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Resource Use Efficiency of Turkish Small Scale Dairy Farmers Supported Through Cooperatives in Cukurova Region, Turkey

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Abstract: Technical efficiencies of cooperative member dairy farmers in Cukurova region were estimated with a stochastic frontier model. Effects of several factors on technical efficiency were analyzed. Farms were grouped based on their efficiency scores. Unit milk costs and gross margins per head cow were calculated for each farm group to give a sense what efficiency means in terms of some farm economic criteria. Concentrate feed and capital costs were found to have statistically significant contributions to milk production. Farm location, herd size, farming experience, on-farm feed growing, milking by equipment and grazing had effects on efficiency. However, only positive effect of farming experience and negative effect of grazing were statistically significant. Results show that 75% of the variation in milk production can be attributed to inefficiency. Mean efficiency score of the sample farms was estimated to be 68% implying there is plenty of scope to increase production under existing technology without incurring higher costs. Lower unit costs of milk and higher gross returns of efficient farmers show that technical efficiency is an important component of competitiveness. It was concluded that farmers should be encouraged and supported to increase use of concentrate feed and decrease share of grazing for obtaining higher milk yields. However, in the long run structural enhancements are required to transform small subsistence farms into more market oriented units. Economic analyses show that many farmers cannot cover full economic costs but they can still generate farm income since family labor does not incur cash costs.

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

INTRODUCTION

Most of Turkish livestock production is realized in small scale, family operated units. According to 2001 General Agricultural Census data there are approximately 3 million agricultural holdings in Turkey and share of livestock specialized farms is only 2.36%. Although, percentage of agricultural holdings dealing with both crop and livestock production is as high as 67%, livestock farming is carried out as a sideline activity in these units. Also about 60% of cattle-raising farms own <5 animals (DIE, 2001).

In 2007, a great part (91%) of the total milk production (12 million tons) in Turkey is obtained from cows. Despite high number of milking cows (4 million), average milk yield per head cow (2600 kg) is low compared to that of European countries (www.fao.org).

Since milk is a very important nutrient and milk demand is expected to increase paralleling to increasing population, low productivity problem of Turkish dairy farming has been recognized as a major problem. During recent years, Turkish government has supported cooperatives that assist milk producers and encouraged farmers to become cooperative members. Turkish government established several ways to support smallholders. For example Ministry of Agriculture and Rural Affairs (MARA) provided two to four cows to villagers on a grant or loan basis with a long repayment period at low interest rates. Social Support Project in Rural Areas (SSPRA) is another support program targeting only disadvantaged people. Both programs have a very strong social support component and similar objectives. But there are minor differences between them in terms of target people, terms and conditions of the credit supplied.

Adana province in Cukurova region of Turkey is one of the supported regions. MARA distributed dairy cows and pregnant pure-bred heifers to 1200 farmers through 15 agricultural cooperatives in Adana Province. Government

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also distributed cows to 575 farmers through 6 cooperatives in the context of SSPRA. In total, 1775 farmers are beneficiaries of these two projects. Between 1990-2006, total 4150 cows were provided to farmers.

Low productivity problem can be approached from two different perspectives: introducing new technologies (high yield breeds and technological investments) or increasing efficiency under current conditions through extension and elimination of factors causing inefficiency. It is very important for policy makers to know relative importance of these factors.

The objectives of this study are to estimate resource use efficiency of small scale dairy farmers to determine effects of different production practices on efficiency and to find out how efficiency is reflected in economic indicators such as unit milk costs and gross margins per standard cow equivalent units.

MATERIALS AND METHODS

In 2006, farm level cross sectional data were collected by interviewing 121 cooperative member dairy farmers who are supported by MARA and SSPRA. Districts of Adana Province covered by the research area are as follows: Yuregir, Ceyhan, Yumurtalik, Imamoglu in plain areas; Karaisali and Kozan in transition zones and Aladag, Tufanbeyli and Feke in mountainous zones.

One output (Milk in kg) and six inputs were used in the analysis. Inputs consist of six major Components: grain and Concentrates (CONC) in kg, green and dry Fodder (FODDER) in kg, Labor (LAB) as man-hours, Veterinary and medical costs (VET), Capital costs (CAP) and Other Variable Costs (OVC) in monetary units. Only inputs related to milk production were used in the analysis. All values were expressed as per head cow per year.

