011, the most sugar (white sugar equivalents) producing countries were Brazil with 35.5 million tons, India with 23.9 million tons, EU with 14.5 million tons and China with 10.6 million tons. In 2010-

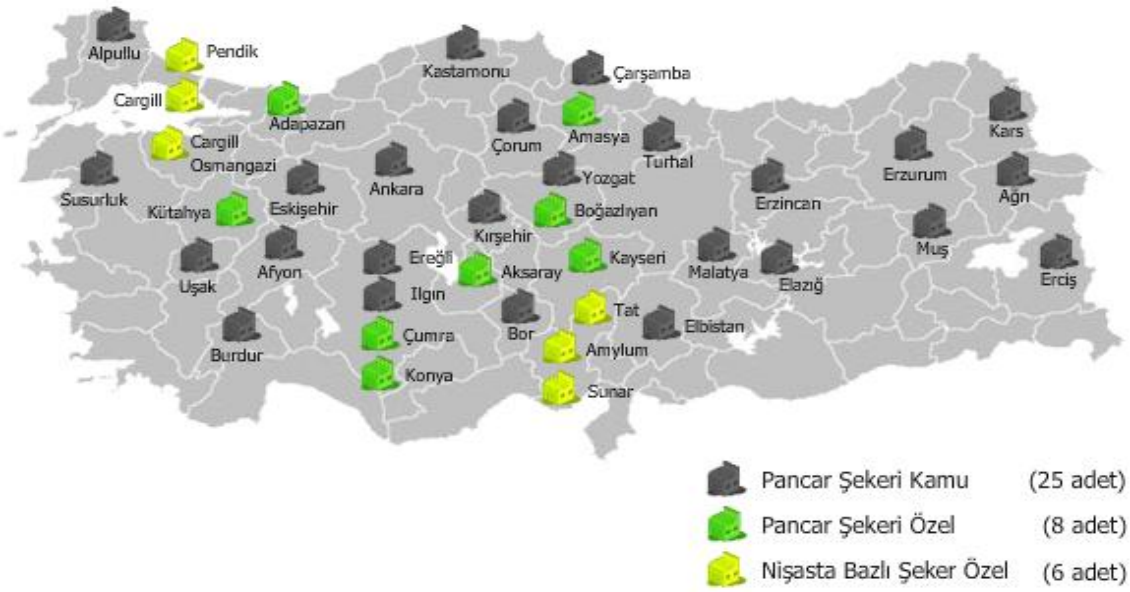

Figure 1. Sugar Factories in Turkey.

2011 saccharose based white sugar production in the world per capita per annum is 21 kg. In Turkey, two types of sugar production takes place starch based sugar production and saccharose based sugar production. As for saccharose based, beet sugar is produced while for starch based glucose syrup, isoglucose (high fructose corn syrup- HFCS) and crystal fructose are produced. Beet sugar production and domestic sales in Turkey were 2 million 531 thousand and 2 million 159 thousand tons in 2009-2010 marketing year; 2 million 262 thousand tons and 1 million 768 thousand tons in 2010-2011 marketing year. Turkey's share in world beet sugar production has been 8% since 2010-2011.

RESEARCH METHODOLOGY

Malmquist total factor productivity ındex

At first (1953) Sten Malmquist developed an index to measure standard of living in consumption analyses. However, later on Malmquist index and its variations turned out to be mainly used in production analyses. Although most of the studies focused on measuring total factor productivity (TFP) analyses, it was started to be used in other areas. Yet, in these first studies, variance in productivity was defined as technical variance. However, it was only later that it started to be used to measure efficiency variance predominantly. In this context, Malmquist Index took part in productivity related literature with Caves (1982). Malmquist Productivity Index was generated utilizing Sephard's distance functions (Mohammadi and Ranei, 2011,1970). Because Malmquist Productivity Index does not require input and output prices at hand, it is a more convenient method of measurement when the prices cannot be accessed or even known. Besides, Malmquist Index excludes presumptions like profit maximization and expenditure minimization, which is why it is also helpful for producers who have different aims and who want to use productivity measurement. Studies of Fare et al. (1989) showed that Malmquist Productivity Index can be analyzed under two components being variance in technical efficiency and variance in technology. All in all, this index has been started to be used more and more in total factor productivity analyses (Bozdağ and Atan, 2009).

Depending on the common technology, the index presents the bulk variance in total factor productivity between two points of different times by measuring distance ratio between them. In addition, the index puts forward the reasons of variance by identifying variance in productivity of multiple firms or only one firm in two different periods of time. Variance in technical efficiency is interpreted as the effect of catching production frontier; variance in technology is interpreted as the movement of the production frontier. These effects constitute the main components of variance in total factor productivity which equals the multiplication of variance in technical variance and variance in technology (Lorcu, 2010). In Malmquist Index, when output vector is given, depending on the most shrinking input vector the input distance function defines production technology proportionately. Congruently, output distance function defines production technology proportionately depending on the most expanding output vector when output vector is given (Kasap, 2010).

