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Cost and Return Analysis and Technical Efficiency of Small Scale Milk Production: A Case Study for Cukurova Region, Turkey

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Abstract: Technical efficiencies of small scale dairy growing farms in Cukurova region of Turkey were estimated with a stochastic frontier model. A cost and return analysis was also carried out. Data were obtained through a questionnaire study and face to face interviews with farmers. Five inputs (grains and concentrates, green and dry fodder, labor, veterinary costs and other costs) and four inefficiency variables (herd size, cow quality, source of labor and share of milk in gross return) were used in the analysis. Except labor, all inputs of the production function part of the model were found to have positive elasticities. Mean efficiency of the sample farmers is estimated to be around 78%, ranging from 0.43-0.98 indicating that there is significant scope for increasing efficiency under current technology. Results of the inefficiency analysis indicate that 96% of the variation in milk production is due to inefficiency. Efficiency levels are all affected in the expected direction by the selected determinants of the inefficiency model however, only cow quality variable was found to be statistically significant. Comparison of the technical efficiency scores with the results of the cost and return analysis showed that one third of the farmers are producing milk above their selling prices. It was concluded that in the short run efficiency could be improved through methods (such as training) without requiring higher costs. However, in the long run structural enhancement such as introduction of high breed milking animals would be required.

Key words: Dairy farming, technical efficiency, stochastic frontier analysis, inefficiency model, Turkey

INTRODUCTION

A great part of Turkish livestock farming is carried out on a small scale as a family sideline activity. According to the 2001 Agricultural Census results, only 2.36% of all agricultural holdings are specialized exclusively in livestock and 59.71% of cattle-raising farms own <5 animals.

A great part of milk production (91%) in Turkey is obtained from cows. Despite high number of milking cows (5 million), average milk yield per head cow (1900 kg) is very low in Turkey compared to that of the developed countries.

Low productivity has been recognized to be a major problem in Turkish dairying for a long time. Turkish government is trying to develop policies to increase milk productivity. This problem can be approached from two different perspectives. One is introducing new technologies (high yield breeds and technological investments) and the other is increasing efficiency under current conditions (through extension and elimination of factors causing inefficiency). Hence, policy makers need to know contributions of several factors to low milk productivity problem. Traditional production economics treat producers as successful optimizers. They either maximize outputs or minimize costs under given conditions. All deviations from maximum output or minimum cost input combination is attributed to random statistical noise. However, despite their intentions, producers are not always able to achieve optimization. Therefore, econometric models should account for efficiency (Kumbhakar and Lovell, 2003). Efficiency measurement is important because this is a first step of a process that might lead to considerable savings under current technology. The objectives of this study are to determine individual efficiencies of smallholder dairy growing farmers in Cukurova region, identify factors explaining efficiency variations among farmers and make some suggestions.

MATERIALS AND METHODS

The data were collected by interviewing 66 dairy growing farmers in Adana Province in April and May

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Table 1: Summary statistics for variables used in the inefficiency analysis

Variables	Min.	Max.	Mean±SD
Output			
Milk (kg head^{-1})	1500	4500	3105±62
Production function variables			
Feed-grain and concentrates (kg head^{-1})	499.11	3374.52	1607.21±611.48
Feed-dry and green fodder (kg head^{-1})	365.00	3832.50	1442.40±712.15
Labor (man h head^{-1})	91.60	308.57	176.64±36.74
Veterinary costs (YTL head^{-1})	20.00	131.58	71.49±24.71
Other expenses (YTL head^{-1})	231.82	820.00	427.66±107.82
Inefficiency function variables			
Herd size (head animal)	1.00	120.00	8.59±18.98
Cow capital (YTL head^{-1})	1000	3000	1732.58±448.54
Family labor (dummy, 0 if family)	0.00	1.00	0.36±0.48
Share of milk in gross return (%)	0.12	0.85	0.54±0.15

SD = Standard Deviation; YTL = Turkish Currency Unit

2005. Since, efficiency analysis requires firms working under similar conditions, villages were selected purposively. The variables of the analysis are outlined in Table 1, along with some descriptive statistics.

About 46 out of 66 farms have five or <5 milking cows. Number of farms having >5 but at most thirty milking cows is 18. Only 2 farms have >30 cows. Besides producing milk and keeping cows, dairy growers may also produce crops and keep beef herds and small ruminants as part of their production activities. Therefore, on-farm labor and capital may be used for purposes other than the production of dairy output. Although, there are a number of outputs (such as cheese and yoghurt) produced along milk, it is very difficult to quantify them. Hence, only milk output was considered in this analysis. Inputs consist of five major components: grain and concentrates, green and dry fodders, labor input as man h/year, veterinary costs and other costs. Milk, feed and labor are expressed in physical units. Veterinary costs and other costs are expressed as monetary units. Feeds are expressed as their dry matter content (in kg per cow per year). All values are measured as units per cow per year. Only inputs used for milking cows were considered in the analysis. In the distribution of feed and labor inputs to milking cows, standard animal unit and man-h coefficients were employed respectively.

