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Production Efficiency and Total Factor Productivity Growth in Turkish State Agricultural Enterprises

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Abstract

This paper examines the productivity performance of Turkish State Agricultural Enterprises using Data Envelopment Analysis approach. Regarding this, the paper mainly focuses on production efficiency or technical efficiency and total factor productivity growth of the enterprises over the 1999-2003 period. In the second stage of the study, we use a regression analysis to estimate the affects of potential factors influencing the production efficiency of the enterprises. The empirical results indicate that during this period, the agricultural enterprises experienced technical regress, on average, while the technical efficiency improved 1.5 percent. On the other hand, the total factor productivity decreased 1.2 percent due to 2.7 percent technical regress over the study period. Also, the results of regression estimation indicate that irrigation rate, tractor as an indicator of existing technology, and the geographic regions of enterprises are important determinants of production efficiency.

Key words: *State agricultural enterprises in Turkey, total factor productivity growth, data envelopment analysis*

Introduction

Agriculture is one of the main sectors of the Turkish economy in terms of employment and production. The shares of agricultural sector in total employment and in gross domestic product are 32.6 % and 13.4 % respectively (SIS, 2004).

In Turkey, the agricultural production is mainly provided by the individual farmers and private agricultural enterprises. However, the private enterprises are small-sized and multi-pieces. The average size of enterprise is six hectares in Turkey while the average size of enterprises is thirteen hectares in 25 EU member countries (SIS 2002). The smallness and fragmentation of agricultural holdings in Turkey may cause total factor productivity of Turkish agricultural sector is far behind that of agricultural sectors of EU countries[1]. Therefore, Turkish agricultural sector needs to be reorganized to increase level of productivity and to ensure enough and safe food for the increasing population. The agricultural incentive policies should also be continued for the farmers by the Turkish government. In this context, it is known that despite the World Trade Organization's decisions, agricultural sector has been protected and supported by the most countries in the world. The developed countries, such as many of the EU member countries, the USA, and Japan provide their farmers a direct support worth of millions of dollars from

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the government budgets apart from product prices each year (www.ceterisaribus.net/dünya/genel.html-49.korkut.boratav).

Since 2004, Turkey has implemented the direct income support program for the agricultural sector in Turkey in 2004. Also, the agricultural sector is supported by the agricultural sale cooperatives and agricultural credits are provided by Ziraat Bank. The other important supportive units in agricultural sector are the State Agricultural Enterprises (SAEs) in Turkey. There are currently total 37 sate agricultural enterprises affiliated with General Directorate of Agricultural Enterprises (GDAE) and they carry out their activities in different geographical regions of Turkey. These agricultural enterprises were originally established under the title of Agricultural Combines in 1937. Upon declaration of World War II, 14 combines were founded in different parts of the country to meet the Turkish army's need for food. Then, these combines were reorganized under the title of the SAEs in 1950 for meeting the Turkish farmers' needs for seed, breeding animal and sapling. In 1984 under the name of GDAE, they obtained the status of Economical State Organization possessing 5304 employees and a land of 3,769,037 hectares (GDAE 2003). The state agricultural enterprises play important role in providing vegetal seed and animal kept for breeding in the agricultural sector of Turkey. Turkish farmers also need approximately 877,000 tons of certified cereal seed for each year, but only 282,000 tons of seed are provided by the state enterprises. Also, the annual need for animal kept for breeding is approximately 25 thousand units in Turkey, but only 10 percent of it can be provided by the SAEs. In addition to these products, the SAEs produce fodder crops, such as sainfoin, alfalta, Hungarian cow vetches, ordinary cow vetches, and maize (Gökalp 2000). Hence, one can say that the SAEs play an important role in the Turkish agricultural sector. Therefore, studying the performance of the SAEs at the regional level gains importance as far as Turkey is concerned.

