

## Efficiency analysis of Serbian banking sector using data envelopment analysis: pre-pandemic era

### Analiza efikasnosti bankarskog sektora pomoću metode analize obavijenosti podataka: pre pandemijski period

Aleksandra Marcikić Horvat<sup>a</sup>, Boris Radovanov<sup>b</sup>, Dragana Milić<sup>a</sup>, Nada Milenković<sup>a\*</sup>

<sup>a</sup> University of Novi Sad, Faculty of Economics in Subotica, Serbia

<sup>b</sup> Novi Sad School of Business, Novi Sad, Serbia

#### Article info

Original scientific paper/ Originalan naučni rad

Received/ Rukopis je primljen:

19 May, 2022

Revised/ Korigovan:

21 September, 2022

Accepted/ Prihvaćen:

24 October, 2022

DOI:

<https://doi.org/10.5937/bizinfo/2202041M>

UDC/ UDK:

336.71:519.8(497.11)

#### Abstract

*During the last decade, the question of measuring efficiency became inevitable factor of successful management of banks. Therefore, the basic goal of this paper is to apply DEA - Data Envelopment Analysis in comparing unit efficiency of Serbian banking sector for three years period of time (2017, 2018 and 2019). DEA is a technique of mathematical programming which uses analysis and comparison of efficiency of different entities and it is suitable to solve problems of different number and nature of inputs and outputs. The presented paper employs an output-oriented data envelopment analysis with a constant return to scale assumption. The selected input variables are total assets and total capital, while net operating income and net profit were used as output variables. Results showed that the average efficiency of Serbian banking sector is about 50% in the observed years. Opportunity Bank achieved the maximal efficiency score in the entire time period while Mirabank had the lowest efficiency score.*

**Keywords:** data envelopment analysis, efficiency, banking sector

#### Sažetak

*Tokom poslednje decenije, pitanje merenja efikasnosti postalo je neizbežan faktor uspešnog upravljanja bankama. Stoga je osnovni cilj ovog rada da se primeni DEA - Data Envelopment Analysis u poređenju efikasnosti bankarskog sektora Srbije za trogodišnji period (2017, 2018. i 2019.). DEA je tehnika matematičkog programiranja koja koristi analizu i poređenje efikasnosti različitih entiteta i pogodna je za rešavanje problema različitog broja i vrste ulaznih i izlaznih jedinica. Predstavljeni rad koristi analizu obuhvata podataka orijentisanu na izlaz. Odabrane ulazne varijable su ukupna aktiva i ukupan kapital, dok su neto poslovni prihod i neto dobit korišćeni kao izlazne varijable. Rezultati su pokazali da je prosečna efikasnost bankarskog sektora Srbije oko 50% u posmatranim godinama. Opportuniti banka je ostvarila maksimalnu ocenu efikasnosti u čitavom vremenskom periodu, dok je Mirabanka imala najnižu ocenu efikasnosti.*

**Ključne reči:** metode analize obavijenosti podataka, efikasnost, bankarski sektor


## 1. Introduction

Banks, like any other organization, strive to achieve the highest possible results with as little investment as possible. Unlike other organizations, banks have a special role in the economy of one country, given that they are the driver of economic development. Banks have come a long way in their development from traditional to industrial and finally international. Consequently, today's banks are

significantly different from traditional ones - they used to deal mainly with lending, deposit and exchange operations, while today banks are mostly universal and offer a wide range of services, which greatly facilitate business and offer numerous legal benefits. There are 26 banks operating in Serbia, most of which are foreign private banks. The directions in which this sector is moving are concentration, technological innovation and deregulation. One of the trends in the development of

\*Corresponding author

E-mail address: [nada.milenkovic@ef.uns.ac.rs](mailto:nada.milenkovic@ef.uns.ac.rs)

This is an open access paper under the license 

banking in Serbia is the concentration of capital, most often through mergers and acquisitions. The number of banks is decreasing from year to year, and bearing in mind that some of the banks are operating at a loss, there is speculation about the need to further reduce this number. When performing mergers and acquisitions, owners are most interested in the end results, which often show improvement. On the other hand, employees in banks that participate in integration most often suffer the consequences due to the fact that a large number of workers are fired due to overlapping positions.

