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Economic Efficiency of Cattle-Fattening Farms in Amasya Province, Turkey

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Abstract: Over the last decade, beef cattle production has increased in importance in Turkey due to growing demand, which has been accompanied by an increased supply response. However, there is insufficient information on the productive efficiency and productivity of cattle-fattening farms. This study evaluated productive efficiency measures for sample cattle-fattening farms in Amasya Province, Turkey and explored the determinants of economic efficiency. Data Envelopment Analysis (DEA) was used to calculate productive efficiency measures. Farm managers from 54 randomly selected farms were interviewed in the 2004-2005 production periods. Economically inefficient farms needed to lower their costs by 18% to perform as well as the best-practice farms in the sample. Positive relationships were found between economic efficiency and feeding frequency, the ratio of Holsteins in the herd, fattening period, existence of a management record, contacts with extension services and credit use. Economically efficient farms had larger barns, more animals and gained much more income per animal compared to inefficient farms. Policy measures aimed at developing better farm-level training and farm extension programs, helping farm operators improve their herd and providing farmers with greater access to credit are recommended to increase productive efficiency in the research area.

Key words: DEA, determinants of efficiency, efficiency measures, cattle, farms, Turkey

INTRODUCTION

Over the last decade, the importance of beef cattle production has increased in Turkey due to growing demand for beef. Beef cattle production is one of the most important economic activities in Turkey, which has approximately 1.6 million beef cattle heads. Approximately, 8% of all Turkish livestock farms specialize in cattle fattening and produce about 409 thousand tons of beef a year (Turkstat, 2006). However, low levels of education, poor extension services, insufficient physical infrastructure and lack of credit in Turkey often make it difficult for Turkish cattle breeders to understand and adopt new production technologies. As a result, Turkish beef cattle raisers have failed to fully exploit potential technology and have made inefficient decisions. Many policy makers have therefore focused on improving productivity and efficiency to promote growth in Turkish meat production. However, such efforts have been hindered by insufficient information at the farm level on productive efficiency and productivity, especially for cattle-fattening farms.

Many previous empirical studies have focused on calculating farm level efficiency measures (Binam *et al*., 2003; Binam *et al*., 2004; Alvarez and Arias, 2004; Zavela *et al*., 2005; Cinemre *et al*., 2006; Cinemre and Ceyhan, 2006; Bravo *et al*., 2007). Some studies have also addressed the issue of productive efficiency in meat production (Ruiz *et al*., 2000; Perez *et al*., 2003; Somwaru and Valdes, 2004; Chiang *et al*., 2004; Karagiannis and Tzouvelekas, 2005; Galanapoulos *et al*., 2006; Kahi and Hirooka, 2006; Trestini, 2006; Krasachat, 2007). However, while a few efficiency analysis have been applied to Turkey (Cinemre *et al*., 2006; Cinemre and Ceyhan, 2006; Bozoglu and Ceyhan, 2007), no previous studies have examined farm level productive efficiency measures and their determinants for Turkish cattle-fattening farms.

Therefore, the objectives of this study were: to calculate farm-level productive efficiency measures for cattle-fattening farms in Amasya, Turkey, to identify important factors causing differential efficiency among cattle-fattening farmers in Amasya and to develop policies based on these productive efficiency measures and their determinants.

MATERIALS AND METHODS

The research area: The study was conducted in Amasya (40°16'16"N, 36°31'53"W), a province in Northern Turkey. Amasya Province encompasses 55,199 ha; of this area, approximately 46% is used for agricultural

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production and there are approximately 35,000 farms. Cattle-fattening operations exist in all regions of Turkey, but the largest are in Amasya. The selected study area had 2% of the total number of cattle in Turkey and approximately 5% of the total beef cattle heads in Turkey. Most Turkish cattle-fattening operations are relatively small. The Turkish Statistical Institute (Turkstat, 2006) reported that approximately, 89% all operations had fewer 14 than 40 head but that these small lots marketed 79% of cattle annually. In the research area, there were approximately, 1500 cattle-fattening farms, 55% of which were unspecialized family farms with fewer than 5 cattle. The remaining farms were specialized, commercial farms. Cattle in the research area were a mix of beef breeds, crossbreeds, or dairy cattle steers (mostly Holstein steers). The Amasya region was selected as the study area because all the beef produced by its specialized farms is directed towards large cities with high beef demand such as Istanbul, Ankara and Izmir. However, the other beef suppliers in Amasya are mainly family farms, which market beef locally for domestic needs. Considering the distribution of specialized farms, the percentage of large cattle-fattening farms in Amasya is greater than the national average. In the research area, 8% of the specialized cattle-fattening farms had >100 beef cattle heads, while the national average was only 2%.
Further, 58% of the farms in the research area had 1-30 beef cattle heads; the Turkish average was 69%, indicating that cattle-fattening farms are more commercial in the research area relative to the Turkish average (Table 1).

Other characteristics also set beef production in the research area apart from that in the nation as a whole. Carcass weight averaged 292 kg in the research area, while the national value was 169 kg. Carcass yield, which is proportion of the animal's live weight salvaged at carcass point, was also somewhat higher than the national average. In the research area, cattle-fattening farms used 11.80 kg feed per kg of production, compared to the national average of 13.15 kg feed per kg of production. Cattle-fattening farms in the research area sold their beef cattle when they reached 432 kg in size, after approximately, 9-month fattening periods. Daily weight gain in the research area was also more than the national average (Table 1).

DEA model for cattle-fattening farms: Data Envelopment Analysis (DEA) was used to estimate productive efficiency measures. DEA is one of the most popular methods for estimating the best-practice production frontier and provides an analytical tool for determining efficient and inefficient behavior. Since, DEA is less data demanding, works with small sample sizes and does not require knowledge of the proper functional form of the frontier, error and inefficiency structures, it has been preferred over Stochastic Frontier Analysis (SFA). Stochastic models such as SFA necessitate a large sample size to make reliable estimations (Coelli *et al*., 2005).