Hence, the main aim of this study is to examine the production performance of the SAEs in terms of technical efficiency, change in technical efficiency, technological change and total factor productivity change. We also estimate the possible affects of some potential factors influencing the efficiency of production of the enterprises by using regression analysis. It is known that technical efficiency and total factor productivity indices are the common criteria used in determining the production performance of the economic decision units. While the efficiency is defined as the ratio of the actual output to maximum output obtained by using the best production technigues or the willingness and ability of an enterprise to produce a maximum outout with a given input sets and technology, productivity is defined as the ratio of outputs to inputs. Total factor productivity (TFP) change is divided into two main parts, namely technical efficiency change and technological change (progress or regress). The improvements in the technical efficiency and in technological change indices comprise the main element of reaching higher economical performance level and thus gaining higher competition power. In this context, the technical efficiency improvement is an indicator of decision making unit's to adapt the global technology and therefore tells the "catch-up" part of the total factor productivity (Coelli and Rao 2003).

There exist various methods related to measuring the technical efficiency and total factor productivity change of decision-making units in the literature. Among these the most commonly used two methods are Stochastic Production Frontier Analysis (SFA) and Data Envelopment Analysis (DEA). Regarding these approaches, while the SFA uses parametric econometric methods, the DEA uses nonparametric (linear) programming methods. However, both approaches utilize the Malmquist productivity index to measure total factor productivity growth. These approaches arise from the assumption that some enterprises do not use their resources effectively. In other words, certain enterprises are making inefficient production or producing below the best-practise production frontier.

In this study, we use the DEA[2] to measure technical efficiency levels and in total factor productivity growth in state agricultural enterprise over the 1999-2003 period. The DEA has been used in many studies by Lovell (1993), Ali and Seiford (1993), Fare *et al*. (1994), Charnes *et al*. (1995), Seiford (1996), Coelli *et al.* (1998), Zaim and Taşkın (1997), Zaim and Bayaner (2001), Karadağ *et al*. (2005), and Deliktas and Balcilar (2005). There is also a substantial body of literature measuring agricultural productivity growth, such as Çakmak and Zaim (1992), Arnade (1994), Rao and Coelli (1998), Suhariyanto and Thirtle (2001), Ruttan (2002), Thirtle *et al.* (2003), Coelli and Rao (2003), Nkamleu (2004), and Deliktaş *et al*. (2005).

This paper has five sections including introduction part. Section two describes the DEA and Malmquist total factor productivity index employed in the study. Section three provides the data resources and variables that are used. Section four presents empirical findings of the study, and section five concludes the study.

Methodology

Data Envelopment Analysis

Data envelopment analysis (DEA) is a non-parametric method which was developed by Charnes et al., 1978. This method uses input and output data of enterprises to construct a piece-wise linear surface or the best-practice frontier for a given data. The frontier is constructed by the solution of a sequence of linear programming problems for each enterprise.

DEA can be either output oriented or input oriented. The input oriented DEA method seeks the maximum possible proportional decrease in input usage with a given output levels while the output oriented DEA method constructs the frontier by seeking the maximum possible proportional increase in output production with a given set of inputs. Under the constant returns to scale technology, these two methods give the same results in terms of technical efficiency index, but under the variable returns to scale technology technical efficiency index may differ (Coelli and Rao, 2003).

In this study, we used the output-oriented DEA model under the constant returns to scale[3], because we assumed that the SAEs should maximize their outputs with a given set of inputs. Following Coelli and Rao, (2003), the output-oriented DEA model for N enterprises in a particular time period can be defined as follows.

$$\begin{aligned} &\max_{\phi,\lambda} \phi, \\ &\text{st} \quad -\phi \; y_{it} + Y\lambda \geq 0, \\ &\qquad x_{it} - X\lambda \geq 0, \\ &\qquad \lambda \geq 0, \end{aligned} \tag{1}$$

where

$\mathbf{y}_i$ is a Mx1 vector of output quantities for the i-th enterprise;

x_i is a Kx1 vector of input quantities for the i-th eneterprise;
Y is a NxM matrix of output quantities for all N enterpirses;
X is a NxK matrix of input quantities for all N enterprises;
λ is a Nx1 vector of weights, which provides information on the peers of the inefficient i-th enterprise;
ϕ is a scalar.

