EVALUATION OF EFFICIENCY OF TRADE COMPANIES IN SERBIA USING THE DEA APPROACH

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Abstract

In recent years, the concept of company efficiency and its measurement using Data Envelopment Analysis (DEA) has received a great deal of attention in the professional literature. Keeping this in mind and taking into account that, to our knowledge, there is no comprehensive study on the efficiency of trade companies in Serbia using the DEA model, the paper seeks to explore this topic. The results of the research into the efficiency of the top 14 retailers in Serbia, suggest that, considering the existing macroeconomic environment, the overall efficiency of the commercial sector in Serbia is satisfactory. To promote the efficiency of trade companies in Serbia in the future, it is necessary to take full advantage of new business models, contemporary concepts of cost management, information and communication technologies, and the concept of sustainable development, by following the example of global retail chains. Developing a private label is another useful tool for increasing corporate efficiency. Companies would also benefit greatly from developing a private label and increasing organic food sales.

Key words: efficiency, technology, environment, DEA models, Serbia.

1. INTRODUCTION

In recent years, the concept of company efficiency and its measurement using Data Envelopment Analysis (DEA) has received a great deal of attention in many countries by scholars and practitioners alike. Keeping this in mind and taking into account that, to our knowledge, no comprehensive studies have been conducted on the efficiency of trade companies in Serbia using the DEA model, the paper seeks to explore this topic. Thus, the principal aim of the current research is to provide an assessment of the efficiency of the top 14 retailers in Serbia so that adequate measures for improvement of the overall performance of the commercial sector in Serbia can

be developed and implemented. This is, among other things, the main contribution of the paper.

There is a wealth of international literature devoted to evaluating the efficiency and productivity of companies using the DEA method (Malmquist, 1953; Andersen & Petersen, 1993; Donthu & Yoo, 1998; Tone, 2001; Tone, 2002; Tone & Tsutsui, 2009; Tone & Tsutsui, 2010; Asmild et al., 2004; Fare et al., 1994; Fare eta al, 1995; Moreno, 2010; Vaz et al, 2010; Wang, 2011; Moreno & Sanz-Triguero, 2011; Vaz & Camanho, 2012; Lau, 2013; Gandhi & Shankar, 2014; Al-Refaie et al, 2015; Anand & Grover, 2015; Majumdar & Asgari, 2017; Bambe, 2017; Qiu & Meng, 2017; Sarmento et al, 2017 ; Ko et al, 2017; Hsu, 2018; Haidar, 2018). However, this topic has not been sufficiently explored by Serbian authors (Lukic, 2015). To our knowledge, research aimed at exploring the efficiency and productivity of trade companies in Serbia using the DEA is almost non-existent. Hence, this paper aims to address the gap in the extant literature.

The main hypothesis of this research is that in order to improve the efficiency and productivity of trade companies, it is necessary to continuously assess these two factors using the DEA approach. Based on the results of the research, adequate measures can be developed and implemented to better control the factors affecting the efficiency of such companies. The paper is primarily focused on retailers in Serbia.

To measure retailer efficiency, various DEA models have been used in parallel, including the CCR model, the BCC model, the Super-Efficiency DEA model, and the Super Slacks-Based Model (SBM).

For the purpose of this research, the original empirical data were obtained from the Serbian Business Registers Agency. The data conform to International Accounting Standards and International Financial Reporting Standards and are thus comparable to similar data for the advanced economies. Therefore, the results of the research can be compared against the data for global retail chains, which will provide a good insight into the position of trade companies in Serbia in terms of their efficiency.

2. DEA MODELS

The paper provides a brief theoretical analysis of the DEA models including the CCR model, the BCC model, the Super-efficiency DEA model, the Slacks-Based Model, the Super Slacks-Based Model (Super SBM model), the radial super-efficiency model, and the DEA projection.

(A) CCR model

The CCR model is based on constant returns-to-scale. This means that a proportionate increase in all inputs results in a proportionate increase in all outputs. The dual of the multiplier from CCR is:

$$Min\ \theta$$

subject to constraints

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta x_{io} \qquad i = 1 \ldots . m$$

$$\sum_{j=1}^{n} \lambda_j y_{kj} \geq y_{ko} \qquad k = 1 \ldots . s$$
$$\lambda \geq 0 \qquad j = 1 \ldots . n$$

where θ means the technical efficiency of a decision-making unit (DMU), and λ is the dual variable for identification of comparable inefficient units. If θ* equals to one, this means that a DMU is technically efficient.

