Efficiency of the banking sector in Poland compared to other countries in the region

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ABSTRACT

The banking system is one of the most important components of the financial systems on which modern economies are largely based. The occurrence of instability in this area may lead to serious economic problems. Therefore, the interest of researchers in this area has been focused mainly on assessing the effectiveness and efficiency of the banking sector, which will allow for identifying possible areas for improvement.

In this paper, we discuss the use of efficiency as one of the basic measures used to assess the functioning of the banking sector. The aim of this study is to examine the efficiency of the banking sector in Poland, and then to compare the obtained results with selected countries of the region in 2014–2018. The paper presents theoretical considerations in the field of the financial system, the banking system and the efficiency of entities.

In the empirical part of the paper, we conducted our own research on the efficiency of the banking sector in Poland using the DEA (Data Envelopment Analysis) method. The results were compared with those obtained in selected countries in the region. The selected countries of the region are: Bulgaria, the Czech Republic, Estonia, Croatia, Hungary, Lithuania, Latvia, Romania and Slovakia.

JEL Classification: C14; G21

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1. INTRODUCTION

The banking system is an important component of the financial system, which is the basis for the functioning of modern economies. The key purpose of its existence is to ensure that individual entities, i.e. businesses and individuals, can invest their cash. On the other hand, it makes it

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possible to obtain financing for business development or consumption. It thus allows the transfer of funds from entities with a surplus to those in deficit. The banking system is also an important part of the payment infrastructure, enabling payments and settlements to be made between the entities concerned. Due to its important role in the economy, issues related to ensuring its proper functioning are therefore of great importance. The occurrence of instability in this area may lead to the inhibition of the development of enterprises and individual entities and, consequently, to serious economic problems. In order to counteract such a situation, the interest of researchers focuses on assessing the effectiveness and efficiency of the banking sector. Such an assessment allows for the timely identification of areas that need to be improved.

Our aim is to examine the efficiency of the banking sector in Poland and then compare the results obtained with selected countries in the region in 2014–2018 using the non-parametric DEA (Data Envelopment Analysis) method. The selected countries of the region are: Bulgaria, the Czech Republic, Estonia, Croatia, Hungary, Lithuania, Latvia, Romania and Slovakia. The subject matter undertaken is important because of the extremely important role of the banking sector for the health of the economy as a whole, as described above. The study also provides important added value, as it allows us to compare the efficiency of the banking sectors in countries with a relatively short recent banking history (post-transition) and to identify those that have developed better over the years.

The study was carried out on the basis of the non-parametric DEA method, which makes it possible to analyse the efficiency of entities by referring to the relationship of multiple inputs and outputs without knowing the precise relationship between them.

This paper consists of five chapters. The second chapter presents the essence of the financial system and its models. Two basic models of the financial system found in the literature (Anglo-Saxon and continental) are also characterised. The essence of the functioning of the banking system is presented, indicating that its main purpose is to transfer money from surplus to deficit entities. This is followed by a discussion of the risks involved in banking activities, i.e. credit, operational, market and liquidity risks. The third chapter presents the theoretical foundations of banking sector efficiency. A definition of efficiency of entities' operations is provided and the concept of effectiveness is discussed. The basic methods of measuring efficiency are indicated, i.e. ratio analysis, parametric and non-parametric models, including the DEA method. The following section reviews the literature on efficiency measurement in relation to the banking sector. The fourth chapter is the authors' empirical study. The research sample is described, with the rationale behind the assumed inputs and effects included in the model, as well as the choice of period and countries analysed. The non-parametric DEA method used in the study is also presented in more detail. The characteristics of the economies and the banking sector and the results of the study are presented. Chapter five provides a summary.

2. FINANCIAL SYSTEM

2.1. Concept and functions

The starting point for considering the banking sector is to understand the fundamentals of the financial system. It is difficult to imagine the functioning of modern economies without an efficient financial system, which is a key element of them. It enables the financial and investment needs of individual system participants to be met and allows financial transactions to take place between them. By its action, it stimulates the economy and boosts its growth. The financial system is made up of both a market sphere and a public sphere, which complement each other. The inefficiency of financial markets in certain areas is offset by the activity of public finance. Depending on the financial system model adopted in a given economy, its structure may look different. According

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to the classical division, the system may be dominated by banking entities (continental model) or capital market entities (Anglo-Saxon model). The infrastructure that ensures the technical side of the financial system is also an important element of the system. It is formed by both the IT infrastructure and relevant regulations.