The scalar will take value between $1\leq \phi <\infty$, and ϕ-1 indicates the proportional increase in outputs that could be produced by the i-th enterprise. Then, *1/ϕ* defines technical efficiency index, which varies between zero and one, with a value of one indicating any point on the frontier or full efficiency for the i-th enterprise.

Malmquist Productivity Indices

Data envelopment analysis uses Malmquist (1953) productivity indices based on distance functions. Distance functions can be considered as either input-oriented or output-oriented distance functions. An input-oriented distance function defines the production technology as the minimal proportional contraction of the input vector, given an output vector. However, the output-oriented distance function, given an input vector, considers a maximal proportional expansion of the output vector into consideration. In this study, we consider an output oriented distance function to determine the best-practice production frontier, because our aim is to measure the maximal increase in agricultural production, with a given input levels of the state agricultural enterprises.

By following Coelli et al. (1998) and Färe et al (1994) we define production technology at time *t*=1, …,*T*, which represents the outputs, $y_t = (y_1, \ldots, y_M)$, which can be produced using the inputs $x_t = (x_1, \ldots, x_K)$, as:

$$S^t = \{(x_t, y_t) : x_t \text{ can produce } y_t\}. \tag{2}$$

where x is a non-negative input vector $x=(x_1,x_2,\ldots.x_n)$ and y is a non-negative output vector $y=(y_1,y_2,\ldots..,y_m)$

The output distance function relative to technology of S^t can be defined as:

$$D_0^t(x_t, y_t) = \min\{\theta : (x_t, y_t / \theta) \in S^t\}. \tag{3}$$

where θ denotes scalar or maximum output. It will take a value greater than one or equal to one. $\theta - 1$ shows the proportional increase in outputs that could be produced by the i-th enterprise with given inputs and $1/\theta$ defines a technical efficiency score which varies between one and zero. Then, the distance function given equation (2) is the inverse of Farell's (1957) measure of technical efficiency, which calculates how far an observation is from the frontier of technology. Distance $D_0^t(x_t, y_t) = 1$ if and only if (x_t, y_t) is on the frontier of the technology and production is technically efficient. If $D_0^t(x_t, y_t) < 1$, production is in interior area to the production frontier of technology at t time and (x_t, y_t) is not technically efficient. Similarly, we can define output distance functions with respect to time period t+1, which is;

$$D_0^t(x_{t+1}, y_{t+1}) = \min\{\theta : (x_{t+1}, y_{t+1} / \theta) \in S^t\}. \tag{4}$$

Following Färe et al. (1994), we can express one mixed index that measures proportional change in outputs, $y_{t+1,}$ given inputs, $x_{t+1,}$ under the technology at time period t and we can also define proportional change in outputs, $y_{t,}$ given inputs, $x_{t,}$ under the technology at time period t+1. Then, the Malmquist index of productivity change between period *t* and *t+1* is defined as

$$M_0^{t,t+1} = \left[\left(\frac{D_0^{t+1}(x_{t+1}, y_{t+1})}{D_0^t(x_t, y_t)} \right) \left(\frac{D_0^t(x_{t+1}, y_{t+1})}{D_0^{t+1}(x_t, y_t)} \right) \right]^{1/2}, \tag{5}$$

where $D_0^{t+1}(x_t, y_t)$ denotes the distance from the period *t* observation to the period *t+1* technology. Efficiency and technical changes are the two components of TFP change (see Nishimizu and Page, 1982; and Färe et al., 1994, for pioneering studies) as defined below:

$$\text{Efficiency Change } (EC) = \frac{D_0^{t+1}(x_{t+1}, y_{t+1})}{D_0^t(x_t, y_t)}, \tag{6}$$

