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УНИВЕРЗИТЕТ У БЕОГРАДУ
ФАКУЛТЕТ ОРГАНИЗАЦИОНИХ НАУКА

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DEA Window Analysis Approach for Measuring the Efficiency of Serbian Banks Based on Panel Data

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Efficiency assessment based on multiple inputs and outputs which are not necessarily financial is considered to be a complex process. Data envelopment analyses (DEA) is firstly introduced for the purpose of evaluating the efficiency of non-profit units. In this paper, an extended DEA – Window analysis is used for the efficiency assessment of banks in Serbia based on panel data for the period from 2005 to 2011. This analysis provides trends of efficiency and the rank of each bank evaluated in terms of its profit and operating effectiveness. Furthermore, the obtained results allow for an analyses of trends of the overall banking sector efficiency.

Keywords: Panel data, DEA, Window analysis, Banks efficiency, Serbian banking

1. Introduction

In this paper we analyze the performance of twenty-eight commercial banks in Serbia over THE period 2005 – 2011. Available data before 2005 are not comparable because in Serbian banks' reporting was not regulated by the law. In 2005, as the independent institution, the National Bank of Serbia implemented the regulations for banking system in Serbia.

The evolving process of the banking system started in 2001 along with the transition of the Serbian economy when the country had approximately 90 banks. Since that year, until now, some banks were liquidated. Some merged with others, and the remainder were privatized.(SS BOFOS)

The banking system of The Republic of Serbia consists of the Central Bank (National Bank of Serbia) and commercial banks. Banks in Serbia are independent in their pursuit of profit-oriented business activities based on the principles of solvency, profitability and liquidity. At this moment, there are thirty-three banks in Serbia competing for customers in a market with 7.12 million citizens (the province Kosovo and Metohia not included in the number). Among the banks in Serbia (33 banks), we can find a number of banks that are still (or at least partially) owned by the Republic of Serbia (8 banks). Some of the banks are foreign banks (21 banks) and there are also public-privately owned banks (4 banks) (NBS | Banking Sector, 2012).In our analysis, we excluded five banks because these five banks were not operating during the whole analyzed period. They either did not enter Serbian market before 2005, or they do not do business now (proclaimed bankruptcy). We excluded the Opportunity banka a.d. Novi Sad, Moskovska banka a.d. Beograd, Dunav banka a.d. Zvecan, Jugobanka a.d. Kosovska Mitrovica, Poljoprivredna banka Agrobanka A.D. Beograd. For the purpose of this research we used the annual panel data.

The extended version of data envelope analysis (DEA) – Window analysis designed for assessing the efficiency of decision making units (DMU) based on panel data is used for efficiency evaluation of selected banks operating in Serbia. Reviewing the literature, the authors mainly found studies dealing with a similar principle of approaches in measuring the efficiency of banks over a period of time. In the mentioned literature, there are several differences in the methods used (DEA Windows analysis or Malmquist Index analysis) and several differences in the models considered, i.e. considered aspects and goals of analyses.

The main objective of the paper is to evaluate the efficiency of Serbian banks in order to follow the dynamics of efficiency of each of the banks and the banking sector as a whole. Furthermore, banks' management can identify trends of annual efficiency, which can help them improve their business results.

It would be interesting to see how the Global Financial Crisis (GFC) affected the Serbian bank sector. Particularly, we tend to determine the difference between the period before, and the period after the GFC beginning. This can be done by DEA Time series, i.e. Window analysis.

The paper is organized as follows. In the next section, Section 2, we introduce the methodologies which are used, namely DEA analysis with a main focus on Window analysis. Section 3 describes the approach used in this particular study, and discusses the data used, while the Section 4 identifies and discusses the results. Finally, in Section 5 the conclusions are given.

2. Theory and methodology

Data Envelopment Analysis

Data Envelopment Analysis (DEA) was originally introduced by Charnes, Cooper and Rhodes (1978) and is a non-parametric linear programming approach, capable of handling multiple inputs as well as multiple outputs (Paradi, Asmild, Aggarwall, & Schaffnit, 2004). Precisely, this approach allows handling different types of input and output together.

