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Short Communication

Dea ranking of municipalities of the Republic of Serbia based on efficiency of SMEs in agribusiness [4]

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Abstract: *The most important aspect of any business is efficiency. The goal is to achieve a greater output results using less inputs, i.e. to maximize the use of available inputs. Numerous mathematical and statistical procedures, such as DEA technique (Data Envelopment Analysis), take an important place in the process of the effective management of the company and its business activities. This paper illustrated the application of DEA technique in assessing the business efficiency of SMEs in agribusiness in Vojvodina Measuring the efficiency of business operations of SMEs is based on the values of the following indicators: fixed assets, working capital, number of companies, number of employees, total income, profit and loss. The data used to calculate the values of indicators of business efficiency were obtained from the Statistical Office of the Republic of Serbia, based on the annual accounts of SMEs in agribusiness for four-year average (2008-2011). The aim of this paper is statistical assessment of business efficiency of SMEs in agribusiness using DEA technique, and then, based on the results obtained, to perform the ranking of Vojvodina municipalities in which observed SMEs were located, and finally, based on 4 models, to show sensitivity of DEA technique compared to different combination of input / output indicators, so therefore, caution is needed when this method is used. If the combination of parameters in the model is better, the results are more realistic, since if a key parameter is omitted, wrong decisions could be made.*

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***Key words**: small and medium-sized enterprises (SME), business efficiency, DEA technique, agribusiness.*

Dea pristup rangiranju opština prema efikasnosti msp u agrobiznisu Srbije

***Apstrakt:** Najvažniji aspekt svakog poslovanja jeste efikasnost. Cilj je da se uz što manje ulaze postignu što veći izlazni rezultati, tj. raspoloživi ulazi maksimalno iskoriste. Brojne matematičko-statističke procedure, poput tehnike DEA (Data Envelopment Analysis) analize, zauzimaju značajno mesto u procesu merenja efikasnog upravljanja preduzećima i njegovim aktivnostima. U radu je ilustrovana primena DEA tehnike u oceni efikasnosti poslovanja MSP u agrobiznisu u Vojvodine. Merenje efikasnosti poslovanja malih i srednjih preduzeća se zasniva na vrednostima sledećih pokazatelja: stalna imovina, obrtna sredstva, broj firmi, broj zaposlenih, ukupan prihod, dobit i gubitak. Podaci koji se koriste za izračunavanje vrednosti pokazatelja efikasnosti poslovanja dobijeni su iz Zavoda za Statistiku, a na osnovu završnih računa MSP u agrobiznisu za četvrogodišnji prosek (2008-2011 god.). Cilj istraživanja ovog rada je, najpre statističko ocenjivanje efikasnosti poslovanja MSP u agrobiznisu primenom DEA tehnike, a zatim da se na osnovu dobijenih rezultata izvrši rangiranje opština Vojvodine kojima pripadaju posmatrana MSP i najzad da se na osnovu 4 modela pokaže koliko je DEA tehnika osetljiva metodologija na promenu kombinacija ulazno/izlaznih indikatora, zbog čega se mora biti vrlo obazriv u primeni iste. Što je kombinacija parametara u modelu bolja to su i rezultati realniji, jer ako se izostavi neki ključan parametar mogu se doneti pogrešne odluke.*

***Ključne riječi:** mala i srednja poduzeća (MSP), efikasnost poslovanja, DEA tehnika, agrobiznis.*

1. Introduction

New technologies afford higher yields, and the new principles of management of agricultural enterprises provide an opportunity to increase business efficiency. In times of economic crisis, there is a need for optimizing business operations and increasing efficiency, in order to ensure profitability of the agricultural sector. Small and medium-sized enterprises in agribusiness have an important role in the realization of these goals (Ceranić and Maletic, 2010; Maletic, Ceranic & Popovic, 2011; Popovic et al., 2011). Therefore, it is necessary to continuously perform efficiency evaluation of their business. Small and medium entrepreneurship in Serbia according to the number of companies, as well as business results, is the most represented in Vojvodina, so, further research will be focused only on the region of Vojvodina.