Efficiency is defined in a relative sense as the distance between observed input-output combinations and the best-practice frontier. The best practice frontier represents the maximum output attainable from each input level. The farrell input-orientated measure of technical efficiency was used as a measure of productive efficiencies, as farms tend to have greater control over their inputs than over their outputs. The efficiency of a firm consists of two components: Technical Efficiency (TE), which reflects the ability of a firm to use minimal input to reach given the level of output and Allocative Efficiency (AE), which reflects the ability of a firm to use the inputs in optimal proportions, given their respective prices and the production technology. These two measures are then combined to provide a measure of Economic Efficiency (EE). The Farrell measure equals 1 for efficient farms and then decreases with inefficiency (Coelli *et al*., 2005).

We constructed a DEA model assuming that each cattle-fattening farm produces a quantity of beef (y_1) using multiple inputs (x_1) and that each farm (i) is allowed to set its own set of weights for both inputs and output. The data for all farms are denoted by the K×N input matrix (X) and M×N output matrix (Y). Using piecewise technology, an input-oriented measure of TE can be calculated for the i-th farm as the solution to Linear Programming (LP):

$$\begin{aligned} &\text{Miniimize}_{\theta,\lambda}\ \theta \\ &\text{Subject to} \quad -y_i + Y\lambda \geq 0 \\ &\qquad\qquad\quad \theta x_i - X\lambda \geq 0 \\ &\qquad\qquad\quad \lambda \geq 0 \end{aligned} \tag{1}$$

where, θ is the TE score having a value $0<\theta<1$. If the value equals 1, the farm is on the frontier; the vector λ is an N×1 vector of weights which defines the linear combination of the peers of the i-th farm.

The input-based minimum cost for the i-th farm can be obtained by solving the following LP problem:

$$\begin{aligned} &\text{Minimize}_{\lambda, xi*}\quad w_i^T x_i^* \\ &\text{Subject to} \quad -y_i + Y\lambda \geq 0 \\ &\qquad\qquad\quad x_i^* - X\lambda \geq 0 \\ &\qquad\qquad\quad \lambda \geq 0 \end{aligned} \tag{2}$$

Table 1: Characteristics of sample's farms compared to the Turkish farm population

Characteristics	Turkey farm population*	Sample farm**
Statistics for cattle fattening farms		
The percentage of livestock farm (%)	3.600	11.00
The number of specialized cattle fattening farms	30000	683.0
Distribution of cattle fattening farms		
The percentage of small farms (1-30 beef cattle heads) (%)	69.00	58.00
The percentage of medium farms (31-100 beef cattle heads) (%)	29.00	34.00
The percentage of large farms (>100 beef cattle heads) (%)	2.000	8.000
Characteristics of average cattle fattening farms		
Carcass weight (kg)	169.0	2920
Carcass yield (%)	52.00	59.00
Fattening period (days)	287.0	263.0
Daily weight gains (kg)	0.790	1.090
Feed conversion ratio***	13.15	11.80

*Average Turkish cattle fattening farm is based on the results of Yildirim (2000), Karakas (2002) and Ozkan and Erkus (2003). **Average research area's cattle fattening farm is based on the results of Sayili (2001) and Mara (2005). ***Feed conversion ratio is calculated from the number of kilos of feed that are the used to produce per kg of meat

Where:

- w_i = A vector of input prices for the i-th cattle-fattening farm
- T = The transpose function
- x_i^* = The cost-minimizing vector of input quantities for the i-th cattle-fattening farm calculated by the LP, given the input prices w_i and output level
- y_i and λ = A N×1 vector of constant

Eq. 1 and 2 represents the cost minimization under Constant Returns to Scale (CRS) technology. CRS means that output increases in proportion to changes in all inputs. The Economic Efficiency ($EE_{i,CRS}$) of the i-th cattle-fattening farm is calculated as:

$$EE_{i,CRS} = w_i^T x_i^* / w_i^T x_i \qquad (3)$$

where, $EE_{i,CRS}$ is the ratio of the minimum cost to the observed cost, given input prices and CRS technology (Coelli *et al*., 2005).

Coelli *et al.* (2005) pointed out that the CRS model is only appropriate when the farm is operating at an optimal scale. Factors such as imperfect competition and financial constraints may prevent a firm from operating at optimal scale. Since, cattle-fattening farms in the research area conducted their activities under imperfect competition due to imperfect information about market such as input and output prices and because the size of many cattle-fattening farms made them ineligible for institutional loans, we transformed (Eq. 1) to the Variable Returns to Scale (VRS) technology model by adding the convexity constraint: $N1\lambda = 1$, where N1 is an N×1 vector of ones and λ is an N×1 vector of constant to the Eq. 1. In this case, TE scores under VRS was calculated using (Eq. 1), with the convexity constraint added to decompose the TE scores into two components: Pure Technical Efficiency (PTE), which reflects the ability of a firm to obtain maximal outputs at an optimal scale and Scale Efficiency (SE), which reflects the distance of an observed firm from the most productive scale size. Farms that are scales efficient are of appropriate size and thus, do not need to be reorganized to improve output or earnings. Scale efficiency was calculated as the ratio of the TE score of the farm under CRS technology to the TE score of the farm VRS technology.

