

## Production efficiency estimation of Kosovo beef fattening farms

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### Abstract

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A possible accession in the European Union raises a significant opportunities and challenges for the beef-fattening sector in Kosovo. Toward EU accession process, the Kosovo beef sector will have to improve efficiency and competitiveness. The goal of this research study is motivated by the need to understand better the forces that drive competitiveness and the efficiency of the beef fattening sector in Kosovo. Data Envelopment Analyses was used to evaluate the production efficiency of Kosovo beef fattening farms. Research data were collected through surveys from 35 beef fattening farmers across two Kosovo regions. In total 710 fattened bulls were monitored for 180 days. Considering for suspected bias with the bootstrap input-oriented model, input efficiency ranged from 0.60-0.96 with an average of 0.88. Based on the farm, a naive model would induce a bias of 0.01-0.06 in input efficiency use. Research results indicate further input use decreases because the sampled farms are found to operate under decreasing returns to scale.

*Keywords:* DEA; Production efficiency; Bootstrap; Beef fattening; Kosovo

### Introduction

Beef fattening has a very important role in poverty alleviation in Kosovo rural regions. The meat industry in Kosovo can be described as fragmented and incomplete. The meat production sector in Kosovo is dominated by subsistence farms that hold less than nine cattle in their herd. In 2020, the local cattle farms supplied 52% of Kosovo’s market need for beef meat, with the remaining balance of some 46% being imported ( MAFRD Green report 2021). In 2019, the imports of fresh and frozen bovine meat reached EUR 43.9 million. Total meat consumption per capita in Kosovo is estimated at around 49 kg/year (beef meat 21 kg; chicken meat 23 kg; sheep and goat meat 1.2 kg meat) ( MAFRD Green report 2021). The current per capita consumption of cattle meat in Kosovo is therefore still low when compared to CEEC (Central East Europe Countries) and EU countries. However, with economic growth it is expected that the demand will in-

crease, as will the consumption of meat and meat products in Kosovo. According to Kosovo Food and Veterinary Agency (KFVA) Kosovo have 61 licensed beef slaughterhouses, 16 of them also processing meat and 7 chicken slaughterhouses. Currently, meat processors are making mainly products like: sausages, hamburgers, dried meat salamis, hot dogs. Because of the insufficient primary product supply by the Kosovo livestock farmers, local meat processors import 80 percent of the raw materials to meet their production needs. Since the percentage of imports of meat has increased continuously in the last five years, Kosovo continues to import livestock live weight and also carcass meat/frozen meat to fulfil the market demand.

Meat production in Kosovo is generally subsidiary, based on culled dairy cows, and fattening of male calves. The current cattle inventory consists of a large number of dual-purpose breeds mainly Simental. Small-scale cattle farming in Kosovo is the main challenges for development of intensive

cattle-fattening farms. Furthermore, beef cattle producers are keeping their animals in the tied barns and in poor housing conditions. Most of beef cattle are fed with a high content of forage feed in the diet, which restricts growth rates and higher daily weight gains. Kosovo beef fattening farms are facing numerous problems in production and marketing channels of beef meat, which along with growing domestic beef demand results in shortage of supply of domestically produced beef meat.

Many factors are influencing profitability of the beef production in Kosovo. The aim of this research study is to measure production efficiency, to identify the factors affecting production inefficiencies of Kosovo beef fattening farms, and to advocate a policy change for enhancing the competitiveness of Kosovo smallholder beef fattening farms. The approach taken is to derive a statistical measure of profit efficiency; using Data Envelopment Analyses. This approach in turn provides information that is useful in assessing the effect of economic indicators on profit inefficiency. The identification of the determinants of profitability/profit efficiency will assist in determining commercial and policy options for enhancing profitability of beef production in Kosovo.

There exists only a few studies of livestock farms in Kosovo that have employed DEA to determine the production efficiency. For instance, a published research found that the mean technical efficiency (TE) of Kosovar dairy farms was estimated at 0.72 (on a scale of 0 to 1.00) with the potential to increase further technical efficiency (Bajrami et al., 2017). The assessment of the publications point out research studies that have examined economic aspects of the dairy sector in Kosovo (Musliu et al., 2009; Miftari et al., 2010). Although, few articles have looked at the production efficiency of beef fattening farms in Kosovo while considering economic input materials.

