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Efficiency and its determinants in the agro-food industry of Samsun Province, Turkey

Mehmet Bozoğlu[a]*, Bekir Mazgal[b], Vedat Ceyhan[a]

[a]*Ondokuz Mayıs University, Faculty of Agriculture, Department of Agricultural Economics, 55139 Atakum, Samsun, Turkey,* [b]*Forestry and Water Affairs, Regional Directorate of Meteorology, 60200 Tokat, Turkey*
*Sorumlu yazar/corresponding author: *mehmetbo@omu.edu.tr*

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ABSTRACT
The aim of this study is to explore efficiency and its determinants in the agro-food industry in Samsun Province, Turkey. Using data collected from 49 firms, the data envelopment analysis method was used to estimate efficiency measures. The results of efficiency analysis reveal that the mean technical, allocative, and cost efficiencies are 0.90, 0.89, and 0.81, respectively. However, the results indicate that the inefficient firms would have had to lower costs by 19% to perform as well as other similar firms. Having a brand, applying marketing strategies, and establishing cooperation positively influence on the economic efficiency. However, there is a negative relationship between capacity use ratio and the efficiency. To enhance the efficiency in the agro-food industry, decision makers should focus on sound management, preventing unproductive investments and overcapacity, encouraging trademarking, market research, and ensuring cooperation among the agro-food firms.

Keywords:
Agro-food industry
Data envelopment analysis
Determinants of inefficiency
Efficiency analysis
Samsun
Turkey

Samsun İlinde tarıma dayalı sanayide etkinlik ve etkili faktörler

ÖZET
Bu çalışmanın amacı, Türkiye'nin Samsun İlindeki tarıma dayalı sanayide etkinlik ve etkili faöktörlerin araştırılmasıdır. Etkinlik sınırları, 49 firmadan elde edilen veriler kullanılarak ve veri zarflama yöntemi uygulanarak ölçülmüştür. Etkinlik analizi sonuçları, ortalama etkinlik, dağıtım etkinliği ve ekonomik etkinliğin sırasıyla 0.90, 0.89 ve 0.81 olduğunu ortaya koymaktadır. Bununla birlikte, etkinlik analizi etkin olarak çalışmayan firmaların benzer nitelikteki etkin firmalara göre maliyetlerini %19 oranında azaltabileceklerini göstermektedir. Ticari markaya sahip olunması, pazarlama stratejisinin uygulanması ve diğer firmalarla işbirliğine gidilmesi, ekonomik etkinliği pozitif olarak etkilemektedir. Buna karşın, kapasite kullanma oranıyla ekonomik etkinlik arasında negatif bir ilişki söz konusudur. Tarıma dayalı sanayi işletmelerinde ektinliğin artırılması için, iyi yönetişim, verimsiz ve aşırı yatırımların önlenmesi, ticari markalaşmanın teşvik edilmesi, pazar araştırmaları, tarıma dayalı firmalar arasında işbirliğinin sağlanması konularına odaklanılmalıdır.

Anahtar Sözcükler:
Tarıma dayalı sanayi
Veri zarflama analizi
Etkinsizliğin belirleyicileri
Etkinlik analizi
Samsun
Türkiye

1. Introduction

Agro industry is a crucial sector, especially for developing economies in which many agricultural crops may not undergo necessary processing or be utilized locally because of insufficient capacities in agro-food industries (Gurler et al., 2000). Agro-food firms also play an important economic role in buying from domestic markets and settling in rural areas for proximity to input markets.

Due to the importance of the agro-food industry, there have been increasing numbers of studies in Turkey. Thus, the effects of agro-industry on agricultural production had been examined in Turkey (Çetin, 1993; Şengül, 1998; Şengül and Erkan, 1999). Arıkbay (1993) assessed prevailing technology levels and changes in the industry, a topic also investigated by Bingöl (1992) who focused on the vegetable oil industry and technological developments at the national level. From the perspective of policy, Gülse (1996) and Tuncer (1989) investigated Turkey's agro-industrial policies and their effects on the sector.

