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Assessing Production Efficiency of Dairy Farms in Burdur Province, Turkey

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Abstract

This study finds that a sample of 132 dairy farmers located in Burdur Province, Turkey, are producing at a low level of production efficiency. Efficiency ranges from 24 percent to 94 percent, with the average being 50 percent. Eighty one percent 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 a 47 percent saving in cost. Two statistically significant factors associated with the variation in production efficiency are identified: the type of feeding system used and herd size. Use of extension programs explained little of the variation in production efficiency.

Keywords: stochastic frontier analysis, production efficiency, dairy farms

1 Introduction

Turkey's dairy sector historically has been one of its most important farm sectors both in terms of value added and employment. However, since 1990, milk production in Turkey has decreased from 9.6 million tons per year to 8.2 million tons/year, a decline of 15.3 percent (FAO, 2003). Over the same period, number of dairy cows has decreased from 5.9 million in 1990 to 4.2 million in 2003, or by 29 percent.

To help its dairy sector cope with its decline, Turkey has adopted various public policies. They include a milk premium, a livestock headage payment and roughage feed support program. 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 economic pressures that have developed in Turkey's dairy industry over the last quarter century.

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A key to improving the competitiveness of Turkey's dairy industry is to improve its economic efficiency. 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 authors' knowledge, no study has examined the production efficiency of dairy farms in Turkey. The objective of this study is to analyze the production efficiency of dairy farms in Burdur Province, Turkey and to determine farm specific factors that are associated with the variation in efficiency among dairy farmers.

2 Material

The data used in this study were collected through personal interviews with dairy farmers in Burdur Province, Turkey, during the Spring of 2004. This area was selected because milk production and processing are important activities. Forty six percent of farm income comes from the dairy sector in Burdur Province, which is much higher than the 32 percent average for Turkey (SIS, 2003).

A two stage sampling process was used. In the first stage, 18 villages in Burdur, Bucak and Yesilova Counties were identified through communication with the Directory of Agriculture in Burdur Province. According to farms records of the Directory of Agriculture, 80 percent of the dairy cows in Burdur Province are located in these counties. The farmers in the 18 villages formed the population for this study.

In the second stage, 138 farmers from the 18 villages were chosen for interviews using a stratified random sampling procedure. The sample was stratified by herd size. Useable interviews were obtained for 132 farms, which form the data set for this study. The sampling parameters are presented in Table 1.

Table 1: Sampling Parameters of Dairy Producers, Burdur, Bucak and Yesilova Counties, Burdur Province, Turkey, 2004.

Herd Size (cows)	*Farmer population*	*Farmers sampled* *	*Distribution of sampled farmers*
1-5	1022	54	41 %
6-10	640	43	33 %
11+	554	35	26 %
Total	2216	132	100 %

* These are farmers with useable interviews. The original sample included 138 dairy farmers.

A wide range of socio-economic and business characteristics were elicited in the interview. They included number of cows, amount of milk produced, major dairy inputs (feed, labor, capital, and cultivated land), hectares of fodder crops, operator's education and age, farm contact with extension, and membership in cooperative and producer organizations.

Descriptive statistics of the variables are presented in Table 2. The dairy herds ranged from 1 to 48 cows. The average was 10 cows. Input use varied substantially, with the maximum use being at least 11 times the minimum use for each of the four major input categories.

Table 2: Characteristics of Surveyed Dairy Producers, Burdur, Bucak and Yesilova Counties, Burdur Province, Turkey, 2004.

Variable	*Mean*	*Standard deviation*	*Minimum*	*Maximum*
Herd Size (number)	10	9	1	48
Annual Milk Production (kg/cow)	2111	899	340	6750
Concentrate Feed (kg/herd)	1570	574	225	4500
Roughage Feed * (kg/herd)	1796	1130	2	6525
Human Labor (Man-days/herd)	30	17	6	91
Farm Capital (New Turkish Lira/herd)	4019	2414	1610	18100
Fodder Crop (ha)	2.6	2.4	0	14.1
Education Attainment (years)	6	2	0	15
Age (years)	48.5	13.5	23	75
Use Individual Feeding System (%)	62			
Contact with Extension (%)	66			
Cooperative Member (%)	100			

* Roughage feed equals the consumption of succulent roughage plus dry roughage, assuming a dry matter content of 30 % and 90 % respectively.

