Investigation into Technical Efficiency of the Agriculture Sector in the Balkan Region

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Abstract

This study aims to investigate the efficiency of the use of basic production factors (land, labor, capital) in the agricultural sector for the Balkan region. The objective is to evaluate the technical efficiency of their use and to identify regional differences and possibilities to increase agricultural production. The study uses FAO data for 8 Balkan countries (excluding Serbia, Kosovo, and Montenegro because of their data absence). For the evaluation of technical efficiency, we use the average rank method calculated as a mean of productivities of the basic factors of production, as well as econometric modeling (panel data models with fixed effects and random effects, as well as the Stochastic Frontier Approach). The study uncovers that the technical efficiency of land, labor, and capital in the region is relatively low (60%) with huge opportunities for improvement (40%) which translates into great opportunities to increase production. Albania is positioned around the average level (62%) with significant opportunities for efficiency improvement. Improving technical efficiency is of particular importance for increasing the competitiveness of Albanian farms. Effectiveness of the use of agricultural inputs (chemical fertilizers, pesticides, water, etc.), access of farmers to short-term credit, good use of agricultural land, advanced agricultural technologies and innovation, and effective policies to reducing the labor force in agriculture through sector restructuring are determinants of the efficiency of the Albanian agricultural sector.

Key Words: Balkan, gross fixed capital formation, technical efficiency, rank, econometric model, SFA model, arable land, agricultural value added

JEL Code: B23, C01, C02, Q12

1. Introduction

The Balkans, or the Balkan Peninsula, is a geographical area in Southeast Europe. The Balkans includes countries: Albania, Bulgaria, Bosnia and Herzegovina, Croatia, Greece, Kosovo, North Macedonia, Montenegro, Romania, Serbia, Slovenia, and part of Turkey (European Turkey).

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According to the FAO statistics this region has a population of over 60 million people, about 38% of which living in rural areas. According to the FAO, the agricultural sector in the Balkan region employs about 4 million people, with almost half (1.9 million) in Romania and the smallest sector (about 19 thousand) is that of Montenegro. In the Balkan region, about 12.6% of employed workers in the region's agricultural sector, where Slovenia has the lowest number of employed (about 5.4% of its employed) and Albania the maximum with about 43% of its total employed (FAO, 2018).

The focus of this research is the technical efficiency of the agricultural sector in the Balkan region in general and in its specific countries.

To our knowledge, there are no estimates of the level of technical efficiency in the agricultural sector, neither for Albania nor for the Balkans as a whole or specific countries of this region, much less for the last 10. Meanwhile, there are partial estimates for specific products or aspects of agricultural production. Special mention is made of technical efficiency assessments conducted by the World Bank (WB, 2007), as well as by the author of this study and others on vegetable production in Albania (Osmani et al, 2017) and apple production in Korça region (Osmani and Kambo, 2019). Thus, this study is justified by the need to learn the level of technical efficiency in the region and the differences between countries, mainly in terms of using the basic productive factors, such as agricultural land, physical capital investments, and labor. The study aims to provide an aggregate assessment as well as differences in technical efficiency between countries, seen in relation to the role that these factors play in agricultural production.

Evaluating technical efficiency is not an end in itself of this study. We believe that the countries of the region have much to learn from each other in terms of increasing the efficiency of the use of basic factors of production, but also of other agricultural inputs such as fertilizers, water, pesticides, methods, and technologies of plant cultivation, as well as animal breeding.

Aspects of learning can be the methods of using factors of production and agricultural inputs, models of sustainable agricultural development, models of technical innovation, collective action, agricultural development policies, especially those aiming at promoting the effective restructuring of the economy and eliminating structural barriers in agriculture, improving the investment climate, promoting or creating conditions for free trade and competition, as well as institutional strengthening serving the development of the agricultural sector. In relation to these, this study can play a stimulating or reinforcing role for "mutual learning" initiatives and improvements in the framework of development policies.

Based on this presentation, the main objective of the research is to investigate the possibilities for improving the technical efficiency of the basic factors of agricultural production as one of the main aspects for increasing agricultural production in general in the region but also in its specific countries. Through it, we also aim to present a regional comparative picture regarding the situation but possibly also the evolving trends of technical efficiency.

In the context of the agricultural sector, as the literature shows, technical efficiency is an important factor, albeit non-decisive, in increasing the competitiveness of the farm and agricultural products (Matośková and Gálik, 2009). Studies also show that technical efficiency, in addition to transaction costs and the bargaining power of farmers has a strong impact on increasing the competitiveness of agricultural products, (Curtis, 2000).

Lastly, although allocative efficiency is not the focus of our study, we also introduce some general considerations regarding allocative efficiency, because the best combination of agricultural inputs in the production process is a great source for increasing allocative efficiency and hence the economic efficiency of the agricultural sector as a whole.

2. Conceptual framework and review of literature

The technical efficiency of a firm is the ratio between its mean production given its realized firm effect to the corresponding mean production if the firm effect (inefficiency) was zero (Battese and Coelli, 1988). Otherwise, technical efficiency is the ability of a firm (farm) to produce maximum output from a given set of inputs or to produce a given amount of output with minimum inputs (Khaan and Saed, 2011).

