APPLICATION OF WASPAS METHOD IN THE EVALUATION OF EFFICIENCY OF AGRICULTURAL ENTERPRISES IN SERBIA

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ABSTRACT

Recently, as it is known, the evaluation of the efficiency of agricultural enterprises is being more and more performed on the basis of multi-criteria analysis. With this in mind, this paper analyzes the efficiency of agricultural enterprises in Serbia based on the WASPAS method. The goal and purpose of this is to address this issue as thoroughly as possible and propose adequate measures to improve the efficiency of agricultural enterprises in Serbia in the future. The obtained results of empirical research using the given method show that the efficiency of agricultural enterprises in Serbia has recently significantly improved. It was the best in 2018. It was positively influenced by numerous macro and micro factors.

Introduction

The issue of measuring the efficiency of agricultural enterprises based on multi-criteria analysis is very current, complex and significant (Lukic, 2011; Lukic, 2018; Turskis, 2015, Vojteski Kljenak, 2019; Zhang, 2020; Bakić, 2020). Given this, the subject of research in this paper is the analysis of the efficiency of agricultural enterprises in Serbia based on the WASPAS method. The goal and purpose of this is to address this issue as thoroughly as possible and propose adequate measures to improve the efficiency of agricultural enterprises in Serbia in the future. This, among other things, reflects the

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scientific and professional contribution of this paper.

Recently, as it is known, an increasingly rich literature is dedicated to the analysis of the efficiency of companies from different economic sectors based on the WASPAS method. However, there are very few works of this type from the agricultural sector in Serbia (Chavas, 1993; Ashkan Hafezalkotob, 2018; Kolagar, 2019; Kutlu, 2019; Lukic, 2019, 2020a, b, c, d, e, f). In other words, in the literature in Serbia, there is, as far as we know, no comprehensive work dedicated to the analysis of the efficiency of agricultural enterprises in Serbia based on the WASPAS method (Petrovic, 2019). In this paper, based on the reputation of contemporary foreign literature, the efficiency analysis of agricultural enterprises in Serbia is performed using the WASPAS method for the first time. And that, among other things, reflects the scientific and professional contribution of this paper.

Research through the literature in this paper serves as a theoretical, methodological and empirical basis for a proper analysis of the efficiency of agricultural enterprises in Serbia based on the WASPAS method.

The basic hypothesis of the research in this paper is that continuous monitoring of the efficiency of agricultural enterprises is a prerequisite for improvement in the future: in our case in Serbia. This facilitates and indicates what adequate measures should be taken to achieve the target efficiency of agricultural enterprises in Serbia. In this, in the methodological sense of the word, the application of the WASPAS method plays a significant role.

The research is based on data from the Business Registers Agency of the Republic of Serbia, "produced" in accordance with relevant international standards and comparable globally. There are therefore no restrictions in this regard.

Materials and methods

WASPAS (Weighted Aggregates Sum Product Assessment) was proposed by Zavadskas et al. (2012). It respects the unique combination of two well-known approaches to multi-criteria decision making (MCDM): the Weighted Sum method (WS) and the Weighted Product method (WP). The WASPAS method is used to solve various complex problems in multicriteria decision making (e.g., production decision making) (Chakraborty, 2014; Zavadskas, 2013a). An advanced fuzzy WASPAS method has been developed to solve complex problems in the face of uncertainty.

The WASPAS method procedure consists of the following steps (Urosevic, 2017):

Step 1. Determine the optimal performance rating for each criterion.

The optimal performance rating is calculated as follows:

$$x_{0j} = \begin{cases} \max\limits_{i} x_{ij}; & j \in \Omega_{max} \\ \min\limits_{i} x_{ij}; & j \in \Omega_{min} \end{cases}, \quad (1)$$

where:

x_{0j} denotes the optimal performance rating of the *i*-th criterion,

Ω_{max} denotes the benefit criterion (the higher the value, the better),

Ω_{min} denote a set of cost criteria (the lower the value, the better),

m denotes the number of alternatives (*i*=0,1,...,*m*), and

n denotes the number of criteria (*j*=0,1,...,*n*).

Step 2. Determine the normalized decision matrix.

