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Assessing Production Efficiency of Dairy Farms in Sanliurfa Province, Turkey

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Abstract: Study finds that a sample of 21 dairy farmers located in Sanliurfa Province, Turkey are producing at a low level of production efficiency. Efficiency ranges from 24-99% with the average being 56%. The 99% of the variation in output among the sampled farmers is due to differences in their production efficiency. If a farmer with average efficiency improved efficiency to that of the most efficient farmer in the sample then the average dairy farmer could realize an 43% cost saving. Age and contact with extension officer have positive impacat on dairy production efficiency. However, they are not significant.

Key words: Stochastic frontier analysis, production efficiency, dairy farms, farmer, Turkey

INTRODUCTION

Turkey's dairy sector historically has been one of its most important farm sectors in terms of value added and employment. However, decline has characterized Turkey's diary sector in recent years. Number of dairy cows has decreased from 5.9 million in 1990 to 5.4 million in 2012 or by 8.4%. However, milk production has increased, from 9.7 million tons per year in 2000 to 17.4 million tons/year in 2012 an increase of 79% (TSI, 2012). Increase in milk production come from with various public policies.

They include a milk premium, livestock headage payment, roughage feed support, credit subsidy. In addition to this general public policies, Turkish government has run the program so called "Improvement of Dairy Cattle in GAP region through GAP action plan". With this program farms which are located Sanliurfa, Gaziantep, Adıyaman, Mardin, Batman, Sirnak, Kilis and Diyarbakır provinces could have received grant for construction, machinery and cows.

With this program and credit subsidy number of cows and milk production have been increased significantly. Because Turkey is seeking admission to the European Union these policies have come under review as Turkey aligns its agricultural policy with EU agricultural policy. In addition, World Trade Organization rules require countries to reduce their trade barriers including their custom level. These policy changes are likely to exacerbate the historical economic pressures that have been developed over the last quarter century for Turkey's dairy industry. Improving dairy sector's economic efficiency thus becoming more competitive and improving its chances to survive competition not only from the EU but also the rest of the world should be main goal.

Numerous studies have examined dairy production efficiency in both developed and developing countries. Recent studies include Mbaga *et al.* (2003) and Sharma and Gulati (2003). However, to the researcher's best knowledge, no study has examined the production efficiency of dairy farms in Turkey.

The objective of this study is to asses production efficiency of dairy farms which have grant via GAP action plan progrm and to determine farm specific factors that might be causing efficiency variations among dairy farmers in Sanliurfa Province, Turkey.

MATERIALS AND METHODS

The data used in this study were collected through personal interviews with dairy farmers in Sanliurfa Province, Turkey, during the Spring of 2013. This province was selected because number of cows and milk production almost tripled after impletation of GAP action plan program.

In this study, purposeful sampling process was used. Given farms records of Directory of Agriculture of Sanliurfa, 24 farms have been identified as received grant from GAP action plan program. However, only 21 farms were chosen for interviews because other 3 farms have been shut down. A wide range of socio-economic and business characteristics were elicited in the interview.

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They include number of cows, amount of milk produced, major dairy input (feed, labor and veterinary-pharmaceutical expenses), operator's education and age, farm contact with extension and dairy farm whether is primary occupation or not.

Farrell (1957) developed the first theoretical treatment of production technical efficiency (hereafter, referred to as production efficiency). The standard methodology for measuring farm level production efficiency is to estimate a production frontier that envelopes all the input/output data available for the analysis. Within this context, technical efficiency of a farm is measured relative to the input/output performance of all other farms in the sample. Farms located on the production frontier are considered efficient. Farms located inside the frontier are considered inefficient because it is generating less output that is feasible given its level of inputs.

Cobb-Douglas production function is used to estimate the Stochastic Production Frontier (SPF). In preliminary analyses, the Cobb-Douglas Model was found to adequately represent the data given the specification of the translog stochastic frontier involving the four input variables. This function has been widely used to analyze production efficiency in developing and developed countries (Bravo-Ureta and Rieger, 1991; Sharma *et al*., 1999; Binam *et al*., 2004). Taylor argued that despite its well-known limitations, the Cobb-Douglas function provides an adequate representation of production technology as long as the analysis is interested in the efficiency of production and not the structure of the production technology.

Given the choice of the Cobb-Douglas production function, the data available from the survey and the objective of explaining the variation in output among the sampled dairy farms, the following SPF Model was estimated, to have more detail on SPF Model (Battese and Coelli, 1995; Rahman, 2003):

$$\ln Y_i = \beta_0 + \sum_{j=1}^{7} \beta_j \ln X_{ji} + \nu_i - u_i \quad (1)$$

And:

$$u_i = \delta_0 + \sum_{m=1}^{4} \delta_m Z_{mi} \quad (2)$$

Where:

In = Natural logrithm

Y_i = Annual milk production of farm i measured in kg

X_{1i} = Annual consumption of dairy concentrate in kg

X_{2i} = Annual consumption of grain in kg

X_{3i} = Annual consumption of grain in kg

X_{4i} = Consumption of silage in kg

X_{5i} = Annual electricity expenses (Turkish Lira)

