COST EFFICIENCY OF AGROINDUSTRIAL COMPANIES IN VOJVODINA: DEA APPROACH

Vunjak Nenad, Ph.D.[1], Davidović Milivoje[2]
[1]University of Novi Sad, Faculty of Economics in Subotica, Republic of Serbia, vunjakn@ef.uns.ac.rs
[2]University of Novi Sad, Faculty of Economics in Subotica, Republic of Serbia, milivojed@ef.uns.ac.rs

Abstract

The aim of this study is to assess the cost efficiency of 25 agro-industrial companies in Vojvodina. The analysis covers the period from 2010 to 2012, and the efficiency of the companies is estimated using the non-parametric DEA techniques. Data Envelopment Analysis (DEA) is a linear programming technique that estimates technical efficiency using the input-output model. This paper will apply an input oriented model with (a) constant returns to scale (CCR model), (b) variable returns to scale (BCC model). Results of CCR and BCC models indicate that the agro-industrial sector in Vojvodina increased the average efficiency score (from 80.45% to 86.97% (CCR) and from 89.37% to 90.74% (BCC)). Also, research indicates that the introduction of bankruptcy proceedings coincided with improving the efficiency scores and ranking of some companies.

JEL Classification: D24, L16

Keywords: cost efficiency, agro-industrial companies, DEA approach, BCC model, CCR model

1.Introduction

Intersectoral analysis of comparative advantages suggests that the agro-industrial sector could be a generator of development propulsion in Serbia. The agriculture and food industry in Serbia have the potential to generate extraordinary positive externalities on other sectors of the economy (Davidović; 2014, 229). The importance of the agro-industrial sector in Serbia is confirmed by official data of economic statistics. According to the Statistical Office of the Republic of Serbia, the share of gross value added in the agricultural sector in the gross domestic product of the Republic

of Serbia in the last ten years is 11.3%, while one-fifth (20%) of the gross domestic product is created by agro-business companies. Also, the agriculture and food industry participates in the overall export of Republic of Serbia with 20.9% (average for the last 9 years), and an aliquot portion of imports that can be attributed to these activities is only 6.8%. Moving toward a more efficient, competitive, export-oriented, healthier and more sustainable food system is a process that involves tackling longstanding challenges and addressing more sophisticated demands at both the theoretical and the empirical level (Adžić & Bolozan; 2013, 859). Bearing in mind the above, the efficiency of the agribusiness company is *a conditio sine qua none* of the economic development of Vojvodina (Vunjak; 2008, 62).

Empirical studies dealing with the evaluation of the efficiency of DMU (companies and banks) typically use two techniques: parametric Stochastic Frontier Analysis (see Farsi, Filippini & Kuenzle; 2006, Kiyota; 2009, Hasan et. al; 2011, Holmgren; 2013) and non-parametric Data Envelopment Analysis (see Johnes; 2009, Yusof et. al.; 2010, Nigmonov; 2010, Castellanos & Garza-Garcia; 2013) or both at the same time (see for example Andries & Cocris; 2010, Král & Rohácova; 2013).

Analysis of efficiency and growth potential of companies in the agro-industrial sector should be the starting point for designing the model for sustainable economic development of Serbia. Therefore, the main objective of this study is to assess the relative efficiency of 25 agribusiness companies from Vojvodina in the period 2010-2012. DEA approach will be used to assess the cost efficiency - input oriented model with constant (CCR model) and variable (BCC model) return to scale. Both models will include two input variables (operating expenses and financial expenses) and two output variables (operating income and financial income).

2. Data and methodology

The data set includes annual operating and financial revenues and expenditures of the 25 agro-industry companies in Vojvodina in the period 2010-2013. Data are taken from official financial statements provided by the Serbian Business Registers Agency. To measure efficiency scores, we used Efficiency Measurement System (EMS) software.

DEA evaluates efficiency compared to the reference (benchmark) organizational unit that has been identified as the most effective. DEA is then based on a postulate of uniform error model. This implies that deviations in efficiency can be

caused by random factors: any form of deviation in the current efficiency and the estimated efficiency frontier represents inefficiency. It is also the main drawback of this technique, since there are possible errors in assessing the effectiveness of individual DMU and in assessing the reference benchmark value - the efficiency frontier. However, the utility value of DEA methodology stems from a number of advantages (Kho-Fazari et al.; 2013, 1-2): (a) it does not require *a priori* assumption in the context of data distribution, (b) it gives the possibility of simultaneous "handling" of multiple input and output variables, without previous assessment of their relative importance, (c) it results in a single measure of DMU performances.