Output distance function could be defined as the following is S_t output set:

$$D_0{}^t = (x_t, y_t) = min\{\theta : (x_t, y_t/\theta) \in S^t\}$$

In this equation ɵ represents maximum output and is either 1 or a value higher than 1. ɵ -1 with data input shows proportional increase in output produced by ith factory. 1/ ɵ value represents technical efficiency value between 1 and 0. If (x_t ve y_t) data are above the production frontier in t time period, distance becomes $D_0{}^t = (x_t, y_t) = 1$ and thus the production is technically efficient. If $D_0{}^t = (x_t, y_t) < 1$ production in t time period is decided to be inefficient. Similarly, for t+1 time period the distance fucntion is

stated as:

$$D_0{}^t = (x_{t+1}, y_{t+1}) = min\{\theta: (x_{t+1}, y_{t+1}/\theta) \in S^t\}$$

This index measures proportional increase in output in y_{t+1} period acquired with data input in x_{t+1} period under the influence of t time's technology when we form a combined equation from the ones already mentioned. In addition, under t+1 period's technology the proportional variation in output within yt period acquired from x_t period's data input can be measured. Accordingly, Malmquist index between two periods can be expressed as the following with the condition of showing t as base year and t+1 as the following year:

$$M_0{}^{t,t+1}\left[\left(\frac{D_0{}^{t+1}(x_{t+1}, y_{t+1})}{D_0{}^t(x_t, y_t)}\right)\left(\frac{D_0{}^t(x_{t+1}, y_{t+1})}{D_0{}^{t+1}(x_t, y_t)}\right)\right]^{1/2}$$

This final equation is the geometric average of t and t+1 index. In this equation, $D0_t$ (x_t,y_t) represents the distance from the observation in t period to t period's technology. $D0_{t+1}$ (x_t,y_t) represents the distance from observation in t period to t+1 period's technology. At this stage, the only variable is technology. From aforementioned equation the following is acquired (Avcı and Kaya, 2008):

$$Variation in Technical Efficiency (VTE) = \left(\frac{D_0{}^{t+1}(x_{t+1}, y_{t+1})}{D_0{}^t(x_t, y_t)}\right)$$

$$Variation in Technology (VT) = \left[\left(\frac{D_0{}^t(x_{t+1}, y_{t+1})}{D_0{}^{t+1}(x_{t+1}, y_{t+1})}\right)\left(\frac{D_0{}^t(x_t, y_t)}{D_0{}^{t+1}(x_t, y_t)}\right)\right]^{1/2}$$

The multiplication of variance in technical efficiency and variation in technology represents the variation in total factor productivity.

VTFP= VTE*VT

If the index is above 1, total factor productivity is told to be increased between t and t+1; if the index is below 1, total factor productivity is told to be decreased between t and t+1. Data Envelopment Analysis is the most common method of estimating distance functions which are required in the generation of Malmquist total factor productivity index (Deliktaş, 2006).

Data envelopment analysis

Data Envelopment Analysis is a non-parametric technique which has been practiced more commonly lately. The spread of DEA started with the studies of Edwardo Rhodes in Carnegie Mellon University. His analysis compared the performance of curricula of schools which attended/did not attend Program Follow Through. DEA proportional equation (1978) aka CCR model (Charles, Cooper, Rhodes) spawned from the need for estimation of multiple input and output disregarding relative technical efficiency costs of 70 schools. CCR model was used according to a scale under a fixed income presumption. Later on with the studies of Banker, Charles and Cooper BCC model which expresses variable income state was formed. Both CCR and BCC models were used in the measuring of performance in two different ways which are input oriented and output oriented. Thus, DEA became a method which can explain the source of unproductiveness as well as its types. The basic aim of DEA is to state the comparative technical efficiency of different firms who make similar decisions based on the input and output observed (Kutlar et al., 2011).

DEA does not involve an analytical function. Therefore, it has the flexibility to be used in environments where there are multiple input and output. Because they are independent of measurement units of input and output (ton, liter, kg etc.), most non-parametric efficiency measurement methods are able to measure different dimensions of firms at the same time. While calculating comparative efficiency for decision making units, these measurements determine the most appropriate set for each decision making unit by optimizing objective functions separately (Altın, 2010).By setting a limit DEA analyzes the productivity for every firm based on the distance from that limit. When measuring a firm's comparative efficiency, DEA calculates ratio of weighted output to weighted input making use of input/output observed. This method offers the holism for the evaluation of multiple input/multiple output via total factor productivity reasoning which cannot be observed in traditional methods (Babacan et al., 2007).

Although DEA is adequately capable of measuring the performance of decision making units, the analysis should not be seen as an ultimate evaluation; it should be viewed as a relative operation (Altan, 2010).