Measuring the business efficiency of production subjects can be performed using different statistical techniques. One of them is DEA (Data Envelopment Analysis) methodology. The main characteristic of DEA method is that each DMU (Decision Making Unit) is estimated as a relatively efficient or a relatively inefficient. DEA methodology is significantly expanded during the last 30 years. In addition to the agricultural sector, this technique has significant application in the field of testing the efficiency of the banking sector, education sector, etc. (Milind, 2003; Mohamed, 2006; Mihailovic, Bulajic & Savic, 2009; Bulajić et al. 2011a; 2011b; Maletic, Kreca & Bucalo, 2012).

Efficiency evaluation of the agricultural sector is an interesting topic of many authors (Shenngen & Xiaobo, 2002, Jirong, Eric & Gail, 1998). Lilienfeld and Asmild (2007) in their studies have used DEA technique to determine the influence of labor, fertilizers, irrigation, capital and seeds on yields of various crops. Other authors have determined the efficiency of meat and grain production based on inputs such as mechanization, labor, fertilizers, sown area (Monchuk, Chen & Bonaparte, 2010). Author whose data and work are the most appropriate to analysis applied in this paper is Vennesland (2005). He questioned the efficiency of the agricultural sector in Norway, which generally speaking was in problem. DEA model was introduced as a new way of testing the efficiency. By introducing and applying this method it was concluded that 13 of the 18 areas are inefficient and that their business operations could be improved. Efficient and inefficient areas were singled out, and it was noted where and why there are losses. There are also studies on measuring the efficiency of entities in the field of agriculture in Serbia (Maletic and Popovic, 2013).

The aim of this paper is a statistical assessment of business efficiency of SMEs in agribusiness, and furthermore, the obtained results will be used for ranking the municipalities in Vojvodina (total of 45) based on the following selected indicators: total income, fixed assets, working capital, loss, profit, number of employees, number of companies. Each in a special way measures development level and the representation of SMEs. Measuring of business efficiency will be calculated using DEA methodology. Numerous changes have necessitated development of new models, but in this paper AP (Andersen Petersen) model will be presented. It is a model that measures the superefficiency, and is very suitable for ranking the observation units. Furthermore, it will be observed how changes of input / output indicators affect the final results. Respectively, the efficiency of utilization of input indicators will be measured based on four defined models, and thus provide guidance to improve the outputs, especially total income. The data were obtained from The Statistical Office of the Republic of Serbia, based on the annual accounts of SMEs in agribusiness for four-year average (2008-2011). Considering the paper objectives, working hypotheses were formulated: assessing the business efficiency of SMEs in agribusiness in Vojvodina municipalities, based on the results obtained, to perform the ranking by using appropriate methodology, and finally to define several models with different combination of input / output indicators that would show differences in obtained ranks, in order to indicate sensitivity of DEA technique compared to different combination of indicators.

2. DEA methodology

DEA is a technique specifically designed to measure the efficiency of complex entities with various inputs and outputs. The initial goal of the DEA was to measure the performance of non-profit organizations, but in recent years, its use has expanded to the profit sector as well. Based on the results of this analysis, it is possible to determine the inefficiency of individual *Decision Making Units* (DMU), compared to effective units.

Also, another good aspect of this methodology is that the inputs and outputs do not have to meet any requirements, but it is important that they are homogeneous in all DMU which are being compared. Based on the available units, a line that represents efficiency limit ("envelope") is constructed. This line for the efficient units represents maximum output that each unit can achieve with the given inputs and an ‘‘envelope’’ for the inefficient units. From the aspect of “envelopment”, there are two ways - enveloping inputs from the bottom and enveloping outputs from the top.

