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DOES OWNERSHIP STRUCTURE AFFECT BANK PERFORMANCE IN THE COVID-19 PANDEMIC PERIOD? EVIDENCE FROM CROATIA

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Abstract: This paper investigates the relationship between bank ownership and efficiency before and after the COVID-19 pandemic in a sample of 20 Croatian commercial banks in the period from 2015 to 2020. The interconnection between these variables is examined with the use of a dynamic data envelopment analysis (window DEA) framework. Other goals are to measure the relative efficiency of Croatian banks in the observed period as well as the evolvement of the banking sector as a whole. The findings reveal that domestic banks outperform by little foreign-owned Croatian banks during the COVID-19 crisis year 2020, but, moreover, domestic and small-sized banks have experienced the least negative impact of COVID-19 in 2020. The results regarding the impact of bank size on bank efficiency are inconsistent and require additional study. The used methodology and the findings of this empirical research could be of interest to academic members, bank management and policymakers. The latter should be especially interested in the results and the resilience of domestic and foreign banks to external shocks, in order to re-examine their current bank policies and the national attitude towards attracting foreign capital in the banking sector.

Keywords: bank ownership, relative efficiency, data envelopment analysis, window DEA, Croatia.

MSC: 90C05.

1. INTRODUCTION

Commercial banks are undoubtedly the most crucial institutions in the financial system and the country's economic development and this is especially highlighted in developing countries with underdeveloped financial systems. Banks' essential role derives from their large impact on financial stability, and thus, the whole economy, mostly due to a large

number of stakeholders with various (and many times, conflicting) interests that "are being represented by various supervisory and regulatory bodies and judicial authorities" [1]. Banks' crucial intermediary function of transferring the publics' deposits and savings in the business sector once more shows that „banks are the main channel for savings and the allocation of credit" [2]. Therefore, it comes as no surprise that banks' efficiency is widely researched and measured „by academic members, practitioners and regulators" [3]. Moreover, bank efficiency is crucial for economic stability and development. An efficient banking system "plays an important role in entrepreneurship development" [4]. The efficiency of the banking sector is crucial in "promoting economic growth", especially in countries with a bank-based system, such as the Republic of Croatia [5]. It is therefore intensively researched and the Data Envelopment Analysis (DEA) is one of the main nonparametric methodologies employed for efficiency evaluation of banking industries.

Over the last three decades, „the global financial markets have undergone dramatic institutional transformations, affected by liberalization and financial globalization on one hand and changing macroprudential regulation and supervisory roles, on the other hand". Moreover, the bank-based financial sectors of the former socialist countries, previously driven by central planning, lived through the disruptive financial meltdowns in the early 1990s, which required both restructuring and transition. The Croatian banking market was not isolated from these "tectonic" structural changes [6]. The Croatian banking sector has thus undergone substantial changes over the last two to three decades, becoming "a more propulsive and competitive sector with a significant contribution to social stability and economic development" [7]. The Croatian banking system holds a "share of almost 70% of the total assets of the financial sector in 2018" [8] and this share has remained large. Therefore, the efficiency and performance of the banking sector is an issue that is regularly investigated, given the impact of banks and their performance on national financial stability. The efficiency and performance of banks have been furthermore put to the test with the emergence of the COVID-19 pandemic. The crisis caused by the COVID-19 pandemic and the introduced epidemiological measures led to a sudden stagnation of economic and social activities and consequently, a sharp decline in the gross domestic product in Croatia. The contraction of the economy and the noticeable deterioration of the economic climate have significantly increased the overall exposure of the financial system to systemic risks, which from the beginning of 2020 has been at a high level [9].

This paper revolves around the question of whether the ownership structure of banks influences their economic behaviour. In particular, the purpose of this paper is to investigate and explore the relationship between bank ownership (foreign vs. domestic) and performance (i.e. efficiency) before and after the COVID-19 pandemic in a sample of 20 Croatian commercial banks in the period from 2015 to 2020. The interconnection between these variables is examined with the use of a dynamic data envelopment analysis (window DEA - WDEA) framework. In other words, the relative efficiency of Croatian banks is measured in order to determine whether it was impacted by the ownership structure. The main hypothesis revolves around the notion that foreign banks are in general more efficient than domestic banks. There have been many studies (addressed furthermore in the second section of this paper) that highlight the benefits and encourage the internationalization of the banking sectors. In this paper, these aspects will be addressed and analysed concerning the banking sector in Croatia. This is a very contemporary subject that needs to be looked into. To the best of the authors' knowledge, there is not a published study covering this subject regarding the Croatian banking sector. Therefore, the findings

of this paper would contribute greatly to the literature regarding different applications of DEA in banking and would bring new insights to policymakers, bank management and bank stakeholders altogether.

