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Technical efficiency of agriculture in Western Balkan countries undergoing the process of EU integration

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Abstract: The main goal of this paper is to compare the relative technical efficiency of agriculture in Western Balkan countries to those of the European Union and to propose ways to improve the position of Western Balkan countries. The group of Western Balkan countries includes Serbia, Montenegro, North Macedonia, and Albania, which are candidate countries for European Union membership, as well as Bosnia and Herzegovina, which is currently a potential candidate. An input-oriented Data Envelopment Analysis model with the variable return to scale was applied to an 11-year period from 2006 to 2016. Input variables used in the model included labour, land, and capital, and the output was presented as the value of agricultural production. The highest average technical efficiency was achieved by the EU15 countries for the entire eleven-year period, while the Western Balkan countries had the lowest score. The source of this inefficiency was identified in lower levels of agricultural performance, e.g. a lower-level use of the primary production factors – labour and land.

Keywords: agriculture; Data Envelopment Analysis; European Union; Western Balkan

The Western Balkan agricultural sector has undergone constant change in the last few decades, primarily due to its transition from a centrally-planned economy to a market-oriented one. The Western Balkan region is not only a geographically connected but also a politically connected group of countries being considered for European Union (EU) integration. The group of Western Balkan countries includes Serbia, Montenegro, North Macedonia, and Albania, which are candidate countries for membership in the EU, and Bosnia and Herzegovina (B&H) which is currently a potential candidate. This process of structural change in these countries has had a significant influence on production performance in agriculture as well as implications for changes in efficiency and productivity. Structural changes in the countries of Central and Eastern Europe, which can serve as a useful benchmark for Western Balkan countries, caused significant changes in price, production, and trade of agri-food products during the region's pre-accession period and following EU accession. Furthermore, the liberalization process created greater opportunities and rewards in a more competitive mar-

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ket environment (Bojnec et al. 2012). Previous analyses of the efficiency of agriculture in Central and Eastern Europe showed that agricultural production in these countries is less efficient in comparison to the original member states, also known as the EU15 (Nowak et al. 2015). Previous research has also indicated a decrease over time in the efficiency of agriculture in EU countries (Kocisova 2015).

Also, a significant gap still exists between the newer member states and the EU15, especially in terms of labour productivity (Matkovski et al. 2016). This can be partially explained by the different specialisation patterns in these two regions. Central and Eastern European countries are more focused on cereal and raw-material based production, while in the EU15, animal- and processed product-based production results in higher value added per worker (Csaki and Jambor 2019).

An analysis of the competitiveness in the Western Balkan countries during the period of EU integration reveals a significant increase in the foreign trade of agricultural and food products, primarily as a result of market liberalization (Matkovski et al. 2018), but their level of agricultural productivity is significantly lower than in the EU countries. Productivity improvements require a longer period to implement structural changes and adjustments to agricultural policy (Erjavec et al. 2014). Studies analysing the efficiency of the agricultural sector in Western Balkan countries a part of EU integration are rare. Therefore, in this study, we investigated technical efficiency in agriculture, which is determined by the relationship between used inputs and produced output. We used the Data Envelopment Analysis (DEA) because it is one of the most commonly used tools for assessing efficiency. The advantage of the DEA is its ability to handle multiple inputs and outputs (Kocisova 2015). Thus, our main objective was to determine the efficiency of agriculture in the Western Balkan countries during the process of EU integration. This paper should answer two main research questions. First, is the agricultural sector in the Western Balkan performing efficiently? Second, how are these countries positioned according to the efficiency of agriculture in comparison to the EU countries? We will also explore the main sources of inefficiency in agriculture and suggest means for improving efficiency in this important sector.