Several studies have also looked at the structural, financial, and marketing characteristics at local, regional, and sub-sectoral scales (Aksoy and Inan, 1996; Altın and Orhan, 1999; Azabağaoğlu et al., 2003). One region of particular interest is that encompassed by the Southeastern Anatolia Project (GAP), which has considerable development possibilities (Tuncer, 1989; Karlı and Çelik, 1998; Karlı et al., 1999; Karkacier et al., 2001; Karlı, 2002). At more local levels, studies have described the current situation and problems, as well as presented proposals related to the flour, milk, fruit, hazelnut, and dairy processing industries (Tuncer, 1989; Karlı and Çelik, 1998; Aksoyak et al., 1999; Karlı et al., 1999; Karkacier et al., 2001; Karlı, 2002; Azabağaoğlu et al., 2003).

Some studies have also investigated efficiency and productivity, generally based on classic measures for agro-industry. For example, Tarıkahya (1991) compared productivity and technical features among flour factories, Bingöl (1992) examined input use and productivity problems of the vegetable processing industry in the Aegean and Marmara regions and later revealed (Bingöl, 1993) input problems and partial and total factor productivity in the fruit processing industry, Demirci (2001) analyzed performances and total factor productivity in sugar factories. Several studies have also addressed efficiency and (or) competitiveness in the agro-food sector of different countries (Apezteguía and Garáte, 1997; Doucouliagos and Hone, 2000; Oustapasidis et al., 2000; Margono and Sharma, 2006; Sena, 2006; Pérez et al., 2007; Van der Vlist et al., 2007; Latruffe, 2010; Putićová and Mezera, 2011; Reddy and Bantilan, 2012; Furesi et al., 2013). However, no previous studies have examined firm-level economic efficiency and its determinants within Turkey's agro-food industry.

Clarifying firm and subsector-level economic efficiency and its determinants can help in the design of appropriate policy measures aimed at improving the productivity of Turkey's agro-food industry through improving efficiency. With this in mind, our objective are to calculate the firm-level economic efficiency of agro-food industry in Samsun, to identify important factors causing efficiency differentials among those firms, and to infer policy implications based on the economic efficiency scores and their determinants.

This paper is organized as follows. Section 1 describes the scope of this paper as well as its place and importance within the related literature. Section 2 presents the data and the data envelopment model , and Section 3 discusses the research results. Section 4 reveals the conclusions.

2. Materials and Methods

This study was conducted in Samsun Province, located on the northern Black Sea coast of Turkey. Agricultural sector is of great importance in Samsun economy. Agricultural sector accounts for 52.5% of total employment and 8.5% of GDP. Samsun encompasses an area of 957.900 ha and 39.1% of which (374.226 ha) is cultivated land (Altındeğer, 2015) . Only 24.3% of the arable land is irrigated. In Samsun, there are 104.000 farms and their average land is 4.4 hectares. About 40% of agricultural land consists of low plains. These plains give huge production potentials to the province. Samsun has a mild climate, with an average temperature of 14.2 ^{0}C and average annually rainfall of 664.9 mm. Because of convenient arable land and climate conditions, crops range and production potential are very high in the research area. Cereals, fruits and vegetables cover 40.9%, 25% and 8.6% of the cultivated land, respectively. The common agricultural crops grown are hazelnut, wheat maize, rice, oil seeds and tobacco (Altındeğer, 2015). In respect to settlement and agricultural land, Samsun province is more appropriate for agro-food investments than other provinces in the region. However, industry sector has not been developed enough in the region. There were 3.251 enterprises in the industry sector of Samsun and they employed 10.457 people. The sub-sector of food, beverage and tobacco consists of 15.6% of the enterprises and 27.6% of employment (GS, 2011). Thanks to common agricultural produce, agro-food industry for flour, hazelnut, rice, milk, sugar and tobacco has been established in the province.