X_{6i} = Human labor in man-days

X_{7i} = Veterinary-pharmaceutical expenses (Turkish Lira)

Z_{mi} = Socio-economic charecteristics

ν_i = A symmetric, identically and independently distributed $N(0, \sigma_v^2)$ error term. It represents random variation in production due to random exogenous factors, such as measurement errors, unobserved production inputs and statistical noise

u_i = A non-negative error term

It reflects technical inefficiency relative to the stochastic frontier. The socio-economic characteristics (Z_{mi}) examined in this study were defined as follows. Z_{1i} is a binary variable equal to one if the farmer contacted an extension officer in the past year and to zero otherwise. Z_{2i} is a binary variable equal to one if the dairy farm is primary occupation and to zero otherwise. Z_{3i} is a binary variable equal to one if farmer had a degree higher than elementary school and to zero otherwise. Z_{4i} is farmer age. Following Coelli and Perelman (1996), technical efficiency of farm i equals:

$$EEF_i = E\left[\exp(-u_i)\varepsilon_i\right] = E\left[\exp\left(-\delta_0 - \sum_{m=1}^{5} \delta_m Z_{mi}\right)\varepsilon_i\right] \quad (3)$$

where, E is the expectation operator. The technical inefficiency of farm i, i.e., u_i is conditional upon the observed value of ε_i from the estimated Cobb-Douglas stochastic production frontier.

Maximum likelihood is used to estimate simultaneously the unknown parameters of the Cobb-Douglas Stochastic Frontier (Eq. 3) and the measure of inefficiency (Eq. 3). The likelihood function is expressed in terms of the variance parameters, $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2/\sigma^2$ (Battese and Coelli, 1995). γ must lie betveen zero and one with zero indicating that the deviation from production efficiency is due entirely to noise and with one indicating that the deviation is due entirely to the farmer's production inefficiency (Battese and Coelli, 1995). FRONTIER 4.1 (Coelli, 1996) is used to obtain the Maximum Likelihood Estimates (MLE).

RESULTS AND DISCUSSION

Descriptive statistics of the variables are presented in Table 1. The dairy herd varied in size from 23-400 cows with an average of 112 cows. Input use varied substantially among dairy farms.

The maximum likelihood estimates for parameters in stochastic frontier model are presented in Table 2. The coefficient of explanatory variables of concentrated feed and electricity expenses were positive with significant at the 99% level of statistical confidence.

Table 1: Characteristics of dairy farms, Sanliurfa Province, Turkey

Input/Output variables	Minimum	Maximum	Mean	SD
Number of cows (cows/farm)	23.0	400.0	112.0	92.2
Concentrated feed (kg)	38086.9	1666587.0	325239.1	393979.6
Grain (kg)	12695.6	2085714.0	228953.2	508486.9
Dry forage (kg)	0.0	1495856.0	250017.4	355815.3
Silage (kg)	54074.0	3958145.0	753541.5	929823.3
Electricity expenses (TL)	12000.0	96000.0	36238.1	23887.0
Labor (Male labor force unit)	1.0	16.5	5.3	3.6
Veterinary-pharmaceutical expenses (TL)	6500.0	250000.0	71623.8	58817.4

Table 2: Maximum likelihood estimates for parameters of the stochastic frontier for dairy farms, Sanliurfa Province, Turkey

Variables	Coefficient	Standard error	t-value
Concentrated feed (kg)	0.9795	0.2307	4.2462
Grain (kg)	-0.0200	0.0296	-0.6774
Dry roughage (kg)	-0.0334	0.0284	-1.1178
Silage (kg)	-0.0287	0.1094	-0.2624
Electricity expenses (TL)	0.1540	0.0577	2.6821
Labor (Male labor force unit)	-0.3247	0.1347	-2.4095
Veterinary-pharmaceutical expenses (TL)	-0.0687	0.1266	-0.5427
Contact with extension	-1.4251	0.3780	-3.769
Whether dairy farmer or not	1.8306	1.6047	1.1407
Farmer education	-0.1838	0.1823	-1.1008
Farmer age	0.0060	0.0123	0.4883
$\sigma^2 = \sigma_v^2+\sigma_u^2$	0.0868	0.0040	21.2343
$\gamma = \sigma_u^2/\sigma^2$	0.9995	0.0020	485.9975
Log likelihood	-	6.0396	-
LR statistic	-	25.6704	-