A DEA model can be constructed either to minimize inputs or to maximize outputs. An input orientation aims at reducing the input amounts as much as possible while keeping at least the present output levels, while an output orientation aims at maximizing output levels without increasing the use of inputs. (Cooper, Seiford, & Tone, 2000)

Window analysis

Economists especially insist that efficiency is a changeable category, and that it depends on the time! Regarding the previous sentence, we decided to use an appropriate technique - Window analysis technique. Window analysis technique works on the principle of moving averages (Cooper et al. 2007) and is useful in detecting performance trends of a decision making unit over time. Each DMU in a different period is treated as if it were a „different" DMU (more accurately, independent) but remain comparable in the same window (Cooper, Seiford, & Zhu, 2011). *"Such capability in the case of a small number of DMUs and a large number of inputs and outputs would increase the discriminatory power of the DEA models*." (Cooper, Seiford, & Zhu, 2011). Formally, it is necessary to observe n DMUs and they represent the number of decisions making units in a given time period t, while P denotes the total number of time periods, and of course the given time period in the time range $t = 1,\ldots P$. The window size in the label W denotes the number of included time periods, which applies throughout the whole analysis, from where we can calculate the number of analyzed windows (AW) using the simple formula: $AW = P - W + 1$.

It is clear that this procedure implies AW separate analyses, where each analysis examines $n \times W$ DMUs. Using Window analysis we make a sample size of $n \times P$ observations where an observation j in a particular time period t, (referring to DMU_t^j) has an m-dimensional input vector: $x_t^n = \left(x_{1t}^n, x_{2t}^n,,\ldots, x_{mt}^n\right)^T$ and an s-dimensional output vector: $y_t^n = \left(y_{1t}^n, y_{2t}^n,\ldots y_{st}^n\right)^T$. Then a window lW with $n \times W$ observations is denoted starting at time l, $0 \le l \le P-1$ with the width W, $1 \le W \le T - l$. So the matrix of inputs is given as:

$$X_{lW} = \left(x_l^1, x_l^2, \ldots, x_l^n, x_{l+1}^1, x_{l+1}^2, \ldots, x_{l+1}^n, x_{l+W}^1, x_{l+W}^2, \ldots, x_{l+W}^n\right)$$

and the matrix of outputs will be: $Y_{lW} = \left(y_l^1, y_l^2, \ldots, y_l^n, y_{l+1}^1, y_{l+1}^2, \ldots, y_{l+1}^n, y_{l+W}^1, y_{l+W}^2, \ldots, y_{l+W}^n\right)$.

The input oriented DEA window analysis problem with constant returns to scale (CRS) assumption is given by solving the linear program illustrated in Equation 1 below, also similar to the basic DEA models. It is possible to create a DEA window model with output orientation illustrated in Equation 2.

Model 1: Input oriented DEA Window analysis Model

$$\begin{aligned}
&(Min)\, Z_{kl_w}^t \\
&s.t. \\
&Y_{l_w}\lambda \geq y_{kl_w}^t \\
&Z_{kl_w}^t \times x_{kl_w}^t - X_{l_w}\lambda \geq 0 \\
&\lambda_s \geq 0;\ s = 1, 2, \ldots\ n \times W
\end{aligned}$$

2: Output oriented DEA Window analysis

$$\begin{aligned}
&(Max)\, Z_{kl_w}^t \\
&s.t. \\
&X_{l_w}\lambda \leq x_{kl_w}^t \\
&-Z_{kl_w}^t \times y_{kl_w}^t + Y_{l_w}\lambda \geq 0 \\
&\lambda_s \geq 0;\ s = 1, 2, \ldots\ n \times W
\end{aligned}$$

3. Data and methodology

There are a few approaches which can be used for measuring efficiency in banking sector:

- *In bank analyses, **The Production Approach** commonly views banks as producers of services and products using labor and other resources as inputs and providing deposits, loans and others (in value or number of transactions) as outputs*. (Cooper, Seiford, & Zhu, 2011)
- *Under **The Intermediation Approach**, as the name suggests, the bank's intermediary role is mainly studied to examine how efficient the bank is in collecting deposits and other funds from customers (inputs) and then lending the money in various forms of loans, mortgages, and other assets (i.e., investments, etc.)*. (Cooper, Seiford, & Zhu, 2011)
- ***The Profitability Approach** is designed to examine the process of how well a bank uses its inputs (expenses) to produce revenues*. (Paradi, Rouatt, & Zhu, 2010)

We have decided to use the intermediation approach because the idea of intermediation approach is to look more technically at what banks do. *The bank's production process is a black box whose efficiency is simply judged by the amount of output produced from a certain amount of input*. (Jemrić & Vujčić, 2002).