An important principle in the business of any company, including banks, is the principle of efficiency, which can be defined as the ability to achieve the desired goals with minimal use of available resources. A bank that operates efficiently invests in highly profitable investments, grants loans to clients of good creditworthiness and thus has a smaller number of non-performing loans. Also, such a bank uses modern technology and thanks to that employs fewer workers. On the other hand, the bank offers innovative and quality services for which it charges commissions that represent additional income. In this paper, banks are considered as financial organizations that have funds in the form of total assets and capital, on the basis of which they strive to achieve maximum net operating income and net profit. Therefore, the degree of efficiency was determined as the ratio of output and input variables, where total assets and capital were used as input variables, and net operating income and net profit as output variables. These data were analysed using Data Envelopment Analysis (DEA), which is a well-known non-parametric method for efficiency measurement and evaluation.

The main hypothesis is that a large number of banks in Serbia operate with an unsatisfactory level of efficiency. The problem that needs to be examined is the way in which banks can influence the increase of efficiency levels, and the subject of research is the degree of efficiency of their operations and the necessary correction of input and output values in each of the banks to operate efficiently.

The importance of the analysis is multiple and is reflected in the fact that it provides insight into the efficiency of the banking sector, as well as each bank individually. At the same time, the obtained coefficients are comparable with the coefficients of other banks. Given that the financial statements from which the necessary data are drawn are standardized, and the selected balance sheet items are common to each organization that makes them, the comparison of efficiency can be done between banking groups, countries and other non-banking companies or sectors.

## 2. Literature review

In recent years there has been a noticeable increase in the interest of researchers in quest for drivers of efficiency in the banking sector. Also, a broad methodology has been applied and a numerous combinations of determinants have been identified to examine the efficiency of banks.

Feroz et al. (2003) indicate that data envelopment analysis can provide a consistent and reliable measure of managerial or operational efficiency. In terms of financial statement analysis, they demonstrated that DEA can augment the traditional ratio analysis. The estimated targets for improvement of the inefficient banks can help top management in better resource allocation and faster decision-making process that ultimately lead to greater financial stability (Cvetkoska et al., 2021).

Chiu et al. (2009) investigate 43 Taiwanese banks for the period 1998 to 2002. Their study results show that loan quality factors have an impact on a bank's efficiency and bank with a higher performance will be more secure. Titko et al. (2014) attempt to extract from the larger set of inputs and outputs only the most important ones by processing the data using correlation analysis, linear regression analysis, analysis of mean values and two-sample Kolmogorov-Smirnov test. The regression analysis was used to substantiate variables selection. The results show that in time of financial turbulence it is better to use profit-oriented variables as outputs instead of loans. Kumar and Singh (2014) noticed that the major factor resulting in poor performance of large Indian banks is their huge amount of deposits and operating expenses. Alfiero et al. (2017) using the non-parametric Data Envelopment Analysis – Slack Based Model methodology, recognized general growth of technical efficiency, managerial efficiency and scale efficiency in case of Italian saving banks over the 2010-2015 period. Floros et al. (2020) using recent data from PIGS countries which suffer from debt issue. The study results confirm that the choice of inputs and outputs does matter in the case of European banking efficiency, especially because of the controversial role of deposits as input or output. Antunes et al. (2021) suggests a new DEA model to assess the efficiency of 39 Chinese commercial banks over the period 2010–2018. The results indicate that the state-owned banks have the highest efficiency, the rural banks are found to be least efficient, while the foreign banks experience the strongest volatility over the examined period.