There are totally 73 private agro-food factories (23 rice, 19 flour, 17 hazelnut, 6 milk and 2 fodder processing factories, 6 tea and legumes packaging factories) which obtain their inputs directly from agricultural sector. The agro-food industry consists of completely small and medium enterprises (SMEs) and their marketing activities limited generally at local or regional levels. These SMEs have generally low productivity and profitability levels. The 9th Development Plan of Turkey aims to realize rural development by developing agro-food industry and using resources efficiently. Therefore, in order to make agricultural sector efficient, it is expected to encourage integration between agriculture and industry sectors (GNAT, 2011). Samsun province is one of the priority provinces for realizing economic development of the country. The agro-food industry was also determined by the Province Development Strategy as a leading sector for economic development. Considering other sector, agro-food industry has a high employment creation and development potential (GS, 2011). Agro-food industries are labor intensive sector and need less capital than other industries. Developing of agro-food industry can provide important contributions to regional development by increasing contract farming, orienting farms to markets and decreasing marketing problems, processing agricultural crops, creating adding value and migration from rural areas. Therefore, it is important to explore that whether the agro-based industries run effectively and, if not, what reasons for the inefficiency.

To calculate efficiency measures, the data envelopment analysis (DEA) was used to define efficiency in a relative sense as the distance between observed input–output combinations and a best-practice frontier. DEA is one of several techniques that can be used to calculate a best practice production frontier (Coelli et al., 1998; Kumbhakar and Lovel, 2000). The Farrell input-orientated measure of efficiency was used as a measure of efficiency. Farrel (1957) proposed that the efficiency of a firm consists of two components: "technical efficiency" (TE), which reflects the ability of a firm to obtain maximal output from a given set of inputs, and "allocative efficiency" (AE), which reflects the ability of a firm to use the inputs optimal proportions, given their respective prices and the production technology. These two measures are then combined to provide a measure of "economic efficiency" (EE). The Farrell measure equals 1 for efficient firms on the frontier and then decreases with inefficiency.

Based on the suggestion by Charnes et al. (1978), we assumed that each agro-food firm gains income (Y_i) using multiple inputs (x_i^*) and that each firm (*i*) can set its own set of weights for both inputs and output. The input-based cost efficiency for the *i*-th firm can be obtained by solving the following linear programming (LP) problem:

$$Minimize_{\lambda, xi^*} \quad w_i^T x_i^*$$

$$Subject\ to \quad -y_i + Y\lambda \geq 0, \quad x_i^* - X\lambda \geq 0, \quad \lambda \geq 0, \tag{1}$$

where w_i is a vector of input prices for the *i*-th agro-food industry firm, superscript *T* is the transpose function, and x_i^* is the cost-minimizing vector of input quantities for the *i*-th agro-food firm calculated by LP, given input prices w_i and output level Y_i and λ is a Nx1 vector of constant. Eq. (1) represents cost minimization under constant returns to scale (CRS) technology. The total cost efficiency or economic efficiency (EE) of the *i*-th agro-food firm is calculated as:

$$EE = w_i^T x_i^* / w_i^T x_i \tag{2}$$

where EE is the ratio of the minimum cost to the observed cost for the *i*-th firm, given input prices and CRS technology. Coelli et al. (1998) showed that the allocative efficiency was calculated residually as:

$$AE = CE / TE \tag{3}$$

Coelli et al. (1998) noted that the CRS model is only appropriate when a firm is operating at an optimal scale. However, factors such as imperfect competition and financial constraints may lead to operation at a non-optimal scale. Many of the studied agro-food firms had been operated under the conditions of imperfect competition and size and fell below the borrowing limits set by financial institutions in the research area; thus, Eq. (1) was transformed to a variable returns to scale (VRS) technology model by adding the convexity constraint $N1\lambda = 1$, which eliminates scale effects from the analysis (Banker et al., 1984). Then, the efficiency of the firm was calculated by using Eq. (2), replacing the numerator with the minimum cost of the firm under VRS technology. The TE scores can be decomposed into two components: “pure technical efficiency (PTE)”, which reflects the ability of a firm to obtain maximal outputs at an optimal scale, and “scale efficiency (SE)”, which reflects the distance of an observed firm from the most productive scale size. Scale efficiency is the ratio of the minimum cost of the firm under CRS technology to the minimum cost under VRS technology. Efficiency measures under CRS and VRS were calculated using the DEAP 2.1 program developed by Coelli (1996). We chose a two-stage approach to explore inefficiency determinants. A Tobit regression of DEA economic efficiency estimates on potential determinants was conducted, because the efficiency estimates were truncated at 0 and 1. The Tobit model is given as follows:

$$Y_{ij} = \beta_0 + \sum_{i=1}^{N} \beta_i X_i + u_i \ if u_i > -\beta_0 - \sum_{i=1}^{N} \beta_i X_i \tag{4}$$

$$Y_{ij} = 0 \qquad if \quad u_i \leq -\beta_0 - \sum \beta_i X_i ,$$

where Y_{ij} represents measures of economic efficiency for agro-food firm j, X_i represents explanatory variables that influence the economic efficiencies of the firms, N is the number of explanatory variables, and β and u are parameters of the model and random error term, respectively (Ramanathan, 1998).