CONC consists of feeds such as factory made milk feeds, bran and cottonseed meal. FODDER consists of feeds such as hays and corn silage. All feeds were converted to dry matter with coefficients given by Kutlu and Celik (2005). LAB comprises both family and hired labor. However, use of hired labor is very low in the area. VET represents veterinary and medicine costs. CAP covers depreciations and interest on capital while OVC includes variable costs such as salt, vitamins, minerals, artificial insemination, electricity and lighting, water, cleaning, hauling etc.

Six variables were used to explain efficiency differences between farms: Zone of dairy farm (ZONE), Herd size (HSIZE), farming Experience (EXP), Grazing practices (GR), Feed growing on farm (FDGR) and use of Milking Equipment (ME). Table 1 shows descriptive statistics related to the variables used in the analysis. Since only pure-bred cows are distributed through the projects, almost all cows are of the same breed. For this reason, no variable was included to test the breed effects. Also since majority of the farmers (76%) are primary school graduates, education status was not included into the model. Correlations between variables were checked before including them into the model to avoid multicollinearity problems.

In this study, TE effects model developed by Battese and Coelli (1995) was employed. In this model a Cobb Douglas type production function and some exogenous factors influencing technical efficiency are determined simultaneously. The specific model estimated is given by Eq. 1 where Y and X represents outputs and inputs, respectively and LN stands for natural logarithm. Parameters to be estimated were represented by β:

$$\mathrm{Ln}\,(Y_i) = \beta_0 + \sum_{i=1}^{i=6} \beta_i \mathrm{Ln}(X_i) + V_i - U_i \qquad (1)$$

Two sided and normally distributed V term captures the random variation in output which is beyond the control of the manager (e.g., weather, natural disasters etc.), measurement errors and other statistical noise. It is assumed to be identically and independently distributed.

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

Variables	Min.	Max.	Mean	SD
Output				
Milk (kg head^{-1})	1575.00	7500.00	4559.00	1219.00
Production function variables				
Feed-grain and concentrates (kg head^{-1})	642.40	10380.60	2963.34	1605.41
Feed-dry and green fodder (kg head^{-1})	0.00	11160.00	2191.75	2075.50
Labor (man-hours/head)	5.59	103.91	28.45	18.84
Veterinary costs (TL head^{-1})	0.00	500.00	97.21	66.55
Capital costs (TL head^{-1})	101.40	639.04	289.33	106.73
Other variable costs (TL head^{-1})	2.40	278.92	90.97	58.57
Inefficiency function variables				
Zone dummy (0 = plain, 1 = Mountainous)	0.00	1.00	0.55	0.50
Herd size (head animal, in logarithms)	1.00	38.00	4.45	4.56
Farming experience (in years, in logarithms)	1.00	60.00	23.36	14.77
Grazing dummy (0 = no grazing, 1 = grazing)	0.00	1.00	0.49	0.50
Feed production dummy (0 = no, 1 = yes)	0.00	1.00	0.80	0.40
Milking dummy (0 = by hand, 1 = by machine)	0.00	1.00	0.60	0.49

Abbreviations: SD = Standard Deviation; TL = Turkish currency unit

The other non-negative error term (U) is a firm specific one-sided component capturing technical inefficiency effects. It is assumed to be independently distributed of the V and to be a function of a set of explanatory variables (Z) and an unknown vector of coefficients (**δ**). The ratio of the observed output of any farm, relative to the potential output estimated by Eq. 2 shows the Technical Efficiency (TE) of that farm.

$$TE_i = \exp(U_i) = \exp\left(-\sum_{i=1}^{i=6} \delta_i Z_i\right) \quad (2)$$

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 (1996). Further information on the model can be found in Coelli *et al.* (2005).

After determination of technical efficiency scores, farms were grouped by their efficiency scores and unit milk costs and gross margins were calculated for each group. These results were given together with the efficiency scores to give an idea on being technically efficient in terms of some farm economic criteria.

Gross margins were calculated by subtracting all variable costs from gross returns. Since total dairying production costs are related to the total returns of the dairy enterprise, non-milk returns (such as productive stock value increases, manure, etc.) were subtracted from the total costs of dairying. Then total milk cost calculated in this way was divided by total milk production to find unit cost of milk.

RESULTS AND DISCUSSION

Variable and fixed costs represent 72 and 28% of total production costs, respectively. Share of feed expenses in total variable cost is around 89%. Labor cost has the highest share (55%) in fixed costs. A great majority of the labor used is farm family labor. Average cost of 1 kg milk was found to be 0.44 TL.