If we take into account the application of DEA methods in the analysis of the efficiency of the banking sector of Serbia, it cannot be noticed a large number of papers on this topic. Mihailović et al. (2009) conducts an analysis of the efficiency of banks in Serbia in 2005 using as inputs total asset, total capital and number of employees and as outputs interest revenue and revenue before taxation. They used data envelopment analysis, as one of two contacted methods, to compare and rank banks in Serbia. Savić et al. (2012) applied DEA Window analysis to assess the efficiency of Serbian banks based on panel data sample from 2005 to 2011. The analysis consists of inputs such as number of employees, fixed assets and intangible investments, capital and deposit and outputs such as granted loans and deposits and non-interest income. Knežević et al. (2012), referring to developing countries, remark the importance of monitoring the efficiency of banks and compare it with countries in the region. Lukić et al. (2017) emphasize the need for efficient management of assets and liabilities, human resources, capital, operating income and profit in most Serbian banks.

Marjanović et al. (2018) implement the input-oriented DEA CRS/VRS models based on financial performance of commercial banks in Serbia in period 2014–2016 by using as inputs total assets, interest expenditure, operating expenditure and number of employees and as outputs interest income and profit before tax. Their findings point to the fact that two-thirds of banks operate in conditions of inefficiency due to operational and managerial problems. Radojičić et al. (2018) present the results of in-depth analysis of the efficiency of Serbian banks during the period 2005–2016. In terms of average efficiency, the banking sector of Serbia displays an improving trend over the observed period.

### 3. Methodology

Commonly used methodologies in efficiency measurement are the parametric approach and the non-parametric approach. Parametric approaches to efficiency analysis are based on measures of central tendency while the efficiency of each decision-making unit (DMU) is compared with average values. On the contrary, non-parametric approach (such as DEA) compares the efficiency of each individual entity with the highest achieved level of efficiency, rather than the average. It does not require a priori an assumption about the analytical form of the observed inputs and outputs. A significant advantage of the DEA method is that a different number of heterogeneous inputs and outputs can be used in the analysis, which can be represented by different types of metrics (Marcikic Horvat & Budimcevic, 2018).

There are four main phases in conducting an efficiency study using the DEA method:

- Defining and selecting decision-making units whose relative efficiency should be determined;
- Determining input and output variables that are relevant and suitable for assessing the relative efficiency of selected decision-making units;
- Selection of an adequate DEA model;
- Solving DEA models, analysis and interpretation of results.

In the first phase, it is actually decided what will be the subject of the analysis. In order to be able to perform the analysis, it is necessary to determine which data refer to investments and which to results. This data must be expressed numerically in order to be able to compare with each other. After that, it is necessary to determine the primary goal of decision-making units and, based on it, determine whether they strive to minimize input or maximize output variables. The previous phases create preconditions for solving the model and analysis of the solution, which should lead to certain conclusions regarding the level of efficiency and ways of improvement.

In order to determine the efficiency of the banks involved in the analysis, it is necessary to determine which input and output values are adequate in order to obtain the relevant parameters. Input variables are variables that are invested and consumed during the reproduction process in order to result in output values. Given the service

character of banks, the process of reproduction consists of investing a certain amount of money, which is transformed and increased through work. The data were retrieved from the Annual Report published at the website of The National Bank of Serbia for the for-time period of three years (2017, 2018 and 2019). Based on the comprehensive analysis of previous researches and the main objective of this study, two output and two input variables were selected for DEA model. Net operating income and profit were used as output variables, while total assets and total capital were used as input variables. All variables are presented in national currency Serbian dinar (RSD). Input and output variables are presented in Table 1 in thousands RSD.

