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Dynamic Efficiency Assessment of the European Banking Industry: A Literature Review

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Abstract: *This paper aims to survey, identify and present the relevant studies and their findings regarding the efficiency of banking systems in Europe with the application of the Data Envelopment Analysis (DEA) window technique approach. Notwithstanding, another goal is to provide a background on the DEA methodology and present the window technique approach and highlight its strengths and limitations.*

This article implements an extensive literature review of studies that employ the WDEA (window DEA) methodology in the efficiency evaluation of European banking. The conducted literature review has surveyed the Scopus, Web of Science (SSCI and SCI papers) and CROSBI (Croatian Scientific Bibliography) databases with „Data Envelopment Analysis", „Window" and „Bank" as keywords for the search, which resulted in a total of 89 hits (41 in Scopus, 47 on WoS and 1 on CROSBI). Thereafter, a manual survey of these studies has been conducted, which eventually resulted in 12 papers regarding the efficiency of European banking. This study identifies all the relevant previous work regarding the efficiency of European banking with the application of WDEA (DEA-window technique) as well as a presentation of their used models, the selected variables and their findings.

This literature review indicates that the surveyed studies have been published in the period between 2007 and 2020 and have included the time frame from 1995 to 2017. The longest study includes 13 years, whereas the shortest includes 3 analysed years.

The findings primarily show the applicability of WDEA in the literature.

1. INTRODUCTION

Banks are vital intermediaries in the financial system, and especially important in countries with less developed financial systems. As Fotova Čiković & Cvetkoska (2017) stated, banks represent a "backbone of the country's economy" and a crucial influencer of the financial stability and therefore, the banking sector has to "function at its optimum level". Therefore, an analysis of banking efficiency is an important topic from both a microeconomic and a macroeconomic perspective. From a microeconomic perspective, „the efficiency of banks is important because of the increase in competition from foreign banks and the improvement of institutional regulation and supervision, whereas from a macroeconomic perspective, the efficiency of the banking system influences the cost of financial intermediation and the stability of the entire financial system" (Paleckova, 2017).

Efficiency is defined as „a performance indicator of a profit or non-profit organisation and refers to achieving the highest possible results (outputs) with the use of minimum resources (inputs)" (Cvetkoska & Savić, 2017). Bank efficiency has been commonly and consistently measured. In the literature, there are three approaches for measuring efficiency, and these are the ratio indicators, the parametric approaches (the factor analysis, regression analysis and stochastic frontier

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approach) and the non-parametric approaches (which include the Data Envelopment Analysis (DEA) and the Free Disposal Hull (FDH) (Micajkova & Poposka, 2013; Vincova, 2005; Soysal-Kurt, 2017).

Notwithstanding, "there have been two competing paradigms on efficiency analysis for private and public organizations, one of which is the data envelopment analysis (DEA) which is based on a mathematical programming approach, and the other is the estimation of stochastic frontier functions (SFF) which is based on the econometric regression theory" (Wang, 2003).

In this paper, all the relevant window DEA applications have been surveyed, identified, analysed and presented. The main goal of the study is to survey, identify and present the relevant studies and their findings regarding the efficiency of banking systems in Europe with the application of the Data Envelopment Analysis (DEA) window technique approach. Notwithstanding, another goal is to provide a theoretical background on the DEA methodology and present the window technique approach and highlight its strengths and limitations, which are given in Section 2.

The remainder of this paper is structured as follows. The following section provides a theoretical background on the efficiency of the European banking system and the window DEA technique. The third section presents and elaborates on the research methodology and the review process. Section four reveals the results, i.e. the identified and surveyed relevant papers regarding the efficiency measurement of European banks and/or banking systems with the application of WDEA (window DEA) methodology and the last, fifth section opens a discussion and concludes the paper with a summary of the key findings.

2. THEORETICAL BACKGROUND

2.1. Efficiency of the European Banking Sector

The application of the DEA methodology in banking could be in order to address one of the following problems: "a) analysis of banks operating within one country, b) analysis of bank branches in one bank, c) analysis of banks in two or more countries, d) efficiency of bank mergers and e) banking branch development strategies" (Cvetkoska & Fotova Čiković, 2020; Paradi et al., 2004).