The basic DEA models are CCR input oriented model, CCR output oriented model, BCC input oriented model and BCC output oriented models. While output oriented models aim to get the maximum output with the data input, input oriented models aim to get the data output with the minimum input. In other words, output oriented model states how much actual output amount can be increased pro rata without the data input set; input oriented models states how much the input used in the production can be reduced pro rata without reducing the data output amount (Deliktaş, 2006).
The mathematical formulation of CCR input oriented model can be expressed as:

$$MaxZ_0 = \sum_{r=1}^{m} u_{r0} y_{r0}$$

With these constraints:

$$MaxZ_0 = \sum_{r=1}^{m} u_{r0} y_{r0}$$

$$\sum_{r=1}^{m} u_{rj}\, y_{rj} \leq \sum_{i=1}^{n} v_{ij}\, x_{ij} j = 1,2, \ldots\ldots\ldots\ldots\ldots\ldots\ldots k$$

$$u_{r0}, v_{i0} \geq 0 \qquad r = 1, \ldots\ldots\ldots., mvei = 1, \ldots\ldots\ldots., n$$

In CCR output oriented model, for DMU_0 if $Z_0 = 1$ then DMU_0 is efficient; if not DMU_0 is inefficient. CCR model is based on fixed alternative scales assumption. If (x,y) vector can exist then (t_x,t_y) vector can also exist. BCC models in DEA, developed by Barnes, Charles and Cooper, based on flexible income depending on the scale were used later on. Input oriented BCC model can be shown as follows:

$$MaxZ_0 = \left(\sum_{r=1}^{m} u_{r0} y_{r0}\right) - \theta_0$$

Under these constraints:

$$\sum_{i=1}^{n} v_{i0}\, x_{i0} = 1$$

$$\sum_{r=1}^{m} u_{rj}\, y_{rj} \leq \sum_{i=1}^{n} v_{ij}\, x_{ij} - \theta_0 j = 1,2, \ldots\ldots\ldots\ldots\ldots k$$

$$u_{r0}, v_{i0} \geq 0 \qquad r = 1, \ldots\ldots\ldots, mvei = 1, \ldots\ldots\ldots, n$$

In BCC model for DMU_0, If $Z_0 = 1$, DMU_0 is efficient. If not then DMU_0 is inefficient (Kılıç and Akın, 2008).

Research data

In the analysis of active sugar factories in Turkey on technical efficiency, total factor productivity and variance in its components panel data of 2007-2011 Sugar Factories Corporation's Annual Activity Reports is used. The data belonging to the factories are of total production (output), labor force and capital. In the study the output variables are total amount of sugar produced (tons) and monthly profit-loss values of the factories selected; as for input variables total number of laborers and farmers who plant beets are used to represent labor force. Furthermore, to stand for capital and other intermediate goods total values of fuel consumption (tons), beet plantation area (hectares) and processed beet amount (tons) are used.

When using labor force input the total number of permanent laborers, temporary laborers and clerks are used. Total production of crystal sugar, cube sugar, refined sugar and sugar produced for export, which are used as output variables are denominated in terms of metric tons.

EMPIRICAL FINDINGS

Technical efficiency values of active sugar factories in Turkey is measured via data envelopment analysis and analyzed according to their own frontiers. In the measuring of technical efficiency and performance levels DEAP 2.1 packaged software is used. The output oriented approach, which favors maximum output with data input, is adopted when measuring technical efficiency index of the sugar factories. The reason why this method is selected is to track the possible proportional increases in the output resulted from the use of data input. Total factor productivity and the index of its components such as variance in technical efficiency and technological variance are measured via DEA using Malmquist index. Both methods in question enable the comparison of sugar factories' performance due to the size of the scales and the historical trial of the methods.

Technical efficiency ındex of sugar factories

Technical efficiency index or production efficiency measures firms' ability of producing maximum output with data input set. Technical efficiency (TE) index mathematically denominated as the ratio of actual output to maximum possible output. In other words, the rational distance to best production frontier of the decision making unit observed is denominated. The best production frontier is determined by the decision making units out of firms with the best performance of all. In the firms with the best performance technical efficiency index namely actual output/maximum output ratio equals to 1. (TE = 1). The other firms in question have their technical efficiency indices lower than 1. (TE < 1) Because technical efficiency index shows comparative efficiency, it should not be viewed as absolute efficiency.

Technical efficiency of 25 active sugar factories in Turkey is shown in Table 2. Accordingly, Afyon, Çorum and Ereğli Sugar Factories are the fully efficient sugar factories in the time of research. In addition, these three factories are observed to set the best production frontier the whole period. 22 out of 25 sugar factories could not reach the best production efficiency frontier. Kars Sugar Factory became the most efficient in production with average 0,999 technical efficiency index per annum after the aforementioned top three. On the other hand, Alpullu Sugar Factory is observed to be the least efficient with the average of 0,753 index value per annum.