Farm was classified as scale efficient if the SE = 1, or if the $TE_{VRS} = TE_{CRS}$. Farm level scale inefficiency was determined by comparing TE score under Non-Increasing Returns to Scale (NIRS) with TE score under CRS. If SE<1 and $TE_{NIRS} = TE_{CRS}$, farm was classified as scale inefficient due to Increasing Returns to Scale (IRS). If SE<1 and $TE_{NIRS} = TE_{CRS}$, farm was classified scale inefficient due to Decreasing Return to Scale (DRS). The allocative efficiency was calculated residually by:

$$AE_i = EE_{i,VRS} / TE_i \qquad (4)$$

There are four main ways in which environmental variables can be accommodated in DEA analysis: the approach of Banker and Morey (1986), the method proposed by Charnes *et al.* (1981), the approach of adding environmental variables directly into the linear programming formulation and the two-stage approach. If the values of the environmental variable can be ordered from the least to the most detrimental effect upon efficiency, the approach of Banker and Morey (1986) can be followed. If there is no natural ordering of environmental variable then one can use a method proposed by Charnes *et al.* (1981). The mutual problem is that only one environmental variable can be considered by these two methods. In the approach of adding environmental variables directly into the linear programming formulation, prior assumption was required and the environmental variables must be continuous. In the two-stage method, a DEA problem is solved in the first stage of analysis, involving only the traditional inputs and outputs. In the second stage, the efficiency scores from the first stage are regressed upon the environmental variables (Coelli *et al*., 2005). In this study, the two-stage approach was used to assess the influences of various factors on economic efficiency. This approach has several advantages, such as not requiring prior assumptions regarding the direction of influence and the ability to accommodate more than one variable with continuous or categorical variables. A Tobit approach, or censored regression of DEA economic efficiency, estimating the potential determinants, was used because the efficiency estimates had 1 as an upper limit and 0 as a lower limit. A number of previous studies have used the Tobit model (Binam *et al*., 2004; Chavas *et al*., 2005; Cinemre *et al*., 2006), which is given as:

$$EE_i = \beta_0 + \sum_{j=1}^{n} \beta_j V_{ij} + u_i \quad \text{if} \quad u_i > -\beta_0 - \sum_{j=1}^{n} \beta_j V_{ij}$$

$$EE_i = 0 \quad \text{if} \quad u_i \le -\beta_0 - \sum_{j=1}^{n} \beta_j V_{ij}$$

Where:

Ee_{ij} = The measure of economic efficiency for farm I

V_{ij} = Explanatory variables that influence the economic efficiencies of the farms

n = An index of the variables

β and u = Parameters of the model and the random error term, respectively (Ramanathan, 2001)

Bootstrap: We used the bootstrapping method introduced by Efron (1979) to assess the confidence intervals of the efficiency scores. Bootstrapping is a general approach to statistical inference based on building a sampling distribution for a statistic by re-sampling from the data. The procedure applied in this study consists of the following steps. First, bootstrap samples were created by sampling with replacement from the original random sampling. Second, the bootstrap distribution was derived by calculating statistic for each resample. Finally, 95% bootstrap percentile confidence interval for the efficiency scores were constructed by using the interval between the 2.5 and 97.5th percentiles of the bootstrap distribution.

The results throughout the study were obtained from 54 bootstrap iterations. The bootstrap standard error based on re-samples is Hesterberg *et al*. (2003):

$$SE_{boot,\bar{x}} = \sqrt{\frac{1}{B-1}\sum(\bar{x}^* - \frac{1}{B}\sum \bar{x}^*)^2}$$

Where:

x* = The mean value of an individual re-samples

B = The number of re-sample

Data: Farm managers from 54 randomly selected farms were interviewed in the 2004-2005 production periods. Since, 55% of the fattening farms in the research area were family farms with fewer than five beef cattle heads per farm, farms having >5 beef cattle heads were categorized as cattle-fattening farms. The variables used in the second stage to study the determinants of inefficiency came from the same source. The economic efficiency of cattle-fattening farms was modeled in a multiple-input, single-output framework. The quantity of beef produced during the fattening period in 2004 was used to measure the output (kg). Six inputs were used for the economic efficiency analysis: concentrate feed (kg), forage (kg), labor (hours), number of cattle (head), cost of veterinary care and medicine ($) and marketing costs such as transportation, loading and unloading ($).

Table 2, presents descriptive statistics of the variables used in the economic efficiency analysis. The sample cattle-fattening farms produced 15 tons of beef, on average. The minimum was 1.1 tons and the maximum was 51 tons. To reach the present level of production, cattle-fattening farms used approximately 1247 labor hours, 72 tons of concentrate feed and 100 tons of forage, on average. In addition to these inputs, farms paid $1730 for veterinary and medical costs and $825 for marketing costs, on average during the fattening period (Table 2).

The average costs of labor, concentrate feed and forage were $1.48 h^{-1}, $0.22 kg^{-1} and $0.06 kg^{-1}, respectively. The price of beef cattle was $593/head and the interest rate was 0.19 for monetary inputs, such as the marketing and veterinary costs in the data envelopment model.

The most commonly used variables in previous studies to explain the efficiency of a sample farm were size, age of operators, farmer experience, farmer education level, use of extension services, data recording, credit use, feeding frequency and fattening period (Wilson *et al*., 2001; Iraizoz *et al*., 2003; Chavas *et al*., 2005; Cinemre *et al*., 2006).

In this study, the variables included in the Tobit analysis were broadly categorized into three groups: personal characteristics of farmers (age, education and experience of operators and family size); farm characteristics (farm size, land allocated to fodder crops, pasture use, the ratio of Holsteins to the total number of cattle, fattening period, feeding frequency, existing management record) and access to institutions (use of credit and extension services). The age variable included in the Tobit model served to test the hypothesis that younger farmers were more receptive to innovations. Because lack of experience, low level of education and large family size were potential sources of inefficiency, education, operator experience and family size were also included as variables. Farm size was included to reveal the relationship between economic efficiency and farm size, with 1, 2 and 3 representing small (5-35 cattle), medium (36-125 cattle) and large (>126 cattle) farms, respectively.

