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Full Length Research Paper

Assessing the efficiency of hazelnut production

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This study investigates production efficiency of hazelnut farmers located in the Carsamba Plain, Samsun-Turkey. A sample of 78 farmers was selected by a two-stage sampling process. Data Envelopment Analysis and Tobit Regression Analysis found that production efficiency of the hazelnut farmers ranged from 26.1 to 100.0%, with an average of 73.5%. This level of technical efficiency is consistent with the technical efficiency found in other studies of crop production in developing countries. Nevertheless, 70.5% of the hazelnut farms are using inputs inefficiently. A statistically significant positive relationship between a farmer's education and a farm's technical efficiency underscores the need for public investment in rural education to improve the efficient use of inputs. A statistically insignificant relationship between farm size and a farm's technical efficiency implies that education programs should be available to all farmers regardless of the size of their farm. Moreover, the statistically significant relationship between farm fragmentation and efficiency is consistent with the importance of land consolidation program.

Key words: Data envelopment analysis, technical efficiency, hazelnut, Turkey.

INTRODUCTION

Turkey is the world's leading hazelnut producer, account-ing for 73 and 70% of total world production and exports, respectively, in 2005 (FAO, 2007). It is followed by Italy with 14% of world production and 15% of world exports.

About 60% of Turkey's crop is produced in the Eastern Black Sea Region, 15% is produced in the Central Re-gion and the remaining 25% is produced in the Western Black Sea Region. Hazelnut production is the largest source of income for 61% of the 400,000 farm families in the Black Sea region (Gonenc et al., 2006; Kilic, 1997).

Due to the socio-economic importance of the hazelnut, it was included in farm support programs in 1961. Under this program, Fiskobirlik (Hazelnut Agricultural Sale Co-operatives) bought hazelnut at prices well above the world market prices. In response to the high support price, farmers expanded the area planted to hazelnut. The resulting increases in production, along with the negative impact of high prices on demand lead to an ac-cumulation of stocks of hazelnut. In 2000, the Agricultural Reform Project (ARIP) replaced the high price support program with a Direct Income Payment system (DIS). Hazelnut prices declined to the level of world prices and their variability increased. As a result, the role that prices, and thus markets, play in allocating resources increased.

As the role of markets increases, the role that produc-tion efficiency plays in a firm's survival also increases. Many studies have examined production efficiency, both in developed and developing countries settings (see, for example, Coelli, 1995; Fraser and Cordina, 1999; Zaibet and Dharmapala, 1999; Shafiq and Rehman, 2000; Tzouvelekas et al., 2001). A few studies have examined the efficiency of agribusiness firms and farms in Turkey (Zaim and Cakmak, 1991; Yolalan, 1993; Zaim and Cakmak, 1998; Demirci, 2001).

Given the importance of hazelnut production in Turkey, the increasing reliance on markets to allocate resources, and the lack of studies of hazelnut crop production efficiency in Turkey; this study examines the efficiency of hazelnut production in Turkey. The general methodology of this investigation is discussed in the next section, fol-

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lowed by a discussion of the specific methodology used, Data Envelopment Analysis. Next, the data are discussed and analytical results are presented. The paper ends with conclusions and implications for hazelnut production in Turkey and Turkey's farm policy.

METHODOLOGIES FOR ANALYZING PRODUCTION EFFICIENCY

The two most commonly used empirical methodologies for examining production efficiency are (1) Stochastic Frontier Analysis (SFA) (Aigner et al., 1977; Meeusen and van den Broeck, 1977) and (2) Data Envelopment Analysis (DEA) (Charnes et al., 1978). Both techniques are based on Farrell's (1957) seminal paper, and estimate a production frontier boundary. Efficient farms are located on the frontier. Inefficient farms are located inside the frontier boundary because they generate less output than is technically feasible given their level of inputs.

