


Article

# Efficiency of Commercial Banking in Developing Countries

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**Abstract:** The aim of this paper is to evaluate the relative efficiency of commercial banks in three developing countries in Europe (North Macedonia, Serbia, and Croatia) in the period from 2015 to 2019, and to provide targets for improvement for the inefficient banks by using DEA. The variables are selected under the income-based approach. Based on the output-oriented BCC model, unusual results are obtained for a few commercial banks in each country, that is, they are BCC relative efficient, which is contrary to the real situation. In order to identify outliers that can affect the efficiency results, a super-efficiency procedure is applied so that banks with a super-efficiency score higher than 1.2 (outliers) or for which a feasible solution was not found are considered in detail and removed, and then the output-oriented BCC model is rerun. Based on the obtained results, the Macedonian commercial banking system shows the highest efficiency (91.1%), followed by the Croatian (90.9%) and the Serbian (81.9%) banking system. The estimated targets for improvement of the inefficient commercial banks could help their top bank management in better resource allocation and making fact-based and faster decisions by which they can improve the operation of the banks they lead and contribute to the stability of the financial system.

**Keywords:** bank efficiency; developing countries; Data Envelopment Analysis; BCC; super-efficiency; targets for improvement



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## 1. Introduction

The financial system in developing countries is bank-based; therefore, banks play a vital role in maintaining the stability of the financial system. By measuring their performance, the bank management can monitor whether the bank achieved what was planned, or whether there are deviations, and accordingly take proper corrective actions to ensure that the set targets will be achieved. Efficiency is one of the most important indicators for the successful operation of banks. In the existing literature, there is a parametric and non-parametric approach for measuring the banking efficiency. The most popular non-parametric frontier methodology, Data Envelopment Analysis (DEA), originally developed by [1,2], can handle more than one output, which is not the case when using parametric methods (regression analysis), and can provide valuable information for the projection of the inefficient decision-making units (DMUs) on the efficient frontier, that is, for how much they need to decrease and/or increase the variables (inputs and/or outputs). Therefore, we have chosen to apply DEA in our commercial banking study. In the existing literature we have not found a reference that evaluates the relative efficiency of the commercial banks: (1) in three developing countries in Europe: North Macedonia, Serbia, and Croatia; (2) that uses our selected models (BCC [2,3] and super-efficiency; [4] for outlier identification) in those countries; (3) that provides targets for improvement for each relative-inefficient bank that would help bank management in better allocation of the resources and making fact-based decisions, and (4) that considers the observed period of five years (2015–2019), hence motivating us to conduct this study.

The three analyzed countries have all been derived from SFR Yugoslavia and gained independence in the early 1990s. Banks in these countries up until 1990 were financial organizations that in most cases were designed to support the central planning apparatus. The task of the new governments was to create modern commercial banking sectors immediately. As a result, their banking sectors underwent a dramatic transformation and restructuring transition process. Bank privatization was an essential part of the financial reform agendas in these countries [5].

In the early 1990s, when the monetary independence of North Macedonia was declared, the banking system was underdeveloped and poor. Starting with only six banks in 1992, the liberal approach to establishing new banks affected the entrance of new investors in the industry; thus, the number of new banks rose to 20 in just one year [6]. The process of consolidation, which began in 2001, impacted the rise of competition in the banking sector and the foreign capital entrance in the Macedonian banking market. The largest and most important segments of the financial system are in predominant ownership of foreign shareholders. In 2019, 75.4% of the assets of the Macedonian banking sector were foreign-owned, mostly from European Union countries: Austria (11.2%), Bulgaria (2.0%), Greece (21.4%), Slovenia (16.2%), and Turkey (12.2%) [7]. The structural participation of banks in the total assets of the financial system in 2019 has been a staggering 81.4% [8]. The total number of banks operating in the Macedonian banking market in 2019 was 15.

The transition of the banking sector in Serbia had begun in 2000, that is, later than in other Central European countries [9,10]. This transformational process has been quite difficult and the situation at the beginning of the transition process has been referred to as “catastrophic, considering domestic and foreign debt and level of credit activity” [10]. Furthermore, the banking sector at that time was characterized by “a high degree of illiquidity and insolvency of the largest banks, a high percentage of non-performing loans, poor asset quality, unregulated relations with the London Club, Paris Club and the World Bank, and low profitability” [11]. A long and intense process of transition followed. As a matter of fact, in just 5 years’ time, the Serbian banking sector had noted an extraordinary transformation with the foreign ownership increase from 0.5% in 2000 to 66% in 2005 [12]. The banking system in Serbia today is attributed as a highly competitive system with a low level of concentration. Banks owned by foreign entities account for 75.7% of the total assets, capital and employment of the Serbian banking sector in 2019 [13], mostly from European Union countries: Austria (13.5%), France (2.9%), Hungary (13.5%), and Italy (26.8%) [9]. The banking sector in Serbia has transformed over the past decade as a result of reforms by the banking regulation legislative, which influenced a decrease in the number of banks in the system. Moreover, the entrance of foreign capital made the banking system more competitive, and it can serve as a recommendation to the commercial bank management to focus on efficiency improvement, which will eventually lead to an improvement in competitiveness.

According to the author of [14], the break-up of the Yugoslavian monetary system influenced insolvency in technical terms for the Croatian banks. The banking sector reforms started in 1991 with “measures aimed at liberating banks from accumulated bad loans”. During the transition period, major changes occurred and they impacted the quantity of banks and the ownership structure of the banking sector [15]. The banking sector in Croatia can be considered to be a support for the national economy, due to its critical role in the financing of economic activity [16]. The Croatian banking sector in 2019 consisted of 20 commercial banks, operating in a highly concentrated market. Namely, the share of assets of the first five banks accounts for over 80%, meaning that the five largest banks control more than 80% of the total assets in the banking sector. The bank system is dominated by foreign-owned banks, whose share in total bank assets in 2018 was around 90.2%. Banks in Italian ownership account for close to half of total bank assets (48.9%), while banks in Austrian ownership follow, with a share of 29.9% [17].

In the existing literature, there are two approaches for measuring banking efficiency: the parametric and the non-parametric approach. When using the parametric approach

(regression analysis), we can use only one output, and the deviations from the frontier are based on the average result. The non-parametric approach, or the leading frontier methodology Data Envelopment Analysis, measures the efficiency of homogenous DMUs, that is, DMUs that use identical inputs to produce identical outputs that can be expressed in different measurement units. Examples of homogeneous units are: banks, hospitals, pharmacies, universities, supermarkets, fast food restaurants, and so forth. The DMUs that are relative-efficient comprise the efficient frontier. DEA identifies the relative-efficient vs. inefficient DMUs, and provides information for the reference set (benchmarks) for the inefficient units, as well as how they can be projected in the frontier in the future. This information is especially valuable for decision-makers to plan the resource allocation and to make fact-based decisions that will contribute to successful operation of the DMUs they lead.

We provide an in-depth literature review on bank studies with DEA in each of the analyzed developing countries (six in North Macedonia, four in Serbia, and seven in Croatia). In most of the analyzed studies in North Macedonia, Serbia, and Croatia, the intermediation approach is used, while in this study we focus on the operating (income-based) approach for the input–output selection, as in [3]. We assume that the banks' final objective is to maximize the revenues with the incurred total costs that are made to run their operation [3,6] (p. 1454). We use interest and non-interest expenses as inputs, and interest and non-interest income as outputs. The data for the used variables are collected by hand from the official financial statements from the banks' websites and the Bank Bulletin and the Financial Agency FINA (in the case of Croatia). Based on the income-based approach, we assume that the banks' goal is to maximize the revenues (interest and non-interest) by using the given level of costs (interest and non-interest), and therefore the orientation of the DEA model is the output.

In North Macedonia, commercial banking studies use: DEA, DEA and the Analytic Hierarchy Process (AHP), DEA and ratio analysis, and window analysis. In Serbia, the following are used: DEA, Window Analysis, and Malmquist index, while in Croatia, most of the studies use the CCR and the BCC DEA models, and in [18], the BCC model and the super-efficiency procedure are used [19]. The authors of [19] use the same procedure as in [4], but for ranking relative-efficient DMUs. According to the evidence provided by the authors of [20], the super-efficiency procedure, as used in [19], is not adequate for ranking relative-efficient DMUs. In our study, we use the output-oriented BCC model, which is used in the first stage in [3], that we follow in this paper. The BCC DEA model assumes a variable-returns-to scale (VRS) assumption (where the modification in the inputs does not mean a proportional change in the outputs, as in the constant return-to-scale (CRS) assumption). This assumption has economic logic and its estimator exhibits much quicker convergence [21]. First, we run the output-oriented BCC model, and if unusual results are produced we will run the super-efficiency procedure [4] to identify whether there are any outliers that can affect the efficiency results in the sample. If any outliers are identified, it would be carefully considered whether they will be removed, and if any is/are removed, the output-oriented BCC model will be rerun without those units. We believe that scholars and researchers interested in conducting similar banking studies would benefit from the proper model approach.

According to the obtained results with the output-oriented BCC model on each bank sample for each country, we identified unusual results in each sample and after the super-efficiency procedure; we excluded two Macedonian, two Serbian, and one Croatian bank. Then we reran the output-oriented BCC model for each sample (11 Macedonian, 22 Serbian, and 19 Croatian banks, i.e., a total of 55 Macedonian bank-year observations, 110 Serbian bank-year observations, and 95 Croatian bank-year observations).

We present the efficiency results for each commercial bank by year and on average, as well as the average efficiency results by year and for the whole period for each banking sector. The highest average efficiency for the commercial banking sector for the whole observed period was achieved in North Macedonia (91.1%), followed by Croatia (90.9%) and Serbia (81.9%). In North Macedonia, 36.4% of the commercial banks showed an

efficiency level above the average, while in Serbia it was 50.0%, and in Croatia, 52.6%. In the three commercial banking systems, the most efficient were banks that belonged to the group of large banks. In North Macedonia and Serbia, the highest level of efficiency was obtained in 2015 (96.6% and 84.1%, respectively), while the lowest was in 2018 (87.5% and 81.1%, respectively). In Croatia, the highest level of efficiency was obtained in 2019 (91.9%), while the lowest was in 2017 (89.9%). The highest percentage of inefficient banks for the whole observed period was determined in Serbia (45.5%), followed by North Macedonia (27.2%) and Croatia (26.3%). In addition, we provide targets for the improvement of each inefficient commercial bank for each banking system for the last observed year: 2019. Those results are of key importance for top bank management through proper planning of resource allocation and making better and faster decisions to ensure successful operation of the banks.