Definitions for the basic variables used in this study can be found in the OECD Glossary of Statistical terms. According to this dictionary, Gross Value Added in agriculture (GVA) is the value of output in agriculture less than the value of intermediate consumption (OECD Glossary of statistical terms, 2007).

Gross fixed capital formation (GFCF) is the measure of the total value of a producer's acquisitions, less disposals of fixed assets during the accounting period plus certain additions to the value of non-produced assets (such as subsoil assets or major improvements in the quantity, quality or productivity of land) realized by the productive activity of institutional units (OECD Glossary of statistical terms, 2007).

The employed force in agriculture comprises all persons above a specified age who during a specified brief period, either one week or one-day fall into the categories of paid employment or self-employed in the agricultural sector (OECD Glossary of statistical terms, 2007).

Another variable used in this study is also arable land. According to FAO, arable land is land under temporary crops (double-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens, and land temporarily fallow (less than five years), (FAO Nutrition indicators). The empirical literature on technical efficiency is abundant. One of its main threads is the measurement of technical efficiency for specific products or services (such as cereals in Greece, as done by Kourtesi et. Al, 2016; for olives in Greece, by Karagiannis, and Tzouvelekas, 2001), for specific branches or specific economic sectors (as for the agri-food sector as a study carried out by researchers Lachaal and Dhebibi, 2004), or estimation of technical efficiency at regional level (a study done for agricultural production by researchers Shanmugam and Venkataramani, 2006).

Although apparently rare, there is also research to assess technical efficiency at the sector level. We mention the study on technical efficiency for the cereal, crop, food, and non-food sectors with the population of several African countries (Nsiah and Fayissa, 2017). Other researchers (Zhang et al., 2017) have investigated the technical efficiency of the agricultural sector as a whole where the dependent variable is agricultural output represented by the value of agricultural products; as independent or input variables are used land, capital, livestock, labor, fertilizer, and chemicals.

Regarding Albania, according to an early study of the World Bank, the technical efficiency of the farm in Albania is very low, about 28% and seems to have a tendency to decrease with the reduction of the size of the farm (WB, 2007). Some researchers, such as Osmani and Kambo (2019) have studied the technical efficiency regarding apple production in the Korça region and have found that the average level of technical efficiency is about 88% with the possibility of 12% for further growth. Important factors of technical efficiency have been found, amonmg others, the farmers' access to consulting services, the average small size of the plots, and the number of plots planted. Another technical efficiency investigation for Albania is one study related to the production of vegetables in Albania (Osmani et al, 2017).

According to the type of data used, technical efficiency studies are focused on two lines: studies based on cross-sectional or individual data (farms, companies, businesses, sectors) and studies on panel data when they are based on data for several years and for different individuals, territories, sectors or countries. Some of the above-cited studies are based on cross-sectional data (WB, 2007; Osmani and Kambo, 2019; Shanmugam and Venkataramani, 2006; Kourtesi et al., 2016). Other studies are based on panel data (Osmani and Kambo (2019); Karagiannis, and Tzouvelekas, 2001; Satya and Sriram, 2018; Nsiah and Fayissa, 2017; Zhang et al., 2017).

Research questions

Based on the findings of the literature review, as well as on the research problem and the objective of the study as formulated it in the introductory chapter we formulate the following research questions:

a-What is the level of productivity and technical efficiency of the basic factors (labor, land, capital) of production in the agricultural sector in general in the Balkan region?

b-Are there significant differences between the Balkan countries in the level of productivity of the basic factors (labor, land, capital) of the agricultural sector?

c-Are there significant differences between the Balkan countries in the level of technical efficiency of the use of basic factors of agricultural production?

d-What are some of the factors of technical efficiency of the agricultural sector in the Balkan region?

3. Data and Method

Data

In the study, we use annual time series for the period 2008-2017 for the Balkan region. We have taken the data from the FAO database (FAO, 2020: http://www.fao.org/faostat/en/). We include in the study only 8 Balkan countries (Albania, B&H, Bulgaria, Croatia, Greece, Northern Macedonia, Romania, and Slovenia). We have excluded, unfortunately, some other Balkan countries due to the total lack of data (Kosovo) or partial absence (Serbia) or dubious data for some of the indicators (Montenegro). We have excluded as well the Balkan (European) part of Turkey since most of this country is not located in the Balkans. Table 1 below shows the variables that were used in the study.