The normalized performance rating is calculated as follows:

$$r_{ij} = \begin{cases} \frac{x_{ij}}{x_{0j}}; & j \in \Omega_{max} \\ \frac{x_{0j}}{x_{ij}}; & j \in \Omega_{min} \end{cases}, \qquad (2)$$

where:

r_{ij} denotes the normalized performance rating of the *i*-th alternative in relation to the *j*-th criterion.

Step 3. Calculate the relative importance of the *i*-th alternative based on the WS method.

The relative importance of the *i*-th alternative, based on the WS method, is calculated as follows:

$$Q_i^{(1)} = \sum_{j=1}^{n} w_j r_{ij}, \qquad (3)$$

where:

$Q_i^{(1)}$ denotes the relative importance of the *i*-th alternative in relation to the *j*-th criterion, based on the WS method.

Step 4. Calculate the relative importance of the *i*-th alternative, based on the WP method.

The relative importance of the *i*-th alternative, based on the WP method, is calculated as follows:

$$Q_i^{(2)} = \prod_{j=1}^{n} r_{ij}^{w_j}, \qquad (4)$$

where:

$Q_i^{(2)}$ denotes the relative importance of the *i*-th alternative in relation to the *j*-th criterion, based on the WP method.

Step 5. Calculate the total relative significance for each alternative.

The total relative significance (common generalized criterion of weight aggregations of additive and multiplicative methods) (Zavadskas, 2012), is calculated as follows:

$$Q_i = \lambda Q_i^{(1)} + (1-\lambda) Q_i^{(2)} = \lambda \sum_{j=1}^{n} w_j r_{ij} + (1-\lambda) \prod_{j=1}^{n} r_{ij}^{w_j} \quad (5)$$

where:

λ coefficient $\lambda \in [0, 1]$.

When decision makers do not have preferences over the coefficient, the value is 0.5, and equation (5) is expressed as:

$$Q_i = 0.5 Q_i^{(1)} + 0.5 Q_i^{(2)} = 0.5 \sum_{j=1}^{n} w_j r_{ij} + 0.5 \prod_{j=1}^{n} r_{ij}^{w_j} \quad (6)$$

In this paper, for the purposes of applying the WASPAS method in the evaluation of the efficiency of agricultural enterprises in Serbia, the weighting coefficients are determined on the basis of the **AHP** (Analytical Hierarchical Process) method. With this in mind, we will briefly review the theoretical characteristics of the AHP method. The Analytical Hierarchical Process (AHP) method includes the following steps (Saaty, 2008):

Step 1: Forming a pair-wise comparison matrix

$$A = [a_{ij}] = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix} \quad (7)$$

Step2: Normalizing the pair-wise comparison matrix

$$a_{ij}^* = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}, i, j = 1, \ldots, n \quad (8)$$

Step 3: Determining the relative importance, i.e. the weight vector

$$w_i = \frac{\sum_{i=1}^{n} a_{ij}^*}{n}, i, j = 1, \ldots, n \quad (9)$$

Consistency index - CI (consistency index) is a measure of deviation *n* from λ_{max} and can be represented by the following formula:

$$CI = \frac{\lambda_{max} - n}{n} \quad (10)$$

If CI <0.1, the estimated values of the coefficients a_{ij} are consistent, and the deviation λ_{max} from n is negligible. This means, in other words, that the AHP method accepts an inconsistency of less than 10%.

Using the consistency index, the consistency ratio CR = CI / RI can be calculated, where RI is a random index.

Results and Discussion

When measuring the efficiency of agricultural enterprises in Serbia using the WASPAS method, the following criteria were taken: C1 - number of employees, C2 - assets, C3 - capital, C4 - operating income and C5 - net profit. Alternatives were observed in the years: A1 - 2013, A2 - 2014, A3 - 2015, A4 - 2016, A5 - 2017, A6 - 2018 and A7 - 2019 (Calculation of the efficiency of agricultural enterprises in Serbia was performed using the WASPASSoftware-Excel). The obtained results are shown in the tables and figures below. Table 1 shows the initial data for measuring the efficiency of agricultural enterprises in Serbia for the period 2013 - 2019.