(B) BCC model

The CCR model was modified by introducing the BCC model (proposed by Banker-Charnes-Cooper), wherein the constant returns-to-scale (CRS) were replaced with variable returns-to-scale (VRS). A DMU operates under variable returns-to-scale assumption if an increase in input does not result in proportionate changes in output. The BCC model is expressed as follows:

$$Min\ \theta$$

subject to

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta x_{io} \qquad i = 1 \ldots . m$$
$$\sum_{j=1}^{n} \lambda_j y_{kj} \geq y_{ko} \qquad k = 1 \ldots . s$$
$$\sum_{j=1}^{n} \lambda_{j=1} = 1 \qquad j = 1 \ldots . n$$
$$\lambda_j \geq 0$$

The BCC model divides technical efficiency (TE) obtained under the CCR model into: 1) pure technical efficiency (PTE), which ignores the impact of scale size by comparing a DMU to a unit of similar scale, and measures how a DMU utilizes inputs under exogenous conditions; and 2) scale efficiency (SE), which shows how scale size impacts efficiency. The latter is formulated as follows:

$$SE = TE / PTE$$

(C) Super-efficiency DEA model

Super-efficiency DEA model (Andersen and Petersen, 1993) can be formulated as follows:

$$\theta^* = \min \theta_0$$

subject to

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta_0^s x_{io} \quad i = 1, \ldots, m$$
$$\sum_{\substack{j=1 \\ j \neq o}}^{n} \lambda_j\, y_{rj} \geq y_{ro} \quad r = 1, \ldots, s$$
$$\lambda_j \geq 0 \quad j = 1, \ldots, n$$

The super-efficiency DEA model enables the ranking of efficient DMUs similar to ineffective DMUs, based on an efficiency ratio which can be greater than or equal to one.

(D) Slacks-Based Model

Assuming that the number of DMUs (n) is linked to the number of inputs (m) and the number of outputs (s). X_{ji} denotes the input of i^{th} DMU_j, and Y_{jr} is the output of r^{th} DMU_j. Next, assuming that all data are positive, i.e. X_{ji} and $Y_{jr} > 0$ for all possible i = 1, ... , m; r = 1, ... , s; j = 1, ... , n. The Slacks-Based Model proposed by Tone (2001) can be formulated as follows:

$$\min \rho_k = \frac{1 - \frac{1}{m}\sum_{i=1}^{m} S_i^- / X_{ki}}{1 + \frac{1}{s}\sum_{r=1}^{s} S_r^+ / Y_{kr}}$$

subject to

$$\sum_{j=1}^{n} \lambda_j Y_{ji} = Y_{ki} - S_i^-, i = 1, \dots, m$$

$$\sum_{j=1}^{n} \lambda_j Y_{jr} = Y_{kr} + S_r^+, r = 1, \dots, s$$

$$\lambda_j \geq 0, j = 1, \dots, n$$
$$S_i^- \geq 0, i = 1, \dots, m$$
$$S_r^+ \geq =, r = 1, \dots, s$$

The reference point identified in the SBM model is ($X_{ki} - S_i^{-*}, Y_{kr} + S_r^{+*}$).

The essence of the SBM model is that by reducing input or increasing output, an inefficient DMU can be transformed into an efficient unit.

(E) Super Slacks-Based Model

Super SBM, proposed by Tone (2002), can be formulated as follows:

$$\min \rho_k^{ssbm} = \frac{1 - \frac{1}{m}\sum_{i=1}^{m} \frac{\overline{X}_i}{X_{ki}}}{1 + \frac{1}{s}\sum_{r=1}^{s} \frac{\overline{Y}_r}{Y_{kr}}}$$

subject to

$$\sum_{j=1}^{n} \lambda_j X_{ji} \leq \overline{X}_i, i = 1, \dots, m$$

$$\sum_{j=1}^{n} \lambda_j Y_{jr} \geq \overline{Y}_r, r = 1, \dots, s$$

$$\lambda_j \geq 0, j = 1, \dots, n$$
$$X_{ki} \leq \overline{X}_i, i = 1, \dots, m$$
$$Y_{kr} \geq \overline{Y}_r, r = 1, \dots, s$$
$$\overline{Y}_r \geq 0, r = 1, \dots, s$$

The reference point identified in the Super SBM model is ($\overline{X}_i^*, \overline{Y}_r^*$).

Output-oriented Super SBM can be formulated as follows:

$$minimize\ \delta = \frac{\frac{1}{m}\sum_{i=1}^{m} X_i^* / X_{iq}}{\frac{1}{r}\sum_{i=1}^{r} Y_i^* / Y_{iq}}$$

subject to

$$\sum_{j=1,\neq q}^{n} X_{ij}\lambda_j + S_i^- = X_{iq}, i = 1, 2, \dots, m$$

$$\sum_{j=1,\neq q}^{n} Y_{ij}\lambda_j - S_i^+ = Y_{iq}, i = 1, 2, \dots, r$$

$$X_i^* \geq X_{iq}, i = 1,2, \dots, m$$
$$Y_i^* \leq Y_{iq}, i = 1, 2, \dots, r,$$
$$\lambda, S^+, S^-, Y^* \geq 0$$