Table 1: Variables

Nr	Variables	Acronym	Measurement Unit
1	Arable Land	ALAND	**(000) Hectares**
2	Agriculture Value Added	AVA	**Millions US $ 2010 Prices**
3	Agriculture Gross Fixed Capital Formation	GFCFA	**Millions US $ 2010 Prices**
4	Number of Employed in Agriculture	WORKER	**(000) Persons**
5	Gross Fixed Capital Formation per Unit of Arable Land	GFCFA/ALAND	**Millions US $ of GFCF per (000) Hectares of Arable Land**
6	Number of Employed in Agriculture per Unit of Arable Land	WORKER/ALAND	**Workers per 1 Hectare of Arable Land**
7	Agriculture Value Added per Unit of Arable Land	AVA/ALAND	**Millions US $ of AVA per (000) Hectare of Arable Land**

8	Agriculture Value Added per Unit of Employed in Agriculture	AVA/WORKER	**Millions US $ of AVA per (000) Workers**
9	Agriculture Value Added per Unit of Agriculture Gross Fixed Capital Formation	AVA/GFCFA	**AVA US $ per 1 $ US of GFCFA**
10	Amount of insecticides per unit of arable land	INSECT	**Tons per 1000 hectares**
11	Amount of pesticides per unit of arable land	PEST	**Tons per 1000 hectares**
12	**Amount of milk per Cow**	**MILK**	**Hg/An**

Source: Authors

Method

To evaluate the technical efficiency and to obtain more reliable results we use alternative methods. As dependent variables we have used productivity per hectare (value added in agriculture per hectare of arable land), while as independent factors or input variables we have GFCF (Gross Fixed Capital Formation) per hectare of arable land, and employed in agriculture (workers) per hectare of arable land. Below we show the different evaluation methods we used in the study.

The Average Rank method (AR)

According to the rank method we determine the rank of each country and for each of the independent variables that can approximately express the technical efficiency.

Generally, assuming **k** independent variables to determine the rank of each country from the point of view of efficiency, X_1, X_2 and X_3,…,X_n. The ranks for each country and variable would be RX_{1i}, RX_{2i}, RX_{3i},…, RX_{ni}. Calculate the sum of ranks (SUMR) across variables for each country. On this basis we calculate the average AVR rank:

$$\mathbf{AR = \frac{SUMR}{k}}$$

Based on the size of AR we can determine the rank or the approximate position of each country in terms of productivity/efficiency.

The main disadvantage of this method is that productivity is only approximately an expression of the level of technical efficiency. Another disadvantage of this method is related to the fact that for every two countries the distance between two neighboring ranks, e.g. distance between ranks 2 to 3, does not mean that the real distance between the real values of the indicator is the same as the real distance in the case of neighboring ranks, eg 3 and 4. However, the rank of a country also depends on the size of this indicator therefore this method could be functional, in at least approximate terms

The SFA (Stochastic Frontier Approach) Method

The SFA method or model was proposed independently by Aigner, Lovell and Schmid (Aigner, et al., 1977) as well as Meeusen, and van den Broeck (Meeusen and van Den Broeck, 1977).

We have two types of SFA models with panel data: i) models where inefficiency varies by individuals but do not vary over time (time-invariant inefficiency models). ii) models where inefficiency also varies according to time periods (time-varying inefficiency models).

To measure efficiency/inefficiency we use the Cobb-Douglass model with pre-logarithmic variables since the output function is thought to have a concave nonlinear shape. In the case of panel data with $\mathbf{T_i}$ time period for each individual and **n** individuals (countries) this model has the following form:

$$\mathbf{Y_{it} = B_0 + X_{jit}B + v_{it} - u_{it}}$$

Here Y is the dependent variable, the matrix X shows the factors or inputs considered (in logarithmic form) in the model, B is a vector with of **k+1** parameters where **k** is the number of factors.

Unlike the classical model, where the residues are considered only random effects, in the SFA model the residues are divided into two components: random effects (v_i) and inefficiency (u_i) components.

$\mathbf{e_i = v_i - u_i}$**,** (for the model with cross-sectional data)

$\mathbf{e_{it} = v_i - u_{it}}$ (for the model with panel data)

In the time-invariant efficiency model, we have $u_{it} = u_i$. The term u_i is the (non-negative) term of technical inefficiency and can be assumed to have semi-normal positive distributions with mean $\boldsymbol{\mu}$ and dispersion $\sigma_{\mathbf{u}}^{\mathbf{2}}$ .The term $\mathbf{v_{it}}$ indicates the effect of random factors and is assumed to have a normal distribution with mean 0 and dispersion $\sigma_{\mathbf{v}}^{\mathbf{2}}$. Both u_i and $\mathbf{v_{it}}$ are assumed to be independent of each other and of the regressors in the model.

In the time-varying inefficiency model we have:

$$\mathbf{u_{it} = \exp\langle \eta(t - T_i)\rangle u_i}$$

In this formula, $\mathbf{T_i}$ is the last period of the i-th panel when the data panels are unbalanced. If the panel data is balanced, then T_i=T is the same for each panel) while $\boldsymbol{\eta}$ is called the decay parameter and must be evaluated.

After evaluating the term of technical inefficiency, the technical efficiency (TE) itself for each individual of the panel (in time-invariant inefficiency and time-varying inefficiency models) as well as for each time period of the panel (for time-varying inefficiency models) is calculated.

$$\mathbf{TE_{it} = Exp(-u_{it}) = \frac{Y_{it}}{Exp(X_{it}B)}}$$

Here Y_{it} are the observed values of Y, Exp (X_{it}B) is the potential or expected values of the variable Y. The sign taken by the parameter η has a special meaning.