According to Chen-Guo et al. CCR model can be conceived as follows (Chen-Guo et al.; 2007, 51-53):

$$\begin{cases} Max\, h_{j0} = \sum_{k=1}^{s} u_k y_{kj0} \\ s.t. \sum_{i=1}^{m} v_i x_{ij0} = 1 \\ \sum_{k=1}^{s} u_k y_{kj} - \sum_{i=1}^{m} v_i x_{ij} \leq 1, j = 1, \ldots, n \\ u_k \geq 0 \quad k = 1, \ldots, s; v_i \geq 0 \quad i = 1, \ldots, m. \end{cases} \tag{1}$$

If $h_j = 1$, DMU_j is relatively efficient, which implies that it is positioned on the efficiency frontier (production frontier). If $h_j > 1$, DMU_j is relatively inefficient. The more h_j is "distant" from 1 to 0 (further from the efficiency frontier), DMU_j is less efficient (relatively inefficient). To improve the utility value of basic CCR model, the A-P super-efficiency model is used. The results of super-efficiency establish rank of DMU that are relatively efficient. CCR model is based on the hypothesis that potential production set is convex. However, if the product set is not convex, then BCC model is used to evaluate the effectiveness of the DMU. Assuming nDMUs: (x_j, y_j), $x_j \in R_m, y_i \in R_s$, $j = 1,\ldots,n$, BCC model can be conceived as follows:

$$(D) \begin{cases} Min\theta = V_D \\ s.t. \sum_{j=1}^{n} \lambda_j x_j \leq \theta x_0 \\ \sum_{j=1}^{n} \lambda_j y_j \geq y_0 \\ \sum_{j=1}^{n} \lambda_j = 1 \\ \lambda_j \geq 0, j = 1, \ldots, n. \end{cases} \tag{2}$$

Moreover, if ω ∈ Rm, μ ∈ Rs, duality (D) has the following algebraic expression:

$$(P)\begin{cases} Max(\mu^T y_0 + \mu_0) = V_P \\ s.t.\ \omega^T x_j - \mu^T y_0 - \mu_0 \geq 0, j = 1,\ldots,n \\ \omega^T x_0 = 1 \\ \omega \geq 0, \mu \geq 0 \end{cases} \quad (3)$$

BCC model efficiency frontier is not sensitive to the variations in the volume of the input and output factors. This setting extends the DEA technique, since in this situation it is not necessary that the values of input and output variables are positive.

3. Research results

Descriptive statistics of input and output variables is the shown in Table 1.

Table 1: Descriptive statistics

Statistics	FIN INC	FIN EXP	OPER INC	OPER REV
Mean	195.0701	292.2713	5116.142	4520.947
Median	86.637	127.215	3734.888	3380.83
Maximum	1450.186	1550.662	21274.27	17992.76
Minimum	1.308	2.179	70.016	59.898
Std. Dev.	268.823	402.1339	5426.08	4631.609
Skewness	2.244987	1.996989	1.498152	1.437182
Kurtosis	8.799178	6.0789	4.408335	4.203569
Observations	75	75	75	75

Source: Author`s calculation

Individual and average efficiency score, ranking of companies by efficiency scores and ranking of superefficient companies are given in Appendix 1. The mark * indicates a super-efficiency score (shaded areas in the table). Companies that are effective have 100% score, but super-efficiency analysis showed companies that are most effective (with the highest score above 100%). However, for the calculation of the average score in the efficient companies, a score of 100% is used.

Results of the assessment of efficiency are very interesting. They point to several important implications. First, the results of both models indicate varying efficiency score. Extreme examples of this variability are Fidelinka, Ratar Pančevo, Bečejska Pekara, Trivit-Pek and Pik Bečej. Second, dramatic improvement in the technical

efficiency scores of companies Pik Bečej and Fidelinka Subotica coincides with the initiation of bankruptcy proceedings. This implies that the bankruptcy authorities significantly improved the efficiency of these companies. Third, from all of the companies in the sample, only Galenika-Fitofarmacija and meat industry Matijević remained on the efficiency frontier (CCR and BCC estimate). Fourth, the implementation of the BCC model marked a larger number of efficient companies, than in the case of CCR model results. Fifth, the average score for the agro-industrial sector tends towards the efficiency frontier. This indicates that the agro-industrial companies in Vojvodina have constantly increased the technical efficiency. Bearing in mind the implemented input oriented model, the companies reduced the input variables volume from year to year (operating expenses and financial expenses) in order to achieve a constant quantum of output variables (operating income and financial income).