The essence of DEA methodology is to provide data to a manager related exclusively to the particular moment of observation and based on the data entered. Therefore, DEA is not a forecasting technique and the obtained data are not valid for some further research. Also, DEA technique determines the efficiency only in terms of the observed DMU, i.e. it evaluates the efficiency of each DMU based only on entered data (inputs and outputs) and comparing with other DMU. For each inefficient DMU, DEA analysis identifies the sources and the levels of inefficiency for both the inputs and outputs. It is possible to determine the level of inefficiency by comparison to a single DMU or a convex combination of other reference DMU, located on efficient boundary and using proportionally the same level of inputs, and producing proportionally the same or higher level of outputs.

Numerous models have been created due to development of DEA methodology: CCR (Charnes, Cooper and Rhodes), BCC (Banker, Charns and Cooper), AP (Andersen-Petersen) etc.

The model that was used in this study is defined by Andersen & Petersen (1993) AP, which measures the super efficiency and is extremely suitable for ranking the DMU:

$$(Max)h_k = \sum_{r=1}^{s} \mu_r y_{rk} \qquad (1)$$

by constraints

$$\sum_{i=1}^{m} v_i x_{ik} = 1 \qquad (2)$$

$$\sum_{r=1}^{s} \mu_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0, \quad j = 1, 2, ..., n \quad j \ne k \qquad (3)$$

$$\mu_r \ge \varepsilon, \quad r = 1, 2, ..., s \qquad (4)$$

$$v_i \ge \varepsilon, \quad i = 1, 2, ..., m \qquad (5)$$

The optimal values of efficiency scores h_k are obtained by solving the linear model (1)-(5) k-times (once for each DMU in order to compare it with other DMUs). Efficiency score h_k is greater or equal to 1 for all efficient units and smaller than 1 for inefficient units. In this way, ranking of units, according to their efficiency, is enabled. The smaller value of efficiency score h_k the less efficient is the unit.

The result of this model shows how a unit can be deteriorated and still be effective (those over 100%), and therefore the one with the highest score was the highest-ranked, while the one with the lowest score was ranked last.

Ranking of Vojvodina municipalities was made based on the performance of selected indicators that accompany development of small and medium enterprises in agribusiness, using the software EMS (*Efficiency Measurement System*), (Scheel H., 2000).

3. Ranking of Vojvodina municipalities

Of all the indicators, four models were created. These models are developed independently, and then the results are compared, since one of the goals of this research is to examine sensitivity of DEA methodology to change of the input/output parameters (Table 1).

Data analysis in this paper assumes that income and profit are the most important for ranking (which are considered as DEA outputs), followed by working capital and assets which are considered as inputs. Factors that determine the size, i.e., the scope of agriculture in the municipalities, the number of companies and number of employees, will be considered as the least important for analysis, for each municipality. As already known, each DMU, in this case the municipality, will assign different importance to each factor, in order to approach the efficiency limits. Therefore, if there is a need to make an objective ranking, where the DMU are compared to the efficiency limits and exemplary units, it is advisable to apply DEA methodology.

Table 1. The use of different DEA models

Models	Inputs	Outputs
Alfa Model*	Fixed assets Working capital Number of companies	Number of employees Total income
Beta Model	Fixed assets Working capital Loss	Profit
Gamma Model	Fixed assets Working capital Number of companies	Number of employees Total income Profit
Delta Model	Fixed assets Working capital Number of companies Number of employees	Total income Profit

* Note: The model names were appointed by the authors

Based on the results of the four models, super efficiency scores of SMEs in agribusiness in Vojvodina municipalities were obtained. The same results are used for ranking and are presented in Table 2.

