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Determination of Technical Efficiency in Second Crop Maize Growing Farms in Turkey: A Case Study for the East Mediterranean in Turkey

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ABSTRACT

This study analysis the technical efficiency of sec crop maize growing farms in East Mediterranean region of Turkey. Data were collected from maize growing farms through a questionnaire study, carried out following the 2004-2005 growing season. The technical efficiency of maize farming was estimated using Data Envelopment Analysis (DEA). Technical efficiency scores were calculated using an input oriented DEA and Tobit regression analysis was used to identify determinants of technical efficiency. The average land size of the farmer is 141.13 decares. The average number of persons in the farm is 4.55; the average age of farmers is 46, an average experience is 26 years and average education level is 7.29 years. Technical efficiency was calculated as 81% in farm. The results indicate that sec crop maize farmers can reduce inputs by at least 19% while remaining at the same production level. However, Technical Efficiency (TE) ranges between 41 and 100% among the sec crop maize producers in East Mediterranean region. The greatest excesses were observed in fertilizer, machinery and labor use. Factors strongly affecting the efficiency of the farmers were found to be groups of maize harvesting area.

Key words: Technical efficiency, maize, east mediterranean, Turkey, DEA

INTRODUCTION

Maize is a plant that has been beneficial for people since ancient times. It originated from America and was distributed worldwide following the European colonization of America. It is accepted that maize was introduced to Turkey through North Africa, Syria and Egypt in the 1600's. Its use varies widely and, in addition to use as a human food, it is also used as animal feed. It is an important raw material for several industries, including starch, vegetable oil and paper. Maize hybrids can grow between 60 and 42 South meridians (Kirtok, 1997).

People living in developing countries can not reach sufficient food sources originated from animals. It causes malnutrition in those countries. In this case, people tend towards to vegetable-origin proteins such as corn. Because it provides evenly same protein content. Also it supply cheaper protein source than animal sources and it can be found in everywhere (Adeniji, 2008). Of the global maize production, 27% is used in human nutrition and 73% for animal feed. Maize is the third most extensively planted crop, after wheat and paddy. Due to the large yield per area, maize provides the largest harvest. Maize is grown more than 100.000 tons in 101 countries in the world it has the highest average grain harvest in the world (FAO, 2008).

ABD, China, Brazil, Mexico, France account for a significant proportion of maize production. Turkey has 0.4% of the harvested maize area, providing approximately 0.5% of global maize production (FAO, 2008).

In Turkey, maize is the third most important grain crop in terms of plantation size and harvest yield, after wheat and barley; in 2005, 3.9% of the total plantation area and 6.8% of the total grain harvest were estimated to be maize (Turkstat, 2009).

East Mediterranean Region produces almost half of Turkey's maize production (42-48%). Adana province has the highest maize production capacity in Turkey, followed by Sakarya, Mersin, Samsun and Osmaniye (Turkstat, 2009).

As in other countries, agricultural production in Turkey is supported or interventions are made in agricultural markets for a number of reasons, including increasing production, quality and efficiency of agricultural products; broadening the range of agricultural production; protecting producers and consumers and ensuring food safety and sustainable development. To this end, various political tools are utilized, most commonly market price support, input price subsidies, making direct payments and providing research, publication, control, infrastructure services and general services (Yeni and Dolekoglu, 2003; Tastan, 2005). While, these political tools are utilized directly or indirectly in Turkey, the most frequently policy measure is market price support.

In Turkey, maize policy was introduced in 1941 as a result of the appointment of the Turkish Grain Board (TMO). The Turkish Grain Board (TMO) regulated and supported the maize market for many years by purchasing maize. However, in the 2006/2007 marketing year, no maize purchase price was announced and no support purchases were made by TMO, as supply-demand balance was formed in the domestic market and the price was high. However, the act of providing credit to maize production is maintained by the Ministry of Agriculture and Public Affairs (Tasdan, 2007). The Turkish Grain Board paid 459 TL ton^{-1} of maize during the 2009-2010 purchase periods. The Ministry of Agriculture and Public Affairs made a premium payment of 40 TL ton^{-1} for the grain maize.