There is no uniform approach to defining the concept of the financial system in the literature. Pietrzak et al. (2008) define it as a part of the financial sphere or, more broadly, of the economic system, constituting a mechanism through which services are provided that allow the circulation of purchasing power in the economy. According to this approach, the financial system enables the creation and flow of money between entities of the real sphere (pp. 15–16). Thus, its main task is to supply the economy with money by carrying out various types of financial operations between households and businesses. In a broader sense, the notion of the financial system is defined by Owsiak (2015) as a set of logically related organisational forms, legal acts, financial institutions and other elements enabling entities to establish financial relations in both the real and the financial sector. In his view, the financial system is a legally regulated platform used to manage the finances of economic entities. It is a form of intermediation between entities that have surplus capital and those that need funds to finance their activities. It enables households and businesses to make profits by investing their accumulated savings in the financial markets and allocating them to support the activities and development of other actors by providing them with financing in the form of loans and credits. A similar view is taken by the International Monetary Fund (IMF), which points out that the financial system consists of institutional units and markets that interact to mobilise resources for investment and provide facilities, including payment systems, to finance commercial activities (IMF, 2016).

Pietrzak et al. (2008) distinguish three key functions of the financial system:

- monetary,
- capital-redistributive,
- control (pp. 18–19).

The monetary function is one of the basic functions performed by the financial system. It refers to the provision of money to entities in the real sphere as a means of economic exchange and its free movement in the form of carrying out various types of financial operations.

An equally important function is the capital-redistributive function. It primarily includes the ability to invest the savings of households and businesses to make a profit and transfer them to those who make the demand for capital needed for investment.

The control function, on the other hand, refers to the monitoring of invested or borrowed capital in the past in financial terms as well as corporate management (Pietrzak et al., 2008). A different approach to defining the function of the financial system was taken by Merton and Bodie (1998). According to them, the role of the financial system is:

- to provide payment clearing and settlement methods to facilitate trade,
- to provide a mechanism for pooling resources and distributing shares in different companies,
- to provide ways to transfer economic resources over time, across borders and between industries,
- to provide ways to manage risks,
- to provide ways of imparting price information to help coordinate decentralised decision-making in different sectors of the economy,
- to provide ways to address incentives created when information asymmetries exist (p. 5).

2.2. Financial system models

In modern economies, there is no accepted uniform approach to shaping the financial system. The structure of the financial system, i.e. the size and diversity of markets and the entities operating in them, may look different in different countries. This is due to the presence of various

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country-specific conditions, i.e. the economic, institutional or regulatory environment, among others. These factors can directly determine the design of the financial system and influence its functioning. As a result, two models of the financial system are most commonly distinguished in the literature:

- **Anglo-Saxon system**,
- **German-Japanese (continental) system**.

Anglo-Saxon model

According to Iwanicz-Drozdowska et al. (2017), in the Anglo-Saxon model of the financial system, financial markets play a key role (p. 23). Entities operating in this market raise the capital necessary for growth (including the issue of securities, particularly shares or bonds). The form of corporate financing is one of the main features distinguishing between the Anglo-Saxon and German-Japanese financial systems. Financial markets can also be used for profit-oriented investment transactions, i.e. the purchase of securities, as well as to provide day-to-day liquidity or to hedge against currency or interest rate risks. The predominant market within this model is the capital market where transactions between different entities are most often concluded via a stock exchange.

Grosfeld (1994), in her publication on this subject, points out that characteristic of the Anglo-Saxon model of the financial system is also wide access to information on the financial instruments and entities concerned. Both the stock exchange and individual participants publish information on the daily quotation of securities or their financial situation (p. 6). This allows for greater transparency and ease of execution of transactions. As a result, individual market participants can make more optimal investment choices and thus achieve greater financial returns.