Table 2: Descriptive statistics of variables used in efficiency analysis and tobit model

Variables	Mean±SD	Minimum	Maximum
DEA model			
Beef production (kg)	15203.06±13728.89	1150.00	51150.00
Labor (hours)	1247.00±587.61	405.00	2880.00
Concentrate feed (kg)	72641.11±57299.62	5400.00	222752.00
Forage (kg)	100374.70±76888.05	10125.00	289575.00
Number of cattle (head)	56.52±46.52	5.00	167.00
Costs of veterinary and medicine ($)	1730.45±1385.11	74.07	5185.19
Marketing costs ($)	824.77±616.73	74.07	2592.59
Tobit model			
Personal characteristics			
The education level of operator (in years)*	6.94±2.46	5.00	13.00
The experience of operators (in years)	13.13±4.90	1.00	22.00
Family size (person)	5.89±3.67	2.00	9.00
Farm characteristics			
Farm size (The number of beef cattle heads)	34.69±57.33	5	167
Percentage of farms using pasture (%)	7.41±0	0	0
Land allocated to fodder crops (ha)	0.20±0.46	0	2.50
The ratio of Holstein breed on total number of cattle	0.52±0.50	0	1.00
Fattening period (days)	268.50±27.19	210.00	330.00
The number of feeding in a day	2.87±0.34	2	3
The percentage of farms having management record (%)	79.62±0	0	0
Access to institutions			
Credit use ($)	11728.39±21218.30	0	88888.89
The number of contacts with extension services in a month	1.33±0.86	0	4

*From the start of the schooling period

Table 3: Efficiency measures for sample cattle fattening farms (N = 54)

Efficiency measures	Mean±SD	Minimum	No. of efficient farms
Economic Efficiency (EE)	0.822±0.103	0.623	3
Allocative Efficiency (AE)	0.900±0.063	0.731	3
Technical Efficiency (TE)	0.915±0.104	0.671	22
Pure Technical Efficiency (PTE)	0.868±0.120	0.613	13
Scale Efficiency (SE)	0.949±0.081	0.657	14

Similarly, to show the effects of farmers use of extension services on economic efficiency, a variable reflecting the frequency of contacting extension services was included in the model, with 1-4 representing once a week, 1-2 times a month, 3-4 times in 3 years and once in 4 years, respectively. Since, indigenous cattle breeds performed poorly for food intake, daily gains and feed conversion ratios when compared with exotic breeds, we included the ratio of Holsteins as a variable to test the hypothesis that farms mainly based on indigenous breeds were economically inefficient compared to those with larger proportions of Holstein steers. To explore the relationship between economic efficiency and the existence of management records, management records were used as a dummy variable that equaled 1 if a management record was available and equaled 0 otherwise. The pasture variable was included in the Tobit model to test the hypothesis that farms that used pastureland were more efficient. The pasture dummy equaled 0 if the farms used pasture and 1 if they did not.

Table 2 presents some basic characteristics of the sample farms used in the Tobit model. While farm owners had low education levels, operators had moderate levels of experience. For the sample farms, the average family size was 6. Most of the sample farms were medium scale and they allocated only 0.2 ha of land to fodder crops. Approximately, half of the farms preferred raising Holsteins and Holsteins made up 52% of herds, on average. The fattening period was 269 days and farmers fed the cattle three times per day. Generally, pasture use was not common in the research area. The farms had very few contacts with extension services: on average, 1-2 times per month. They also used low levels of credit; credit use averaged approximately 12,000 US dollars per farm.

RESULTS AND DISCUSSION

Overall, the economic efficiency of cattle farms ranged from 0.62-1. The average was 0.82 with a standard deviation of 0.10. On average, inefficient farms would have needed to lower feed, marketing and labor costs by 18% to perform as well as the best-practice farms in the sample (Table 3).

Efficiency measures for sample cattle-fattening farms are presented in Table 3. The relative level of the AE and TE measures provides evidence of the source of deviations from cost-minimizing efficiency. For the sample, the primary source of economic inefficiency was allocative although both technical and allocative measures were very close. Almost 95% of the sample cattle-fattening farms were allocatively inefficient. These farms employed the wrong input mix, given input prices, so that their costs were 10% higher than the cost

Table 4: Confidence Intervals bounds for the efficiency measures

Efficiency measures	Standard DEA estimation	Bias	SE (boot)	Lower bound	Upper bound
Economic Efficiency (EE)	0.822	+0.078	0.036	0.704	0.938
Allocative Efficiency (AE)	0.900	+0.036	0.034	0.812	0.966
Technical Efficiency (TE)	0.915	+0.047	0.033	0.783	0.986
Pure Technical Efficiency (PTE)	0.868	+0.065	0.034	0.743	0.935
Scale Efficiency (SE)	0.949	+0.041	0.027	0.865	0.993

Table 5: Summary of returns to scale results (N = 54)

Variables	IRS	CRS
Average number of farms	40.000	14.000
Average beef production (ton)**	11.020	27.160
Average barn size (m^2)*	104.15	203.57
Average daily labour (h $head^{-1}$)*	0.1500	0.1100
Average concentrate feed (ton $head^{-1}$)**	1.2500	1.3300
Average forage (ton $head^{-1}$)*	1.8000	1.7300
Average number of cattle**	45.000	90.000

The symbols of *, ** in table reflects the significance at the 10 and 5% level, respectively for difference between farms having increasing returns to scale and constant returns to scale

