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Measuring the Productive Efficiency and Identifying the Inefficiency Determinants of Dairy Farms in Amasya Province, Turkey

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Abstract

The aim of the study was to investigate the productive efficiency and to identify the inefficiency determinants of dairy farms in Merzifon, a district of Amasya province located in the Central Black Sea Region of Turkey. Productive efficiency scores were calculated by using Stochastic Frontier Analysis. Tobit model was used to determine the inefficiency determinants. Farm-level research data were obtained from 67 randomly selected dairy farms. Study results revealed that the average amount of milk produced on dairy farms in Merzifon district could be increased in the ratio of 22% with the current technology. The technical efficiency of the sample dairy farms ranged from 0.56 to 0.99 (mean 0.78). Variables such as education level of farm operators, feeding frequency, the ratio of Holstein stock and land allocated to fodder crops affected technical inefficiency negatively. For this purpose, this study proposes new strategies such as providing better agricultural extension services and farmer training programs to increase the educational level of farmers, and providing farmers with the opportunity of accessing loan to enhance their technical efficiency.

Keywords: Dairy farming; stochastic production frontier; technical efficiency; determinants of inefficiency

1. Introduction

Due to its economic size and social importance, agriculture constitutes an economic sector of vital importance for Turkey. The contribution of agriculture to gross domestic product is 7.6%. On the other hand, employment in agriculture constitutes 23.83% of total employment in 2013. According to the figures of Turkish Statistical Institute (TURKSTAT), approximately 3 million farms are engaged in agriculture in Turkey. Agriculture-based industry such as fruits, vegetables, milk, meat etc. industries increases the importance of the agricultural sector (TURKSTAT, 2014). Milk, a vital source of nutrition, is the main nutrient for human beings. Therefore, many farmers are engaged in milk production. Worldwide, dairy farms produced about 520 million tons of cow milk in 2003. Cow milk production has increased approximately 20% in the last ten years. Turkey is one of the largest cow's milk producers in the world accounting for 0.9% of world production. In 2012, Turkey's cow milk production was about 8.6 million tons (FAO, 2014). Nowadays, cow milk production is fluctuating due to high production costs and unsatisfactory farm size. In Turkey, cow milk is mainly produced in mixed farms and unfortunately, the number of specialized dairy farms is scarce. About 1% of all farms in Turkey are involved in dairy farming. Therefore, becoming a self- sufficient country in milk production is one of the top issues in Turkey's agenda. Dairy farming has been a traditional activity in Turkey which creates employment by means of marketing from farmers to consumers such as transportation and processing. Dairy farming also creates demand for input markets, especially for feed industry and veterinary services. However, the scale of production and the profile of dairy farmers are far from optimum level. These factors constitute an impediment in benefiting from the innovations.

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Ultimately, dairy farmers do not continue their activities efficiently. In order to provide sufficient milk to the consumers, many policy makers have determined policies to increase milk production. The basic way to increase milk supply is to improve productivity and efficiency in cow milk production sector in Turkey. Although, increasing cow milk production is at the top of the list, farm-level information about productive efficiency is unsatisfactory. Up to now, many researchers have focused on measuring technical efficiency and identifying inefficiency determinants. They have measured farm-level productive efficiency by using data envelopment analysis (DEA) and stochastic frontier model (SFM) and identified the inefficiency determinants via logit, probit and tobit models. In India, Chenneradу (1967), Sahota (1968) and Lau and Yotopoulos (1971) measured and tested the relative technical efficiency for whole agricultural sector. On the other hand, Sidhu (1974) focused on wheat farms and measured the relative efficiency. At the beginning of the 1980s, the relationship between technical efficiency and development has been at the top of the efficiency analysis agenda. Kalirajan (1984) designed the development policies by using efficiency scores. Then, Kumbhakar (1987) specified the allocative and technical inefficiency by using profit function. Afterwards, the relationship between farm size and technical efficiency has been examined in many studies. Alvares and Arias (2004) conducted a conditional analysis and identified the relationship between farm size and technical efficiency. Papadas and Dahl (1991) also focused on the relationship between farm size and technical efficiency. In Pakistan, Ali and Chaudhry (1990) investigated the inter-regional farm efficiency. Similarly, Battase et al. (1996) examined the wheat farmers and focused on technical inefficiency in Pakistan. Some researchers examined the relative efficiency in transition economy. Morrison (2000) and Mathijs and Swinnen (2001) measured relative efficiency and designed policies in Slovakia, Bulgaria and Hungary, respectively. In Kansas, Laura Gow and Langemeir (1999) focused on cattle activities and estimated the efficiency. In Poland, Latruffe et al. (2002) analyzed the inefficiency determinants for crop and livestock farms. Lerman (2001) measured the efficiency scores associated with land consolidation in Poland. In the same year, Tzouvelekas et al. (2001) estimated the efficiency scores for both organic and conventional farming systems in Greece.