Some researchers have previously estimated the technical efficiency of maize production. Kibaara (2005) estimated the level of technical efficiency in maize production in Kenya using the Stochastic Frontier Approach. The results indicated that the mean technical efficiency of Kenya's maize production is 49%; however, this ranges from 8 to 98%. There is distinct intra and interregional variability in technical efficiency in the maize producing regions. The number of years that the farmer attended formal education, age of the household head, health of the household head, gender of the household, use or non-use of tractors and off-farm income all affect technical efficiency.

Awudu and Eberlin (2001) used a translog stochastic frontier model to examine technical efficiency in maize and bean production in Nicaragua. The average efficiency levels were 69.8 and 74.2% for maize and beans, respectively. In addition, the level of schooling (representing human capital), farming experience (represented by age) and access to formal credit contributed positively to production efficiency, while farmers participation in off-farm employment tended to reduce production efficiency. Large families appeared to be more efficient than small families. A positive correlation was identified between inefficiency and participation in non-farm employment, which suggests that farmers reallocate time away from farm-related activities, such as adoption of new technologies and gathering of technical information that is essential for enhancing production efficiency.

Seyoum *et al*. (1998) investigate the technical efficiency and productivity of maize producers in Ethiopia and compared the performance of farmers within a program of technology demonstration with that of non-participating farmers. Using Cobb-Douglas stochastic production functions, their empirical results show that farmers that participate in the program are more technically efficient, with a mean technical efficiency score of 94%, compared with those outside the project, who had a mean efficiency score of 79%.

Chirwa (2003) estimated technical efficiency among smallholder maize farmers in Malawi and identified sources of inefficiency using plot-level data. It was found that smallholder maize farmers in Malawi were inefficient; with an average efficiency score of 53.11 and 58% of the plots have efficiency scores below 60%. The results of the study reveal that inefficiency declines with plot size; on plots that used hired labor; on plots that use hybrid seeds; and with membership to a farmers club or association.

Although, a considerable number of studies were conducted on maize production and costs, most previous studies focused on farm budget analysis, production cost, policy and market (Akdemir *et al.*, 1994; Gul *et al.*, 1995; Gul and Orhan, 1998; Aktas and Oguz, 2004; Tastan, 2005). In contrast, the present study adopts a management perspective.

The objective of the present study is the measurement of technical and scale efficiency of sec crop maize growing farms in Çukurova region in Turkey. To this end, a modified input oriented DEA approach is applied to 89 farms located in the Çukurova region of Adana and Hatay provinces. The objective of this study is also to inform future policy decisions on improving sec crop maize farming efficiencies, by revealing and explaining variations in technical efficiencies of sec crop maize growing farms and determining the causes of inefficiencies.

MATERIALS AND METHODS

The data used in this study was collected through a questionnaire study from second crop maize growing farmers in two provinces of Turkey. These provinces (Adana and Hatay) account for approximately 65% of East Mediterranean Region's maize harvested area and production (Turkstat, 2008). The survey provides detailed cross-sectional information on revenues and production costs for the surveyed farms during the 2004-2005 production period. Sample farms were selected with a stratified sampling procedure. A total of 89 sec crop maize growing farms were interviewed for the analysis. Farm groups and interviewed farm numbers are given in Fig. 1.

The study used the Data Envelopment Analysis (DEA) method. There are two general approaches to measuring technical efficiency, parametric and non-parametric methods. Data