Grains and concentrate variable includes milk feeds, cracked grains, cereal bran and industrial crop by-products. Green and dry fodder variable includes vegetative parts of grasses containing a high proportion of fiber and crop residues poor in crude protein. Labor variable comprises both family and hired labor used in dairy works and is expressed as man-days per cow. Veterinary costs include veterinary and medicine costs. The other costs variable covers depreciations, water and electricity, bedding and supplies, hauling and cow consumables. Four variables were employed in the inefficiency model: herd size, cow quality, main source of labor and share of milk in gross return. There are several important cow quality related factors (genetic potential, age, previous calving, stage and length of lactation period etc.) affecting milk production. Incorporating all these data to an aggregated milk production function is very difficult. However, omitting them may lead to misspecification problems and biased results. Farmers grow mixed breeds (local and hybrid). In this study, average market value of cows was used to represent all cow related factors. Using average market values of cows to describe cow quality is expected to reduce the significance of cow related explanatory variables not accounted among traditional inputs in the analysis.

Herd size measures effects of scale on inefficiency. Labor source is a dummy variable taking the value of one if the farm uses mostly hired labor, zero otherwise. Share of milk in gross return was chosen to represent level of specialization. Farrell (1957) argues that it is more appropriate to compare a farm's performance with the best actually achieved one rather than with some unattainable ideal. The approach proposed by Farrell (1957) distinguishes between technical and allocative efficiency, where the former refers to the ability of producing a given output with a minimum quantity of inputs under a given technology the latter refers to the choice of the optimal input proportions given relative prices. Economic or total efficiency is the product of technical and allocative efficiency (Bravo-Ureta and Rieger, 1991). Farrell's (1957) model constructs a deterministic efficiency frontier and attributes any deviation from the frontier to inefficiency.

Therefore, it is highly sensitive to measurement errors and extreme observations. On the other hand, stochastic frontier method, developed independently by Aigner *et al*. (1977) and by Meeusen and van den Broeck (1977) uses statistical methods to construct the frontier. Then this potential frontier output is compared to observed outputs of individual farms in measuring their performance. In this study, we adopted the model proposed by Battese and Coelli (1995), where the production function and the exogenous effects influencing technical efficiency are estimated simultaneously. This model is represented as follows:

$$Y_i = \beta X_i + V_i - U_i \quad (1)$$

Estimated values of β in Eq. 1 indicate the relative importance of each input to production. Error term (V_i) is assumed to be independently and identically distributed and captures random variation in output due to factors beyond the control of farmers. The error term (U_i) captures technical inefficiency in production. This term is assumed to be firm specific, nonnegative random variables independently distributed. The technical inefficiency effects, the U_i values are assumed to be a function of a set of explanatory variables (Z_i) and an unknown vector of coefficients (**δ**). The ratio of the observed output of any farm relative to the potential output estimated by Eq. 1 gives the technical efficiency of that farm.

$$TE_i = \exp(U_i) = \exp(-\delta Z_i) \quad (2)$$

If $U_i = 0$, the farm is 100% technical efficient. Maximum likelihood estimates of the parameters were obtained using Frontier 4.1 software developed by Coelli (1992) and Coelli *et al.* (2005).

In addition to efficiency analysis, a cost and return analysis was also carried out. Since, output of cows is not limited to milk and also includes productive value increases of livestock inventory, heifers and manure, costs were also distributed among these outputs in proportion to their gross return. Milk sale prices vary between 0.35 and 0.50 YTL during the analysis period. Average cost of one liter milk was found to be 0.39 YTL. One third of the farmers (22-66), unit costs are above their unit selling price. It is not surprising that those are mostly farmers who are classified as the worst practice ones in terms of their efficiency scores, 15 of them having scores below 0.70.

RESULTS AND DISCUSSION

Maximum likelihood results of stochastic frontier analysis are shown in Table 2. All production function parameters are statistically significant except veterinary costs. Only labor has a negative sign contrary to the expectations. Since a log-linear model is employed, coefficients represent elasticity of milk output with respect to the respective inputs. Concentrate feed, which has the greatest coefficient has the greatest contribution to milk output. Other miscellaneous costs variable follows this. Negative sign of labor variable indicates an out of optimal usage of this input.

Highly significant gamma statistic indicates the presence of a high systematic inefficiency and implies that 95% of the variations in milk production could be attributed to inefficiencies. Table 3 shows the formal tests of the hypothesis associated with the model. The first null hypothesis is that the traditional production function is an adequate representation for the data. This hypothesis is strongly rejected. The generalized likelihood ratio statistics for testing the null hypothesis for the absence of inefficiency effects was found to be 18.73. This statistic has a mixed chi-square distribution with 5° of freedom and found to be statistically significant at 5% level.