LITERATURE REVIEW

In previous decades, productivity and efficiency become significant factors influencing economic development at both micro and macro levels. As a result, various quantitative methods are used to properly measure efficiency. These methods can mainly be divided into two fundamentally different groups: parametric and non-parametric. The parametric approach is primarily based on advanced regression analysis, while non-parametric methods use mathematical programming to measure and compare efficiency. The DEA has become a very popular non-parametric method for efficiency analysis, and it can be successfully applied in a range of different fields, from measuring economic growth on a macro level (Skare and Rabar 2015) to applications in finance, education, health care, tourism, and, most importantly, to agriculture. Table 1 presents a literature review of papers in which the DEA was applied to agriculture, which motivated the research presented here. The selection of references in the literature review was predominantly determined according to similarities to our research in terms of the methodology used and the regions analysed. Of particular interest is Blazejczyk-Majka and Kala (2015), who combined the parametric and non-parametric approach in order to reduce discrepancies among the results obtained. This combined method was used to calculate the technical efficiency of agricultural production in the USA and selected regions in the EU.

A detailed search of the literature revealed a lack of research focused on the technical efficiency of agriculture in the Western Balkan countries, and no comparative analysis of these countries to the EU countries was found. To the best of our knowledge, no studies have been conducted in this field. Therefore, this paper should contribute to filling this gap in the literature.

METHODOLOGY

The main purpose of this study is two-fold: to investigate the relative technical efficiency of agriculture in the Western Balkan countries using the DEA, and to provide a comparative analysis with the EU countries. Efficiency as a relationship between achieved outputs and used inputs was introduced by Farrell (1957), who defines the term technical efficiency as the ability to obtain a maximal output with a given set of inputs. Two decades later, Charnes et al. (1978) developed the DEA method, which is now a commonly used mathematical technique for measuring efficiency in various fields.

Charnes et al. (1978) introduced the basic DEA CCR model with constant return to scale, named by us-

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Table 1. Literature review of papers on technical efficiency of agriculture using the DEA method

Author (year)	Period of analysis	Country /region	Variables	Results
Bojnec and Latruffe (2008)	1994–2003	Slovenia	inputs: land, labour, capital, intermediate consumption outputs: crop revenue, livestock revenue, other revenue	The results in this paper showed that Slovenian farms are relatively highly efficient. Also, results showed that five farm branches (crop, dairy, livestock using feed from the same farm, fruit and forestry) are fully efficient, so these specialisations have the best chance of competing on the European and world market.
Bojnec et al. (2012)	2001–2006	10 new EU member states	inputs: labour, tractors, land, fertilizers, livestock units outputs: gross value added in agriculture	The DEA technical efficiency scores in agriculture vary among the countries analysed. This is explained through a combination of institutional and policy reform factors, technology and relative natural agricultural factor endowments, farm structures, and scale economies that have evolved or emerged from the transition process, as well as farm specialization, foreign direct investments, nominal rate of assistance, time trend and an urban-rural income gap.
Akande (2012)	1999–2009	EU15	inputs: labour, agricultural area, buildings, machinery, cost of materials, livestock unit outputs: crop output, animal output	The results in this paper, through a breakdown of the EU15 into four regional groups, showed that the Western European Region was more efficient with the highest average technical efficiency of 95. The Central European Region shared the same technical efficiency level of 85 with the Southern European Region, while the Northern European region was the least technically efficient (84).
Bojnec and Latruffe (2013)	2004–2006	Slovenia	inputs: land, labour, total assets value, intermediate consumption outputs: crop output, livestock output	The results in this paper showed that small farms are less technically efficient but more allocatively efficient and more profitable.
Spicka (2014)	2011	101 EU regions	inputs: utilized agricultural area, labour input, economics size, livestock units, stocking intensity outputs: crop output, livestock output	The results showed that crop output per ha and livestock output per livestock unit are key output determinants of production efficiency. Also, input results showed that efficient regions had higher land productivity, labour productivity, energy productivity, capital productivity and productivity of contract work than inefficient regions.
Kocisova (2015)	2007–2011	EU	inputs: labour, land, capital outputs: crop output, animal output	The results in this paper showed the efficiency of the EU agricultural sector had decreased over time and the main source of inefficiency was input labelled "total utilised agricultural area.
Nowak et al. (2015)	2010	EU	inputs: labour, capital, land outputs: agricultural production values	This paper indicates that the difference between the states with the highest and the lowest efficiencies is 40. The results in this paper showed that the most efficient agriculture in the analysed period was identified for the EU15.
Le et al. (2019)	2002–2010	9 East Asian countries	inputs: labour, capital stock, agricultural land, fertilizer application outputs: desirable output (total value of agricultural production), undesirable output (agricultural emissions)	The results of efficiency evaluations showed considerable difference in efficiency scores among the nine studied countries and a decline in total factor productivity due to decreases in technical efficiency.