SFA estimates a single regression plane through the data, thus generating a production function (Khan and Maki, 1979; Battese and Coelli, 1995; Parkih and Shah, 1994; Shafiq and Rehman, 2000). The estimated parameters of the production function are used to calculate the average efficiency of the farms that compose the study's data set. In contrast, DEA uses mathematical programming techniques to generate a maximum performance measure for each farm relative to a composite farm derived from all other farms in the data set that lie on or within the frontier (Charnes et al., 1978; Yin, 1998; Sharma et al., 1999). Thus, DEA provides an assessment of each farm's technical performance, whereas SFA provides an assessment of the "average" farm's technical performance (Yin, 1998).

Several authors have evaluated these techniques in the context of agricultural production (Battese, 1992; Bravo- Ureta and Rieger, 1991; Coelli, 1995). The SFA approach permits statistical tests of hypothesis, but both the functional form of the production function and the distribution of the error term must be known. If either is unknown, the non-parametric DEA approach has an advantage because it avoids the statistical problems that can arise from assuming an incorrect functional form or error term distribution. Given the lack of previous studies to assist in specifying the appropriate production function and error term distribution for hazelnut production in Turkey, DEA is chosen for this study.

Empirical model

This discussion of DEA models is brief, and technical detail is limited. For extensive discussions and technical details, see Charnes et al., 1978; Seiford and Thrall, 1990; Lovell, 1993; Ali and Seiford, 1993. DEA first estimates an envelopment surface using data from all farms in the data set. Two basic types of envelopment surfaces can be estimated. One is referred to as a Constant Return to Scale surface (CRS); the other is referred to as a Variable Return to Scale (VRS) surface (Charnes et al., 1978; Banker et al., 1984).

The performance of each farm then is evaluated relative to the envelopment surface. The measure of relative farm performance is called Global Technical Efficiency if a CRS surface is estimated (Iraizoz et al., 2003) and Pure Technical Efficiency if a VRS surface is estimated (Llewelyn and Williams, 1996; Iraizoz et al., 2003). When estimating a CRS surface, farms are assumed to be operating at their optimal level of scale. However, it is widely recognized that several factors, including imperfect competition and financial constraints, can cause farms to operate at less than their optimal scale (Coelli, 1996). If farms are not operating at scale efficiency, Global Technical Efficiency will likely be measured with error (Coelli, 1996). The possibility can not be ruled out that the hazelnut farmers surveyed for this analysis are not operating at scale efficiency. Thus, a VRS surface is estimated and Pure Technical Efficiency is measured.

Pure Technical Efficiency (PTE) of a decision-making unit, in our case a farm, is calculated by solving the following model:

$$Min_{\theta,\lambda}\ \theta_j \quad s.t. \qquad (1)$$

$$\sum_{j=1}^{78} y_j\lambda_j \ge y_j \qquad (1a)$$

$$\sum_{i=1}^{4} X_{ij}\lambda_j \le X_j\theta_j \qquad (1b)$$

$$\sum_{j=1}^{J} \lambda_j = 1$$

$$\lambda_j \ge 0,$$

$$X_I, Y_J \ge 0 \qquad (1c)$$

yj is the amount of hazelnut produced by examined farm j; Xij is the amount of input i used by examined farm j. There are 78 farms in the sample; information is available for 4 inputs. Those are fertilizer, labor, active capital and working capital. j is farm j's weight used to develop the composite farm based on all farms in the sample. Farm j's performance is measured against the composite farm. Constraint (1a) states that the hazelnut production associated with the composite farm (yj) is at least as large as the hazelnut produced by examined farm j. Constraint (1b) states that the weighted average of inputs associated with the composite farm ($Xj\ j$) is no larger than the amount of input i used by examined farm j.

j is farm j's PTE score (Iraizoz et al., 2003) . It is less than or equal to 1, with 1 indicating that the farm lies on the VRS envelopment surface. A PTE score of 1 means that the farm is technically efficient and can not reduce its observed combination of inputs without reducing its output of hazelnut. A PTE score of less than 1 indicates that the farm is technically inefficient. This PTE score can be interpreted as the amount by which the farm can reduce its combination of inputs while still producing the same level of output. For this study, the statistical package used to obtain the PTE scores is FRONTIER Analyst (Version 2.0.0).