Variance in TFP and its components of sugar factories

Variance in total factor productivity consists of two parts being variance in technical efficient (VTE) and variance in total factor productivity (VTFP). VTE puts forward the improvement in technical efficiency of firms' progress in getting close to the best production frontier over time or the performance displayed in reaching to the frontier. If VTE value is higher than 1 it means that the firms are able to internalize global technology by actively using it. Variance in technical efficiency index splits into two components which are variance in pure efficiency (VPE) and variance in scale efficiency (VSE). In other words, the multiplication of variance in pure efficiency and scale efficiency equals variance in technical efficiency (VPE * VSE = VTE). Variance in pure efficiency shows that existing production factors should be managed better (or worse); variance in scale efficiency, on the other hand shows whether or not a firm can produce within an optimal scale. Both VPE and VSE's being higher than 1 demonstrates improvement yet their being lower than 1 demonstrates aggravation. Furthermore, technological variance index (TV) indicates change in the best production frontier. If TV is higher than 1, that shows an increase in the frontier; its being lower than 1 shows the exact opposite, naturally. Finally, variance in total factor production index is acquired from the multiplication of variance in technical efficiency index and technological variance index (VTFP = VTE * VT).

Variance in total factor productivity index with its components of active sugar factories in Turkey is presented by years in Table 3. As mentioned already, index values' being higher or lower than 1 means either improvement

Table 2. Annual technical efficiency index values of sugar factories

Factory	2007	2008	2009	2010	2011	Average
Afyon S.F.	1.000	1.000	1.000	1.000	1.000	1.000
Ağrı S.F.	0.835	0.845	1.000	0.835	0.889	0.881
Alpullu S.F.	0.834	0.893	0.583	0.667	0.789	0.753
Ankara S.F.	0.909	0.908	0.961	0.858	0.918	0.911
Bor S.F.	0.940	0.927	0.917	0.926	0.923	0.927
Burdur S.F.	1.000	0.993	0.809	0.950	0.962	0.943
Çarşamba S.F.	0.764	0.610	1.000	1.000	1.000	0.875
Çorum S.F.	1.000	1.000	1.000	1.000	1.000	1.000
Elazığ S.F.	0.842	0.831	0.882	0.984	0.902	0.888
Elbistan S.F.	1.000	1.000	0.884	0.937	0.927	0.947
Erciş S.F.	1.000	1.000	1.000	1.000	0.983	0.997
Ereğli S.F.	1.000	1.000	1.000	1.000	1.000	1.000
Erzincan S.F.	0.971	0.967	0.955	0.930	0.962	0.957
Erzurum S.F.	1.000	1.000	0.877	1.000	1.000	0.975
Eskişehir S.F.	1.000	1.000	1.000	0.896	0.949	0.969
Ilgın S.F.	0.960	1.000	0.993	1.000	1.000	0.991
Kars S.F.	1.000	0.997	1.000	1.000	1.000	0.999
Kastamonu S.F.	0.936	0.886	0.920	0.826	0.956	0.905
Kırşehir S.F.	0.959	0.990	0.932	1.000	1.000	0.976
Malatya S.F.	0.882	0.903	0.823	0.796	0.865	0.854
Muş S.F.	0.966	1.000	0.942	0.996	0.925	0.966
Susurluk S.F.	0.993	0794	0.603	0.718	1.000	0.822
Turhal S.F.	1.000	1.000	0.916	0.939	0.957	0.962
Uşak S.F.	0.973	0.933	0.918	0.962	0.988	0.955
Yozgat S.F.	1.000	1.000	0.927	0.950	1.000	0.975
Average per year	0.951	0.939	0.914	0.927	0.956	0.937

or regression. However, if the index value period.

In 2008 9 out 25 sugar factories' variance in technical efficiency is found to be 1,000, which means no changes in production performance for those 9 factories. Similar results are observed in the years of 2009 for 5 factories, 2010 for 6, and 2011 for 8. What is more, in 2008 while 6 factories showed improvement, 10 factories showed regression. If we continue listing, in 2009 6 factories showed improvement while 14 show regression; in 2010 13 factories showed improvement while 6 of them showed regression; finally in 2011 12 factories showed improvement while 5 factories showed regression.

With regards to technological variance, 22 out of 25 factories showed improvement while 3 factories experience technological worsening conditions. In 2010, 6 factories showed improvement while 19 showed regression; in 2011, 24 factories showed improvement with only 1 exception Ilgın Sugar Factory which showed technological deterioration.