Operating on a stock exchange is somewhat limited due to the high barrier to entry. Numerous financial, legal and formal requirements have to be met and the necessary permits must be obtained. As a result, the market structure is dominated mainly by large, specialised entities that are able to bear the costs associated with a debut and further operation on the market. According to Grosfeld, an important factor differentiating the models in question is also the greater dispersion of ownership. In the Anglo-Saxon system, through the issue of securities, the shareholders of a given company are many. They are able to influence the strategy and investment decisions taken by the enterprise to a lesser extent than if a greater part of the enterprise is held by one major entity. On the other hand, possible financial problems of a given enterprise will not have such a severe impact on an individual investor with a small share of profits compared to investors with a much larger shareholding.

The financial system model based on financial markets is mainly characteristic of Anglo-Saxon countries. The key representatives of this model are the United Kingdom and the United States. Allen and Gale (2000), in their publication, point out that the main reason for the strong entrenchment of the markets-based financial system in the UK is due to the historical background related in particular to the period of the Industrial Revolution. During this time, there was a huge demand for the capital required to develop businesses and key industries. Due to easy access to the capital market and favourable investment conditions there, i.e. the ability to obtain high and long-term funding, it gained considerable strength compared to funding through banking products, which were less financially viable (pp. 31–32). In the United States, this model gained importance mainly due to the US Securities and Exchange Commission (SEC) enacting stricter regulations in the area of investment banking after the outbreak of the Great Depression in 1929. The US model has gained importance mainly due to the adoption of stricter regulations for the banking sector than for the capital market after the Great Depression of 1929, as well as the introduction of new financial instruments such as options and futures (pp. 33–34).

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The share of stock market capitalisation in the United States and the United Kingdom as a percentage of GDP in 2017 is presented below. The analysis shows that that share in the US in the period under review was approximately 164.9%, while in the UK it stood at about 116.9%, confirming the dominant role of the stock market and the capital market in countries based on the Anglo-Saxon model.

Table 1
Share of stock market capitalisation in selected countries as a percentage of GDP in 2017

	United States	United Kingdom
Share of stock market capitalisation as % of GDP	164.845	116.881

Source: CEIC (2019), CEIC (2020).

Japanese-German model (continental)

The second model of the financial system most often described in the literature is the Japanese-German or otherwise continental model. Its characteristic feature is the high concentration of banking entities in the structure of the system, which significantly dominate the other entities, including the stock exchange (Maciejczyk-Bujnowicz, 2015, pp. 60–61). They perform both a clearing function by intermediating in various types of financial transactions concluded in the market as well as deposit and credit activities. Banks enable households and businesses to invest their surplus capital in the form of bank deposits, which ensure that they earn a return on their invested funds. Investing in the Japanese-German model carries a lower risk compared to the Anglo-Saxon model. Investors are not exposed to fluctuations in market parameters, including but not limited to volatility in securities prices caused by speculative transactions. Therefore, to a greater extent, the bank-based market is perceived as stable and safe. Under this model, the main source for companies to raise the capital needed to develop their business is bank loans and advances. From deposited funds, banks' lending activities are financed. In contrast to the Anglo-Saxon model, obtaining financing by a company does not require the issue of securities. Consequently, they do not lose potential profits from their ownership rights in return for recapitalisation. At the same time, they maintain control of the business, which can be at risk in the case of equity issues, where investors, depending on the size of their stake, can influence decisions taken by the company. In this model, there are also fewer barriers to accessing the dominant market than in the Anglo-Saxon model. The products offered by banks are more accessible to both households and companies. They can invest and raise capital with relative ease, which in the capital market is subject to greater requirements and restrictions. This is particularly evident in the case of households, for which it is essentially impossible to obtain financing from the capital market. As a result, the model in question is dominated mainly by commercial, universal, non-specialised banks geared towards acquiring a broad customer portfolio (Maciejczyk-Bujnowicz, 2015). This is one of important factors that account for the strength of this model.

The bank-based model of the financial system has mainly developed in some European countries, in particular Germany and Japan. Since the beginning of the German financial system, credit and lending institutions have played a dominant role. According to Detzer et al. (2013), the largest players in the market there were mainly joint-stock or private banks, which were created and managed by private investors. Over time, other banking entities, i.e. State Savings Banks and Co-operative Banks, which were state-owned, also gained importance (p. 19). Allen and Gale (2000) point out that one of the reasons for the high concentration of the banking sector in Germany may have been a large share of banks in the ownership of companies. Consequently, they were able to have a greater influence on investment decisions made by companies. Thus,

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companies were more willing to finance their activities through banking products (p. 37). Japan is also an example of a continental financial system. According to Allen and Gale (2000), the banking system in Japan mainly gained importance after the Second World War, when there was large demand for capital among companies, which was met in particular through bank loans and credits. However, a significant role for the state in the banking system was apparent. It set the course for the development of individual sectors of the economy and thus decided for development of which companies to provide financing and in what amount. As in the German banking system, banks in Japan also held shares in the profits of companies, which also determined their development in comparison with other financial institutions operating in the market (pp. 40–41).

