Factors affecting the technical efficiency of dairy farms in Kosovo

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Abstract

A possible accession into the World Trade Organization (WTO) and an expected membership in the European Union raise significant opportunities and challenges for the agricultural sector in Kosovo. As a result of these changes, the sector will have to improve efficiency and competitiveness. This research is motivated by the need to understand better the forces that drive competitiveness in the Kosovo dairy sector. This study estimates the technical efficiency (TE) of 243 dairy farms in Kosovo and relates TE variation to farm size and other primary determinants of TE. A stochastic frontier production function is estimated using a two-stage procedure. Results reveal that concentrate feed intake, land use per cow, and the number of days cows had been kept on pasture have statistically significant impacts on milk productivity per cow. The mean technical efficiency of dairy farms was estimated at 0.72. The major determinants that increase efficiency are breed improvement, intensification of corn production on the farm, improving concentrate feed intake, and using free-range production systems. Given the results from the technical efficiency analysis, it is crucial for the Government of Kosovo to redesign their dairy policy—specifically their grant investment schemes—and target assistance on improving national herd genetics, promoting free range systems and expanding area planted in corn.

Keywords: dairy farm, frontier, Kosovo, policy, technical efficiency

Introduction

Livestock is one of the most important agricultural sectors of Kosovo. With the prospect of ultimately joining the European Union (EU), the Kosovo dairy sector faces the challenge of transforming from an inefficient, small-sized dairy farm sector to one that must eventually compete with the very efficient EU dairy industry. The Kosovo Ministry of Agriculture, Forestry and Rural Development (MAFRD) estimate that livestock generated an annual average of €298 million value of production over the period of 2008-14 (MAFRD, 2015). The dairy subsector alone contributes about 10% of annual GDP (Bytyqi et al., 2014). Total milk production for 2014 in Kosovo was 279 MT valued at €76.7 million (MAFRD, 2015). This production came from a national herd of 261,689 cows distributed across 66,589 households (Table 1).

Table 1. Kosovo number of cattle by cow herd size, by region, 2014

Herd	Total	Prishtina	Mitrovica	Peja	Prizren	Ferizaj	Gjilan	Gjakova
size	261,689	52,475	31,414	44,490	46,772	22,607	23,615	40,316
(1 - 2)	58,727	14,525	7,615	6,840	12,223	6,389	4,353	6,782
(3 -9)	111,003	19,963	13,764	18,859	20,827	9,950	8,748	18,892
(10 - 19)	46,379	8,981	5,505	9,075	6,613	3,448	4,810	7,947
(20 - 29)	19,919	4,053	2,180	3,829	3,167	1,562	2,380	2,748
(30 - 49)	16,165	3,076	1,913	3,564	2,172	987	2,174	2,279
(>50)	9,496	1,877	437	2,323	1,770	271	1,150	1,668

Source: MAFRD (2015).

Even though dairy is one of the most important subsectors of agriculture, the structure of dairy farms (number of cows per farm) in the post-war period (after 1999) has been changing very slowly. Most of the dairy farms are small, producing primarily for self-consumption. Sixty-five percent of the cow inventory in 2014 was on farms with nine or fewer cows. The current inventory consists of a large number of dual purpose breeds. In addition, small-scale dairy farming in Kosovo faces challenges of low milk productivity, traditional breed genetics, fragmented land use and low efficiency. The large number of traditional and cross breeds in the cattle inventory, poor feeding, poor hygiene and breeding conditions, and the lack of managerial knowledge of advanced dairy farm practices among farmers are considered as the main factors (potential determinants) causing low efficiency.