Herd size variable has a negative sign indicating that inefficiency decreases as the number of cows increases in the herd. Significance of this parameter is measured by deleting it from the model, re-estimating the model without it and making likelihood tests. According to Table 3, line-1 the null hypothesis could not be rejected. Hence herd size was found not to have a significant effect on inefficiency of farmers.

Table 2: Maximum likelihood estimates of technical inefficiency model

Variables	Parameters	Estimated value	t-statistics
Stochastic frontier			
Constant	β_0	6.231	8.047**
Ln (feed-concentrate)	β_1	0.179	3.942**
Ln (feed-fodder)	β_2	0.093	2.427**
Ln (labor)	β_3	-0.139	-1.702*
Ln (veterinary costs)	β_4	0.030	0.461
Ln (other costs)	β_5	0.112	1.698*
Inefficiency model			
Constant	δ_0	4.333	2.910**
Ln (herd size)	δ_1	-0.036	-0.540
Cow capital (YTL head^{-1})	δ_2	-0.562	-2.703**
Type of labor	δ_3	-0.191	-1.535
Share of milk in gross return	δ_4	-0.183	1.652*
Variance parameters			
	σ^2	0.052	2.778**
	γ	0.956	16.610**
Log-likelihood function	-	27.762	-

(**): Significant at 1%; (*): Significant at 5%

Table 3: Hypothesis tests for coefficients of technical efficiency variables

Test No.	Null hypothesis	Log likelihood value	t-statistics (λ)	Critical value	Decision
1	H_{00}: $\gamma = \delta_0 = \ldots = \delta_3 = 0$	27.76	32.22	11.07[a]	Reject H_{00}
2	H_{01}: $\delta_1 = 0$	27.60	0.32	3.84[b]	Accept H_{01}
3	H_{02}: $\delta_2 = 0$	23.37	8.78	3.84[b]	Reject H_{02}
4	H_{03}: $\delta_3 = 0$	25.28	3.16	3.84[b]	Accept H_{03}
5	H_{03}: $\delta_4 = 0$	26.31	2.90	3.84[b]	Accept H_{04}

[a]Degrees of freedom: 5[b]Degrees of freedom: 1; All critical values are at 5% level of significance

Table 4: Frequency distributions of technical efficiency scores

Efficiency scores	Frequency
=1.00	-
≥0.90-<1.00	17
≥0.80-<0.90	17
≥0.70-<0.80	13
≥0.60-<0.70	11
≥0.50-<0.60	6
<0.50	2
Mean	0.78
Minimum	0.43
Maximum	0.98
Standard deviation	0.14

Cow capital is the only statistically meaningful variable affecting inefficiency of small scale farms. Negative sign of this variable indicates that farmers having higher quality milking animals are also more efficient than the others.

Use of family labor may have positive and negative effects on efficiencies depending on the situation. It is a source of stronger incentives for efficiency in small scale family farming. On the other hand, market orientation may also create incentives for efficiency. In this study family labor variable has a negative sign indicating that farmers employing hired labor are more efficient than those employing family labor. However, the coefficient of this parameter is not significantly different from zero as indicated by the third hypothesis in Table 3.

Share of milk in gross return is a variable representing specialization level. It is expected to have a positive effect on technical efficiency. Its sign is also in the expected direction. However, coefficient of this parameter is not statistically significant as indicated by the fourth hypothesis in Table 3.

Table 4 shows efficiency distribution of the farms. The predicted technical efficiency of the sample dairy farmers ranges widely from 0.60-0.98. The mean technical efficiency is estimated to be 0.78.

CONCLUSION

Except labor, all of the elasticities in the labor are positive. This implies that increasing inputs other than labor would cause increases in milk yields obtained per head. Since concentrate feed is the variable having the greatest coefficient (hence elasticity) among other variables, it is still the most important input to be considered to increase milk production. Labor input usage is not optimal according to the results.

Based on the results, it could be concluded that a high inefficiency exists among small scale dairy farmers in the region. Average efficiency among farmers is 78%, implying that milk output can be increased on average by 22% with the existing technology. There is a great deal ofscope to increase milk production without introducing higher costs. Training farmers might be a first step towards this end. However, according to the findings the most important factor in the inefficiency model is the cow capital representing type of milking animal. This finding signifies that scope to increase efficiency mainly depends on structural enhancements in the long run such as introducing high yield breeds. Technical efficiency is an important component of economic efficiency. However, allocative efficiency should also be studied to see the role of prices.

Finally, efficiency analysis is based on a single year in this study. Therefore results should be extended to other periods with care. The use of panel data in future researches is suggested to reduce effects of some time related biases in efficiency measurements.

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