Table 6: Results of the Tobit analysis: efficiency determinants

Variables	Estimated coefficient	Marginal effects
Personal characteristics		
Education level of the operator (years)	0.006 (0.005)	0.0039
Experience of the operators (years)	-0.004 (0.003)	-0.0025
Family size (person)	0.002 (0.007)	0.0012
Farm characteristics		
Farm size (proxy)	-0.011 (0.028)	-0.0070
Pasture use (dummy)	-0.037 (0.049)	-0.0023
Land allocated to fodder crops (ha)	0.003 (0.003)	0.0017
The ratio of Holstein breed on total cattle	0.104 (0.269)***	0.0650
Fattening period (days)	0.001 (0.0001)***	0.0006
Feeding frequency (number day^{-1})	0.106 (0.032)***	0.0681
Management record (dummy)	0.068 (0.038)**	0.0442
Access to institutions/public goods		
Credit use (thousand $)	0.00009 (0.00006)*	0.00006
Extension services (number of contacts)	0.033 (0.017)**	0.0213[1]
Likelihood ratio test	57.09 ***	

Standard errors are reported in parentheses. [2]Single (*), double (**) or triple (***) asterisk denotes, respectively, significance at the 10, 5 and 1% level

minimizing level. The estimated TE measures for the sample of cattle-fattening farms varied from 0.67-1, with a sample average of 0.92. The cattle-fattening farms could reduce their input use by 8% level without output reduction. Of the sample farms, 61% had a higher technical efficiency coefficient than the mean technical efficiency. The TE values for large-scale farms were statistically higher than those of medium- and small-size farms ($p<0.05$). This result agrees with Latruffe *et al.* (2004) findings for crop and livestock farms in Poland. They reported a positive size efficiency relationship. On the other hand, negative size efficiency relationship in vegetable farms reported the opposite in Turkey (Cinemre *et al.*, 2006; Cinemre and Ceyhan, 2006). This difference between these studies can be explained by differences in farm type.

In the sample cattle-fattening farms, PTE was the primary cause of the technical inefficiency. PTE was 0.87, on average. SE was 0.95, on average, with a standard deviation of 0.08 (Table 3). Table 4 reports the bias and the lower and upper bounds of the efficiency scores. The biases were small for all efficiency measures. Bootstrapping showed that the confidence intervals for efficiency measures did not vary considerably over the resamples. Based on the results of bootstrapping, the lower and upper bound of technical efficiency scores were 0.783 and 0.986, respectively, while that of allocative efficiency scores were 0.812 and 0.966. Lower bound for PTE was smaller than that of SE. The reverse was the case for the upper bounds of PTE and SE.

The overall economic efficiency scores varied from 0.704-0.938. Standard error for TE, AE and EE derived from bootstrapping distributions were 0.033, 0.034 and 0.036, respectively.

Of the sample farms, 26% had CRS, whereas 74% exhibited a situation in which an increase in input caused output to increase to a larger proportion, termed IRS. None of the sample farms had DRS, which refers to output increasing by less than that the proportion of all inputs (Table 5). The relatively small scale production of the cattle-fattening farms in the research area and in Turkey in general, is the main reason why no farms had DRS. This was because profits were not significantly different between optimum-scale and large-scale farms. However, different results have been reported for trout farms and polyculture farms in Turkey (Cinemre *et al.*, 2006; Cinemre and Ceyhan, 2006).

Since, scale refers to size, we included the descriptive statistics of variables such as beef production per fattening period, barn size, labor use, feed use and number of cattle. As shown in Table 5, small and medium sized farms exhibited IRS, while CRS was observed for large scale farms ($p<0.01$). The 14 scale efficient cattle-fattening farms were large in terms of barn size, number of cattle and beef production. In addition, scale-efficient farms used less labor and forage per head and used more concentrate feed per head, compared to inefficient farms. Therefore, scale efficient farms gained more weight (302 kg $head^{-1}$) than inefficient farms (245 kg $head^{-1}$) during the fattening period.

Table 7: The differences between economically efficient and inefficient cattle fattening farms

Characteristics	Economically efficientfarms (n = 3)	Economically inefficientfarms (n = 51)
Personal characteristics		
The average age of the operator (year)***	35.00 (2.51)	43.86 (1.46)
Average education level of the operator (years)	8.00 (1.73)	6.88 (1.84)
Average experience of the operators (years)	11.33 (1.45)	13.23 (13.70)
Average family size (person)***	5.00 (0.58)	5.94 (0.20)
Basic farm characteristics		
Average total labor (AWU)*	3.33 (1.62)	4.46 (1.25)
Average barn size (m^2)***	253.33 (113.48)	122.67 (13.34)
Average number of cattle (head)***	108.00 (51.60)	53.49 (5.90)
Average farm land (ha)**	17.33 (6.25)	53.80 (24.49)
The percentage of farms keeping management record (%)*	100.00	80.39
Access to institutions/public goods		
Average credit use ($)*	32098.76 (26691.98)	10530.14 (19118.62)
Extension services (average number of contacts per month)*	4.00 (2.85)	2.00 (1.86)
The share of farm operators participating training (%)*	100.00	68.63
Membership to farmers association (%)	33.33	41.18
Capital structure of farms		
Average total capital ($ $head^{-1}$)**	8792.10 (4998.33)	3878.42 (3575.64)
Average working capital ($ $head^{-1}$)**	2664.16 (1332.19)	1255.31 (828.50)
Average machinery and equipment ($ $head^{-1}$)**	1178.82 (678.48)	468.21 (440.36)
Liquidity (current ratio in average)	3.46 (1.86)	2.62 (1.37)
Solvency (debt $asset^{-1}$ in average)*	0.13 (0.09)	0.07 (0.05)
Farm performance		
Average return on assets (%)*	21.16 (5.17)	14.70 (5.84)
Average return on equity (%)*	20.43 (4.99)	13.89 (5.52)
Average farm income ($ $person^{-1}$ in the farm labor)***	14952.70 (9789.09)	7138.10 (3205.10)
Fattening characteristics		
Average beef production (kg $head^{-1}$)**	311.14 (150.41)	263.99 (32.10)
Average land allocated to fodder crops (ha)	0	2.09 (0.66)
Percentage of farms using pasture (%)	0	7.84
The average ratio of Holstein breed on total cattle**	67.00 (6.34)	50.00 (14.27)
Average fattening period (days)***	260.00 (10.00)	269.00 (3.89)
Average feeding frequency (number day^{-1})***	3.00 (0.001)	2.87 (0.04)
Average concentrate feed use (kg $head^{-1}$)**	1274.54 (620.21)	1286.54 (136.89)
Average forage use (kg $head^{-1}$)**	1723.52 (819.05)	1782.20 (184.71)
Average labor use (hours $head^{-1}$)***	14.31 (5.54)	22.99 (1.49)
Average weight gaining from per kg feed (kg)**	0.10 (0.03)	0.08 (0.05)
Average feed use for increasing per kg weight (kg)**	9.64 (4.58)	11.62 (1.21)