Previous literature, however, has not measured the relative importance of the determinants of the inefficiency of the Kosovo dairy subsector. To address this question, stochastic frontier analysis of the dairy sector is used to investigate the relative efficiency level among Kosovo dairy farms and identify the main factors that determine variation in technical efficiency and which factors could potentially improve productivity. The stochastic frontier production approach used to measure an efficiency component was first introduced and developed by Aigner et al. (1977) and Meeusen and Van den Broeck (1977). A second stage of analysis, developed by Kumbhakar et al. (1991) and Battese and Coelli (1995), involves estimating a model having the efficiency component as a function of determining factors. Within this context, technical efficiency of dairy farms in other countries has been widely studied using stochastic frontier analysis (SFA). Kumbhakar et al. (1991) found that U.S. dairy farm technical inefficiency was determined by levels of operator education and farm size. Hallam and Machado (1996) studied efficiency on Portuguese dairy farms and found a positive relationship with farm size but no relationship with degree of specialization. Cabrera et al. (2010) analyzed determinants of technical efficiency on

Wisconsin USA dairy farms and found the use of bovine somatotropin hormone increased milk production significantly, and that technical efficiency was positively related to farm intensification, contribution of family labor and use of complete mixed feed rations. Another analysis of sources of technical efficiency of Wisconsin dairy farms by Chidmi et al. (2011) estimated determinants using a quantile regression approach and found significant differences among factors by levels of technical efficiency. Areal et al. (2012) found that spatial dependence among dairy farms in England and Wales is important in explaining variation in technical efficiency. Niskanen and Heikkilä (2015) focused on the effect of farmland parcel fragmentation on technical efficiency of Finnish dairy farms.

Several studies have been conducted about the Kosovo dairy sector. Bytyqi et al. (2005) compared improved dairy breeds for milk production, fertility and body condition; Musliu et al. (2009) studied economic losses associated with variation in raw milk quality; Miftari et al. (2010) assessed the role of demographic and socio-economic factors on consumer expenditures on milk and milk products; Bytyqi et al. (2010) studied the effect of cattle breeds and seasonality on milk output; Bytyqi et al. (2011) conducted a descriptive economic cost analysis of dairy farms; and Kokko et al. (2014) evaluated needed improvements in management practices based on a survey of Kosovo dairy farms. However, to date, no study has provided estimates of the technical efficiency level of dairy farms in Kosovo and the determining factors. The present research addresses this gap in the literature.

The present study represents the first use of a stochastic frontier production model to estimate the technical efficiency of dairy farms in Kosovo. Therefore, the study provides an important contribution to the literature and provides recommendations for dairy farmers and policymakers regarding how to allocate investments to improve Kosovo's dairy farm efficiency in the future.

Materials and methods

Specification of the stochastic frontier model

When modeling the impact of technical inefficiency of production, it is assumed that inputs are exogenously set, and the objective is to maximize output from a given set of inputs; therefore, only quantities are modeled, and no price information is included in the modeling (Kumbhakar et al., 2015). Following Kumbhakar et al. (2015), a stochastic production frontier model with output-oriented technical inefficiency can be specified as:

$$ln\gamma_i = ln\gamma_i^* - \mu_i, \quad \mu_i \geq 0, \tag{1}$$

$$ln\gamma_i^* = f(x_i;\beta) + v_i, \tag{2}$$

where i denotes the i^{th} dairy farm, γ_i is a scalar measure of the observed output (daily milk output per cow per farm), γ_i^* is the maximum output in the frontier, $\boldsymbol{x}_i$ is a $1xj$ vector of input variables (feed, land use, etc.), β is $jx1$ vector of corresponding coefficients, v_i denotes a zero-mean random error, and $\mu_i \geq 0$ is production inefficiency. The term μ_i is the log difference between the maximum and the actual output ($\mu_i = ln\gamma_i^* - ln\gamma_i$), therefore $\mu_i x 100\%$ is the percentage by which the milk production per farm can be increased using the same inputs if production is fully efficient. In other words, it gives the percentage of milk production that is lost due to technical inefficiency (Kumbhakar et al., 2015). Rearranging equation (1)

$$exp(-\mu_i) = \frac{\gamma_i}{\gamma_i^*}, \qquad (3)$$

$\exp(-\mu_i)$ gives the ratio of actual output (milk production per farm) to the maximum possible output. This ratio is referred to as the technical efficiency of dairy farm i. Since $\mu_i \geq 0$, the ratio can take on values between 0 and 1, with a value of 1 implying that the dairy farm is fully technically efficient (Kumbhakar et al., 2015). The value obtained from equation (3) is multiplied by 100 and represents the percentage of the maximum output (milk production) that is produced by dairy farm i.