If η> 0, the inefficiency decreases over time, versus the baseline. If η <0 the inefficiency increases with the passage of time, the inefficiency increases against the base level, and if η = 1 we simply have the time-invariant efficiency model. The baseline is the inefficiency for the i-th individual for the last period of time.

Other important parameters of the SFA model are:

$$\boldsymbol{\sigma_s^2 = \sigma_v^2 + \sigma_u^2 \quad \lambda^2 = \frac{\sigma_u^2}{\sigma_v^2} \quad \gamma = \frac{\sigma_u^2}{\sigma_s^2}}$$

Here $\boldsymbol{\sigma_s^2}$ is the sum of the dispersions of the two components of the error term of the model. λ is the ratio of the dispersion of the term inefficiency to that of the random term, γ is the part (γ <= 1) that occupies the dispersion of the inefficiency component in $\boldsymbol{\sigma_s^2}$.

An important step in technical efficiency analysis is testing the hypothesis on the existence of inefficiency / technical efficiency. This can be done in two ways:

First way: Using the One-Side LR test:

$$\mathbf{H_0 : \sigma_u^2 = 0 \ \text{against} \ H_1 : \sigma_u^2 > 0}$$

If H_0 is not accepted, then in the model we have technical inefficiency

Second way: Generalized LR Test:

$$\mathbf{H_0 : \gamma = 0 \ \text{against} \ H_1 : \gamma > 0}$$

The LR statistics is first calculated as follows:

$$\mathbf{LR = -2(Ln(LR_0) - Ln(LR_1))}$$

Here LR_0 is the value of LR when H_0 is true (there is no inefficiency term in the model) and LR_1 is the value of the LR test when H_1 is true (there is an inefficiency term in the model).

The Fixed Effecst (FE) model

The FE model is a distribution-free model (Kumbakhar and Lovell, 2000). It has the form:

$$\mathbf{Y_{it} = A_0 + X'_{it}A + v_{it} - u_i}\text{, ose}$$

$$\mathbf{Y_{it} = (A_0 - u_i) + X'_{it}A + v_{it}}\text{, ose}$$

$$\mathbf{Y_{it} = a_i + X'_{it}A + v_{it}}\text{, per i=1,2,3,…, n; t=1,2,3,…,T}$$

Here Y and X are variables (in logarithmic form), A_0 is the free parameter of the model, A is the vector of the regression coefficients, v_{it} is the random term that varies according to individuals and time periods, u_i is a term that varies according to individuals, and they are unobservable fixed effects for each individual that in this model indicate inefficiency. After the fixed effects are evaluated, with any of the known evaluation methods (Osmani, 2017), since they can be negative, we do the transformation:

$$\mathbf{u_i = max(a_i) - a_i \geq 0}$$

Then technical efficiency for each individual can then be calculated:

$$\mathbf{TE_i = EXP\ (-u_i)}$$

The advantage of this model is its simplicity and being distribution-free. A disadvantage is that these models cannot include time-invariant regressors, because between them would exist complete linearity and the model would be simply inestimable. In addition, this model captures not only the difference between individuals but also the effect of the environment (exogenous factors) which is constant for individuals but can vary between individuals. Another weakness of this model is the assumption that efficiency does not change over time. FE models can be evaluated with the OLS method.

The Random Effects (RE) model

In these models, unlike the FE models, the individual term is assumed not fixed, but random and unrelated to the model regressors. If there is no correlation between it and the regressors, its estimates are more efficient than the estimates of FE model. In addition, the time-invariant variable can be included in the model. RE models can be evaluated with the GLS method (Generalized Least Squares) or with the ML method (Maximum Likelihood).

The estimation using GLS method

In this case the RE model could be written:

$$\mathbf{Y_{it} = A_0 + X'_{it}A + v_{it} - u_i}\text{, ose}$$

$$\mathbf{Y_{it} = (A_0 - \mu) + X'_{it}A + v_{it} - u_i^*}\text{, ose}$$

$$\text{Ku, } \mathbf{\mu = E(u_i)} \text{ (i=1,2,3,…,N; t=1,2,3,…,T)}$$

If we make:

$$\mathbf{u_i^* = u_i - \mu \quad a^* = A_0 - \mu}$$

Then we would have:

$$\mathbf{Y_{it} = a^* + X'_{it}A + v_{it} - u_i^*},$$

Using GLS method we estimate **a*** and **Â.** Then we calculate:

$$\mathbf{\varepsilon_{it} = Y_{it} - X'_{it}A}$$

$$\mathbf{a_i = \frac{1}{T}\sum_i (\varepsilon_{it} - a^*)}$$

At the end the efficiency term is calculated:

$$\mathbf{u_i = \max(a_i) - a_i \geq 0}$$

Then time-invariant technical efficiency for each individual is calculated:

$$\mathbf{TE_i = \exp(-u_i)}$$

If the distribution **u** term is assumed to be semi-normal, we make $\mu = 0$. The parameter μ can also be thought of as a function of some exogenous variables, so we can also estimate another model to identify the factors of inefficiency.