Source: Authors

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ing the first letters of the authors' names. The assumption of constant return to scale can be accepted only if the Decision Making Units (DMUs) operate under the condition of their optimal size (Kocisova 2015). Since this is not the case in our study, we used the BCC model (Banker et al. 1984) instead, which allows the variable return to scale. In our study, we applied the input-oriented BCC model to calculate and compare the relative technical efficiency of agriculture in the Western Balkan countries with that of the EU. The input-oriented DEA model attempts to determine the maximum possible proportional reduction in usage of inputs while keeping the levels of achieved outputs constant. The DEA is carried out by solving the following model (Banker et al. 1984) of linear programming for each DMU (country) separately for each year:

$$\begin{aligned} &\min \theta - \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right) \\ &\text{s.t.} \ \sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta x_{io} \quad i = 1, 2, \ldots, m; \\ &\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = y_{ro} \quad r = 1, 2, \ldots, s; \\ &\sum_{j=1}^{n} \lambda_j = 1 \\ &\lambda_j, s_i^-, s_r^+ \geq 0 \quad \forall \ i, j, r \end{aligned} \tag{1}$$

where: n – number of DMUs; DMU_o – country being evaluated.

Table 2. Descriptive statistics

		Labour (number of people)	Land (thousands ha)	Capital (millions USD)	Value of agricultural production (1 000 International Dollars I$)
Western Balkan					
2016	Max	590 423.25	3 440.00	396 626 534.00	3 662 358 587 322.00
	Min	18 936.14	255.00	12 762 472.00	96 008 382 476.00
	Std. dev.	245 595.99	1 207.07	162 624 218.10	1 348 362 443 611.34
	Average	316 078.60	1 670.14	139 818 376.20	1 405 312 912 351.00
2006	Max	676 601.82	3 537.00	259 791 965.00	3 718 996 156 211.00
	Min	20 867.06	515.00	12 527 092.00	151 798 685 849.00
	Std. dev.	290 335.57	1 178.12	114 100 800.01	1 400 941 809 745.17
	Average	381 317.01	1 711.00	103 907 144.80	1 274 393 375 918.60
EU15					
2016	Max	993 689.02	28 718.02	5 732 922 525.00	36 657 009 933 319.00
	Min	2 893.14	130.52	280 939 148.00	198 729 518 064.00
	Std. dev.	345 701.41	9 396.40	1 722 420 605.53	11 935 152 500 252.90
	Average	374 754.38	8 650.79	2 104 786 334.53	10 820 324 663 775.80
2006	Max	1 085 927.21	29 312.70	6 211 743 925.00	36 916 759 235 715.00
	Min	3 896.60	129.00	201 392 393.00	182 340 036 716.00
	Std. dev.	405 394.32	9 855.43	1 697 045 145.25	11 869 114 753 453.90
	Average	455 507.24	9 149.27	2 046 641 410.13	10 907 692 439 835.30
New member states					
2016	Max	2 065 258.32	14 374.00	4 215 563 729.00	19 309 020 072 226.00
	Min	2 870.75	10.38	13 826 896.00	64 265 969 856.00
	Std. dev.	723 102.44	4 881.44	1 166 140 121.45	5 588 095 428 303.58
	Average	386 323.34	4 183.51	797 880 817.33	3 888 476 004 717.17
2006	Max	2 979 468.96	15 957.00	3 626 949 962.00	16 481 825 642 518.00
	Min	3 316.86	9.20	56 217.00	80 009 615 181.00
	Std. dev.	1 033 007.94	5 300.28	990 627 345.43	4 758 344 078 664.05
	Average	540 669.82	4 449.12	680 978 262.58	3 425 403 002 852.00