Survey design and data collection

The data used in this study were collected from farmers located in the Carsamba Plain, Samsun Province, Turkey, during the summer of 2007. This area was selected for several reasons. Hazelnut is

Table 1. Sampling parameters, Carsamba plain, Turkey, 2007.

Farm size (ha)	Farmers sampled
0.1 - 2.5	42
2.6 - 5.0	23
5.1+	13
Total	78

SOURCE: Original calculations using data from survey, Carsamba Plain, 2007.

the dominant crop, accounting for 90% of the total crop area (Kilic et al., 2005). Moreover, input and output markets, soil types, production techniques, and agricultural infrastructure are generally homogeneous across farms. Using one year sample means that the data could be affected by abnormal weather conditions. However, there was no abnormal climatical event during the summer of 2007 in the Carsamba Plain. An average yield of hazelnut for Carsamba county was 1070 kg/ha between 2001 and 2007. In our sample farm data for hazelnut yield was 973 kg/ha (SIS, 2009).

A two-stage sampling process was used. In stage one, a random sample of 13 villages was selected out of a population of 124 villages. The 13 villages were home to 1250 hazelnut producers. In stage two, 78 farmers were chosen for interviews using a stratified random sampling design. The farms were stratified by three farm size categories: 0.1 - 2.5 hectares, 2.6 - 5.0 hectares, and greater than 5.0 hectares. The number of farms sampled in each size category is reported in Table 1.

A wide range of socio-economic and business characteristics were elicited in the interview. They included labor usage, fertilizer usage, active capital, working capital, farm size, number of parcel, farm operator's education, age and experience.

The variation in yield and input use among the 78 surveyed farmers is sufficiently large to permit an analysis of production efficiency (Table 2) . The mean yield of hazelnut was 973 kg/ha, with range from 127 to 2000 kg/ha. Among the four inputs for which information was collected, the ratio of the standard deviation to the mean was smallest for labor at 0.31 and highest for working capital at 0.95.

EMPIRICAL RESULTS

The distribution of PTE scores for the 78 sampled farms is presented in Table 3. The average PTE score was 73.5%. A PTE score of 100% was obtained for 29.5% of the farms. Thus, 70.5% of the hazelnut farms were technically inefficient. The lowest PTE score was 26.1%.

Since to the authors' best knowledge no study of hazelnut farm efficiency exists, results from this study are compared with results from studies of other crop farms in developing countries. PTE scores of 90% or higher were found for 40% of cotton farms in Pakistan's Punjab (Shafiq and Rehman, 2000), 48% of horticultural farms in Oman (Zaibet and Dharmapala, 1999), and 14% of rice farms in Bangladesh (Coelli et al., 2002). In comparison, this study found that 38.5% hazelnut farms had a PTE score of 90% or higher. Thus, technical efficiency of Turkey's Carsamba Plain hazelnut producers is comparable to the technical efficiency found for other crop farms in developing countries.

Results from the DEA can be used to determine how much a farm's Pure Technical Efficiency can be improved by reducing a given input while maintaining the same level of output. The survey collected information for four inputs: working capital, active capital, fertilizer, and labor. On average for the surveyed farmers as a group, their use of each of the four inputs can be reduced between 24 and 29% while maintaining the same level of output (Table 4).