In order to estimate the technical efficiency of dairy farms in Kosovo, a stochastic production frontier, first proposed by Aigner, Lovel and Schmidt (1977) and Meesusen and Van Den Broeck (1977), is used. The aim of this production frontier model is to identify the dairy farms that are more productive and those that are less productive: how much more milk could be produced given the amounts of feed, pasture days and land use, and whether the efficiency level is affected by the feeding amounts, hay ratio, barn production system, wheat and corn ratio, the ratio of Holstein and Simental stock, farm records and farm location by region.

Technical efficiency is estimated in the production frontier framework using 243 cross-sectional observations of Kosovo dairy farmers in 2014. A Cobb-Douglas production function is used to model the production technology (2) with a two-sided, normally distributed error term. Deviations from technical inefficiency (μ_i) are one-sided using a half-normal distribution. A two-stage estimation procedure is used in this study. In the first stage, technical efficiency scores were estimated via (1) and (2). In the second stage, the technical inefficiency estimates were regressed against a set of variables (factors) in order to explain the variation in inefficiency (Battese and Coelli, 1995). Following Kumbhakar et al. (2015), the original specification was specified for cross-sectional data with an error term with two components, one accounting for random events and the other for technical inefficiency. The model was specified as follows:

$$\gamma_i = x_i\beta + (v_i - \mu_i) \qquad i = 1, \ldots., N, \qquad (4)$$

where γ_i is the milk production per cow per day for dairy farm i, x_i a $1xj$ vector of input quantities (land use per cow, days in pasture, hay, concentrate and silage fed to cows in kg per day and number of cows) for farm i, β denotes the vector of the respective estimated parameters, v_i are random variables assumed to be independently and identically distributed (IID) $N(0, \sigma_v^2)$ and independent of the μ_i, which are non-negative random variables assumed to account for technical inefficiency in production. The v_i are assumed to capture random variation in output due to factors beyond the control of farms, such as weather variations (Kompas and Che, 2006). According to Coelli (1996), the v_i are often assumed to be IID, $N(0, \sigma_v^2)$. Following Coelli (1996), the μ_i are assumed half-normally distributed. This specification was also based on the skewness test results, which indicate that the distribution of residuals skews to the left, which is consistent with a production frontier specification (Kumbhakar et al., 2015).

As noted by Kompas and Che (2006), the estimated values of β indicate the relative importance of each input to production. The specified model allows for a non-negative random component in μ_i, in order to generate a measure of technical inefficiency, or the ratio of actual to expected maximum output given inputs and the existing technology.

The stochastic production function (4) is estimated in double-log form. Subsequently, the estimated inefficiency estimates in log form are estimated in the inefficiency model as follows:

$$\mu_i = w_i\alpha + \varepsilon_i \qquad i = 1, \dots, N, \qquad (5)$$

where w_i is a vector containing fifteen production variables (total feed per day, hay ratio, barn, wheat ratio, corn ratio, Holstein ratio, Simmental ratio, farm records and regions were included as dummy variables) (see Table 2 for the variables listed under the inefficiency effects). Gjakova region is the omitted region in the inefficiency model.

The maximum likelihood estimation approach which includes the specification of the distribution of the errors terms is surely the most common approach used in the estimation of stochastic frontiers (Battese and Tessema, 1997). The package *frontier* in STATA was used to obtain maximum likelihood estimates of the stochastic production frontier with a half normal distribution for the technical inefficiency error term μ_i. The residuals were collected from this estimation and then transformed into estimates of observation level technical inefficiency (μ_i). The parameters in Equation (5) were estimated by least squares.

