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DEA efficiency of Serbian banks-comparison of three approaches

Ефикасност банака у Србији применом ДЕА анализе – компарација три приступа

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Abstract: The aim of this paper is to analyse three approaches in order to give a comprehensive analysis of the efficiency of the banking sector in Serbia. The paper analyses the intermediate, operating and profitability approach for measuring bank efficiency in order to give an answer to the question which is the most efficient and where can be improvements made. The paper applies a non-parametric data envelopment analysis (DEA) on a sample of 23 banks operating in Serbia in the period during and after the covid-19 pandemic, i.e. for 2019, 2020 and 2021. The results of the analysis showed that efficiency is the highest according to the intermediate approach, while the efficiency of banks is the lowest in the approach of measuring profit efficiency. The fact that the lowest levels of efficiencies in each approach were achieved by small banks with a small market share should be added to the results of the analysis. The results of the research are certainly influenced by low interest rates and the activities of mergers and acquisitions, which are intensive on the Serbian banking market.
Keywords: DEA, Bank efficiency, intermediary approach, operating approach, profitability approach.
JEL classification: G21, G14, C61, C67

Сажетак: Циљ овог рада је да анализом три приступа да свеобухватну анализу ефикасности пословања банкарског сектора Србије. У раду се користе интермедијарни, оперативни приступ и приступ ефикасности генерисања профита у циљу давања одговора на питање који од њих је најефикаснији и где се могу учинити побољшања. У раду је примењена непараметарска анализа обавијености података на узорку од 23 банке које послују у Србији у период уочи и након пандемије covid-19, тј. за 2019, 2020 И 2021. годину. Резултати анализе су показали да је највећа ефикасност према интермедијалном приступу, док је најмања ефикасност банака у приступу мерења генерисања профита. Резултатима анализе треба

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додати чињеницу да су најмање нивое ефикасности постизале мале банке са малим тржишним учешћем. На резултате истраживања свакако имају утицаја ниске каматне стопе И активности мерџера И аквизиција, који су интензивни на банкарском тржишту Србије.
Кључне речи: DEA, ефикасност банака, интермедијални приступ, оперативни приступ, профитни приступ.
ЈЕЛ класификација: G21, G14, C61, C67

Introduction

The financial system of Serbia relies mainly on banking institutions. Therefore, the efficiency of the banking sector is crucial for the functioning of the financial system. Banks are the most supervised institutions by the National bank of Serbia. After the global financial crisis, the Basel Committee on Banking Supervision strengthened the standards of banks supervision focusing more on the risk management regarding the capital (capital buffers) (Martin, 2021) and for the first time liquidity was also supervised by Basel III standards (Milojević & Redžepagić, 2021). Besides the regulation and supervision of banks, one important analysis is the efficiency of the banks operating in the financial system. Efficiency analyses are important for the decision makers in the banks as well as for the policy makers.

Efficiency can be measured in many different ways. The aim of this paper is to measure the efficiency of the banks operating in Serbia using and comparing different approaches. Namely, the functioning of banking institutions can be considered throughout the intermediary function, operating function and profitability function. Considering these facts, we analyse and compare the efficiency of all three functions of the banks in order to have a systematic overview of the banks' efficiency in the Serbian banking sector and to give an answer which function is the most efficient in the Serbian baking sector. This comparison of all three approaches is rare in the literature; therefore, this paper aims to fill this gap. In this way there is a contribution from the theoretical as well as from the practical point of view as this systematic approach covers the gap in literature and gives also a basis for the decision makers in the banking industry.

For the purpose of our research, we use data envelopment analysis (DEA). DEA is a non-parametric method of efficiency analysis of the decision making unit. The decision making units in our research are the banks. DEA was used first time by Charnes et al. (1978) and since then widely used also for the efficiency measuring of companies and financial institutions.

We use DEA on the sample of all Serbian banks in the period from 2019 to 2021. Our aim is to compare three different approaches used in the banking sector analysis and to show which banks are more efficient regarding the different approaches.

The paper is structured as follows. After the introduction, we present the theoretical background on which our research is based. Data and methodology part of the paper is committed to the sample and the methodology of our research. The results and discussion section includes the results of the descriptive statistics and the DEA analyses of the banks.

The conclusion summarizes the results of our research and gives recommendations for further research.