3 Methods

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 the farm is generating less output that is feasible given its level of inputs.

A Cobb-Douglas production function is used to estimate the stochastic production frontier (SPF)[4]. This function has been widely used to analyze production efficiency in developing and developed countries (Bravo-Ureta and Rieger, 1991; Sharma *et al.*,

[4] In preliminary analyses, the Cobb-Douglas model was found to adequately represent the data, given the specification of a translog stochastic frontier involving the four input variables.

1999; BINAM *et al.*, 2004). TAYLOR *et al.* (1986) 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 production efficiency among the sampled dairy farms, the following SPF model was estimated[5]:

$$\ln Y_i = \beta_0 + \sum_{j=1}^{4} \beta_j \ln X_{ji} + v_i - u_i \tag{1}$$

and

$$u_i = \delta_0 + \sum_{m=1}^{6} \delta_m Z_{mi} \tag{2}$$

where, $\ln$ denotes natural logrithm; Y_i is annual milk production of farm i measured in kilograms; X_{1i} is annual consumption of purchased dairy concentrate in tons; X_{2i} is annual consumption of roughage feed in tons (equals consumption of succulent roughage plus dry roughage, assuming a dry matter content of 30 % and 90 % respectively (BRAVO-URETA and RIEGER, 1991); X_{3i} is human labor in man-days; X_{4i} is total farm capital defined by opportunity cost of total value of assets in New Turkish Lira (TL), and Z_{mi} are socio-economic charecteristics. v_i is 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 is 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 farmer age. Z_{2i} is a binary variable equal to one if the farmer had a degree higher than elementary school and to zero otherwise. Z_{3i} is a binary variable equal to one if the farmer used an individual feeding system and to zero otherwise. Z_{4i} is a binary variable equal to one if the farmer contacted an extension officer in the past year and to zero otherwise. Z_{5i} is total number of cows in the herd. Z_{6i} is number of hectares planted to fodder crops. Because all of the sampled farmers were members of the Agricultural Sale Cooperatives, this variable was not included in the regression equation.

Following COELLI and PERELMAN (1996), technical efficiency of farm i equal:

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

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

[5] For more detail on the SPF model, see BATTESE and COELLI (1995) and RAHMAN (2003)

Maximum likelihood is used to estimate simultaneously the unknown parameters of the Cobb-Douglas stochastic frontier (Equation 1) and the measure of inefficiency (Equation 2). The likelihood function is expressed in terms of the variance parameters, $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \frac{\sigma_u^2}{\sigma^2}$ (BATTESE and COELLI, 1995). γ must lie between zero and one. Zero indicates that the deviation from production efficiency is due entirely to noise; one indicates 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).

4 Results and Discussion

The estimated Cobb-Douglas production function is presented in Table 3. As expected, the production inputs have a positive coefficient, implying that the amount of milk produced increases as the use of these inputs increase. Except for forage feeds, the coefficients are significant at least at the 95 percent level of statistical confidence.

Table 3: Maximum-likelihood estimates of profit frontier function of dairy farmers, Burdur, Bucak and Yeşilova Counties, Burdur Province, Turkey, 2004.

Variable	*Parameters*	*Coefficients*	*t-ratio*
Constant	β_0	2.03	1.00
$\ln(concentratefeed)$	β_1	0.284*	4.11
$\ln(foragefeed)$	β_2	0.06	1.54
$\ln(labor)$	β_2	0.15*	2.64
$\ln(capital)$	β_3	0.39**	2.54
Variance parameters			
$\sigma^2 = \sigma_v^2 + \sigma_u^2$		0.12	5.82
$\gamma = \frac{\sigma_u^2}{\sigma^2}$		0.89*	6.08
Log likelihood		-0.37	
LR statistic		14.56	

*,** significant at the 1 and 10% level respectively

To test for efficiency, the following base calculations were made: $\sigma^2 = \sigma_v^2 + \sigma_u^2 = 0.115$ and $\gamma = \frac{\sigma_u^2}{\sigma^2} = 0.89$. The null hypothesis that $\gamma = 0$ is rejected at the 99% level of statistical confidence (LR test statistics is 14.56), indicating that technical inefficiency effect exists. A γ^* of 0.81 indicates that 81 percent of the variation in output among the dairy farmers is due to differences in production efficiency[6].

