Efficiency analysis of cattle breeding farms in Thrace Region, Turkey

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Gökhan Unakıtan
Ph.D. in Agricultural Economics
Namık Kemal University
Namık Kemal University, Faculty of Agriculture, Department of Agricultural Economics,
59030, Değirmenaltı, Tekirdağ, Turkey
E-mail: unakitan@nku.edu.tr

Nihal Kumbar
Ph.D. in Agricultural Economics
Tekirdag Directorate of Provincial Food Agriculture and Livestock
Tekirdağ Directorate of Provincial Food Agriculture and Livestock, Tekirdağ, Turkey
E-mail: nikumtr@yahoo.com

Abstract

Turkey is one of the most favorable countries for agriculture and animal husbandry regarding to geographical structure. The livestock sector has been constituted approximately 10% of the national income of Turkey. According to the Turkish Statistics Institute's data, the number of bovine animals of Turkey and Thrace region is 14 million 222 thousand and 43 thousand respectively. The artificial insemination, which has been successfully applied in the region for many years, has provided important advances in the presence of bovine animals regarding genotype characteristics and the ratio of cultural and cultural hybrid animal to total animal existence is very high. Due to this situation, the Thrace region is regarded as a region that has the characteristic of being a breeding warehouse of Turkey. The aim of this study is to determine the efficiency of cattle breeding farms, investigate the reasons for inefficiency of ineffectiveness farms, determining the precautions to be taken for the development of cattle breeding and analyzing the factors effecting economic efficiency which producing in Thrace Region. Data Envelopment Analysis method was used in the efficiency analysis of the cattle breeding farms in the study. According to the results of the analysis, the technical efficiency coefficient of the farms ranged from 0.071 to 1 and average score has been calculated as 0.49. Also, Tobit model was used to determine the effects of variables such as education level, experience year, number of affiliated agricultural cooperative and number of animals in the farms on efficiency.

Keywords: Efficiency analysis. Technical efficiency. Cattle breeding

1. Introduction

The function of the livestock sector is animal food production. Animal foods have many superior properties considering human diet. It is recommended that 40-60% of a person's daily protein need to be provided from animal nutrients in order to be able to talk about a balanced diet (Özüdoğru, 2012).

Turkey is one of the most favorable countries for agriculture and animal husbandry regarding to geographical structure. The livestock sector has been constituted approximately 10% of the national income of Turkey. It is estimated that the protein requirement will be double up to the current amount in the near future, considering that young people make up the most of the population. 88% of total milk production (4.5-5.5 million milk cows) and 67% of red meat production (9.5-11 million cattle) is met by domestic production. The sustainability of cattle breeding farms and thus the livestock sector is related to the low cost per unit of milk and meat yields (Taş, 2010).

Thrace region has a special prtion for Turkey in cattle breeding. According to the Turkish Statistics Institute’s (TSI) data, the number of bovine animals of Turkey and Thrace region are 14 million 222 thousand and 43 thousand respectively (TUİK, 2016). The artificial insemination, which has been successfully applied in the region for many years, has provided important advances in the presence of bovine animals regarding genotype characteristics and the ratio of cultural and cultural hybrid animal to total animal existence is very high. As a result of this situation, the region is regarded as a region that has the characteristic of being a breeding warehouse of Turkey. Cattle’s breeding is mostly directed to milk production in the region. Cultures and hybrid animals originate predominantly (73.8%) Holstein breeds in the Thrace region.

Because of the high animal husbandry potential and productivity, Thrace Region has been preferred to the research area. These are the facts that the operations of cattle husbandry farms are not carried out effectively and the level of activity of the enterprises should be revealed. Depending on the efficiency scores that will occur, it will be possible to be inferences and to make suggestions for cattle breeding farms.

The aim of this study is to determine the efficiency of cattle breeding farms, investigate the reasons for inefficiency of ineffectiveness farms, determining the precautions to be taken for the development of cattle breeding and analyzing the factors effecting economic efficiency which producing in Thrace Region.