$$\text{Technical Change } (TC) = \left[\left(\frac{D_0^t(x_{t+1}, y_{t+1})}{D_0^{t+1}(x_{t+1}, y_{t+1})} \right) \left(\frac{D_0^t(x_t, y_t)}{D_0^{t+1}(x_t, y_t)} \right) \right]^{1/2}, \tag{7}$$

or

$$M_0^{t,t+1} = EC \cdot TC. \tag{8}$$

A value of $M_0^{t,t+1} > 1$ will indicate positive TFP growth from period t to period t+1 while value less than one indicates a negative TFP growth.

The efficiency change shows the relative technical efficiency change index under constant returns to scale. It measures the degree of catching up to the best- practice frontier for each observation between period t and period t+1. The efficiency change component can be decomposed into scale efficiency and pure efficiency change. The pure efficiency is obtained by re-computing efficiency change under the variable returns to scale. If the calculated efficiency levels under constant returns to scale and variable returns to scale technologies for a particular unit are different, it indicates that the unit has scale inefficiency. The scale technical efficiency can be calculated from the difference between the two technologies. Therefore, the ratio of efficiency under constant returns to scale to the efficiency under variable returns to scale gives the scale efficiency (Coelli *et a*l. (1998) and Nkamleu, 2004).

On the other hand, the technical change index, equation 7, measures the shift in the frontier of technology or innovation between two adjacent time periods. However, it does not tell us which unit actually caused the frontier to shift. In order to find out innovator enterprises, we can look at the component distance functions in the technical change index. This index tells us what happened to the production frontier at the input level and mix of each unit. Then, that unit has contributed to a shift production frontier between period t and t+1 (Fare et al. (1994). That is,

$$\begin{aligned} &TC^k > 1 \\ &D_0^t(x^{k,t+1}, y^{k,t+1}) > 1 \quad \text{and} \\ &D_0^{k,t+1}(x^{k,t+1}, y^{k,t+1}) = 1 \end{aligned} \tag{9}$$

where k denotes each decision- making unit.

The required output-oriented distance functions for the Malmquist total factor productivity index, given suitable panel data available, can be calculated using DEA-like linear programs. For the i-th enterprise, the DEA calculates four distance functions to measure the TFP change between two periods. Fare et al (1994) assume a constant returns to scale (CRS) technology t oto measure these distance functions. The required four linear programming problems for periotd t and t+1 are :

$$\left[D_o^{t+1}(x_{t+1}, y_{t+1}\right]^{-1} = \max_{\phi,\lambda} \phi$$

Subjet to $-\phi y_{i,t+1} + Y_{t+1}\lambda \geq 0$

$$x_{i,t+1} - X_{t+1}\lambda \geq 0, \quad \lambda \geq 0, \qquad (10)$$

$$\left[D_o^{t}(x_{t}, y_{t}\right]^{-1} = \max_{\phi,\lambda} \phi$$

Subjet to $-\phi y_{i,t} + Y_{t}\lambda \geq 0$

$$x_{i,t} - X_{t}\lambda \geq 0, \quad \lambda \geq 0, \qquad (11)$$

$$\left[D_o^{t+1}(x_{t}, y_{t}\right]^{-1} = \max_{\phi,\lambda} \phi$$

Subjet to $-\phi y_{i,t} + Y_{t+1}\lambda \geq 0$

$$x_{i,t} - X_{t+1}\lambda \geq 0, \quad \lambda \geq 0, \qquad (12)$$

$$\left[D_o^{t}(x_{t+1}, y_{t+1}\right]^{-1} = \max_{\phi,\lambda} \phi$$

Subjet to $-\phi y_{i,t+1} + Y_{t}\lambda \geq 0$

$$x_{i,t+1} - X_{t}\lambda \geq 0, \quad \lambda \geq 0, \qquad (13)$$

It should be noted that in the linear programs 12 and 13, the production points are compared to two different technologies, namely t and t+1. Here, ϕ does not need to be less or equal to one. The data point colud lie above the best practice production frontier.

