EFFICIENCY ANALYSIS ON CATTLE FATTENING IN TURKEY

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Abstract. In Turkey, it is a common knowledge that there are many structural and sectoral problems in cattle fattening which is closely related to the beef production. Nowadays, due to these emerging problems, beef price has greatly increased and beef import began to cope with higher prices. Main purpose of this research is to determine the technical efficiency and working conditions of cattle fattening farms in Aydin province of Turkey, where cattle farming has progressed for the last decade. Efficiency scores are calculated with Data Envelopment Analysis and Stochastic Frontier Analysis techniques. Primary data used for this situation are obtained by survey technique from cattle farms which are determined by sampling method in Aydin province. The average technical efficiency calculated by both methods is found as 0.803 and 0.710. When analyzing the calculated technical efficiency of the farms, it is found that technical efficiency is increased by the scale of the farm. According to results of analyses, there is a positive relation between efficiency scores of cattle fattening farms, and certain factors such as attending training and extension events, general farming experience, and cattle fattening experience. It is found that through a few critical improvements cattle fattening farming can be improved and as a consequence of this situation beef prices may settle down to the average after this process.

Keywords: cattle fattening, DEA, efficiency, stochastic, Turkey.

Introduction

Meeting the demands for beef, which is vitally important for human nutrition, cattle breeding has become the main agricultural policy of almost all countries. In livestock sector in Turkey, especially in cattle fattening, which is directly related to beef production, it is a well-known fact that there are many institutional and sectorial problems. It has been assumed that agricultural policies proposals should be formed by determining the weakest links in the red meat supply chain and taking steps strengthening these links. Due to some unjustified speculative market expectation and the fact that meat supply does not meet the demand meat price fairly increased in Turkey. Thus, in the midst of 2010 the Ministry of Food, Agriculture and Livestock chose to import live cattle. However, many of these problems in this sector continue. Analysis of the numbers of butchered animals showed that sheep are in first place followed by cattle and goat. Yet beef meat has the first place in the overall meat production and sheep meat come second. The Turkish Aydin province keeps approximately 3% of all livestock of Turkey (Turkstat, 2012).

There are three main targets forming the basis of agricultural policy in Turkey. These are macroeconomic stability, matching standards for EU and matching the standards for international competition. Production efficiency is prerequisite to match these targets. To create and apply sustainable policies about efficiency, the need for the studies, which would analyze relations between the current efficiency scores of agricultural enterprise and factors affecting these scores, increases (Gunduz, 2011). Studies in Turkey and international field related to agricultural production efficiency are generally about crop production. Studies related to cattle farming are focused on dairy farms. Studies addressing cattle fattening are very rare. Stochastic frontier analysis (SFA) method is used in the research related to dairy cattle farming in England and found no positive relation between such variables as education, experience and efficiency (Bravo-Ureta and Rieger, 1991). Reinhard et al. (1999) calculated environmental and technical efficiency by using SFA method in Dutch dairy farms and found that these farms work with an average of 0.89 technical efficiency and 0.44 environmental efficiency. By using Data Envelopment Analysis (DEA), the efficiency scores of cattle fattening farms in USA-Louisiana were calculated and it was found that there is a positive relation between age, education and efficiency scores (Rakipova and Gillespie, 2000). In the research, which DEA and SFA methods were used to calculate technical efficiency scores of dairy farms in Sweden, it was found that these farms work with an average of 0.77 efficiency and farm scale has a positive effect on efficiency (Johansson, 2005). By using SFA method, Trestini (2006) reported that farms work with 0.79 efficiency, related to cattle fattening in Italy. Production efficiency of dairy farms in Turkey-Burdur was found 0.50 by using SFA and Cobb-Douglas production function, and it is accepted that, such variables as age and education has no significant effect on efficiency. However feeding system and herd scale have positive effects on efficiency (Binici et al., 2006). According to the research in Malaysia, which used SFA, Cobb-Douglas and Translog Production functions, the average efficiency is 0.68 and farm scale and type has no significant effect, however farming experience should be increased (Serin et al., 2008). According to other research in Turkey-Cukurova on small-scale dairy farms, which used the SFA method, the technical efficiency was on average 0.78 and it is concluded that the effect of herd scale is statistically insignificant on efficiency (Alemdar et al., 2010). Ceyhan and Hazneci (2010) used DEA method on the cattle-fattening farms in Turkey-Amasya