In the literature, it is possible to reach a large number of articles and papers using the efficiency analysis. Cloutier and Rowley (1993) found that livelihoods operating in Quebec province of Canada, Hazneci (2007) breeding farms operating in the province of Sulova in Amasya, Johannson (2005) milk farms operating in Sweden, Nizam and Armağan (2005)

Members of the Cattle Breeders' Association, Şanal and Light (2014) cattle breeding enterprises in Erzurum are the studies on the efficiency analysis of cattele breeding farms. In the analysis of the enterprises engaged in vegetable production, Engindeniz and Coşar (2013), tomato growing in İzmir, Dhungana et al. (2004) The Egyptian enterprises operating in Nepal, the agricultural enterprises engaged in cotton production by Aktürk and Kıral (2002), the private forest enterprises granted the right to operate Slovenian public forests in the study carried out by Mörec and Jeromel (2011), Işgın et al. (2014) in cotton production can be counted as, Parlakay et al. (2015) estimated the technical efficiency for dairy farms in Hatay province of Turkey. Bagchi and Zhuang (2016) computed technical and scale efficiency of Chinese litchi farmers. Pereira and Tavares (2017) evaluated the technical and scale efficiency of the regions Northeast, traditional Mid-South and expansion Mid-South, according to the production costs of cane sugar in 2007/2008 to 2011/2012 harvests in Brazil. Aydin and Unakitan (2018), analyzed the efficiency of different sized farms in the Thrace region.

2. What is Efficiency

Efficiency and productivity, anyway, are two cooperating concepts. The measures of efficiency are more accurate than those of productivity in the sense that they involve a comparison with the most efficient frontier, and for that they can complete those of productivity, based on the ratio of outputs on inputs. Lovell (1993) defines the efficiency of a production unit in terms of a comparison between observed and optimal values of its output and input. The comparison can take the form of the ratio of observed to maximum potential output obtainable from the given input, or the ratio of minimum potential to observed input required to produce the given output. In these two comparisons the optimum is defined in terms of production possibilities, and efficiency is technical.

The performance of production units is assessed by the "productivity" or "efficiency" of these units (Lovell, 1993). Although related to the concepts of productivity and efficiency are quite different indicators. "Productivity" is the ratio of the output to the input in production. If the enterprise under consideration is producing a single output using a single input, the efficiency of this production process is simply determined by a rate of the output to the input. Theoretically, this type of simplification can be done, but in reality, businesses can create multiple products using many inputs. In this case, inputs and outputs can be aggregated in an economically acceptable manner to obtain a single rate.

"Efficiency" is measured by the difference between actualizing at the end of production and the optimum amount of input-output. This criterion is defined as the ratio between the maximum potential output the production unit received and the amount of data input it achieves. A similar definition can be made as the ratio between the amount of input that the firm uses to achieve a certain level of production based on the input level and the minimum amount of input required to obtain a certain output amount. The efficiency is a sign of success in achieving the goal. The level of efficiency or inefficiency is measured by the difference between targeted and actual performance (Kara et al. 2013).

3. Material and Methods

According to the TURKVET database, there are 44125 cattle breeding farms operating in Thrace Region. The distributions of these farms in the region are 18542 in Edirne, 14365 in Tekirdağ and 11218 in Kırklareli. These farms have provided that the main material of the study. Assuming that farms which have fewer than five heads of cattle are not economically and they have exluded from sampling. Firstly, 50 pilot surveys have been applied and the final sample volume has been calculated by the obtained cattle unit and average of the standard deviation in the study area. As a result of the pilot survey, the cattel unit (CU) and average of the standard deviation have been found to be 20.25 CU and 18.31 CU, respectively. Sample size was calculated as 220 farms assuming that 90% confidence level and 10% error margin by the following simple random sampling formula.

$$n = \frac{NZ^2\sigma^2}{d^2(N-1)+Z^2\sigma^2}$$

Where N: main population, Z: confidence level, σ: standart deviation, d: error

Data envelopment analysis (DEA) method was used in the efficiency analysis of the cattle breeding farms in the study. This method which is widely used in the literature, the efficiency of farms with more than one input and output can be calculated.

The DEA can be solved with input or output oriented. Input oriented is defined as the analysis of changes in the input quantities by keeping the output quantities constant and the output oriented is defined as the examination of the changes in the output quantities by keeping the input quantities constant.