Instead of the Introduction section presented in Section 1, in Section 2 we provide a literature review for bank efficiency in North Macedonia, Serbia, and Croatia. In Section 3, we focus on variables and explanations of the data and methodology, while in Section 4, we present and analyze the obtained results. In Section 5 we provide a discussion on the results, while in Section 6 we conclude the paper.

## 2. Literature Review on Bank Efficiency in Three Developing Countries

A literature survey on DEA journal-published articles in four decades, that is, starting from the first DEA study published in 1978 [1] until the end of 2016, has been made by the authors of [22]. They found that in the last two analyzed years (2015 and 2016), the most DEA applications were in agriculture, banking, supply chains, transportation, and public policy. In addition, the authors of [23] made the first bibliometric analysis on DEA in banking in the period from 1986 to 2019, where they analyzed 791 articles published in peer-reviewed journals listed in the Scopus database. They used text-mining to extract the abstract keywords in three different periods (pre-2000, 2001–2010, and 2011–2019) in order to identify research hotspots, and they provide directions for further research in banking.

We provide an in-depth literature review on DEA studies on bank efficiency in North Macedonia (Section 2.1), Serbia (Section 2.2), and Croatia (Section 2.3).

### 2.1. Literature Review on Bank Efficiency in North Macedonia

The first banking study with DEA in North Macedonia is by the author of [24]. The sample for analysis consists of 15 Macedonian commercial banks, and the observed period is from 2005 to 2008. A two-stage approach has been applied, so that DEA (the input-oriented CCR model) is used in the first stage, and the analytic hierarchy process (AHP) in the second stage, to set weight restrictions in the DEA model. The average efficiency for the whole observed period is 84%. The lowest relative efficiency was achieved in 2005 (76%), while the highest was in 2007 (93%).

The authors of [25] measured the efficiency of the Macedonian banking sector during the period 2008–2011 using the DEA approach. They measured the technical, pure technical, and scale efficiency of 15 banks in North Macedonia using two DEA models: CCR and BCC with input orientation. They used the intermediation approach, and selected the total deposits received and labor costs as inputs, with loans to banks and customers, and investments as outputs. They found that the average technical efficiency of the Macedonian banking industry noted an increase in the period from 2008 to 2010, and thereafter noted a decrease in efficiency in the last year of the observed period, that is, in 2011. The group of large-sized banks showed the highest pure efficiency results and the greatest scale of inefficiency.

The authors of [26] measured the efficiency of the banking sector in North Macedonia from two perspectives. First, they made a comparative analysis focused on the indicators of efficiency of the Macedonian banking sector with attention on the countries of Central and Southeastern Europe in the observed period from 2003 to 2012. Second, they estimated the relative efficiency of 14 Macedonian commercial banks in the period from 2007 to 2013 by

using DEA, that is, the output-oriented DEA-CCR model. The used inputs were deposits and operating costs, while loans and net interest income were chosen as outputs. The average efficiency result of the Macedonian banking sector has been at sky-scraping in 2008 (90.35%) and it truncated in 2012 (79.83%). In the whole observed period, five banks were identified as relative-inefficient. The highest number of relative-efficient banks (six banks) was identified in 2008, and the lowest number of efficient banks (three banks) was in 2011 and 2012.

The authors of [27] used the same variables and time-frame as in the study by the authors of [26], but they applied the output-oriented DEA-BCC. The average efficiency results of the Macedonian banking sector was highest in 2008 (93.66%) and the lowest results were obtained in 2009 (86.96%). In addition, four banks were identified as relative-efficient.

The authors of [28] used DEA Window analysis, and as inputs, selected the total deposits (deposits from banks and other clients), interest costs and operating (non-interest) costs (costs for salaries, amortization, administrative costs, and other operating costs), while total loans (issued to banks and other clients), interest revenue, and non-interest revenue (fee and commission revenue and other operating revenue) were selected as outputs. The observed period was from 2008 to 2015. The main findings show that the average efficiency of the banking industry in North Macedonia in the observed period is 88.77%. The group of large-sized banks has the highest efficiency results in the Macedonian banking sector.

The authors of [6] assessed the efficiency of Macedonian banks in the period from 2007 to 2017 by using Window analysis (VRS assumption and output orientation). As inputs, they selected interest and non-interest expenses, while the outputs were interest and non-interest revenues. The obtained results show that in the first few years after the global financial crisis, there was lower efficiency in the majority of banks. The lowest average efficiency was achieved in 2011 (65.25%), while the highest was in 2007 (84.04%).

## 2.2. Literature Review on Bank Efficiency in Serbia

The authors of [29] evaluated the scale of productivity change of Serbian banks in the period 2007–2010. They also presented the modern scientific methods for testing the efficiency and productivity of bank operations, highlighting that new scientific methods should be used as a supplement to traditional financial report analysis using known indicators of efficiency. They calculated the Malmquist productivity index for efficiency estimation for each individual bank and changes in productivity within the analyzed period. Their findings show a productivity decrease of the banking sector in the observed period.

The authors of [30] used DEA to measure the efficiency of Serbian banks in the period 2014–2016. The results of their research show that less than one-third of Serbian banks operated efficiently in the observed period. They claim that the main roots of inefficiency were the inefficient management operations of disadvantageous conditions. Under the VRS assumption, 11 banks in 2014 were relative-efficient, eight were efficient in 2015, and nine were relative-efficient in 2016. Under the CRS assumption, there were seven, six, and five relative-efficient banks in 2014, 2015, and 2016, respectively.

The measurement of the Serbian bank efficiency in 2016 with DEA (with a constant return-to-scale assumption) was made by the authors of [31]. The selected inputs were the total assets, number of employees, and capital, whereas the outputs were the operating income and net profit. They found that out of 30 banks, only eight banks were efficient.

The authors of [32] used an extended DEA Window analysis to assess the efficiency of the banking sector in Serbia. They used panel data for the period from 2005 to 2011. In their study, they provided two analyses: the profit efficiency model (with interest expenses and non-interest expenses as inputs, and interest income and non-interest income as outputs), and the operating efficiency model (with the number of employees, fixed assets and intangible investments, capital and deposits as inputs, and granted loans and deposits and non-interest income as outputs). Most of the banks have been “located in the range of efficiency between 60% and 70%”, in both the profit and operating efficiency measurement. They identified only five banks to be relative-efficient in the whole observed period.

### 2.3. Literature Review on Bank Efficiency in Croatia

The authors of [33] were the first to implement the DEA in banking in Croatia. They analyzed the banking sector in the period 1995–2000 and used the input-oriented CCR and BCC models. Their findings imply that foreign-owned banks and new banks are, on average, more efficient compared with domestic banks and old banks, respectively. The average CCR efficiency of the banks was 0.445 in 1995 and 0.745 in 2000, while the average BCC efficiency was 0.777 in 1995 and 0.852 in 2000.

The author of [34] used DEA to measure the efficiency in four countries of southeastern Europe: Bulgaria, Croatia, Kosovo, and Montenegro. The intermediation approach was used, and deposits and total costs were selected as inputs, while the net loans of provisions and total revenues were selected as outputs. The observed period for Bulgaria, Croatia, and Kosovo was 2002–2005, while for Kosovo it was only 2005. In Croatia, the average CRS score was 80.5, while the average VRS score was 87.1%. In addition, in Croatia, the foreign banks showed higher efficiency under both assumptions (CRS and VRS).

The authors of [35] used CCR and BCC output-oriented models and the intermediation approach in the selection of variables. They selected interest expenses, non-interest expenses, other expenses as inputs, and interest incomes, non-interest incomes, and other incomes from business activity as outputs. The observed period was from 2005 to 2010. Their findings show that efficiency has been declining since 2007, and 2008 is the year with the lowest efficiency results.

The authors of [36] used the CCR and BCC output-oriented models in the period from 2008 to 2012. The variables were selected under the profitability approach, that is, as inputs, interest expenses and total operating expenses were selected, while as outputs, interest income and total operating income were selected. Their results show the lowest average relative efficiency in 2012, while the highest was in 2008 (according to the CCR model), whereas the BCC model shows the lowest average efficiency in 2009.

The authors of [16] estimated the relative efficiency of the Croatian banking sector in 2016. They have applied input-oriented CCR and BCC models. The used inputs are interest costs, commission and fee costs, and general and administrative costs and amortization, while the used outputs are interest revenues and non-interest revenues, that is, commission and fee revenues. Their findings show that 11 out of 24 banks were efficient in 2016. More interestingly, they could not find a statistically significant difference regarding the ownership of the banks.

The authors of [37] used the CCR and BCC output-oriented models and the intermediation approach in the selection of variables. They selected deposits and total equity as inputs and loans and income from fees and commissions as outputs. Their study observed the period from 2004 to 2016. According to the results, the group of large banks is most efficient (when using the BCC model), while medium-sized banks are most efficient (when using the CCR model). They found “small-sized banks to be the least efficient bank group in Croatia”.

One of the studies regarding the efficiency of the Croatian banking sector has also presented new data regarding the impact of the EU accession on bank efficiency [18]. In this study, the BCC output-oriented model and super-efficiency model were implemented [19]. The observed period is from 2006 to 2015. They used the intermediation approach and selected interest and non-interest expenses as inputs, and interest and non-interest revenues as outputs. Their findings show that Croatian banks have gained benefits from the EU accession and that it had an impact on its efficiency by 45%. Their findings show that there are a few commercial banks that have maintained their superior efficiency positions over the years (such as Zagrebačka Banka d.d., Privredna Banka Zagreb).