The efficiency of banking has been one of the most common DEA applications worldwide. Namely, Gattoufi et al. (2008) analysed 136 banks in 16 different countries in the Middle East and North Africa between 2003 and 2006. The results indicate an improvement in the ranking of the largest number of banks that passed through mergers and acquisitions during 2005 and 2006. Thus, with a few exceptions, the positive influence of mergers and acquisitions on the performance of banks has been determined.

Kaur and Kaur (2010) analysed unbalanced panel data for 52 banks from 1990 to 50 banks in 2008 in India and the results of their study show that throughout the analysed period the average efficiency of public sector banks was 73.4%, while for private banks 76.3%.

Sufian, Zulkhibri and Charon (2007) analyse the efficiency of commercial banks in Singapore in the period 1998-2004 and focus on the impact of mergers and acquisitions in banking on

banking efficiency. The results indicate that during the pre-merger process, banks were able to produce the same amount of outputs with only 93.82% of the amount of used inputs, and would reduce the inputs by 6.18% to produce the same amount per merger. In the period after the merger, however, the banks in Singapore recorded average overall efficiency of 98.77%.

The efficiency of the European banking sector has been widely assessed with the use of the leading non-parametric methodology DEA. This should not come as a surprise, considering that DEA represents the most renowned and implemented non-parametric methodology which has been widely used in the measurement of efficiency in many industries, but mostly in "agriculture, banking, supply chain, transportation, education and public policy" (Emrouznejad & Yang, 2018).

Hartman & Storbeck (1996) use the DEA window analysis technique to investigate the development of the loan operation efficiency of 12 Swedish banks over 9 years. They have selected this research period due to "gradual relaxation of regulations in Swedish banking, which meant new challenges and opportunities". Moreover, their study "has demonstrated the increasing inefficiencies throughout the bank sector, which can be explained predominantly by the increasing credit losses".

Rakocevic & Dragasevic (2009) have employed the AHP method to assess the efficiency of the banking sector in Montenegro and to show "the multicriterial methods for ranking and comparing banks".

Micajkova & Poposka (2013) have focused on a sample of 15 commercial banks in Macedonia in the period 2008-2011. The results of the CCR model show significant growth in the efficiency of the Macedonian banks in the period from 2008-2010 and a decrease in efficiency in 2011. The average efficiency in 2008 was 0.596, the average efficiency in 2010 increased to 0.779, while in 2011 it decreased to 0.697. Sparkasse Bank is the most efficient bank with a score of 0.92, and the Central Cooperative Bank is the most inefficient with an average score of 0.295. When using the BCC model, the number of efficient banks as well as the average total efficiency for the sector since the CCR model shows that the main source of inefficiency is inefficient volumes.

Andries & Ursu (2016) explore the efficiency of 783 commercial banks from the EU during the period 2004–2010. Their findings show that the global financial crisis had "a significant and positive impact on both the cost and profit inefficiencies of the commercial banks from the EU and that this impact is higher on Eurozone banks". Moreover, the profit efficiency has been less impacted by the large public banks.

Cvetkoska et al. (2021) have investigated the relative efficiency of three European developing countries (North Macedonia, Croatia and Serbia) in the period from 2015 to 2019. Their findings indicate that Macedonian banks noted the highest efficiency in the observed period (91.1%), followed by the Croatian (90.9%) and the Serbian (81.9%) banks.

2.2. Window Data Envelopment Analysis (WDEA)

The Data Envelopment Analysis has been developed and introduced by Charnes, Cooper & Rhodes (1978), but the idea of measuring efficiency has been laid out by Farell (1957), who developed the concept of "best-practice frontiers and came up with the first measurement scheme and efficiency concept" (De Borger et al., 2002).

Data Envelopment Analysis (DEA) is one of the most applied mathematical linear programming approaches for assessing the relative efficiency of homogeneous DMUs (Decision- Making Units). Decision-Making Units (DMUs) are "any type of entities that use certain input variables to produce various forms of output variables" (Rakocevic & Dragasevic, 2009). Thus, DMUs can be banks, countries, hospitals, universities, restaurants, etc. (Tsaples & Papathanasiou, 2020).

The window DEA technique has been first introduced by Klopp (1985), as a possibility to incorporate the time dimension in the efficiency analysis, which would enable following the efficiency alterations of the decision-making units (DMUs) over time (Cvetkoska & Savić, 2017). Some scholars claim that the window DEA technique has been proposed by Charnes et al. (1985) "in their efforts to assess relative efficiency in cross-sectional and time-varying data" (Flokou et al., 2017). However, "DEA window analysis is based on a dynamic perspective, regarding the same DMU in the different period as entirely different DMUs" (Jia & Yuan, 2017).