Data and sample

A survey was developed to collect the primary data on the socio-economic characteristics of farmers including farmer age, gender, household size, years of formal education, years of experience in milk production, farm size, farm specialization, capital assets, milk production per year, milk sales per year, milk quality, cost of inputs such as labor, feeding costs, transportation and depreciation costs.

Two hundred and forty-three (243) randomly selected households were surveyed. Since this study aimed to have countrywide scope, all seven regions were sampled. In order to reduce the geographic bias and have a representative sample across the regions, a randomized, stratified sample using a weighting technique was used. The population list of participant farmers in the farm subsidy programs of MAFRD in 2014 was used to estimate the weights per region.

The data collection process was conducted in all the seven regions of Kosovo, during a period of two months, specifically from mid-July to mid-September 2015.

Results and discussion

Descriptive statistics of farm and non-farm specific variables

The summary statistics for the output and input variables included in the stochastic production frontier and the inefficiency models, including the sample size, mean, standard deviation and a description for each variable are presented in Table 2.

Average milk production per cow per day in 2014 was 11.85 liters. Average farm size was 10.49 ha, or 1.03 ha per cow. Pastures are an important part of milk production on dairy farms in Kosovo. The annual average days of cows on pasture were 133 days. Average daily feeding rates per cow were 3.4 kg of concentrate and 8.7 kg of silage. Recommended silage feeding rate is within the suggested range of 7 to 13 kg per cow (MAFRD, 2014). Many farmers, regardless farm size, produce their own corn or grass silage (USAID, 2007).

Table 2. Definitions and summary statistics for the independent variables

Variable	Description	n	Mean	SD
	Production function			
Nocows	Number of dairy cows per dairy farm	243	8.25	5.06
Mcowday	Daily milk production per cow (liters/cow)	243	11.85	2.07
Landuse	Total land use (ha)	243	10.49	10.73
Dayspast	The annual number of pasture days	243	133.09	55.27
Haykgday	Daily amount of hay per cow (kg)	243	10.38	4.06
Conckgday	Daily amount of concentrate per cow (kg)	243	3.39	1.5
Silkgday	Daily amount of silage per cow (kg)	243	8.72	9.58
	Inefficiency effects			
Totalfeedday	The total amount of feed per cow per day (kg)	243	23.19	3.88
Hayratio	The ratio of hay to total amount of feed per cow	243	0.47	0.2
Barn	If the cows are tied in the barn (yes=1)	243	0.98	0.13
Grains	Total area planted to grains (ha)	243	6.11	8.19
Wheat	Total area planted to wheat (ha)	243	3.62	5.82
Corn	Total area planted to corn (ha)	243	2.3	2.8
Holsteinratio	The ratio of Holstein stock in the herd	243	0.08	0.2
Simentalratio	The ratio of Simmental stock in the herd	243	0.66	0.37
Frecords	If the farmer keeps farm records (yes=1)	243	0.62	0.49
PrishtinaR	If the farmer is located in Prishtina region (yes=1)	243	0.3	0.46
MitrovicaR	If the farmer is located in Mitrovica region (yes=1)	243	0.16	0.37
PejaR	If the farmer is located in Peja region (yes=1)	243	0.12	0.33
PrizrenR	If the farmer is located in Prizren region (yes=1)	243	0.12	0.33
FerizajR	If the farmer is located in Ferizaj region (yes=1)	243	0.07	0.25
GjilanR	If the farmer is located in Gjilan region (yes=1)	243	0.16	0.37

SD - standard deviation. Source: authors.

Dairy farms in Kosovo use one of two barn production system alternatives: tied or free stall systems. The tied system dominates, as 98% of farms used this system in the barn, while only 2% of them used a free stall production system. Farmers planted a significant amount of grains for their dairy operations. Among several grains, wheat and corn constituted 96% of the planted grains in 2014. On average, farmers planted 6.11 ha of grains, including wheat (3.62 ha) and corn (2.3 ha).