Two approaches have been used to analyze the relationship between firm specific attributes and production efficiency. One approach is a two-step procedure. First, the efficiency scores are estimated; then these scores are regressed against the firm specific attributes (Sharma et al., 1999). Kalirajan (1991) and Ray (1988) advocate this procedure. The second procedure, advocated by Kumbhakar et al. (1991) and Battese and Coelli (1995), involves incorporating the firm-specific attributes directly into the estimation of the production frontier. The primary argument for the second approach is that firm specific attributes directly impact efficiency. The primary disadvantage of the second approach is that it requires a priori knowledge of whether the attribute has a positive or negative relationship with technical efficiency (Sharma et al., 1999; Coelli et al., 2002).

Given the lack of a priori knowledge of whether the examined farm attributes have a positive or negative relationship with the technical efficiency of hazelnut production, the two-step procedure is used. Moreover, results from the two-step procedure are more straightforward to interpret, especially for policy decision-making (McCarty and Yaisawarng, 1993; Yu, 1998).

The firm specific attributes most often analyzed in previous studies (Khan and Maki, 1979; Aly et al., 1987; Lockheed et al., 1980; Alemdar and Oren, 2006) were the size of the farm, the farmer's education, the farmer's age (or experience), and number of land parcels owned. Information on each of these attributes was collected for this study.

The following regression equation is used to examine the relationship between farm-specific attributes and PTE:

$$PTE_j = \alpha_0 + \alpha_1 z_{j1} + \alpha_2 z_{j2} + \alpha_3 z_{j3} + \alpha_4 z_{j4} + \omega_j \quad (2)$$

PTE_j is farm j's Pure Technical Efficiency score. z_{j1}, z_{j2}, z_{j3}, and z_{j4} are the independent variables, representing, respectively, farm size, number of land parcels owned, farmer's education level, and farmer's age. Farm size is measured as the number of hectares farmed. Farmer's education level is measured as a dummy variable, with 1 assigned to farmers with a high school degree and 0 assigned to farmers less than high school degree. Because

Table 2. Characteristics of hazelnut production among hazelnut farmers, Carsamba Plain, 2007.

Input/output variable	Minimum	Maximum	Mean	Standard deviation
Hazelnut yield (kg/ha)	126.6	2000.0	973.3	330.4
Active capital	26029.0	317105.7	59722.0	35004.6
Working capital	38.9	23037.5	4179.1	3976.4
Labor (hours/ha)	265.8	1832.6	1049.8	321.8
Fertilizer (kg/ha)	20.0	300.0	98.0	62.1

Source: Original calculations using data from survey, Carsamba Plain, 2007.

Table 3. Distribution of farm level measures of pure technical efficiency for hazelnut production, Carsamba plain, 2007.

Pure technical efficiency (%)	Number of hazelnut farms	Share of total sampled farm (%)
100	23	29.5
90.0 - 99.9	7	9.0
80.0 - 89.9	7	9.0
70.0 - 79.9	5	6.4
60.0 - 69.9	12	15.4
50.0 - 59.9	6	7.7
< 50.0	18	23.0

SOURCE: Original calculations using data from survey, Carsamba Plain, 2007.

Table 4. Potential improvement in pure technical efficiency of producing hazelnuts by reducing an input while maintaining output, Carsamba Plain, 2007.

Input	potential improvement in pure technical efficiency (%)
Working capital	28.7
Active capital	24.4
Fertilizer	24.0
Labor	24.0

SOURCE: Original calculations using data from survey, Carsamba Plain, 2007

Because PTE ranges in value from 0 to 1, a censored two-limit Tobit model, with limits of 0 to 1 is estimated (Table 5).

Previous studies have found no consistent empirical relationship between farm size and a farm's technical efficiency. They have found a positive relationship (Aly et al., 1987; Bagi, 1982; Sharma et al., 1999; Iraizoz et al., 2003) , no conclusive relationship (Bravo-Ureta and Riger, 1991; Iraizoz et al., 2003), and an inverse relationship (Berry and Cline, 1979; Townsend et al., 1998; Grabowski et al., 1990). This study found a positive rela-tionship between farm size and PTE score, but it was not statistically significant at the five percent test level. A two-sided test was used given the mixed empirical evidence from previous studies.