Data

The data used in this study were obtained from 1999-2003 accounting records of 37 state agricultural enterprises. However, five enterprises were excluded from study due to lack of sufficient data. The inputs used in the analysis are labor, amortization[4] as a capital input, amount of fertilizer in thousands of metric tons, cultivatable land (hectare), seed in thousands of metric tons, annual mean rainfall in mm by district from the Meteorology department, animal feed in real value, and livestock in the beginning of each year for 32 state agricultural enterprises. Livestock includes total combined real value (base 1994) of cattle and sheep for each enterprise. Agricultural output employed in the study includes the total combined annual vegetal and animal production values in real terms (base 1994) for 32 state agricultural enterprises over the 1999-2003 period.

Data related to the possible factors that affect production efficiency of the state agricultural enterprises are ratios of irrigated land to total arable land, share of animal output to total output, and fertilizer amount to arable land, number of tractors, geographic regions of enterprises, and number of official employees used as an indicator of bureaucracy.

Empirical Results

The DEA is applied to a sample of 32 state agricultural enterprises over the 1999-2003 period. Technical efficiency and total factor productivity growth indices are obtained using the computer program DEAP 2.1 written by Coelli (1996). Table 1 shows the empirical results related to efficiency levels, total factor productivity growth components on average at the regional level.

Technical Efficiency

Annual average technical efficiency levels of the 32 state agricultural enterprises for the 1999-2003 period are given in the third column of Table 1. While an enterprise's technical efficiency index is equal to one indicate the existence of a full technical efficiency or show that this enterprise is located on the best production frontier, whereas index less than one reveals enterprise's inefficiency degree as a percentage. Technical efficiency index less than one also expresses that under present technology maximum output can not be produced with given set of inputs and then, actual output can be increased proportionally.

As can be seen from Table 1, the Marmara region, on average, has the highest technical efficiency level while the Eastern Anatolia has the lowest technical efficiency level among the regions.

Atatürk and Karacabey enterprises located in the Marmara region, Anadolu enterprise located in the Central Anatolia region, and Ceylanpınar located in the Southeastern Anatolia region have full efficiency levels. These enterprises are those determining the best-practice production frontier during the 1999-2003 period.

On the other hand, Sakarya, K.Maraş, Ulaş, Karaköy, and Altındere enterprises have the lowest technical efficiency levels regarding to their regions. Moreover, Ulaş, Karaköy and Altındere enterprises are the most inefficient enterprises among 32 enterprises.

Total Factor Productivity Growth

The total factor productivity growth index is decomposed into technical efficiency change and technical change indices. Technical efficiency change index is greater than one, then there is an improvement in efficiency or catching-up effect the best-practice frontier. On the other hand, if it is less than one then then is a deterioration in production performance of the decision making unit. The technical efficiency change is decomposed into pure efficiency and change and scale efficiency changes. The scale efficiency change index being greater one indicates the success of enterprise to produce in optimal scale, while pure efficiency change index greater one indicates that there is a learning process, as predicted by theories of intra-firm diffusion (Nkamleu, 2004).

The annual average values of total factor productivity growth components for agricultural enterprises over the study period are reported in Table 1, along with regional averages for the 1991-2003 period. The average technical efficiency change indices of 32 enterprises show that the level of efficiency has increased over the whole period. It also appears that both pure and scale efficiencies have contributed to the growth of overall efficiency.