Raw milk and cheese sales represent the main income sources for most of the dairy farmers. Cow breeds were reported as Holstein, Simmental, Busha and mixed. The mixed group consisted of cross breeds, and other secondary breeds such as Graufi, Montbeliarde and Angus. Cross breeds are dominant on the sampled dairy farms. Lastly, seven variables were incorporated into the inefficiency model as dummy variables including farm record keeping and six regional locations: Prishtina, Mitrovica, Peja, Gjilan, Prizren or Ferizaj regions.

Stochastic production frontier model estimation results

Maximum likelihood estimates of the stochastic frontier production function parameters are presented in Table 3. Among the six estimated coefficients, five are statistically significant at P<0.10 and three of these at P<0.01. All the estimated coefficients have the expected signs. The coefficient for the number of cows, even though it has the expected sign, is not statistically significant.

Table 3. Maximum likelihood estimates of the production function

Variables	Parameters	Std. err.	t-value
Production function			
Constant	2.235	0.082	24.36***
lnlandusecow	0.038	0.011	3.3***
lndayspast	-0.011	0.005	-2.6**
lnhaykgday	0.044	0.023	1.68*
lnconckgday	0.126	0.02	6.28***
lnsilkgday	0.064	0.009	6.59***
lnNocows	0.023	0.017	1.13
Variance parameters			
lnsig2v	-5.022	0.261	-19.27***
lnsig2u	-3.962	0.294	-13.02***
Log likelihood	185.27		
chibar2(01)	7.35***		

Significance levels: *P<0.10, **P<0.05, ***P<0.01. Std. err. - standard error.

Since all the variables are estimated as natural logarithms, their coefficients can be interpreted as output elasticities. The negative elasticity (-0.01) of pasture days implies that a 1% increase in the number of days that cows are kept in pastures will result in a 0.01% decrease in milk production per cow. Pasturing is considered as an extensive production system, resulting in lower milk yields (Kolver and Mueller, 1998; Dartt et al., 1999; Bargo et al., 2002; Nehring et al., 2011).

Feeding rates of concentrates and silage are highly significant (P<0.01), indicating that they have a significant, positive relationship with the daily milk productivity of cows. The amounts of concentrate and silage fed per day have the highest impact on the productivity level with elasticities equal to 0.12 and 0.06, implying that a 1% increase in concentrate or silage results in an estimated increase in output per cow (milk production) of 0.12% and 0.06%, respectively. Concentrate is mainly used with pasture based systems, as a supplementary feed to improve milk production (Stockdale, 2000; Bargo et al., 2002; Holmes and Roche, 2007; Turki et al., 2012; Hills et al., 2015). Also, hay per cow per day is significant at the 10% level, implying that an increase in hay is associated with a higher milk production per cow. On average, farmers fed 10 kg of hay per day per cow, constituting 47% of the total feed volume in kg per cow. According to Huffman (1939), most cows consume from 1.13 to 1.36 kg of hay per 45.35 kg of body weight.

Hay (0.04) has the next highest elasticity, followed by land use (0.03), and number of cows (0.02). The sum of the elasticities equals 0.31, revealing that dairy farms in Kosovo operate under decreasing returns to scale (DRS). This relationship implies that the combination of inputs and outputs is not scale-efficient (Aldeseit, 2013). Similar results where farms were operating under DRS were also obtained by Sharma et al. (1997), Wadud and White (2000), Fraser and Graham (2005), Wei (2014), and Mwajombe and Mlozi (2015).

The parameter estimates of this model assume the inefficiency error terms are half-normally distributed. A null hypothesis of interest is that there is no inefficiency. The likelihood ratio for this hypothesis is 7.35 with a p-value of 0.003. According to Masunda and Chiweshe (2015), the significance of the likelihood ratio test confirms the presence of the one-sided error term in the composite error term, indicating the presence of technical inefficiencies in production. Furthermore, the variance parameters of the model are statistically significantly different from zero. According to Hanzeci and Ceyhan (2015), their significance indicates that a deterministic function is not an adequate representation of the observed output data.