The aforesaid research assessment confirms that there is narrow present empirical research on the production efficiency of Kosovo beef fattening farms. This research study was administered to answer this limitation and to look into the other identified problems. Clearly, this research is directed to determine the Pure Technical, Efficiency of beef fattening farms in Kosovo. The results of this empirical research can be utilized as a basis for Kosovo beef fattening farmers in developing farm standards to increase competitiveness of Kosovo beef fattening farms to substitute the imported beef meat.

To carry out the empirical research, there is an application of the non-parametric framework of bootstrap data envelopment analysis. After the development of the benchmarking model, the research study evaluates possible causes of variations in efficiencies. The specific question to be answered

in this research is: Do input use increases or decreases help sustain optimal earnings in Kosovo beef fattening farms.

## **Material and Methods**

The employed primary farm data for this empirical research were gathered from June 2019 to December 2019 from 35 beef fattening farm operating in two regions: in the west and central region of Kosovo, representing the main beef cattle production in Kosovo. Production information were obtained through face-to-face interviews with beef fattening farmers. In total 710 fattened bulls were monitored for 180 days. The main variables captured in the data included: gross seasonal revenues from fattened bulls and production input costs such as feed costs, other production input costs such as, family labor, and veterinary costs as well as farm size data.

Presently, decision making units (DMUs) performance problems are frequently estimated with DEA, as a non-parametric approach (Toloo & Salahi, 2018). This generally facilitates the process of quantifying efficiency use. The other strand of the literature relies on parametric methods such as the stochastic frontier analysis (SFA) of Aigner et al. (1997) and others that may achieve efficiency scores comparable to those under DEA. Thus, choosing one approach over the other can become a point of discussion as in Błażejczyk-Majka & Kala (2015).

Data Envelopment Analysis (DEA) was employed to measure the Technical Efficiency (TE), Pure Technical Efficiency (PTE), and Scale Efficiency (SE) of the beef fattening farmers. This method is popular for estimating the optimal production efficiency points as it provides an analytical tool for determining efficient and inefficient points (Tumer et al., 2020). Therefore, an input-oriented DEA was used to compare input efficiency use between farms and to explore what farm-level variables could predict TE. As a mathematical technique, DEA solves performance evaluation problems and quantifies input efficiency use. The input-oriented Banker-Charnes-Cooper (BCC) and Charnes-Cooper-Rhodes or CCR (Charnes et al., 1978) models were used. After characterizing PTE and SE from these models, PTE scores received from the beef fattening farms were used as outcomes in additional analyses to understand farm-level characteristics that affect efficient input use. All analyses were conducted in R that is a programming language and software for statistical analysis.

Logically, this research decides to use the input-oriented Banker-Charnes-Cooper or BCC (Banker et al., 1984); and Charnes-Cooper-Rhodes or CCR (Charnes et al., 1978). The goal is to capture both the technical and primarily the pure

technical input efficiency points for the beef fattening farms. One important reason as to why the BCC and CCR models are adopted jointly is that they allow studying scale efficiency. Using both models can shed light on the main source of input inefficiency of each beef fattening farms.

It is of importance to explain first the naive DEA estimator (Simar and Wilson, 1998), prior to establishing the input-oriented BCC model, which assumes variable returns to scale (VRS).

$$\widehat{\Omega}_{DEA} = \{-y_i + Y\gamma \geq 0; x_i - X\gamma \geq 0; \sum_{i=1}^N \gamma_i = 1, \gamma \geq 0\} \quad (1)$$

Following the DEA estimator in equation (1), the naive input-oriented BCC model under VRS can be formulated:

$$\text{Min } \hat{\theta} = \gamma\theta$$

Subject to:

$$\{-y_i + Y\gamma \geq 0; \theta x_i - X\gamma \geq 0; \sum_{i=1}^N \gamma_i = 1, \gamma \geq 0\} \quad (2)$$

From (2) is the Pure Technical Efficiency (PTE) for an individual beef fattening farm. Per beef fattening farm denotes gross seasonal revenues from fattened bulls and is the vector of inputs. The total inputs and output are contained in (X) and (Y), respectively. The inputs include feed costs, other production input costs such as, labor, and veterinary costs as well as farm size.