However, few studies have addressed the issue of technical efficiency in dairy production. Latruffe et al. (2002) included the dairy activities when measuring the efficiency in Poland. Considering the efficiency studies in agriculture in Turkey, the case is a little bit different. Few researchers have focused on efficiency analysis in Turkey. Zaim and Çakmak (1998) analyzed the efficiency for whole agricultural sector by using macro-level data. At the same time, Günden et al. (1998) examined the productivity and efficiency in agriculture in Turkey. Afterwards, some researchers conducted farm-level studies on efficiency (Aktürk, 2000; Demirci, 2001; Cinemre et al., 2006). But, studies measuring farm-level technical efficiency and its determinants in dairy farming are very scarce. In order to increase farm-level information and fill the gap in efficiency analysis studies on dairy farming, the study focused on measuring productive efficiency and the factors influencing inefficiency. The aims of this study were as follows; (i) to estimate the productive efficiency in dairy farmer-level in Merzifon, a district of Amasya province located in the Central Black Sea Region of Turkey, (ii) to identify the factors influencing technical efficiency on dairy farms, and (iii) to develop strategies and policies to increase efficiency level.

2. Material and Method

2.1. The Description of the Study Area

The study area is Merzifon, a district of Amasya province located in the Central Black Sea region of Turkey. Merzifon covers an area of 970 square kilometers. Farm lands constitute 22% of total area. Agricultural activities are being conducted on a total of 4080 farms. Merzifon has a hot summer continental climate. The mean temperature is 11.7 ^{0}C and the annual average precipitation is 416.5 mm. Dairy farming and cattle fattening are the leading sub-sectors in rural Merzifon. The study area accounts for 0.17% of the total number of cattle. The number of cattle and sheep kept in Merzifon district are 15540 and 6900 respectively. The land area allocated to fodder crops constitutes 4% of total agricultural area. Broad bean and alfalfa are the main fodder crops in the study area. The mean hay yield for broad bean and alfalfa are 4000 and 12000 kg per hectare, respectively (MFAA, 2014).

2.2. Efficiency Model for Dairy Farms

When measuring relative productive efficiency, Stochastic Frontier Analysis (SFA), introduced by Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck, was used (1977).

The study estimated the technical efficiency by calculating the distance between actual milk production value and the estimated frontier milk production value in sample farms under current production technology (Coelli et al., 1998). The dependent variable of SFA was the variable of milk yield per cow in kg. A two-stage procedure was followed in the study. In the first stage, technical efficiency scores were estimated. The influencing factors were included in the model in second stage of the efficiency analysis to explain the inefficiency (Coelli et al., 1998). Since the results of the likelihood ratio-type test showed that Cobb-Douglas is more appropriate functional form in comparison to Translog-one, Cobb-Douglas type production function was used. The model used in the study was presented below:

$$\ln(T_i) = \ln(X_i)\beta + V_i - U_i, \quad i = 1,\ldots\ldots\ldots,67 \qquad (1)$$

where T_i is the milk yield per cow of the i th dairy farm, X_i is a vector of inputs for i-th dairy farm, β is a vector of unknown parameters, V_i is the random variables, which were assumed to be independently and identically distributed with $N(0,\sigma_V^2)$ and independent of U_i, and U_i represents the non-negative random variables, which are assumed both to account for technical inefficiency and be independently distributed as truncations at zero of $N(\mu_i,\sigma_U^2)$. In inefficiency effect model, $\mu_i = z_i\delta$, where (z_i) is a vector of explanatory variables that may influence the technical efficiency of a dairy farm, and (δ) is a vector of parameters to be estimated by maximum likelihood estimator. The level of technical inefficiency was estimated by using the formula of $e^{-U(i)}$. FRONTIER, Version 4.1, developed by Coelli (1994) was used to produce maximum-likelihood estimates.