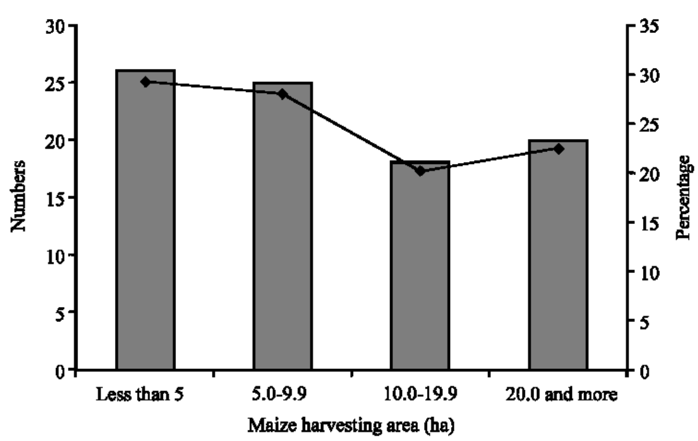

Fig. 1: Farm groups and interviewed farm numbers

Envelopment Analysis (DEA) is a non-parametric method and can easily handle multiple input and output cases. Moreover, in DEA, application inputs and outputs can have very different units of measurement without requiring any a priori tradeoffs or any input and output prices. Given these highly desirable features of non-parametric methods, it is not surprising that they have become very popular (Fousekis *et al*., 2001).

An input oriented BCC (Banker-Charnes-Cooper model) model is given below for N Decision Making Units (DMU), each producing M outputs by using K different inputs (Coelli *et al*., 1998; Dagistan *et al*., 2009; Gul *et al*., 2009):

$$\mathrm{Min}_{\theta,\lambda} \quad \theta$$

$$\text{subject to}$$

$$\begin{aligned} &-y_i + Y\lambda \geq 0 \\ &\theta x_i - X\lambda \geq 0 \\ &N1'\lambda = 1 \\ &\lambda \geq 0 \end{aligned}$$

where θ is a scalar, N1' is convexity constraint and λ is N×1 vector of constants. Y represents output matrix and X represents the input matrix. The value of θ will be the efficiency score for the ith firm. This linear programming problem must be solved N times, once for each firm in the sample. A θ value of 1 indicates that the firm is technically efficient according to the Farrell (1957) definition.

A ratio of technical efficiency scores obtained from DEA under CRS (Constant Return to Scale) and VRS (Variable Return to Scale) assumptions measures the Scale Efficiency (SE). This scale efficiency measure can be interpreted as the ratio of the average product of a firm operating at a point to the average product of another firm operating at a point of technically optimal scale. A value of scale efficiency equal to 1 implies that the farm is scale efficient and a value less than 1 suggests the farm is scale inefficient. A farm operating under decreasing returns to scale conditions means that it is operating under super-optimal conditions. On the other hand, a farm operating under increasing returns to scale is operating under sub-optimal conditions (Dagistan *et al*., 2009; Gul *et al*., 2009).

An input oriented DEA model was chosen and one output and five inputs were used in the DEA model. These are:

- **Output (Y):** Second crop maize yield per unit area (kg ha^{-1}).
- **Inputs:** (X1) pure nitrogen applied to unit area (kg ha^{-1})
- (X2) pure phosphorus applied to unit area (kg ha^{-1})
- (X3) amount of seed used in sec crop maize unit area (kg ha^{-1})
- (X4) total labor used (h ha^{-1}) in maize farming from land preparation through harvest (both family and hired labor)
- (X5) total machinery working hours (h ha^{-1})

DEA scores were estimated using the DEAP software (version 2.1), developed by Coelli (1996). Efficiency scores of the farms were calculated under constant and variable return to scale assumptions (CRS and VRS). The Tobit regression model was used to determine causes of inefficiencies after calculating DEA scores. Several socio-economic factors were regressed upon DEA VRS scores in this model. Farmer age, education level, maize harvesting areas groups, number of irrigation, number of pesticide and off-farm income were used.

DISCUSSION

Structural properties in second crop maize farming: East Mediterranean Region consists of Adana, Hatay, Icel and Osmaniye provinces and has the highest agricultural production in Turkey. Although it has only 5.3% of total agricultural land area (1.4 million hectare), the region produces 8.82% of total agricultural production value and 11.43% of total plant production value (SIS, 2003). East Mediterranean region has a surface area of 4.06 million ha, of which 34.6% (1.45 million ha) (SIS, 2003) is agricultural land. Agricultural land, compared with 32.4% agricultural usage for Turkey. The principle agricultural products of the region are wheat, cotton, citrus fruit, maize and groundnuts. Approximately 39% of the agricultural land area is irrigated.