and found that fattening period and economic efficiency have positive relation. In USA-Wisconsin, a research, which used SFA and Cobb-Douglas production function, revealed that the average efficiency of dairy farms is 0.88 (Cabrera et al., 2010). By using DEA method in Turkey-Eastern Mediterranean region, Dagistan et al. (2009) noted that farmers should adapt the new technology to increase efficiency. That dairy farms in Turkey-Izmir work with the average of 0.59 efficiency and farms scale has a positive effect on efficiency were found by (Koyubenbe and Ozden, 2011). In a Lithuanian research on crop farms, livestock farms and mixed farms, with DEA method employed, the technical efficiency was found with an average of 0.48 for crop farms, 0.72 for livestock farms and 0.56 for mixed farms (Balezentis and Krisciukaitiene, 2012). In researches of livestock farms such variables as farm or herd scale, farmer's age, education, and experience are included into the research because they are considered as effective factors on efficiency.

Based on the mentioned literary sources, the chosen aim of this study was to identify the parameters, which are efficient on technical efficiency scores of cattle fattening farms in Turkey-Aydin, and to make some proposals to help find the solutions of problems in beef and cattle fattening in Turkey.

Materials and methods

The bulk material of this research consists of the data, which were gathered by face-to-face interview technique from cattle farms in Aydin. The macro data required for this research were taken from such institutions as Turkish Statistical Institute (2012) and Aydin Provincial Directorate of Agriculture (2011). To determine the efficiency of cattle fattening in Turkey-Aydin, 44 914 cattle farms were considered as a population. The number of sample was calculated by using maximum sample size in limited population (Newbold, 1995). As these farms were not separated from each other in terms of whether they are cattle fattening farms or dairy farms, the number of cattle farms in all districts of province was calculated according to total cattle count. For this purpose 95% confidence interval and 10% error level were used. It was planned to make a survey of 95 cattle fattening farms. Cattle Count Unit (CCU) was used to homogenize the overall cattle number of related farms (Aras, 1988). In the calculated efficiency, the number of fattening cattle (X_1), fattening period (X_2), overall cost of compound feed (X_3), overall cost of roughage (X_4), overall cost of grain (X_5), cost of vet-medicine X_6), general expenses (X_7) , labor used in cattle fattening (X_8) were used as input and gross production value (GPV) was used as output (Y). Male labour unit (MLU) was considered while calculating labour in cattle fattening calculations (Erkus and Demirci, 1985). The number of fattening cattle (NFC), daily weight gains (DWG), fattening period and marketing prices were used for calculating GPV (Koknaroglu *et al.*, 2006). The factors leading to inefficiency, such as education level (Z_1), farmer's age (Z_2), general farming experience (Z_3), cattle fattening experience (Z_4), attending training and extension events (Z_5), barn type (Z_6) (closed, semi closed, open), use of additives to fasten fattening (Z_7), acting according to the ration formulation (Z_8), planning field of forage crops (Z_9), total farm land (Z_{10}) and farm scale (Z_{11}) (groups) were considered.

Efficiency analysis was carried out in analyzing the cattle-fattening farms. For calculation of efficiency score, the distance of decision-making unit (DMU) to an efficient frontier should either be calculated or predicted. Hypotactic frontier can be calculated or predicted with different methods under various hypotheses. These methods can be classified into two groups; parametric and non-parametric methods. In this study, SFA method is used as an example of parametric and DEA method is used as an example of non-parametric method. Main efficiency criterion in DEA is the division of overall output to the overall input. In other words, technical efficiency criterion (for j^{th} decision point) for any decision point can be expressed with the formula below.

$$TE = \frac{u_1 y_1 + u_2 y_2 + \ldots + u_n y_n}{v_1 x_1 + v_2 x_2 + \ldots + v_m x_m} \quad (1)$$

In this formula, there "n" pieces output and "m" pieces input for j^{th} decision point. Here u_n represents the weight of n^{th} output, y_n represents the amount of n^{th} output, v_m represents weight of m^{th} input and x_m represents the amount of m^{th} input. SFA, also known as econometrical approach, was developed by various researchers in 1977 (Aigner *et al.*, 1977; Battese and Corra, 1977; Meeusen and Van Den Broeck, 1977). Production function is formulated as below (Aigner *et al.*, 1977; Meeusen and Van Den Broeck, 1977);

$$Y_i = X_i \beta + v_i - u_i (i: 1,2,..., n) \quad (2)$$

$$\varepsilon_i = v_i - u_i \quad (3)$$

Here x_i represents the input vector of i^{th} DMU, β represents coefficient, v_i represents the random variable independent from u_i and the one which has normal distribution and that can not be controlled by DMU, u_i represents independent random variable that reflects inefficiency and ε_i represents the error term. In explanation of u_i the model below is developed (Battese and Coelli, 1995).