Western Balkan – Serbia, Montenegro, North Macedonia, Albania and Bosnia and Herzegovina; New member states – Bulgaria, Cyprus, Czechia, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia

Source: Author's calculations

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Assume that we have s output variables and m input variables. Observed output and input values are y_r and x_i respectively, thus y_{ro} is the amount of output r used by DMU_o, while x_{io} is the amount of input i used by DMU_o. s_r^+ and s_i^- are the output and input slacks. λ is the DMU's weight and ε is a non-Archimedean element smaller than any positive real number. The efficiency score is θ.

As previously mentioned in the literature review, authors have used different variables for inputs and outputs to analyse technical efficiency in the agricultural sector. Most authors used labour, land, and capital as aggregate input variables, and they used agricultural production (crop and livestock production) as output variables. Our study assessed the change in technical efficiency in agriculture for five Western Balkan countries and the EU countries for the period 2006–2016. It is important to note that Croatia was omitted from the DEA model due to a lack of data on capital stock. Kosovo, which has a special UN status as a UN protectorate, was also excluded from our analysis due to a lack of data available in the FAOSTAT database, which is a particular problem for researchers and policymakers (Osmani et al. 2013). Therefore, three inputs were used in the DEA model:

– labour input was measured by the number of people working in agriculture, and data were retrieved from The World Bank database (The World Bank 2019);
– land input was measured by the number of hectares of agricultural land expressed in thousands of hectares, and data were retrieved from the FAOSTAT database (FAOSTAT 2019);
– capital input was measured by capital stock in agriculture as the value of gross fixed capital formation of agriculture, forestry, and fishing, expressed in millions of USD (current prices), and data were retrieved from the FAOSTAT database (FAOSTAT 2019). Capital stock includes a country's physical investment in its agriculture (Le et al. 2019).

The output of agricultural production was selected as the only output variable in the DEA model. Agricultural production was measured as the total value of agricultural production (net production value in constant 2004–2006 in 1 000 International Dollars I$). The data was retrieved from the FAOSTAT database (2019). The descriptive statistics for these variables are presented in Table 2.

RESULTS AND DISCUSSION

In all countries of the Western Balkan, agriculture is of substantially greater economic importance than it is in the EU, and agriculture is also an important factor in maintaining social equilibrium as it employs a large portion of the rural population (Volk et al. 2014). Moreover, in all Western Balkan countries, agriculture is still very important to the overall economy: about 23% of the population works in this sector, agriculture contributes about 11% in total GDP, and agri-food products comprise approximately 13% of total exports (Figure 1).

Partial productivities in agriculture are significantly worse in Western Balkan countries than in the EU (Figure 2). This discrepancy is particularly evident in labour productivity, where the gap between the countries of the Western Balkan and the EU is 1 : 4.7. The gap in land productivity is less evident at 1 : 1.5, although some countries (e.g. Montenegro and B&H) have very low efficiency in total agricultural land use, which is a consequence of the structure of the land itself.[1] The reasons for weak performances vary, and they are difficult to resolve in the short term without substantial changes. There are significant challenges due to a low level of knowledge and education among farmers, weak extension services, and deficient rural financial services help introduce modern production methods or invest in new technologies (Erjavec et al. 2014). Even though Kosovo was not included in this analysis, the agricultural situation there is not favourable either. According to Latruffe and Desjeux (2014), one of the reasons for this is stagnation due to the majority of farms being used for individual consumption rather than for the open market.

The results obtained from the BCC input-oriented DEA model are shown in Figure 3 and Table S1 [Table S1 in electronic supplementary material (ESM); for the supplementary material see the electronic version]. The highest average technical efficiency was achieved in the EU15 countries for the entire ten-year period, and this finding is consistent with similar previous research (Kocisova 2015; Nowak et al. 2015). The values of the average efficiency score lie between 0.65 (achieved in 2009) and 0.75 (achieved in 2011). The countries that joined the EU after the EU15 was formed were grouped as the "new" EU member states. The minimum average efficiency score of 0.38

[1]These two countries, where the land productivity is lowest, have a relatively high share of pastureland as part of total agricultural land. These areas are not used intensively for agricultural production and contribute significantly to the lower level of land productivity.