Different sets of input and output data are used to follow two models in estimating efficiency. In this paper, two analyses are carried out. The first is related to banks' profit efficiency and second one is related to banks' operating efficiency. For the profit efficiency model all available data are taken from banks' income statements. The description of input and output data is shown in Table 1.

Table 1 : Profit efficiency model from intermediation aspect

Inputs	Description
Interest expenses	Accrued normal and default interest expenses for the reporting period irrespective of the time it falls due.
Non-interest expenses	Sum of two positions from income statement: fee and commission expenses and other operating expenses.
Outputs	**Description**
Interest income	Accrued normal and default interest income for the reporting period irrespective of the time it falls due.
Non-interest income	Sum of two positions from income statement: fee and commission income and other operating income.

For the operating efficiency model all available data are taken from banks' balance sheets. The description of input and output data is shown in Table 2.

Table 2 : Operating efficiency model from intermediation aspect

Inputs	Description
Number of employees	Based on data collected from the National Bank of Serbia.
Fixed assets and intangible investments	The sum of two positions from the balance sheet: intangible assets (investments in identifiable non-monetary assets without physical substance to serve for the production or delivery of goods and services, to be leased out to other parties or used for administrative purposes) and fixed assets and investment property (land, buildings, equipment, other fixed assets, investment property and equipment provided by finance leases, as well as investments in acquiring fixed assets and investment property). (NBS | Accounting Regulations, 2012)
Capital	The position from balance sheet (consists of equity and other capital, reserves, revaluation reserves, unrealized losses in respect of securities available for sale, accumulated profit / loss).
Deposits	The sum of two positions from balance sheet: transaction deposits (banking deposits that have immediate and full liquidity, with no delays or waiting periods) and other deposits.
Outputs	**Description**
Granted loans and deposits	Position from balance sheet.
Non-interest income	Sum of two positions from income statement: fee and commission income and other operating income.

The descriptive statistics for the performance variables used in the analyses are given below in Table 3 for the profit model and in Table 4 for the operating model. The data in the following two tables is expressed in thousands of Serbian Dinars (RSD), except the number of employees.

Table 3: Overall descriptive statistics for data used in profit efficiency model

	Inputs		Outputs	
Statistic	**Interest expenses**	**Non-interest expenses**	**Interest income**	**Non-interest income**
Mean	1,800,499.52	2,075,078.63	4,563,408.30	2,088,448.86
Median	1,140,674.50	1,363,187.00	2,918,808.00	1,226,145.50
S.D.	2,019,229.97	1,725,054.70	4,980,425.77	2,471,197.93
I Quartile	379,256.00	776,947.25	1,283,059.50	558,694.75
III Quartile	2,468,261.25	2,879,555.00	5,953,639.25	2,586,256.75
Minimum	15,786.00	193,041.00	202,239.00	80,715.00
Maximum	11,652,708.00	8,820,418.00	31,090,463.00	16,190,122.00

As regards the table above, we could conclude that interest income is much higher than non-interest income. Based on more detailed analyzes conducted, we can see that after 2007 only Postanska stedionica had a higher non-interest income than interest income, and the difference between these two positions is melting every year. Among all banks, the smallest standard deviation is for the non-interest expenses input.

At the end of 2011, in the Serbian banking sector, half of the banks were operating with less than 679 employees. In general, the distribution of used data is positively skewed, which means that extreme scores are larger or in other words there are more low scores than high scores. In Table 4 we can see the average number of employees for the whole period and a more descriptive statistics.

Table 4. Overall descriptive statistics for data used in operating efficiency model

	Inputs				Outputs	
Statistic	Number of employees	Fixed assets and intangible investments	Capital	Deposits	Granted loans and deposits	Non-interest income
Mean	992.76	2,218,608.27	12,445,773.77	38,626,804.57	35,858,694.78	2,088,448.86
Median	702.50	1,410,922.00	6,823,957.00	22,650,330.00	20,625,058.00	1,226,145.50
S.D.	803.21	1,966,413.96	13,722,122.87	44,456,351.29	41,607,388.60	2,471,197.93
I Quartile	396.25	773,837.50	3,230,344.50	9,765,784.75	8,266,978.75	558,694.75
III Quartile	1,376.25	2,960,685.75	15,496,964.50	52,113,694.25	46,174,798.50	2,586,256.75
Min	107	250,154.00	895,976.00	1,884,923.00	999,658.00	80,715.00
Max	3,209	9,093,120.00	80,414,325.00	236,510,888.00	249,337,726.00	16,190,122.00

4. Findings and analysis

In order to obtain the following results, we used the software EMS 1.3 (Scheel, 2000) for academic purposes. The banks' performance over a seven-year period of time is considered, and then a three-year window is selected. The window length was determined by experimenting with different length sizes without using the formula given by Sun (1988), according to which the window length should be four years. We suggest that our panel with 28 banks is large enough to provide an adequate discriminatory power in the process of ranking.