The enterprises in the Central Anatolia, and the South Eastern Anatolia regions almost have full technical efficiency level on average. Therefore, there appears no technical improvement during the study period related to these regions. On the other hand, all of the other regions have an improvement in technical efficiency levels on average.. The Marmara and Aegean regions, which are relatively more developed regions in economic

Table 1. Annual Averages of Efficiency Levels and Total Factor Productivity Growth Components for the State Owned Agricultural Entrprises Over the 1999-2003 Period

Regions of Turkey	Name of Enterprise	Mean technical efficiency*	Technical efficiency change	Technical change	Pure efficiency change	Scale efficiency change	Total factor productivity change
Aegean	Acıpayam	0.661	1.012	0.930	1.000	1.012	0.941
Marmara	Atatürk	1.000	1.000	1.066	1.000	1.000	1.066
	Gelemen	0.936	1.101	1.657	1.101	1.000	1.824
	Gökçeada	0.870	0.922	0.956	1.000	0.922	0.881
	İnanlı	0.726	1.205	0.880	1.038	1.161	1.061
	Karacabey	1.000	1.000	0.911	1.000	1.000	0.911
	Kumkale	0.586	1.109	0.913	1.046	1.060	1.012
	Sakarya	0.512	0.971	1.013	1.039	0.934	0.983
	Tahirova	0.947	1.000	1.056	1.000	1.000	1.056
	Türkgeldi	0.595	1.166	0.977	1.083	1.077	1.138
	mean	***0.797***	***1.053***	***1.048***	***1.034***	***1.017***	***1.104***
Mediterranean	Çukurova	0.927	0.970	0.923	1.000	0.970	0.896
	Dalaman	0.858	1.118	0.997	1.118	1.000	1.115
	Hatay	0.966	1.004	1.120	1.000	1.004	1.124
	K.Maraş	0.550	0.904	1.010	0.994	0.909	0.913
	Sultansuyu	0.972	1.038	0.977	1.000	1.038	1.015
	mean	***0.792***	***1.025***	***1.013***	***1.030***	***0.994***	***1.038***
Central Anatolia	Anadolu	1.000	1.000	0.923	1.000	1.000	0.923
	Altınova	0.974	1.000	1.020	1.000	1.000	1.020
	Bala	0.593	0.862	1.059	0.977	0.882	0.913
	Gözlü	0.969	1.000	0.915	1.000	1.000	0.915
	Hafik	0.920	1.000	0.945	1.000	1.000	0.945
	Koçaş	0.943	1.024	0.986	1.000	1.024	1.009
	Konuklar	0.528	1.131	0.831	1.006	1.124	0.940
	Malya	0.590	0.991	0.993	0.997	0.994	0.984
	Polatlı	0.920	0.957	1.082	0.965	0.992	1.036
	Ulaş	0.314	1.022	0.934	1.001	1.022	0.955
	mean	***0.750***	***0.999***	***0.974***	***0.994***	***1.004***	***0.969***
Black Sea	Göhüyük	0.927	0.925	0.838	0.988	0.936	0.775
	Karaköy	0.491	0.991	0.938	1.019	0.972	0.929
	Kazova	0.754	1.062	1.159	1.000	1.062	1.231
	mean	***0.691***	***1.011***	***0.971***	***0.997***	***1.014***	***0.981***
Eastern Anatolia	Alpaslan	0.660	0.824	0.986	0.932	0.884	0.813
	Altındere	0.447	0.953	0.795	1.000	0.953	0.757
	Karabekir	0.714	1.388	0.880	1.000	1.388	1.221
	mean	***0.639***	***1.019***	***0.942***	***0.992***	***1.026***	***0.959***
South Eastern Anatolia	Ceylanpınar	1.000	1.000	0.767	1.000	1.000	0.767
General mean		***0.777***	***1.015***	***0.973***	***1.009***	***1.006***	***0.988***

Notes: * Mean efficiency level is the arithmetic mean for thirty-two state owned agricultural enterprises over the 1999-2003 period.

terms (Onder *et al*. 2006), have higher average growth rates in efficiency than the other regions.