Input-oriented Super SBM can be formulated as follows:

$$minimize\ \delta_I = \frac{1}{m}\sum_{i=1}^{m} X_i^* / X_{iq}$$

subject to

$$\sum_{j=1,\neq q}^{n} X_{ij}\ \lambda_j + S_i^- = X_{iq}, i = 1, \dots, m$$

$$\sum_{j=1,\neq q}^{n} Y_{ij}\lambda_j - S_i^+ = Y_{iq}, i = 1,2, \dots, r$$

$$X_i^* \geq X_{iq}, i = 1, \dots, m$$
$$Y_i^* = Y_{iq}, i = 1,2, \dots, r$$
$$\lambda, S^+, S^- \geq 0$$

3. EFFICIENCY OF TRADE COMPANIES IN SERBIA

The current chapter evaluates the efficiency of the top 14 retailers (DMUs) in Serbia in 2017 using the DEA approach. Table 1 shows input/output data. For the purpose of this evaluation, the cost of goods sold, earnings per employee, and capital are considered as inputs, while revenue and profit are considered as outputs.

Table 1. Input/output data

DMU	(I) Cost of goods sold (in RSD million)	(I) Earnings per employee (in RSD million)	(I) Capital (in RSD million)	(O) Revenue (in RSD million)	(O) Profit (in RSD million)
Delhaize Serbia	69,345	8,347	53,740	94,884	4,264
Mercator-S	73,310	6,135	14,147	90,747	-6,851

Nelt Co.	69,520	3,159	11,481	78,024	1,330
Mol Serbia	37,001	354	9,770	40,369	759
Knez Petrol	36,473	638	1,888	39,218	592
Phoenix Pharma	34,823	878	4,750	37,689	738
Mercata	35,143	610	866	36,360	342
Veletabak	29,092	786	775	31,610	556
OMV Srbija	26,196	178	8,427	30,406	109
Lukoil Srbija	25,094	414	7,837	29,158	1,880
Delta Agrar	20,899	684	16,612	27,772	829
Metro Cash & Carry	22,811	1,278	4,185	26,660	-203
Dis	19,093	934	6,229	22,623	131
Jugoimport - SDPR JP	11,563	972	16,705	21,977	3,133

Source: Serbian Business Registers Agency

Table 2 provides descriptive statistics of input/output data.

Table 2. Descriptive statistics of input/output data

Statistics of input/output data (in RSD million)

	Cost of goods sold	Earnings per employee	Capital	Revenue	Profit
Max	73,310	8,347	53,740	94,884	4,264
Min	11,563	178	775	21,977	-6,851
Mean	36,454.5	1,811.93	11,243.7	43,392.6	543.5
SD	19,227.5	2,356.47	12,863.9	24,091.8	2,371.8

Source: Authors' calculations using the DEA model - DEA-Solver LV8.0/CCR (CCR-I)

The data in Tables 1 and 2 show that earnings per employee were above the average only in three retail companies: Delhaize Serbia, Mercator-S and Nelt Co. This is a significant efficiency factor, especially when measured as profit per employee.

Table 3 shows the correlation matrix of input/output data.

Table 3. Correlation matrix of input/output data

Correlation	Cost of goods sold	Earnings per employee	Capital	Revenue	Profit
Cost of goods sold	1	0.82335	0.47488	0.97876	-0.292
Earnings per employee	0.82335	1	0.80089	0.91461	-0.1254
Capital	0.47488	0.80089	1	0.62628	0.36623
Revenue	0.97876	0.91461	0.62628	1	-0.2304
Profit	-0.292	-0.1254	0.36623	-0.2304	1

Source: Authors' calculations using the DEA model - DEA-Solver LV8.0/CCR (CCR-I)

The data in Table 3 show that there is a significant positive correlation between earnings per employee and the cost of goods sold, capital, and income. Moreover,

there is a weak negative correlation between the earnings per employee and profit. Considering that profit per employee is a major efficiency indicator, it is necessary to increase the efficiency of human resources management in trade companies in Serbia. There is also a significant correlation between capital and earnings per employees and income. However, the relationship between capital and the cost of goods sold and profit is weak. This suggests the need for more effective management of capital.

Table 4 shows a comparative analysis of the efficiency of the top 14 retailers in Serbia in 2017 using the DEA approach.