The remainder of this paper is organized as follows. Section 2 presents the literature review on banking efficiency regarding bank ownership and empirical studies employing the DEA methodology in the Croatian banking sector. Moreover, a tabular overview of all DEA applications in the Croatian banking sector is presented. The methodology and data are explained in Section 3. The results from the empirical research are given in Section 4, following a discussion in Section 5 and concluding remarks, limitations of the study and future work are presented in Section 6.

2. LITERATURE REVIEW

2.1. Literature review on studies investigating the relationship between bank ownership and bank performance

The banking sectors in Southeastern Europe transformed at the beginning of the 1990s with the break-up of the SFR Yugoslavia. All of the Southeastern European countries have been obliged to move from „the system of planned economy and to rapidly build economic systems based on market principles and rules, compatible and comparable to those of the developed countries" [10]. These processes have resulted in a large portion of foreign capital entering these banking markets and the banking sectors in SEE countries are now predominately foreign-owned.

There are many controversial and contradictory opinions on the subject of whether foreign bank ownership leads to better efficiencies and performance and this is a research subject that has been addressed commonly in the scholarly literature. Demirguc-Kunt & Huizinga (1998) [11] found that "foreign banks in developing countries have greater margins and profits than domestic banks", which partly explains the better performance of foreign-owned banks in most empirical studies. However, their empirical results reveal that, despite that, "foreign banks are shown to be less profitable in developed countries". Altunbas et al. (2001) [12] have focused on three different ownership types: private commercial banks, public savings banks, and mutual cooperative banks in a sample of German banks in the period from 1989 to 1996, in order to estimate the scale economies, cost and profit efficiencies. They have employed a variety of models for evaluating cost and profit efficiencies in combination with the cost and alternative profit frontiers and the intermediation approach with three inputs (labour, physical capital, and deposits) and five outputs (mortgage loans, public sector loans, other loans, other earning assets and off-balance-sheet item). Their empirical results reveal that "larger banks tend to realize greater economies", regardless of the bank ownership type. Fries & Taci (2005) [13] have analysed 289 banks from 15 post-communist countries and found that "banking systems in which foreign-owned banks have a larger share of total assets have lower costs". Moreover, they claim that "private banks are more efficient than state-owned banks, and privatized banks with majority foreign ownership are the most efficient and those with domestic ownership are the least". Košak & Čok (2008) [14] have examined the relationship between bank ownership and bank profitability in six Southeastern European countries (SEE-6): Croatia, Bulgaria, Romania, Serbia, FYR Macedonia and Albania, but they could not reveal "any substantial statistically significant differences between profitability measures of domestic

and foreign-owned banks". Berger et al. (2009) [15] have focused on banks in China over the period 1994-2003. Their results indicate that "Big Four banks are by far the least efficient, foreign banks are most efficient and minority foreign ownership is associated with significantly improved efficiency". Barry et al. (2011) [16] investigated the banking industries in six Southeast and East Asia countries in the post-crisis period from 1999 to 2004. In the first stage, they implemented the DEA methodology to assess the cross-country differences in efficiency. Their findings show that the banks that are owned by minority private shareholders and banks that are foreign-owned have obtained higher efficiency, which is in line with the findings of [15]. Mamatzakis et al. (2017) [17] have focused on 132 Chinese banks from 2005 to 2015 and their findings reveal that "banks with high state shareholding tend to have poorer performance and low profitability, banks with higher domestic privately shareholders are generally operated more profitably." They have also found that the foreign ownership may worsen bank performance. However, "ownership type diversity is positively associated with bank performance, and banks with concentrated ownership are worse performing". Ozili et al. (2017) [18] studied banks in Nigeria and found that "banks with high ownership concentration have a higher return on assets, higher net interest margin and higher recurring earning power while banks with dispersed ownership have a lower return on assets but have a higher return on equity". Belousova et al. (2018) [5] have applied a combination of the stochastic frontier analysis (SFA) methodology with an intermediary approach to investigate how the type of ownership affects the profit efficiency of selected Russian banks in the period 2004 – 2015. Their results indicate that "foreign-owned banks are the most efficient, followed by state-owned banks and private domestic banks". Interestingly, they conclude that foreign-owned banks are more efficient than other banks in economically stable periods, whereas state-owned banks showed greater efficiency in financial turmoil periods due to state support.

Research and evidence on the impact of bank ownership on the banks' performance in the region of Southeastern Europe are scarce and some of these countries have been included only as subsets in broader studies. Therefore, this paper would enrich the literature and would inspire other scholars to implement the DEA methodology for this purpose.

2.2. Literature review on studies employing DEA in the investigation of the efficiency of the Croatian banking sector

The use of the DEA methodology in banking is great and ever-growing, however, the application of DEA in Croatian banking is rather limited, especially until 2016. The authors have surveyed the following papers regarding the application of DEA in the banking sector of the Republic of Croatia (See Table 1). Other than the studies in Table 1, the authors have also come across a few papers regarding the Croatian banking sector using the Fourier-flexible frontier cost function from 1994 to 2000 [19], a stochastic-frontier analysis study for 1994 and 1995 [20] and frontier analysis for calculating each Croatian bank specific X-efficiency from 1994 through 2014 [21]. Reviewing the literature, it becomes obvious that there is only one study [22] out of thirteen that employs the window DEA technique, whereas the other twelve studies employ BCC and/or CCR DEA models. Their used input and output variables, together with their DEA models and crucial findings have been laid out in Table 1.