Table 2. Ranking based on four DEA models

Municipalities	Alfa		Beta		Gamma		Delta	
	Score (%)	**Rank**	**Score (%)**	**Rank**	**Score (%)**	**Rank**	**Score (%)**	**Rank**
Ada	56.67	43	5.46	41	56.67	43	54.30	40
Alibunar	81.49	28	11.94	34	81.49	31	64.68	35
Apatin	73.01	33	11.56	35	73.36	33	62.97	36
Bac	111.42	6	26.27	24	111.42	9	98.30	13
Bac. Palanka	81.56	27	14.91	31	81.56	30	79.18	25
Backa Topola	92.27	17	55.84	10	99.88	17	99.15	12
Bac. Petrovac	102.21	11	24.57	25	102.21	16	101.36	11
Becej	153.62	1	246.16	1	153.62	3	150.93	2
Bela Crkva	94.34	15	6.81	39	94.34	21	60.17	38
Beocin	85.22	21	10.18	36	85.22	26	88.22	18
Coka	112.08	5	1.59	43	112.08	8	66.03	34
Indjija	99.38	13	106.97	6	134.81	6	124.33	6
Irig	96.18	14	26.92	23	96.18	18	51.10	43
Kanjiza	114.28	4	127.31	3	159.91	1	133.99	4
Kikinda	63.48	40	37.02	18	70.13	39	67.57	33

Kovacica	85.30	19	108.62	5	110.21	10	127.80	5
Kovin	64.29	39	27.07	22	64.52	41	61.95	37
Kula	69.54	35	110.56	4	116.21	7	113.70	8
Mali Idjos	105.96	8	39.82	17	107.43	12	92.97	15
Nova Crnja	81.92	26	31.50	20	86.50	24	56.06	39
Novi Becej	70.14	34	3.66	42	70.14	38	69.30	31
N. Knezevac	47.63	44	7.44	38	47.63	44	45.39	44
Novi Sad – city	119.42	3	91.12	7	137.47	5	145.74	3
Odzaci	85.28	20	34.27	19	85.81	25	75.95	26
Opovo	104.77	10	0.00	45	104.77	14	68.64	32
Pancevo	83.66	23	130.58	2	159.42	2	154.75	1
Pecinci	58.58	42	18.59	29	58.58	42	51.66	42
Plandiste	44.27	45	5.83	40	44.27	45	39.75	45
Ruma	59.40	41	69.90	8	70.33	37	82.74	19
Secanj	83.32	24	21.57	27	83.61	27	81.17	23
Senta	107.92	7	12.90	33	107.92	11	109.63	9
Sid	68.67	36	51.96	12	72.28	35	72.53	29
Sombor	84.90	22	56.98	9	95.73	19	90.49	17
Srbobran	81.00	29	41.48	16	86.54	23	72.11	30
Sr. Mitrovica	76.45	31	43.49	13	81.09	32	80.45	24
Sr. Karlovci	150.63	2	0.34	44	150.63	4	81.56	21
Stara Pazova	73.17	32	13.78	32	73.32	34	75.54	27
Subotica	78.66	30	53.48	11	82.52	28	81.22	22
Temerin	67.57	37	19.22	28	68.48	40	53.75	41
Titel	105.02	9	16.31	30	105.02	13	101.79	10
Vrbas	101.55	12	23.13	26	102.23	15	124.26	7
Vrsac	92.56	16	42.73	15	92.67	22	92.85	16
Zabalj	82.44	25	9.39	37	82.44	29	82.29	20
Zitiste	67.53	38	30.46	21	70.69	36	72.73	28
Zrenjanin	90.67	18	43.44	14	95.15	20	94.77	14

Source: Author's calculation

What is noticeable in this table is that there are big differences between ranks of individual municipalities. Therefore, before any further analysis of the causes which determine the differences, the degree of rank correlation of the tested models will be defined (Table 3). Gamma and Delta models have a positive and statistically significant correlation with the first two models. This shows that a set of inputs and outputs (the most numerous one) in gamma and delta models describes the efficiency more comprehensively. Accordingly, a number of indicators included in the analysis, define several municipalities as effective, considering that the efficiency is seen from different angles. In other words, DEA analysis aims to find what is best in each municipality.

Table 3. Correlation of ranks

Models	Alfa	Beta	Gamma	Delta
Alfa	-	0.12^{ns}	0.88**	0,613**
Beta		-	0.38**	0,61**
Gamma			-	0,76**
Delta				-

ns- non significant   ** - significant at P ≤ 0.01

Differences in ratings are best to explain through examples of individual municipalities. *Becej* is the only municipality that has been ranked highly in all four models, twice in the first and once in the second and third place. Regardless of inputs or outputs that have been observed, there was always a high efficiency in the municipality, primarily because the municipality has a small number of companies, but has very good results, and thus leaves behind municipalities that are much bigger but inefficient since most of the companies do not operate well enough.