Table 4. Efficiency of the top 14 retailers in Serbia using DEA models SSR and BCC

No	DMU	Model = SSR - I		Model = SSR - O		Model = BCC - I		Model = BCC - O		RTS of projected DMU
		Score	Rank	Score	Rank	Score	Rank	Score	Rank	
1	Delhaize Serbia	0.885	14	0.885	14	1	1	1	1	Decreasing
2	Mercator-S	1	1	1	1	1	1	1	1	Constant
3	Nelt Co.	0.9508	11	0.9508	11	1	1	1	1	Decreasing
4	Mol Serbia	1	1	1	1	1	1	1	1	Constant
5	Knez Petrol	1	1	1	1	1	1	1	1	Constant
6	Phoenix Pharma	0.9541	10	0.9541	10	0.9574	14	0.9619	14	Decreasing
7	Mercata	1	1	1	1	1	1	1	1	Constant
8	Veletabak	1	1	1	1	1	1	1	1	Constant
9	OMV Srbija	1	1	1	1	1	1	1	1	Constant
10	Lukoil Srbija	1	1	1	1	1	1	1	1	Constant
11	Delta Agrar	0.9431	12	0.9431	12	0.9687	13	0.977	13	Decreasing
12	Metro Cash & Carry	0.9724	9	0.9724	9	1	1	1	1	Increasing
13	Dis	0.9333	13	0.9333	13	1	1	1	1	Increasing
14	Jugoimport - SDPR JP	1	1	1	1	1	1	1	1	Constant
	Statistics									
	Mean	0.9742			0.9742	0.9947		0.9956		
	Max	1			1	1		1		
	Min	0.885			0.885	0.9574		0.9619		
	SD	0.036			0.036	0.0136		0.0115		

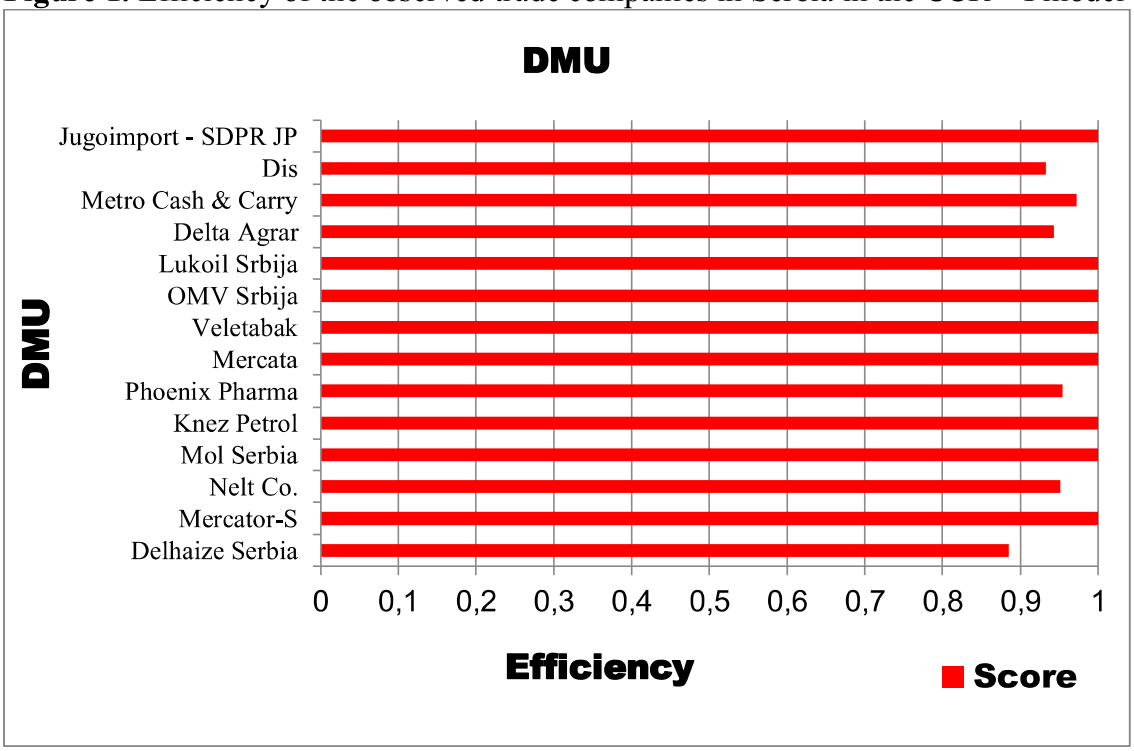
Authors' calculations using the DEA model - DEA-Solver; Returns-to-Scale (RTS)

The data in Table 4 show that in the input-oriented model SSR - I with constant returns to scale, eight of the 14 companies are efficient, while six are inefficient. The output-oriented model SSR – O with constant returns to scale shows the same results. In the input-oriented model BCC – I with variable returns to scale, twelve companies are efficient, while two are inefficient. The output-oriented model BCC – O with variable returns to scale shows the same results. Delhaize Serbia retail chain is efficient in the BCC - I model and the BCC – O model, but inefficient in the SSR - I and SSR – O models. In order to improve its efficiency, Delhaize Serbia needs to manage its inputs better, i.e. optimise the usage of inputs. Mercator-S is efficient in both DEA models. Delhaize Serbia and Mercator-S, as the top two companies in

Serbia, control the retail market. Such market position has had a positive impact on their efficiency. Companies engaged in the trading in petroleum products (Mol Serbia, Knez Petrol, OMV Srbija, Lukoil Srbija) are efficient in both DEA models. The results of these calculations indicate that, in general, the efficiency of companies in Serbia is satisfactory.