The data used in the study were collected via personal interviews with the agro-food firms in Samsun Province. Out of 59 rice, flour and hazelnut processing factories, we interviewed with 49 agro-food processing enterprises (20 rice, 17 flour, and 12 hazelnut factories) that were privately owned and obtained their inputs directly from agricultural sector.

Economic efficiency was modeled by a multiple input and single output framework. Output value in dollars was used to measure output, assuming the existence of a perfectly competitive market structure. Some previous empirical studies have similarly used the monetary value as the dependent variable (Aigner et al., 1977; Battese and Coelli, 1988). The efficiency analysis included four inputs which are labor (annual working units, AWU), energy cost ($/year), working capital ($/year), and covered area of the firm (m^2).

The variables included in the Tobit analysis can be divided into three broad groups: personal characteristics of the operators (education and experience), firm characteristics (type of ownership, capacity use ratio, ratio of family labor, existence of marketing strategies, existence of a working plan, percentage of firms planning new investment, percentage of making market research), and access to institutions (credit use, existence of research and development [R&D] investment, and existence of cooperation). Type of ownership was represented by values of 0 and 1, reflecting ownership by individuals or a corporation, respectively. Other dummy variables were as follows: having a brand (having=1, not having=0), applying marketing strategies (applying=1, not applying=0), conducting market research (conducting=1, not conducting=0), planning future investment (planning=1, not planning=0), having R&D investment (having=1, not having=0), and establishing cooperation (cooperating=1, not cooperating=0).

3. Results and Discussion

The basic characteristics of sample agro-food firms were given in Table 1. The agro-food firms had output values of $19 million, on average, with the minimum being $0.4 million and the maximum $51 million. To reach that level of output value, the firms used approximately 35 AWU of labor, $42,220 of energy, $18 million of working capital per year, and 1310 m2 of covered area. Costs of labor and buildings amounted to $5.99/h and $270/$m^2$, respectively. The interest rate was taken as 0.26 for

Table 1. Descriptive statistics of variables used in the DEA and Tobit models

Variables	Mean	St. deviation	Minimum	Maximum
DEA model				
Output ($ million/year)	19.26	3.00	0.40	111.11
Labor (AWU)	35.27	27.66	8.00	120.00
Energy cost ($1000/year)	42.22	102.82	3.70	666.67
Working capital ($ million/year)	17.78	27.86	0.41	111.11
Area covered by the firm (1000 m^2)	1.31	0.91	0.22	4.50
Tobit Model				
Personal characteristics				
Education level of operators (year)	9.53	3.70	5.00	15.00
Experience of operators (year)	13.71	6.42	1.00	28.00
Firm characteristics				
Type of firm ownership (%)	57.06	-	-	-
Capacity use ratio (%)	37.00	25.00	9.00	100.00
Existence of marketing strategies (%)	22.00	-	-	-
Firms planning new investment (%)	28.80	-	-	-
Firms making market research (%)	40.70	-	-	-
Access to institutions				
Credit use ($1000/year)	625.11	1416.44	2.96	4444.45
Existence of R&D investment (%)	15.30	-	-	-
Existence of cooperation (%)	28.60	-	-	-

monetary inputs in the data envelopment model. While firm operators generally had low education levels, they had moderate levels of experience in their works. Most of the firms were owned as a company and had considerably low capacity use ratios. Approximately 41% of the firms conducted market research. However, only 22% of the firms applied marketing strategies, and only 29% of the firms planned their future investments. Levels of R&D investment and cooperation were also low, as was credit use, which averaged approximately $625,000.