Table 1: A literature review of studies applying DEA in the efficiency measurement of the Croatian banking system

Authors	Period	Variables	Model	Results and findings
Jemrić & Vujčić, 2002 [23]	1995 – 2000	**Operating Approach:** **Inputs:** interest and related costs, commissions for services, gross wages and other administration costs. **Outputs:** interest revenues, non-interest revenues. **Intermediation approach:** **Inputs**: fixed assets and software, number of employees, total deposits received. **Outputs:** total loans extended and CNB bills and MoF treasury bills.	CCR and BCC model, input-oriented, operating and intermediation approach	Foreign-owned banks are on average more efficient compared to domestic banks and new banks are more efficient than old ones.
Toci, 2009 [24]	2002 – 2005	**Inputs:** deposits and total costs. **Outputs**: loans net of provisions and total revenues.	DEA (CRS and VRS models) plus Malmquist Total Factor Productivity Change Index	The average efficiency for the sector as a whole increased from 0.728 in 2002 to 0.834 in 2003 and remained virtually stable thereafter. Foreign banks continuously improved their intermediation efficiency while domestic banks were less so.
Jurčević & Mihelja Žaja, 2013 [25]	2005 – 2010	**Inputs:** interest expenses, non-interest expenses, other expenses. **Outputs:** interest incomes, non-interest incomes, and other incomes from business activity.	CCR and BCC output-oriented models	Lowest efficiency scores in 2008, but with visible lower values of efficiency already in 2007.
Bambulović & Huljak, 2016 [26]	1994 – 2015	**Inputs:** Number of employees, Physical assets reported on the bank's balance sheet, Deposits and short-term credits. **Output:** Gross loans.	DEA production approach from three different perspectives: input, output and hyperbolic	Larger and foreign-owned institutions are on average more technically efficient.
Tuškan & Stojanović, 2016 [22]	2008 – 2012	**Inputs:** interest expenses and total operating expenses. **Outputs**: interest income, total operating income.	CCR and BCC output-oriented DEA model, profitability approach	CCR-model (output-oriented, CRS): the worst average relative efficiency was recorded in 2012 and the highest in 2008. BCC-model (output-oriented, VRS), the lowest average efficiency was recorded in 2009. DEA window analysis had its lowest values in 2008.
Kordić & Višković, 2018 [27]	2016	**Inputs:** interest costs, commission and fee costs, and general and administrative costs and amortization. **Outputs:** interest revenues and noninterest revenues i.e. commission and fee revenues.	Input-oriented constant return to scale (CCR) and input-oriented variable return to scale (BCC) DEA models, operating approach	11 of 24 banks are overall technically efficient in 2016. According to the BCC model, 12 banks are pure technically efficient. Inefficient domestic banks were forced to exit from the market and the remaining domestic banks have improved their efficiency over time.
Pavković, Cesarec & Stojanović, 2019 [28]	2004 – 2016	**Inputs:** deposits and total equity. **Outputs:** loans and income from fees and commissions.	CCR and BCC models, output-oriented, intermediation approach	Results indicate that large banks are the most profitable and most efficient banks' group using variable returns to scale (BCC model), while the medium-sized banks appear most efficient using constant returns to scale (CCR model).