Annual summary TFP ındices of sugar factories

A summary of annual TFP indices of sugar factories is demonstrated in Table 4. Accordingly, variance in total factor productivity (5.2%((1,057 – 1,000)*100=5.2)) in 2008 indicates improvement. While 9.2% improvement in TFP is observed in 2009, in 2010 7.3% regression took place. In 2011, the final year included in this study, 18.5% improvement is observed. On the average, 6.1%TFP improvement in sugar factories is observed within this research period. 0.2% of this improvement roots from variance in technical efficiency; other 6% roots from technological advancement. Variance in pure efficiency and variance in scale efficiency is identified to be 0.1%.

Table 4 can be analyzed more clearly with the help of a chart. Figure 2 indicates the variance in productivity of sugar factories by years. The most increase is observed in 2011 hereunder.

Average Malmquist TFP ındices of sugar factories per annum

In Table 5, VTFP summary of sugar factories is presented. Sugar factories approximately showed 6% technological advancement. 19 out of 25 sugar factories improved while the other 6 regressed. Within the

Table 3. Annual indices of TFP and its components of the sugar factories.

Factory	Year	VTE	VT	VPE	VSE	VTFP
Afyon S.F.	2008	1.000	1.233	1.000	1.000	1.233
	2009	1.000	3.409	1.000	1.000	3.409
	2010	1.000	0.313	1.000	1.000	0.313
	2011	1.000	1.018	1.000	1.000	1.018
Ağrı S.F.	2008	1.012	0.975	1.014	0.998	0.987
	2009	1.183	0.975	1.169	0.012	1.153
	2010	0.835	1.035	0.847	0.985	0.864
	2011	1.065	1.060	1.064	1.001	1.130
Alpullu S.F.	2008	1.071	1.042	1.108	0.967	1.116
	2009	0.653	1.233	0.634	1.030	0.805
	2010	1.144	0.912	1.152	0.994	1.043
	2011	1.182	1.373	1.179	1.002	1.623
Ankara S.F.	2008	0.999	1.054	0.986	1.014	1.053
	2009	1.058	1.164	1.059	0.998	1.231
	2010	0.893	0.900	0.903	0.989	0.804
	2011	1.070	1.048	1.059	1.010	1.121
Bor S.F.	2008	0.987	1.079	0.993	0.994	1.064
	2009	0.989	1.180	0.987	1.002	1.167
	2010	1.010	0.866	1.006	1.004	0.874
	2011	0.996	1.056	0.996	1.000	1.051
Burdur S.F.	2008	0.993	1.059	0.993	1.000	1.051
	2009	0.814	1.194	0.814	1.000	0.972
	2010	1.175	0.819	1.177	0.998	0.962
	2011	1.013	1.050	1.013	1.000	1.063
Çarşamba S.F.	2008	0.798	1.025	0.800	0.998	0.818
	2009	1.640	1.144	1.588	1.033	1.875
	2010	1.000	1.281	1.000	1.000	1.281
	2011	1.000	2.579	1.000	1.000	2.579
Çorum S.F.	2008	1.000	1.116	1.000	1.000	1.116
	2009	1.000	1.258	1.000	1.000	1.258
	2010	1.000	0.939	1.000	1.000	0.939
	2011	1.000	1.043	1.000	1.000	1.043
Elazığ S.F.	2008	0.988	1.021	1.018	0.970	1.009
	2009	1.061	1.031	1.018	1.043	1.094
	2010	1.115	1.291	1.131	0.986	1.440
	2011	0.916	1.286	0.942	0.972	1.179
Elbistan S.F.	2008	1.000	1.309	1.000	1.000	1.309
	2009	0.884	0.478	0.893	0.990	0.423
	2010	1.060	0.888	1.055	1.005	0.941
	2011	0.990	1.045	0.987	1.003	1.035
Erciş S.F.	2008	1.000	1.010	1.000	1.000	1.010
	2009	1.000	1.036	1.000	1.000	1.036
	2010	1.000	0.910	1.000	1.000	0.910
	2011	0.983	1.002	0.991	0.992	0.985