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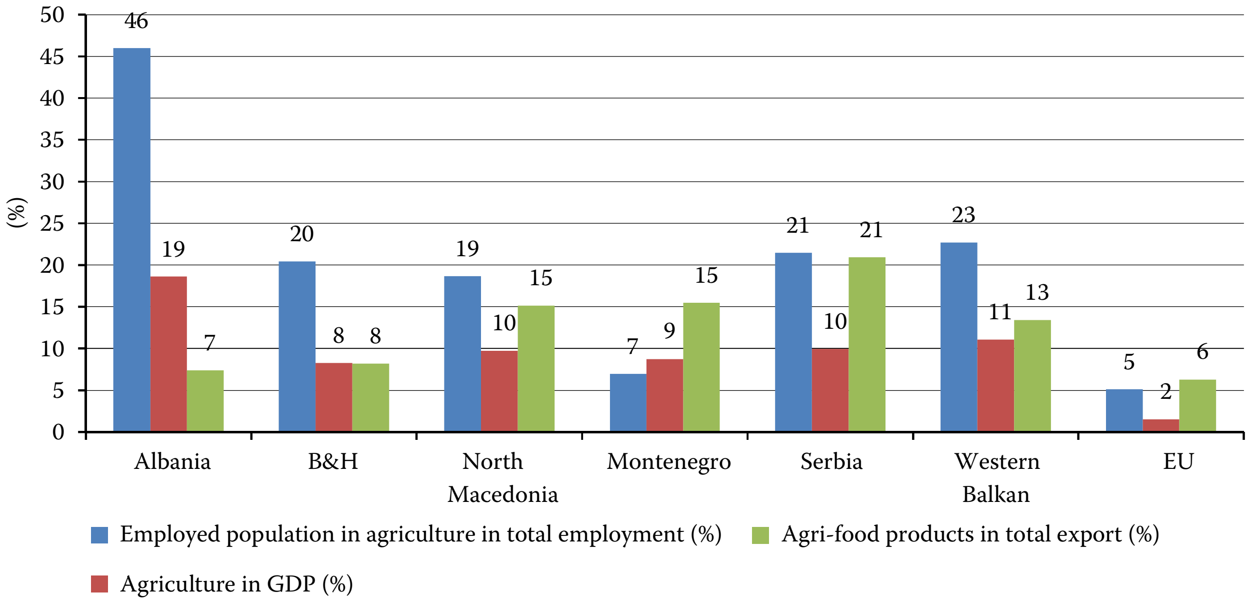

Figure 1. Economic relevance of agriculture (average 2005–2016)

Source: Authors' calculations based on FAOSTAT (2019), The World Bank (2019) and UN Comtrade (2019)

was obtained in 2012 for the "new" states, while the maximum score of 0.56 was obtained in 2016. The Western Balkan countries are characterised by the lowest average efficiency scores, which were between 0.32 (in 2008 and 2015) and 0.56 (in 2010). The difference between the average efficiency score in the "new" EU member states and Western Balkan countries is not large, but both groups of countries are behind the EU15 (Figure 3). The countries with the consistently highest relative technical efficiency score in this 10-year period are Belgium, France, Germany, Italy, and the Netherlands [Table S1; Table S1 in electronic supplementary material (ESM); for the supplementary material see the electronic version].