Maximum likelihood results of the stochastic frontier analysis are shown in Table 2. Concentrated feed and capital cost inputs are statistically significant at 5 and 1% levels, respectively. Both feed variables and capital costs are significant and have positive signs as expected. Veterinary expenses, labor and other variable costs variables have negative signs, contrary to expectations. However, none of them is statistically significant at 5% level. Negative signs of these variables show that they are over-utilized. Negative sign of labor could be partly explained by low opportunity cost of family labor and some farmers use of a great part of family labor in grazing. Veterinary treatments are expected to have a positive effect on production. Except four, all farmers make veterinary expenses. However, amount of expenses does not imply a timely treatment. Some farmers might have missed the right time for medical applications. Negative sign of the other cost variable might be an indicator of great differences among farms in terms of this type of expense.

Table 2: Maximum likelihood estimates of technical inefficiency model

Variables	Parameter	Value	t-statistics
Stochastic frontier			
Constant	β_0	6.728	13.261**
Ln (Feed-Concentrate)	β_1	0.078	1.865*
Ln (Feed-Fodder)	β_2	0.002	0.260
Ln (Labor)	β_3	-0.017	-1.409
Ln (Veterinary costs)	β_4	-0.033	-0.789
Ln (Capital costs)	β_5	0.310	4.456**
Ln (Other variable costs)	β_6	-0.029	-1.056
Inefficiency model			
Constant	δ_0	0.644	3.759**
Region	δ_1	-0.032	-0.493
Ln (Herd size) (heads)	δ_2	-0.067	-1.055
Ln (Farming experience) (years)	δ_3	-0.065	-2.181*
Grazing (Dummy)	δ_4	0.154	2.126*
Feed production (Dummy)	δ_5	-0.038	-0.575
Milking equipment (Dummy)	δ_6	-0.035	-0.549
Variance parameter	$\sigma^2 = \sigma_v^2+\sigma_u^2$	0.058	4.395**
	$\gamma = \sigma_u^2/(\sigma_v^2+\sigma_u^2)$	0.748	3.335**
Log-likelihood function		9.946	-

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

Since the model employs a log linear equation, coefficients represent elasticity of milk output with respect to relevant inputs. For example 1% increase in capital expense will result in about 0.3% increase in milk production. Since sum of the coefficients is less than unity (0.31), decreasing returns to scale holds.

The estimated value for the variance parameter (gamma) is 0.75 (significant at 1% level) and implies that inefficiencies account for about 75% of the variations in milk production. Hence, it is possible to take some measures to increase efficiency under current technology.

Table 3 shows hypothesis tests. The first null hypothesis which specifies that the inefficiency effects are absent is rejected based on both chi-square and Wald tests. Hence, traditional production function is not an adequate representation of the data.

ZONE is a dummy variable. It takes zero for farms located in flat and plain areas and one for mountainous areas and transition zones. Negative sign of this variable implies that farms located in plain areas are less efficient that those in mountainous areas and transition zones. However, this result is not significant at 5% level.

HSIZE was included into the model in logarithms to investigate scale gains/losses among farmers. Its negative sign implies that efficiency increases with herd size conforming to expectations. However, H_0 hypothesis cannot be rejected implying that this variable is not statistically significant. Insignificance may be attributable to the insufficient variation in herd size among

Table 3: Hypothesis tests for coefficients of technical efficiency variables

Test no.	Null hypothesis	Log likelihood value	Test statistics (λ)*	Critical value	Decision
1	$H_{00}: \gamma = \delta_0 = \ldots = \delta_6 = 0$	1.67	16.54	14.85[a]	Reject H_{00}
2	$H_{01}: \delta_1 = 0$	9.82	0.24	3.84[b]	Accept H_{01}
3	$H_{02}: \delta_2 = 0$	9.37	1.14	3.84[b]	Accept H_{02}
4	$H_{03}: \delta_3 = 0$	7.17	5.54	3.84[b]	Reject H_{03}
5	$H_{04}: \delta_4 = 0$	7.97	3.94	3.84[b]	Reject H_{04}
6	$H_{05}: \delta_5 = 0$	9.78	0.32	3.84[b]	Accept H_{05}
7	$H_{06}: \delta_6 = 0$	9.79	0.30	1.32[b]	Accept H_{06}

*$\lambda = -2$ (log likelihood (H_0)-log likelihood (H_1)); [a]Critical value at 5% level of significance with eight degrees of freedom was taken from Table 1 of Kodde and Palm (1986). Corresponding chi-Square value is 15.51; [b]Chi-square value at 5% level of significance with one degrees of freedom