The mean value of technical efficiency of dairy farms in Kosovo was estimated at 0.72, ranging from 0.67 to 1 (fully efficient). Considering these results, if the average dairy farm could eliminate their technical inefficiency, their output would increase by a factor of 1.39 (100/72). Increasing their technical efficiency would help to increase productivity and their overall competitiveness.

As displayed in Figure 1, there is variation in the distribution of the estimated efficiency scores as a function of the levels of milk production per cow per day. Most of the dairy farmers are operating on a range of 0.7 to 0.8 TE, corresponding to the range of 10 to 14 liters of milk productivity per cow per day.

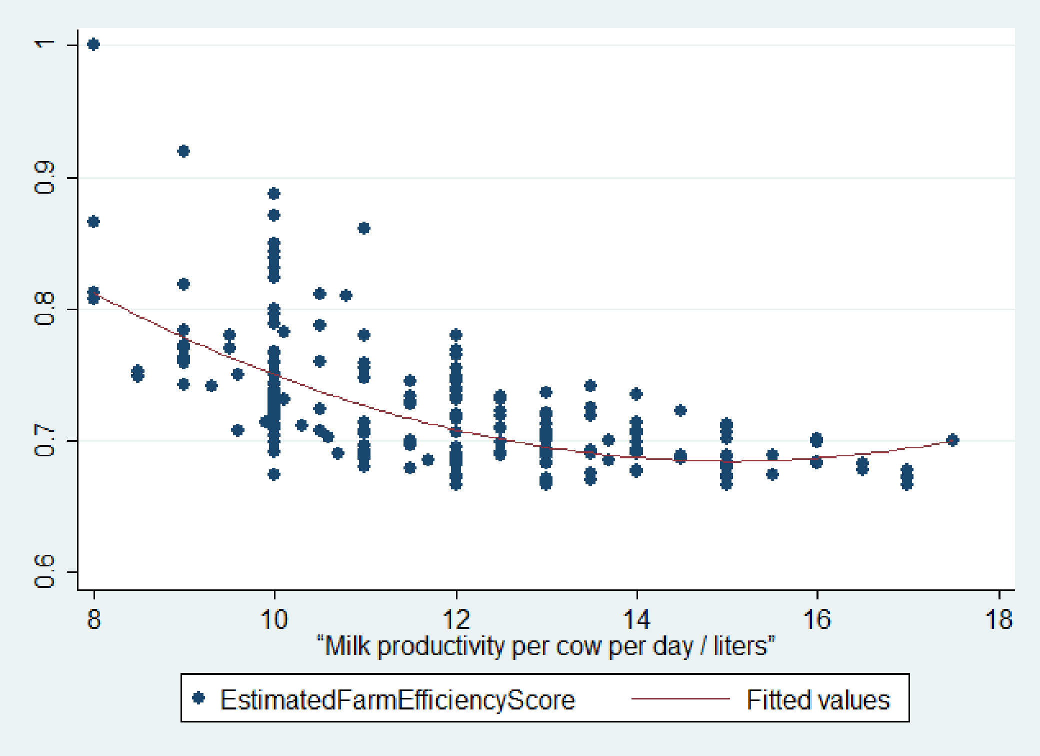

Figure 1. Relationship between estimated technical efficiency and milk production per cow

The estimated levels of technical efficiency were also compared by the farm size in terms of number of dairy cows. Table 4 presents the estimated levels of TE tabulated by the farm size.

Table 4. Farm size and technical efficiency level of dairy farms in Kosovo

Farm size (cows)	Number of farms	TE	Standard deviation	Minimum	Maximum
(1-4)	40	0.72	0.04	0.67	0.87
(5-15)	183	0.72	0.05	0.67	1
(16-25)	17	0.73	0.07	0.67	0.92
(26-35)	3	0.73	0.08	0.67	0.82
Total	243	0.72	0.05	0.67	1

TE - technical efficiency. The difference in TE among farm sizes is statistically insignificant.