Table 2 presents efficiency measures for the agro-food firms. The efficiency analysis indicated that overall economic efficiency ranged from 0.56 to 1, with an average of 0.81 and standard deviation of 0.12. On average, inefficient firms would have needed to lower costs by 19% to perform as well as the best-practice firms. The hazelnut firms showed higher economic efficiency than the flour firms ($p < 0.05$). The differences between rice and hazelnut and flour firms were not statistically significant (*p*s > 0.05). While the most efficient firms were in the hazelnut processing sector, excessive capacity was also occurred in this sector. In the 2004–2005 marketing season, hazelnut prices and profitability increased because of low yield and administrative high prices. However, insufficient and weak organization of the firms affected efficiency negatively.

The relative levels of allocative and technical measures indicate that the primary source of economic inefficiency was allocative. Almost 90% of the firms were allocatively inefficient. These firms employed the wrong input mix, given input prices, so that their costs were 11% higher than the cost-minimizing level. No statistically significant difference was observed between sectors in terms of

Table 2. Efficiency measures for the agro-food firms

Efficiency measures	Rice (n = 20)		Flour (n = 17)		Hazelnut (n = 12)		Average (n = 49)	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Overall	0.811^{ab}	0.126	0.758^{a}	0.110	0.883^{b}	0.079	0.810	0.118
Allocative	0.875^{a}	0.077	0.906^{a}	0.064	0.913^{a}	0.084	0.895	0.075
Technical	0.927^{b}	0.087	0.837^{a}	0.096	0.967^{b}	0.041	0.905	0.096
Pure technical	0.751^{a}	0.090	0.756^{a}	0.105	0.940^{b}	0.068	0.799	0.122
Scale	0.810^{a}	0.111	0.903^{b}	0.118	0.972^{b}	0.055	0.882	0.120

Note: The different letters above the mean of efficiency measures reflect that there is statistically significance differences among the sub-sectors at the 5%.

allocative efficiency scores ($p > 0.05$). The estimated technical efficiency measures for the firms varied from 0.67 to 1, with an average of 0.91. This result suggests that the firms could reduce their input use by 9% without a reduction in output value. For 63% of the firms, the technical efficiency coefficient was higher than the mean. The technical efficiency measures for rice and hazelnut firms were statistically higher than that of flour firms ($p < 0.05$; Table 2). While Apeztequía and Gárate (1997) found that the efficiency levels vary from 0.68 to 0.93 for Spanish agrofood industry, Doucouliagos and Hone (2000 estimated technical efficiency scores as relatively high levels (0.83-0.97) for Australian dairy processing industry in the period of 1970-1996. However, Yodfiatfinda et al. (2012) estimated the average technical efficiency scores of constant return to scale and variable return to scale for the large scale enterprises of the Malaysian food processing industry in the period of 2000-2006 as 0.68 and 0.95, respectively. Decomposition of the technical efficiency measures showed that pure technical inefficiency resulted from management failures that was the primary cause of technical inefficiency. Pure technical efficiency averaged 0.799 (Table 2), while scale efficiency averaged 0.88 with a standard deviation of 0.12. Pure technical efficiency in hazelnut firms was higher than that in rice and flour firms.

Table 3 provides descriptive statistics of the scale-related variables such as output value, firm size, working capital, energy cost, labor use, and capacity use ratio. Scale-efficient firms had larger output values and working capital. Analysis of the individual firms indicated that 14% had constant returns to scale (CRS), whereas 78% had increasing returns to scale (IRS), and 8% had decreasing returns to scale (DRS), on average. Rice firms showed IRS, while half of the hazelnut firms had CRS and the other had half IRS. Among the flour firms, IRS was common, with only two having CRS. In addition, the scale-efficient firmsused less labor and energy than the DRS firms.