The following shows the share of bank assets in Japan and Germany as a percentage of GDP in 2017. The analysis shows that these countries are characterised by a high degree of banking sector concentration in the structure of the financial system. The share of bank assets as a percentage of GDP in 2017 in Japan was around 157.5%, while in Germany it was around 91%.

Table 2
Share of bank assets in selected countries as a percentage of GDP in 2017

	Japan	Germany
Share of banks' assets as % of GDP	157.51	91.07

Source: The Global Economy (2019).

To conclude the discussion of the existence of different models of the financial system, it should be considered whether those distinguished are valid in modern economies. Banks are currently operating in a global environment in which an advanced digital transformation is underway. As a result, it can be expected that new different models have developed. Perhaps this is the case if other criteria for division are adopted. There is no doubt that countries may have a mixed system, i.e. the banking system and the capital market are partially equally important for institutional participants or even individuals.

In the Anglo-Saxon system, the capital market is the main source of financing enterprises or meeting the financial needs of individuals, and in the continental system, these main sources are banks. Taking into account that the two distinguished models of the financial system are the result of historical conditions (habits of society that have not changed fundamentally); the models defined in this way are up-to-date and continue to be useful for describing reality.

Of course, the effects of implementing advanced digital transformation may lead to changes in such a way that there will be no link in the direct relationship between the customer and the financial institution. Then only the regulator will be aware of how the service provider is classified (bank or other financial institution), and the customer will not be interested in this.

2.3. The modern banking system

The banking system is a structure in which banks play a dominant role. Depending on their type, they perform different functions in the economy. Central banks mainly supervise and stabilise the macroeconomic situation in individual markets, in particular by maintaining an overall price equilibrium. Commercial banks, on the other hand, focus on maximising their own profit. They are mainly oriented towards granting loans and credits, investing surplus cash and carrying out payment transactions between the various entities of the banking system. The activities of banks, like all businesses, are exposed to various risks that may affect the efficiency of their operations. Therefore, it is important to take measures to mitigate these risks and their negative effects on

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banks. Legal regulations, which precisely define the principles of their functioning in the banking system and economy, may be helpful in this respect.

In the collective work edited by Jaworski and Zawadzka (2002), the banking system is defined as both banking institutions and the norms conditioning their interrelationships and relations with the environment (p. 38). Thus, according to the cited approach, the banking system is a plane on which mainly banks and other institutions conducting activities characteristic of banks operate. Its proper functioning requires the existence of strict legal norms that regulate the interrelationships between banking institutions, as well as households and enterprises, thus preventing various types of financial abuse and limiting the occurrence of negative market fluctuations that threaten the stability of the banking system as well as the entire economy. Four basic functions performed by the banking system have been distinguished, which include:

- raising and investing money,
- making cash transfers,
- providing pricing information,
- creating the conditions for the transformation of investment resources (Crane et al., 1995).

The key players in the banking system are commercial banks of which there are many types. Which types of them will develop in a given economy mainly depends on macroeconomic, legal and political conditions. One of the dominant types of commercial banks are universal banks. Their characteristic feature is the versatility and multifunctionality of their operations. According to Jaworski and Zawadzka, universal banks offer both the possibility of depositing funds and granting financing in the form of credits and loans, as well as providing additional services of a banking nature, i.e. concluding transactions typical of the capital market (p. 29). The largest universal banks in the world and in Europe by asset size in 2018 are presented below.