The estimation using ML method

In this case, the RE model could be written:

$$\mathbf{Y_{it} = f(X_{it}, A) + v_{it} - u_i}$$

$$\mathbf{v_{it} \sim N(0, \sigma_v^2)}, \ \mathbf{u_i \sim N^+(0, \sigma_u^2)}$$

ML gives more efficient estimates but makes more rigorous assumptions about the normality of the model error term.

For more detailed information on how to evaluate technical efficiency see (Kumbhakar and Lovell, 2000; Kumbhakar et al., 2015; Prasada Rao, 2012; Osmani, 2017; Wooldridge, 2001; Henderson, 2003, Satya and Sriram, 2018; Rashidghalam et al., 2016; Belotti et al., 2013).

Data processing and evaluation of efficiency models are performed using STATA, GRETL, and Excel software.

4. Results

At the beginning we evaluate the position regarding the technical efficiency for each country included in the analysis based on the average rank calculated on three basic indicators: value added per hectare of arable land (AVA / ALAND), value added for each employee in agriculture (AVA / WORKER) and for each unit of gross capital formation in agriculture (AVA / GFCFA).

Table 2 below shows the values of the three basic variables in question, the ranking of countries by each variable, and the average rank for each country.

Table 2: Rank-based technical efficiency by country

Country	AVA/ALAND		AVA/WORKER		AVA/GFCFA		Average Position	Rank
	Value	**Position**	**Value**	**Position**	**Value**	**Position**		
Albania	3.42	7	4.75	2	6	5	4.7	**3**
Bosnia & Herzegovina	1.01	3	7.31	4	6.31	7	4.7	**4**
Bulgaria	0.67	1	10.14	5	3.35	2	2.7	**1**
Croatia	2.07	4	11.38	6	5.18	4	4.7	**5**
Greece	2.96	6	18.19	8	3.48	3	5.7	**8**
North Macedonia	2.37	5	7.29	3	8.78	8	5.3	**6**
Romania	0.87	2	4.2	1	6.21	6	3	**2**
Slovenia	4.56	8	12.69	7	2.51	1	5.3	**7**
Average	**2.2**	**4.5**	**9.5**	**4.5**	**5.2**	**4.5**	**4.5**	**4.5**

Source: calculations by the authors and FAO data

Note 1: Higher position or rank means better position or rank.

Note 2: Croatia, Albania, Bosnja&Herzegovina have resulted in the same average rank.

The differencing in ranking is done on the basis of AVA / Worker. Differenting was also done for North Macedonia and Slovenia.

Note 3: Equal difference between ranks does not mean equal difference between corresponding indicator values.

We argue that the distances in productivity, albeit efficiency ranks do not accurately reflect the distances between indicators in values.

Based on the rank regarding the productivity of each country, technical efficiency looks better for B&H, Greece, and Slovenia; it seems to be lower for Bulgaria and Romania, while Albania and Croatia are at an intermediate level.

Further, we perform technical efficiency assessments with the other methods presented above: the fixed-effects model method, the random-effects model (estimation with two methods, GLS and ML), time-invariant inefficiency, and time-varying inefficiency models. The factors taken into account are GFCF per hectare of arable land and the number of employed per hectare of arable land. The dependent variable is the added agricultural value per hectare of arable land.

The model to be estimated is as follows:

$$\mathbf{Ln(AVA/ALAND_{it}) = Cons + a_1 Ln(GFCFA/ALAND_{it}) + a_2\ Ln(WORKER/ALAND_{it}) + (v_{it} - u_i)}$$

for i=1,2,3,…, n=8 and for t=1,2,3,…,T=10

Table 3 shows the results of the technical efficiency as obtained with these analytical methods. For ease of comparison in the table are presented also ranks for each country.

Table 3: TE (technical efficiency) according to alternative models

Country	FIX_TE	RGLS_TE	RLM_TE	TINVAR_TE	TVAR_TE	Average TE	RANK_TE
Albania	0.63	0.551	0.55	0.647	0.744	**0.62**	**3**
Bosnia & Herzegovina	0.399	0.554	0.426	0.442	0.429	**0.45**	**4**
Bulgaria	0.323	0.468	0.36	0.363	0.285	**0.36**	**1**
Croatia	0.653	0.692	0.634	0.67	0.676	**0.67**	**5**
Greece	0.991	0.858	0.898	0.954	0.963	**0.93**	**8**
North Macedonia	0.537	0.583	0.519	0.656	0.586	**0.58**	**6**
Romania	0.311	0.43	0.328	0.343	0.391	**0.36**	**2**
Slovenia	1	0.656	0.808	0.898	0.893	**0.85**	**7**
Average	*0.605*	*0.599*	*0.566*	*0.622*	*0.621*	*0.60*	-

Source: Calculations by the authors based on FAO data.