The annual average technical change indices of the agricultural enterprises are presented in the fifth column in Table 1. Technical change index being greater than one means the upward movement of production frontier or technical progress, while its being smaller than one shows technical regress or downward movement of the best practice frontier. The annual average technological change index for 32 enterprises is measured as 0.973 over the study period. In other words, in the period concerned the annual average technological progress is negative (%2.7). However, the Marmara and Mediterranean regions have technological progress, on average.

When the enterprises are considered separately, the results show that Gelemen, Kazova, Hatay, Polatlı, Atatürk, and Tahirova enterprises experience the highest technological progress. These enterprises can also cause upward movement of production function by the method described by Fare et al. (1994).

$$TC > 1, D_0^t(x_{t+1,}y_{t+1}) > 1, D_0^{t+1}(x_{t+1,}y_{t+1}) = 1 \tag{14}$$

According to this criterion, Gelemen, Kazova, Hatay, Polatlı, Atatürk, and Tahirova are innovator enterprises that shift the best production function upward over the time period.

Total factor productivity growth is simply the multiplication of efficiency and technical change indices. These two changes constitute the total factor productivity growth index. The last column of Table 1 provides the average annual growth for the SAEs in Turkey over the study period. As can be seen from the Table 1, the total factor productivity has decreased by 1.2 percent on average. The negative annual average technical progress for 32 enterprises indicates that technical change has been the main constraint of achievement of high levels of total factor productivity growth over the study period, because improvement in technical efficiency was outweighed by technical regress.

On the other hand, the Marmara and Mediterranean regions have performed well in total factor productivity growth in agriculture. On average, the total factor productivity indices of these regions have increased by 10.4 and 3.8 percents respectively due to both improvement in technical efficiency and technical progress over the 1999-2003 period.

The Regression Analysis

An important question is which factors have impact on efficiency differentials among the state agricultural enterprises. There could be various reasons, but in this study we only consider a set of inefficiency effects variables explained in section 3. The affects of potential factors on the state agricultural enterprises' production performance is estimated by the regression method. In the regression analysis, we use the annual technical efficiency (TE) indices obtained by using the DEA for 32 enterprises as dependent variable. On the other hand, the ratio of irrigated land to arable land (RL), the number of tractors as an indicator of existing technology (TR), the share of animal production in the total production as a composition of existing technology (AP), fertilization rate of cultivatable land (FR), the number of official employees (BR) as an indicator of bureuccracy, and geographical region dummy (RG), which is 1= for Aegean, Marmara and Mediterranean regions and 0= the other regions, variables are included in the model as independent variables. The regression analysis estimated using generalized least squares (GLS) method and based on panel data (5x32=160) of 32 enterprises. It is argued that in panel data estimation, individual heterogeneity can be controlled and panel data give more informative data, more variability, less collinearity among the variables, more degrees of freedom and more efficiency (Baltagi 2003).

The estimated regression model is as follows;

$$\underset{}{TE_{it}} = \underset{(18.978)}{0.6973} + \underset{(5.015)}{0.2927}RL_{it} + \underset{(5.697)}{0.0047}TR_{it} + \underset{(0.572)}{0.0018}AP_{it} + \underset{(1.432)}{0.0124}FR_{it}$$

$$-\underset{(-4.588)}{0.0070}BR_{it} + \underset{(3.363)}{0.0890}RG_{it} \tag{15}$$

$$R^2 = 0.965 \qquad F = 718.302$$
$$\overline{R}^2 = 0.964$$

In the regression equation, the values in parentheses show t-statistics. According to this statistics most of the parameters of variables are statistically significant at 5 % significance level, apart from the parameters of share of animal production (SP) and fertilization rate. F-statistics also shows that the estimated model is statistically significant. The R-square has a quite high value and indicates that the descriptive degrees of variables are high.

From the view of economic point, the sign of the significant parameters indicates that the ratio of irrigated land to arable land, number of tractors and geographical region dummy variables influence production efficiency positively, whereas the number of official employees variable affects the production efficiency negatively. That is, the excess of the number of official employees may lead to bureaucracy and thus to production inefficiency that may occur as a result. On the other hand, the share of animal product in total agricultural product and fertilization rate variables do not affect the performance of the state agricultural enterprises.