Davidovic, Uzelac & Zelenovic, 2019 [6]	2006 – 2015	**Inputs:** interest and non-interest expenses. **Outputs:** interest and non-interest revenues.	BCC DEA output-oriented model and A-P super-efficiency model, intermediation approach	Croatian banks have largely benefited from the EU membership, and the efficiency score after the EU association increased by about 45%. Contrary to the agency theory hypothesis, state-owned banks are permanently more efficient than private banks.
Učkar & Petrović 2021 [29]	2014 – 2019	**Intermediation approach: Inputs:** fixed and intangible assets, number of employees, total deposits received and other liabilities. **Outputs:** total loans and securities. **Operating Approach: Inputs:** interest cost, non-interest cost, labour-related administrative costs and other administrative costs (including amortization, advertising and representation). **Outputs:** interest income and non-interest income (fees and commissions income).	BCC and CCR DEA models, input-oriented	The four largest banks have been fully efficient or achieved above-average efficiency throughout the observed period. The results for the medium and small banks are mixed. The results from the DEA CCR model indicate that all domestic banks are relative inefficient in the whole observed period, except for the largest domestic bank Hrvatska Poštanska Banka d.d. The BCC DEA model, on the other hand, reveals that only Hrvatska Poštanska Banka d.d. and Samoborska Banka d.d. from the domestic banks are relative efficient in the whole observed period. In both CCR and BCC models, foreign and large banks are the most efficient.
Gardijan Kedžo & Tuškan Sjauš, 2021 [30]	2009 – 2018	**Inputs:** interest expenses, non-interest expenses, general administrative expenses and depreciation and total expenses on value adjustments and loss provisions. **Outputs:** interest income and non-interest income.	DEA BCC model with a sensitivity analysis (Bootstrap BCC + Fuzzy BCC)	The results reveal the significant impact of the market processes on banks' business performance, which led to a more efficient banking system. Two banks (Erste Bank d.d. and Zagrebačka Banka d.d.) were found to be dominant over the others regardless of the changes in the sample and data fuzziness (and both are large foreign-owned banks).
Tuškan Sjauš & Mihelja Žaja, 2020 [31]	2012 – 2018	**Inputs:** interest expenses, non-interest expenses and other expenses (labour-related and capital-related administrative expenses and other expenses from the bank's business activity). **Outputs:** interest incomes, non-interest incomes and other incomes from business activity.	DEA superefficiency SBM model (output-oriented, variable returns to scale)	Croatia's accession to the European Union did not by itself strongly impact banking sector efficiency, but rather the consequences of the crisis on business performance as well as in M&A and failure activities. The number of efficient DMUs decreased in 2013 sharply and stayed low until 2018.
Peša, Maté & Jerić, 2021 [4]	2016 – 2018	**Inputs:** total deposits, number of employees, interest expenses and HHI index. **Outputs:** total loans and interest income.	Input and output-oriented DEA models.	The results for Croatia indicated that the banking system was efficient in all observed years (2016-2018), using both input- and output-oriented approaches, but the use of the Malmquist index showed a slight decrease in efficiency (efficiency score of 0.997). Small banks are more efficient than large banks in Croatia.
Cvetkoska, Fotova Čiković & Tasheva, 2021 [32]	2015 – 2019	**Inputs:** interest and non-interest expenses (i.e. fee and commission expense, staff expense, administrative costs, depreciation, and other expenses). **Outputs:** interest and non-interest revenues (i.e. fee and commission revenue, and other revenues).	Output-oriented BCC model, income-based approach	The Croatian banking system as a whole obtained an average efficiency result of 90.9%. The least efficient bank is Croatia Banka d.d. (73.9%), which is a domestic-owned bank. Eight banks have shown relative efficiency in the whole observed period (5 of which are foreign-owned).

To fill in the gap and to give an insight into the efficiency of the Croatian banking sector in the period after the long-term recession that ended in 2015, this research has been conducted. Furthermore, the DEA methodology has been applied in order to gain insights into the efficiency of the whole banking sector as well as the impact of bank ownership on the efficiency before and after the first year of the COVID-19 pandemic.

3. METHODOLOGY AND DATA

After its introduction in 1978 in the groundbreaking paper *Measuring the efficiency of decision making units* by Charnes, Cooper and Rhodes [33], the Data Envelopment Analysis (DEA) methodology has instantly been recognized as a useful methodology for measuring the relative efficiency of different entities, called Decision-Making Units (DMUs), given multiple criteria. In the last four decades, the popularity of DEA has been growing and the literature shows that the main applicative area of DEA remained the performance measurement in economics and business [34]. Moreover, the study of Emrouznejad & Yang (2016) [35] reveals that banking is among the top industries that mostly apply the DEA methodology in the measurement of efficiency (together with agriculture, supply chain, transportation, education and public policy).

DEA (Data Envelopment Analysis) is a mathematical nonparametric linear programming methodology used to measure efficiency and enjoys several advantages over other traditional parametric efficiency measurement approaches. In that sense, shortages of the accounting indicators approach for efficiency measurement mentioned earlier are eliminated by the DEA approach [22]. The DEA method has been widely applied in the empirical estimation of financial institutions, health care, and education sectors' efficiency worldwide. Notwithstanding, the technique has increasingly been the preferred method to investigate the impact of mergers and acquisitions on bank efficiency, in particular, if the sample size is small and is also one of the most common methods used in assessing relative efficiency in the banking sector altogether.

Although there are numerous examples of the application and popularity of DEA in measuring efficiency in different national banking industries, banks and their branches, this method has not reached its popularity in the banking sector of the Republic of Croatia and such papers are relatively scarce until 2016. Namely, as shown in Table 1, thirteen empirical papers are implementing DEA in measuring the efficiency of the Croatian banking sector, however, only three of them were published before 2016. Hunjak and Jakovčević (2001) [36] claimed this is „due to some subjective reasons (supplementary education of management is required in order for the whole potential of information obtainable through the use of this method to be utilized to the full extent) but also a number of objective reasons resulting from its main limitation". Moreover, there are some very real limitations to the DEA methodology, such as the ignorance of the "effect of exogenous variables on the calculation and operation, the notion that results are potentially sensitive to the selection of input and output variables, not offering any possibilities or ways for efficiency improvement" [37]. Moreover, assuming that the data is error-free and the sensitivity to outliers is stated as the biggest limitation of this methodology [38]. Although DEA faces some serious limitations, its strong suits prevail over its limitations by far as follows: it is very convenient for small samples, it does not require a priori specification of the functional form of the data (nor an a priori determination of the weights for those

variables), it allows for simultaneous use and analysis of multiple input and output variables and it provides a comparison of each unit with its "peer group".