Note: FIX-TE=Eficenca teknike sipas modelit FE; RGLS-TE=Eficenca teknike sipas modelit RE te vleresuar me metoden GLS; RLM-TE=Eficenca teknike sipas modelit RE te vleresuar me metoden LM; TINVAR-TE=Eficenca teknike me metoden SFA duke supozuar eficence time-invariant; TVAR-TE=Eficenca teknike me metoden SFA duke supozuar eficence time-variant; RANK_TE=Eficenca teknike me metoden e rangut.

Table 3 shows that at the regional level the technical efficiency of the agricultural sector is estimated at about 60%, with the possibility for further improvement of 40%. This result shows that in terms of technical efficiency in the region there is huge potential for further improvement of the use of basic factors of production land, labor, and capital investment. In terms of technical efficiency of the basic factors of agricultural production, Albania is above the regional average (62% with a possibility of further improvement of 38%) and comes after countries such as Greece, Slovenia, and Croatia, leaving behind countries such as Bulgaria, Northern Macedonia, and Romania. The table and calculations also show that there is some amazing correlation between the results obtained with the rank method and the results obtained with the other methods (Spearman correlation coefficient, calculations are not shown here, is 0.83).

Table 4 shows the main descriptive statistics for all technical efficiency indicators.

Table 4: Main summary Statistics

Variable	Mean	Median	Minimum	Maximum	Std. Dev.
FIX_TE	0.605	0.553	0.311	1.000	**0.257**
RGLS_TE	0.599	0.579	0.339	1.000	**0.143**
RLM_TE	0.566	0.531	0.253	1.000	**0.201**
TINVAR_TE	0.622	0.651	0.343	0.954	**0.215**
TVAR_TE	0.621	0.639	0.230	0.969	**0.236**
Variable	**C.V.**	**Skewness**	**5% Perc.**	**95% Perc.**	IQ range
FIX_TE	0.424	0.464	0.311	1.000	**0.564**
RGLS_TE	0.238	0.812	0.401	0.941	**0.145**
RLM_TE	0.355	0.587	0.319	0.985	**0.322**
TINVAR_TE	0.347	0.170	0.343	0.954	**0.457**
TVAR_TE	**0.380**	**0.026**	**0.264**	**0.965**	**0.479**

Source: Calculations by the authors based on FAO data.

Table 4 shows, among others, that Albania is in the best half of the region in terms of technical efficiency, according to all estimation methods, except for time-invariant and time-variant efficiency models.

To show how approximate the technical efficiency assessments obtained with different approaches are we calculate the correlation coefficients for each pair of technical efficiency indicators (See Table 5).

Table 5: Correlation coefficients (5% critical value, two-tailed) = 0.2199 for n = 80)

FIX_TE	RGLS_TE	RLM_TE	TVAR_TE	TINVAR_TE	
1.000	0.767	0.949	0.981	0.965	FIX_TE
	1.000	0.914	0.796	0.764	RGLS_TE
		1.000	0.944	0.920	RLM_TE
			1.000	0.969	TVAR_TE
				1.000	TINVAR_TE

Source: Calculations by the authors based on FAO data.

The results shown in Table 5 indicate that the correlation for each pair of efficiency indicators is quite high, generally over 0.9, (except for the correlation coefficient between RGLS_TE and TINVAR_TE; between RGLS_TE and TVAR_TE; between FIX_TE and RGLS_TE that are somewhat lower but high anyway). This shows, first, that each of the measurement methods can be used quite correctly to evaluate technical efficiency. Secondly, the high degree of correlation between these results also shows that the estimates obtained for technical efficiency could be considered quite consistent, and therefore quite reliable. The arithmetic mean of the efficiency estimates obtained according to the different methods could serve as an aggregate estimate of the technical efficiency.

The model for the factors of technical efficiency

Further, we try to investigate possible factors of technical efficiency. Technical efficiency assessments according to three of the methods (FE fixed effects model, SFA time-variant model, and SFA time-invariant efficiency model) are very approximate, which is indicated by the pair correlation coefficients. Therefore, to construct the factorial model of technical efficiency we have chosen as a dependent variable one of them, TINVAR_TE.

For efficiency factors we consider the quantity of pesticides (PEST) and insecticides (INSECT) per unit of arable land. We argue that these factors can affect soil productivity, and therefore technical efficiency. In our case, we suppose these variables can be considered as proxies (instrumental variables) for all individual factors of labor, land, and capital efficiency in agriculture. We assume also the milk yield in cows (MILK) is another proxy factor of efficiency, representing all individual efficiency factors in the livestock sub-sector. These considerations are due to the lack of sufficient analytical data for individual variables, for each country or every year. We believe that these variables can represent approximately all the other missing variables with a direct effect on the level of technical efficiency. Thus, the amount of pesticides/insecticides and milk productivity reflect the degree of intensification of agriculture in a given country, social and human capital, farmers' access to advisory services, availability of irrigation water, cultivation methods and technologies, animal nutrition, and breeding in general, etc.

Below (Table 6) we present the estimation results of the SFATime-invariant inefficiency model (TINVAR_TE SFA model), which helps us to obtain an average 10-year assessment (2008-2017) of technical efficiency. The factors taken into account are again the capital stock and the number of employed (per unit of arable land). The dependent variable is the added agricultural value per unit of arable land.