Table 3. Summary of returns to scale results for the agro-food firms

Variables	Sector											
	Rice (n = 20)			Flour (n = 17)			Hazelnut (n = 12)			Average		
	IRS	CRS	DRS	IRS	CRS	DRS	IRS	CRS	DRS	IRS	CRS	DRS
Number of firms	20	–	–	12	2	3	6	6	–	38	7	4
Output (million $/year)	1.50	–	–	3.02^{a}	19.26^{b}	18.52^{b}	53.33*	74.07*	–	10.37^{a}	65.93^{b}	22.22^{a}
Area covered by firm (1000 m^2)	0.80	–	–	1.15^{a}	2.65^{ab}	2.87^{b}	1.79	1.58	–	1.07^{a}	1.47^{a}	3.28^{b}
Working capital ($ million/year)	1.39	–	–	2.83^{a}	17.03^{b}	17.04^{b}	50.37	69.63	–	9.63^{a}	60.00^{b}	20.74^{a}
Energy cost ($1000/year)	10.44	–	–	28.76^{a}	353.70^{b}	187.65^{ab}	17.53*	23.21*	–	17.35^{a}	25.71^{a}	307.41^{b}
Labor (AWU)	12.95	–	–	29.50^{a}	75.00^{b}	74.00^{b}	57.50*	66.33*	–	25.61^{a}	61.14^{b}	85.50^{c}
Capacity use ratio (%)	0.16	–	–	0.40^{a}	0.71^{b}	0.74^{b}	0.27	0.28	–	0.25^{a}	0.30^{a}	0.81^{b}

[1]The different letters above the figures reflect that there is statistically significance differences among the return the scales (IRS, CRS, and DRS).
*indicates that there is a difference between the firms having increasing returns to scale and the firms having constant returns to scale at the 10% significance level.

Table 4 presents the results of the Tobit model on the relationship between economic efficiency and its determinants. The likelihood ratio test statistic, which tested the hypothesis that all variables included in the model were statistically nonsignificant, was rejected at the 1% level. All variables evaluated in the "firm characteristics" group, with the exception of future investment and the capacity use ratio, had positive signs. The coefficient of applying marketing strategies was positive, indicating that firms that applied marketing strategies were more efficient than those that did not ($p < 0.05$). Likewise, the positive result for having a brand implied that those firms tended to be more efficient ($p < 0.01$). The capacity use ratio had a negative sign, implying that firms with lower capacity use ratios were more efficient ($p < 0.05$). However, the variables of ownership type, conducting market research, and future investment were not statistically significant ($p > 0.10$). The education level and experience level of the operator indicated that more educated and more experienced operators were more efficient than the others. However, neither of the variables was statistically significant ($p > 0.10$). Lachaal et al. (2004) revelad also that an increase in the share of skilled labor contributes to higher efficiency levels of production in the Tunisian agrofood firms.

All variables related to institutional groups positively influenced economic efficiency. For example, the coefficient for cooperation with other institutions suggested that this practice increases firm efficiency ($p < 0.05$). Using credit and having R&D investment were also associated with greater efficiency, although these variables were not statistically significant ($p > 0.10$).

Table 5 presents a comparison of efficiency measures between economically efficient and inefficient firms based on survey results. The results of comparative efficiency analysis showed that economically efficient agro-food industry firms had much higher output values and relatively high levels of working capital ($p < 0.01$). In addition, a relatively high percentage of efficient firms had a brand and applied marketing strategies and established cooperation with other firms ($p < 0.10$). The efficient firms had also lower energy costs and lower capacity use ratios compared to the inefficient firms ($p < 0.10$).

Table 4. Efficiency determinants in the Tobit model

Variable	Estimated coefficient	Standard error
Personal characteristics of operators		
Education level of operators (years)	0.437	0.601
Experience of operators (years)	0.421	0.333
Firm characteristics		
Type of firm ownership (%)	0.196	0.443
Capacity use ratio (%)	–0.323*	0.152
Firms having a trademark (%)	0.172**	0.483
Firms applying marketing strategies (%)	0.884*	0.445
Firms conducting marketing research (%)	0.468	0.491
Firms planning new investment (%)	–0.141	0.616
Access to institutions		
Credit use ($1000/year)	0.175	0.311
Firms investing in R&D (%)	0.111	0.103
Firms establishing cooperation (%)	0.123*	0.517
Log likelihood	26.559**	

* and ** denote that the parameters are statistically significant at the 5% and 1% levels, respectively.