1. Literature review

Charnes, Cooper and Rhodes (1978) were the first to apply data envelopment analysis in their research. Since then DEA is widely used in all industries where efficiency is in the focus of the measurement. DEA technical efficiency models can be input or output oriented, dependent on the desirable decision making demand. According to that it can measure the ability to get the maximum output without modifying the inputs, and second it can measure the achievement of the given output levels by minimizing the input variables. In the bank efficiency literature, the starting point is that the bank will use a business model that minimizes the input prices and the costs of its output variables or a model that maximizes profits by the given the prices (Hughes & Mester, 2008). The former is input oriented and the latter is output oriented.

Using DEA models in the finance industry, especially in the banking industry, many approaches have been set. The literature in this field is focused basically on one approach and rarely considers all approaches together. Besides that, DEA analysis is widely used as two-stage analysis. It is important in the stage analysis to make a difference between internal and external two-stage models.

Internal two-stage DEA models are known also as network DEA models. These models are structured in two stages (Chen et al., 2009). One type of efficiency is measured in the first stage and another type of efficiency in the second stage, but the output variables in the first stage are at the same time the input variables in the second stage. So, for example, there can be several combinations of efficiency measures: cost efficiency and productive efficiency (Wanke & Barros, 2014); the deposit producing process efficiency and the profit earning process efficiency (Wang et al., 2014); profit efficiency and market efficiency (Liu et al., 2015; Lu & Lo, 2006; Seiford & Zhu, 1999).

External two-stage models use the combination of DEA analysis in the first stage and a regression analysis in the second stage (Milenković et al., 2022; Paleckova, 2019; Simar & Wilson, 2011; Sufian, 2010). In these models, DEA efficiency index is measured first, and some regression methods like Bootstrap, Tobit, OLS, AHP, ANN and others are used in the second stage (Henriques et al., 2020).

Regarding the several approaches used in DEA analysis and variables used in them, there is no consensus in the literature which variables are used. There are even differences in variables used in the same approach. The use of the variables depends on the decision making unit (DMU) and the desirable efficiency that should be analysed. In the following subsection, we synthesize the variables used in different approaches in the existing literature.

1.1. Branch efficiency approach

The branch efficiency is a service oriented approach which measures mostly the cost efficiency of the banks' branches. This approach uses bank level data. Cvetkoska and Savić (2017) use a sample of eight branches. They use a survey to collect data for the input and output variables. In their case, the input variables are personnel, equipment, business premises, and material expenses, and the output variables are lending to citizens, corporate lending, domestic payment operations – total transactions, domestic payment operations – officers, domestic payment operations – average per employee, bank cards, ATM transactions, POS terminals and imprinters transactions, denar saving passbooks, foreign currency saving passbooks and current accounts, deposits structure, realized inflows from legal entities, realized outflows from legal entities, total F/X purchase, inflows from individuals, and outgoing payments from individuals (Cvetkoska & Savić, 2017).

Wu et al. (2006) use the neutral network DEA approach to evaluate branch efficiency of the banks. They use a sample of large Canadian banks. The inputs used in this model are personnel expenses and other expenses of the branches, and the output variables are deposits, revenues and loans of the branches.

Paradi and Zhu (2013) give an overview of the branches research using DEA in their research, with all inputs and outputs used in different studies.

1.2. Intermediary approach

The intermediary approach is used for comparisons between banks and cross-country comparisons of banks. This approach is based on the primary function of the bank the intermediation; therefore, this approach measures the efficiency of generating loans and other placements from the available sources.

Boďa and Zimková (2015) use total deposits, total capital and operating expenses as input variables, and total loans and net interest income as output variables.

Sufian (2011) is one of the rare authors that compare different approaches. In his intermediary approach he uses deposits, labour and capital as input variables, and loans and investments as output variables. Similar to Sufian (2011), Barros et al. (2011) use the number of employees, deposits and total assets as inputs, and loans and securities as outputs.

Milenkovic et al. (2022) use the intermediary DEA approach in the first stage using deposits, labour expenses and capital as inputs, and loans and investments as output variables.

Jemric and Vujicic (2002) combine balance sheet data and survey data, while in comparison of the operating and intermediary approach they use the following variables for the intermediary approach: fixed assets and software, number of

employees and total deposits received as inputs; total loans extended and short-term securities issued by official sectors - CNB bills and MF treasury bills as outputs.

1.3. Operating approach

The operating approach considers the efficiency of banking operations; it is also called the production approach. The aim of this approach is to minimize the operational costs of the banks.