Some socio-economic indicators of maize farms are given Table 1, in the enterprises surveyed in the present study; the average age of the maize growers was 46.54 years. There was no significant difference between the Adana and Hatay farm groups with respect to growers age and education level. The average duration of education was 7.29 years. The average family size in the surveyed households was 4.55 people. There was no significant difference between the farm groups with respect to demographic characteristics. Of this family size, 53% were men and 47% were women (Table 1). The major crops grown on the surveyed farms were wheat, maize and cotton.

Particularly after the 1960's, the increased use of water in agriculture led to increases in harvest and production and allowed increased variety in production. With the Sec Crop Project, implemented by the Turkish Ministry of Agriculture in 1982, maize agriculture in the region increased while cotton plantations decreased. Most of the producers who gave up cotton production started to grow maize and soya beans. In the fields under observation, the number of maize plantation fields has increased since 1985. The region has a production advantage compared to other regions in terms of the use of good quality seed.

The study results showed that growers use chemical fertilizer 2.02 times during the production period. Nitrogen fertilizer (250.48 kg ha^{-1}) and P fertilizer (28.32 kg ha^{-1}) were applied during June, July and August.

Most maize land in the region is irrigated by irrigation channels. In the surveyed area, the frequency of irrigation was 5.6 times during the maize production period. Irrigation was generally used from June through August.

Table 1: Socio-economic characteristics of farmers growing second crop maize

Input/output variables	Average
Average population on farm (persons)	4.55
Male	53%
Female	47%
Head of farm: Duration of education (years)	7.29
Head of farm: Maize growing experience (years)	25.82
Farmer age (years)	46.54
Enterprises' land area (decares)	141.13
Agricultural Income from Farming (YTL)	188.14
Off-farm Income (YTL)	387.64

Table 2: Summary statistics for variables used in the efficiency analysis

Input/output variables	Min.	Max.	Mean	SD
Outputs				
Maize yield (kg ha^{-1})	4000.00	14728.68	7341.16	1631.22
Iuputs				
Fertilizer-N (kg ha^{-1})	14.04	970.00	250.48	182.57
Fertilizer-P (kg ha^{-1})	4.26	333.33	75.66	59.87
Seed-kg ha^{-1})	22.50	35.00	29.64	2.50
Labor (h ha^{-1})	3.91	126.67	28.32	31.60
Machinery operating time (h ha^{-1})	2.63	60.00	11.25	10.05

Table 3: Frequency distributions of technical efficiency scores obtained with DEA model

	DEA		
Efficiency scores	CRS	VRS	SE
1.00	8	16	8
0.90-1.00	6	16	20
0.80-0.90	11	40	29
0.70-0.80	28	15	17
0.60-0.70	16	2	4
0.50-0.60	9	0	9
0.40-0.50	9	0	2
<0.40	2	0	0
Minimum	0.31	0.68	0.41
Maximum	1.00	1.00	1.00
Mean	0.72	0.88	0.81
Standard deviation	0.17	0.08	0.15

It was observed that spraying for weeds was not common, but hoeing was a very common treatment for weeds. The average number of pesticide applications was 1.1 times.

When coefficients of variations are taken into consideration, it is clearly seen from Table 2 that the greatest variations are in fertilizer, seed and pesticide use. Those large variations may be an indicator of mismanagement problems.

The research findings indicate that, in the region, there is much greater use of fertilizers than the recommended amount. Also research organizations suggest to use 180-240 kg ha^{-1} nitrogen (Anonymous, 1994). It is seen that rates of fertilizer application vary greatly between producers. Communicating the study findings to agricultural producers and providing information about the appropriate application of fertilizers may affect the attitude of the producers. In comparison, it can be seen from Table 2 that producers act more consciously in utilizing agricultural machinery, seed and labor resources.