The model to be estimated has the following form:

$$\mathbf{Ln(AVA/ALAND_i) = Cons + a_1 Ln(GFCFA/ALAND_i) + a_2\, Ln(WORKER/ALAND_i) + (v_i - u_i)}$$

per i=1,2,3,…, 8

The estimated model is shown in Table 6.

Table 6: Time invariant inefficiency model (Variabli i varur: Ln(AVA/ALAND)

	Coef.	Std. Err.	z	P>z
Ln(GFCFA/ALAND)	0.215891	0.077308	2.79	**0.005**
L(WORKER/ALAND)	0.155271	0.080870	1.92	**0.055**
Cons	1.636511	0.123728	13.23	**0.000**
Mu	-0.72124	3.632019	-0.2	**0.843**
Lnsigma2	-0.2026	2.278942	-0.09	**0.929**
Ilgtgamma	4.276178	2.31728	1.85	**0.065**
sigma2	0.816609	1.861004		
Gamma	0.986295	0.031324		
sigma_u2	0.805417	1.861004		
sigma_v2	**0.011192**	**0.001948**		

Log-Lik=44.363, Wald $\chi^2(2)$ =18.08, P($\chi^2(2)$>18.08) =0.0001

The *Ilgtgamma* parameter that shows the effect of efficiency on the level of production is significant (P = 0.065), which means that efficiency has a significant role in increasing agricultural production. Using this model, we calculate the technical efficiency. Data on efficiency and basic variables used in the model, according to the above explanations, are shown in Figure 7.

Table 7: Variabls of the technical efficiency model (Averages for the period 2008-2017)

	PEST	INSECT	MILK	TINVAR_TE
Albania	0.832	0.353	26730.4	**0.647**
Bosnia &Herzegovina			27310.2	**0.442**
Bulgaria	0.561	0.082	36124.7	**0.363**
Croatia	2.207	0.123	42332.8	**0.67**
Greece	3.222	1.209	43867.3	**0.954**
North Macedonia	0.233	0.046	29494.9	**0.656**
Romania	0.769	0.103	32516.1	**0.343**
Slovenia	**5.923**	**0.241**	**56820.2**	**0.898**

To estimate the model of technical efficiency factors and to eliminate possible problems from the presence of autocorrelation and heteroskedasticity in the error term we use heteroskedasticity-corrected OLS. The evaluation results are given in Table 8 and Table 9. We have estimated the effect of milk productivity level on technical efficiency with a specific model because between productivity on one hand and the use of pesticides and insecticides on the other one exists high collinearity.

Table 8: TE dependent on the quantity of pesticides and insecticides

	Coefficient	***Std. Error***	***t-ratio***	***p-value***	
Const	0.473885	0.0600818	7.887	0.0014	***
INSECT	0.231502	0.0270734	8.551	0.0010	***
PEST	**0.0621874**	**0.00913092**	**6.811**	**0.0024**	***

Sum squared resid	**4.806055**	**S.E. of regression**	**1.096136**
R-squared	**0.953752**	Adjusted R-squared	0.930627
F(2, 4)	41.24480	P-value(F)	0.002139
Log-likelihood	−8.616452	Akaike criterion	23.23290
Schwarz criterion	**23.07064**	**Hannan-Quinn**	**21.22728**

Table 9: TE dependent on the cow milk productivity

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.194069	0.159336	1.218	0.2689	
MILK	**1.23965e-05**	**2.84492e-06**	**4.357**	**0.0048**	***

Sum squared resid	**13.38969**	**S.E. of regression**	**1.493859**
R-squared	0.759876	Adjusted R-squared	**0.719855**
F(1, 6)	18.98704	P-value(F)	**0.004784**
Log-likelihood	−13.41168	Akaike criterion	**30.82337**
Schwarz criterion	**30.98225**	**Hannan-Quinn**	**29.75176**

The modeling results show that in general the countries that use more inputs; here pesticides and insecticides per hectare, as well as those having the highest productivity in cow's milk have the highest technical efficiency.

5. Discussion

In reply to research question a) and question b) the study found that in terms of land productivity the Balkan region is characterized by relatively low (average) productivity levels of basic factors of production. Regional variance is also considerable (from 1.01 to 4.5 6). Albania is above the regional average (3.42 out of 2.2) and only Slovenia and Greece are better than it.

In terms of labor productivity, Albania is at very low levels (4.75) and regional variance is high in this regard (from 4.2 to 18.19). It ranks penultimate in the region.

Albania is above the regional average in terms of capital investment productivity (GFCF).

It seems that the combination of the levels of these three indicators determines its place (rank) in relation to the productivity of the basic factors of production as a whole; In this view, Albania is ranked below the average and is positioned at the bottom of the regional rank (third from the bottom).