As the technical efficiency is known, two components are distinguished as pure technical efficiency and scale efficiency in order to distinguish the sources of inefficiency or efficiency. A low pure technical efficiency score means a lack in the use of minimum input, while a low-scale efficiency means a production in the non-optimal scale. Scale efficiency indicates losses due to non-optimal production scale (Coelli et al., 1998).

Pure technical efficiency indicates the efficient usage of the inputs according to variable return to scale assumption. If technical efficiency values for constant return to scale and variable return to scale are different for a specific production unit, this indicates that the production unit has scale inefficiency. Accordingly, scale efficiency could be explained in this way (Zaim, 1999).

Technical efficieny = Pure technical efficiency x Scale efficiency

In the constant-return models, any increase in the amount of input is in the same proportion in the amount of output, while in the case of the variable-return models in scale, each increase in the amount of input is seen at different rates in the amount of output.

In a production process, when a certain amount of inputs are increased, the increase in the output level is greater than the increase in the inputs it means that incremental return to scale, if the increase in the output is less than the increase in the inputs it means reducing return to scale. Finally, if the amount of increase in the outputs and the amount of increase in the inputs are equal we can say constant return to scale (Coelli et al. 1998).

The allocative efficiency shows how the farmer is operating both technically and economically. That is to say, producers use the most yielding input composition when they make production, and that they achieve the lowest cost. The allocative efficiency is calculated by the following formula.

$$Allocative\ efficiency\ = \frac{Economic\ efficiency}{Technical\ efficiency}$$

Cost effeciency or economic efficiency is the ratio of the minimum cost of a given product to the cost of a farm.

In the efficiency analysis, firms with an efficiency coefficient between 0.95 and 1 can be classified as effective, those between 0.90 and 0.95 as less effective, and those below 0.90 as ineffective (Charnes et al., 1978).

Farrell's (1957) input oriented efficiency measures used in this study due to the producers tend to control their inputs more than output. While veterinary costs (including vaccine, medicine, artificial insemination costs), labor costs, factory feeds and other feeds costs were included in the model as inputs animal gross production value was used as output in the model. In this context, model was created with 4-input and 1-output variables.

Due to the efficiency score varying from 0 to 1, the "tobit regression" is used in this study, since the classical least squares method estimates coefficients larger than necessary.

In the study, the two-stage approached method was used to determine the effects of variables such as education level, experience, number of affiliated organizations, and number of animals in the farms (CU) on efficiency. The two-stage approach is a recommended method, because it does not require any assumption about the effect of the variables and can be used with more than one continuous or interrupted variable. In the first step of this approach, efficiency coefficients are obtained for each farm. In the second stage, the relationship between the variables that can affect the effectiveness and effectiveness is estimated with the help of the appropriate regression model.

Since the efficiency coefficients varying from 0 to 1, "tobit regression" is used instead of the ordinary least squares method. Tobit model was developed by Tobin, an extension of the Probit model. The sample in which the information of the dependent variable is only relevant for some observations is known as the censored sample. For this reason, the Tobit Model is also called a censored or intermittent regression model (Gujarati, 1999). The general expression of the Tobit model is as follows (Ramanathan, 1998).

$$u_i > -\beta_0 - \sum_{i=1}^{N} \beta_i X_i \quad \text{ise} \quad Y_{ij} = \beta_0 + \sum_{i=1}^{N} \beta_i X_i + u_i$$

$$u_i \leq -\beta_0 - \sum \beta_i X_i \quad \text{ise} \quad Y_{ij} = 0$$

Where Y_{ij} is economic efficiency of i^{th} farm, X_i is influencing independent variables of efficiency, N number of independent variables, β is parameter of the model and u is error term.

When it is known that the error terms for the tobit models are normally distributed (or have a parametric distribution function in general), maximum likelihood and other similarity-based processes yield consistent and asymptotically normal estimators of normal distribution. However, predictors are inconsistent when the default parametric form of the similarity function is incorrectly determined. The Tobit model uses a normal continuous dependent variable censored at a given value.