The ownership of more than one parcel of land, or land fragmentation, is common in both the study area and Turkey. Lerman (2005) and Alemdar and Oren (2006) found that land fragmentation was associated with a statistically significant lower level of technical efficiency for farm production in Georgia and wheat production in Turkey, respectively. The rationale given for the finding was that land fragmentation limits the benefits from mechanize-tion. This study also found a negative relationship between

Table 5. Tobit Regression Analysis of factors associated with pure technical efficiency of producing hazelnut, Carsamba plain, 2007.

Variable and summary statistic	Coefficient	Standard error	t-value
Farm Size	0.00334	0.00297	0.26
Number of Parcels	-0.11847*	0.06106	1.94
Farmer's Education	0.02268*	0.01244	1.82
Farmer's Age	0.00214	0.00553	0.70

Notes: *indicates significance at the five percent test level.
SOURCE: Original calculations using data from survey, Carsamba Plain, 2007.

between land fragmentation and technical efficiency. It was statistically significant at the five percent test level. A one-tail test was used since a negative relationship was hypothesized a priori.

Education usually is postulated to have a positive influence on technical efficiency because education partly determines a farmer's stock of human capital (Lockheed et al., 1980). The greater is the stock of human capital, the better a farmer's ability to organize the factors of production for maximum efficiency (Huffman, 1977). Previous empirical studies support this conceptual argument (see for example, Huffman, 1974, for the United States; Belbase and Grabowski, 1985, for Nepal; Pinheiro, 1992, for the Dominican Republic; and Kalirajan and Shand, 1985, for the Philippines). This study also found a statistically significant positive relationship between a farmer's education level and the farm's PTE score at the five percent test level. Given the expected a priori positive relationship, a one-sided test was used.

The a priori relationship between a farmer's age and technical efficiency is indeterminate. Older farmers have acquired more human capital through their experiences, but they also may be less willing to adopt new ideas. Consistent with an indeterminate a priori relationship, findings from previous empirical studies are mixed. For example, Abdullai and Huffman (1998) found that older rice farmers in Northern Ghana were less efficient than younger farmers while Coelli et al. (2002) found that younger rice farmers in Bangladesh were more efficient than older rice farmers. This study finds that age was statistically insignificant at the five percent test level. Given an indeterminate a priori relationship, a two-sided test was used.

Summary, conclusions and policy implications

Data Envelopment Analysis was used to analyze the production efficiency of a sample of 78 hazelnut farmers located in the Carsamba Plain of Samsun Province, Turkey. On average, these surveyed farmers could achieve the same level of output while reducing their use of the four inputs examined in this study, working capital, active capital, fertilizer, and labor; by 24 to 29%. This finding suggests that educational programs to improve production efficiency potentially can improve the profits earned by hazelnut farmers.

Consistent with other studies, a statistically significant and positive relationship is found between a farmer's education and a farm's technical efficiency. The consistency of this finding underscores the need for public investment in rural education. Melor (1976) argued that this investment is a key strategy for improving not only farm productivity but also societal welfare.

A statistically insignificant relationship was found between the size and technical efficiency of a farm at the five percent test level. This finding, especially when combined with the mixed findings of previous studies concerning the relationship between farm size and technical efficiency, implies that education programs should not be targeted at specific farm sizes. Instead, education programs should be available to all farmers regardless of the size of their farm.

A statistically significant and negative relationship at the five percent test level was found between the number of parcels in a farm and the farm's technical efficiency. This finding suggests that the land consolidation program implemented in the South Eastern part of Turkey should be extended to Turkey's Black Sea region.

The scope of this study is limited. It investigates only the efficiency of hazelnut production in the Carsamba Plain of Turkey. Results of efficiency studies for a given area also can vary from year to year because of the variability in farm production due to climatic conditions. These limitations point to the need for additional analyses of different crops, different years, and different regions in order to examine the robustness of the findings of this study.

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