**Table 1.** Input and output variables in thousands RSD

Bank (DMU) 2019	Total assets	Total Capital	Net operating income	Net profit
Addiko bank	94.756.920	22.386.667	5.291.238	1.107.695
AIK bank	223.600.839	57.319.673	12.357.305	8.230.318
API bank	9.443.082	1.413.215	2.097	-240.795
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	493.955	306.155
Unicredit banka	441.577.253	85.846.985	13.420.579	7.590.686
Vojvodanska banka	215.048.577	31.842.377	7.609.313	5.982.870
Sberbank	157.360.045	25.304.344	4.164.398	6.113.883
Srpska banka	13.744.154	3.593.816	4	

Srpska banka	401.165.980	67.560.513	19.003.608	8.145.182
Unicredit banka	5.937.892	2.133.010	176.725	-322.469
Vojvodanska banka	15.930.961	1.494.829	840.347	-601.924
Sberbank	10.776.218	2.430.479	653.892	6.484
Srpska banka	57.459.595	8.082.158	3.218.647	620.816
Unicredit banka	16.146.648	3.127.726	1.975.517	426.452
Vojvodanska banka	316.087.334	44.238.385	16.112.801	8.155.854
Sberbank	220.036.784	19.517.180	9.013.078	2.225.767
Srpska banka	111.057.393	15.917.579	3.783.586	996.082
Unicredit banka	291.924.334	57.908.928	16.496.139	6.628.209
Vojvodanska banka	121.659.363	24.688.423	4.903.776	1.309.826
Sberbank	12.887.132	3.340.172	361.847	21.696
Srpska banka	437.400.289	77.828.498	18.136.908	9.221.647
Unicredit banka	87.602.369	26.323.288	3.559.920	285.955
Bank (DMU) 2017	Total assets	Total Capital	Net operating income	Net profit
Addiko bank	94.115.810	21.945.443	5.727.755	1.218.248
AIK bank	209.359.749	61.161.912	18.337.117	12.080.194
API bank	10.671.360	1.634.994	286.849	-173.756
Sberbank	564.859.578	119.006.802	27.017.436	11.847.694
Srpska banka	1.863.780	1.841.243	121.588	-2.644
Unicredit banka	86.933.902	9.091.129	1.936.203	345.102
Vojvodanska banka	26.870.287	3.949.539	3.170.464	1.902.074
Sberbank	161.921.004	20.894.563	1.932.260	2.632.240
Srpska banka	158.441.193	51.199.228	8.129.666	2.230.094
Unicredit banka	14.999.131	3.793.039	2.903.031	1.807.884
Vojvodanska banka	41.449.177	6.119.707	1.880.519	194.631
Sberbank	11.706.404	3.489.499	585.756	62.546
Srpska banka	369.183.538	63.260.055	18.576.152	8.117.368
Unicredit banka	6.022.727	2.468.710	149.959	-485373
Vojvodanska banka	14.925.253	1.714.100	607.734	-1.090.752
Sberbank	7.756.956	2.145.329	523.746	7.113
Srpska banka	44.121.316	7.388.340	3.242.085	442.574
Unicredit banka	2.733.218	14.123.297	1.712.694	353.086
Vojvodanska banka	287.987.802	40.404.589	13.544.830	6.030.737
Sberbank	140.488.253	15.874.902	10.059.504	3.879.268
Srpska banka	96.682.054	14.833.361	4.735.689	1.189.346
Unicredit banka	264.621.343	57.443.503	16.536.378	6.626.785
Vojvodanska banka	116.032.677	24.123.795	4.296.726	802.911
Sberbank	14.100.809	3.297.724	425.838	29.216
Srpska banka	362.748.552	69.340.495	14.498.628	6.633.319
Unicredit banka	73.255.431	27.199.182	2.657.022	-458.856

What is clear at first glance, in Table 1, is that the input values significantly exceed the values of the output values, which in some cases are even negative. The largest value of input in 2019 has Banca Intesa (as much as 752,697,959 thousand RSD), followed by Unicredit Bank and Komercijalna Bank with significantly lower values (527,424,238 and 508,232,616 thousand RSD). Mirabank (only 8,340,603 thousand RSD), API Bank and Bank of China (10,856,297 and 12,253,481 thousand RSD) have the lowest input values. When it comes to output values in the same year, the highest value is also recorded by Banca Intesa (40,399,233 thousand RSD), as well as

Komercijalna banka and Raiffeisen banka. API Bank and Mirabanka have the lowest output values - these banks even reach negative exit values (-238,698 and -73,263 thousand RSD). In both cases, the downward trend in output is the result of a loss that is higher than net operating income. This is largely due to excessive reliance on interest income with significantly lower fee and commission income, which has an increasing share in the modern bank. Also, it is noticeable that these banks have extremely high labor costs, which are almost equal to the realized net operating profit.