In comparison to the intermediary approach, Jemric and Vujicic (2002) use interest and related costs, commissions for services and related costs, labour related administrative costs (gross wages), and capital related administrative costs (amortization, office maintenance, office supplies etc.) as input variables in their operating approach. For the output variables, they use interest and related revenues, and non-interest revenues (commissions for provisions of services and related revenues).

Paleckova (2019) measures the cost efficiency of the Czech and Slovak commercial banks using interest expenses, other operating expenses and personal expenses as inputs and interest income as the output variable.

In his comparative research into the operating approach, Sufian (2011) uses the following inputs: interest expenses, labour, and the following variables for the outputs interest income and non-interest income.

Boďa and Zimková (2015) use capital and total operational expenses as input variables, and total deposits, total loans and net interest income for the output variables.

1.4. Profitability approach

The profitability or also value-added approach is used to measure the efficiency of earning revenue in banks. It is commonly used in bank efficiency measurement because of the importance of profit in financial institutions like banks.

In the efficiency of the profit earning process, Wang et al. (2014) use deposits as the input variable in the second stage and non-interest income, interest income and non-performing loans as the output variables.

Sufian (2011) has a different view of the profitability approach and he uses labour, capital and interest expenses as inputs, and deposits, loans and investments as output variables in his research.

Profit oriented approach by Boďa and Zimková (2015) means that the input variable is total operating expense and the output variable is net interest income.

In the first stage of the DEA efficiency analysis, Seiford and Zhu (1999) use the profitability approach using employees, assets and equity as inputs, and revenues and

profits as output variables. The same variables are used by Luo (2003) in his research on profitability and marketability efficiency of large banks.

2. Data and methodology

In this paper, efficiency of the Serbian banking sector in the last three years will be analysed as the relation between achieved outputs and used inputs. Therefore, Data Envelopment Analysis (DEA) is a very popular and suitable method for efficiency assessment of various decision making units (DMUs). DEA tends to present DMUs' efficiency in outputs maximization while using minimum inputs or inputs minimization when attaining maximum outputs. Additionally, DEA is conducted based on existent and known data on inputs and outputs. In this analysis, banks that operate on Serbian market in 2019, 2020 and 2021 will be observed as different DMUs and their efficiency will be calculated by three different approaches: intermediary, operating and profitability approach. These approaches use the same DEA methodology, while the selection of input and output variables differs, as presented in the Table 1.

Table 1: Description of efficiency approaches

Intermediary approach	Operating approach	Profitability approach
Inputs: Deposits, Labour, Capital	Inputs: Interest expenses, Labour, Non-interest expenses	Inputs: Loans, Investments
Outputs: Loans, Investments	Outputs: Interest income, Non-interest income	Outputs: Interest income, Non-interest income, Net income

Source: the authors' research

For intermediary approach deposits, labour and capital are used as input variables, while loans and investments are output variables. The operating approach uses different variables. Interest expenses, labour and non-interest expenses are on the side of inputs, while interest income and non-interest income are selected on the side of outputs. The third approach which will be applied is profitability approach, which uses loans and investments as input variables and interest income, non-interest income and net income as output variables. All values of the variables are presented in thousands of RSD.

Data were collected from the National Bank of Serbia database. Descriptive statistics for all input and output variables are presented in Tables 2, 3 and 4. The descriptive statistics shows that there are no significant changes in the values of the input and output variables during the considered three years.

Table 2: Descriptive statistics for input and output variables in 2019 shown in 000 RSD

	Minimum	Maximum	Standard deviation	Mean
Deposits	3148129.00	538672810.00	137469847.29	177353752.00
Capital	1413215.00	100067067.00	29568573.20	43630100.00
Loans	3445960.00	425076129.00	103189962.28	136243697.50
Investments	0.00	143761175.00	41832752.40	54810173.00
Labour	141504.00	6213247.00	1614607.51	1708452.00
Interest income	172604.00	22673804.00	5856083.38	8478563.50
Interest expenses	27399.00	2879692.00	802930.76	1497478.00
Non-interest income	31551.00	12194157.00	2943444.69	2704357.50
Non-interest expenses	2739.00	4502305.00	1088061.28	641941.50
Net income	0.00	12329459.00	3698071.12	4136715.50

Source: the authors' research

Table 3: Descriptive statistics for input and output variables in 2020 shown in 000 RSD