Coefficients are less than unity implying that variables are efficiently allocated and utilized. Allocation levels of those factors are in second stage of production surface. The coefficient of grain, dry forage, silage, labor usage and veterinary-pharmaceutical expenses are negative. However, only labor is significant at the 99% level of statistical confidence. Negative sign of coefficients implies that total revenue of dairy farms decreases with increase in usage of those inputs. Those inputs allocation are already in stage III of the production surface and to come back to the stage of efficiency, the allocation has to be reduced. Contact with an extension officer during the past year was negatively related to inefficiency level of dairy farm efficiency, implying that contact with extension officer increase dairy farm efficiency. However, it is statistically insignificant. This finding is consistent with the findings of Feder *et al.* (2003), Binam *et al.* (2004) and Rahman (2003). Each of studies involved farmers in developing countries. The inability to find statistical significance has been attributed to bureaucratic inefficiency, deficiency in program design, (Feder *et al.*, 2003; Binam *et al.*, 2004) and the use of a "top-down" instead of participatory approach (Braun *et al.*, 2000). Dairy farms whether treated as an primary occupation has sign of positive with inefficiency but not significant. This study finds that age parameters has sign of positive implying that it is negatively related with production efficiency but statistically insignificant at

Table 3: Distribution of farm level measures of technical efficiency for dairy farms, Sanliurfa Province, Turkey

Decile range of technical efficiency	Number of dairy farms	Share of total sampled farm (%)	Cumulative share of total sampled farm (%)
0.10-0.20	1	4.8	4.8
0.21-0.30	5	23.8	28.6
0.31-0.40	1	4.8	33.4
0.41-0.50	4	19.0	52.4
0.51-0.60	2	9.5	61.9
0.61-0.70	1	4.8	66.7
0.71-0.80	1	4.8	71.5
0.81-0.90	2	9.5	81.0
0.91+	4	19.0	100.0

Mean efficiency: 0.56

the 10% test level. Finding is in line with a priori indeterminate relationship. Then, a priori relationship between a farmer's age and technical efficiency is indeterminate. Older farmers have acquired more human capital through their experiences but they also may be less willing to adopt new ideas. Consistent with an indeterminate a priori relationship, findings from empirical previous studies are mixed. For example, Abdulai and Huffman (1998) find that older rice farmers in Northern Ghana were less efficient than younger farmers while Coelli *et al.* (2002) find that younger rice farmers in Bangladesh were more efficient than older rice farmers. Binici found that age has no statistically significant effect on cotton farms technical efficiency in Turkey.

Education parameters has negative sign implying that it is positively associated with dairy farm efficiency but it is statistically insignificant. Similar insignificant results were reported for farmers in Bangladesh, Ethiopia (Weir, 1999) and Cameroon (Binam *et al.*, 2004).

To test efficiency, the following base calculations were made: $\sigma^2 = \sigma_v^2+\sigma_u^2 = 0.0868$ and $\gamma = \sigma_u^2/\sigma^2 = 0.9995$ The null hypothesis that $\gamma = 0$ is rejected at the 99% of statistical confidence (LR test statistics is 25.67) indicating that technical inefficiency effect exists. A γ^* of 0.9986 indicates that 99.8% of the variation in output among the farmer is due to differences in production efficiency (γ does not equal the ratio, variance of inefficiency to total residul variance because the variance of u_i equals, $[(\pi-2)/\pi]\sigma^2$, not σ^2. Thus, the relative contribution of inefficiency to total variance (γ^*) equals $\gamma/[\gamma+(1-\gamma)\pi/(\pi-2)]$ (Rahman, 2003)).

Table 3 presents the distribution of production efficiency scores. A total of 19% of the 21 sampled dairy farms had a production efficiency score that indicated that they were operating at 90% or more of their potential production efficiency based on the estimated production efficiency frontier. The highest score was 99%. On the other hand, 52% of the sampled dairy farms had efficiency scores of <50%. The lowest score was 17% and the average score was 56%. When taken as a group, these scores suggest high potential for increasing output and/or reducing inputs by improving production efficiency. For example if a farmer with average efficiency improved efficiency to that of the most efficient farmer in the sample then the average dairy farms could realize an 43% (i.e., 1-(56/99)) cost saving.

CONCLUSION

Stochastic Production Frontier analysis is used to analyze the production efficiency of a sample of 21 dairy farmers located in Sanliurfa Province, Turkey. These farms have an average efficiency score of 56% which is markedly low. This finding implies that concern is warranted about the ability of Turkey's dairy sector to compete within the European Union if Turkey is admitted.

Further analysis reveals that 99% of the variation in output among the sampled farmers is due to differences in their production efficiency. There is a potential to improve production efficiency if a farmer with average efficiency improved efficiency to that of the most efficient farmer in the sample then the average dairy farms could realize a 43% decrease in production cost. However, this study also finds no statistically significant relationship between contact with extension and the degree of farm production efficiency. A potential explanation for this finding is that Turkey's extension program uses a top-down as opposed to a participatory approach. The top-down approach may fail to capture the attention of Turkey's farmers especially the most efficient producers. Thus, the success of a national education campaign to raise awareness of the value of an individual feeding system may require a revamping of Turkey's extension program. If this option is deemed infeasible by policy makers an alternative may be the creation of a dedicated program using other delivery mechanisms.

Inputs used such as concentrated feed and electricity expenses were efficiently allocated and utilized. However, grain, dry forage, silage, labor usage and veterinary-pharmaceutical expenses allocation are already in stage III of the production surface and to come back to the stage of efficiency, the allocation has to be reduced.

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