Flokou et al. (2017) define the window DEA methodology as a "compromise between contemporaneous and inter-temporal analyses where DEA is applied successively on overlapping periods of constant width (called a window)". The window analysis technique works "on the principle of moving averages" (Paleckova, 2017).

The specificity of the window analysis, in comparison with the DEA BCC and CCR models, is in the "analysis of panel data" and it is addressing "the performance of a DMU over time by treating it as a different entity in each period". The panel data can better capture the volatility of efficiency over time (Tuškan & Stojanović, 2016). According to Fried et al. (2008), the objective of the window analysis is to "alleviate volatility in efficiency estimates" and its purpose is "to track efficiency trends through successive overlapping windows".

The DEA methodology has its strengths over parametric methodologies. Namely, it is appropriate for small samples, it does not require pre-specified functional form on the data. However, the DEA has also some limitations, such as the assumption that the data is error-free and the sensitivity to outliers (Gaganis & Pasiouras, 2009). Fotova Čiković & Lozić (2022) state a few other limitations, 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". Even so, they highlight all the other strengths of DEA: "the simultaneous analysis of multiple inputs and outputs, the comparison of each inefficient unit with its "peer group" and the non-requirement of previous knowledge of the explicit functional form linking input and output variables nor a priori determination of the weights for those variables".

Moreover, the window DEA technique involves more observations than the DEA, which is considered a major strength. The DEA window analysis technique, together with the Malmquist Index analysis technique has more advantages than the DEA CCR and BCC models, "due to the analysis of panel data" and it can "better capture the variations of efficiency over time and use them as the more appropriate tool for efficiency measurement", compared to the CCR and BCC DEA models (Tuškan & Stojanović, 2016). However, Cooper et al. (2007) state that the fact that the first and the last year in the analysis „are not tested as frequently as the other analysed years" is its main disadvantage and this could be overcome with the use of "a bootstrap in DEA to obtain efficiency scores of DMUs in the sample" (Simar & Wilson, 2000).

3. RESEARCH METHODOLOGY

The used methodology for this study is the extensive literature review, and it has been undertaken to summarize relevant past findings regarding the efficiency of European banks and banking systems with the application of the window Data Envelopment Analysis (WDEA).

This research and extensive literature review started with a survey of the two most relevant global scientific databases, namely the Scopus and the Web of Science database and the regional/national Croatian Scientific Bibliography (CROSBI). The following keywords have been used: „Data Envelopment Analysis“ AND “Bank” AND “Window”. The research process and the steps taken are shown in Figure 1. In the first step, the most relevant scientific databases for this research have been identified. In the second step, the survey and collection of documents (i.e. papers) have been initiated without limiting the time of publication or the scientific area of research, which was then followed by elimination of the duplicate documents and elimination of the grey literature, which has led to the identification of 12 relevant empirical studies that employ the dynamic WDEA in European banking. In the next step, a thorough qualitative analysis of the surveyed papers, their models and their findings will follow as a result of the extensive literature review. A presentation and a qualitative analysis of the selected studies, their used models, data and, most importantly, their findings, are presented in the next section.