[1]Figures in parentheses are standard deviations. [2]Single (*), double (**) or triple (***) asterisk denotes, respectively, significance at the 10, 5 and 1% level

Table 6, presents results of the Tobit model based on the relationship between economic efficiency and its determinants. Most of signs related to efficiency determinants were as expected. All variables evaluated in the farm characteristics group, with the exception of farm size and pasture use, had positive values. The feeding frequency coefficient was positive, which indicated that farms with higher feeding frequency were more efficient than farms with lower feeding frequency, as expected ($p<0.01$). Farms with higher proportions of Holsteins tended to be more efficient ($p<0.01$). In the research area, indigenous breeds and their crosses had shorter and lighter carcasses. Because of small size and weight, indigenous breeds were not popular compared to exotic commercial breeds. Ruiz *et al*. (2000), Somwaru and Valdes (2004) and Trestini (2006) reported similar results. Farms having management records were more efficient than farms without these records ($p<0.05$). However, the variables of farm size, family size, education level of operators, experience, pasture use and land allocated to fodder crops were not related to economic efficiency ($p>0.10$).

All variables belonging to the institutions group positively influenced the economic efficiency. A larger number of contacts with extension services were associated with greater economic efficiency ($p<0.05$). Similar results were reported by Helfand (2003) for Brazil, Kaliba and Engle (2006) for Binam *et al*. (2004) for Cameroon. Another outcome of the Tobit model was the significant effect of credit use on economic efficiency. Credit use enhanced the economic efficiency of the sample farms; farms using more credit were more efficient ($p<0.10$). In the research area, the shortage of working capital, due to high input costs and low returns on outputs, together with high credit costs, was common and negatively affected farm efficiency. Therefore, increased credit use increased economic efficiency, a conclusion supported by the findings of Helfand (2003), Binam *et al*. (2004), Zavela *et al*. (2005), Chavas *et al*. (2005), Cinemre *et al*. (2006) and Bozoglu and Ceyhan (2007).

The differences between economically efficient and inefficient cattle fattening farms were presented in Table 7. The comparative analysis results indicated that the economically efficient cattle-fattening farms raised large number of cattle in larger barns with a relatively high level of working capital ($p<0.01$). They also had more farmland ($p<0.05$). However, their labor uses, both totals labor and per head, was lower than those of inefficient farms ($p<0.10$). In addition, efficient and inefficient farms had different farmer profiles. Farmers on efficient farms were younger and had smaller families ($p<0.01$). The number of contacts with information sources such as extension services, private firm advisers and cooperatives by efficient farms was greater than by inefficient farms ($p<0.10$). Similarly, the ratio of farm operators participating in training was higher for efficient farms than for inefficient farms ($p<0.10$). Efficient farms also had higher total capital, machinery and equipment capital, farm income per person, returns on assets and equity and better access to credit with relatively higher solvency than did inefficient farms ($p<0.05$). Concerning fattening characteristics, economically efficient farms produced more beef using relatively less concentrate feed and forage compared to inefficient farms, preferring Holsteins to native breeds ($p<0.05$). Feeding frequency on efficient farms was higher than on inefficient farms ($p<0.01$). Similarly, feed conversion was higher for efficient farms than for inefficient farms ($p<0.05$).

CONCLUSION

The results of this study suggest that substantial decreases in inputs or gains in outputs could be attained by using better the existing technology on cattle-fattening farms. Policymakers should focus on enhancing farmers' access to information via better extension services and farmer training programs, providing farmers with greater access to credit, encouraging management record keeping and improving beef cattle herds to increase efficiency.

Training and extension programs for farmers should be provided in the research area to improve the economic efficiency of individual farms up to at least the level of the best cattle-fattening farms. Farmer training and extension activities are relatively low-cost methods of achieving increases in productive efficiency. However, such increases strongly depend on the effectiveness of the presentations by research and extension organizations.

Turkey's Ministry of Agriculture and Rural Affairs (MARA) has tried to prepare and implement extension and training programs throughout the country, including the research area. Branches of some feed companies and some private veterinary clinics have also contributed by transferring information to cattle-fattening farmers. However, the efficiency of such efforts is still unsatisfactory due to bureaucracy, limited investment, insufficient numbers of skilled extension persons and information gaps on technical and economic aspects of cattle fattening (Sayin, 2001). Training focusing on the fattening period, feeding and management recordkeeping may help increase efficiency in the research area.