The important advantage of the DEA technique is that it can be used to identify the source of inefficiency and indicate necessary improvements in how inputs and/or outputs are utilized. The projections of input and output variables for 2016 are presented in Table S2 [Table S2 in electronic supplementary material (ESM); for the supplementary material see the electronic version]. These projections are in fact guidelines for decision-makers on how to improve the efficiency of the agricultural sector. This means the results of the research

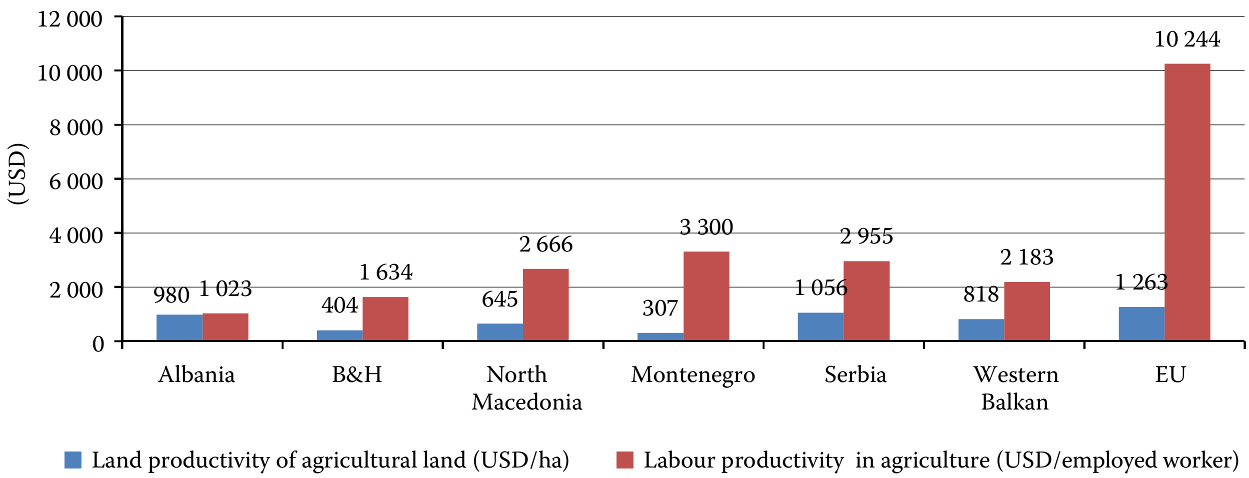

Figure 2. Partial productivities of agriculture (average 2005–2016)

Source: Authors' calculations based on FAOSTAT (2019) and The World Bank (2019)

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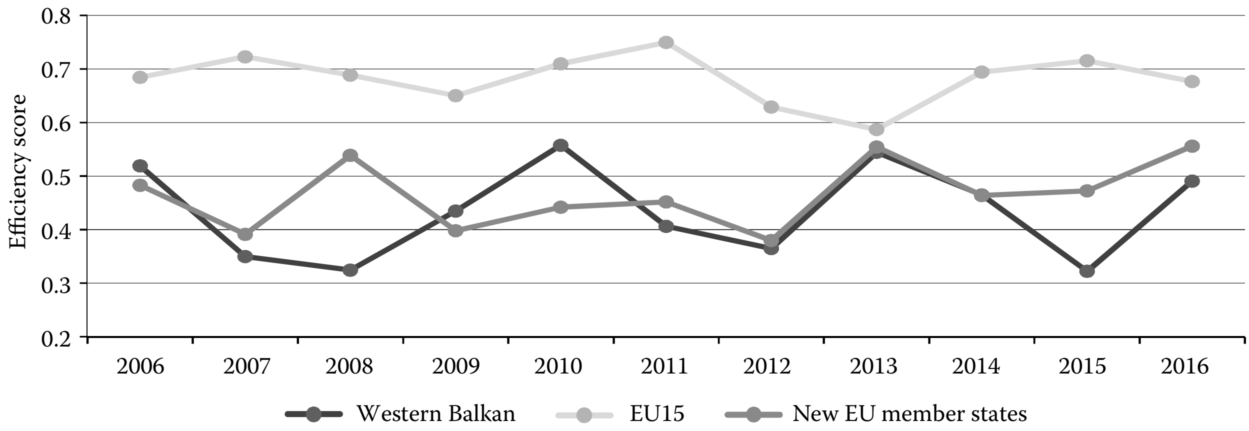

Figure 3. Average efficiency scores

Source: Authors' calculations

presented here can be used in making effective political decisions concerning agricultural policy, which can be useful in defining agricultural support measures that will contribute to increasing efficiency when using certain inputs. In other words, guidance has been provided to formulate such a model of support for agriculture that would focus on reducing the gap in the technical inefficiency in agriculture between the Western Balkan countries and the EU countries, which will only be possible if inefficiently used inputs are identified. This should be the starting point for formulating agricultural policy mechanisms that would reduce or completely neutralize the relatively inefficient use of production factors.