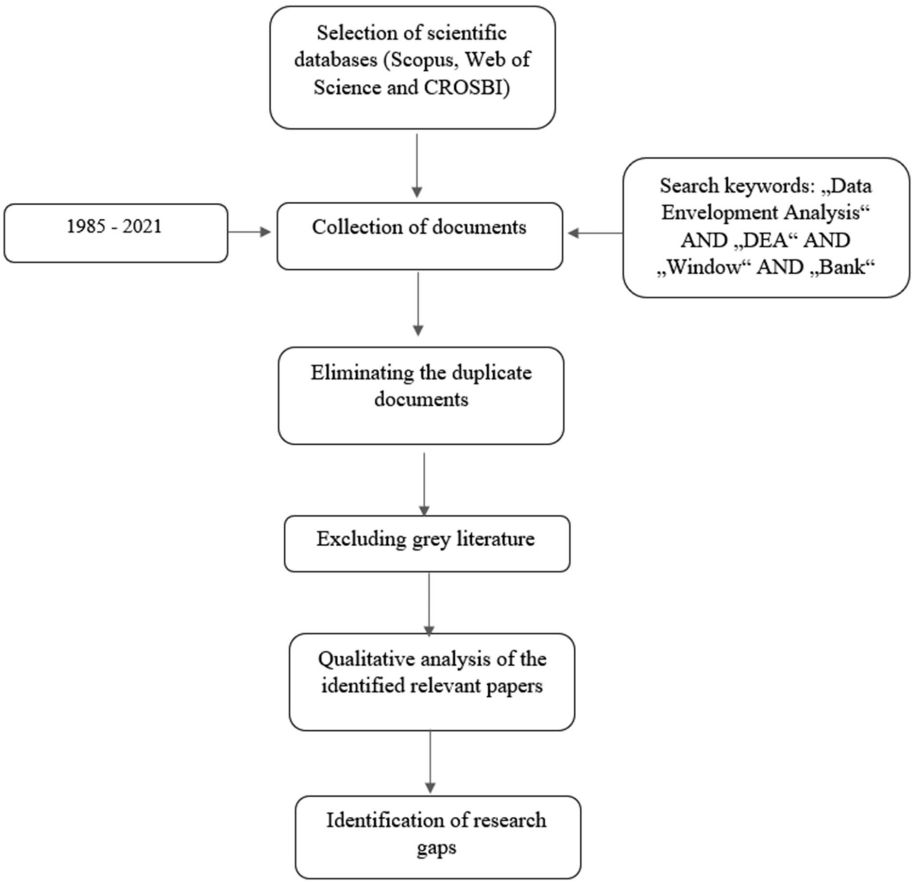

Figure 1. The selection process of the papers for the literature review
Source: Author

4. RESULTS: THE APPLICATIONS OF WINDOW DEA IN EFFICIENCY EVALUATION IN EUROPEAN BANKING

The conducted in-depth literature review has surveyed the Scopus, Web of Science (SSCI and SCI papers) and CROSBI (Croatian Scientific Bibliography) databases using the keywords „*Data Envelopment Analysis*“ AND “*Window*” AND “*Bank*”, searching for empirical studies that explore and measure the efficiency of banking in Europe.

The results from the literature review resulted in a total of 89 hits (41 in Scopus, 47 on WoS and 1 on CROSBI), which eventually resulted in analysis of a total of 12 papers regarding the efficiency of European banking with the application of the window DEA. In this study, all the relevant published empirical studies employing the window DEA technique regarding the efficiency of European banking have been identified, presented and qualitatively analysed. Moreover, their used variables and DEA models have been presented together with their findings.

A short overview of the applications of window DEA in European banking is presented in Table 1, and a thorough qualitative analysis of their results and used models are presented thereafter.

Table 1. Application of WDEA in European banking efficiency evaluation

Author/s and year of publication	Paper	Time frame	Country
Kisielewska, Guzowska, Nellis & Zarzecki (2007)	*Polish banking industry efficiency: A DEA window analysis approach*	1995–2003	Poland
Gaganis & Pasiouras (2009)	*Efficiency in the Greek Banking Industry: A Comparison of Foreign and Domestic Banks*	1999–2004	Greece
Savić, Radosavljević & Ilievski (2012)	*DEA Window Analysis Approach for Measuring the Efficiency of Serbian Banks Based on Panel Dana*	2005–2011	Serbia
Zimkova (2014)	*Window analysis of technical efficiency: Case of the Slovak banking system*	2000–2012	Slovakia
Repkova (2014)	*Efficiency of the Czech banking sector employing the DEA window analysis approach*	2003–2012	Czech Republic
Tuškan & Stojanović (2016)	*Measurement of cost efficiency in the European banking industry*	2008–2012	28 European banking systems
Paleckova (2017)	*Application of window Malmquist index for examination of efficiency change of Czech commercial banks*	2004–2013	Czech Republic
Fotova Čiković & Cvetkoska (2017)	*Efficiency of the Macedonian banking sector: A non-parametric approach*	2008–2015	North Macedonia
Degl'Innocenti, Kourtzidis, Sevic & Tzeremes (2017)	*Investigating bank efficiency in transition economies: A window-based weight assurance region approach*	2004–2015	9 new EU members in Central and Eastern Europe
Cvetkoska & Savić (2017)	*Efficiency of bank branches: empirical evidence from a two-phase research approach*	2009–2011	North Macedonia
Drab & Kocisova (2019)	*Efficiency of the banks: the case of the Visegrad countries*	2005–2016	Visegrad countries: Czech Republic, Slovakia, Poland and Hungary
Cvetkoska & Fotova Čiković (2020)	*Assessing the relative efficiency of commercial banks in the Republic of North Macedonia: DEA window analysis*	2007–2017	North Macedonia