2.3. Research Data

Research data were obtained from dairy farmers in Merzifon, a district of Amasya. A well-structured questionnaire was administered to the dairy farmers to collect farm-level data. Sixty-seven farms were selected by using random sampling technique with a precision level of 10% and 95% confidence interval based on the criteria of the number of cows to obtain resource use and production data for 2012-2013 production periods. When estimating production function, feed (kg/cow), labor (hours/cow), living space (m^2/cow) and working capital ($/cow) were used as independent variables. The variables of working capital included the costs of veterinary services, medicine and marketing. In the second stage of the efficiency analysis, the variables measured from the sample dairy farms were used. The education level of farm operators and experience of sample dairy farmers as well as records (dummy, 0 reflects keeping record while 1 reflects not keeping record) were the explanatory variables used in the second stage because they were potential sources of technical inefficiency. Farm organization membership was as a dummy variable, which was equal to 1 if the dairy farmer was the member of at least one farm organization and 0 otherwise in order to reveal the relationship between membership and technical efficiency. To examine the relationship between technical efficiency scores and area allocated to fodder crops, the variable of fodder crops area in hectare was included in the inefficiency model. The presence of pasture area was another dummy variable. Pasture dummy equaled 0 if the farms used pasture and 1 if they did not. Loan use in $ per year, number of feedings and the ratio of Holstein stocks on farm were the other variables included in inefficiency model. The variables of farmers participating educational program in order to reveal the effects of farmers' contact with extension services and other information sources on technical inefficiency were also included.

Some basic characteristics of sample farms are presented in Table 1. It is clear from the Table 1 that total capital and total farmland of sample dairy farmers were low. The mean age of farm managers was 46 years. Their experience in dairy farming was satisfactory, where as their education level was moderate. Sample dairy farms conducted their activities on 4 hectares. They had 9 cows, where the daily yield per cow was approximately 14 kg. In general, they tended to use equity rather than agricultural loan. However, 38 percent of the sample dairy farmers preferred to use agricultural loan. The mean value of loan use for the sample dairy farmers was $1,910 per year. Considering the production characteristics, sample dairy farm used approximately 12 kg of feeds (42% was compound feed while the rest was other feeds) per cow in a day and 0.65 hours labor per cow, and allocated 8 m^2 living space to per cow to produce 14 kg milk.

Table 1: Basic Characteristics of Dairy Farms: Descriptive Statistics

	Mean	Standard deviation	Minimum	Maximum
Family size (persons)	6.13	1,69	2.00	11.00
Age of farm owner	46.31	11.06	26.00	68.00
Owner's experience in dairy farming	14.43	6.99	5.00	45.00
Education level (years)	6.59	2.63	0	13.00
Farm size (ha)	3.67	2.61	0.98	6.05
Total capital ($)				
Number of cow	8.85	5.06	5.00	34.00
Milk yield per cow (kg/day)	13,74	3.39	10.00	22.00
Compound feed (kg/day)	4.94	0.80	3.00	7.00
Other feed (kg/day)	7.48	1.64	5.00	13.00
The number of feeding	2.12	0.33	2.00	3.00
Barn size (m^2/cow)	7.98	4.84	3.00	34.39
Fodder crops area (ha)	0.24	0.47	0	2.50
Labor per cow (hours/day)	0.65	0.11	0.40	0.92
Working capital ($ per cow)	142.16	18.96	96.01	200.00
Credit use ($/ year)	1910.26	2109.27	0	7608.69

3. Results and Discussion

The results of the stochastic frontier analysis are shown in Table 2. Stochastic frontier analysis shows that the variance parameters of the model are statistically significant indicating that a deterministic production function is not an adequate representation of the research data. The results of the likelihood-ratio (LR) test * reveal that the production function is stochastic. It means that technical inefficiency has an influence on milk production. According to the maximum-likelihood estimates, the signs of the all variables are expected in the stochastic production frontier. The coefficients of the variables of feed, labor, living space and working capital indicate the positive relationship among feed, labor, living space and working capital and milk yield per cow. The highest elasticity is estimated for feed and capital. It is clear that the variables of feed and capital have much influence on milk production than others have (Table 2). This is followed by the elasticity of labor demand. The lowest elasticity pertains to barn ($p<0.05$). The sum of the elasticity shows that increasing returns to scale creates an opportunity in the study area. The results of the test for existing constant return to scale reveal that there is a variable return to scale in the study area ($F=2.92$, $p<0.05$). The mean value of technical efficiency score of sample dairy farms was 0.78 and varied from 0.56 to 0.99. Considering these results, it can be concluded that dairy farms may decrease their quantity of inputs with a ratio of 22% without making any reduction in milk production by increasing their technical efficiency. Increases in technical efficiency scores may result in reduction in costs and increases in gross margin in sample dairy farmers. In the study area, a technical efficiency score of 4% of the sample dairy farms was smaller than 60%. On the other hand, the efficiency score of 63% of dairy farms was greater than 71%. Technical efficiency scores of the rest varied from 61% to 70% (Figure 1, Table 3).