The high level of technical efficiency in the "old" EU member states stems from a generally high level of economic development and from the EU model of agricultural policy. Specifically, in its first three decades, the Common Agricultural Policy (CAP) was predominantly oriented towards production coupled methods to support agricultural production. The results were significant capital investments and accelerated intensification in agricultural production, which is evident from the level of partial productivity in agriculture in the EU (Figure 2).

The lower level of partial agricultural productivity in the Western Balkan countries (Figure 2) basically shows lower efficiency in the use of the primary production factors (labour and land), resulting in the inefficient use of total inputs. The reasons for the lower level of partial productivity, and thus inefficient agricultural production, should be sought in the structure of agricultural production, which is relatively extensive in the countries of the Western Balkan where there is a predominance of plant production (most often dry land farming) and long-term stagnation in livestock production. Also, the structural problem creates a fragmentation of farms with widespread small, semi-natural households with low level capital investments. Typical for all countries of the Western Balkan is the very small average size of agricultural holdings: the average for the Western Balkan countries is 2.51 ha/agricultural holding (Lovre 2016). This ownership structure significantly limits the penetration of capital into the agricultural sector and slows down the processes of agricultural modernisation that transform this economic sector from labour-intensive to capital-intensive. Such farms have hidden unemployment, i.e. inefficient use of labour inputs, which is particularly evident in Albania but is also present in other Western Balkan countries. Although the land is used more efficiently, a large number of commercially oriented farms are focused on plant production, so the lack of livestock unit per ha of agricultural land significantly limits efficient land use.

CONCLUSION

The main goals of this paper were to compare the relative technical efficiency of agriculture in the Western Balkan countries to the EU and to propose ways to improve these countries' position. An input-oriented DEA model with variable return to scale was applied in which input variables in the model included labour, land, and capital, while output was represented by the value of agricultural production. The linear programming model [Equation (1)] was solved for 5 Western Balkan countries and 27 EU countries for each year from 2006 to 2016.

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The results clearly show the average relative technical efficiency of agriculture in the Western Balkan countries is noticeably worse than in the EU countries. This study also discovered the sources of this inefficiency in agriculture in the countries that were studied. The main problem of agricultural inefficiency in the Western Balkan countries stems from poor results in labour productivity. This is a consequence of agriculture's unfavourable resource structure, which is mostly due to fragmented ownership and the slow development of the non-agricultural sector that does not have the capacity to accept a surplus of labour from agriculture.

Research into the technical efficiency of agriculture, the main objective of this paper, identifies sources of inefficiency, and the purpose was to identify potentials for improving the efficiency of agricultural production in the Western Balkan countries. In this context, the implications of this paper are reflected in the competent indicators of the position of agriculture in these countries in comparison to the EU. These contribute to a better understanding of the agricultural situation in the Western Balkan countries, which could be important during pre-accession negotiations with the EU. More specifically, the results of this paper can be used by policymakers to identify which factors improve or degrade the efficiency of agriculture. Also, agricultural producers can benefit from this research, as their decisions about how to utilize inputs and outputs are vital for agricultural efficiency. The novelty of this research is an in-depth analysis of the technical efficiency of agriculture in the Western Balkan countries, which is explained over time in the context of the EU integration process. As this paper identified the factors affecting technical efficiency, the focus of our future research will be advanced econometric modelling of the impact of these factors.

This paper, however, does have some limitations. Data from the FADN database were inaccessible and therefore could not be used, and Croatia and Kosovo were not included in the analysis due to a lack of data in the FAOSTAT database. Furthermore, the most significant qualitative limitation of this research is the absence of proposed agricultural policy measures, which would have improved the research conducted in this paper. This should be the subject of future studies.

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