The empirical analysis is carried out on a data sample of 20 commercial banks operating in the Republic of Croatia from the period 2015 - 2020. The timeline has been selected following the economic outlook in Croatia. Namely, the Croatian economy experienced recession „since the last quarter of 2008 for almost six years continuously and it shrank 13% cumulatively" and 2014 is the year in which Croatia's recession is considered over [39]. For that reason and for more objective results, the year 2015 as the first post-recession year is selected as the first year for observation.

The envelopment form of the output-oriented BCC DEA model is given in (1) – (5): (Cooper, Seiford & Tone, 2007) [40]:

$$(BCC - Oo) \qquad \max_{\eta_B, \lambda} \eta_B \tag{1}$$

subject to

$$X\lambda \leq x_0 \tag{2}$$

$$\eta_B y_0 - Y\lambda \leq 0 \tag{3}$$

$$e\lambda = 1 \tag{4}$$

$$\lambda \geq 0 \tag{5}$$

where ηB is a scalar. The input data for DMUj (j = 1, …, n) are (x_{1j},x_{2j},…,x_{nj}), and the output data are (y_{1j},y_{2j},…,y_{nj}); 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, λ 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 ([40], p. 22, 91–92); ([41], p. 33–34). The efficiency in the BCC model requires the realization 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" ([32], p. 8).

In this study, the DEA window analysis technique has been employed. This technique has been introduced by Gerald A. Klopp (1985) [42], who developed this approach while working as a chief statistician for the U.S. Army Recruiting Command ([40], p.323). Some scholars claim that the window DEA technique has been proposed by Charnes et al. (1985) [43] "in their efforts to assess relative efficiency in cross-sectional and time-varying data" [44]. Nevertheless, "DEA window analysis is based on a dynamic perspective, regarding the same DMU in different periods of time as entirely different DMUs" [45].

The main goal of the window analysis is to „capture the variations of efficiency over time", whereas its specific role is to add a dynamic perspective to the DEA methodology, assessing the efficiency of a DMU over a period of time, „treating it as a different entity in each time period", which enables allows for marking the performance of each DMU in the sample ([46], p. 142). Moreover, Fried et al. (2008) [47] have put it as an objective to "alleviate volatility in efficiency estimates" and its purpose is "to track efficiency trends through successive overlapping windows".

Reviewing the literature, Savić et al. (2012) [48] have mainly found studies employing a similar principle of approaches in measuring the bank efficiency of banks over a period of time. In the mentioned literature, there are several differences in the methods used (DEA Windows analysis or Malmquist Index analysis) and several differences in the models considered, i.e. considered aspects and goals of analyses. DEA Window analysis and

Malmquist Index analysis techniques are more specific than, for example, the DEA Charnes-Cooper-Rhodes (CCR) and Banker-Charnes-Cooper (BCC) models, due to analysis of panel data [22]. Moreover, as shown in Table 1, there is only one study (Tuškan & Stojanović, 2016 [22]) out of thirteen that implements the WDEA in measuring the efficiency of the Croatian banking sector. This is the reason the window DEA (WDEA) has been chosen as a methodology for this research with two inputs (interest expenses and non-interest expenses) and two outputs (interest revenues and non-interest revenues), as shown in Table 2.

Table 2. Selected input and output variables for the window DEA model.

Character of variable	**Variables**	**Specification of the variables**
INPUT	interest expenses (I1)	
	non-interest expenses (I2)	Expenses on fees and commissions General administrative expenses and depreciation Expenses on value adjustments and provisions Other operating expenses
OUTPUT	interest revenues (O1)	
	non-interest revenues (O2)	Income from fees and commissions Other operating income

4. RESULTS

The used data are extracted manually from the Croatian National Bank's Bank Bulletin and banks' official financial reports. The presented results reveal the mean efficiency of each bank, the mean efficiency by year of the whole Croatian banking system as well as a more detailed analysis of the bank ownership's impact on efficiency.

The sample consists of 20 commercial banks (n=20), six years are considered (k=6), the length of the window is 3 years (p=3), and the number of windows is 4 (w=k-p+1=6-3+1=4). In each window, there are 60 banks (n x p), and the number of "different" banks is 180 (60 banks x 3 windows). Every window covers 3 years (for example, window 1 covers 3 years as follows: 2015, 2016 and 2017; window 2 covers data for 2016, 2017 and 2018; and so on), as presented in Table 3.

Table 3. Windows in the DEA window analysis model.

window 1	2015	2016	2017			
window 2		2016	2017	2018		
window 3			2017	2018	2019	
window 4				2018	2019	2020

SOURCE: Authors' construction.