Table 1. Initial data for measuring the efficiency of agricultural enterprises in Serbia

	Number of employees	Assets	Capital	Operating income	Net profit
2013	36015	570352	305601	315477	21418
2014	33256	641869	353052	316220	17515
2015	33498	688188	382718	321608	16960
2016	32244	781508	480683	352715	20392
2017	32023	815393	508124	330809	20936
2018	32330	846778	523357	349616	32466
2019	31247	874451	544362	350328	19932

Note: The number of employees is expressed in whole numbers. The data are expressed in millions of dinars. Companies from the agriculture, forestry and fisheries sectors are included.

Source: Serbian Business Registers Agency

Table 2 shows descriptive statistics of initial data for measuring the efficiency of agricultural enterprises in Serbia.

Table 2. Descriptive Statistics

Descriptive Statistics				
	N	Minimum	Maximum	Mean
1 Number of employees	7	31247.00	36015.00	32944.7143
2 Assets	7	570352.00	874451.00	745505.5714
3 Capital	7	305601.00	544362.00	442556.7143
4 Operating income	7	315477.00	352715.00	333824.7143
5 Net profit	7	16960.00	32466.00	21374.1429
Valid N (listwise)	7			

Source: Author's calculation done by using the SPSS software program

Data from descriptive statistics show that in 2018, the best performances of agricultural companies were in Serbia. Net profit was above average.

Table 3 shows the correlation matrix of initial data used to measure the efficiency of agricultural enterprises in Serbia.

Table 3. Correlation matrix

Correlations					
		1	2	3	4
1 Number of employees	Pearson Correlation	1	-.918**	-.905**	-.749
	Sig. (2-tailed)		.004	.005	.053
	N	7	7	7	7
2 Assets	Pearson Correlation	-.918**	1	.996**	.868*
	Sig. (2-tailed)	.004		.000	.011
	N	7	7	7	7
3 Capital	Pearson Correlation	-.905**	.996**	1	.879**
	Sig. (2-tailed)	.005	.000		.009
	N	7	7	7	7
4 Operating income	Pearson Correlation	-.749	.868*	.879**	1
	Sig. (2-tailed)	.053	.011	.009	
	N	7	7	7	7
5 Net profit	Pearson Correlation	-.141	.429	.441	.491
	Sig. (2-tailed)	.763	.337	.322	.264
	N	7	7	7	7
**. Correlation is significant at the 0.01 level (2-tailed).					
*. Correlation is significant at the 0.05 level (2-tailed).					

Source: Author's calculation done by using the SPSS software program

There is a significant correlation between the initial data, apart from net profit. In order to increase the efficiency of agricultural enterprises in Serbia in the future, it is necessary to manage profits as efficiently as possible. In addition to efficient marketing management, the application of modern concepts of cost management in agricultural companies in Serbia has a significant role in that.

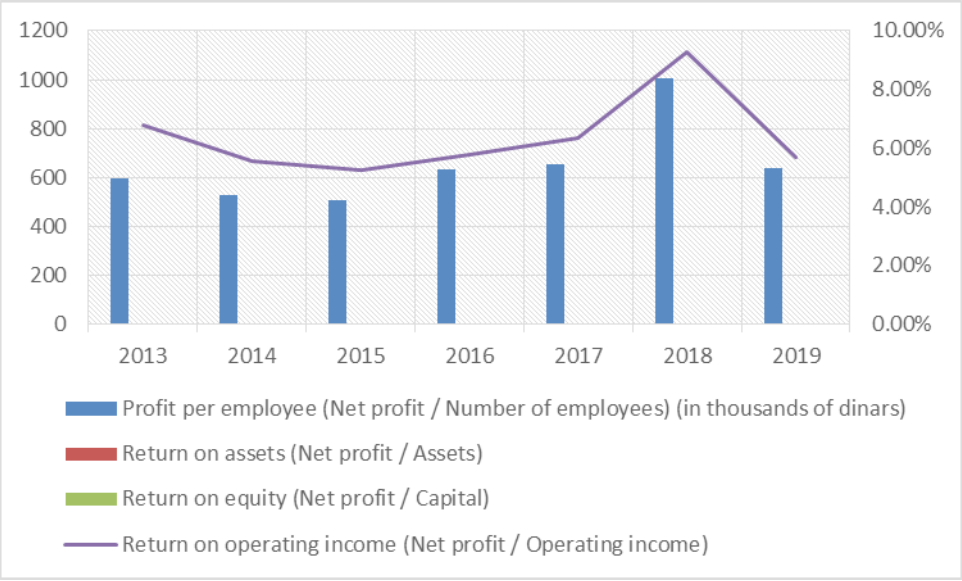
Table 4 and Figure 1, in order to make the efficiency analysis as complex as possible, show the ratio analysis of agricultural enterprises in Serbia.