### 3. Variables, Data and Methodology

The aim of this paper is to evaluate and measure the relative efficiency of commercial banks in each of the three developing countries in Europe—North Macedonia, Serbia, and Croatia—under the operating (income-based) approach in a period of 5 years (2015–

2019) and to provide efficiency results for each commercial bank and each commercial banking sector, as well as to give targets for improvement for inefficient banks. We have not included 2020 in the analysis due to the lack of available statements.

We use the operating (income-based) approach as in [3] (p. 1454), according to which the final objective of banks, as business units, is to generate revenue from the total cost that is incurred to run the business [38]. Therefore, we follow [3] in the selection of inputs and outputs: interest and other operating (non-interest) expenses as inputs, and interest and other operating (non-interest) revenues as outputs. The definition of the used variables (inputs and outputs) is given in Table 1. The data for the input and output variables for each commercial bank in each country were collected by hand from the banks’ official and published financial reports—the P&L statement (in the case of Macedonian commercial banks), in the same way that data were collected according to the official website of the National Bank of Serbia and financial reports separately from each commercial bank in Serbia and from the Croatian National Bank’s Bank Bulletin (in the case of Croatian commercial banks) (Table 1). We use a balanced panel data set for each of the analyzed countries.

**Table 1.** Definition of inputs and outputs.

Input Variables	Source
Interest expenses	Banks’ official and published financial reports—P&L Statement
Other operating (non-interest) expenses: fee and commission expense, staff expense, administrative costs, depreciation, and other expenses	Banks’ official and published financial reports—P&L Statement
Output Variables	Source
Interest revenues	Banks’ official and published financial reports—P&L Statement
Other operating (non-interest) revenues: fee and commission revenue, and other revenues	Banks’ official and published financial reports—P&L Statement

In North Macedonia, the total number of active commercial banks in 2019 was 15. We have excluded the Macedonian Bank for Development and Promotion from the analysis due to the nature of its operations (it has a specific development function in the sector and does not engage in the deposits collection), as well as Eurostandard Banka AD Skopje because the data were not available in 2019. In addition, the National Bank of the Republic of North Macedonia revoked the license of Eurostandard Banka AD Skopje in 12 August 2020 due to non-compliance with the minimum requirements for operating as a bank. Therefore, our Macedonian commercial banks sample counts 13 banks (a total of 65 bank-year observations). In Serbia, the total number of active banks in 2019 was 26. We have excluded the OTP Banka Srbija AD Novi Sad from the analysis due to lack of data for 2015–2017 for the used variables. In Croatia, the total number of active commercial banks at the end of 2019 was 20, and the Croatian banking sample consists of all of these banks (a total of 100 bank-year observations).

The descriptive statistics for the commercial banks in North Macedonia, Serbia, and Croatia is given in Appendices A–C, respectively. Only the sample after excluding the outliers is considered for the descriptive statistics. Taking the fact that we are using the income-based approach into account, we assume that the banks’ goal is to maximize the outputs (revenues) with the given level of inputs (expenses), that is, that we are using output orientation. We follow [3] in the selection of the DEA model (as in their first stage) and we present below the envelopment form of the output-oriented BCC model.

The envelopment form of the output-oriented BCC DEA model is given in (1)–(5) [39]:

$$\begin{aligned}
 & (BCC - O_o) \\
 & \max_{\eta_B, \lambda} \eta_B \tag{1}
 \end{aligned}$$

subject to

$$X\lambda \leq x_0 \quad (2)$$

$$\eta_B y_0 - Y\lambda \leq 0 \quad (3)$$

$$e\lambda = 1 \quad (4)$$

$$\lambda \geq 0 \quad (5)$$

where  $\eta_B$  is a scalar. The input data for DMU $j$  ( $j = 1, \dots, n$ ) are  $(x_{1j}, x_{2j}, \dots, x_{mj})$ , and the output data are  $(y_{1j}, y_{2j}, \dots, y_{sj})$ ; the data set is given by two matrices  $X$  and  $Y$ , where  $X$  is the input data matrix, and  $Y$  is the output data matrix,  $\lambda$  is a column vector and all its elements are non-negative, while  $e$  is a row vector and all its elements are equal to 1 [39] (pp. 22, 91–92), [40] (pp. 33–34). The BCC efficiency requires fulfillment of two conditions: (1) the result of the BCC efficiency to be equal to 1 (100%), and (2) all slacks to have a zero value.

On each country's bank data set, we will apply the output-oriented BCC DEA model and analyze the obtained results. In the case of unusual results to be obtained, we will apply the super-efficiency procedure as proposed by [4]. This procedure works as follows: to evaluate the DMUs efficiency, we will not include all DMUs in the sample, but we will exclude one DMU. Then the efficiency results will be estimated without that DMU, and once they are obtained, the efficiency of the excluded DMU will be evaluated regarding those that are identified as relative-efficient. This procedure will be repeated by dropping one different DMU each time, until all of them are once excluded. If the super-efficiency result of a DMU is higher than 1.2, this DMU should be considered as an outlier [20]. If we identify outliers, we will further explore whether to exclude them from the analysis, taking into consideration our banking expertise in the analyzed samples, and then if any outliers are excluded, the output-oriented BCC DEA model will be rerun.

The results are obtained by using the software MaxDEA 8 Ultra (licensed version), and they are presented in the section that follows.

#### 4. Results

The Macedonian, Serbian, and Croatian banking efficiency results are presented in Sections 4.1–4.3, respectively.

##### 4.1. Macedonian Commercial Banking Efficiency Results

Based on the efficiency results of the output-oriented BCC DEA model on a sample of 13 commercial bank-year observations (a total of 65 bank-year observations) in North Macedonia, unusual results were obtained for one bank in the group of small-sized banks (banks in North Macedonia are classified according to their total assets in three groups: small-sized, medium-sized, and large. Large banks have assets higher than 37.95 bln. MKD, middle-sized banks have assets between 9.45 and 37.95 bln. MKD, while small-sized banks have assets lower than 9.45 bln. MKD [41]). Capital Banka AD Skopje was identified as relative-efficient in the whole observed period, but the real situation does not reflect that. More precisely, the bank operated with a low level of net profit in 2015 (15,612,000.00 MKD) and 2019 (2,071,000.00 MKD), while in 2017 and 2018, it experienced high loan-impairment losses (and ended the year with a net loss of 175,804,000.00 MKD and 1,868,000.00 MKD, respectively). We have applied the [4] super-efficiency procedure and found that for Capital Banka AD Skopje, there was no feasible solution in each of the observed years. The BCC model has identified this bank as relative-efficient because it was not comparable with the other banks based on the data used, and the algorithm compares it only with itself. Additionally, for another small-sized bank—TTK Banka AD Skopje—a feasible solution was not found in 2016 and 2017, while in the other years its super-efficiency results were much higher than the one proposed by the authors of [20], which is 1.2. TTK Banka AD Skopje showed super-efficiency results of 2.3171, 1.4319, and 1.7252 in 2015, 2018, and 2019, respectively. Consequently, we have excluded those two banks from the analysis and rerun



the output-oriented BCC model on a sample of 11 Macedonian bank-year observations (a total of 55 bank-year observations).

In Figure 1, we present the efficiency results for 11 commercial banks in North Macedonia in the observed period of 5 years (2015–2019), the average efficiency results of each bank, as well as the average efficiency of the banking sector by year and for the whole period. In addition, we visualize the efficiency results for each bank, as well as for the banking sector by year by using the line sparkline where orange marks the high points (the highest efficiency results (s)), while the average efficiency results for each commercial bank is visualized by using data bars from conditional formatting in Excel.

Bank	2015	2016	2017	2018	2019	Sparkline (line)	Average
Centralna Kooperativna Banka AD Skopje	100.0%	100.0%	98.8%	82.7%	100.0%		96.3%
Halk Banka AD Skopje	87.6%	81.4%	73.7%	76.8%	75.9%		79.1%
Komercijalna Banka AD Skopje	100.0%	100.0%	100.0%	100.0%	100.0%		100.0%
NLB Banka AD Skopje	100.0%	100.0%	100.0%	100.0%	100.0%		100.0%
Ohridska Banka AD Skopje	89.5%	79.2%	77.2%	76.3%	56.4%		75.7%
ProCredit Banka AD Skopje	85.9%	79.7%	79.1%	71.8%	76.5%		78.6%
Silk Road Banka AD Skopje	100.0%	100.0%	100.0%	100.0%	100.0%		100.0%
Sparkasse Banka AD Skopje	100.0%	100.0%	100.0%	98.9%	92.9%		98.4%
Stopanska Banka AD Bitola	100.0%	87.0%	80.1%	76.5%	89.1%		86.5%
Stopanska Banka AD Skopje	100.0%	100.0%	100.0%	100.0%	100.0%		100.0%
Uni Banka AD Skopje	100.0%	83.7%	100.0%	79.5%	73.2%		87.3%
<b>Average</b>	<b>96.6%</b>	<b>91.9%</b>	<b>91.7%</b>	<b>87.5%</b>	<b>87.6%</b>		<b>91.1%</b>

Figure 1. Macedonian commercial banking efficiency results.

According to the presented results in Figure 1, we can see that four Macedonian banks are relative-efficient in the whole period, and they are: Komercijalna Banka AD Skopje, NLB Banka AD Skopje, Stopanska Banka AD Skopje (which belong to the group of large banks), and Silk Road Banka AD Skopje, which belongs to the group of small-sized banks. Ohridska Banka AD Skopje has the lowest average efficiency results (75.7%) and it is the only bank that has decreased its efficiency year by year. This is due to the high impairment costs of financial assets in 2016, which include the provisions for growth of the portfolio, as well as additional reservations at the discretion of the relevant bodies of the bank. However, Ohridska Banka AD Skopje was acquired by the powerful Steiermarkische Sparkasse Group (already operating in the Macedonian banking market) in 2019, so further growth and better efficiency are expected.

Six banks note average efficiency results above the average of the banking system (91.1%). The average banking efficiency was the highest in 2015 (96.6%), while it was the lowest in 2018 (87.5%). The lowest number of relatively efficient banks in 2018 is related with the lower interest income of Macedonian banks. Even though Macedonian banks noted an increased volume of activities in 2018, this was not enough to support the growth of interest income. Banks managed to offset some of that decline through downsizing on the expenditure side, but that space is getting narrower [42].