The specified DEA model (Window-O-V) has been solved with the application of the DEA-Solver-LV software, and additional details for this software can be found in [40]. The efficiency results from DEA will identify which banks are relative efficient and which are, relative inefficient. Efficient banks will be assigned a score of 1, i.e. 100%, while inefficient ones will be assigned an efficiency score lower than 1.

As a first step of the analysis, the average efficiency of the whole banking sector and its efficiency evolvement have been graphically presented in Figure 1. The DEA results shown in Figure 1 indicate that the Croatian banking sector has exhibited an increase in efficiency from 70.88% in 2015 to 72.94% in 2016, until a decrease and a relative efficiency result of 68.55% in 2017 and then another increase to 78.39% in 2019 until the pandemic year 2020 (with a decrease in efficiency to 68.68%, which is the lowest result in the whole analysed period). The decrease in efficiency in the year 2017 is in line with the results of [32], who found 2017 to be very challenging due to the "collapse of the largest national agri-business concern Agrokor Group, whose collapse was reflected in the banking market and the Croatian economy in general".

Therefore, the average result for each bank for the period 2015 - 2020 has been presented in Table 4, together with the bank ownership data that has been extracted from banks' official statements and websites in 2020. These results reveal that no bank has been relatively efficient in the whole observed period. The highest efficiency results for the whole observed period are obtained by the group of large banks (Privredna Banka Zagreb d.d. with 97%, Zagrebačka Banka d.d. with 85.20% and Erste Banka d.d. with 81.71%), except for the small-sized Samoborska Banka d.d. (89.50%). However, these results only give an average efficiency grade for the observed period and do not answer the question of whether bank ownership impacted efficiency after the COVID-19 crisis.

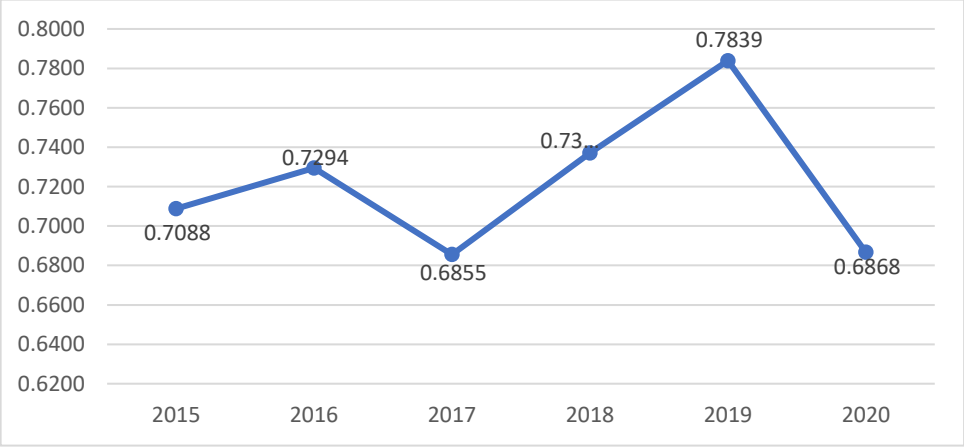

Figure 1: Average efficiency scores for the banking sector in Croatia in the period 2015-2020. (Source: Authors' calculations.)

Table 4: Average efficiency scores for each bank in the observed period 2015-2020.

Commercial bank	**Mean efficiency result**	**Bank ownership***
Addiko Bank d.d.	0.5580	100% Addiko Bank AG Wien (AT)
Agram Banka d.d.	0.7621	100% Croatian (CRO)
Banka Kovanica d.d.	0.7717	100% Italian (ITA)
Croatia Banka d.d.	0.5037	100% Croatian (CRO)
Erste&Steirmaerkische Bank d.d.	0.8171	41% Steirmaerkische Bank (AT), 59% Erste group (AT)
Hrvatska poštenska Banka d.d.	0.7642	100% Croatian (CRO)
Imex Banka d.d.	0.7213	100% Croatian (CRO)
Istarska kreditna Banka Umag d.d.	0.7942	90% Croatian (CRO)
J&T Banka d.d.	0.4089	100% J&T Finaince Group (CZ)
Karlovačka Banka d.d.	0.7834	100% Croatian (CRO)
KentBank d.d.	0.7064	100% Suzer group Turkey (TUR)
OTP Banka d.d.	0.8642	100% OTP Banka (HUN)
Partner Banka d.d.	0.6612	100% Croatian (CRO)
Podravska Banka d.d.	0.5873	80% Italian (ITA)
Privredna Banka Zagreb d.d.	0.9700	97,50% Luxembourg (LU)
Reiffeisenbank Austria d.d.	0.7286	100% Reiffeisen Bank Int. Wien (AT)
Samoborska Banka d.d.	0.8950	100% Croatian (CRO)
Sberbank d.d.	0.5561	100% Sberbank Europe (RUS)
Slatinska Banka d.d.	0.7328	76% Croatian (CRO)
Zagrebačka Banka d.d.	0.8520	100% Italian (ITA)