The interesting part of this analysis refers to municipalities of *Bac, Coka, Senta, Sremski Karlovci and Titel.* Namely, all of these municipalities have achieved relatively high ranks in Alpha and Gamma model, but not so well in Beta and Delta model. The main difference, compared to the Alpha and Gamma model, is that the Beta model included a loss as an input. Perhaps the key factor for this difference in the rankings is that the Beta model has only one output, and that is profit. In this way, other business factors were not considered, and municipalities that have made small profit were initially positioned worse. This is exactly the case with these municipalities because they all had small profits in the observed time period. However, when the outputs include additional indicators, such as number of employees and total income, the situation is significantly changed. In this case, a much "wider" picture in efficiency evaluating is observed, and other business results are reviewed. Thus, municipality that achieves better results for a given output gets better ranked. The more output factors included in the analysis, the more municipalities would become effective. Also in the case of Gamma and Delta models, it can be seen that significant differences occur in efficient and inefficient municipalities as a result of the transfer of only one output indicator on the input side (number of employees, since in the second case is seen as a resource or input). The reverse situation is in the case of Ruma and Sombor municipalities because they are high ranked in Beta model and low-ranked by Alpha and Gamma model. The reasons are the same as in municipalities mentioned above, except, in this case, the number of companies should be highlighted as an important factor. When this indicator is included as an input, then municipalities are ranked low - considering the large number of companies they are not efficient. When the number of companies is not considered, then the efficiency increases. Municipalities of *Kula* and *Pancevo* are also very interesting, because they are low ranked by Alpha model, whereas in the remaining three models are highly ranked, especially the *Municipality of Pancevo*. The main reason for this is that profit is now included in the analysis. These two municipalities are among the leaders of the Province in terms of profit, and this factor has a great impact on their overall ranking. Therefore, DEA is not only sensitive in terms of the total number of inputs and outputs. If, for example, a dominant indicator is included in the analysis, the final results could be changed completely.

4. Conclusion

Efficiency is tested through four models that differed only in various combinations and numbers of input / output indicators. Thus, the resulting ranks are used for DEA sensitivity analysis on a variety of input and output parameters.

Based on the applied DEA models, super efficiency of all small and medium-sized agricultural enterprises in Vojvodina was measured. Based on these results, ranking of municipalities was carried out. Generally, the results were significantly different within the applied models. However, there were municipalities (e.g. Bečej, City of Novi Sad) that occupied a high position in all models (alpha, beta, gamma and delta), because they have a small number of firms that achieved very good results, and left behind the municipalities that are much larger but inefficient, because their companies often do not operate well enough. Also, some municipalities (Plandište, Novi Kneževac, Pećinci) based on all four models take the last places in the rank. This suggests that SMEs in these municipalities underuse their input indicators (regardless of their combination), and are very inefficient.

The most of municipalities had a different rank by models, because SMEs in these municipalities have a various types of reactions regarding the change of input indicators. In fact, even with the smallest changes in the data, the final order can be significantly changed (best demonstrated for the indicator of profit). The more indicators in the analysis, the more DMU (municipalities) would appear to be effective, due to the fact that efficiency will be considered from several aspects, and the DEA will find what is best for each DMU (evidenced by gamma model, with most inputs and outputs, and thus the most efficient units). It can be said that DEA technique is extremely sensitive and decision-making, and if the goal is to get the most realistic and reliable picture of efficiency of all the entities, then all inputs and outputs factors that are most relevant should be chosen. If the parameters are better introduced into the model, the result will be better, because leaving out a key parameter can lead to wrong decisions. What it suggests as a conclusion is that different methods can lead to different results in the selection of those groups of independent variables that best explain the observed phenomena, even when using identical data.