Table 4 presents the distribution of production efficiency scores. Only two percent of the 132 sampled dairy farms had a production efficiency score that meant the farm was operating at 90 percent or more of their potential production efficiency based on the estimated production efficiency frontier. The highest score was 94 percent. The lowest score was 24 percent, and the average score was 50 percent. Fifty-nine percent of the sampled dairy farms were operating at less than 50 percent efficiency. When taken as a group, these scores suggest considerable potential for improving production efficiency by increasing output and/or reducing inputs. For example, if a farmer with average efficiency increased the farm's efficiency to that of the most efficient farm in the sample, this average dairy farmer could realize a 47 percent (i.e., 1- (50/94) saving in costs.

Table 4: Distribution and summary statistics for production efficiency scores of dairy farmers in Burdur, Bucak and Yesilova Counties, Burdur Province, Turkey, 2004.

Production Efficiency Score (%)	*Number of Dairy Farms*	*Percent of Dairy Farms*
$>$90.0	2	2
$>$80.0 $\leq$90	8	6
$>$70.0 $\leq$80	7	5
$>$60.0 $\leq$70	15	11
$>$50.0 $\leq$60	23	17
$>$40.0 $\leq$50	35	27
$>$30.0 $\leq$40	28	21
$>$20.0 $\leq$30	14	11
Less Than 20	0	0
Mean	50	
Minimum	24	
Maximum	94	

Previous studies of the production efficiency of dairy farms have found that on average production efficiency was 83 percent for a sample of U.S. (New England) dairy farms (Bravo-Ureta and Rieger, 1991), 92 percent to 95 percent depending on type of production function specified for a sample of Canadian (Quebec) dairy farmers (Mbaga *et al.*, 2003), 77 percent for a sample of Ecuadorian dairy farms (Bailey *et al.*, 1989), 79 percent and 84 percent for a sample of dairy farmers in the Northern and Western

[6] γ does not equal the ratio of the variance of inefficeincy to total residual variance. The reason is that the variance of u_i equals $\left(\frac{\pi-2}{\pi}\right)\sigma^2$, not σ^2. Thus, the relative contribution of inefficiency to total variance γ^* equals $\frac{\gamma}{\left(\frac{\gamma+(1-\gamma)\pi}{\pi-2}\right)}$ (Rahman, 2003).

regions of India, respectively (SHARMA and GULATI, 2003). This comparison does not mean that this sample of Turkish dairy producers is less efficient than these dairy farmers in other countries. The reason is that the production frontier may differ among each country. This comparison only means that, relative to their production frontier, the sample of Turkish dairy farmers Burdur province did not operate as close to their production frontier as did the producers in the other studies.

Table 5 contains the results for the regression analysis of the factors associated with the variation in production efficiency among the sampled farms. The dependent variable is the degree of production efficiency (see equation 3). Because of the way that equation 3 is written, a variable with negative sign means that it is positively related to the efficiency of the farm.

Table 5: Maximum-likelihood estimates of variables associated with production efficiency of dairy farmers, Burdur, Bucak and Yeşilova Counties, Burdur Province, Turkey, 2004.