Table 3. Cont'd

Ereğli S.F.	2008	1.000	1.511	1.000	1.000	1.511
	2009	1.000	1.374	1.000	1.000	1.374
	2010	1.000	0.741	1.000	1.000	0.741
	2011	1.000	1.089	1.000	1.000	1.089
Erzincan S.F.	2008	0.996	1.002	1.000	0.996	0.998
	2009	0.987	1.057	0.967	1.021	1.043
	2010	0.974	0.890	0.965	1.009	0.867
	2011	1.035	1.046	1.031	1.003	1.082
Erzurum S.F.	2008	1.000	1.002	1.000	1.000	1.002
	2009	0.877	1.157	0.877	1.000	1.015
	2010	1.140	0.823	1.140	1.000	0.938
	2011	1.000	1.040	1.000	1.000	1.040
Eskişehir S.F.	2008	1.000	1.141	1.000	1.000	1.141
	2009	1.000	1.249	1.000	1.000	1.249
	2010	0.896	0.805	0.970	0.924	0.721
	2011	1.059	1.067	0.988	1.072	1.130
Ilgın S.F.	2008	1.042	1.255	1.000	1.042	1.308
	2009	0.993	1.138	1.000	0.993	1.131
	2010	1.007	1.467	1.000	1.007	1.477
	2011	1.000	0.853	1.000	1.000	0.853
Kars S.F.	2008	0.997	0.857	1.000	0.997	0.854
	2009	1.003	1.165	1.000	1.003	1.169
	2010	1.000	1.360	1.000	1.000	1.360
	2011	1.000	1.171	1.000	1.000	1.171
Kastamonu S.F.	2008	0.947	1.018	0.945	1.002	0.964
	2009	1.039	1.113	1.052	0.987	1.155
	2010	0.897	0.891	0.896	1.002	0.800
	2011	1.158	1.049	1.142	1.015	1.214
Kırşehir S.F.	2008	1.032	1.083	1.031	1.001	1.118
	2009	0.941	1.197	0.952	0.989	1.127
	2010	1.073	1.154	1.054	1.018	1239
	2011	1.000	1.064	1.000	1.000	1.064
Malatya S.F.	2008	1.024	1.060	1.044	0.981	1.086
	2009	0.911	1.074	0.905	1.007	0.978
	2010	0.967	0.872	0.962	1.006	0.844
	2011	1.086	1.153	1.093	0994	1.253
Muş S.F.	2008	1.036	1.001	1.028	1.008	1.037
	2009	0.942	1.044	0.944	0.998	0.984
	2010	1.057	0.939	1.059	0.998	0.992
	2011	0.929	1.039	0.927	1.002	0.965
Susurluk S.F.	2008	0.800	1.114	0.807	0.992	0.891
	2009	0.759	1.305	0749	1.013	0.990
	2010	1.191	0.838	1.192	0.999	0.998
	2011	1.393	2.419	1.388	1.004	3.368

Table 3. Cont'd

Turhal S.F.	2008	1.000	1.097	1.000	1.000	1.097
	2009	0.916	0.611	0.939	0.976	0.560
	2010	1.025	0.889	1.010	1.015	0.912
	2011	1.019	1.053	1.022	0.997	1.073
Uşak S.F.	2008	0.958	1.012	0.956	1.002	0.969
	2009	0.984	1.088	0.978	1.007	1.071
	2010	1.048	0.888	1.032	1.015	0.931
	2011	1.027	1.046	1.025	1.003	1.074
Yozgat S.F.	2008	1.000	0.926	1.000	1.000	0.926
	2009	0.927	1.100	0.931	0.996	1.019
	2010	1.026	0.843	1.036	0.990	0.864
	2011	1.052	1.052	1.037	1.015	1.107

Table 4. Annual Malmquist TFP summary table.

Year	VTE	VT	VPE	VSE	VTFP
2007	0.985	1.073	0.987	0.998	1.057
2008	0.970	1.126	0.966	1.004	1.092
2009	1.018	0.911	1.020	0.998	0.927
2010	1.035	1.145	1.032	1.003	1.185
2011	1.002	1.060	1.001	1.001	1.061
Average	0.985	1.073	0.987	0.998	1.057

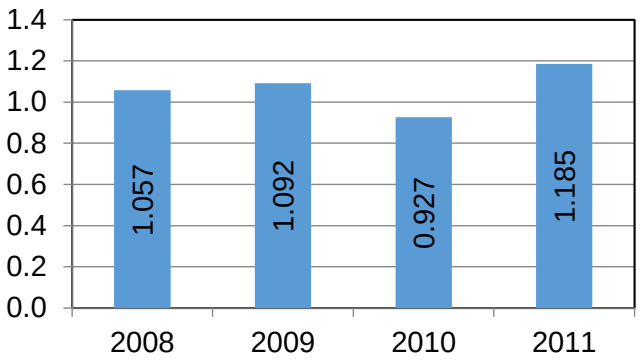

Figure 2. Average variance in Malmquist TFP per annum.

research period, Çarşamba Sugar Factory showed the most technological advancement with 40.3% followed by Susurluk Sugar Factory with 31% and Ilgın Sugar Factory with 15.7%. The most downgrade in technology is observed in Elbistan Sugar Factory with 12.7% followed by Turhal Sugar Factory with 11% and Yozgat Sugar Factory with 2.5%.

Çarşamba Sugar Factory was the factory with the most technical efficiency with 7% followed by Elazığ Sugar Factory with 1.7% and Ağrı Sugar Factory with 1.6%. Within the research period, 6 factories showed no variance in technical efficiency; 9 factories showed improvement while the remaining 10 factories showed regresson. The lowest technical efficiency is observed in Elbistan Sugar Factory. The other factories with lowest technical efficiencies were Alpullu Sugar Factory and

Table 5. Average VTFP summary ındices of sugar factories per annum.