#### 4.2. Serbian Commercial Banking Efficiency Results

Based on the efficiency scores of the output-oriented BCC DEA model on a sample of 24 commercial bank-year observations (a total of 120 bank-year observations) in Serbia, unusual results were obtained for two banks (Srpska Banka AD Beograd and Mirabank AD Beograd-Novu Beograd) that were identified as relative-efficient for the whole observed period. The profitability result of Srpska Banka AD Beograd decreased by 89.97% in 2019 compared to 2015. In 2019, a commission was formed to focus on the future of Srpska Banka AD Beograd. Mirabank a.d. Beograd-Novu Beograd, on the other hand, has been operating with losses in the observed period of five years due to structural changes in the bank. Mirabank a.d. Beograd-Novu Beograd and the Bank of China were newcomers to the local Serbian banking market in 2015. In addition, the financial management of Mirabank a.d. Beograd-Novu Beograd prepared financial statements, but based on a concern and

involvement basis, because the bank is a loss-making entity gaining unsatisfied financial results. Furthermore, a positive fact for this bank is the well UAE capitalization and the significant support from the Group with subordinated debt. This support could possibly bring further improvement and strengthening of economic trade and relationship between the United Arab Emirates and Serbia through Mirabank a.d. Beograd-Novi Beograd.

After applying the super-efficiency procedure, we have not found a feasible solution for Srpska Banka AD Beograd and the explanation is the same as for Capital Banka AD Skopje, explained in Section 4.1, while Mirabank AD Beograd-Novi Beograd was identified as an outlier in the whole analyzed period. Therefore, we have excluded those banks and rerun the output-oriented BCC model on a sample of 22 Serbian commercial banks (a total of 110 bank-year observations).

We present the efficiency results for Serbian commercial banking in Figure 2. According to the obtained results, we can see that four Serbian banks are relative-efficient in the whole analyzed period, and they are: Agroindustrijsko Komercijalna Banka AD Beograd, Banka Intesa AD Beograd, Raiffeisen Banka AD Beograd, and Unikredit Bank Srbija AD (Stari Grad), which belong to the group of large banks according to the classification by the National Bank of the Republic of Serbia. According to the selected parameters based on the classification from the National Bank of the Republic of Serbia, the primary focus is that the recent banking sector, that is, in 2019, without any change, has been represented by 26 commercial banks. In addition, their foreign ownership affects 19 banks and nine domestic-owned banks [13]. Mobi Banka AD Belgrade has the lowest average efficiency results (38.9%), and it has operated at a loss during the observed period, having been reflected in the final fiscal year of 2019 with a loss of 491,556,000 RSD. Eleven banks have average efficiency results above the average of the Serbian commercial banking system (81.9%). The average banking efficiency was the highest in 2015 (84.1%), while it was lowest in 2018 (81.1%).

Bank	2015	2016	2017	2018	2019	Sparkline (line)	Average
Addiko Bank a.d. Beograd	61.7%	61.5%	66.9%	63.3%	80.0%		66.7%
Agroindustrijsko Komercijalna Banka a.d. Beograd	100.0%	100.0%	100.0%	100.0%	100.0%		100.0%
ALTA banka a.d. Beograd	100.0%	100.0%	92.2%	100.0%	100.0%		98.4%
API Bank a.d. Beograd	100.0%	100.0%	100.0%	100.0%	43.1%		88.6%
Banca Intesa a.d. Beograd	100.0%	100.0%	100.0%	100.0%	100.0%		100.0%
Bank of China Srbija a.d. Beograd	99.4%	92.6%	89.9%	100.0%	100.0%		96.4%
Banka Poštanska Štedionica a.d. (Pallula)	99.7%	94.2%	57.5%	55.0%	59.9%		73.3%
Credit Agricole Banka Srbija a.d. Novi Sad	67.9%	63.1%	58.3%	60.0%	67.1%		63.3%
Direktna Banka a.d. Kragujevac	76.2%	100.0%	100.0%	100.0%	75.1%		90.3%
Erste Bank a.d. Novi Sad	91.7%	81.0%	79.9%	74.6%	79.2%		81.3%
Eurobank a.d. Beograd	100.0%	95.2%	94.8%	91.5%	90.9%		94.5%
Expobank a.d. Beograd	66.0%	51.2%	100.0%	66.0%	78.7%		72.4%
Halkbank a.d. Beograd	50.4%	87.1%	79.2%	72.8%	77.9%		73.5%
Komercijalna Banka a.d. Beograd	99.7%	100.0%	97.4%	100.0%	96.3%		98.7%
Mobi Banka a.d. Beograd	44.8%	31.0%	28.5%	36.7%	53.9%		38.9%
MTS Banka a.d. Beograd	73.6%	93.6%	100.0%	100.0%	100.0%		93.4%
NLB Banka a.d. Beograd	83.7%	76.5%	84.7%	75.6%	71.6%		78.4%
Opportunity Banka a.d. Novi Sad	62.6%	59.9%	53.9%	53.9%	62.5%		58.6%
ProCredit Bank A.D. Beograd	83.3%	79.1%	73.5%	61.1%	69.8%		73.4%
Raiffeisen Banka a.d. Beograd	100.0%	100.0%	100.0%	100.0%	100.0%		100.0%
Sberbank Srbija a.d. Beograd	90.1%	76.4%	81.7%	72.9%	80.1%		80.2%
Unicredit Bank Srbija a.d. (Stari Grad)	100.0%	100.0%	100.0%	100.0%	100.0%		100.0%
<b>Average</b>	<b>84.1%</b>	<b>83.7%</b>	<b>83.6%</b>	<b>81.1%</b>	<b>81.2%</b>		<b>81.9%</b>

Figure 2. Serbian commercial banking efficiency results.

### 4.3. Croatian Commercial Banking Efficiency Results

Based on the obtained results with the output-oriented BCC DEA model, unusual results were obtained for Samoborska Banka d.d., which was relative-efficient in the whole observed period, but this bank operated with losses from 2015 to 2017 (a loss of 7,768,000 HRK, 9,428,000 HRK, and 7,052,000 HRK in 2015, 2016, and 2017, respectively). The bank operated with profit in 2018 (1,050,000 HRK) and increased the profit to 3,599,000 HRK in 2019. After applying the super-efficiency procedure [4], no feasible solution was found for this bank in the whole observed period; hence, we have excluded

Samoborska Banka d.d. from the analysis and rerun the output-oriented BCC model on a sample of 19 bank-year observations (a total of 95 bank-year observations).

In Figure 3, we show the efficiency results for Croatian commercial banking. According to the presented results, we can see that eight banks are relative-efficient in the whole observed period. These include all the banks from the large banks' group (the Croatian National Bank classifies banks as small-sized banks (banks with a market share of less than 1%), middle-sized banks (banks with a market share between 1 and 5%) and large banks (banks with a market share above 5%) [43])—a total of five large banks (Erste & Steiermaerkische Bank d.d., Hrvatska Postanska Banka d.d., Privredna Banka Zagreb d.d., Reiffeisenbank Austria d.d., and Zagrebačka Banka d.d.)—and Banka Kovanica d.d., Istarska Kreditna Banka d.d., and Slatinska Banka d.d.

Bank	2015	2016	2017	2018	2019	Sparkline (line)	Average
Addiko Bank d.d.	62.3%	74.9%	80.3%	76.0%	85.1%		75.7%
Agram banka d.d.	82.4%	82.9%	84.1%	90.4%	96.7%		87.3%
Banka Kovanica d.d.	100.0%	100.0%	100.0%	100.0%	100.0%		100.0%
Croatia banka d.d.	84.9%	81.6%	67.4%	66.5%	69.0%		73.9%
Erste&Steiermaerkische Bank d.d.	100.0%	100.0%	100.0%	100.0%	100.0%		100.0%
Hrvatska postanska banka d.d.	100.0%	100.0%	100.0%	100.0%	100.0%		100.0%
Imex banka d.d.	100.0%	87.0%	73.7%	74.3%	71.4%		81.3%
Istarska Kreditna Banka Umag d.d.	100.0%	100.0%	100.0%	100.0%	100.0%		100.0%
J&T banka d.d.	65.9%	68.2%	100.0%	100.0%	100.0%		86.8%
Karlovacka banka d.d.	74.3%	100.0%	100.0%	100.0%	100.0%		94.9%
KentBank d.d.	100.0%	72.9%	69.9%	78.6%	79.7%		80.2%
OTP banka d.d.	92.6%	100.0%	100.0%	100.0%	100.0%		98.5%
Partner banka d.d.	100.0%	91.1%	75.7%	78.4%	70.9%		83.2%
Podravska banka d.d.	76.3%	87.4%	73.1%	77.7%	79.1%		78.7%
Privredna banka Zagreb d.d.	100.0%	100.0%	100.0%	100.0%	100.0%		100.0%
Reiffesenbank Austria d.d.	100.0%	100.0%	100.0%	100.0%	100.0%		100.0%
Sberbank d.d.	84.9%	90.3%	84.8%	82.8%	93.8%		87.3%
Slatinska banka d.d.	100.0%	100.0%	100.0%	100.0%	100.0%		100.0%
Zagrebacka banka d.d.	100.0%	100.0%	100.0%	100.0%	100.0%		100.0%
<b>Average</b>	<b>90.7%</b>	<b>91.4%</b>	<b>89.9%</b>	<b>90.8%</b>	<b>91.9%</b>		<b>90.9%</b>

Figure 3. Croatian commercial banking efficiency results.

The least efficient bank in the Croatian banking system is Croatia Banka d.d. (73.9%). This can be explained by the impairment of loans and advances to customers, as well as the process of consolidation of the liquidity structure at the level of the entire bank.

Ten banks have average efficiency results above the average of the Croatian banking system (90.9%). The average banking efficiency was highest in 2019 (91.9%), while it was lowest in 2017 (89.9%). The lowest efficiency in 2017 is understandable, as the collapse of the largest national concern Agrokor Group is put in this context. The leading agri-business group Agrokor Group's fall was reflected in the banking market and the Croatian economy in general.