	Minimum	Maximum	Standard deviation	Mean
Deposits	3175997.00	587544810.00	153490871.05	147636351.57
Capital	1710107.00	109014630.00	30329628.12	28330732.17
Loans	3364720.00	462543282.00	113454048.40	111091951.30
Investments	63.00	159029527.00	45793926.76	33462531.43
Labour	147222.00	6376881.00	1761033.96	1861813.22
Interest income	30100.00	22209990.00	5727963.06	5831813.48
Interest expenses	6794.00	2367475.00	717708.32	826966.87
Non-interest income	36509.00	11825359.00	2842490.84	2391241.35
Non-interest expenses	3920.00	4325330.00	1077940.97	779315.39
Net income	0.00	9801586.00	2942948.21	1795150.43

Source: the authors' research

Table 4: Descriptive statistics for input and output variables in 2020 shown in 000 RSD

	Minimum	Maximum	Standard deviation	Mean
Deposits	3539155.00	614369840.00	185385459.93	182155226.09
Capital	1740554.00	119042009.00	33728588.38	31289618.87
Loans	3076103.00	505875568.00	148540016.10	141063176.48
Investments	0.00	153827349.00	47213902.26	37827461.13
Labour	162251.00	6862623.00	1885800.77	2040924.26
Interest income	23966.00	22315269.00	6230920.06	6467620.78
Interest expenses	12766.00	2264569.00	738467.72	853366.78
Non-interest income	47978.00	18988785.00	4494652.87	3587699.35
Non-interest expenses	5560.00	7561620.00	1709127.60	1164230.04
Net income	0.00	10371359.00	2863822.84	2180890.57

Source: the authors' research

One of the main characteristics of DEA method is that it compares efficiency of each DMU with the best one, rather than the average. Various metrics of input and output variables may be used; therefore, the application area of this method is very wide, both on micro and macroeconomic level. Recently, various types of DEA models were developed in order to incorporate some specifics of different application areas and obtain more reliable results. Using DEA methodology efficiency scores that lie between 0 and 1 will be calculated for each DMU separately for every year. It is important to state that those results represent relative efficiency measures, because they depend on the number of DMUs involved, as well as on the number and structure of the inputs and outputs (Radovanov et al., 2020). Results of DEA method show how many decision making units are ineffective, compared to the effective ones. It is also possible to suggest the desired changes of input and output variables, in order to improve the efficiency score of inefficient units. Furthermore, output oriented DEA model with variable return to scale (Banker et al., 1984) will be applied to analyse the efficiency of the Serbian banking sector:

$$\max \phi \qquad (1)$$

$$s.t. \sum_{j=1}^{n} x_{ij}\lambda_j \leq x_{io} \quad i = 1, 2, \dots, m;$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j \geq \phi y_{ro} \quad r = 1, 2, \dots, s;$$

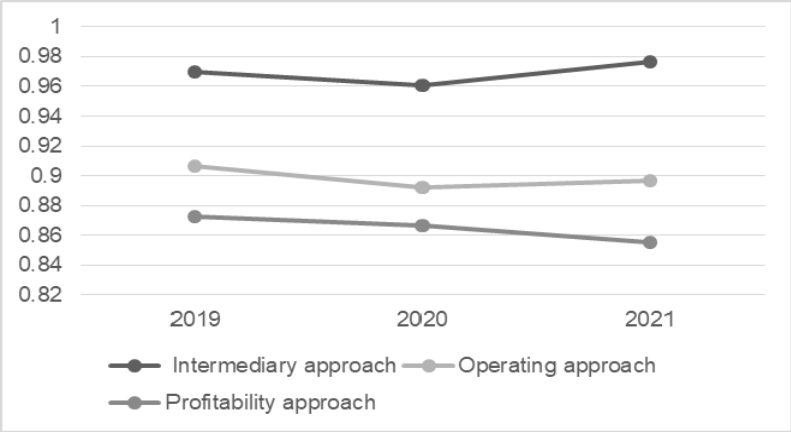
$$\sum_{j=1}^{n} \lambda_j = 1$$
$$\lambda_j \geq 0$$

where n is the number of DMUs and DMU_o represents the bank under evaluation. Assume that we have *s* output variables and *m* input variables. Observed output and input values are y_r and x_i respectively, thus y_{ro} is the amount of output *r* used by DMU_o, while x_{to} is the amount of input *i* used by DMU_o. λ is the DMU's weight and the efficiency score is ϕ. The main disadvantages of DEA are sensitivity to the choice of input and output variables and the inability to predict. DEA presents an ex-post analysis based on already known data (Škare & Rabar, 2016). 'Rule of thumb' states that to apply DEA successfully, the number of selected DMUs has to be at least two to three times higher than the number of variables used as inputs and outputs combined, so that efficiency results would be adequately dispersed (Sarkis, 2007).