Table 5. Differences between economically efficient and inefficient agro-food firms

Characteristics	Economically efficient firms (n = 5)	Economically inefficient firms (n = 44)
Personal characteristics of operators		
Education level of operators (years)	8.60 (3.29)*	9.14 (3.75)
Experience of operators (years)	14.80 (6.60)	13.59 (6.54)
Operators knowing a foreign language (%)	–	9.00
Firm characteristics		
Output ($ million/year)***	59.13 (53.17)	14.61 (23.17)
Labor (AWU)	44.80 (23.50)	34.18 (28.11)
Energy cost ($1000/year)*	25.03 (13.92)	44.18 (68.36)
Working capital ($ million/year)**	52.76 (49.59)	13.73 (21.88)
Firm size (m^2)	1360.00 (694.98)	1300.45 (942.38)
Type of firm ownership (number of companies/total firms)	40.00	59.00
Capacity use ratio*		
Ratio of family labor	0.30 (0.99)	0.31 (0.12)
Firms having a trademark* (%)	0.04 (0.04)	0.06 (0.08)
Firms applying marketing strategies* (%)	100.00	75.00
Firms following a working plan (%)	80.00	75.00
Firms planning new investment (%)	20.00	43.00
Firms conducting market research (%)	20.00	19.00
	40.00	31.81
Access to institutions		
Credit use ($ 1000/year)	–	843.90 (1192.20)
Firms investing in R&D (%)	20.00	7.00
Firms establishing cooperation* (%)	60.00	25.00

* Figures in the parentheses indicate the standard error.
*, ** and *** donate that the parameters are statistically significant at the 5% and 1% levels, respectively.

4. Conclusions

In this paper, we presented an approach for estimating economic efficiency and the results of such an analysis for individual agro-food firms in Samsun Province. The DEA method was used to estimate the economic efficiency of agro-food firms and then applied the Tobit model to examine the determinants of economic efficiency. As the first study to use the DEA approach to estimate the economic efficiency of agro-food firms in Turkey, this report provides several important insights into the long-term vitality of Turkey's agro-food industry. Our results indicate 81% efficiency among the studied agro-food firms and suggest that inefficient firms should lower their costs by 19%. Of the firms, 90% had allocative inefficiencies and this allocative inefficiency is the primary source of economic inefficiency. Trademarking, marketing, R&D strategies, and cooperation positively affected economic efficiency, whereas the investment plans of entrepreneurships and capacity use ratio in the sector negatively affected economic efficiency. Technical efficiency averaged 91%, suggesting that firms could decrease their input use by 9%. Pure technical inefficiency resulted from management failures was the primary cause of technical inefficiency. Hazelnut processing firms were managed more efficiently than flour and rice firms. Efficient firms were generally geared toward the export market, which may have made them more efficient.

In order to increase future economic efficiency of the firms, both operators of the firms and policy makers should focus on developing sound management, preventing unproductive investments, decreasing overcapacity and production costs, and encouraging trademarking, conducting marketing research, cooperation, and pursuing export opportunities. Globalization has increased the importance of sound firm management, and our results suggest that poor management had a main negative impact on economic efficiency. Sound management could help ensure optimum input use, and managers should consider how best to maximize returns and minimize costs. Governmental and professional organizations such as the Ministry of Industry and Trade as well as industry, trade, and business organizations should set up training courses on firm management. Family firms should also be encouraged to hire expert managers.

Despite of the overcapacity in the sub-agro-food sectors, some firms were planning new future investments. Entrepreneurs should analyze the feasibility of the sector before making new investments and avoid unproductive investment. The government policies should courage productive investments for the sector. Increasing competition and effective government controls on product quality and standardization, as well as on environmental and fiscal necessities, could help decrease the idle capacity in the sector.

Developing of market research strategies could help to maintain agro-food firms and increase their market shares. State aid to encourage marketing research, cooperation, and trademarking should also be improved. Globalization obligates both vertical and horizontal cooperation for increasing competitiveness. Enlarging and cooperating existing agro-food firms could result in higher economic efficiency through economies of scale.

Furthermore, the adoption of advanced production technology has played a critical role in expanding and enhancing the efficiency of the industry. Smaller firms may be hindered by a lack of human and financial resources, but larger firms may be better situated to adopt new technologies. Moving up the value-added chain and improving efficiency are clearly main paths that the agro-food sector in Samsun could pursue to maintain and improve market competitiveness.

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