Technical efficiency of farms: The results of the input oriented DEA analysis are given in Table 3. The results show that 8 farms under CRS and 16 farms under VRS were found to be fully efficient. Two farms under CRS showed a performance below 0.40. Predicted technical efficiencies differ among sample farms, ranging between 0.41 and 1.00, with a mean technical efficiency of 0.81 (Table 3). These results indicate that there are some opportunities for improving resource-use efficiency. The surveyed farms may reduce their inputs by an average of 19% while achieving the

Table 4: Farm characteristics with respect to returns to scale

Characteristics	No. of farms	Maize planting area (ha)	Yield (kg ha^{-1})	Mean gross return (TL ha^{-1})
Sub-optimal	78	12.57	7165.27	2116.26
Optimal	8	29.68	8840.67	2612.00
Super-optimal	3	10.97	7915.56	2366.38

Table 5: Input slacks and number of farms using excess inputs

Input	No. of farms	Mean slack	Mean input use	Excess input use (%)
Fertilizer-N (kg ha^{-1})	39	56.57	250.48	22.58
Fertilizer-P (kg ha^{-1})	63	25.26	75.66	33.38
Seed (kg ha^{-1})	5	0.07	29.64	0.23
Labor (h ha^{-1})	28	9.11	28.32	32.17
Machinery operating time (h ha^{-1})	50	3.29	11.25	29.22

same production level. Considering the enterprise performing at minimum efficiency, the results suggest that a saving of 39% will be achieved in input use on condition that this enterprise becomes active. For the inefficient farms, the causes of inefficiency may be either inappropriate scale or misallocation of resources. Inappropriate scale suggests that the farm is not taking advantage of economies of scale, while misallocation of resources refers to inefficient input combinations. Since, mean scale efficiency of the sample farms is relatively high (0.88), it can be concluded that inefficiencies are mainly due to improper use of inputs rather than inappropriate scale.

The mean scale efficiency of the surveyed sec crop maize farms is 0.81. Of the 89 sec crop maize enterprises, 8 show constant returns to scale, 78 show increasing returns to scale. There are 3 farms practicing under decreasing returns to scale conditions. The characteristics of optimal, sub-optimal and super-optimal farms are given in Table 4. As seen from Table 4, there are great differences between maize yield per ha and mean gross return per unit.

Excess use of inputs: Following the Data Envelopment Analysis, it was found that enterprises functioned at an average efficiency level of 88%. That is to say, it was determined that enterprises could reduce their inputs by an average of 12% in the present condition.

It was found that 63 of the examined enterprises make excessive use of phosphor (average level 33.38% excess), 50 enterprises make excessive use of machine power (average 29.22%), 39 apply excessive nitrogen (average 22.58%), 28 employ excess labor (average 32.17%) and 5 enterprises use seed excessively (average 0.23%) (Table 5).

Determinants of technical efficiency: VRS DEA technical efficiency scores were regressed on farm specific characteristics in order to identify sources of inefficiencies. Since, efficiency scores range between 0 and 1, a two-tailed Tobit model was employed in place of OLS regression (Ray, 2004). The results of the Tobit regression analysis are given in Table 6.

The area used for sec crop maize was found to have a positive effect on efficiency. This parameter is statistically significant at the 5% level.

Number of pesticide application is expected to have an adverse effect on efficiency, due to pesticide cost associated increases in the total cost and also increase in machinery and labor use. As expected, this parameter was found to have a negative effect, but the effect is not significant at the 5% level.

The number of irrigation applications also has a negative sign, as expected, although this parameter is not significant at the 5% level.

Table 6: Results of tobit model for efficiency scores

Variable	Coefficient	Std. error	Z-score	Significance
C	0.857833	0.037676	22.76866	0.0000
Maize area groups	0.023404	0.009333	2.507645	0.0122
No. of pesticide applications	-0.031681	0.022145	-1.430642	0.1525
No. of irrigation applications	-0.017452	0.015337	-1.137887	0.2552
Farmer age	0.000069	0.000059	1.171195	0.2415
Education level	-0.000518	0.000573	-0.903213	0.3664
Off-farm income (TL)	0.001069	0.002661	0.401704	0.6879
R-squared = 0.266583				
Adjusted R-squared = 0.203202				

Farmer's age is not statistically significant even at the 10% level. This parameter has a positive sign.