The advantage of the BCC model under VRS is that return to scale properties are not fixed by assumption. These properties are discussed in Bogetoft & Otto (2011). For this reason, the research study chooses the BCC model under VRS as the desirable input related model. Here, there is a use of the CCR model only when the study examines scale efficiency (SE) which is a ratio of input efficiency received from the CCR to that of the BCC model. Interpretively, a beef-fattening farm with an SE of 1.00 has the most productive scale size, while SE values lower than 1.00 would indicate further room for improvement to achieve the respective scale.

An interesting development to answer bias in efficiency scores includes the work of Simar & Wilson (1998, 2000). They propose to utilize the bootstrap DEA, which may en-

able one to achieve bias corrected efficiency scores. In the context of the bootstrap BCC model, to compute the efficiency scores, there is a need to first define the DEA estimator .

$$\widehat{\Omega}_{DEA}^* = \{-y_i + Y\gamma \geq 0; x_i - X^*\gamma \geq 0; \sum_{i=1}^N \gamma_i = 1, \gamma \geq 0\} \quad (3)$$

The bootstrap formulation in (3) presents a pathway that will be valuable for the study in which there is a formulation of the bootstrap input-oriented BCC model under VRS.

$$\text{Min } \hat{\theta}^* = \gamma\theta$$

Subject to:

$$\{-y_i + Y\gamma \geq 0; \theta x_i - X^*\gamma \geq 0; \sum_{i=1}^N \gamma_i = 1, \gamma \geq 0\} \quad (4)$$

From these estimations, the bootstrap efficiency can be considered as an estimate of . That is, in a similar way, as in the case of using naive estimations. For example, can be viewed as an estimate of . Thus, the question of whether beef fattening farms are efficiently using their inputs can be settled empirically.

## Results and Discussion

Summary statistics for the variables used for analysis are presented in Table 1. The summary statistics characteristics of sampled beef fattening farms over the full course of a season reports the estimated average revenues per fattened bulls is 1082 euros, the estimated average of feed expenses per fattened bulls is 257.83 euros, the estimated average of other expenses per fattened bulls is 71.02 euros and the estimated average of fattened beef cattle number per farm was 49 beef cattle.

The efficiency scores throughout this section take values between 0 and 1. Figure 1, motivated by Bogetoft & Otto (2011), shows that 11 out of 35 farms under the naive BCC model are efficient. The data in Figure 1 shows the result of the pooled efficiency measures of beef fattening farms using the DEA method. Out of 24 inefficient beef fattening farms the DEA results show that two beef fattening farms have a low mean efficiency score of 60% relative to the most effi-

**Table 1. Descriptive statistics (N = 35)**

Statistics	Unit	Mean	St. Dev.	25 <sup>th</sup> PCTL	Median	75 <sup>th</sup> PCTL
<b>Output</b>						
Revenues	Euros/Bull	1,082	136	990	1,110	1170
<b>Input</b>						
Feed expenses	Euros/Bull	257.83	52.26	227.40	247.60	302.53
Other expenses	Euros/Bull	71.02	34.67	41.90	64.66	100
Farm size	Bulls/Farm	49	35	21	43	58

cient farm. This result indicates 40% of input waste, suggesting that beef cattle farms could reduce input cost by this percentage and attain the same output level as efficient peers. Thirteen beef fattening farms have a low mean efficiency score range between 70- 85% relative to the most efficient farms and the remaining nine beef fattening farms have a low mean efficiency score range between 90- 96% relative to the most efficient farm. The average input efficiency of sampled beef fattening farms is 88%.

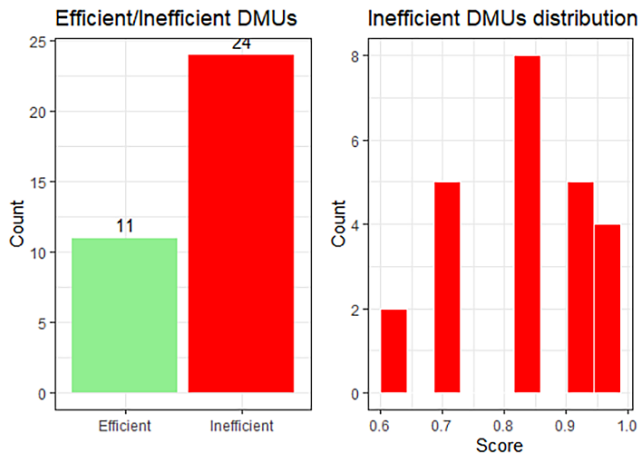


Fig. 1

The four-year average technical efficiency of small sized beef farms in Hungary (86.2%) is higher than that of Croatian beef farms (74.4%). The average technical efficiency of small-sized Croatian beef farms was significantly higher than of medium-sized farms ( Kovacs et al., 2022).