In reply to the research question c), the results of the study in terms of technical efficiency indicate that at the regional level the technical efficiency of land, labor, and capital use is also relatively low (about 60%), with significant regional differences (from 95% to 36%). Albania is close to the region's average level (62%) but several countries are characterized by quite low levels. These results show that the opportunities to increase the efficiency of the use of these basic factors in the region are still formidable (about 40%). Albania also has room for significant improvements (about 38%), which is expected to translate into a significant increase in agricultural production.

In reply to the research question d), the study shows that important factors for increasing the technical efficiency of land, labor, and capital use in agriculture are pesticides/insecticides and milk yield in cows. As an illustration, Slovenia and Greece use respectively 5,923 and 3.22 tons of pesticides per 1000 hectares, while Albania uses only 0.832 and Northern Macedonia only 0.233, not to mention the difference in the quality of pesticides used in Albania from those used in the other countries mentioned above. The same can be said for fertilizers. At a time when Slovenia and Croatia use about 205 and 202 kg of chemical fertilizers, Albania uses only 84 kg. It is worth studying the experience of Greece which uses only 77 kg/ha.

In fact, these factors are not determinants of efficiency in the true sense of the word; true efficiency determinants are a complex of factors that determine both the increase and improvement in the use of these agricultural inputs. Such factors may be specific incentives and policies for the use of agricultural inputs, education and technical assistance to farmers for the use of new technologies, rational use of agricultural inputs and the development of innovation skills, farmers' access to water and credit, methods of breeding, nutrition and breeds in livestock, etc. Due to the lack of data in the database, it was not possible to measure the direct effect of these factors on efficiency.

Increasing technical efficiency depends not only on the better use of basic factors (labor, land, capital) that would come through the above improvements but also on improving the ratios between these elements. Perhaps increasing or regulating the amount of physical capital in relation to agricultural land or labor could lead to an increase in the efficiency of these elements, ie more production only as a result of the regulation of these ratios. To illustrate, Slovenia has 4.78 units of capital per unit of labor at a time when Albania has only 0.72. Greece has 0.85 units of capital per unit of land while Albania has only 0.57 units.

In this context, the improvement (reduction) of the ratio of labor with agricultural land could also be of huge importance. Albania has this ratio equal to 0.781, at a time when for Slovenia it is 0.385 (about twice as small), for Greece is 0.205 (about 4 times smaller), it is smaller even Northern Macedonia (0.294).

6. Limitations

The non-inclusion of Kosovo, Serbia, and Montenegro in the study, due to the problems with data for these countries, limits to some extent the Balkan focus of the study. The reliability of the data, in how realistically they describe the situation in the respective countries, also has a lot to do with the reliability of the study results. In addition, in the absence of capital stock data, we have used Gross Fixed Capital Formation as a proxy variable for capital stock.

7. Conclusions

This study focuses on the technical efficiency of the agricultural sector in the Balkan region, in terms of the use of basic factors of agricultural production: land, labor, and capital. Evaluation of technical efficiency for the region and its specific countries is the main objective of the study. The study aims, at the same time, to assess the main proxy factors that affect the level of technical efficiency. Econometric modeling, such as panel models with fixed and random effects as well as parametric models of technical efficiency (Stochastic Frontier Approach, or SFA model), are the main methods of evaluating technical efficiency. Data are taken from the FAO database.

The study concludes that the technical efficiency of the use of fundamental factors of agricultural production is relatively low (about 60%), with the possibility of improvement of about 40%.

The variance of technical efficiency in the region is also high (59% between the countries with the highest and the lowest efficiency). This means that the opportunities for increasing agricultural production in the region are great.

The study reveals that Albania also in particular has large reserves in terms of increasing the efficiency of basic factors of production (about 38% more). Albania has the largest reserves for increasing productivity and efficiency in the use of labor force in particular; compared to other countries it is overloaded with labor, which affects the low level of labor productivity.

Policy implications

As the literature shows, technical efficiency, although not decisive, has a significant impact on the competitiveness of farms (agricultural products).

The strong effect of the use of pesticides and insecticides on technical efficiency shows that increasing the quantity and quality of agricultural inputs (fertilizers, pesticides, insecticides) seems imperative, because, as the data show, Albania is behind leading countries in the region (Slovenia, Greece) in this regard. This includes tightening controls and stricter rules on the quality of agricultural inputs used on farms. This means that all factors impacting their use should be better in the focus of agricultural policy.

Some policy measures that could have an effect in these directions could be subsidies to reduce the purchase prices of agricultural inputs, measures to further improve irrigation systems and use/manage them more efficiently, enable and improve access to short-term credit for the purchase of agricultural inputs, strengthening advisory services for better farm management but also for technological innovations, the use of modern methods in production/breeding, but also the better use of agricultural inputs and improving commercial and technical information for farmers.

Increasing and better use of agricultural land for production could be an important direction in increasing its efficiency. Agricultural land is a rare asset of Albania and measures for its misuse or non-use must be both severe in terms of punishment and effective in terms of promoting effective use.

Based on the significant impact that milk yield has on efficiency, improving the quality of breeds, as well as better livestock breeding, could have a significant effect on increasing the technical efficiency of agricultural production as a whole.

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