Variable	*Parameter*	*Coefficient*	*t-ratio*
Constant	δ_0	0.893	2.40
Age	δ_1	-0.032	-0.85
Education	δ_2	-0.043	-0.59
Feeding Type	δ_3	-0.164*	-2.12
Contact with Extension	δ_4	-0.050	-0.68
Total Herd Size	δ_5	-0.067*	-1.80
Forage Feed land	δ_6	0.002	1.10

* significant at the 5 % level

This study finds that age is positively related with production efficiency but is statistically insignificant at the 90 percent level of statistical confidence. This finding is in line with the expected *a priori* indeterminate relationship. Older farmers have acquired more human capital through their experiences, but they also may be less willing to adopt new ideas. Consistent with this *a priori* expectation, 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 *et al.* (2006) found that age has no statistically significant effect on the technical efficiency of cotton farms in Turkey.

Education is positively associated with efficiency, but it is statistically insignificant. Similar results were reported for farmers in Bangladesh (RAHMAN, 2003), Ethiopia (WEIER, 1999), and Cameroon (BINAM *et al.*, 2004). Conceptually, education improves the skill and entrepreneurial ability of the farmer to organize inputs for maximum efficiency. However, JOSHI (1998) argues that the gains from education are higher in modernized agriculture than in traditional agriculture. The findings in this study are consistent with Joshi's argument.

Contact with an extension officer during the past year was positively related to efficiency but statistically insignificant. This finding is consistent with the findings of FEEDER *et al.* (2004); BINAM *et al.* (2004); RAHMAN (2003). Each of these studies involved farmers in developing countries. The inability to find statistical significance has been attributed to bureaucratic inefficiency, poor program design, (FEEDER *et al.*, 2004; BINAM *et al.*, 2004) and the use of a "top-down" instead of participatory approach (BRAUN *et al.*, 2002). Turkey's extension program has been characterized by a top-down approach (AKTAŞ, 2004). Thus, the lack of a participatory approach may explain the insignificance of Turkey's extension program in terms of its impact on the efficiency of these Turkish dairy farms.

The number of hectares of fodder crops is statistically insignificant and does not have the expected sign. Farmers who harvest larger acreages of fodder crops may use too much roughage in their feed rations because it is available. Proper nutritional balance between feed concentrates and roughage feed is widely recognized as a key to attaining production efficiency (BAILEY *et al.*, 1989).

In the study area, two types of feeding systems are used. In one system, the cows are fed individually. In the other system, the cows are fed as a group. Use of an individual feeding system was associated with a greater degree of efficiency. This relationship was significant at the 95 percent level of statistical confidence. One reason that an individual feeding system is more efficient is that the farmer can feed each cow a ration tailored to her production potential. In a group feeding system, the highest producing cows may not produce to their potential because they may not necessarily eat the right amount of feed.

Farm size had a positive relationship with dairy farm efficiency. This relationship was significant at the 95 percent level of statistical confidence. It is consistent with previous studies (BRAVO-URETA and RIEGER, 1991; TAUER, 2001) and with the expected existence of economies of size from economic theory.

5 Conclusion and Policy Implications

Stochastic Production Frontier analysis is used to analyze the production efficiency of a sample of 132 dairy farmers located in Burdur Province, Turkey. These farms have an average efficiency score of 50 percent. Further analysis reveals that 81 percent of the variation in output among the sampled farmers is due to differences in their production efficiency. These findings imply that the average dairy farmer in this sample has the potential to substantially increase their efficiency without changing their production frontier. Operating at a high efficiency relative to the production frontier is an important factor in remaining competitive and thus in business over time.

The analysis identified two statistically significant factors associated with the variation in production efficiency: individual instead of group feeding of cows, and larger herd size. Both factors are potentially attainable, although both have implementation costs. In particular, policy makers either must allow market forces to reward the formation of larger dairy farms or they must implement policies that help small dairy producers adjust by either getting larger, or by developing niche markets, or by exiting dairy farming, including the potential use of public funds to pay an exit bonus.

Individual feeding of cows could become the centerpiece of a national education campaign to improve dairy herd production efficiency. However, this study finds no statistically significant relationship between contact with extension and the degree of farm production efficiency. Thus, the success of a national education campaign to raise awareness of the value of individual dairy feeding systems may require a revamping of Turkey's extension program. If this option is deemed infeasible by policy makers, an alternative approach may be to create a separate program using other delivery mechanisms.

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