In other words, DEA measure of efficiency is relative, since it depends on the entities included in the analysis and the number of these entities, as well as the number and structure of inputs and outputs.

Results obtained in the study are in accordance with the analysis of Gverovski et al. (pp. 87-94, 2011). Namely, the number of SMEs presents an indicator that directly determines the level of development of all the other input indicators, and, accordingly, the overall development of a municipality.

References

Andersen P. & Petersen N. A. (1993): A Procedure for Ranking Efficient Units in Data Envelopment Analysis, *Management Science*, 39(10), 1261-1264.

Bulajić M., Savić G., Savic S., Mihailović N., Martić M. (2011a): Efficiency assessment of banks in Serbia*. TTEM- Technics Technologies Education Management*, Bosnia and Herzegovina, Sarajevo, 6 (3), 657-662.

Bulajić M., Savić G. & Savić S. (2011b): *DEA approach in ranking the banks in Serbia.* Paper presented at the XXXVIII Symposium on Operational Research. Faculty of Economics, University of Belgrade. The Proceedings *SYMOPIS-2011*, (pp.134-137).

Ceranic S. & Maletic R. (2010): Small and medium enterprises as development factor of agribusiness in Republic of Serbia. *Apstract magazin*, Hungary, 4 (3-4), 45-50.

Gverovski, M., Risteska A. & Dimeski S. (2011): Small and medium enterprises: economic development drivers. *Management*, 16 (59), 87-94.

Jirong, E., & Gail (1996):). A Shadow-Price Frontier Measurement of Profit Efficiency in Chinese Agriculture. *American Journal of Agricultural Economics*, 78(1), 146-156.

Lilienfeld A. & Asmild M. (2007): Estimation of excess water use in irrigated agriculture: A Data Envelopment Analysis approach. *Agricultural water management*, 94, 73–82.

Maletic R., Ceranic S. & Popovic B. (2011): Small and medium enterprises as factors in reducing poverty in rural communities Serbian, *Economics of Agriculture*, Belgrade, 57 (1), 121-132.

Maletic R., Kreca M. & Bucalo D. (2012): *DEA technique in a function of measuring banks efficiency*. Paper presented at the "Life Cycle Engineering and Management", The Proceedings DQM-2012, pp.429-435, Belgrade

Maletic R., Maletic P., Kreca M. & Popovic B. (2013): Comparative analysis of ranking municipalities in Vojvodina using DEA and I-distance methods. *Int. J. Agricult. Stat. Sci.*, 9 (2): 471-480.

Milind S. (2003): Efficiency of banks in a developing economy: The case of India. *European Journal of Operational Research*, 148 (3), 662-671.

Mihailovic, N., Bulajic, M., & Savic, G. (2009). Ranking of banks in Serbia. *YUJOR*, 19 (2), 323-334.

Mohamed M. (2006): Modeling the efficiency of GCC banks: a data envelopment analysis approach. *International Journal of Productivity and Performance Management* 56 (7), 623-643. Doi: 10.1108/17410400710823651

Monchuk C.D., Chen Z. & Bonaparte Y. (2010): Explaining production inefficiency in China's agriculture using data envelopment analysis and semi-parametric bootstrapping. *China Economic Review*, 21 (2), 346–354.

Popovic B., Maletic R., Ceranic S., Paunovic T. & Jankovic-Soja S. (2011): Defining homogenous areas of Serbia based on development of SME in agribusiness using the cluster analysis. *TTEM - Technics Technologies Education Management*, Bosnia and Herzegovina, Sarajevo, 6, (3), 811-818.

Shenngen F. & Xiaobo Z. (2002): Production and productivity growth in Chinese Agriculture: New National and Regional Measures. *Economic Development and Cultural Change*, The University of Chicago.

Scheel H. (2000): EMS - Efficiency Measurement System User's Manual. Version 1.3. http://www.wiwi.uni-jena.de/Mikro/pdf/ems.pdf, April 10, 2014

Vennesland B (2005): Measuring rural economic development in Norway using data envelopment analysis.