$$u_i = z_i \delta \quad (4)$$

In this formula, z_i represents specific features that reflect the technical inefficiency of DMU, and δ represents coefficient. This instance is defined as the rate of observed technical efficiency output to the calculated production function (Coelli *et al.*, 2005).

$$TE = e^{x_i \beta + v_i - u_i} / e^{x_i \beta + v_i} = e^{-u_i} \quad (5)$$

In efficiency analysis done by using SFA method in developed and developing countries, mostly Cobb-Douglas type production function method is preferred (Binici et al., 2006). In this research, efficiency is estimated by Cobb-Douglas production function, which has discrete normal distribution and maximum likelihood method (Battese and Coelli, 1995). Estimated Cobb-Douglas type production function for this research

consists of: one output, eight and eleven inputvariables which, are considered to have effect on inefficiency as below;

$$\ln Y_i = \beta_0 + \sum_{j=1}^{8} \beta_j \ln X_{ji} + \nu_i - u_i \quad (6)$$

$$u_i = \delta_0 + \sum_{m=1}^{11} \delta_m Z_{mi} \quad (7)$$

DEA and SFA analysis were made by using Deap 2.1 and Frontier 4.1 software, which were developed by Tim Coelli. Non-parametric Spearman rank correlation method was used to show how DEA and SFA scores cover each other.

Results

As large scaled farms are outnumbered, in analysis, appropriate distribution between groups is not provided. To fulfill this aim, in Turkey-Aegean region farms were classified under four different groups which consisted of 14.99 or less, 15.00–39.99, 40.00–59.99 and 60.00 or more CCU (Armagan et al., 2004). In this study, all data were analyzed in four groups. Descriptive statistics are given in Table 1.

Table 1. **Summary Statistics of Variables Used in Efficiency Analysis**

	Group1 (N:51)	Group2 (N:15)	Group3 (N:8)	Group4 (N:21)	Total (N:95)
Output					
Y:(TL)	4634.29 (3748.19)*	15601.95 (11338.2)	30620.19 (32173.17)	144907.25 (131620.53)	39562.02 (83840.36)
Inputs					
X1:(head)	3.78 (2.34)	9.67 (6.59)	19.13 (15.73)	99.95 (83.73)	27.55 (55.04)
X2:(month)	6.25 (2.98)	9.8 (3.78)	7.13 (2.47)	7.24 (4.50)	7.11 (3.63)
X3:(TL**)	1808.63 (1536.11)	3838.40 (1948.05)	8546.10 (8700.83)	39995.33 (37101.50)	11238.30 (23193.29)
X4:(TL)	1167.48 (969.45)	2679.2 (2747.41)	4382.5 (3906.49)	22491.24 (19172.11)	6730.26 (12870.71)
X5:(TL)	422.41 (686.79)	2184.00 (2288.25)	8377.14 (11442.47)	9060.76 (9315.93)	3390.87 (6673.32)
X6:(TL)	164.90 (198.14)	416.67 (441.10)	1258.13 (1395.35)	7618.57 (6772.39)	2028.28 (4444.08)
X7:(TL)	179.18 (326.75)	1510.87 (3661.01)	1844.25 (2956.43)	8925.52 (9378.71)	2437.41 (5784.82)
X8:(MLU) (Hour)	4.59 (2.55)	5.27 (1.91)	7.00 (3.38)	10.05 (5.32)	6.13 (3.96)
Inefficiency Variables					
Z1:(1-5)	1.92 (1.02)	2.14 (1.17)	2.00 (1.20)	2.38 (1.24)	2.05 (1.10)
Z2:(year)	46.86 (12.64)	45.64 (11.46)	46.00 (9.17)	49.86 (11.64)	47.54 (12.11)
Z3:(year)	28.43 (15.83)	26.43 (11.67)	31.88 (13.08)	27.67 (14.61)	28.38 (14.61)
Z4:(year)	24.27 (15.80)	24.64 (13.51)	23.13 (8.84)	24.57 (16.19)	24.46 (14.91)
Z5:(Yes,No;1,0)	0.35 (0.48)	0.53 (0.52)	0.38 (0.52)	0.43 (0.51)	0.4 (0.49)
Z6:(1,2,3)	2.47 (0.81)	2.33 (0.90)	2.75 (0.46)	2.48 (0.75)	2.47 (0.78)
Z7:(Yes,No;1,0)	0.06 (0.24)	0.13 (0.35)	0.38 (0.52)	0.19 (0.40)	0.13 (0.33)
Z8:(Yes,No;1,0)	0.27 (0.45)	0.20 (0.41)	0.50 (0.53)	0.52 (0.51)	0.34 (0.48)
Z9:(da)	14.25 (14.69)	22.33 (20.38)	22.75 (43.33)	150.33 (386.76)	46.33 (187.77)
Z10:(da)	56.18 (58.98)	46.27 (34.61)	116.63 (106.62)	156.62 (214.97)	81.91 (120.91)
Z11:(1,2,3,4)	1.00	2.00	3.00	4.00	1.99 (1.23)
DWG (kg)	0.78 (0.21)	0.75 (0.15)	0.96 (0.30)	0.96 (0.23)	0.83 (0.23)
Market Prices (TL)	15.39 (1.05)	15.80 (1.57)	15.19 (0.99)	16.07 (0.98)	15.59 (1.15)