Source: Author

Kisielewska, Guzowska, Nellis & Zarzecki (2007) have implemented the window DEA technique to investigate the efficiency and productivity of the largest ten Polish commercial banks in the period from 1995-2003, using intertemporal and locally intertemporal data. Furthermore, they explore the productivity changes within the sector with the Malmquist Index approach. In their study, the chosen sample of the 10 largest banks represents roughly 80 % of the banking sector's total assets. They have applied the DEA window analysis approach "in order to accommodate a relatively small sample size with a large number of performance variables". For this study, they developed six performance DEA models with different input and output variables. The obtained results show that the average cost efficiency estimates within each particular model, i.e. depending on the model applied, average efficiency across the sample of banks rose and fell between 1995 and 2003. "The minimum average estimates are obtained with model 1A (57 per cent) and maximum with model 3 (90 per cent)". The authors conclude that the largest banks in Poland have noted "an upward trend in the average level of efficiency" during the analysed period.

Gaganis & Pasiouras (2009) have focused on a sample of 18 foreign and 21 domestic banks operating in Greece in the period from 1999 to 2004 in order to measure the influence of bank ownership on efficiency. In their study, they employ an input-oriented data envelopment analysis (DEA) BCC model window technique with a profit-oriented approach and a Tobit regression model. The variables used for the DEA model are as follows: staff expenses and other administrative expenses as inputs and net interest income and net commission income plus other operating income as outputs. The obtained results show that the "average pure technical efficiency during the whole observed period was 0.7325, whereas the scale efficiency varied between 0.5772 and 0.8703 with an average equal to 0.6830". Interestingly, they could not prove that domestic banks are more efficient than foreign-owned banks in Greece.

Savić, Radosavljević & Ilievski (2012) have measured the efficiency of commercial banks in Serbia for the period from 2005 to 2011. In their empirical study, they have developed two DEA models with an intermediation approach: a profit efficiency model and an operating efficiency model. In the first model, they selected two inputs (Interest expenses and Non-interest expenses) and two outputs (Interest income and Non-interest income), whereas, in the second model, they employ Number of employees, Fixed assets and intangible investments, Capital and Deposits as inputs and Granted loans and deposits and Non-interest income as outputs. The findings from the profit DEA model show that only two banks are relative efficient while „all other banks show some kind of inefficiency" and 11 out of 28 banks note an efficiency result between 60% and 70%. The results from the operating DEA model indicate that almost all of the banks in the sample experience dynamic changes in efficiency throughout the years. However, in this model, there are no banks with efficiency lower than 50%, while four banks are relative efficient in the whole period (Agroindustrijska komercijalna banka, Banka Postanska stedionica, Volksbank, ProCredit Bank). Thus, most of the banks in the sample have a range of efficiency between 60% and 70%, regardless of whether it is a profit or operating efficiency of the banks. The authors conclude the paper with the notion that the Serbian banking sector experiences "annual constant increase in efficiency".

Zimkova (2014) aims to measure the technical efficiency of 10 Slovak commercial banks in the period 2000 – 2012. The input-oriented BCC slacks-based measure model of data envelopment analysis (SBM) has been employed. The selected inputs for the window DEA model were Deposits and Fixed assets, whereas Earning assets (Loans and commercial papers) were selected as outputs within a 4 years length of the window. The obtained results indicate that the largest Slovak bank by asset size, Slovenská sporiteľna, was found technically efficient in a total of 5 years, and the most

efficient from the analysed sample. According to the window DEA analysis, technically most efficient banks are Slovenská sporiteľna and Tatra banka.

Repkova (2014) has examined the efficiency of the Czech banking sector employing the input-oriented window DEA technique for the period 2003–2012, implementing the SBM (slack based model – non-radial) model. The sample consists of 11 commercial banks. In this study, the intermediation approach has been adopted with labour and deposits as inputs and loans and net interest income as outputs for the DEA model. The obtained results show that the average efficiency results from the CCR model show an efficiency varying from 70–78 %, whereas the efficiency results from the BCC model vary between 84 and 89 %. The difference between the efficiency results between the CCR and the BCC model are as a result of the elimination of the "part of the inefficiency that is caused by a lack of size of production units" in the BCC model. The large banks (Československá obchodní banka, Česka spořitelna and Komerční banka) noted the lowest efficiency scores in the Czech banking sector, and the reasons behind its inefficiency are "the excess of deposits in the balance sheet and inappropriate size of operation".