Conclusion

In this study, the relative performance of 32 state agricultural enterprises located different regions of Turkey was measured for the 1999-2003 period. The relative performance of the agricultural enterprises, namely, technical efficiency, efficiency change, technological change and total factor productivity change indices were calculated by using Data Envelopment Analysis. Additionally, we used regression analysis to estimate the affects of potential factors influencing the production efficiency of enterprises.

The results of the study indicate that the average annual technical efficiency index for the state agricultural enterprises was less than one indicating that the enterprises generally could not produce maximum output with a given set of inputs for 1999-2003 period. However, the most enterprises that have efficiency change indices bigger than one were found successful in catching-up the best production frontier. The obtained negative annual average technical progress for the enterprises indicates that technical change has been the main constraint of achievement of high levels of total factor productivity growth for the SAEs in the study period.

On the other hand, when we examine the regions separately, the results show that the regions including various number of state agricultural enterprises have different production performances. It was found that the Marmara region, on average, has the highest technical efficiency level while the Eastern Anatolia has the lowest technical efficiency level during the study period. The Marmara and Mediterranean regions have also the best performance in regarding to efficiency improvement and technological progress, on average, while the other regions have technical regress over the 1999-2003 period. Also, the Marmara and Mediterranean regions have performed well in total factor productivity growth due to improvement in efficiency and in raising technology. On the other hand, the other regions suffered a regression in total factor productivity, on average. However, some enterprises namely, Altınova, Koçaş, Polatlı, Kazova, and Karabekir in the mentioned regions experienced growth in productivity during this period.

According to the results of regression analysis, while the ratio of irrigated land to arable land, the number of tractors, regional location, the rate of fertilized land, and the share of animal production influence enterprises' production efficiency positively, the number of employees affects it negatively.

These results have important implications for policy targeting. It is known that state agricultural enterprises differ from profit-oriented private sector enterprises with regard to essential characteristics such as to provide cheap certified seeds and breeding animals for the farmers. However, this situation doesn't change the fact that enterprises act in accordance with market conditions in regards to using their existing resources efficiently.

One can suggest that the productivity level of Turkish agricultural sector must be increased by research and development policies and also application and implementation of new production techniques by the state agricultural enterprises which have undertaken a significant mission in development of the Turkish agricultural sector.

From this point of view, while determining the new statuses of the sate agricultural enterprises irreversible mistakes should not be made. The GDAE acting responsively in this regard has been planning to rent the certain unproductive enterprises to the private sector. For this purpose, the six of the SAEs that are not productive have been put on bidding and their renting process to private enterprises still continues (www.tigem.gov.tr).

Notes

1. Malmquist total factor productivity change index is 1.098 over the 1980-2002 period for the 14 EU countries and it is 0.995 in the same period. They indicate that the EU countries' avarege annual total factor productivity growth rate is 9.8 % and Turkey's is .05% (minus) in the same period (Deliktaş et.al. 2005)
2. The major advantages of this method are that it does not impose any restriction on the functional form of production relationship and it does not require any price data Moreover, DEA can simultaneously be applied to multi-inputs and multi-outputs. One of the primary disadvantages is that DEA is highly sensitive to variable selection and data errors (Kalirajan and Shand 1999).
3. It should be stressed that the returns to scale properties of technology is very crucial in TFP measurement as far as Malmquist index is concerned. As Grifell-Tatjè and Lovell (1995) illustrated, a Malmquist TFP index might not correctly measure TFP changes when variable returns to scale (VRS) assumed for the technology. Therefore

it is important to impose constant resturns to scale (CRS) on any technology which is used to estimate distance functions regarding the calculation of Malmquist TFP index.

4. Taymaz and Saatçi (1997) were used amortization as the best representative variable of the capital.

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