Factory	VTE	VT	VPE	VSE	VTFP
Afyon S.F.	1.000	1.076	1.000	1.000	1.076
Ağrı S.F.	1.016	1.011	1.017	0.999	1.026
Alpullu S.F.	0.986	1.126	0.988	0.988	1.111
Ankara S.F.	1.002	1.037	1.000	1.003	1.040
Bor S.F.	0.995	1.038	0.995	1.000	1.034
Burdur S.F.	0.990	1.021	0.991	0.999	1.011
Çarşamba S.F.	1.070	1.403	1.062	1.008	1.501
Çorum S.F.	1.000	1.083	1.000	1.000	1.083
Elazığ S.F.	1.017	1.150	1.025	0.992	1.170
Elbistan S.F.	0.981	0.873	0982	0.999	0.857
Erciş S.F.	0.996	0.989	0.998	0.998	0.984
Ereğli S.F.	1.000	1.138	1.000	1.000	1.138
Erzincan S.F.	0.998	0.996	0.990	1.007	0.994
Erzurum S.F.	1.000	0.998	1.000	1.000	0.998
Eskişehir S.F.	0.987	1.052	0.989	0.998	1.038
Ilgın S.F.	1.010	1.157	1.000	1.010	1.169
Kars S.F.	1.000	1.123	1.000	1.000	1.123
Kastamonu S.F.	1.005	1.014	1.004	1.001	1.020
Kırşehir S.F.	1.010	1.123	1.008	1.002	1.135
Malatya S.F.	0.995	1.035	0.998	0.997	1.029
Muş S.F.	0.989	1.005	0.988	1.002	0.994
Susurluk S.F.	1.002	1.310	1.000	1.002	1.312
Turhal S.F.	0.989	0.890	0.992	0.997	0.880
Uşak S.F.	1.004	1.006	0.997	1.007	1.009
Yozgat S.F.	1.000	0.975	1.000	1.000	0.975
Average	1.002	1.060	1.001	1.001	1.061

Eskişehir Sugar Factory.

Figure 3 which is prepared in the light of Table 5 presents the productivity comparison of the factories. Accordingly, 18 out of 25 sugar factories in Turkey indicated improvement in total factor productivity within the research period. The other 7 factories indicated regression in TFP. The factory which indicated the most increase in factor productivity is Çarşamba Sugar Factory with 50.1%. Susurluk Sugar Factory with 31.2% and Elazığ Sugar Factory with 17% came after Çarşamba SF. On the other hand, Elbistan Sugar Factory became the factory with the least productivity with 14.3% succeeded by Turhal Sugar Factory with 12% and Yozgat Sugar Factory with 2.5%.

CONCLUSION AND RECOMMENDATIONS

Production of sugar which is an important agricultural product is an area subjected to development of financial policies because of issues related to health, export and foreign source dependency. For this very reason, increase in total factor productivity and channeling of sources to efficient areas gain importance for sugar factories. In order to develop policies to increase the performance of sugar factories first we need to determine the state of efficiency and productivity of current production units. There are many methods to measure productivity and efficiency; however, Data Envelopment Analysis, a non-parametric method of measurement, is used in this study. As for measuring variance in total factor productivity Malmquist total factor productivity index is used.

In Turkey, a total of 33 sugar factories (25 of which belong to the government, 6 to Pankobirlik and 2 to private sector) are in production currently. 25 sugar factories which operate under the status of public institution belonging to TSFC have 70% share in sugar production sector. Total production analyses of those 25 factories are included in this study. Productivity analyses of sugar factories conducted in a time when the discussions on privatization are popular are expected to

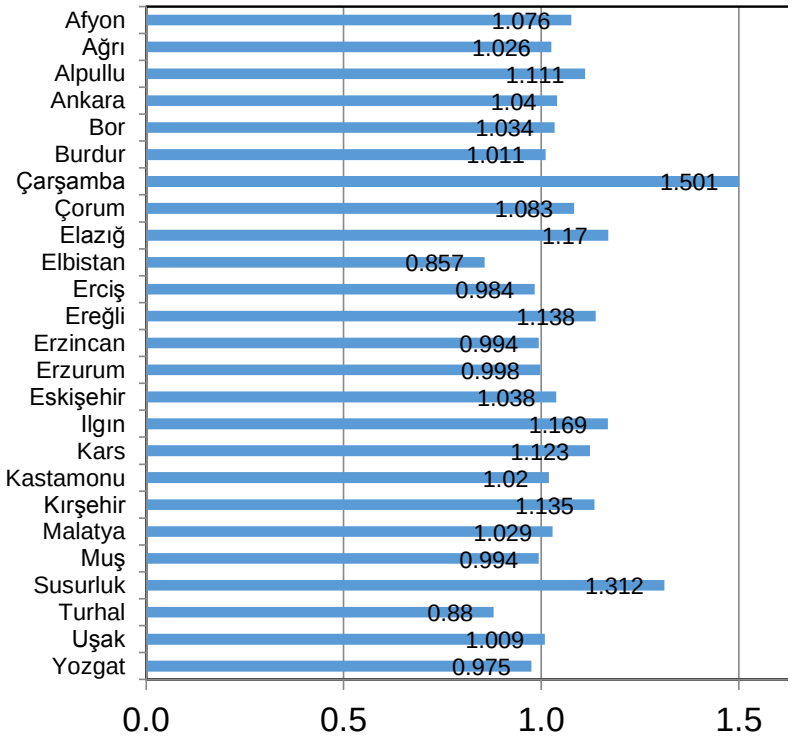

Figure 3. Average variance in Malmquist TFP per annum.