Tuškan & Stojanović (2016) have implemented two different approaches to the efficiency evaluation of banking systems: namely, the financial indicators and the Data Envelopment Analysis (DEA) methodology. They have employed both the CCR and BCC output-oriented DEA models and the output-oriented window analysis technique for the 28 European banking systems. The observed period is 2008–2012. Interest expenses and total operating expenses have been used as input variables, whereas interest income and total operating income as output variables. The results from the DEA window analysis indicate the lowest efficiency in 2008 (0.659), due to the "onset of the financial crisis in that year" and the highest in 2011 (0.732).

Paleckova (2017) has applied the Window Malmquist index approach (which is a combination of the window DEA and the Malmquist index analysis) to assess the efficiency of the Czech banking system in a sample of 16 commercial banks operating in the period 2004–2013. The two basic input-oriented DEA models (CCR and BCC) have been simultaneously used in this study. This study is the first empirical study implementing the DEA Window Malmquist index approach for the Czech banking sector. The intermediation approach has been adopted for this study with two input variables (labour and deposits) and two output variables (loans and net interest income). The findings from this study reveal that in the CCR model "most banks reached a Window Malmquist index of above 1.00", which means that most banks increased their efficiency in the period 2004–2013. The findings in the BCC DEA model show positive efficiency changes but on a smaller scale. Interestingly, this study showed new insights regarding the efficiency of large banks. Namely, the findings indicate that the largest banks have an inadequate size and noted "the lowest values in scale efficiency". Thus, this empirical study concludes that "large banks are the least efficient banks in the Czech banking industry", as in Repkova (2014).

Fotova Čiković & Cvetkoska (2017) have analysed the efficiency of the banking sector in North Macedonia in the period from 2008 to 2015. In their output-oriented DEA model, they have employed total deposits, interest costs and operating (non-interest) costs as inputs and total loans, interest revenue and non-interest revenue as outputs. The results from their empirical study reveal that the average relative efficiency of the banking sector as a whole is 88.77%. Interestingly, they found no bank in their sample that has been relatively efficient in each of the observed years as well as any of the windows. Ultimately, their findings are in accordance with many previous studies in banking and prove that large banks are most efficient in the North Macedonian banking system.

Degl'Innocenti, Kourtzidis, Sevic & Tzeremes (2017) have investigated the efficiency of 116 banks for 9 new EU members (namely, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania) in the region of Central and Eastern European (CEE) in the period 2004-2015. They have applied the Weight Assurance Region (WAR) model and selected deposits as an intermediate variable in the two-stage data envelopment analysis model. Their window DEA represents an expansion of the WAR model, with a main goal "to include the dimension of time into analysis". The inputs used in the first stage are total assets and personnel expenses, while deposits function as the output. In the second stage of the research, deposits represent inputs, whereas loans and securities are the outputs.

Their findings indicate that the bank inefficiency in CEE countries "is mainly driven by the profitability stage rather than the value-added activity stage". More specifically, they found Czech, Hungarian and Polish banks from the top-20 banks' group to be most efficient. On the other hand, Romania notes low-efficiency results over most of the observed period.

Cvetkoska & Savić (2017) have focused solely on one Macedonian commercial bank (namely Komercijalna banka A.D. Skopje) and have investigated the efficiency of the bank branches for three years (from 2009 to 2011) in two phases. In the first phase of the research, the DEA window analysis was used as a tool for "monitoring the trend of the relative efficiency of each branch under consideration". In their study, the output-oriented BCC DEA window analysis model with 4 inputs (personnel, equipment, business premises, and material expenses) and 16 outputs (lending to citizens, corporate lending, domestic payment operations – total transactions, domestic payment operations – officers, domestic payment operations – average per employee, bank cards, ATM transactions, POS terminals and imprinters transactions, denar saving passbooks, foreign currency saving passbooks and current accounts, deposits structure, realised inflows from legal entities, realised outflows from legal entities, total F/X purchase, inflows from individuals, and outgoing payments from individuals) has been implemented. This research is one-of-a-kind since it focuses on one bank and its branches and it offers great managerial implications, i.e. the results provide valuable information for the bank's management since they identify and point out the efficient and inefficient branches.