Providing farmers with greater access to credit would require government support through legal and regulatory frameworks. Although, the Turkish government has given an interest rate subsidy to all farmers, Sayin (2001) reported that cattle-fattening farmers did not use this credit due to high transaction costs. Thus, a government supported pilot program that reduces the transaction costs of providing credit to farmers would have the potential to increase efficiency. Such a credit program could help farmers expand their facilities from small lots with small herds to modern facilities benefiting from economies of scale, which may also increase the economic efficiency.

Improvement of cattle herds is another strategy to increase efficiency. The government should support and encourage farmers to improve their beef cattle herds. One approach is to seek and exploit genetically more profitable animals for beef cattle production.

Indigenous breeds were not productive and could not support commercial beef production. The use of these breeds should be discouraged. Instead, progressive upgrading to exotic breeds is recommended in the research area. Until now, MARA has tried to upgrade indigenous cattle by using artificial insemination (MARA, 2005).

However, much effort is still needed to reach upgrade targets in the research area. On the other hand, strategies oriented toward an increase in herd size and intensification of processing (market orientation) may also lead to improved efficiency.

Defining a suitable breeding system for the improvement of exotic and indigenous cattle may also contribute to improved efficiency in the research area. Harmonizing breeding evaluations performed by the government may help in defining breeding systems. Although, there have been individual efforts to evaluate breeding in Turkey, these efforts have not been well integrated.

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REFERENCES

Alvarez, A. and C. Arias, 2004. Technical efficiency and farm size: A conditional analysis. J. Agric. Econ., 30: 241-250. DOI: 10.1111/j.1574-0862.2004.tb00192.x.

Banker, R.D. and R.C. Morey, 1986. Efficiency analysis for exogenously fixed inputs and outputs. Operations Res., 34: 513-521. DOI: 10.1287/opre.34.4.513.

Binam, J.N., K. Sylla, I. Diarra and G. Nyambi, 2003. Factors affecting technical efficiency among coffee farmers in Coted lvoire: Evidence from the centre west region. Afr. Dev. Rev., 15: 66-76.

Binam, J.N., J. Tonye, N. Wandji, G. Nyambi and M. Akoa, 2004. Factors affecting the technical efficiency among smallholder farmers in the Slash and Burn agriculture zone of Cameroon. Food Policy, 29: 531-545. DOI: 10.1016/j.foodpol.2004.07.013.

Bozoglu, M. and V. Ceyhan, 2007. Measuring the technical efficiency and exploring the inefficiency determinants of vegetable farms in Samsun Province, Turkey. Agric. Syst., 94: 649-656. DOI: 10.1016/j.agsy.2007.01.007. http://ideas.repec.org/a/eee/agisys/v94y2007i3p649-656.html.

Bravo, U.B.E., D. Solis, V.H. Moreria Lopez, J.F. Maripani, A. Thiam and T. Rivas, 2007. Technical efficiency in farming: A meta-regression analysis. J. Prod. Anal., 27: 57-72. DOI: 10.1007/s11123-006-0025-3.

Charnes, A., W.W. Cooper and E. Rhodes, 1981. Evaluating program and managerial efficiency: An application of data envelopment analysis to program follow through. Manage. Sci., 27: 668-697, DOI: 10.1287/mnsc.27.6.668.

Chavas, J.P., R. Petrie and M. Roth, 2005. Farm household production efficiency: Evidence from the Gambia. Am. J. Agric. Econ., 87: 160-170. DOI: 10.1111/j.0002-9092.2005.00709.x.

Chiang, F.S., C.H. Sun and J.M. Yu, 2004. Technical efficiency analysis of milkfish (chanos chanos) production in Taiwan: An application of the stochastic frontier production function. Aquaculture, 230: 99-116. DOI: 10.1016/j.aquaculture.2003.09.038.

Cinemre, H.A., V. Ceyhan, M. Bozoglu, K. Demiryürek and O. Kilic, 2006. The cost efficiency of trout farms in the Black Sea Region, Turkey. Aquaculture, 251: 324-332. DOI: 10.1016/j.aquaculture.2005.06.016.

Cinemre, H.A. and V. Ceyhan, 2006. Application of utility efficient programming to determine economic efficiency of Turkish farmers in the Central Anatolian Region. New Zealand. J. Crop Horticult. Sci., 34: 381-391. DOI: 0014–0671/06/3404–0381.

Coelli, T.J., D.S.P. Rao, C.J. Odonnell and G.E. Battese, 2005. An Introduction to Efficiency and Productivity Analysis. 2nd Edn. Springer, New York, pp: 350. ISBN: 978-0-387-24265-1.

Efron, B., 1979. Bootstrap methods: Another look at the jackknife. The Ann. Statist., 7: 1-26. http://www.jstor.org/sici?sici=0090-5364%281979%297%3A1%3C1%3ABMALAT%3E2.0.CO%3B2-B&origin=serialsolutions.

Galanopoulos, K., S. Aggelepoulos, I. Kamenidov and K. Mattas, 2006. Assessing the effects of managerial and production practices on the efficiency of commercial pig farming. Agric. Syst., 88: 125-214. DOI: 10.1016/j.agsy.2005.03.002.

Helfand, S.M., 2003. Farm size and the determinants of productive efficiency in the Brazilian Center West. In: Conference of the International Association of Agricultural Economists, Durban, pp: 1-9. http://www.warda.org/workshop/RicePolicy/Amaza/Amaza.Nigeria.paper.pdf.

Hesterberg, T., S. Monaghan, D.S. Moore, A. Clipson, and R. Epstein, 2003. Bootstrap methods and permutation tests. Companion Chapter 18 to the Practice of Business Statistic: W.H. Freeman and Company, New York, pp: 85. http://bcs.whfreeman.com/pbs/default.asp?s=&n=&I=&v=&o=&ns=0&t=&uid=0&rau=0.