3. Results and discussion

Results of the applied DEA model show that Serbian banking sector operates at an enviable level of efficiency, since the average efficiency scores are higher than 0,85 for all applied approaches. The highest efficiency scores are achieved if intermediary approach is applied, while profitability approach has the lowest average efficiency scores in the observed three years (Figure 1). Answering the research question which function of the banks is the most efficient, it can be seen that it is the intermediary, then the operating, and the profitability function is on the third place. These findings show that there is space to enhance the profitability and the cost efficiency of the banking industry in Serbia.

Figure 1: Average Efficiency Scores



Source: the authors' research

Considering the efficiency scores separately for each approach, we can conclude which banks were more or less efficient in the analysed period. This finding is important to the decision making units of each bank in order to make decisions improving the position of each individual bank.

The intermediary approach has been shown as the most efficient approach. Banks in the Serbian financial sector are the most efficient when it comes to the intermediate i.e. converting collected deposits to loans and investments. The average scores of the individual banks in the considered period was above 0.9 except Alta bank and Raiffeisen bank (Table 5.).

Table 5: Results of DEA model: Intermediary Approach

DMU	2019	2020	2021
API	1.00	0.96	1.00
ADDIKO	1.00	1.00	1.00
AIK	1.00	1.00	1.00
INTESA	1.00	1.00	1.00
BOC	1.00	1.00	1.00
POSTANSKA STEDIONICA	1.00	1.00	1.00
CREDITAGRICOLE	1.00	1.00	1.00
ERSTE	1.00	1.00	1.00
EUROBANKDIREKTNA	1.00	1.00	0.97
EXPO	0.85	0.90	0.93
HALK	0.90	0.91	0.96
ALTA	0.86	0.63	0.91
KOMERCIJALNA BANKA	1.00	1.00	1.00
MIRABANK	1.00	1.00	1.00
NLB	1.00	1.00	1.00
OTP	0.92	0.99	1.00
3 BANKA	1.00	1.00	1.00
PROCREDIT	1.00	1.00	1.00
RAIFFEISEN	0.87	0.85	0.91
NASA AIK	0.97	0.92	0.90

SRPSKA	1.00	1.00	1.00
MOBI	0.92	0.94	0.86
UNICREDIT	1.00	1.00	1.00
Mean	0.97	0.96	0.98
St. deviation	0.05	0.08	0.04
Minimum	0.85	0.63	0.86
Maximum	1.00	1.00	1.00

Source: the authors' research

When it comes to the operating approach, it is on the second place among the efficiency of the approaches. This means that when it comes to the cost management of the banks, they have been showed as less efficient compared to the intermediation. Lower efficiency scores were shown by Api bank, Poštanska štedionica, Expo, Alta and Mobi bank (Table 6.). According to the asset classification of the banking sector in Serbia, these banks are classified as small banks. We can therefore conclude that lower levels of the operating efficiency approach is caused by the cost inefficiency of the above listed small banks.

Table 6: Results of DEA model: Operating Approach

DMU	2019	2020	2021
API	0.39	0.38	0.56
ADDIKO	1.00	1.00	1.00
AIK	1.00	1.00	1.00
INTESA	1.00	1.00	1.00
BOC	1.00	1.00	1.00
POSTANSKA STEDIONICA	0.63	0.61	0.73
CREDITAGRICOLE	0.83	0.83	0.84
ERSTE	0.78	0.82	0.96
EUROBANKDIREKTNA	0.97	1.00	0.90
EXPO	0.75	0.83	0.73
HALK	0.96	0.85	0.78
ALTA	1.00	0.69	0.79
KOMERCIJALNA BANKA	1.00	1.00	1.00

MIRABANK	1.00	1.00	1.00
NLB	0.81	0.84	0.86
OTP	1.00	1.00	1.00
3 BANKA	1.00	1.00	1.00
PROCREDIT	0.89	1.00	0.95
RAIFFEISEN	1.00	1.00	1.00
NASA AIK	0.96	0.96	1.00
SRPSKA	1.00	1.00	1.00
MOBI	0.86	0.70	0.53
UNICREDIT	1.00	1.00	1.00
Mean	0.91	0.89	0.90
St. deviation	0.15	0.16	0.15
Minimum	0.39	0.38	0.53
Maximum	1.00	1.00	1.00