*The likelihood-ratio test statistics, $\lambda = -2\{\ln[\text{likelihood}(H_0)] - \ln[\text{likelihood}(H_1)]\}$, have approximately chi-square distribution with parameter equal to the number of parameters assumed to be zero in the null hypothesis, (H_0), provided.

Table 2: Maximum Likelihood Estimates of the Cobb-Douglas Stochastic Frontier Model

Variables	Parameters	Standard error	t- value
Production function			
Constant	4.13	2.21	1.87**
Ln (Feed)	0.50	0.13	3.95***
Ln (Labor)	0.39	0.13	3.00***
Ln (Barn)	0.14	0.11	1.36 *
Ln (Capital)	0.50	0.09	5.55***
Sum of elasticity of inputs	1.53		
F statistics CRTS[a]	2.92**		
Variance parameters			
σ^2			
γ	2.66	0.60	4.43***
Log likelihood	0.49	0.11	4.45***
$\chi^2(1)$	123.02	30.64	4.01***
	43.82**		
Inefficiency effects			
Education level (year)			
Experience of farmers (year)			
Farmers' organization membership[1]	0.15	0.11	1.36*
Record keeping[2]	0.02	0.06	0.33
Participating education program[3]	-0.23	0.84	-0.27
Fodder crops area (ha)	0.33	0.74	0.22
Pasture use[4]	-0.17	0.78	-0.41
The ratio of Holstein Stock	0.84	0.36	2.33**
The number of feeding	0.38	0.98	0.39
Credit use ($)	11,80	1,97	5.98***
	0.92	0.66	1.39**
	-0.13	0. 80	-0.16

[a] CRTS= constant return to size

*, **, ***: significance at the 10%, 5% and %1 level, respectively.

[1] Dummy variable, in which 0 reflects none membership to farmers' organization while 1 reflects membership to farmers' organization.

[2] Dummy variable, in which 0 reflects not to keep record while 1 reflects keeping record.

[3] Dummy variable, in which 0 reflects not to participate education program while 1 reflects participating the education program.

[4] Dummy variable, in which 0 reflects not to use pasture while 1 reflects using pasture.

Figure 1: Percentage Distribution of Technical Efficiency Scores for Dairy Farms in Amasya Province Frequency

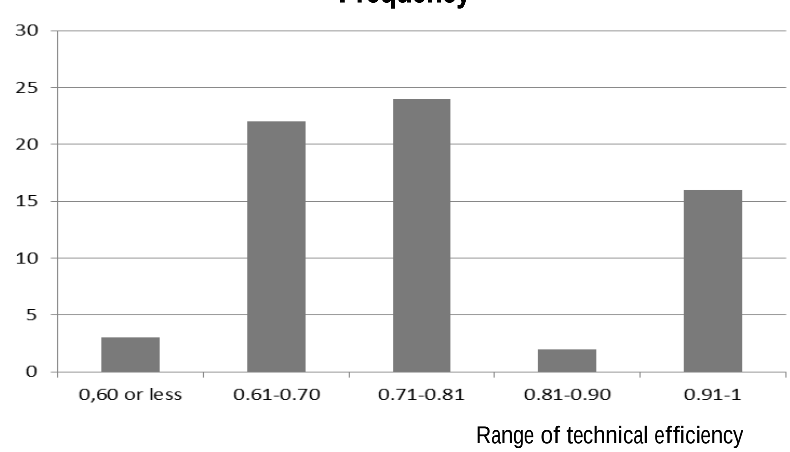

Table 3: Farm Size and Technical Efficiency on Dairy Farms in Amasya Province

	Number of farms	Technical efficiency	Standard deviation	Minimum	Maximum
Small farms (1-22 cow)	58	0.76	0.123	0.56	0.99
Large farms (23–34 cow)	9	0.86	0.147	0.64	0.99
Total	67	0.78	0.129	0.56	0.99

*The difference between farm sizes is statistically significant at the 10% level.