We exclude the obtained efficiency for DMUs inside every window and in the next summarized tables (Table 5 for Profit model and Table 6 for Operating model) we give the super-efficiency scores for each bank within each year. In order to calculate the results of overall super-efficiency we used the average of super-efficiency in five windows (for each bank separately), and the average of annual super-efficiency. We rank all the banks by average annual super-efficiency.

The mentioned super-efficiency in the following tables is calculated in the same way as with Anderson-Peterson model, noting that we work with an input orientation and CRS assumption. In the following text efficiency and super-efficiency will be considered as synonyms.

Profit model

Based on the analysis of the average efficiency (by years), only two banks are efficient (Agroindustrijska komercijalna banka and JUBMES banka) while all other banks show some kind of inefficiency. Even 11 banks out of 28 show an efficiency score between 60% and 70%.The least efficient bank overall was Privredna banka Beograd. As many as seventeen banks have an efficiency lower than average. It is interesting that Raiffeisen banka and Volksbanka, since 2005 until today, show a constant efficiency increase, from the previous 43.26% to 95.42% and from 27.74% to 99.63% respectively. The JUBMES banka is the most dynamic in efficiency changes. If we want to determine which banks have the biggest inter-annual increase in efficiency we can see that those banks are JUMBES banka and Banka Postanska stedionica. Their peaks took place between 2007. and 2008. On the contrary, the largest decreases in efficiency are recorded at KBC banka (between 2005 and 2006) and Agroindustrijska komercijalna banka (between 2007 and 2008).

Table 5 . Super-efficiency according to profit model

		Average efficiency per year [%]							Overall super-efficiency	
Rank	**Bank name**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**by windows**	**by years**
1	Agroindustrijska komercijalna banka	154.70	199.29	223.52	150.56	111.74	86.69	94.63	151.92	145.87
2	JUBMES banka	137.07	105.79	71.59	149.68	100.53	78.61	112.19	105.56	107.92
3	KBC banka	262.82	109.77	38.59	49.34	57.52	56.64	66.51	73.23	91.60
4	Banka Postanska stedionica	40.96	40.99	27.21	84.93	116.96	99.71	101.42	74.07	73.17
5	Čacanska banka	77.79	56.50	56.73	67.66	78.60	84.05	85.45	70.22	72.40
6	Srpska banka	68.45	67.46	59.82	72.55	61.40	77.85	88.75	68.61	70.90
7	Unicredit Bank Srbija	39.04	59.51	44.56	75.15	83.35	82.08	103.53	68.99	69.60
8	Raiffeisen banka	43.26	43.41	52.53	74.15	78.57	91.52	95.42	68.28	68.41
9	ProCredit Bank	50.99	38.62	40.31	63.94	91.61	87.21	99.71	65.99	67.48
10	Banca Intesa	43.90	36.27	45.65	74.22	85.12	91.04	92.28	67.05	66.92
11	Société Générale banka Srbija	57.25	49.50	44.12	62.61	79.65	87.63	82.89	64.90	66.24
12	OTP banka Srbija	75.64	55.15	45.60	52.63	51.36	58.70	112.30	57.63	64.48
13	Volksbank	27.74	38.72	44.78	59.73	83.89	91.91	99.63	63.59	63.77
14	Eurobank EFG	25.78	38.56	41.37	77.62	85.04	82.96	82.20	64.21	61.93
15	Univerzal banka	44.87	50.86	49.90	75.57	71.71	73.59	64.68	63.33	61.60
16	Razvojna banka Vojvodine	53.86	47.68	48.38	63.94	72.01	79.84	63.89	61.72	61.37
17	Komercijalna banka	42.78	42.08	40.45	62.78	67.30	77.74	89.35	58.89	60.35
18	Hypo Alpe-Adria-Bank	50.95	43.07	44.75	66.83	72.62	69.82	70.77	60.01	59.83
19	Erste Bank	35.49	27.43	44.87	55.57	66.42	75.50	83.87	55.05	55.59
20	Credy banka	63.09	37.08	32.29	50.20	57.62	64.04	75.10	50.72	54.20
21	NLB banka	40.14	27.84	35.02	60.79	65.30	72.24	75.66	53.28	53.85
22	Findomestic banka	40.42	35.60	43.92	51.39	60.20	64.88	52.77	50.71	49.88
23	Crédit Agricolebanka Srbija	38.38	25.17	32.49	43.38	60.57	70.43	76.13	47.67	49.51
24	Marfin Bank	31.52	30.97	40.08	46.32	49.36	83.49	59.58	48.49	48.76
25	Piraeus Bank	44.09	31.66	34.19	59.54	60.94	53.17	49.71	48.50	47.61
26	Alpha Bank Srbija	48.60	34.73	34.88	59.13	38.37	50.78	55.52	44.82	46.00
27	Vojvodjanska banka	33.01	23.64	33.39	54.69	53.24	56.17	64.11	45.38	45.46
28	Privredna banka Beograd	35.58	42.71	39.76	49.61	45.28	50.73	48.65	45.01	44.62