4. Conclusion

Subject of the research presented in this paper is the technical efficiency of agro-industrial sector in Vojvodina. Evaluation of effectiveness is realized by implementing CCR and BCC models. Also, we have exploited the input oriented model to determine whether the company can reduce the quantum of inputs (operating and financial expenses), in order to realize a constant quantum of output (operating and financial income). The results indicate that some companies significantly increased/decreased efficiency score. Also, the initiation of bankruptcy proceedings coincides with the recent increase in the efficiency of the individual companies. In addition, the use of BCC model identified a number of companies which are relatively efficient. Finally, the agro-industrial sector has increased the average efficiency score in this period. In addition, a significant increase in efficiency was recorded through observation of the results of assessing the efficiency with CCR model.

References

1. Adžić, S. & Bolozan, Đ. (2013). Towards a Conceptualization of a New Food Production System in Slavonia and Vojvodina (Proceedings), Interdisciplinary Management Research IX, 9, 849-859.
2. Agarwal, S. (2009). Measuring the Efficiency of Public Transport Sector in India: An Application of Data Envelopment Analysis, available at: http://astro.temple.edu/~banker/dea2009/paper/Agarwal.pdf (accessed 10-02-2014)

3. Andries, M.A. & Cocris, V. (2010). A Comparative Analysis of the Efficiency of Romanian Banks, Romanian Journal of Economic Forecasting, 2010(4), 54 – 75, *ISSN* 1582-6163
4. Castellanos, G.S., Garza-Garcia, G.J., (2013), Competition and Efficiency in the Mexican Banking Sector, BBVA Research, Working Paper No. 13/29 available at: http://www.bbvaresearch.com/KETD/fbin/mult/WP_1329_Mexico_BankingSector_tcm348-405322.pdf?ts=10102013 (accessed 10-02-2014)
5. Chen-guo, D., Ting, L. &Jie, W., (2007), Efficiency Analysis of China's Commercial Banks Based on DEA: Negative Output Investigation, China-USA Business Review, 6(2) (Serijal No. 35), 50-56, *ISSN*1537-1514
6. Cooper, W.W., Seiford, L.M. & Tone, K. (2007). Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software, Springer, *ISBN*-10: 0387452818*; ISBN*-13: 978-0387452814, New York
7. Davidović, M., (2014), Finansiranje agrarne industrije u AP Vojvodini, Odeljak u monografiji: Adžić, S., Pejanović, R., Performanse i razvojne mogućnosti agrarne industrije u Vojvodini, str. 229-278, Univerzitet u Novom Sadu, Ekonomski fakultet u Subotici, Poljoprivredni fakultet u Novom Sadu, ISBN 978-86-49901-90-2, Novi Sad-Subotica
8. Farsi, M., Filippini, M. & Kuenzle, M.,(2006). Cost Efficiency in Regional Bus Companies: An Application of Alternative Stochastic Frontier Models, Journal of Transport Economics and Policy, 40 (1), 95–118, ISSN 0022-5258
9. Hasan, M. Z., Kamil A. A. & Baten, A. (2011). Measuring Dhaka stock exchange market efficiency: A stochastic frontier analysis, African Journal of Business Management, 5(22), 8891-8901, ISSN 1993-8233
10. Holmgren, J. (2013). The Efficiency of Public Transport Operations – An Evaluation Using Stochastic Frontier Analysis, Research in Transportation Economics, 39(1), 50-57, *ISSN* 0739-8859
11. Johnes, J. (2010). Efficiency of Islamic and conventional banks in the GCC (A comparison based on Financial Ratios and Data Envelopment Analysis), Lancaster Centre for Economic Research Report, Issue 1. available at: http://www.lancaster.ac.uk/media/lancaster-university/content assets/documents/lums/golcer/i1.pdf (accessed 10-02-2014)
12. Kho-Fazari, K., Yang, Z., Paradi, C.J., (2013), A Distribution-Free Approach to Stochastic Efficiency Measurement with Inclusion of Expert Knowledge, Journal of Applied Mathematics, 2013, 1-21 available at: http://dx.doi.org/10.1155/2013/102163 (accessed 10-02-2014)

13. Kiyota, H. (2009). Confronting the Global Financial Crisis: Bank Efficiency, Profitability and Banking System in Africa, available at: http://www.uneca.org/sites/default/files/page_attachments/aec2009hiroyukikiyoto.pdf (accessed 10-02-2014)
14. Král, P. & Rohácova, V., (2013), Measuring the Efficiency of Public Road Transport Companies in the Slovak Republic Using DEA and SFA, Statistika: Statistics and Economy Journal, 93(2), 76-85, ISSN 1804-8765 (Online), ISSN 0322-788x (Print)
15. Nigmonov, A. (2010). Bank Performance and Efficiency in Uzbekistan, Eurasian, Journal of Business and Economics, 3(5),1-25, ISSN 1694-5972
16. Vunjak, N., (2008), Finansijski menadžment (Poslovne finansije), Proleter a.d. Bečej, Ekonomski fakultet u Subotici, ISBN 978-86-84819-24-8
17. Yusof, K., Razli, R.A. & Tahir, M.I. (2010). An Evaluation of Company Operation Performance Using Data Envelopment Analysis (DEA) Approach: A Study on Malaysian Public Listed Companies, International Business Management, 4(2), 47-52, ISSN 1993-5250