*Information regarding bank ownership has been extracted from banks' official statements and websites in 2020.
Source: Authors' calculations

To successfully answer that crucial question, a more comprehensive analysis of the efficiency results by years has been conducted (Table 5). Nine out of twenty banks are mainly domestic banks, whereas eleven are foreign-owned banks. What is interesting is that the results show that domestic banks retained and/or increased their relative efficiency by a greater proportion than foreign-owned banks. Namely, 54.5% of the foreign banks have retained and/or increased their efficiency in the crisis of the 2020 year, whereas 45.5% decreased their efficiency. On the other hand, 66.7% of domestic-owned banks retained and/or increased their efficiency in 2020, whereas 33.3% decreased their efficiency as a result of COVID-19. The biggest decrease in efficiency in the year 2020 due to the pandemic has been spotted in the two largest banks (Zagrebačka Banka d.d. and Erste Banka d.d.), Sberbank d.d. and the small-sized bank Croatia Banka d.d., whereas the biggest increase in efficiency in 2020 has been seen in the domestic small-sized banks Istarska Kreditna Banka d.d. and Slatinska Banka d.d. (from efficiency result 96.9% and 85.2% in 2019 to 100% and 88.7% in 2020, respectively). Consequently, unlike previous studies, this study shows that domestic and small-sized banks have experienced the least

negative impact of COVID-19 in 2020. These results bring new insights to regulators, investors and shareholders.

Table 5: Efficiency results by years (2015 – 2020).

Bank	2015	2016	2017	2018	2019	2020	Bank ownership*
Addiko Bank d.d.	0.323	0.56	0.586	0.634	0.611	0.635	100% Addiko Bank AG Wien (AT)
Agram Banka d.d.	1	0.946	0.811	0.5987	0.612	0.604	100% Croatian (CRO)
Banka Kovanica d.d.	1	0.697	0.787	0.7164	0.734	0.697	100% Italian (ITA)
Croatia Banka d.d.	0.816	0.76	0.444	0.4265	0.448	0.128	100% Croatian (CRO)
Erste&Steirmaerkische Bank d.d.	1	0.863	1	1	0.845	0.194	41% Steirmarkische bank, 59% Erste group (AT)
Hrvatska Poštenska Banka d.d.	0.529	0.526	0.54	0.9904	1	1	100% Croatian (CRO)
Imex Banka d.d.	0.451	0.759	0.575	0.5431	1	1	100% Croatian (CRO)
Istarska Kreditna Banka Umag d.d.	0.567	0.651	0.753	0.8252	0.969	1	90% Croatian (CRO)
J&T Banka d.d.	0.401	0.341	0.446	0.4674	0.397	0.401	100% J&T Finance Group (CZ)
Karlovačka Banka d.d.	0.77	0.837	0.752	0.7524	0.857	0.733	100% Croatian (CRO)
KentBank d.d.	0.823	0.729	0.699	0.6008	0.68	0.706	100% Suzer group Turkey (TUR)
OTP Banka d.d.	0.621	0.827	0.809	0.9287	1	1	100% OTP Banka (HUN)
Partner Banka d.d.	0.757	0.747	0.606	0.6327	0.57	0.654	100% Croatian (CRO)
Podravska Banka d.d.	0.56	0.65	0.513	0.5561	0.619	0.626	80% Italian (ITA)
Privredna Banka Zagreb d.d.	0.86	0.964	1	0.9962	1	1	97.50% Luxembourg (LU)
Reiffeisenbank Austria d.d.	0.543	0.688	0.62	0.6729	0.852	0.994	100% Reiffeisen bank Int. Wien (AT)
Samoborska Banka d.d.	1	0.675	0.716	1	0.979	1	100% Croatian (CRO)
Sberbank d.d.	0.458	0.648	0.518	0.6947	0.654	0.364	100% Sberbank Europe (RUS)
Slatinska Banka d.d.	0.696	0.722	0.535	0.7047	0.852	0.887	76% Croatian (CRO)
Zagrebačka Banka d.d.	1	1	1	1	1	0.112	100% Italian (ITA)

SOURCE: Authors' construction, based on the results from the DEA model.

5. DISCUSSION

In this paper, the relative efficiency of commercial banks in the Republic of Croatia has been measured with the application of the window DEA methodology, using balanced panel data for the sample of 20 commercial banks over the period of six consecutive years (2015 to 2020).