Table 4: Frequency distributions of technical efficiency scores

Efficiency scores	Frequency	Unit cost of milk TL L^{-1}*	Gross margin of dairy enterprise TL*/SCE
= 100	-	-	-
0.90-<1.00	4.00	0.28	676
0.80-<0.90	23.00	0.39	497
0.70-<0.80	24.00	0.44	360
0.60-<0.70	39.00	0.53	154
0.50-<0.60	27.00	0.69	-83
<0.50	4.00	1.44	-834
Mean	0.68	-	-
Minimum	0.34	-	-
Maximum	0.93	-	-
Standard deviation	0.12	-	-

*TL = Turkish currency unit; SCE: Standard Cow Equivalent

smallholders (82 out of total 121 farm have <5 cows). EXP in logarithms, represents farming experience of the operator and is expressed in years. This variable has a negative sign as expected and is statistically significant. So, efficiency increases with experience.

GR stands for grazing applications, a production application employed by almost half of the farmers. These farmers are also using concentrate feeds in addition to grazing on pastures or stubbles. Overall average grazing time is 59 days and average daily grazing duration is 2.36 h. Experts suggest that pure breed cows be fed in barns with concentrated feeds and fodders in order to obtain high milk yields. Results confirm this expert opinion. Farmers grazing their milking cows are less efficient than those not grazing. This result is also highly significant. Average efficiency scores of non-grazing and grazing farms are 0.72 and 0.64, respectively. Non-parametric Mann-Whitney U test results show that this difference is significant at 1% level.

Dummy variable, FDGR, distinguishes farmers producing their own feed from other farmers not adopted this production application. Although, statistically insignificant, positive sign of this variable implies that farmers growing their own feed are more efficient than those obtaining their feed from market.

Another dummy variable, ME takes zero if milking is by hand and one otherwise. Negative sign of this variable shows that farmers milking by equipment are more efficient than those milking by hand. However, this variable is not statistically significant.

Table 4 shows efficiency distribution of the farms, average unit milk costs and gross returns per standard cow equivalent unit by efficiency groups. The predicted technical efficiency of the sample dairy farmers ranges from 0.34-0.93.

The mean technical efficiency is estimated to be 0.68. Unit cost of milk in a farm operating close to the efficiency frontier is 28% cheaper than a farm whose efficiency score is between 0.80-0.89. It is also clearly seen that as efficiency decreases, unit milk costs increase and gross margins decrease rapidly. As it is seen some inefficient farmers cannot cover even their variable costs.

CONCLUSION

Negative signs of some variables indicate overuse of some inputs. Reason of negative sign of veterinary costs requires further research, since it might be an indicator of missing right time for medical treatments. Labor has negative sign but since almost >95% of the farms does not use hired labor this input does not incur cash costs. Based on the results of the efficiency analysis, it could be concluded that a relatively high inefficiency exists among small scale farmers in the region. Average efficiency of the sample farmers is 68%. This score implies that milk output could be increased on average by 32% with the existing technology without introducing higher costs.

In the inefficiency model, statistically significant contributors are farming experience of the operator and grazing applications. Farming experience is a factor beyond the control of the farm operator. However, specific extension strategies targeting inexperienced farmers may be developed.

Since grazing application is the most significant factor increasing inefficiency, farmers should be encouraged to feed their milking cows in barns and increase share of concentrates. Experts suggest that pure breed cows be fed with concentrate feeds.

Actually there is not wrong with mixed feeding systems (concentrate plus grazing) but in Turkey, public pastures have become degraded over years. Most probable reason of farmers grazing cows on pastures and stubbles is insufficiency of their economic and financial resources. Farmers might be substituting concentrate feeds with their labor which is abundant. Reduction of grazing time and use of concentrate feeds are also expected to reduce the need for labor. Unit milk cost and gross return per standard animal unit analyses show the importance of technical efficiency in enhancing compatibility of farms.

Based on the low efficiency levels and the fact that some farmers even cannot cover their variable costs of dairy farming, it can be concluded that although there are some social gains of the cooperative projects (such as new job creation, income diversification, etc.) there are many things to be done in an economic sense.

In the short run, training and extension services are required together with some financial support. In the long run, structural enhancements are required in order to transform small subsistence dairy farms into large and market oriented farms. Lastly, since efficiency analysis is based on a single year, results should be extended to other periods with care.

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