Table 4. Ratio analysis

	Profit per employee (Net profit / Number of employees) (in thousands of dinars)	Return on assets (Net profit / Assets)	Return on equity (Net profit / Capital)	Return on operating income (Net profit / Operating income)
2013	594.6967	3.76%	7.01%	6.79%
2014	526.6719	2.73%	4.96%	5.54%
2015	506.2989	2.46%	4.43%	5.27%
2016	632.4277	2.61%	4.24%	5.78%
2017	653.7801	2.57%	4.12%	6.33%
2018	1004.207	3.83%	6.20%	9.29%
2019	637.8852	2.28%	3.66%	5.69%

Source: Author's calculations

Figure 1. Ratio analysis



Source: Author's calculations

The ratio analysis shows that the best performances of agricultural companies in Serbia were in 2018. In that year, for example, the highest profit per employee was achieved.

The weighting coefficients of the criteria are shown in Table 5 and Figure 2. They were determined using the AHP method. (The calculation was performed using the software program AHPSoftware-Excel.)

Table 5. The weighting coefficients of the criteria

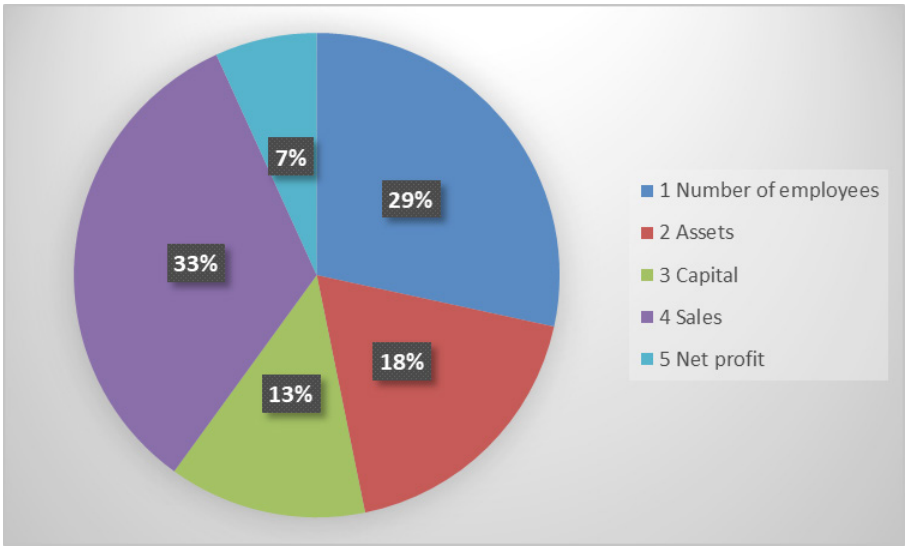
	Criterion		Weights
Table	1	Number of employees	28.4%
	2	Assets	18.4%
	3	Capital	13.2%
	4	Sales	33.2%
	5	Net profit	6.8%

Result	**Eigenvalue**				**Lambda:**	**5.223**		**MRE:**	**33.2%**	
	Consistency Ratio	**0.37**	**GCI:**	**0.18**	**Psi:**	**6.7%**	**CR:**	**5.0%**	**MRE est**	**33.4%**

Matrix		**Number of employees**	**Assets**	**Capital**	**Sales**	**Net profit**	**normalized principal Eigenvector**
		1	2	3	4	5	
Number of employees	1	1	2	3	1/2	4	28.43%
Assets	2	1/2	1	2	1/2	3	18.37%
Capital	3	1/3	1/2	1	1/2	3	13.18%
Sales	4	2	2	2	1	3	33.23%
Net profit	*5*	*1/4*	*1/3*	*1/3*	*1/3*	*1*	*6.80%*

Source: Author's calculation using AHPSoftware-Excel

Figure 2. Weighting coefficients of the criteria



Source: Authors' calculations

According to the importance of the observed criteria, sales come first. They follow in order: number of employees, assets, capital and net profit. This means that improving sales management can significantly affect the efficiency of agricultural enterprises in Serbia.