Nowadays, various variants of DEA model are developed in different areas of application. The most popular are CCR (after Charnes, Cooper and Rhodes, developed in 1978) and BCC models (after Banker, Charnes and Cooper, developed in 1984) with the main difference in modelling return to scale. CCR model assumes constant return to scale, while BCC model allows variable return to scale. Efficiency measurement for each decision-making unit (DMU) in CCR model is attained as a maximum of a ratio of weighted sum of outputs to weighted sum of inputs. The solution of the following linear programming model provides the efficiency measure for DMU (Jemric & Vujcic, 2002):

$$\max_{u,z_0} z_0 = \sum_{r=1}^s u_r y_{r0}$$

subject to:

$$\begin{aligned} \sum_{r=1}^s u_r y_{rj} - \sum_{i=1}^m v_i x_{ij} &\leq 0, j = 1, 2, \dots, n \\ \sum_{i=1}^m v_i x_{i0} &= 1 \\ u_r &\geq 0, r = 1, 2, \dots, s \\ v_i &\geq 0, i = 1, 2, \dots, m \end{aligned}$$

where  $x_{ij}$  is the perceived input amount of the  $i$ th type of the  $j$ th DMU and  $y_{rj}$  is the perceived output amount of the  $r$ th type for the  $j$ th DMU.

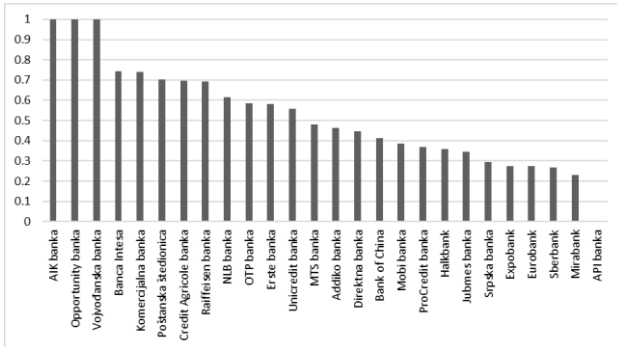
In our study, we applied the output-oriented CCR model to calculate and compare the relative technical efficiency of Serbian banking sector. The choice of DEA model orientation depends on whether decision-makers have more influence on improving input or output levels. The output-oriented model tries to determine the maximum possible proportional increase of outputs while keeping the levels of used inputs constant (Radovanov et al., 2020). Therefore, output oriented CCR DEA method is applied, because banks do not aim to reduce the total assets or capital. Instead, the bank will strive to achieve higher net operating income and profits in order to improve efficiency level.

#### 4. Results and discussion

Achieved average efficiency scores are presented in Figures 1, 2 and 3. The results of efficiency scores lie between 0 and 1 i.e., between 0% and 100%. It is evident that when it comes to the absolute amount of total assets, capital, net operating income and profit, Banca Intesa,

UniCredit Bank and Komercijalna Banka dominate, while the other observed banks have significantly lower values. Results of applied DEA method provide a clear answer to the question of whether high absolute amounts of these balance sheet items imply high business efficiency.

**Figure 1.** Efficiency scores of Serbian banking sector in 2019



Results presented in Figure 1 show that in 2019 three banks operated efficiently: Vojvodjanska banka, Opportunity banka and AIK banka. The lowest efficiency score has API bank 0.0024 (0.24%). The average efficiency of the banking sector of Serbia in 2019 was 0.5196 (51.96%). This value is slightly higher 0.5403 (54.03%) if we exclude the efficiency score achieved by API bank, which is dramatically lower compared to the others. This indicates that improvement can be made in the given sector because it operates at a level that represents only slightly more than half of the possible capacities. In this period, 12 banks operated with above-average efficiency, five banks operated with efficiency over 70%, and two banks operated with the efficiency below 30%.