Figure 1 shows the efficiency of the observed trade companies in Serbia in the CCR – I model.

Figure 1. Efficiency of the observed trade companies in Serbia in the CCR – I model



Source: Figure created by the authors

Naturally, the issue of inefficiency must be addressed so as to increase the overall efficiency of companies in Serbia. Efficiency can be enhanced by decreasing inputs or increasing outputs. Table 5 shows the results of the analysis of slacks identified in trade companies in Serbia using the slacks-based measure (CCR – I) for 2017.

Table 5. Slacks-based measure of the efficiency of the top 14 retailers in Serbia (in RSD million)

CCR - I model				Slack	Slack	Slack	Slack	Slack
No.	DMU	Score	Rank	Cost of goods sold	Earnings per employee	Capital	Revenue	Profit
1	Delhaize Serbia	0.885	14	0	2,240.67	0	0	3,467.78
2	Mercator-S	1	1	0	0	0	0	0
3	Nelt Co.	0.9508	11	0	0	0	0	732.273
4	Mol Serbia	1	1	0	0	0	0	0
5	Knez Petrol	1	1	0	0	0	0	0

6	Phoenix Pharma	0.9541	10	0	0	0	0	400.613
7	Mercata	1	1	0	0	0	0	0
8	Veletabak	1	1	0	0	0	0	0
9	OMV Srbija	1	1	0	0	0	0	0
10	Lukoil Srbija	1	1	0	0	0	0	0
11	Delta Agrar	0.9431	12	0	0	1,897.08	0	1,017.93
12	Metro Cash & Carry	0.9724	9	0	0	0	0	551.5
13	Dis	0.9333	13	0	0	0	0	986.878
14	Jugoimport - SDPR JP	1	1	0	0	0	0	0
	Statistics							
	Mean	0.9742	5.5	0	160.048	135.506	0	511.213
	Max	1	14	0	2,240.67	1,897.08	0	3,467.78
	Min	0.885	1	0	0	0	0	0
	SD	0.036	5.5157	0	598.844	507.016	0	935.528

Source: Authors' calculations using the DEA model - DEA-Solver

The Data in Table 5 indicate that, for example, for Delhaize Serbia to be even more efficient, it should reduce spending on salaries by RSD 2,240.67 million (26.84%) and increase profit by RSD 3,467.78 million (81.32%). The same should be done by other inefficient companies in Serbia (Nelt Co., Phoenix Pharma, Delta Agrar, Metro Cash & Carry, and DIS). In order to increase the overall efficiency of the commercial sector in Serbia, it would be necessary to reduce spending on salaries by RSD 160,048 million, reduce capital by RSD 135,560 million, whereas profit should be increased by RSD 511,213 million. All of these are average values.

To gain a detailed insight into the efficiency of the top 14 retailers in Serbia, the authors have also employed the Super - SBM model (Table 6).

Table 6. Efficiency of the top 14 retailers in Serbia in the Super - SBM model

No	DMU	Super – SBM oriented (Super – SBM – I – C)		Super – SBM oriented (Super – SBM – O – C)		Super – SBM oriented (Super - SBM – I – V)		Super – SBM non-oriented (Super - SBM - C)		Super – SBM non-oriented (Super - SBM - V)	
		Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
1	Delhaize Serbia	0.682196	14	0.556994	11	1	1	0.433695	12	1.76411	1
2	Mercator-S	1.017366	7	1.023063	6	1	1	1.017366	6	1.068651	9
3	Nelt Co.	0.729452	13	0.585817	10	1	1	0.484675	10	1.234287	6
4	Mol Serbia	1.016094	8	1.014256	8	1	1	1.014256	8	1.115402	8
5	Knez Petrol	1.01861	6	1.017843	7	1	1	1.015747	7	1.056217	10
6	Phoenix Pharma	0.743666	12	0.679277	9	0.7449	14	0.655812	9	0.731884	13
7	Mercata	1.170516	5	1.140862	5	1	1	1.140862	5	1.155133	7
8	Veletabak	1.474926	2	1.342994	2	1	1	1.31646	3	1.372624	5
9	OMV Srbija	1.187271	4	1.19934	4	1	1	1.171159	4	1.432274	3
10	Lukoil Srbija	1.371338	3	1.335672	3	1	1	1.334685	2	1.383081	4
11	Delta Agrar	0.823307	10	0.489737	12	0.8474	13	0.446335	11	0.481604	14
12	Metro Cash & Carry	0.836835	9	0.136337	14	1	1	0.116342	14	0.999166	12
13	Dis	0.754688	11	0.164536	13	1	1	0.132975	13	0.999635	11

14	Jugoimport - SDPR JP	1.872204	1	2.159292	1	1	1	1.668972	1	1.737511	2
	Statistics										
	Mean	1.049891		0.917573		0.9709		0.853524		1.180827	
	Max	1.872204		2.159292		1		1.668972		1.76411	
	Min	0.682196		0.136337		0.7449		0.116342		0.481604	
	SD	0.328668		0.51511		0.0767		0.459274		0.336286	

Source: Authors' calculations using the DEA model - DEA-Solver

This measurement method also points to the conclusion that, overall, the efficiency of trade companies in Serbia is satisfactory.