The initial decision matrix is shown in Table 6.

Table 6. Initial matrix

Initial matrix					
weights of criteria	0.284	0.184	0.132	0.332	0.068
kind of criteria	1	1	1	1	1
	C1	**C2**	**C3**	**C4**	**C5**
A1	36015	570352	305601	315477	21418
A2	33256	641869	353052	316220	17515
A3	33498	688188	382718	321608	16960
A4	32244	781508	480683	352715	20392
A5	32023	815393	508124	330809	20936
A6	32330	846778	523357	349616	32466
A7	31247	874451	544362	350328	19932
MAX	36015	874451	544362	352715	32466
MIN	31247	570352	305601	315477	16960

Source: Authors' calculations

The normalized decision matrix is shown in Table 7.

Table 7. Normalized matrix

Normalized matrix					
weights of criteria	0.284	0.184	0.132	0.332	0.068
kind of criteria	1	1	1	1	1
	C1	**C2**	**C3**	**C4**	**C5**
A1	1.0000	0.6522	0.5614	0.8944	0.6597
A2	0.9234	0.7340	0.6486	0.8965	0.5395
A3	0.9301	0.7870	0.7031	0.9118	0.5224
A4	0.8953	0.8937	0.8830	1.0000	0.6281
A5	0.8892	0.9325	0.9334	0.9379	0.6449
A6	0.8977	0.9684	0.9614	0.9912	1.0000
A7	0.8676	1.0000	1.0000	0.9932	0.6139

Source: Authors' calculations

The weighted normalized decision matrix is shown in Table 8.

Table 8. Weighted normalized matrix

Weighted normalized matrix						
	C1	**C2**	**C3**	**C4**	**C5**	**Qi1**
A1	0.2840	0.1200	0.0741	0.2969	0.0449	0.8199
A2	0.2622	0.1351	0.0856	0.2976	0.0367	0.8172
A3	0.2642	0.1448	0.0928	0.3027	0.0355	0.8400
A4	0.2543	0.1644	0.1166	0.3320	0.0427	0.9100
A5	0.2525	0.1716	0.1232	0.3114	0.0439	0.9025
A6	0.2549	0.1782	0.1269	0.3291	0.0680	0.9571
A7	0.2464	0.1840	0.1320	0.3298	0.0417	0.9339

Source: Authors' calculations

Table 9 shows the exponentially weighted decision matrix.

Table 9. Exponentially weighted matrix

Exponentially weighted matrix	C1	C2	C3	C4	C5	Qi2
A1	1.0000	0.9244	0.9266	0.9636	0.9721	0.8024
A2	0.9776	0.9447	0.9444	0.9644	0.9589	0.8066
A3	0.9796	0.9569	0.9546	0.9698	0.9568	0.8303
A4	0.9691	0.9795	0.9837	1.0000	0.9689	0.9047
A5	0.9672	0.9872	0.9909	0.9789	0.9706	0.8990
A6	0.9698	0.9941	0.9948	0.9971	1.0000	0.9563
A7	0.9605	1.0000	1.0000	0.9977	0.9674	0.9270