**Figure 2.** Efficiency scores of Serbian banking sector in 2018

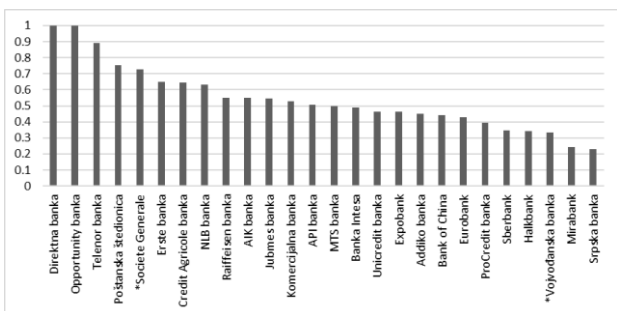


Figure 2 shows the obtained efficiency scores in 2018. Direct Bank and Opportunity Bank operate under maximal efficiency in this year. In the last place according to the level of efficiency is Srpska banka with a efficiency score of 0.2295 (22.95%). The average efficiency score in this period was 0.5421 (54.21%), which is 0.0225 (2.25%) higher than in 2019, which means that the average efficiency of the Serbian banking sector decreased in the observed period. Within the banking sector of Serbia, 11 banks operated in 2018 with the level of efficiency above the average. Efficiency over 70% is achieved by four banks, while two banks operate with the efficiency score below 30%.

**Figure 3.** Efficiency scores of Serbian banking sector in 2017

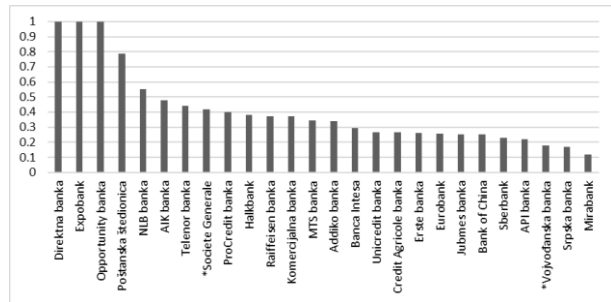


Figure 2 shows the obtained efficiency scores in 2017 where three banks achieved 100% efficiency: Direktna banka, Expobanka and Opportunity banka. The lowest efficiency score is achieved by Mirabanka with a value of 0.1201 (12.01%). The average efficiency score in 2017 is 0.4098 (40.98%), which is the lowest value in the observed three years. Efficiency above this average is achieved only by 8 banks. Efficiency score over 70% is achieved by four banks, while 12 banks operate with efficiency below 30%.

The following figure (Figure 4) refers to the distribution of average efficiency score of Serbian banking sector during observed period of time (2017, 2018 and 2019).

**Figure 4.** Average efficiency scores in the entire time period

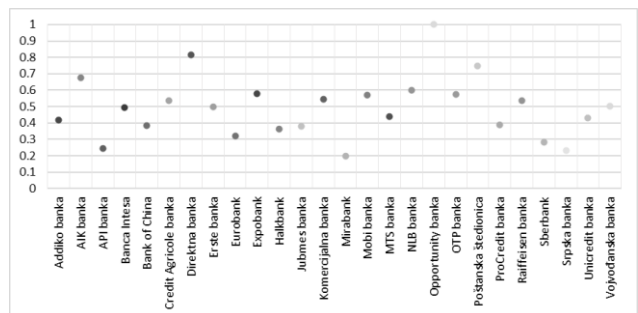


Figure 4 shows that only Opportunity Bank operated with 100% efficiency in the entire period of time. In second and third place are Direct Bank with an average efficiency of 0.8154 (81.54%) and Postanska Stedionica Bank with an average efficiency of 0.7483 (74.83%). With an average efficiency level below 30% operated Sberbank, API Bank, Srpska banka and finally Mirabanka, which operates with an average efficiency below 20% (0.1980 or 19.80%). Overall, efficiency of banks can change dramatically over observed period of time (Bulajić et al., 2013).