Operating model

Erste banka can be considered as a bank on the right path because in the whole analyzed period, except for 2006, its efficiency score never fell. The same conclusion can be made for Findomestic bank. All the other banks have more dynamic changes in efficiency. Five banks that reported the biggest amounts of efficiency decrease are the following: ProCredit Bank, Hypo Alpe-Adria-Bank, Univerzal banka, Komercijalna banka and Srpska banka. In the operating model we can see that there is no bank with efficiency lower than 50%, while four banks have an efficiency score above 100% (Agroindustrijska komercijalna banka, Banka Postanska stedionica, Volksbank, ProCredit Bank). As mentioned in the above model, seven banks, in the case of this model, report an efficiency between 60% and 70%, which also represents the range with most banks. In the case of operating model the least efficient bank overall was Razvojna banka Vojvodine. The banks which show the biggest inter-annual increase in efficiency are Banka Postanska stedionica (between 2006 and 2007) and Agroindustrijska Komercijalna banka (between 2005 and 2006). It is interesting that these two banks also had the largest decrease in efficiency between 2007 and 2008.

Table 6. Super-efficiency according to operating model

Rank	Bank name	Average efficiency per year [%]							Overall super-efficiency	
		2005	2006	2007	2008	2009	2010	2011	by windows	by years
1	Agroindustrijska komercijalna banka	134.66	251.51	244.52	102.03	89.36	147.92	85.42	155.11	150.77
2	Banka Postanska stedionica	120.03	78.67	296.72	83.83	109.74	101.78	94.99	136.45	126.54
3	Volks bank	85.41	84.59	79.04	123.96	105.54	171.67	112.02	109.04	108.89
4	ProCredit Bank	119.47	97.23	118.13	104.52	96.86	95.44	92.67	103.73	103.47
5	Hypo Alpe-Adria-Bank	144.70	98.99	102.92	90.77	88.11	86.51	85.60	96.45	99.66
6	Piraeus Bank	87.91	143.23	85.99	101.59	81.49	93.73	80.94	96.67	96.41
7	Société Générale banka Srbija	93.00	66.30	71.23	84.03	118.27	115.25	79.58	90.42	89.67
8	Erste Bank	90.44	59.05	84.83	89.16	89.54	101.47	111.34	87.56	89.40
9	Unicredit Bank Srbija	94.61	65.70	83.19	74.55	99.18	96.40	102.23	86.12	87.98
10	OTP bankaSrbija	91.60	60.82	64.26	88.85	93.25	84.45	99.93	81.41	83.31
11	Crédi tAgricole banka Srbija	86.75	79.39	81.83	75.77	74.20	81.71	97.19	80.10	82.40
12	Marfin Bank	88.24	66.28	71.74	58.11	71.15	118.79	87.47	76.59	80.25
13	Privrednabanka Beograd	57.67	39.36	45.80	76.55	93.25	128.82	113.29	76.94	79.25
14	Cacanska banka	86.79	60.21	60.47	80.51	79.19	100.21	79.66	76.52	78.15
15	Banca Intesa	71.20	66.77	71.21	88.46	71.97	75.17	68.95	74.60	73.39
16	Raiffeisen banka	114.22	77.29	76.54	61.59	53.84	57.35	57.74	67.81	71.22
17	NLB banka	79.41	50.17	71.80	85.80	74.99	64.44	64.05	71.36	70.09
18	Findomestic banka	36.75	53.96	61.25	78.43	76.62	87.45	93.79	70.82	69.75
19	Univerzal banka	74.70	66.78	80.66	75.17	67.13	65.92	57.09	71.07	69.64
20	KBC banka	88.00	60.00	47.99	48.57	56.38	85.45	90.91	61.91	68.18
21	Komercijalna banka	64.49	61.01	79.69	76.42	70.23	58.66	58.22	69.40	66.96
22	Alpha Bank Srbija	64.82	68.89	80.76	44.72	56.65	80.75	71.57	65.47	66.88
23	Eurobank EFG	74.34	51.96	71.02	76.56	56.72	62.54	61.73	65.20	64.98
24	Credybanka	128.41	60.30	47.18	56.46	67.85	46.02	47.64	60.21	64.84
25	Vojvodjanska banka	83.49	61.09	55.59	55.37	45.83	48.89	51.02	54.99	57.32
26	JUBMES banka	84.76	45.17	67.74	38.86	50.03	49.10	50.46	52.91	55.16
27	Srpskabanka	86.12	58.95	53.34	41.73	50.46	47.28	37.44	51.51	53.62
28	Razvojna banka Vojvodine	54.28	56.35	57.86	61.93	46.85	45.51	47.79	53.72	52.94