As expected, the estimated levels of efficiency are consistent among the farm size groups, likely attributable to the fact that dairy farmers in Kosovo use similar production technology. There is no statistical difference of TE among farm size groups; however, dairy farms with more cows (>15) tend to be slightly more efficient, considering also their degree of specialization. According to Błażejczyk-Majka and

Kala (2015), one of the methods to improve farm efficiency and thus their competitiveness is to increase the degree of specialization.

Direct Payments (DP) represents the largest agricultural subsidy program in Kosovo, initiated in 2009 from MAFRD. For dairy farmers, it includes the Subsidy per Head Scheme (SPHS), subsidy on milk quality and area payments for wheat and maize. SPHS is coupled to the current number of cows and supports the dairy farmers with a specific amount of money per head on an annual basis. Similarly, area payments for wheat and maize are coupled to the area planted with these grains. Only the subsidy on milk quality is given based on the quality of milk produced on the farm. Subsequently, in order to test whether the Subsidy per Head Scheme (SPHS) has had an observable effect on productivity, TE estimates were compared among two groups: a sample of dairy farmers that were supported with SPHS and a sample of non-supported farmers (see Table 5).

Supported farmers include those receiving support through SPHS or with other schemes of Direct Payments (DP) program such as the subsidy on milk quality and area payments for amount of land planted to wheat and corn. The results revealed that there is no significant difference in terms of efficiency level between supported and non-supported dairy farmers. Moreover, non-supported dairy farmers had on average a higher efficiency level.

Table 5. A comparison of technical efficiency level between SPHS supported and non-supported dairy farmers

SPHS	Number of farms	TE	Standard deviation	Minimum	Maximum
Supported	132	0.72	0.05	0.67	1
Non-supported	111	0.73	0.05	0.67	0.87
Total	243	0.72	0.05	0.67	1

TE - technical efficiency. The difference in TE between groups is statistically insignificant.

A weakness of this test is that subjects were self-selected into the participation and non-participation groups so that there is no randomization for selection into either group. A robust check was conducted by regressing technical efficiency estimates with the farm and operator characteristics as control variables and a binary variable indicating whether the i-th farm was participating in the program or not. As expected, the coefficient of the binary variable was statistically insignificant. In addition, when characteristics of participants versus non-participants were compared, no discernable differences were found on the characteristics that were observed.

Determinants of technical inefficiency

For the second stage of this study, to identify the factors that affect inefficiency, the estimated levels of technical inefficiency were modeled as a function of independent variables including total amount of feed, hay ratio to total feed, barn production system, wheat and corn ratios to total planted grains area, the ratio of Holstein stock, the ratio of Simmental stock, farm record keeping and all the regions represented in the study sample. Results of this estimation are presented in Table 6. It is important to note that technical inefficiency increases as the index gets larger.

Table 6. Inefficiency model estimates

Variables	Parameters	Std. err.	t-value
Inefficiency model			
Constant	0.176	0.048	3.69***
Totalfeedday	0.001	0.001	0.73
Hayratio	-0.093	0.023	-4.06***
Barn	0.066	0.028	2.38**
Wheatratio	-0.012	0.016	-0.78
Cornratio	-0.047	0.017	-2.81***
Holsteinratio	-0.141	0.021	-6.69***
Simentalratio	-0.089	0.011	-8.09***
Frecords	-0.003	0.008	-0.35
PrishtinaR	-0.025	0.015	-1.63
MitrovicaR	0.006	0.016	0.35
GjilanR	0.005	0.017	0.3
PejaR	-0.014	0.017	-0.85
PrizrenR	-0.031	0.018	-1.74*
FerizajR	-0.019	0.02	-0.97

Significance levels: *P<0.10, **P<0.05, ***P<0.01. Std. err. - standard error.