An even more detailed insight into the efficiency of the top 14 retailers in Serbia in 2017 has been obtained using radial super-efficiency DEA (Table 7).

Table 7. Efficiency of the top 14 retailers in Serbia in the radial super-efficiency model

No	DMU	Super – Radial - SSR - I		Super – Radial - SSR - O		Super – Radial - BCC - I		Super – Radial - BCC - O	
		Score	Rank	Score	Rank	Score	Rank	Score	Rank
1	Delhaize Serbia	0.885043	14	0.885043	14	1	12	1.905309	2
2	Mercator-S	1.047215	6	1.047215	6	3.065721	2	1.147423	5
3	Nelt Co.	0.954873	10	0.954873	10	2.789806	3	1.519595	3
4	Mol Serbia	1.024983	8	1.024983	8	2.13251	5	1.239417	4
5	Knez Petrol	1.026054	7	1.026054	7	1.319677	9	1.083332	6
6	Phoenix Pharma	0.954087	11	0.954087	11	0.957356	14	0.961933	14
7	Mercata	1.327915	5	1.327915	5	1.697337	7	1	7
8	Veletabak	1.871808	2	1.871808	2	2.246235	4	1	7
9	OMV Srbija	1.49794	4	1.49794	4	1.988744	6	1	7
10	Lukoil Srbija	1.573848	3	1.573848	3	1.607623	8	3.093739	1
11	Delta Agrar	0.943087	12	0.943087	12	0.968747	13	0.976961	13
12	Metro Cash & Carry	0.975074	9	0.975074	9	1.019476	11	1	7
13	Dis	0.933311	13	0.933311	13	1.114605	10	1	7
14	Jugoimport - SDPR JP	3.616612	1	3.616612	1	4.715518	1	1	7
	Statistics								
	Mean	1.330846		1.330846		1.901668		1.280551	
	Max	0.69633		0.69633		1.024029		0.564381	
	Min	3.616612		3.616612		4.715518		3.093739	
	SD	0.885043		0.885043		0.957356		0.961933	

Source: Authors' calculations using the DEA model - DEA-Solver

The data in Table 7 show that all 14 companies are inefficient in the Super - Radial - SSR - I and Super - Radial - SSR – O models. In the Super - Radial – BCC model, only one of the 14 companies is efficient. In the Super - Radial - BCC – O

model, six of the 14 companies are efficient. This suggests that it is imperative to manage inputs and outputs more efficiently in order to achieve the efficiency frontier.

When measuring efficiency, it is important to consider the deviation of current input/output data from their projections. Table 8 shows this data for the top 14 retailers in the CCR - I model for 2017.

The data in Table 8 indicate that, for example, in the case of Delhaize Serbia, the costs of goods sold, earnings per employee, and capital increased by -11.496%, -38.34%, and -11.496%, respectively, while profit decreased by 81.327%, in comparison to projections. This has negatively impacted the company's effectiveness. Similar results were obtained for other inefficient companies. As far as efficient companies are concerned, for example Mercator-S, the input/output data match the projections.

Table 8. Projections of efficiency of input/output data of the top 14 retailers in Serbia using the CCR – I model