4. Results

Data envelopment analysis was used to measure the efficiency of cattle breeding farms which operating in Thrace Region. In the model, animal gross production value was taken as output when factory meal, other food, veterinary, vaccination, medicine, artificial insemination costs and annual labor costs were taken as inputs. The efficiency scores of 220 cattle breeding farms which producing in Thrace region have been given in Table 1.

While the technical efficiency coefficient of the farms varies between 0.071 and 1, the average technical efficiency coefficient was calculated as 0.49. Technical efficiency coefficient indicates that inefficient farms can reduce their inputs by 51 percent without any reduction in output. In other words, inefficient farms can achieve up to 51% more output with the same amount of input they use, relative to the efficient farms.

When the pure technical efficiency and scale efficiency are examined, it is seen that the averages are 0.62 and 0.80 respectively. Although these two terms are components of the technical efficiency, it can be argued that the main problem is caused by technical inefficiency, although the inefficient farms in cattle breeding produce problems at optimum scale sizes.

It has been found that the economic efficiency of the farms varies between 0.035 and 1 and the average economic efficiency calculated as 0.42. Other farms which is the economic inefficient need to reduce producing costs by 58% in order to reach the level of self-similar and economically efficient farms.

The resource allocative efficiency for the surveyed farms varies between 0.21 and 1, and its average score is 0.68. This coefficient indicates that some of the farms in the study area are producing the wrong combination of inputs at the current technology level and considering the current input prices. These farms will have been 32% more expensive producing than the minimum costly input composition.

Table 1: Efficiency measuremets of farms

Efficiency measurements	Mean	Std. deviation	Min.	Max
Technical efficiency	0.49	0.21	0.071	1.00

Pure technical efficiency	0.62	0.23	0.098	1.00
Scale efficiency	0.80	0.17	0.071	1.00
Economic efficiency	0.42	0.18	0.035	1.00
Allocative efficiency	0.68	0.15	0.210	1.00

The distributions of the farms which have different efficiency scores given in Table 2. The number of farms is 13 which has full technical efficiency, represents a share of 5.9% among all farms. When analyzed from the point of view of resource allocation efficiency of the farms, it is seen that % 3.6 is fully efficient. In relation to this, the number of farms with full economic efficiency is 8.

Table 2: Distributiton of the efficiency scores

	Technical		Allocative		Economic	
	Number	%	Number	%	Number	%
Full efficient ($0.95 \leq TE \leq 1$)	13	5.9	8	3.6	8	3.6
Loss efficient ($0.90 \leq TE \leq 0.949$)	2	0.9	10	4.6	1	0.4
Non-efficient ($TE \leq 0.899$)	205	93.2	202	91.8	211	96.0
Total	220	100.0	220	100.0	220	100

Results of the scale efficiency analysis have been given in Table 3. According to the results, 82.3% of the farms have provide increasing returns on the scale while 8.6% of the farms have provide decreasing returns on to the scale. The scale efficiency coefficient of the farms is calculated to be 0.80 and is also compatible with the data in Table 3.

Table 3: Scale efficiency of the farms

	Number	%
Increasing returns on scale	181	82.3
Constant returns on scale	20	9.1
Decreasing returns on scale	19	8.6
Total	220	100.0

In this part of the study, the factors affecting the economic efficiency of the farms are explained with the Tobit model. While the economic efficiency coefficients of the firms in the model are used as dependent variables, education level, experience year, number of affilated agricultural cooperative, and animal number (CU) are used as independent variables. Table 4 gives the mean, standard deviation, minimum and maximum values of the independent variables.

Table 4: Descriptive statistics of variables on Tobit model

Variables	Mean	Std. Deviation	Min.	Max.
Experience year	24.72	11.52	1.00	60.00
Education level	6.82	2.88	5.00	15.00
Animal number (catte unit)	23.79	55.45	3.50	796.13
Affilated cooparetive (number)	1.54	0.50	1.00	3.00

The coefficients, standard deviations and significance levels of the independent variables have been given in Table 5. According to the model results, the independent variables' signs are consistent with the expectation. In the model, all independent variables have been affected economic efficiency positively.