The estimates of the inefficiency model parameters show that the coefficients for the variables of hay ratio (P<0.01), barn (P<0.05), corn ratio (P<0.01), the ratio of Holstein stock (P<0.01), the ratio of Simmental stock (P<0.01), and the region of Prizren (P<0.10) are statistically significant. The other variables including the total amount of feed, wheat ratio, farm record keeping and the other region variables (Prishtina, Mitrovica, Peja, Ferizaj, and Gjilan) are statistically insignificant. All the variables included in the model have the expected signs.

Keeping cows tied in the barn decreases the efficiency level, considering that it has a significant positive relationship with inefficiency. In contrast, all the other significant variables have a negative relationship with inefficiency. Increasing the hay ratio increases the efficiency level. However, hay should be combined with other supplementary feeds (concentrates and silage) in order to improve efficiency. Hutton and Parker (1966) showed that grazing time and hay feeding as a supplement had large and significant effects on milk yield, milk composition and live weight. Currently, hay is used throughout the year on dairy farms in Kosovo. Cattle are kept in the barn from mid-November until the end of April (winter period). Over this period, feeding is mostly hay-based (Bytyqi et al., 2009; Kokko et al., 2014). Further, the model identifies several factors that affect the technical efficiency positively. Intensity of corn planted relative to other grains ratio decreases technical inefficiency. Wheat and corn constitute the main grains for the dairy farmers in Kosovo. While corn production is mainly used for cattle feeding, wheat is used for human consumption, which explains the lack of significance for the wheat ratios in the inefficiency model. As expected, the Holstein and Simmental stock ratios significantly decrease technical inefficiency. Crossbreeds are dominant on dairy farms in Kosovo, mainly based on the native breed Busha (Bytyqi et al., 2009). The results reveal a negative relationship between the inefficiency and the dairy farmers located in Prizren region. This region is known as a suitable area for the development of dairy activities. Compared to other regions of Kosovo, farmland in Prizren has a low cost irrigation system: water is moved by gravity.

Conclusions

The technical efficiency levels of 243 dairy farms in Kosovo in the 2014 farming season were estimated using primary data from the seven regions of Kosovo. A stochastic frontier production function approach with a two-stage estimation procedure was utilized to measure the efficiency level of dairy farms and identify the main efficiency determinants. The results reveal that feeding ratios per cow (concentrates, silage and hay), land use per cow and the number of days cows are kept on pastures have significant effects on milk productivity per cow. The mean technical efficiency of dairy farms was estimated at 0.72, suggesting that dairy farms can increase their output considerably, without increasing input use. Moreover, dairy farmers with more than 15 dairy cows showed higher level of efficiency, while farmers with 1-15 cows had slightly lower efficiency levels but not a statistically significant difference. This empirical evidence suggests that variation in herd size does not have much impact on efficiency. More importantly, the results revealed that there is no significant difference in terms of efficiency level between supported and non-supported dairy farmers with the Direct Payments program and there does not appear to be a difference in observed characteristics between these two groups. Improvement in technical efficiency requires adequate subsidy schemes, therefore a revision of the Direct Payments program is necessary by the government. Output driven subsidies instead of coupled subsidies might help to improve the efficiency of supported farmers.

Furthermore, the findings from the study suggest that funds should be reallocated to improving genetics of the national herd by increasing the ratio of Simmental and Holstein stock on the dairy farms throughout Kosovo. The current stock tends to be dual purpose. Furthermore, promoting free-range production systems, expanding area planted to corn, and increasing and combining the levels of hay use with concentrates and other supplementary materials can be expected to improve the technical efficiency of dairy farms and to increase their productivity, and thereby increase their overall competitiveness. Considering that Kosovo plans to join EU in the future, the dairy sector needs to increase competitiveness.

The results from this study are particularly important for the policy makers in Kosovo and should provide insights for the future formulation of dairy policy, with a special focus on designing the farm investment programs funded by grants. The current agricultural policy involves a number of grant programs to support the upgrading of farm practices in Kosovo. Those programs focusing on farm investment could benefit from these findings by stressing the need for breed selection and production practices.

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