Model = CCR-I				Cost of goods sold			Earnings per employee			Capital			Revenue			Profit		
No.	DMU	Score	Rank	Data	Projection	Diff. (%)	Data	Projection	Diff. (%)	Data	Projection	Diff. (%)	Data	Projection	Diff (%)	Data	Projection	Diff. (%)
1	Delhaize Serbia	0.885	14	69,345	61,373.3	-11.496	8,347	5,146.79	-38.34	53,740	47,562.2	-11.496	94,884	94,884	0	4,264	7,731.78	81.327
2	Mercator-S	1	1	73,310	73,310	0	6,135	6135	0	14,147	14,147	0	90,747	90,747	0	-6,851	-6,851	0
3	Nelt Co.	0.9508	11	69,520	66,098.6	-4.921	3,159	3,003.53	-4.921	11,481	10,916	-4.921	78,024	78,024	0	1,330	2,062.27	55.058
4	Mol Serbia	1	1	37,001	37,001	0	354	354	0	9,770	9,770	0	40,369	40,369	0	759	759	0
5	Knez Petrol	1	1	36,473	36,473	0	638	638	0	1,888	1,888	0	39,218	39,218	0	592	592	0
6	Phoenix Pharma	0.9541	10	34,823	33,224.2	-4.591	878	837.688	-4.591	4,750	4,531.91	-4.591	37,689	37,689	0	738	1,138.61	54.284
7	Mercata	1	1	35,143	35,143	0	610	610	0	866	866	0	36,360	36,360	0	342	342	0
8	Veletabak	1	1	29,092	29,092	0	786	786	0	775	775	0	31,610	31,610	0	556	556	0
9	OMV Srbija	1	1	26,196	26,196	0	178	178	0	8,427	8,427	0	30,406	30,406	0	109	109	0
10	Lukoil Srbija	1	1	25,094	25,094	0	414	414	0	7,837	7,837	0	29,158	29,158	0	1,880	1,880	0
11	Delta Agrar	0.9431	12	20,899	19,709.6	-5.691	684	645.072	-5.691	16,612	13,769.5	-17.111	27,772	27,772	0	829	1,846.93	122.79
12	Metro Cash & Carry	0.9724	9	22,811	22,181	-2.762	1,278	1,242.7	-2.762	4,185	4,069.41	-2.762	26,660	26,660	0	-203	348.5	-271.68
13	Dis	0.9333	13	19,093	17,819.7	-6.669	934	871.713	-6.669	6,229	5,813.6	-6.669	22,623	22,623	0	131	1,117.88	753.342
14	Jugoimport - SDPR JP	1	1	11,563	11,563	0	972	972	0	16,705	16,705	0	21,977	21,977	0	3,133	3,133	0
	Statistics																	
	Mean	0.9742	5.5	36,454.5	35,305.6	-2.5807	1,811.93	1,559.61	-4.4981	11,243.7	10,505.5	-3.3964	43,392.6	43,392.6	0	543.5	1,054.71	56.7947
	Max	1	14	73,310	73,310	0	8,347	6,135	0	53,740	47,562.2	0	94,884	94,884	0	4,264	7,731.78	753.342
	Min	0.885	1	11,563	11,563	-11.496	178	178	-38.34	775	775	-17.111	21,977	21,977	0	-6,851	-6,851	-271.68
	St Dev	0.036	5.5157	19,953.3	18,793.4	3.6024	2,445.42	1,864.4	10.0632	13,349.6	11,795.3	5.2685	25,001.2	25,001.2	0	2,461.33	2,989.59	219.061

Source: Authors' calculations using the DEA model - DEA-Solver

4. REGRESSION ANALYSIS OF THE EFFICIENCY OF TRADE COMPANIES IN SERBIA

Using regression analysis, the authors have investigated the impact of specific factors on the efficiency of the observed companies in Serbia. The linear regression equation is:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + e$$

where X means profit, a and b are coefficients, and e is the random error.

From this equation it follows that the efficiency is a function of the cost of goods sold, the earnings per employee, capital, revenue, and profits.

Table 9 and Figure 2 show the results of regression analysis.

Table 9. Regression analysis of the efficiency of the observed companies in Serbia

Model summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.846[a]	.716	.538	.02448	.716	4.033	5	8	.040	2.510

a. Predictors: (Constant), Profit, Earnings Per Employee, Cost Of Goods Sold, Capital, Revenue

b. Dependent Variable: Model = SSR – I, Score (efficiency)

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.012	5	.002	4.033	.040[b]
	Residual	.005	8	.001		
	Total	.017	13			

a. Dependent Variable: Model = SSR – I, Score (efficiency)

b. Predictors: (Constant), Profit, Earnings Per Employee, Cost Of Goods Sold, Capital, Revenue

Coefficients[a]