It is interesting to note that the banks that operate with the highest efficiency level are not the ones that have the highest absolute amounts of input, but vice versa. The best example of this is Opportunity Bank. Banks that have a significantly higher amount of capital and assets are located mainly in the group of banks with an efficiency of 50% to 70%. This suggests that large banks in Serbia generate a smaller percentage of outputs from available inputs compared to smaller banks. It can also be notices that the large number of banks with medium to high



average efficiency in this three years period are domestically owned. The reason for this may be the compulsion of domestic banks to make the best use of available resources because, unlike foreign banks, they cannot withdraw funds from the parent bank abroad. Also, smaller state-owned banks are less efficient than larger domestic banks who are successfully struggling with foreign competition (Bulajić et al., 2013).

The most efficient banks on the territory of Serbia in the three-year period were Opportunity Bank (operates efficiently in all three years), Direct Bank (operated efficiently in two of three years), AIK Bank, Vojvodjanska Bank and Expobank (operates efficiently in one of three years). From the above, it can be concluded that smaller banks that are oriented towards small clients - small businesses, individuals and households - operate far more efficiently in Serbia, than banks that work with larger companies and rely on investment banking business. Actually, the poor performance of larger banks mainly stems from their huge deposits and operating costs (Kumar & Singh, 2014).

## 5. Conclusion

The main goal of this paper was to evaluate the efficiency of Serbian banking sector during three years (2017, 2018 and 2019) using output-oriented CCR DEA model. Based on the presented results, it can be concluded that banks in Serbia operated most efficiently in 2018. In the next year the average efficiency decreased by 0.04%, which is a consequence of faster growth of input values compared to the growth of net operating income and a simultaneous decline of net profit. Although the decrease in efficiency in 2019 is a negative indicator of the movement of this score, the encouraging fact is that this score did not fall below the value achieved in 2017.

Banks that operated efficiently in Serbia during observed period of time are precisely in the category of banks with low or medium levels of input values. When it comes to output values, labor costs and depreciation in many cases distinguishes efficient from inefficient banks, which indicates the need to modernize and automate business processes. In fact, bank with a higher performance will be more secure (Chiu et al, 2009).

The presented methodology results explain the positioning of banks in Serbia in the pre-pandemic period. Undoubtedly, to better understand the long-term potential of the Serbian banking sector, the post-pandemic period should be taken into consideration. Also, according to Knežević et al. (2012), it would be of great importance to monitor the efficiency of banks in relation to banks from other countries in order to determine the position of the Serbian banking sector in the region.