Analysis of the entire banking sector

Based on previous analysis, Table 7 shows banks' participations in different aspects of efficiency within whole banking sector (given in percentages). Separately looking at profit and operating aspects we can conclude that the largest percentage of the banks hasefficiency between 60% and 70%. In profit model 92.86% of the banks have efficiency below 100% and the same goes for 88.89% of banks in operating model.

Table 7. Frequency distribution for overall super-efficiency by years

	Overall super-efficiency by years					
	Profit model			**Operating model**		
Statistic	Frequency	Percentage	Cumulative Percentage	Frequency	Percentage	Cumulative Percentage
E < 0.4	0	0.00%	0.00%	0	0.00%	0.00%
0.4 ≤ E < 0.5	7	25.00%	25.00%	0	0.00%	0.00%
0.5 ≤ E < 0.6	4	14.29%	39.29%	4	14.81%	14.81%
0.6 ≤ E < 0.7	11	39.29%	78.57%	7	25.93%	40.74%
0.7 ≤ E < 0.8	3	10.71%	89.29%	5	18.52%	59.26%
0.8 ≤ E < 0.9	0	0.00%	-	6	22.22%	81.48%
0.9 ≤ E < 1.0	1	3.57%	92.86%	2	7.41%	88.89%
1.0 ≤ E < 1.1	1	3.57%	96.43%	2	7.41%	96.30%
1.1 ≤ E < 1.2	0	0.00%	-	0	0.00%	-
1.2 ≤ E < 1.3	0	0.00%	-	1	3.70%	100.00%
1.3 ≤ E < 1.4	0	0.00%	-	0	0.00%	-
1.4 ≤ E < 1.5	1	3.57%	100.00%	0	0.00%	-

Looking at banks' operating efficiency through their annual operations (Table 8) for the period from 2005 to 2011, we can see that the banking sector had its highest peak in 2005 (88.80%), and after that it oscillated between 74.64% – 88.80%, with an average value of 80.75%. If we look at the profit model, the average annual efficiency increased every year, so it had its highest peak in 2011 (80.24%). The reason for this may be found in the banking sector's situation, which is that the banks are more oriented towards the income from already granted loans. The reasons for banks' orientations towards already given loans may be found in the lack of payment-capable clients or in the long-term impacts of GFC.

Table 8. Banks efficiency over years separately according to used models

	Banks super-efficiency by years [%]						
Models	2005	2006	2007	2008	2009	2010	2011
Profit	61.01	51.43	49.67	68.38	71.65	74.96	80.24*
Operating	88.80*	74.64	86.19	75.87	76.24	85.67	77.88

Note: Asterisk (*) indicates the best average

Efficiency trends for some mentioned banks are shown in the following figures: (Profit model – Figure 1) and (Operating model – Figure 2).