Appendix 1: Efficiency scores and ranking of companies

Kompanija	CCR *			CCR rank			BCC*			BCC rank		
	2010	2011	2012	2010	2011	2012	2010	2011	2012	2010	2011	2012
CARNEX VRBAS	80.06	80.29	86.92	**16**	**17**	**13**	85.96	81.1	90.67	**16**	**19**	**15**
VETERINARSKI ZAVOD SUBOTICA	78.1	81.95	85.33	**20**	**15**	**16**	80.04	82.22	86.19	**21**	**18**	**17**
CRVENKA FABRIKA ŠEĆERA	84.68	87.89	92.60	**7**	**9**	**8**	146.47	94.80	96.14	**5**	**10**	**12**
BAG BAČKO GRADIŠTE	78.27	217.37	125.16	**19**	**2**	**2**	91.52	166.08	459.34	**13**	**5**	**5**
BANAT NOVA CRNJA	81.88	80.00	77.90	**13**	**19**	**21**	82.26	80.04	79.04	**19**	**20**	**22**
BANAT BANATSKI KARLOVAC	29.74	41.25	69.30	**25**	**25**	**25**	81.93	72.68	73.15	**20**	**25**	**24**
BEČEJSKA PEKARA	667.51	85.58	79.72	**1**	**11**	**18**	169.97	95.02	85.5	**4**	**9**	**18**
DUVANSKA INDUSTRIJA ČOKA	79.03	83.16	86.37	**17**	**13**	**15**	88.16	97.41	98.79	**14**	**8**	**10**
IMLEK	85.66	84.47	89.32	**6**	**12**	**10**	495.91	926.07	878.57	**1**	**1**	**1**
DIJAMANT	80.66	80.04	88.85	**14**	**18**	**12**	114.70	91.42	97.65	**8**	**14**	**11**
GALENIKA-FITOFARMACIJA	116.94	111.21	108.94	**3**	**3**	**3**	117.13	112.46	109.27	**7**	**6**	**6**
TRIVIT-PEK	80.56	93.38	156.47	**15**	**7**	**1**	140.29	94.36	597.18	**6**	**11**	**3**
VITAL VRBAS	86.73	76.42	77.02	**5**	**21**	**22**	102.87	78.37	79.08	**10**	**21**	**21**
ŽITKO	77.84	72.82	71.82	**21**	**24**	**23**	78.50	73.84	71.84	**22**	**24**	**25**
NEOPLANTA	78.9	82.95	84.7	**18**	**14**	**17**	84.65	85.85	88.18	**17**	**16**	**16**
MLEKARA SUBOTICA	82.64	79.94	78.68	**11**	**20**	**20**	87.52	82.23	80.17	**15**	**17**	**20**
RATAR PANČEVO	326	99.02	70.35	**2**	**5**	**24**	465.47	362.13	75.00	**3**	**4**	**23**
SEĆERANA ŽABALJ	84.62	86.78	89.77	**8**	**10**	**9**	91.53	88.97	91.2	**12**	**15**	**14**
TE-TO SENTA	83.98	96.02	95.67	**9**	**6**	**6**	112.63	109.77	101.92	**9**	**7**	**8**
PTUJ-TOPIKO	72.48	73.4	79.52	**22**	**22**	**19**	72.95	75.09	81.66	**23**	**22**	**19**
SOJA PROTEIN	82.04	80.36	86.40	**12**	**16**	**14**	95.64	93.76	94.78	**11**	**12**	**13**
DUKAT SOMBOR	83.5	90.49	95.13	**10**	**8**	**7**	84.00	91.67	107.18	**18**	**13**	**7**
MATIJEVIĆ	107.19	108.99	104.02	**4**	**4**	**5**	490.57	923.18	862.52	**2**	**2**	**2**
PIK BEČEJ	59.27	73.07	88.86	**24**	**23**	**11**	62.11	74.41	99.54	**25**	**23**	**9**
FIDELINKA SUBOTICA	60.55	336.14	106.53	**23**	**1**	**4**	67.61	479.78	462.76	**24**	**3**	**4**
Average score	80.45	84,37	86.97	----	----	----	89.37	89.33	90.74	----	----	----

Source: Author`s calculation