## References

- Alfiero, S., Bocchino, U., Esposito, A., & Doronzo, R. (2017). The Rise and Fall of Italian Saving Banks. A DEA Efficiency Approach. *Corporate Ownership & Control*, 14(4-2), 349-361. <https://doi.org/10.22495/cocv14i4c2art2>
- Antunes, J., Hadi-Vencheh, A., Jamshidi, A., Tan, Y., & Wanke, P. (2022). Bank efficiency estimation in China: DEA-RENNA approach. *Annals of Operations Research*, 315(2), 1373-1398. <https://doi.org/10.1007/s10479-021-04111-2>
- Bulajić, M., Jeremić, V., Knežević, S., & Žarkić-Joksimović, N. (2013). A statistical approach to evaluating efficiency of banks. *Economic research*, 26(4), 95-104. <https://doi.org/10.1080/1331677X.2013.11517632>
- Chiu, Y., Chen, C., & Bai, X. (2009). Efficiency and risk in Taiwan banking: SBM super-DEA estimation. *Applied Economics*, 43(5), 587-602. <https://doi.org/10.1080/00036840802599750>
- Cvetkoska, V., Fotova Čiković, K., & Tasheva, M. (2021). Efficiency of Commercial Banks in Developing Countries. *Mathematics*, 9(14), 1597. <https://doi.org/10.3390/math9141597>
- Feroz, E. H., Kim, S., & Raab, R. L. (2003). Financial Statement Analysis: A Data Envelopment Analysis Approach. *The Journal of the Operational Research Society*, 54(1), 48-58. <https://doi.org/10.1057/palgrave.jors.2601475>
- Floros C., Zopounidis, C., Tan, Y., Lemonakis, C., Garefalakis, A., Tabouratzi, E. (2020). Efficiency in Banking: Does the Choice of Inputs and Outputs Matter? *International Journal of Computational Economics and Econometrics*, 10(2), 129-148. <https://doi.org/10.1504/IJCEE.2020.107370>
- Jemric, I., & Vujcic, B. (2002). Efficiency of banks in Croatia: A DEA approach. Jemric, I., Vujcic, B. Efficiency of Banks in Croatia: A DEA Approach. *Comparative Economic Studies*, 44, 169-193. <https://doi.org/10.1057/ces.2002.13>
- Knežević, S., Marković, M., & Barjaktarović-Rakočević, S. (2012). Assessing Efficiency in Banking, Industry: *Journal of the Institute of Economics in Belgrade*, 40(3), 71-92.
- Kumar, N., Singh, A. (2014). A Study of Technical Efficiency of Banks in India using DEA. *Journal of Business and Management*, 16(9), 37-43.
- Lukić, R., Sokić, M., Vojteski Kljenak, D. (2017). Efficiency Analysis of Banking Sector in Republic of Serbia. *Business Excellence and Management*, 7(4), 5-17.
- Marcikić Horvat, A., & Budimčević, K. (2018). Efficiency Analysis of Airlines using DEA model, 3rd International Thematic Monograph – Thematic Proceedings, *Modern Management Tools and Economy of Tourism Sector in Present Era* (pp. 221-230), Association of Economists and Managers of the Balkans in cooperation with the Faculty of Tourism and Hospitality, Ohrid, Macedonia.
- Marjanović, I., Stanković, J., & Popović, Ž. (2018). Efficiency Estimation of Commercial Banks based on Financial Performance: Input Oriented DEA CRS/VRS Model. *Economic Themes*, 56(2), 239-252. <https://doi.org/10.2478/ethemes-2018-0014>
- Mihailović, N., Bulajić, M., & Savić, G. (2009). Ranking of Banks in Serbia. *Yugoslav Journal of Operations Research*, 19(2), 323-334.
- Radojčić, M., Savić, G., & Jeremić, V. (2018). Measuring the efficiency of banks: the bootstrapped I-distance GAR DEA approach. *Technological and Economic Development of Economy*, 24(4), 1581-1605. <https://doi.org/10.3846/tede.2018.3699>
- Radovanov, B., Dudic, B., Gregus, M., Marcikić Horvat, A., & Karovic, V. (2020). Using a two-stage DEA model to measure tourism potentials of EU countries and Western Balkan countries: An approach to sustainable development. *Sustainability*, 12(12), 4903. <https://doi.org/10.3390/su12124903>

- Savić, G., Radosavljević, M., & Ilijevski, D. (2012). DEA Window Analysis Approach for Measuring the Efficiency of Serbian Banks Based on Panel Data. *Management Journal of Sustainable Business and Management Solutions in Emerging Economies*, 17(65), 5-14. <https://doi.org/10.7595/management.fon.2012.0028>
- Titko, J., Stankeviciene, J., & Lace, N. (2014). Measuring Bank Efficiency: DEA Application. *Technological and Economic Development of Economy*, 20(4), 739-757. <https://doi.org/10.3846/20294913.2014.984255>
- Narodna Banka Srbije. (2022). *Bilans stanja/uspeha banaka*. Narodna Banka Srbije. <https://nbs.rs/sr/finansijske-institucije/banke/bilans-stanja/>