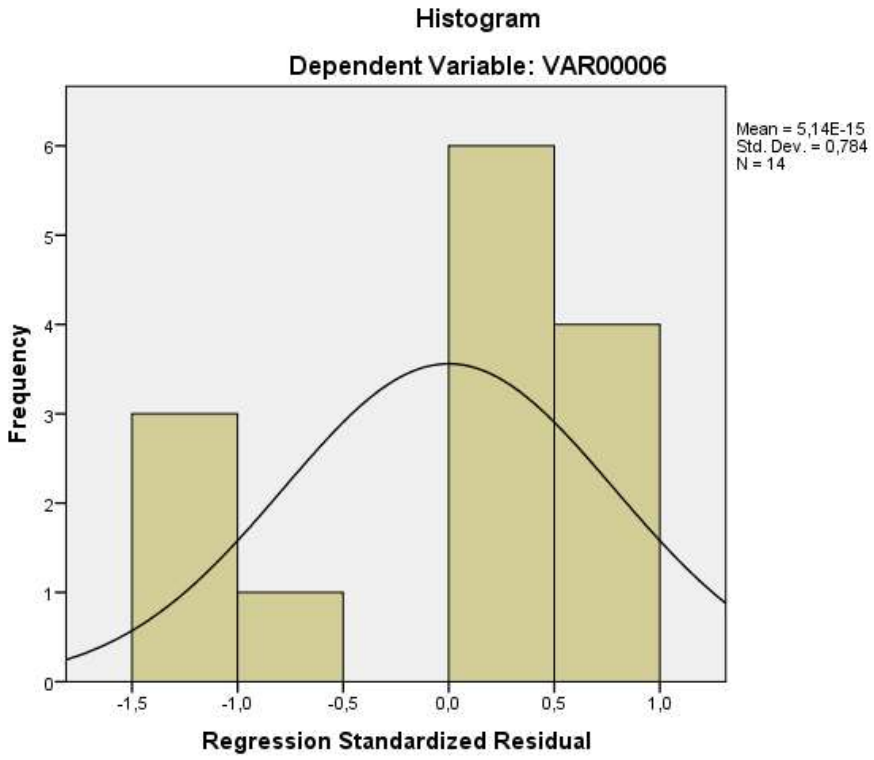
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-orde	Partial	Partial
1	(Constant)	.956	.026		37.238	.000			
	Cost of goods sold	-1.145E-005	.000	-6.342	-2.183	.061	-.312	-.611	-.411
	Earnings per employee	-2.826E-005	.000	-1.918	-2.028	.077	-.557	-.583	-.382
	Capital	-4.016E-006	.000	-1.488	-1.815	.107	-.700	-.540	-.342
	Revenue	1.226E-005	.000	8.505	2.255	.054	-.395	.623	.425
	Profit	3.889E-007	.000	.027	.075	.942	-.385	.027	.014

a. Dependent Variable: Model - SSR – I, Score (efficiency)

Source: Authors' calculations using the SPSS

The impact of these factors on the efficiency of the observed companies in Serbia is significant (adjusted R Square .538; Sig. F Change .040). This applies in particular to the costs of goods sold and revenue.

Figure 2. Histogram of the efficiency of the observed companies in Serbia (Note: VAR00006 - Efficiency)



Source: Figure created by the authors

5. CONCLUSION

The conducted empirical research using the DEA approach shows that in the SSR - I model with constant returns to scale, eight of the 14 companies are efficient, while six are inefficient. The SSR – O model with constant returns to scale shows the same results. In the BCC - I model with variable returns to scale, twelve companies are efficient, while two are inefficient. The BCC – O model with variable returns to scale shows the same results. Delhaize Serbia retail chain is efficient in the BCC - I and the BCC – O models, but inefficient in the SSR - I and SSR – O models.

To improve its efficiency in the future, Delhaize Serbia needs to manage its input more efficiently, i.e. to optimise it. Moreover, the research results indicate that this company should reduce earnings per employees by RSD 2,240.67 million (26.84%) and increase profit by RSD 3,467.78 million (81.32%). The same should be done by other inefficient companies in Serbia (Nelt Co., Phoenix Pharma, Delta Agrar, Metro Cash & Carry, and DIS). Mercator-S is efficient in both DEA models. Delhaize Serbia and Mercator-S, as the top two companies in Serbia, control the retail market. Such market position has had a positive impact on their efficiency. The results further show

that, in the case of Delhaize Serbia, the cost of goods sold, earnings per employee, and capital increased by -11.496%, -38.34, and -11.496%, respectively, while profit decreased by 81.327% in comparison to projections. This has negatively impacted the company's effectiveness. Similar results were obtained for other inefficient companies. As far as efficient companies are concerned, for example Mercator-S, the input/output data match the projections.

Companies engaged in the trading in petroleum products (Mol Serbia, Knez Petrol, OMV Srbija, Lukoil Srbija) are efficient in both DEA models.

In order to increase the overall efficiency of the commercial sector in Serbia, it is necessary to reduce spending on salaries and capital by RSD 160,048 million and RSD 135,560 million, respectively, and increase profit by RSD 511,213 million.

The results of the regression analysis demonstrate that the factors considered (the cost of goods sold, earnings per employee, capital, revenue and profit) have a major impact on the efficiency of the observed companies in Serbia.

In the radial super-efficiency model, the number of inefficient trade companies in Serbia is significantly higher. However, based on the results of the empirical research, it may be concluded that, overall, the efficiency of these companies in Serbia is satisfactory. In order to increase their efficiency in the future, it is necessary to employ contemporary methods for the management of costs, human resources, capital, assets, financial leverage, sales revenues, and profits. In addition, companies need to take advantage of the benefits of modern information and communication technologies, some Japanese business concepts, multichannel retail, and organic product sales. Developing a private label is another useful tool for increasing corporate efficiency.

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