*Values in parentheses is the standard deviation; **Local Currency (1 US Dollar=1.8619 TL)

Average efficiency scores calculated for cattle fattening farms were 80% for DEA and 71% for SFA. Result of Spearman rank correlation to reveal how the conclusion of these two analyses agree with each other was 0.346 ($p<0.01$). Therefore, it is possible to say that in farms whose efficiency scores are calculated with DEA method have also higher result which are calculated with SFA method. When efficiency scores of farm groups are considered, it is seen that scale of farm positively affects efficiency scores. It is a prescribed situation that DEA values are higher than SFA scores because DEA is a non-parametric method (Table 2). These values are close to results of some studies (Trestini, 2006), higher for other studies (Serin et al., 2008).

With Cobb-Douglas type production function, the results of SFA calculated by using maximum likelihood

method are given in Table 3. It shows that variance parameters are statistically significant at the 0.01 level. These values show that any traditional production function is not enough to explain GPV and technical efficiency (inefficiency) has an important role on GPV. High Gamma values (73%) reveal that farms have an inefficiency problem. The LR test revealed that inefficiency variables have an effect on GPV and these variables reflect a stochastic process. As Cobb-Douglas type production function is represented completely in a logarithmic way, the coefficients belonging to the model give rate of return to scale and give elasticity at the same time (Kumbhakar and Lovell, 2000). The sum of the explanatory variables' regression coefficient is 0.914.

Table 2. **Summary Statistics of Farm Efficiencies**

Group Number	Group1 (N:51)		Group2 (N:15)		Group3 (N:8)		Group4 (N:21)		Total (N:95)	
Analyse	DEA	SFA	DEA	SFA	DEA	SFA	DEA	SFA	DEA	SFA
Min.	0.114	0.303	0.494	0.457	0.527	0.517	0.445	0.437	0.114	0.303
Max.	1.000	0.978	1.000	0.986	1.000	0.886	1.000	0.998	1.000	0.998
Mean	0.726	0.674	0.852	0.711	0.864	0.712	0.932	0.771	0.803	0.710
standard deviation	0.257	0.204	0.177	0.165	0.179	0.143	0.141	0.146	0.232	0.181

Table 3. **Maximum Likelihood Estimates of Stochastic Cobb-Douglas Frontier Analysis**

	Coefficients	Std. Err.	t-ratio
Stochacstic Efficiency Frontier Function			
Constant	5.819	0.105	55.2405***
X_1*:(head)*	1.126	0.027	41.7111***
X_2*:(month)*	0.894	0.050	17.8852***
X_3*:(TL**)*	0.029	0.016	1.758*
X_4*:(TL)*	-0.864	0.520	-1.6622*
X_5*:(TL)*	0.007	0.004	1.8967*
X_6*:(TL)*	-0.149	0.079	-1.886*
X_7*:(TL)*	0.016	0.008	2.0163**
X_8*:(MLU) (Hour)*	-0.143	0.038	-3.7974***
Statistical Results of The Model			
σ^2	0.219	0.292	7.489***
γ	0.729	0.079	9.23077***
Number of Observations	95		
Log- likelihood Function	113.869		
LR statistic (X^2)	45.078***		
H_0	Rejected		
Inefficiency Model			
Constant	1.770	0.664	2.6656***
Z_1*:(1-5)*	-0.066	0.067	-0.9812
Z_2*:(year)*	-0.010	0.011	-0.9282
Z_3*:(year)*	-0.029	0.012	-2.5221**
Z_4*:(year)*	-0.036	0.010	-3.6382***
Z_5*:(Yes,No;1,0)*	-0.416	0.154	-2.7031***
Z_6*:(1,2,3)*	-0.148	0.127	-1.1659
Z_7*:(Yes,No;1,0)*	0.270	0.249	1.0822
Z_8*:(Yes,No;1,0)*	-0.323	0.135	-2.3968**
Z_9*:(da)*	0.076	0.067	1.1231
Z_{10}*:(da)*	-0.014	0.012	-1.1736
Z_{11}*:(1,2,3,4)*	-0.191	0.060	-3.2091***
*P<0.10 **P<0.05 ***P<0.01			