Table 3
A breakdown of the world's 10 largest universal banks by asset size in 2018

No.	Name	Country of origin	Value of assets (billions of USD)
1	Industrial & Commercial Bank of China Ltd	China	4 027.44
2	China Construction Bank Corp.	China	3 376.52
3	Agricultural Bank of China Ltd.	China	3 287.36
4	Bank of China Ltd.	China	3 092.21
5	Mitsubishi UFJ Financial Group Inc.	Japan	2 812.88
6	BNP Paribas SA	France	2 336.66
7	Credit Agricole Group	France	2 123.61
8	Japan Post Bank Co. Ltd.	Japan	1 911.48
9	Sumitomo Mitsui Financial Group Inc.	Japan	1 848.20
10	Mizuho Financial Group Inc.	Japan	1 837.80

Source: S&P Global (2019).

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Table 4
List of Europe's top 5 universal banks by asset size in 2018

No.	Name	Country of origin	Value of assets (billions of USD)
1	BNP Paribas SA	France	2 336.66
2	Credit Agricole Group	France	2 123.61
3	Banco Santander SA	Spain	1 670.79
4	Deutsche Bank AG	Germany	1 543.55
5	Societe Generale SA	France	1 485.31

Source: S&P Global (2019).

Investment banks are another important type of commercial banks. Unlike the universal banks described above, they are characterised by a greater degree of segmentation of banking services. Their activities are mainly based on performing financial operations of an investment nature, including in particular the sale and purchase of securities and derivatives on behalf of clients (Jaworski & Zawadzka, 2002). Investment banks mainly target large companies and financial institutions that are looking for attractive forms of investment and raising capital for the development of their business. By definition, they have more capital at their disposal compared to other banks, and securities-based transactions allow them to achieve higher returns than from standard banking products, i.e. deposits and loans. At the same time, their activities are subject to considerable risk due to the relatively high volatility of financial instrument prices and high susceptibility to speculation.

The table below shows the world's largest investment banks by asset size in 2018.

Table 5
A breakdown of the world's top 5 investment banks by asset size in 2018

No.	Name	Country of origin	Value of assets (billions of USD)
1	JPMorgan Chase & Co.	United States	2 622.53
2	HSBC Holdings PLC	United Kingdom	2 558.12
3	Bank of America Corp.	United States	2 354.51
4	Citigroup Inc	United States	1 917.38
5	Wells Frago & Co.	United States	1 895.88

Source: S&P Global (2019).

2.4. Banking risks

In the context of analysing the efficiency of the banking sector, it is also reasonable to discuss issues related to the risks to which banking entities are exposed. The activities of banks, like all other enterprises operating in the markets, are susceptible to various factors. These can have both a positive and negative impact on their financial standing. These include the macroeconomic environment, institutional environment or the internal structure and organisation of banks. Since banks are seen as public trust entities which the functioning of many market players relies heavily on, it is therefore important to maintain their stability, which then translates into the stability of the entire financial system. It is therefore of paramount importance to identify all the risks to which banking entities are exposed and to monitor them afterwards in order to respond quickly and efficiently to possible risks and to limit their negative effects. The Basel Committee on Banking

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Supervision in the New Capital Accord identifies three basic types of risks relating to banking activities:

- credit risk,
- operational risk,
- market risk (BIS, 2006).

Following the global financial crisis of 2007, liquidity risk and the methods used to measure and monitor it also gained importance, as described, among other things, in the so-called Third Capital Agreement issued in December 2010 (BIS, 2010).

From the point of view of the operation of banking entities, the most important is credit risk. Bessis (2015) defines it as the risk associated with the failure of bank customers to repay loans on time. The author also points out that credit risk in banking activities is the deterioration of the customer's financial situation and, consequently, their ability to systematically pay their obligations to the bank (p. 3). As a result of this approach, credit risk is both the currently occurring delays in repayment of money borrowed from the bank and the potential possibility that customers will default on the terms of the loan agreement in the future. The bank's exposure to this type of risk depends mainly on the nominal value of the loan at risk and its share in the bank's entire loan portfolio, as well as the duration of the loan. Its occurrence may significantly affect the bank's liquidity balance.

Credit risk monitoring is carried out, among other things, through a review of individual loan portfolio exposures based on an assessment of the borrower's financial situation and an analysis of internal ratings. The Basel Committee on Banking Supervision, in the New Capital Accord, indicates the basic parameters that should be included in the measurement of banks' credit risk using the internal ratings approach. These include the Probability of Default (PD), the Loss Given Default (LGD), the Exposure at Default (EAD) and the Effective Maturity (M) (BIS, 2006).