The economic efficiency of the farm seems to increase when the farm size increases ($p < 0.001$). According to this result which is appropriate to the economic theory, it is seen that the economic efficiency increases with the increase of the number of animals in the farms. Increases the number of affiliated agricultural cooperative has a positive effect on economic efficiency ($p < 0.05$). Sharing information on production in agricultural cooperatives increases knowledge and consciousness of producers and affects efficiency in production. It is observed that the economic efficiency of the farms also increased with the increase of the education level ($p < 0.01$). In the same way, it can be said that the economic efficiency increases with the increase of the owner's experience year ($p < 0.01$).

Table 5: Results of Tobit model

Variables	Coefficient	Std. Deviation	Z statistic
Farm size	0.001007	0.000248	4.062028
Affilated cooperative	0.111602	0.020514	5.440141
Education level	0.015672	0.003703	4.232159
Experience year	0.004323	0.000975	4.434257
Log likelihood	46.12		

5. Conclusion

In the study, the input use efficiency of cattle breeding farms operating in Thrace region was examined. In the efficiency analysis; factory feed, other feeds, veterinary cost and annual labor costs were taken as input and animal gross production value was taken as output.

According to the results, the technical efficiency coefficient of the farms varied from 0.071 to 1 and average score has been calculated as 0.49. As the data envelopment analysis give us relative results, due to the dependent on the existence of very successful farms in the region, the average efficiency coefficient is 0.49. There are 12 farms which have been fully technical efficiency, its mean their technical efficiency coefficient equal to 1. Besides, pure technical efficiency and scale efficiency are measured as 0.62 and 0.80 respectively. According to the coefficients, the inefficiency farms affected from the technical efficiency. In other words, this stuation it can be explained as the excessive input use or the failure to obtain as many products as necessary.

The resource allocative efficiency varies between 0.21 and 1, with an averagescore is 0.68 in the region. Score indicates that some of the farms are producing with the wrong input combination at the current technology level and considering the current input prices. These farms are 32% more expensive than the minimum costly input composition.

When the economic efficiency of the farms is examined, it is determined that it varies between 0.035 and 1 and the average is 0.42. Other farms which are economic inefficiencies need to reduce producing costs by 58% in order to reach the level of self-similar and economically efficient farms. There are 6 farms that operate fully efficient in the economic manner, ie, with a minimum costly input combination.

Technical efficiency scores were found to be higher than economic efficiency scores in the examined farms. This result indicates that producers need more information on choosing the appropriate input composition at market price level rather than technical informations. On this issue, the lack of education insufficiency and input usage consciousness of the farms' owners are in shortage. According to target of the farms are profit maximization, it turns out that farms can not provide this.

According to the Tobit model results estimated to determine the factors affecting the economic efficiency of the farms, the signs of the independent variables were consistent with the expectation. When the farm size increase, the economic efficiency will be increase ($p < 0.001$). According to this result which is appropriate to the economic theory, it is seen that the economic efficiency increases with the increase of the number of animals in the farms. The increase in the number of affiliated cooperative of the farms owners seems to have a positive effect on economic efficiency ($p < 0.05$). In cooperatives and the other agricultural organizations, that important information about production sharing with the members which increases knowledge and consciousness of the producers and affects efficiency in production. It is observed that the economic efficiency of the farms also increased with the increase of the education level ($p < 0.01$). In the same way, it can be said that the economic efficiency increases with the increase of the owner's experience ($p < 0.01$).

In order to increase the efficiency of cattle breeding farms, it is firstly necessary to increase the farm size. In this regard, labor per unit animal, mechanization cost, maintenance and repair cost, shelter cost, etc. costs will be reduced. It is necessary to increase the number of large livestock farms that save labor and mechanization, allow animals to grow on more suitable conditions and make profitable and hygienic production possible. The necessary legislative arrangements must be made as work on the necessary arrangements to transform existing producers' cooperatives into a more productive structure will help to increase the effectiveness of livestok farms. With the support of producer cooperatives, the necessary technical information on cattle livestock must be provided to farms owners and employees. It should be ensured that the producers produce consciously in the direction of the education given to them, not the way they see each other.

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