Source: Authors' calculations

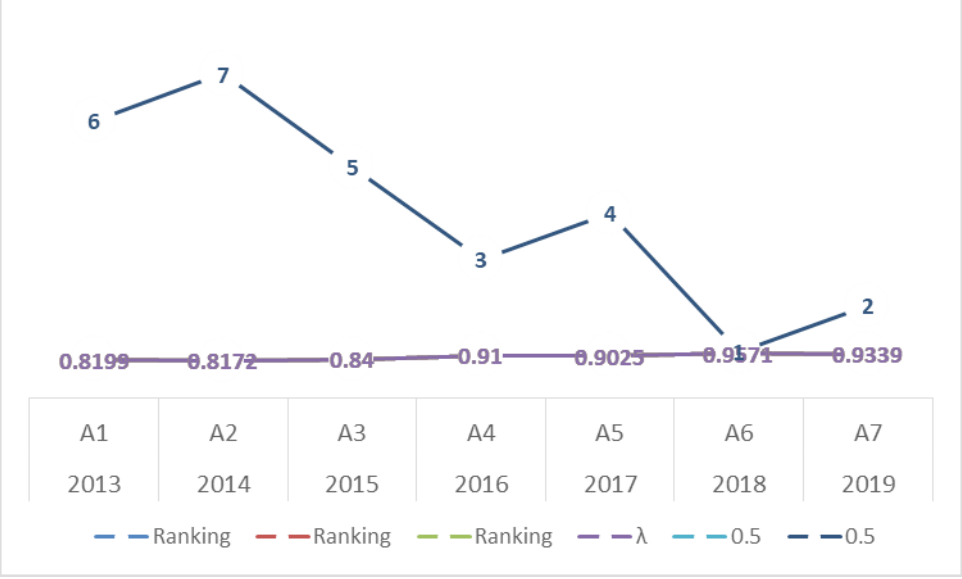
Table 10 and Figure 3 show the ranking of alternatives.

Table 10. Ranking of alternatives

	Ranking				λ	0.5	
	Alternatives	Qi1	Qi2	Qi	Qi		Ranking
2013	A1	0.8199	0.8199	0.8199	0.8199		6
2014	A2	0.8172	0.8172	0.8172	0.8172		7
2015	A3	0.8400	0.8400	0.8400	0.8400		5
2016	A4	0.9100	0.9100	0.9100	0.9100		3
2017	A5	0.9025	0.9025	0.9025	0.9025		4
2018	A6	0.9571	0.9571	0.9571	0.9571		1
2019	A7	0.9339	0.9339	0.9339	0.9339		2

Source: Authors' calculations

Figure 3. Ranking of alternatives



Source: Authors' calculations

The obtained results of the research on the efficiency problems of agricultural enterprises in Serbia on the basis of the WASPAS method show that the highest efficiency was achieved in 2018. They are therefore identical with the results of descriptive statistics and ratio analysis. The order of all other years is as follows: 2019, 2016, 2017, 2015, 2013 and 2014. The efficiency of agricultural enterprises in Serbia has been at a satisfactory level lately. This was positively influenced by numerous macro and micro factors (general economic conditions, stable exchange rate, low inflation, low bank interest rate, subsidies and grants, reduced unemployment rate, increased living standards, regulation of the labor market of farmers, increasing understanding of the importance of insuring agriculture from adverse climate change, increased placement of agricultural products on foreign markets and branding of agricultural products. general economic conditions, stable exchange rate, low inflation, low bank interest rate, subsidies and grants, reduced unemployment rate, increased living standards, regulation of the labor market of farmers, increasing understanding of the importance of insuring agriculture from adverse climate change, increased placement of agricultural products on foreign markets and branding of agricultural products, increased production of organic products, application of modern technology in agriculture).

Conclusions

Based on the conducted analysis of the efficiency of agricultural enterprises in Serbia on the basis of the WASPAS method, the following can be concluded:

Agricultural companies in Serbia were the most efficient in 2018. The order of all other years is as follows: 2019, 2016, 2017, 2015, 2013 and 2014. The efficiency of agricultural enterprises in Serbia has been at a satisfactory level lately. This was positively influenced by a number of macro and micro factors, such as: general economic conditions, stable exchange rate, low inflation, low bank interest rate, subsidies and grants, reduced unemployment rate, increased living standards, regulation of the labor market of farmers, increasing understanding of the importance of insuring agriculture from adverse climate change, increased placement of agricultural products on foreign markets and branding of agricultural products. It plays a significant role the increasing production of organic products, the application of modern technology in agriculture, and the development of cooperatives.

Empirical research in this paper has shown that the WASPAS method is very suitable and simple for evaluating the efficiency of agricultural enterprises. Given that, as well as that there is a developed software program and available empirical data (Agency for Business Registers of the Republic of Serbia, Statistical Yearbook of the Republic of Serbia and others), it is recommended that it be used in the future to continuously evaluate the efficiency / performance of agricultural enterprises in Serbia. This provides an adequate basis for taking appropriate measures in order to achieve the target efficiency of agricultural enterprises in Serbia.

Conflict of interests

The authors declare no conflict of interest.

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