#### 4.4. Setting Targets for Efficiency Improvement for the Relative-Inefficient Commercial Banks

One of the advantages of using DEA is because it provides information for targets for improvement, that is, increase and/or decrease in the used variables for the DMUs that are identified as relative-inefficient.

In Figures 4–6, we provide targets for improvement for the inefficient commercial banks in North Macedonia, Serbia, and Croatia, respectively for the last year of the observed period.

Based on Figure 4, we can see that Halk Bank AD Skopje should decrease the interest expense by 12.8% (to 415,741 thousands MKD) and increase the interest revenue and the non-interest revenue by 24.1% (to 273,1531 thousands MKD) and by 38.5% (to 1,302,194 thousands MKD), respectively, in order to be projected on the efficient frontier, that is, to be relative-efficient. In addition, Sparkasse Banka AD Skopje should decrease the non-interest expense by 1.7% (to 925,143 thousands MKD) and increase the interest revenue and the non-interest revenue by 7.1% (to 877,914 thousands MKD) and by 8.6% (to 395,197 thousands MKD), respectively, to be relative-efficient. The other results can be explained in an analogous way.

Bank	Projection (Interest Expense)	Percent change	Projection (Non interest Expense)	Percent change	Projection (Interest Revenue)	Percent change	Projection (Non interest Revenue)	Percent change
Halk Bank AD Skopje	415,741.41	-12.8%	1,679,048.00	0%	2,731,531.09	24.1%	1,302,193.67	38.5%
Ohridska Banka AD Skopje	411,614.44	-0.4%	1,660,827.00	0%	2,698,200.33	43.6%	1,285,392.59	48.4%
ProCredit Banka AD Skopje	221,900.65	-32.4%	823,221.00	0%	1,166,009.98	23.5%	513,059.55	33.7%
Sparkasse Banka AD Skopje	150,700.00	0%	925,143.49	-1.7%	877,913.50	7.1%	395,196.59	8.6%
Stopanska Banka AD Bitola	151,534.69	-2.9%	512,548.00	0%	597,711.55	25.1%	226,596.67	10.9%
Uni Banka AD Skopje	258,360.95	-7.3%	984,197.00	0%	1,460,475.24	26.8%	661,491.01	37.5%

Figure 4. Targets for improvement for the inefficient Macedonian commercial banks (in 000 MKD Denars).

Bank	Projection (Interest Revenue)	Percent change	Projection (Non Interest Revenue)	Percent change
Addiko Bank a.d. Beograd	5,675,970.08	20.0%	2,342,728.25	20.0%
API Bank a.d. Beograd	795,469.54	61.9%	303,544.23	56.9%
Banka Poštanska Štedionica a.d. (Palilula)	15,579,739.96	40.1%	7,356,133.31	40.6%
Credit Agricole Banka Srbija a.d. Novi Sad	6,456,287.46	32.9%	3,354,152.18	32.9%
Direktna Banka a.d. Kragujevac	3,788,475.78	24.9%	1,740,523.81	24.9%
Erste Bank a.d. Novi Sad	11,852,178.09	20.8%	4,268,113.15	20.8%
Eurobank a.d. Beograd	8,488,281.91	9.1%	3,516,718.42	20.1%
Expobank a.d. Beograd	870,698.94	21.3%	306,895.04	45.7%
Halkbank a.d. Beograd	3,245,443.39	22.1%	1,300,455.13	26.0%
Komercijalna Banka a.d. Beograd	14,158,331.15	3.7%	8,306,514.81	3.7%
Mobi Banka a.d. Beograd	2,486,217.97	66.0%	1,434,326.55	46.1%
NLB Banka a.d. Beograd	4,390,248.43	28.4%	1,752,994.10	28.4%
Opportunity Banka a.d. Novi Sad	3,793,125.07	37.5%	1,563,296.44	71.7%
ProCredit Bank A.D. Beograd	5,365,789.26	30.2%	3,552,249.13	57.7%
Sberbank Srbija a.d. Beograd	6,714,905.23	19.9%	2,822,745.56	28.9%

Figure 5. Targets for improvement for the inefficient Serbian commercial banks (in 000 SRB Dinars).

Bank	Projection (Interest Expense)	Percent change	Projection (Non interest Expense)	Percent change	Interest Revenue	Projection (Interest Revenue)	Percent change	Projection (Non Interest Revenue)	Percent change
Addiko Bank d.d.	86,902.66	-1.8%	511,100.00	0%	569,800.00	669,344.61	14.9%	304,247.55	14.9%
Agram Banka d.d.	20,296.42	-42.6%	87,554.00	0%	123,616.00	127,851.27	3.3%	41,838.98	3.3%
Croatia Banka d.d.	10,910.00	0%	60,803.00	0%	53,109.00	76,969.22	31.0%	28,541.90	31.0%
Imex Banka d.d.	12,483.00	0%	48,475.00	0%	53,213.00	74,499.03	28.6%	16,339.40	56.9%
KentBank d.d.	15,443.00	0%	77,607.00	0%	88,839.00	111,510.72	20.3%	26,813.16	73.2%
Partner Banka d.d.	15,781.76	-4.8%	47,311.00	0%	60,793.00	85,720.70	29.1%	12,655.13	29.1%
Podravska Banka d.d.	16,032.00	0%	108,121.00	0%	104,639.00	132,257.18	20.9%	55,336.46	20.9%
Sberbank d.d.	52,105.94	-37.4%	253,517.00	0%	345,322.00	368,132.07	6.2%	132,305.23	24.5%

Figure 6. Targets for improvement for the inefficient Croatian commercial banks (in 000 HRK).

According to Figure 5, we can see that all the inefficient Serbian banks should increase the outputs (interest and non-interest revenue) by a certain percentage, and they do not have changes (decrease) in the inputs. Mobi Banka AD Beograd should increase the interest revenue the most (66%), while Opportunity Banka AD Novi Sad should increase the net interest revenue the most (by 71.7%).

Based on Figure 6, we can see that Agram Banka d.d. should decrease the interest expense by the highest percentage (42.6%), while it should increase the interest and the non-interest revenue by 3.3%. In addition, four banks (Croatia Banka d.d., Imex Banka d.d., KentBank d.d., and Podravska Banka d.d.) should only increase the interest and the non-interest revenue for a certain percentage in order to be relative-efficient. Out of

these four banks, Croatia Banka d.d. should increase the interest revenue by the highest percentage (31%), while KentBank d.d. should increase the non-interest revenue by the highest percentage (73.2%).

## 5. Discussion

In this paper, we measured the relative efficiency of commercial banks in three developing countries in Europe—North Macedonia, Serbia, and Croatia—from the operating (income-based) approach by using DEA. For the observed period of five years (2015–2019), we used balanced panel data for the three samples.

According to the obtained results, the highest average efficiency for the commercial banking sector for the whole observed period is obtained in North Macedonia (91.1%), followed by Croatia (90.9%) and Serbia (81.9%). However, the average level of efficiency results show that the Macedonian and Serbian banking sector have decreased their efficiency from 96.6% and 84.1% in 2015 to 87.6% and 81.2% in 2019, respectively. On the other hand, the average commercial banking efficiency in Croatia increased from 90.7% in 2015 to 91.9% in 2019. The Croatian economy has suffered after the global crisis in 2009, which resulted in a six-year-long recession, having formally emerged from the recession in the fourth quarter of 2014. Even though the Croatian economy has experienced some setbacks in the observed period (namely, the collapse of the Agrokor Group in 2017, resulting in a low 89.9% efficiency of the banking sector), it made it through the rough patch and improved efficiency thereafter. This efficiency improvement can also be interpreted as an implication of the benefits from the EU accession in July 2013, and such a conclusion is in line with the study of the authors [18], whose findings present that the EU accession has positively impacted Croatian banks' efficiencies by 45%.

The rationale for the decrease in bank efficiency in North Macedonia and Serbia should be explored in a wider political and economic context. Namely, the observed period from 2015 to 2019 was quite challenging for North Macedonia. In 2015 and 2016, the internal political risks and political uncertainty and instability increased due to the clouding of the domestic political situation and the outburst of the Greek debt crisis. Furthermore, the domestic political turmoil and the refugee crisis have emphasized the risks of a non-economic nature. The Governor referred to 2016 as another "stressful" year for the Macedonian economy, mostly because of the escalation of the political situation in April 2016. All of these processes affected the expectations of the population and the speculation regarding the stability of the exchange rate, which ultimately negatively affected the banking sector [44,45]. Although the political situation was eventually controlled, the Macedonian economy stalled in 2017, while 2018 was a year of gradual stabilization after the effects of pronounced domestic risks. The banking system noted slightly lower profits, and consequently, a lower return on assets and equity indicators in 2019 [46–48]. Unlike Croatia, North Macedonia submitted its EU membership application in 2004, but is still an EU candidate country among the other current EU candidate countries (Albania, Montenegro, Serbia, and Turkey).

The Greek debt crisis has also affected the Serbian economy, mostly by the potential risks and spillovers materializing through the Greek state-owned subsidiaries operating in Serbia. The key risks for the Serbian banks that were identified for the whole observed period were: high euroisation of the domestic financial system, the high share of NPLs, and the increased financial system procyclicality. The high percentage of NPLs of Serbian commercial banks negatively affected the banks' risk propensity and credit growth, thus, in turn, negatively affecting the banking sector profitability and posing a systemic risk [49,50].

Four Macedonian banks (36.3%), four Serbian banks (18.2%) and eight Croatian banks (42.1%) are relative-efficient for the whole observed period. In the three developing countries, most of the relative-efficient banks for the whole observed period are large banks as in [27,28] for the Macedonian banking sector, and as in [18] for the Croatian banking sector. The Croatian relative-efficient banks include all the banks from the large banks' group—a total of five large banks and three small-sized banks. These findings are in line

with [18], who found that Zagrebačka Banka d.d. and Privredna Banka Zagreb d.d., as part of the large banks' group, maintained their high level of efficiency throughout the years.