The ratio of CRS and VRS provides the measurement of scale efficiency. If the ratio of the two is equal to 1, it indicates scale efficiency, while  $<1$  indicates scale inefficiency (Bielik, 2004). The notion of scale efficiency (SE) helps us understand the loss of those farms, other than SE farms, that are not operating optimally (Frangu et al., 2021). One finding of the study shows, the sampled farms appear to be operating under decreasing returns to scale (DRS).

In Table 2, SE efficient beef fattening farms under the naive input efficiency analysis have mean revenues per fattened bulls of 1115.42 euros over the period of 180 days of fattening season. Comparably, beef fattening farms under DRS have mean revenues per fattened bulls of 1010.23 euros per beef fattening season. The variability in revenues values per fattened bulls is 104.51 euros for SE beef fattening farms, and this variability is higher for DRS farms 171.75 euros per fattened bulls. The results of the study finds that the SE mean for feed expenses under the naive input efficiency analysis is 218.51 euros per fattened bulls, while beef fattening farms under DRS have mean feed expenses per fattened bulls of 275.85 euros. The variability in the feed expenses per fattened bulls is 54.79 euros for SE beef fattening farms, and this variability is higher for DRS farms 40.83 euros per fattened bulls. The SE mean of other expenses under the naive input efficiency analysis is 60.71 euros per fattened bulls while beef fattening farms under DRS have mean other expenses per fattened bulls of 75.74 euros. The variability in other expenses per fattened bulls is 30.71 euros for SE beef fattening farms, and this variability is higher for DRS farms 35.96 euros per fattened bulls. The SE mean of farm size under the naive input efficiency analysis is 19 fattened bulls per fattening farm while beef fattening farms under DRS have mean farm size of 62 fattened bulls per farm. The variability in farm size per fattened bulls is 13 bulls for SE beef fattening farms, and this variability is higher for DRS farms 33 bulls per fattening farms. Under the bootstrap specification, it is found that all farms are experiencing DRS. The study singles out in Table 2 the bootstrap based input and output mean values. These values are the same as those of the descriptive statistics in Table 1 because all the sampled farms are found to be operating under DRS. For instance, there is an output mean revenues per fattened bulls of 1082.36 euros over the period of 180 days of fattening season with variability of 136.09 euros. This suggests a non-negligible under representation of 72.13 euros of the mean revenues per bulls fattening season for DRS farms under the naive compared to the bootstrap specification.

Table 2. Naive and bootstrap input information under scale efficiency and decreasing returns to scale

		Naive PTE				BSC PTE	
		SE (N = 11)		DRS (N = 24)		DRS (N = 35)	
Output and inputs	Units	Mean	St.Dev.	Mean	St.Dev.	Mean	St.Dev.
Revenues	Euro/Bull	1115.42	104.51	1010.23	171.75	1082.36	136.09
Feed expenses	Euro/Bull	218.51	54.49	275.85	40.83	257.83	52.26
Other expenses	Euro/Bull	60.71	30.71	75.74	35.96	71.02	34.67
Farm size	Bulls/farm	19	13	62	33	49	35

## Conclusions

In this study, the DEA method was used for the first time to evaluate the technical efficiency of Kosovo beef fattening farms. One of the possible limitations of this research could be the small sample size. Therefore, the study suggests it would be useful to obtain a bootstrap procedure. The research study examined the contrasting input efficiency levels using the bootstrap procedure. This specification yielded bias corrected input efficiency scores. The bootstrap procedure was helpful to find that all the sampled farms were facing decreasing returns to scale and that scaling down and not up can be the efficient way forward. After accounting for suspected bias with the bootstrap input-oriented model, input efficiency ranged from 0.60-0.96 with an average of 0.88%. To offset the shortages of beef meat in Kosovo market the imports of live beef animals as well as fresh and frozen bovine meat has increased steadily from year 2016 to year 2020 (MAFRD Green report 2021) This partly contributes to Kosovo beef fattening farms inability to be more competitive in domestic beef markets. This suggests that Kosovo beef fattening farms should focus on developing the optimal use of inputs to reduce input waste and cost inefficiencies.

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