Formal education of the farmer was found to have a negative effect on efficiency, but this parameter is not statistically significant.

The relationship between education and efficiency is the topic of many scientific studies conducted on efficiency. While, some researchers have reported that the relationship between efficiency and education is positive, others found that the relationship is negative or there is no relationship at all. Bravo-Ureta and Evenson (1994) found, in a study conducted in Paraguay, that there was no significant relationship between education and efficiency. In a study to determine the efficiency of wheat producers in the Southeastern Anatolia Region of Turkey, Alemdar and Oren (2006) determined that education has a negative impact on technical efficiency.

In an efficiency study conducted on maize producers in Cameroon, Binam *et al*. (2004) found that the level of formal education was not closely related to efficiency. Kumbhakar *et al*. (1989) reported a positive relationship between the educational status of dairy operators in Utah and the efficiency of the enterprises. Similarly, Huang and Kalirajan (1997) determined that the efficiency of enterprises increased as a result of higher educational levels among managers of maize and rice enterprises in China. In a study of the efficiency of dairy plants in England, Bravo-Ureta and Rieger (1991) found a positive but non-significant relationship between education and efficiency. It is remarkable in the examined studies that the relationship between education and efficiency is not generally strong in the developing countries. Off-farm income was found to have a positive effect on efficiency, but this parameter is not significant at the 10% level.

This study aimed to provide estimates of the technical efficiency of sec crop maize production enterprises in the East Mediterranean region of Turkey and to explain variations in technical efficiency between farms. The results indicate that mean technical efficiency is 81%. Therefore, there is a 19% scope for increasing maize production by using the present technology. However, Technical Efficiency (TE) ranges between 41 and 100% among the sec crop maize producers in East Mediterranean region. The greatest excesses were observed in fertilizer, machinery and labor use. All these excesses adversely affect technical efficiencies of second crop maize farming. Inefficiencies indicate a sub-optimal use of these inputs. In the light of these results, choosing a crop pattern appropriate for the soil type and appropriate use of agricultural inputs is one of the topics to be highlighted in terms of sustainability. In order to promote more sustainable forms of agriculture, producers should be informed about the conservation of scarce sources and the optimal use of chemical or resource-intensive inputs.

In similar studies carried out on this issue, the variation in technical efficiency was found to be 50% (for instance; in corn enterprises operating in the Jimma Zone region, in Southwest Ethiopia). Accordingly, specific differences were detected between the enterprises in terms of their technical efficiency in access to animal ownership, participation in additional programs and access to infrastructure. Therefore, it was suggested that improving farmers' (in Jimma region) access to infrastructure can increase the technical efficiency of corn production (Yilma and Berg, 2001). In corn enterprises operating in the Local Government Area of Ogbomoso South in Oyo state (Nigeria), total variation due to technical inefficiency was found to be 13% (Oyewo *et al*., 2009). The technical efficiency of Himachal agricultural enterprises in the North West Himalayan Region was calculated by using a frontier production function. Technical inefficiency in corn production was calculated to be 35-42%. In addition, efficiency in the use of seed, male workforce and the use of chemical and farm fertilizers gradually increased. The study therefore emphasised that it was of the utmost importance to train the female workforce in the principles of resource management (Sharma *et al*., 2008). In corn enterprises operating in the Chitwan region of Nepal, fertilizers represented the biggest share among the production costs, followed by workmanship and tractor costs. Moreover, the number of school years per household and corn production land per household was found to have positive effects on the cost efficiency of the corn enterprises. Scale impact analysis of the specialized corn production enterprises showed that production increase drastically exceeded the total costs and, in turn, yield increased according to the scale of the enterprise (Paudel and Matsuoka, 2009).

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