However, three Macedonian banks (27.2%), 10 Serbian banks (45.5%), and five Croatian banks (26.3%) are relative-inefficient in the whole observed period. In the Republic of Croatia, most of the relative-inefficient banks (four) for the whole observed period were in the group of small banks (as in [18]), while in North Macedonia, the relative-inefficient banks were from the middle-sized banks group. The Serbian banking sector is the least efficient of the three analyzed sectors under the income-based approach.

## 6. Conclusions

The stability of the financial system is of crucial importance for each country. Developing countries have a bank-based financial system; hence, its stability is affected by the banks' stability. Therefore, measuring the performance of banks is of key importance in making faster and better decisions that will ensure their successful operation.

DEA is the most popular non-parametric frontier methodology for performance measurement. DEA has been widely applied in banking [23], but based on our search in the existing literature, we have not found a study that measures the efficiency in the three developing European countries—North Macedonia, Serbia, and Croatia—with our model selection (output-oriented BCC [2,3] and super-efficiency procedure for outlier identification [4]), our period of analysis (2015–2019), and with a special emphasis on setting targets for improvement for the inefficient commercial banks. We were thus motivated to conduct such a study and to enrich the existing literature, as well as to help the top bank management in strategic planning and decision-making with the banks they lead. In addition, we want to point out that when the BCC model is used, a DMU that could not be compared with other DMUs that are part of the analysis is compared with itself, therefore obtaining a result that it is relative-efficient. In analyzing the obtained results, what is needed is solid knowledge of the DMUs of interest and how they actually operate, based on which the unusual results can be determined, that is, the results that do not reflect the real situation. By using the super-efficiency procedure [4], we were able to identify whether in the analysis the outliers could affect the efficiency results, and thus analyze them in detail regarding how they operate before making the decision to remove them. After removing the outliers and DMUs for which a feasible solution (in the super-efficiency procedure) will not be found, the BCC model can produce more reliable results that can be re-analyzed and interpreted. There are still (young) scholars and researchers that use the super-efficiency procedure [19] to rank relative-efficient DMUs, but based on the evidence provided by the authors of [20], it is not adequate for this purpose. Therefore, with this study, we want to point out to the (young) scholars and researchers not to immediately interpret the results obtained with the BCC model, but to put them in the context of the actual operation of the DMUs and use the super-efficiency procedure [4] to identify outliers (if any), as well as to analyze the outliers in detail before their removal.

In this paper, we have applied the income-based approach and selected interest and non-interest expenses as inputs, and interest and non-interest revenues as outputs. We used the output-oriented BCC model because we believe that the banks' objective under the income-based approach is to maximize the revenues with the given levels of expenses. Regarding the selection of the approach, the variables, and the output-oriented model, we were following the Reference [3]. We have run the model for each sample of commercial banks, however, after achieving unusual results in each sample, we have implemented the super-efficiency procedure as proposed by [4], and we have carefully determined the outlier exclusion, afterwards rerunning the output-oriented BCC model on each sample with the remaining commercial banks.

Based on the obtained results, the most efficient is the Macedonian banking sector, followed by the Croatian and Serbian banking sectors. The most efficient group of banks in all the bank systems is the group of large banks. For each inefficient commercial bank, we provided targets for improvement to be projected on the efficient frontier.

In our future research, we plan to include the COVID-19 and post-COVID-19 period in order to analyze the efficiency of banks in those three European developing countries, and to examine the determinants of efficiency.

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**Conflicts of Interest:** The authors declare no conflict of interest.

### Appendix A

Descriptive statistics for the variables (inputs and outputs) in commercial banks in North Macedonia (in 000 MKD Denars).

	Interest Expense	Other Operating Expense	Interest Revenue	Other Operating Revenue
Mean	351,103	1,401,188	1,663,551	702,653
Standard Error	34,343	147,684	188,693	90,217
Median	278,721	901,580	1,040,009	362,724
Standard Deviation	254,691	1,095,256	1,399,381	669,064
Kurtosis	0.57	0.74	- 0.78	0.58
Skewness	1.01	1.23	0.85	1.28
Range	1,062,283	4,284,237	4,266,362	2,596,021
Minimum	68,337	278,877	243,498	103,964
Maximum	1,130,620	4,563,114	4,509,860	2,699,985
Count	55	55	55	55

Figure A1. Summary statistics.

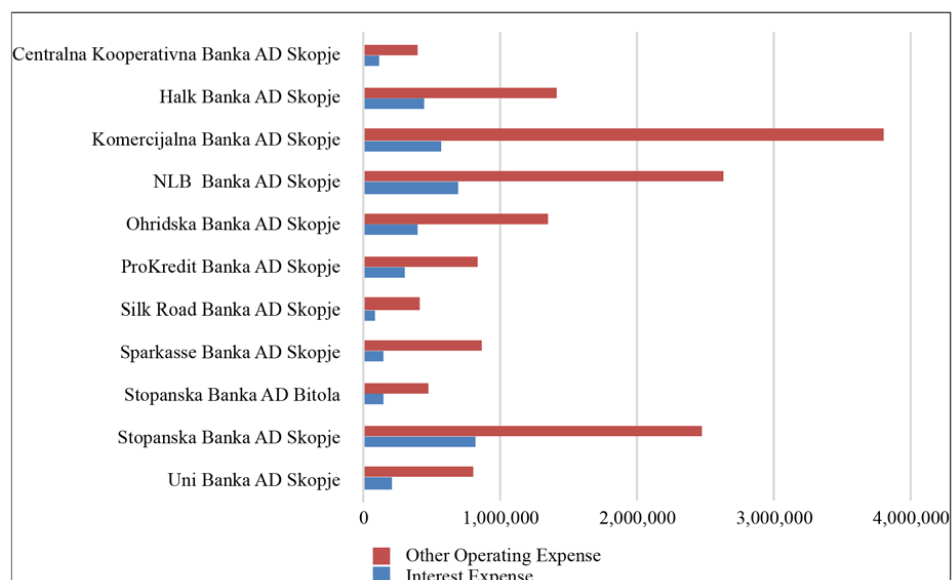


Figure A2. Mean for the inputs for each bank.

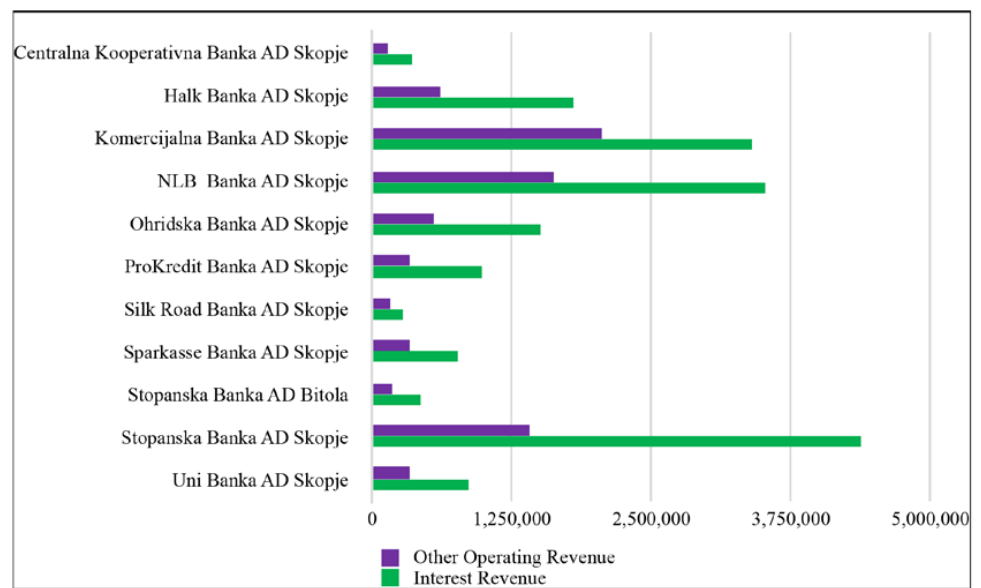


Figure A3. Mean for the outputs for each bank.

### Appendix B

Descriptive statistics for the variables (inputs and outputs) in commercial banks in Serbia (in 000 SRB Dinars).

	Interest Expense	Other Operating Expense	Interest Revenue	Other Operating Revenue
Mean	1,018,678	2,589,135	5,797,795	2,585,036
Standard Error	107,297	251,006	575,364	286,905
Median	502,564	1,695,391	3,788,932	1,487,136
Standard Deviation	1,120,215	2,632,570	6,034,467	3,009,083
Kurtosis	4.33	2.90	1.58	2.76
Skewness	1.99	1.73	1.43	1.74
Range	5,265,646	12,075,283	25,160,989	13,176,680
Minimum	60,854	217,408	258,483	80,457
Maximum	5,326,500	12,292,691	25,419,472	13,257,137
Count	110	110	110	110

Figure A4. Summary statistics.



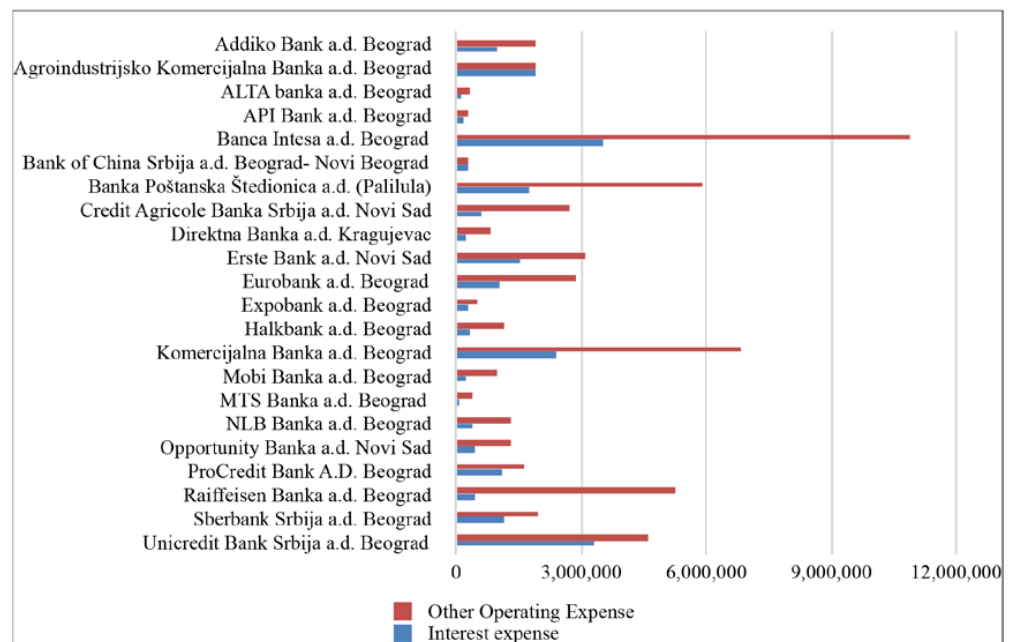


Figure A5. Mean for the inputs for each bank.