The findings reveal that domestic banks outperform by little foreign-owned Croatian banks and domestic bank ownership has represented a somewhat "safety net" from the negative impact of the first pandemic year. This is not in line with previous studies that claim that "foreign-owned banks are the most efficient, followed by state-owned banks and private domestic banks" [5] and is somewhat in line with the findings of [14], who could not reveal "any substantial statistically significant differences between profitability measures of domestic and foreign-owned banks". Domestic banks appear to be more efficient, and took the first hit of the pandemic solidly, except for one bank (Croatia Banka d.d. was the only one with a fall), but no significant conclusions regarding the impact of the COVID-19 pandemic can be drawn. This calls for additional research and the inclusion of the latter COVID-19 years into the research, for a more comprehensive analysis. However, the notion that domestic banks could be more efficient than foreign-owned banks could bring managerial implications as well as comprehension and regard for this issue from the governments and policy-makers.

The results regarding the bank size, however, are inconsistent and require additional research. The dramatic fall in the efficiency of the large banks Zagrebačka Banka d.d. (from an average relative efficiency of 100% from 2015-2019 to 11.2% in 2020) and Erste Banka d.d. (from an average relative efficiency of 94.16% from 2015-2019 to 19.4% in 2020) is somewhat eye-catching, considering all the previously published studies ([12], [26], [28], [29]) that claim that large banks tend to be more efficient than small-sized and medium-sized banks. Moreover, [30] found Erste Bank d.d. and Zagrebačka Banka d.d. "to be dominant over the others regardless of the changes in the sample and data fuzziness". It can be concluded that these banks, due to their great exposure to credit risk in both personal and corporate lending, have taken the greatest hit from the COVID-19 pandemic. These inconsistent results impose the need for additional research and an extension of this study after the COVID-19 pandemic ends, in order to get more insights and draw precise conclusions. Moreover, it would be convenient to include all the Southeastern European countries (EU and non-EU members) to investigate whether the EU membership has any impact on bank efficiency as well as the entrance of any particular FDI in the banking sector.

The used methodology and the findings of this empirical research could be of interest to academic members, bank management and policymakers. The latter should be especially interested in the results and the resilience of domestic and foreign banks to external shocks, in order to re-examine their current bank policies and the national attitude towards attracting foreign capital in the banking sector.

6. CONCLUSION

Considering the many contradictory scholarly conclusions regarding the impact of bank ownership on bank performance and efficiency, this has been a research field that is very often addressed in the scholarly literature, due to the crucial impact of commercial banks on national financial stability altogether. However, research and evidence on the impact of bank ownership on the banks' performance in the region of Southeastern Europe are scarce and some of these countries have been included only as subsets in broader studies. This paper would enrich the literature and would inspire other scholars to implement the DEA methodology for this purpose.

DEA is the leading and most popular non-parametric methodology nowadays for measuring the relative efficiency of homogeneous units that can be applied to many different industries. In the last four decades, the popularity of data envelopment analysis (DEA) has been growing rapidly and the literature shows that the main applicative area of DEA remained the performance measurement in economics and business. Although DEA was initially developed as a tool for evaluating the efficiency of the production units which produce a real output using real inputs, the method found its application in many different problems where the DMUs can be of a different nature [34], especially in the banking industry.

In this study, the income-based approach with two input variables (interest expenses and non-interest expenses) and two output variables (interest revenues and non-interest revenues) has been applied. The DEA window analysis technique - BCC output-oriented model (BCC-O) has been used following [32], since „banks' objective under the income-based approach is to maximize the revenues with the given levels of expenses". The main objective of this paper is to investigate and explore the relationship between bank ownership and performance (i.e. efficiency) before and after the COVID-19 pandemic in a sample of 20 Croatian commercial banks in the period from 2015 to 2020.

The findings indicate that domestic banks perform better during crises and external shocks such as the COVID-19 pandemic and are more efficient than foreign-owned banks. However, this empirical study does not support previous studies [12] that bank size has a crucial impact on the banks' efficiency.

This is a novel study. Namely, even though the DEA methodology has already been implemented in empirical studies regarding the Croatian banking sector (as shown in Table 1), to the best of one's knowledge there aren't any published empirical studies investigating how bank ownership affects the bank's performance and efficiency. Moreover, most of the published studies regarding the Croatian banking sector with the implementation of DEA used BCC and CCR DEA models, and only [22] applied the window DEA technique. Therefore, this is an original study that provides valuable insights to policymakers, bank regulators, bank management as well as potential bank investors and other bank stakeholders. Hence, the practical managerial implications of this study are mirrored in the reconsideration of whether the entrance of foreign capital in the banking sector contributes to greater bank efficiency, and thus, greater bank performance and profit. Therefore, the generally accepted scientific point of view that FDI in banking brings mostly positive effects on the banks' performance and profitability should be re-examined.

This study is, however, not without limitations. Namely, the COVID-19 pandemic has impacted economies from early 2020 until 2022. This study only shows the first impact of COVID-19 on banks' efficiencies in the year 2020 only. Further investigation is required with all the pandemic years in order to get more specific and relevant results.

In future research, the authors plan to include the years after the end of the COVID-19 pandemic and to include all the Southeastern European countries (EU and non-EU members) to draw further conclusions regarding the impact of COVID-19 on the banking sectors in Southeastern Europe.

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