Inefficiency effect model shows that the variables of schooling ($p<0.10$), fodder crops area ($p<0.05$), the ratio of Holstein stock ($p<0.01$) and the number of feeding ($p<0.05$) are statistically significant. However, the variables of experience, farmers' organization membership, record keeping, pasture use, participating education program and credit (loan) use are statistically insignificant ($p>0.10$). All the signs related to efficiency determinants are as it is expected. Factors influencing the education level of farm operator, fodder crops area, the ratio of Holstein stock and the number of feeding affect the technical inefficiency negatively (Table 2). The study findings related to the education level of farm operator variable confirmed the hypothesis of Shultz (1964), that education increases the adoption capability of innovations and run up farmers' managerial experience (Table 2). According to the comparison between efficient and inefficient farms, it is clear that the profiles of technically-efficient dairy farmers are more satisfactory than those of inefficient dairy farmers. Technically-efficient farmers are well educated and more skillful (Table 4). This finding also corroborates the results of Kalirajan and Shand (1985), Phillips and Marble (1986), Pinherio (1992), Kebede (2001), Binam et al. (2004) and Zavela et al. (2005). According to the amount of area allocated to fodder crops variable, increasing fodder crop area in farmland reduces the technical inefficiency on dairy farms. The land allocated to fodder cropsin technically-efficient dairy farms is more than that of inefficient dairy farms (Table 2 and 4). Based on the negative and significant sign of the variable of ratio of Holstein stock, it is suggested that having more Holstein stock decreases the technical inefficiency of the sample dairy farms (Table 2). In the study area, using indigenous stock was common and this affects the technical inefficiency negatively. Considering the variable of feeding frequency, this negative and statistically significant coefficient confirms the hypothesis that farms having more feeding frequency are more efficient than the others (Table 2). Similarly, technically-efficient dairy farms in the study area use much more compound feed per cow and feeding is more frequent than others of inefficient one. On the other hand, feed use and living space allocated per cow, labor use and working capital per cow are less than those of inefficient dairy farms (Table 4)

Table 4: The Differences between Technically Efficient and Inefficient Dairy Farms in Amasya Province

Characteristics	Technically efficient farms (N=16) (TE=0.78, StD 0.13)	Technically inefficient farms (N=51) (TE=0.98, StD=0.02)
Family size (persons)	6.22 (1.78)	5.88 (1.45)
Age of farm owner	45.88 (10.70)	47.59 (12.31)
Experience (year)	14.00 (6.75)	15.71 (7.70)
Schooling (years)	6.42 (2.42)	7.12 (3.22)
Milk yield per cow (kg/year)	12.13 (1.94)	18.46 (2.01)
Compound feed (kg/day)	4.98 (0.75)	4.82 (0.95)
Other feed (kg/day)	7.37 (1.39)	7.70 (2.23)
The number of feeding	2.12 (0.33)	2.06 (0.24)
Barn size (m^2/cow)	6.70 (1.97)	7.41 (2.74)
Labor (hours/day)	0.65 (0.11)	0.70 (0.07)
Working capital ($ per cow)	129.20 (25.07)	152.27 (21.60)
Credit use ($/ year)	3661.67(4026.67)	3402.96 (4275.00)
Fodder crops area (ha)	0.23 (0.49)	0.28 (0.44)
The ratio of Holstein Stock	0.185 (0.16)	0.78 (0.24)

*Figures in parentheses are standard error.

4. Conclusions

Study findings reveal that sample dairy farms have the opportunity to reduce the quantity of inputs considerably under the same condition. Increasing the ratio of fodder crops area, optimizing feeding frequency, considering herd characteristics, preferring Holstein stock instead of indigenous stock, increasing technical information level of dairy farmers through well-organized extension services and farmer education programs and developing loaning system to increase living space for per cow may reduce the technical inefficiency in the study area. It is recommended that focusing on fodder crops, feeding frequency, pasture management, quality of stocks, cooperation among farmers and marketing efficiency when organizing extension and education programs may improve the technical efficiency of sample dairy farms. The attainment of the extension and education programs highly depends on farmers' contacting frequency with information sources. Since transferring of innovations such as new production system, new marketing application etc. may increase the technical efficiency of sample dairy farmers, the frequency of contact of dairy farmers with related person is very important. Similarly, Demiryürek (2000) stressed the positive correlation between technical efficiency and total information score of farmers. Developing the policy that facilitates accessing loans with low transaction costs will improve the technical efficiency of dairy farmers and increase the scale of the barn in the study area. On the other hand, not only the public but also the private enterprises should make investments to the physical infrastructure (roads, communications, etc.) in the study area which may result in improvement in the technical efficiency of dairy farmers.

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