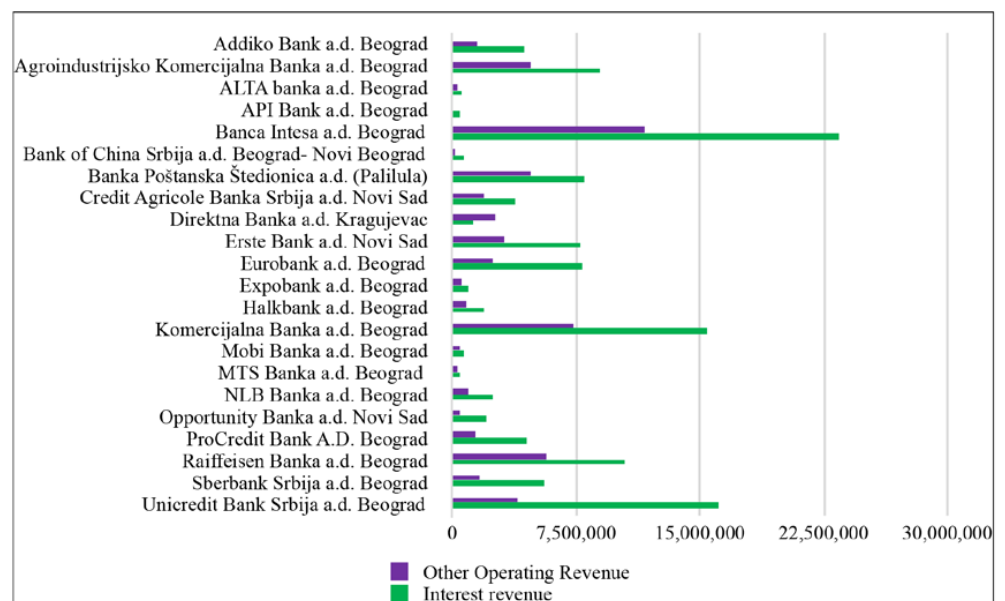


Figure A6. Mean for the outputs for each bank.

### Appendix C

Descriptive statistics for the variables (inputs and outputs) in commercial banks in Croatia (in 000 HRK).

	Interest Expense	Other Operating Expense	Interest Revenue	Other Operating Revenue
Mean	202,327	503,384	734,506	278,478
Standard Error	46,462	69,313	119,333	43,667
Median	44,031	86,538	127,650	40,065
Standard Deviation	452,853	675,581	1,163,113	425,613
Kurtosis	23.63	1.72	5.48	4.11
Skewness	4.58	1.56	2.32	1.95
Range	3,075,699	2,988,692	5,672,099	2,199,208
Minimum	6,543	36,466	32,157	6,601
Maximum	3,082,242	3,025,158	5,704,256	2,205,809
Count	95	95	95	95

Figure A7. Summary statistics.

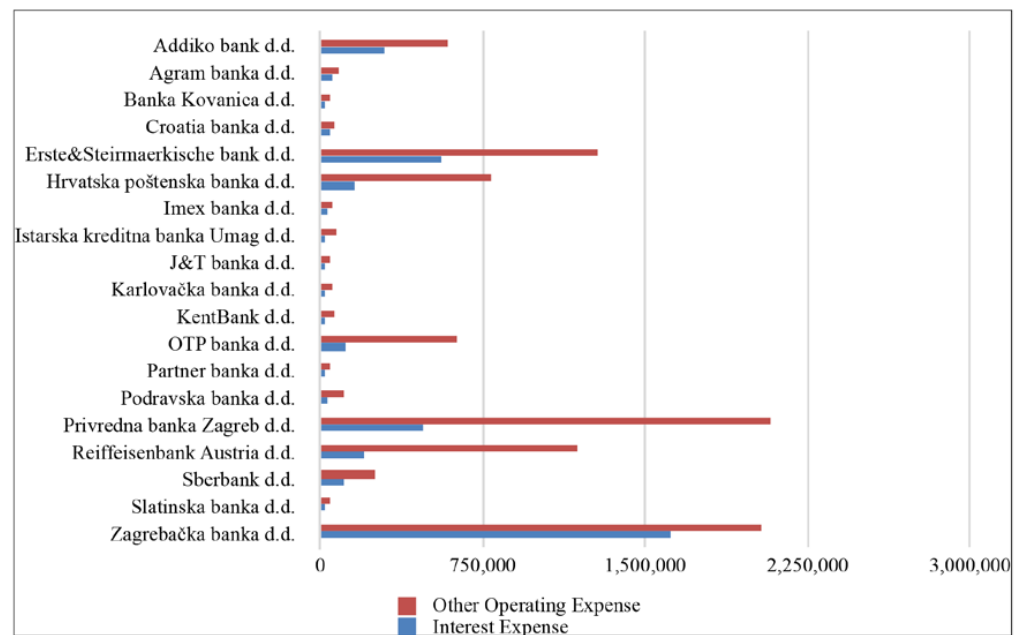


Figure A8. Mean for the inputs for each bank.

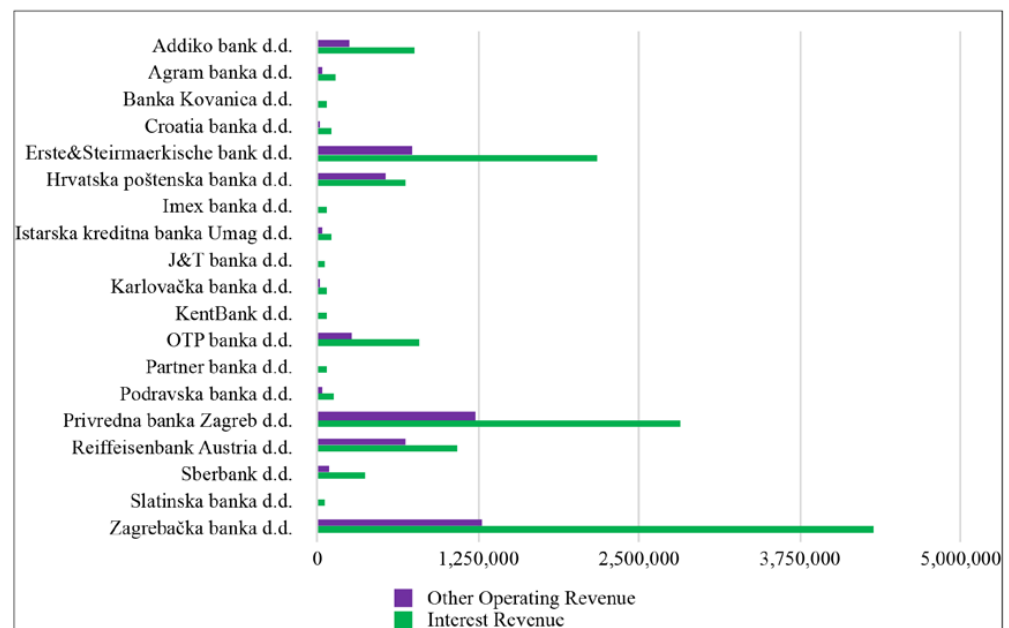


Figure A9. Mean for the outputs for each bank.

## References

- Charnes, A.; Cooper, W.; Rhodes, E. Measuring the efficiency of decision-making units. *Eur. J. Oper. Res.* **1978**, *2*, 429–444. [CrossRef]
- Banker, R.D.; Charnes, A.; Cooper, W.W. Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Manag. Sci.* **1984**, *30*, 1078–1092. [CrossRef]
- Banker, R.D.; Chang, H.; Lee, S. Differential impact of Korean banking system reforms on bank productivity. *J. Bank. Financ.* **2010**, *34*, 1450–1460. [CrossRef]
- Banker, R.D.; Gifford, J.L. *A Relative Efficiency Model for The Evaluation of Public Health Nurse Productivity*; School of Urban and Public Affairs, Carnegie Mellon University: Pittsburgh, PA, USA, 1988.
- Bonin, J.; Hasan, I.; Wachtel, P. *Privatization Matters: Bank Efficiency in Transition Countries*; Discussion Papers 8; Institute for Economies in Transition: Helsinki, Finland, 2004; Chapter 1, pp. 1–39, ISBN 951-686-898-3.
- Cvetkoska, V.; Fotova Čiković, K. Assessing the relative efficiency of commercial banks in the Republic of North Macedonia: DEA window analysis. *Croat. Oper. Res. Rev. CRORR* **2020**, *11*, 217–227. [CrossRef]
- National Bank of the Republic of North Macedonia Home Page. Available online: <https://www.nbrm.mk/ns-newsarticle-izvestaj-za-rizicite-vo-bankarskiot-sistem-na-republika-severna-makedonija-vo-2019-godina-en.nsp> (accessed on 2 June 2021).
- National Bank of the Republic of North Macedonia Home Page. Available online: [https://www.nbrm.mk/content/%D0%A4%D0%A1%D0%A0\\_2019.pdf](https://www.nbrm.mk/content/%D0%A4%D0%A1%D0%A0_2019.pdf) (accessed on 25 May 2021).
- Mandić, K.; Delibasić, B.; Knežević, S.; Benkovic, S. Analysis of the financial parameters of Serbian banks through the application of the fuzzy AHP and TOPSIS methods. *Econ. Model.* **2014**, *43*, 30–37. [CrossRef]
- Filipović, M.; Hadžić, M. Banking sector in serbia: Impacts of late transition and global crisis. In *Overcoming the Crisis: Economic and Financial Developments in Asia and Europe*; Bojnec, Š., Brada, C.J., Kuboniwa, M., Eds.; University of Primorska Press: Koper, Slovenia, 2012; pp. 1–10, ISBN 978-961-6832-32-8.
- Knežević, A.; Dobromirov, D. The determinants of Serbian banking industry profitability. *Econ. Res. Ekon. Istraživanja* **2016**, *29*, 459–474. [CrossRef]
- Bonin, J.; Hasan, I.; Wachtel, P. *Banking in Transition Countries*; BOFIT Discussion Papers 12; Institute for Economies in Transition: Helsinki, Finland, 2008; Chapter 1; pp. 1–34. ISBN 978-952-462-915-7.
- National Bank of Serbia Home Page. Available online: [https://nbs.rs/export/sites/NBS\\_site/documents-eng/kontrola-banaka/quarter\\_report\\_IV\\_19.pdf](https://nbs.rs/export/sites/NBS_site/documents-eng/kontrola-banaka/quarter_report_IV_19.pdf) (accessed on 1 June 2021).
- Jovančević, R. Macroeconomic environment and the banking system of croatia. In *Banking Reforms in South East Europe*; Šević, Z., Ed.; Edward Elgar Publishing Ltd.: Cheltenham, UK, 2002; pp. 1–360. ISBN 978-1-84064-377-0.
- Stojčić, N. Two decades of croatian transition: A retrospective analysis. *South East Eur. J. Econ. Bus.* **2013**, *7*, 63–76. [CrossRef]
- Kordić, L.; Visković, J. Investigating efficiency of Croatian banking sector—Further steps towards more efficient banks. In *Proceedings of the 7th International Scientific Symposium Gospodarstvo istočne Hrvatske—Vizija i razvoj—Economy of Eastern Croatia—Vision and Growth*, Osijek, Croatia, 24–26 May 2018; pp. 1023–1031.
- Croatian National Bank Home Page. Available online: <https://www.hnb.hr/documents/20182/2868711/ebilten-o-bankama-32.pdf/3a0e4fc0e413-49da-2a9b-3c9fc0ff0b84> (accessed on 10 June 2021).