Iraizoz, B., M. Rapun and I. Zabelata, 2003. Assessing the technical efficiency of horticultural production in Navarra, Spain. Agric. Syst., 78: 387-403. DOI: 10.1016/S0308-521X(03)00039-8.

Kahi, A.K. and H. Hirooka, 2006. Economic efficiency of Japanese Black cattle selection schemes utilizing crossbreeding with the Holstein breed. Anim. Sci. J., 77: 178-187. DOI: 10.1111/j.1740-0929.2006.00335.x.

Kaliba, A.R. and C.R. Engle, 2006. Cost efficiency of catfish farms in Chicot County, Arkansas: The impact of extension services. Aquac. Econ. Manage., 10: 223-243. DOI: 10.1080/13657300600985413.http://dx.doi.org/10.1080/13657300600985413.

Karagiannis, G. and V. Tzouvelekas, 2005. Explaining output growth with a heteroscedastic non-neutral production frontier: The case of sheep farms in Greece. Eur. Rev. Agric. Econ., 32: 51-74. DOI:10.1093/erae/jbi004.

Karaka, E., 2002. Production parameters and economic productivity of cattle fattening farms in Bursa. J. Fac. Vet. Med., 21: 83-88.

Krasachat, W., 2007. Economic efficiency of feedlot cattle farms in Thailand. In: Conference on International Agricultural Research for Development, Tripentag, Proceedings. Tripentag. University of Göttingen, Cuvillier Verlag Gottingen, Germany, pp: 1-4. ISBN: 3-86727-372-3.

Latruffe, L., K. Balcombe, S. Davidova and K. Zawalinska, 2004. Determinants of technical efficiency of crop and livestock farms in Poland. Applied Econ., 36: 1255-1263. DOI: 10.1080/0003684042000176793. http://dx.doi.org/10.1080/0003684042000 176793.

MARA (Ministry of Agricultural and Rural Affairs), 2005. http://www.tkb.gov.tr.

Ozkan, U. and A. Erku, 2003. Economic analysis of cattle fattening farms in Bayburt. Ankara. Research report No: 103, Agricultural Economics Research Institute. (Turkish). http://aeri.org.tr/PDF/103-PRBayburt.pdf.

Pirez, J., J. Gil and I. Sierra, 2003. Technical efficiency of meat sheep production systems in Spain. Small Rumin. Res., 69: 237-241. DOI: 10.1016/j.small rumres.2006.02.003. http://www.sciencedirect.com/science?_ob=MImg&_imagekey=B6TC5-4JKJT5S-1-1&_cdi=5161&_user=736649&_orig=browse&_coverDate=05%2F31%2F2007&_sk=999309998&view=c&wchp=dGLzVlz-zSkWb&md5=d82dedb 2487e732f6b18bd5025ef0132&ie=/sdarticle.pdf.

Ramanathan, R., 2001. Introductory Econometrics with Applications. 5th Edn. South Western College Publishers, New York. pp: 704. ISBN: 0-03-034342-9.

Ruiz, D.M., L.P. Sempere, A.G. Martinez, J.J.R. Alcaide, J.O. Pamio, F.P. Blanco and D. Garcia, 2000. Technical and allocative efficiency analysis for cattle fattening on Argentina Parnpas. Agric. Syst., 65: 179-199. DOI: 0308-521X/ 00/00032-9. http://www.science direct.com/science?_ob=MImg&_imagekey=B6T3 W-417ND2H-3-1M&_cdi=4957&_user=736649&_orig=browse&_coverDate=09%2F30%2F2000&_sk=999349996&view=c&wchp=dGLbVzb-zSkzk&md 5=5e63976b3c55de337551366a626c8bc8&ie=/ sdarticle.pdf.

Sayili, M., 2001. Economic analysis of cattle fattening farms in Suluova District of Amasya, Tokat. Thesis (Ph.D.), University of Gaziosmanpasa, pp: 125.

Sayin, C., 2001. Livestock policy and the effect of reform. Akdeniz Univ. J. Agric. Faculty, 14: 1301-1315 (in Turkish). http://www.akdeniz.edu.tr/ziraat/tr/dergi.htm.

Somwaru, A. and C. Valdes, 2004. Brazil's beef production and its efficiency: A comparative study of scale economics. In Annual Conference on Global Economic Analysis, 7, Washington, Proceedings, The World Bank, Washington DC, United States, pp: 1-19. https://www.gtap.agecon.purdue.edu/resources/download/1860.pdf.

Trestini, S., 2006. Technical efficiency of Italian beef cattle production under a heteroscedastic non-neutral production frontier approach. In: Conference on Food, Agriculture and the Environment, 10, Minnesota, pp: 1-18. http://www.apec.umn.edu/faculty/frunge/Minn-ItalyConf2006/Trestini.pdf.

TURKSTAT, 2006. Turkish Statistical Institute. http://www.turkstat.gov.tr.

Wilson, P., D. Hadley and C. Asby, 2001. The influence of management characteristics on the technical efficiency in UK potato production. Agric. Econ., 24: 329-338. DOI: 10.1111/j.1574-0862.2001.tb00034.x. http://www3.interscience.wiley.com/journal/118987 929/issue.

Yildirim, I., 2000. Economic analysis of cattle fattening farms in Central District of Van. Research report No: 20, University of Yuzuncuyil (Turkish).

Zavela, H., E. Mabaya and R. Christy, 2005. Smallholders' cost efficiency in Mozambique: Implications for improved maize seed adoption. Staff Paper SP-2005-04, Department of Applied Economics and Management, Cornell University. New York. http://aem.cornell.edu/research/researchpdf/sp/Cor nell_AEM_sp0504.pdf.