Source: the authors' research

The profitability approach of the Serbian banks' efficiency is the lowest among the analysed approaches. This means that there is a potential for increasing the profitability of the Serbian banking sector. Lower efficiency scores are shown by Api bank, Expo, Halk, Alta, NLB, Procredit, Nasa AIK and Srpska bank. These are banks with lower market share except Procredit bank, which focuses on entrepreneur loans. The lower levels of profit efficiency can be explained because of the lower interest rate levels on the given loans by the banks as well as the high costs of lowering NPL (Vesić et al., 2019). Furthermore, the Serbian banking market records a large number of acquisitions in recent years, where the less profitable banks are targets for the acquiring banks.

Table 7: Results of DEA model: Profitability Approach

DMU	2019	2020	2021
API	0.78	0.69	1.00
ADDIKO	0.87	0.85	0.79
AIK	1.00	1.00	1.00
INTESA	1.00	1.00	1.00
BOC	1.00	1.00	1.00
POSTANSKA STEDIONICA	1.00	1.00	1.00

CREDITAGRICOLE	1.00	1.00	1.00
ERSTE	0.91	0.91	0.93
EUROBANKDIREKTNA	1.00	1.00	0.86
EXPO	0.48	0.47	0.44
HALK	0.69	0.68	0.63
ALTA	0.56	0.83	0.75
KOMERCIJALNA BANKA	1.00	1.00	0.87
MIRABANK	1.00	1.00	1.00
NLB	0.72	0.75	0.65
OTP	1.00	0.91	1.00
3 BANKA	1.00	1.00	1.00
PROCREDIT	0.85	0.68	0.73
RAIFFEISEN	1.00	1.00	1.00
NASA AIK	0.72	0.79	0.75
SRPSKA	0.48	0.48	0.40
MOBI	1.00	1.00	1.00
UNICREDIT	1.00	0.90	0.84
Mean	0.87	0.87	0.85
St. deviation	0.18	0.17	0.18
Minimum	0.48	0.47	0.40
Maximum	1.00	1.00	1.00

Source: the authors' research

Conclusion

The aim of this research was to compare the three commonly used approaches and to show which is the most efficient. As the literature review showed, these approaches are seldom used in a comparison. Among the three considered approaches, the most efficient is the intermediary, then the operating, and the profitability approach is on the third place. Each approach considers the efficiency of the banks from a different angle. The intermediary approach measures the efficiency of deposits, labour and capital to generate loans and investments. The operating approach measures the cost efficiency by putting in relationship interest expenses, non-interest expenses and labour cost with interest income and non-interest income. The profitability approach measures the

ability of the banks to generate profit, or precisely measures the efficiency of achieving interest income, non-interest income and net income on the basis of loan and investment placements.

The limitations of this study are mainly linked with the applied methodology, since the results of DEA models highly depend on the selection of sample and variables. DEA is a relative method and can only measure efficiency compared to other units. Therefore, modification of number of banks in the analysis or choice of different input or output variables would surely lead to some changes in the efficiency scores and results. At the same time, DEA has no predictive possibilities and the results remain sensitive to the choice of both DMUs and variables. Furthermore, we did not focus on the determinant which are affecting the efficiency of the banks in this study. Further research should investigate the internal and external determinant of the bank efficiency.

Considering the period during and after the COVID-19 pandemic, the Serbian banking sector has shown high efficiency scores in all three considered approaches. Lower scores have been shown by smaller banks with lower market share in the Serbian banking market.

It is important to mention that the reason for the lower profit efficiency lays in the low interest rates, which were on the historic minimum level during the pandemic. The reason for the lower scores can also be high activity of mergers and acquisitions in the last year, and the synergic effects of the M&A can be expected in the coming years. It can also be noticed that the less efficient and small banks are expected to be acquired by the more efficient bigger banks. Besides that, the Serbian banking market is regarded as low-concentrated (Bukvić, 2020). According to the results of this study more mergers and acquisitions are to be expected on the Serbian market in order to increase the efficiency scores on several levels.

The importance of the results showed is also valuable from the practical point of view for the bank managers. In all three approaches we listed the banks' efficiency scores based on which the decision makers can conclude which banks can improve either the cost, profitability or intermediary efficiencies. Considered on the whole, it can be concluded that the most improvement is required in the profit efficiency management of several banks. Therefore, the profitability in the banking sector can be improved by taking over the less profitable small banks from the banks which have more market share in order to increase the profit levels.

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