Drab & Kocisova (2019) have measured the technical efficiency of domestic commercial banks in the Visegrad countries (V4, which include Czech Republic, Hungary, Poland and Slovakia) with the application of an input-oriented BCC and CCR Window DEA with an intermediation approach and thus, estimate the change efficiency in the banking sector. The observed period is from 2005 to 2016. In their window DEA model, they have used three sub-periods (windows), as follows: 2005-2008, 2009-2012 and 2013-2016. The obtained results from the empirical research indicate that the efficiency of the banking sector in the Visegrad countries "increased during the analysed period except for the 2009-2011 period", due to a slowdown as a consequence of the financial crisis and "subsequent changes in the regulatory requirements or banks' loan assessment behaviour". Moreover, the findings show that the Hungarian banking sector is most efficient (with an average efficiency score of 78.83%), Czech is second best (with a technical efficiency score 68.63%), and Slovak and Polish banking sectors have been ranked third and fourth with efficiency scores of 60.52% and 58.32%, respectively.

Cvetkoska & Fotova Čiković (2020) have focused their research on the North Macedonian banking sector, and have empirically measured its profit efficiency with the application of the window DEA technique on a sample of 14 commercial banks in the period from 2007 to 2017. Their

output-oriented BCC window model uses interest and non-interest expenses as inputs and interest and non-interest revenues as outputs and the length of the window is 6 years. Their findings indicate that there were obvious consequences of the Global Financial Crisis, which has left banks inefficient in the first few years shortly after its occurrence. The large banks are the most efficient in their sample, as in Fotova Čiković & Cvetkoska (2017). The overall results show that the banking sector in North Macedonia noted the highest efficiency results in the year 2007 (84.04%) and the lowest in 2011 (65.25%).

5. DISCUSSION AND CONCLUSION

According to the obtained results from the extensive literature review, nine of the total twelve surveyed papers focus on a single banking market (i.e. national banking sector), whereas three studies are cross-country studies and include 28 European banking systems, 9 new EU members in Central and Eastern Europe and the Visegrad countries: Czech Republic, Slovakia, Poland and Hungary (in Tuškan & Stojanović, 2016; Degl'Innocenti, Kourtzidis, Sevic & Tzeremes, 2017 and Drab & Kocisova, 2019, respectively). Three of the surveyed papers concern the banking system in North Macedonia (in all of which, one of the authors is Cvetkoska), and two are focused solely on the banking sector in the Czech Republic. The findings from this literature review indicate that the surveyed studies have been published in the period between 2007 and 2020 and have included the time frame from 1995 to 2017, i.e. most of the surveyed papers (in particular, 9 out of 12) analyse the period after 2003. The shortest study is 3 consecutive years: 2009-2011 (Cvetkoska & Savić, 2017), whereas the longest is 13 years – 2000-2012 (Zimkova, 2014).

The group of large banks is proven to be most efficient in the papers of Fotova Čiković & Cvetkoska (2017) and Cvetkoska & Fotova Čiković (2020). However, Repkova (2014) and Paleckova (2017) showed that large banks are the least efficient banks in the Czech banking system.

In the last step of the research approach, an identification of the research gap has been set. Thus, it can be concluded that papers and empirical studies in the SEE region are quite modest, papers and empirical studies of banking with WDEA in Northern and Western Europe are practically non-existent and the window DEA technique has been rather neglected by researchers.

Window DEA provides a dynamic perspective of the relative efficiency of decision-making units and thus, should be implemented more often by researchers of the banking industry as well as any other industry.

The DEA methodology has many advantages over parametric methodologies, and the window DEA has even more strengths due to the dynamic perspective and the entrance of the time dimension. And even though there have been many rebuttals (that have been addressed in Section 2), many scholars agree that "DEA's advantages outweigh by far its limitations" (Škuflić et al., 2013; Stolp, 1990; Fotova Čiković & Lozić, 2022).

The scientific contribution of this article is threefold: first, it provides an in-depth extensive literature review on studies regarding the banking efficiency in Europe with the implementation of window DEA and focuses on 12 relevant studies; second, it presents the window DEA technique, its strengths and limitations; and finally, this article should be considered a stepping stone for future work and employment of WDEA in banking, and in any other industry for that matter.

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