be fruitful for both politicians and academicians interested.

According to the results of this study, Afyon, Çorum and Ereğli Sugar Factories were the fully efficiency firms among the active sugar factories in Turkey. These 3 factories are also observed to be the ones that set the best production frontiers for the selected period of time. On the other hand, 22 out of 25 sugar factories could not reach the best production efficiency frontier. After those top 3 factories Kars Sugar Factory was the one with most production efficiency with 0,999 average technical efficiency index per annum; Alpullu on the other hand was the factory with lowest production efficiency with 0,753 index value.

Considering VTE values for the year 2008, production performance of 9 factories out of 25 did not change. The number of sugar factories which showed no change in production performance were observed to be 5 in 2009, 6 in 2010 and 8 in 2011. The number of factories which show progress or regression are as follows: in 2008, 6 factories showed progression when 10 showed regression; in 2009, 6 of them showed progression when 14 showed regression; in 2010, 13 factories showed progression when 6 showed regression; in 2011, 12 of the factories showed progression when 5 showed regression.

When it comes to technological variance in 2008 and 2009, 22 out of 5 factories showed progression when 3 showed regression. In 2010 6 factories showed technological progression when 19 factories showed technological regression. In 2011, all factories except for 1 (Ilgın showed regression) showed progression.

In the evaluation of total factor productivity, 5.2% improvement was observed in 2008. The percentage is identified to be 9.2% in 2009. Despite the 7.3% deterioration in 2010, in 2011 18.5% improvement took place. Within the time period selected in this study on average 6.2% TFP improvement for sugar factories was observed. 0.2% of this improvement rooted from variance in technical efficiency, the other 6% rooted from technological advancement. Variance in pure efficiency and scale efficiency showed 0.1% progression. The most increase in productivity occurred in 2011.18 out of 25 sugar factories in Turkey assured progression whereas 7 factories showed deterioration in total factor productivity in the research time. The most increase in productivity was Çarşamba Sugar Factory with 50.1% followed by Susurluk with 31.2% and Elazığ with 17%. On the other hand, Elbistan Sugar Factory was the one with lowest with 14.3% followed by Turhal with 12% and Yozgat with 2.5%.

On average, sugar factories went through 6% technological improvement. 19 out of 25 sugar factories

showed technological improvement while the rest showing deterioration. The most technological improvement occurred in Çarşamba Sugar Factory with 40,3% folllowed by Susurluk with 31% and Ilgın with 15,7%. Elbistan Sugar Factory went through the most technological deterioration with 12,7% followed by Turhal with 11% and Yozgat with 2,5%. What is important here is that in the factories where technological deterioration occurred, regression in total factor productivity was also observed. Çarşamba Sugar Factory was the one with the most variance in technical efficiency among sugar factories in Turkey. It is also observed as the one with most variance in total factor productivity and technological improvement. Elazığ (1,7%) and Ağrı (1,6%) Sugar Factories succeeded Çarşamba Sugar Factory in listing of factories most variance in technical efficiency. Within the research period, 6 of the factories' technical efficiency remained unchanged. In 9 of the factories improvement in technical efficiency was observed while in remaining 10 factories deterioration in technical efficiency occurred. The lowest variance score in technical efficiency is observed in Elbistan Sugar Factory. Alpullu and Eskişehir Sugar Factories were identified as the other factories with low scores.

In conclusion, it is obvious that betterments must be carried out for the scales of sugar factories (such as beet processing capacity). Factories presenting technological improvement should focus on policies leading for a better management of sources such as labor force, the number of farmers and hectares of plantation. In addition, Malatya, Erzincan, Elazığ, Elbistan, Kastamonu, Kırşehir, Yozgat, Turhal, Çorum ve Çarşamba Sugar Factories are on hold for privatization approval thanks to the attempts of Prime Ministry Privatization Administration. In this study, Çarşamba Sugar Factory was found to be the one with most increase in total factor productivity; whereas Elbistan, Turhal and Yozgat Sugar Factories were observed to be the ones with most regression. In this respect, the production performances of factories in question after they are privatized is also reference point for future studies which enhance the importance of current study.

Conflict of Interests

The authors have not declared any conflict of interests.

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