18. Davidović, M.; Uzelac, O.; Zelenović, V. Efficiency dynamics of the Croatian banking industry: DEA investigation. *Econ. Res. Ekon. Istraživanja* **2019**, *32*, 33–49. [CrossRef]
19. Andersen, P.; Petersen, N.C. A procedure for ranking efficient units in data envelopment analysis. *Manag. Sci.* **1993**, *39*, 1261–1264. [CrossRef]
20. Banker, R.D.; Chang, H. The super-efficiency procedure for outlier identification, not for ranking efficient units. *Eur. J. Oper. Res.* **2006**, *175*, 1311–1320. [CrossRef]
21. Banker, R.D.; Park, H.U. Three stage approach to analyze organizational ability. *Data Envel. Anal. J.* **2021**, *5/1*, 27–54. [CrossRef]
22. Emrouznejad, A.; Yang, G. A survey and analysis of the first 40 years of scholarly literature in DEA: 1978–2016. *Socio Econ. Plan. Sci.* **2018**, *61*, 4–8. [CrossRef]
23. Cvetkoska, V.; Savić, G. DEA in banking: Analysis and visualization of bibliometric data. *Data Envel. Anal. J.* **2021**, in press.
24. Cvetkoska, V. A Two-Stage Approach for Measuring the Efficiency Applying the Methods DEA and AHP. Master's Thesis, The University of Belgrade, Belgrade, Serbia, 2010.
25. Micajkova, V.; Poposka, K. Efficiency of macedonian banks: A DEA approach. *Res. J. Financ. Account.* **2013**, *4*, 141–149. Available online: <https://www.iiste.org/Journals/index.php/RJFA/article/view/7769/7848> (accessed on 20 May 2021).
26. Naumovska, E.; Cvetkoska, V. Measuring the efficiency of the banking sector in the Republic of Macedonia. *Annu. Collect. Fac. Econ. Skopje* **2014**, *49*, 221–238. [CrossRef]
27. Naumovska, E.; Cvetkoska, V. Efficiency of the macedonian banking sector. *Yugosl. J. Oper. Res.* **2016**, *26*, 317–329. Available online: <http://elib.mi.sanu.ac.rs/files/journals/yjor/56/yujorn57p317-329.pdf> (accessed on 26 May 2021). [CrossRef]
28. Fotova Čiković, K.; Cvetkoska, V. Efficiency of the Macedonian banking sector: A non-parametric approach. *CEA J. Econ.* **2017**, *12*, 17–26. Available online: <http://journal.cea.org.mk/index.php/cejournal/article/view/115> (accessed on 20 May 2021).
29. Marković, M.; Knežević, S.; Brown, A.; Dmitrović, V. Measuring the productivity of Serbian banks using Malmquist index. *Manag. J. Sustain. Bus. Manag. Solut. Emerg. Econ.* **2015**, *20*, 1–10. [CrossRef]
30. Popović, Ž.; Stanković, J.; Veselinović, I. Analysis of bank efficiency in the Republic of Serbia: DEA approach. In Proceedings of the 48th International Scientific Conference: Contemporary Approaches in the Analysis of Economic Performances, Niš, Serbia, 6 October 2017; pp. 233–242.
31. Lukić, R.; Sokić, M.; Kljenak, D.V. Efficiency analysis of banking sector in Republic of Serbia. In *Business Excellence and Management*; Faculty of Management, Academy of Economic Studies: Bucharest, Romania, 2017; Volume 7, pp. 5–17.
32. Savić, G.; Radosavljević, M.; Ilijevski, D. DEA window analysis approach for measuring the efficiency of serbian banks based on panel data. *Manag. J. Theory Pract. Manag.* **2012**, *17*, 5–14. [CrossRef]
33. Jemrić, I.; Vujčić, B. Efficiency of banks in croatia: A DEA approach. *Comp. Econ. Stud.* **2002**, *44*, 169–193. [CrossRef]
34. Toçi, V.Z. *Efficiency of Banks in South-East Europe: With Special Reference to Kosovo*; Working Paper No. 4; Central Bank of the Republic of Kosovo: Prishtina, Kosovo, 2009; pp. 1–36.
35. Jurčević, B.; Žaja, M.M. Banks and insurance companies efficiency indicators in the period of financial crisis: The case of the Republic of Croatia. *Ekon. Istraživanja Econ. Res.* **2013**, *26*, 203–224. [CrossRef]
36. Tuškan, B.; Stojanović, A. Measurement of cost efficiency in the European banking industry. *Croat. Oper. Res. Rev.* **2016**, *7*, 47–66. [CrossRef]
37. Pavković, A.; Cesarec, A.; Stojanović, A. Profitability and efficiency of the Croatian banking sector: Impact of bank size. *Int. J. Trade Glob. Mark.* **2018**, *11*, 243–258. [CrossRef]
38. Leightner, J.E.; Lovell, C.A.K. The impact of financial liberalization on the performance of Thai banks. *J. Econ. Bus.* **1998**, *50*, 115–131. [CrossRef]
39. Cooper, W.; Seiford, L.; Tone, K. *Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software*, 2nd ed.; Springer Science-i-Business Media, LLC: New York, NY, USA, 2007; pp. 1–34, ISBN 978-0-387-45283-8.
40. Cvetkoska, V.; Barišić, P. The efficiency of the tourism industry in the Balkans. *Proc. Fac. Econ. East Sarajevo* **2017**, *14*, 31–41. [CrossRef]
41. National Bank of the Republic of North Macedonia Home Page. Available online: <https://www.nbrm.mk/ns-newsarticle-izvestaj-za-rizicite-vo-bankarskiot-sistem-na-republika-severna-makedonija-vo-2020-godina.nspix> (accessed on 15 May 2021).
42. National Bank of the Republic of North Macedonia Home Page. Available online: <https://www.nbrm.mk/ns-newsarticle-izvestaj-za-finansiskata-stabilnost-vo-republika-severna-makedonija-vo-2018-godina.nspix> (accessed on 16 May 2021).
43. Croatian National Bank Home Page. Available online: <https://www.hnb.hr/documents/20182/123145/h-procjena-stabilnosti-financijskog-sustava/6dc837fa-3c55-48fa-ac21-b353f27fb6b8> (accessed on 5 June 2021).
44. National Bank of the Republic of North Macedonia Home Page. Available online: [https://www.nbrm.mk/ns-newsarticle-ghodishien\\_izvieshtaj\\_za\\_2015\\_ghodina.nspix](https://www.nbrm.mk/ns-newsarticle-ghodishien_izvieshtaj_za_2015_ghodina.nspix) (accessed on 25 May 2021).
45. National Bank of the Republic of North Macedonia Home Page. Available online: <https://www.nbrm.mk/ns-newsarticle-godisen-izvestaj-za-2016-godina.nspix> (accessed on 25 June 2021).
46. National Bank of the Republic of North Macedonia Home Page. Available online: <https://www.nbrm.mk/ns-newsarticle-godisen-izvestaj-za-2017-godina.nspix> (accessed on 25 June 2021).
47. National Bank of the Republic of North Macedonia Home Page. Available online: <https://www.nbrm.mk/ns-newsarticle-godisen-izvestaj-za-2018-godina.nspix> (accessed on 25 June 2021).
48. National Bank of the Republic of North Macedonia Home Page. Available online: <https://www.nbrm.mk/ns-newsarticle-godisen-izvestaj-za-2019-godina.nspix> (accessed on 25 June 2021).

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49. National Bank of Serbia Home Page. Available online: [https://nbs.rs/export/sites/NBS\\_site/documents-eng/publikacije/fs/fsr\\_2017.pdf](https://nbs.rs/export/sites/NBS_site/documents-eng/publikacije/fs/fsr_2017.pdf) (accessed on 25 June 2021).
  50. National Bank of Serbia Home Page. Available online: [https://nbs.rs/export/sites/NBS\\_site/documents-eng/publikacije/fs/fsr\\_2019.pdf](https://nbs.rs/export/sites/NBS_site/documents-eng/publikacije/fs/fsr_2019.pdf) (accessed on 25 June 2021).