Roughage expenses, vet-medicine expenses and increase in labor usage decreases the GPV while increase of NFC, fattening period, compound feed expenses, grain expenses, and general costs increase the GPV. All of these results are statistically significant. In the study in USA-Wisconsin it is concluded that all inputs have a positive effect on outputs (Cabrera *et al.*, 2010) while in the study carried out in Turkey-Cukurova it is concluded that labor has negative effects (Alemdar *et al.*, 2010). It is seen that NFC, fattening period and roughage expenses have great influence on GPV. In the study of Turkey-Amasya it is found that efficiency and fattening period have positive relation (Ceyhan and Hazneci, 2010). It is not wrong to say according to research results that farms

misuse roughage. The farms producing their own roughage do not consider production cost and overuse roughage whereas those who purchase roughage from other producers often are unable to adjust roughage, compound feed, and grain mixture density. Vet-medicine expenses and labor usage generally effects the GPV negatively as they are most expensive low scale family farms. As NFC increases, it is proved in the research that cost of fattening per cattle decreases and results in increase of GPV. The results related to variables, which show the reasons of inefficiency of farms, are given in Table 3.

Among these variables, the general farming experience, cattle fattening experience, attending training and extension courses, acting according to the ration formulation and farm scale are found negatively statistically significant. As general farming experience and cattle fattening experience of farmers and farm scale increase, the inefficiency decreases. These results are in agreement with Johansson (2005), Binici *et al.* (2006), Trestini (2006), Koyubenbe and Ozden (2011) while they contradict with Bravo-Ureta and Rieger (1991), Alemdar *et al.* (2010). Furthermore it is seen that attending training and extension courses and acting according to the ration formulation increases the probability of working efficiently. Similarly, the study carried out in Malaysia shows that increased experience has a positive effect on efficiency (Serin *et al.*, 2008). Farms are determined to work with 71% efficiency according to SFA method. If these farms happen to decrease their input by 29% as long as they keep their output amounts, they will reach their full efficiency potential.

Discussion and conclusion

According to the results of this study, farms work with 71% efficiency and among the variables that provide this efficiency percentage, roughage expenses, vet-medicine expenses, and labor usage affect GPV negatively while NFC, fattening period, grain expenses, compound feed expenses and general expenses affect GPV positively. The results of the model showed that inefficiency variables have vital importance on GPV. Based on these results, there are some advices below to increase production efficiency;

- Increasing the scale of farm will decrease the cost for per cattle and will increase efficiency in production. However, the interviews with farmers about the necessary sources in order to increase cattle numbers have showed that they have finite opportunities because only large scale farms have sufficient credit rating. For this reason, when supporting producers with credits thiscircumstance should be taken into consideration.
- Producers must care about roughage amounts used and to act according to the ration formulation to overcome problems about roughage and to increase efficiency of fattening.
- Problem of inactive labor was pointed out in most farms. This problem is a result of both failing to separate dairy and fattening farms what is characteristic of small scale family farms. Making these farms more professional both solves inactive labor problem and decreases unnecessary expenses.
- It is an accepted fact that experience has positive effect on efficiency. Cattle fattening should be made conscious as in all other livestock farms. Therefore capital and experience should be unified and to make this possible, either contractual production or organization should be selected.
- It is obvious that there is a need for profesional training and extension courses, experience and improvement above pointed issues. Agriculture consultancy system is a good step in this direction. Producers should be supported by increasing the number of free training and extension courses close to their residences.
- Worlds' Meat consumption will grow by 73 percent over the current levels by 2050. The surge in livestock production that took place over the last 40 years resulted largely from an increase in the overall number of animals being raised but it is not possible to increase the number of animals endlessly (FAO, 2011). As it stands, there are no technically or economically viable alternatives to intensive production for providing the bulk of the livestock food supply for growing cities. Efficiency gains the only way to meet the demand. So each region has to develop their own policies to increase efficiency.

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