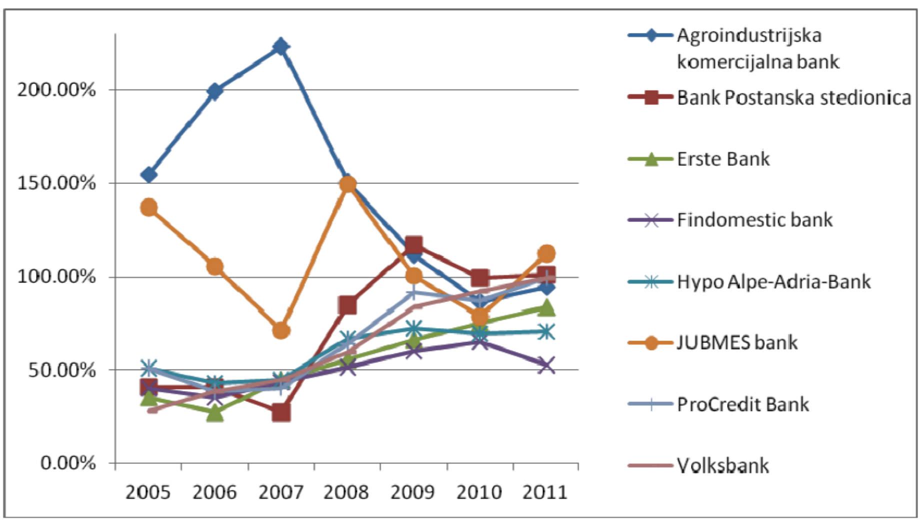

Figure 1. Efficiency trends for Profit model

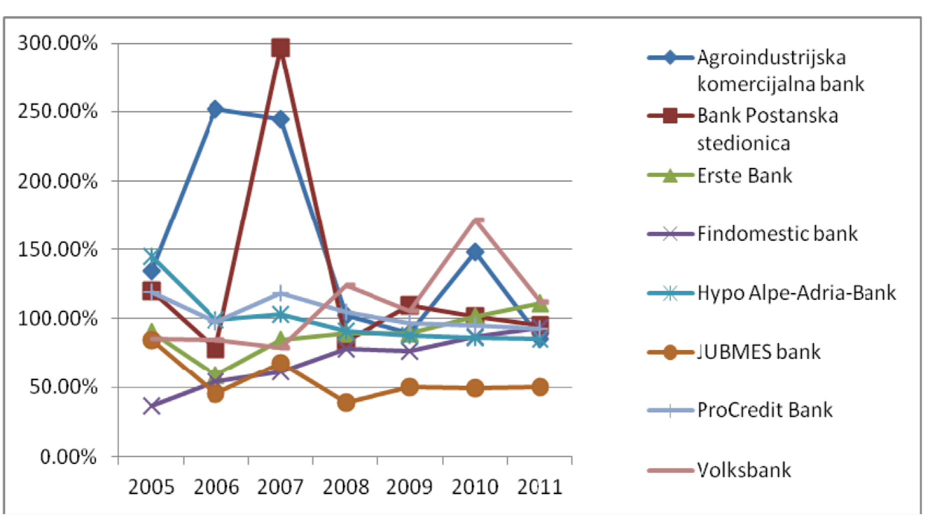

Figure 2: Efficiency trends for Operating model

Conslusion

This paper employs a window DEA to evaluate the efficiency from the profit and operating aspects of the bank sector in Serbia in the 2005 to 2011 period. Using the panel data and Window analysis we had an opportunity to examine efficiency trends in the banking sector in Serbia, and to perform the same ranking as in the Anderson-Peterson model.

Further analysis revealed that the majority of banks are located in the range of efficiency from 60% to 70%, regardless of whether it is a profit or operating efficiency of the banks. Only one bank (Agroindustrijska komercijalna banka) exceeds the efficiency of 100% in both observed aspects. In fact, only five banks exceed the efficiency of 100% in some of the analyzed models. During the period in which banks were analyzed, if we consider the profit model, it is evident that the banking sector has the annual constant increase in efficiency. In the operational model minor fluctuations are observed, that cannot be clearly connected with GFC; we can only assume that there is a potential impact of GFC's long life, however, if we want to confirm the impact of GFC, it would be necessary to conduct additional analyzes. In the case of operating model, the banking sector firstly shows the effects of bank privatization and saturation in the issuance of loans.

Based on this example it is very clear that when the goal of future analysis is set properly, and used inputs and outputs are appropriate, then the Window analysis can be used on panel data.

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