Another equally important risk in the activities of banking entities is operational risk. According to the definition included in Article 4(52) of the Regulation of the European Parliament and of the Council of 26 June 2013 on prudential requirements for credit institutions and investment firms, operational risk is defined as the risk related to internal procedures, human and system errors and external events, including legal risks (European Parliament & the Council). In its simplest sense, it is the risk associated with the operational functioning of banks. Within the definition quoted above, the most important operational risk factor is regulation – that of both internal and external nature that creates the infrastructure and institutional framework for banking activities. The risk in this area mainly refers to the possibility that the rules that define the functioning of banking entities may not be properly framed, so they may not operate fully efficiently.

Market risk is also a significant threat to the functioning of the banking sector. It is classified as an external banking risk, which means that its sources are not directly related to banks' activities. The Basel Committee on Banking Supervision classifies these mainly as risks related to the volatility of interest rates, prices of financial instruments, currencies as well as commodities (BIS, 2006, p. 157). From the point of view of banking entities, key are interest rate risk and currency risk. Interest rates are the basic parameter on which the pricing of most services provided by banks is based. Any deviation of these from desired levels can have a negative impact on the revenue, profits and efficiency of the business. A relatively low interest rate can lead to liquidity problems for banks due to less interest on the part of customers in placing cash in low-yielding bank deposits, while at the same time there is a high proportion of loans and advances due to the lower cost of obtaining them. Excessively high interest rates, on the other hand, contribute to a decrease in lending and an increase in liabilities to depositors, which consequently increases the risk of potential losses. Banks' foreign exchange risk is mainly related to the high volatility of exchange rates, which is characteristic of the foreign exchange market. As market risk is generated mainly by external factors, it is more difficult to manage than the above-discussed

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credit or operational risks, which depend to a large extent on the actions taken by banks. In order to hedge against this type of risk, banking entities use, among other things, derivative instruments, one of the basic functions of which is to hedge against the risk of price volatility. These include futures, options and swaps based on interest rates or currencies respectively.

The last of the main types of risk mentioned in the area of banking activities is liquidity risk. In its recommendation on liquidity risk management of banks, the Financial Supervision Authority defines it as the possibility of losing the ability to finance assets and meet obligations in a timely manner, resulting in the recording of financial losses (UKNF, 2015, p. 6). In its simplest sense, it is the risk that a bank may lose some of the cash necessary to conduct its current and long-term operations (lending and deposits). Inevitably linked to the issue of liquidity risk is the concept of liquidity gap. The Financial Supervision Authority defines it as a mismatch between the maturity of assets and the maturity of liabilities (UKNF, 2015). Inadequate portfolio construction on both the active and passive side is the main source of this type of risk in banking activities. Another source of this risk may also be the other risks discussed above, i.e. credit risk, operational risk and market risk. Negative fluctuations in the area of loan repayment or interest rates may significantly reduce the bank's cash holdings and thus lead to solvency problems, increasing the exposure of banking entities to liquidity risk. Thus, an extremely important issue with regard to liquidity risk is its monitoring, which allows potential risks to be identified. It is mainly based on the ongoing verification of liquidity ratios, liquidity gap and cash flow analysis. This area of banks' activities is also subject to periodic supervision by the Asset and Liability Management Committee. The Basel Committee on Banking Supervision in its Basel III regulation imposes additional requirements on banking entities to hedge *liquidity* risk, i.e. the *Liquidity Coverage Ratio (LCR)* and the *Net Stable Funding Ratio (NSFR)* (UKNF, 2020).

3. EFFICIENCY OF THE BANKING SECTOR

3.1. The essence of efficiency

The assessment of the performance of banking entities is one of the most relevant issues undertaken in analyses of the banking system. The basic measure relating to the verification of banks' activities is their efficiency. In its simplest sense, it expresses the relationship between effects and inputs, indicating whether banks achieve the highest possible profits for a given level of inputs. The concept of efficiency is very often confused with the concept of effectiveness, derived from the science of praxeology, which by definition is supposed to lead to a predetermined goal. There are many ways to measure efficiency in the literature. Among them, three key approaches dominate, i.e. indicator analysis, parametric and non-parametric methods, among which the DEA method, which is the subject of this article, has gained the greatest interest among researchers.

In the literature, efficiency is variously defined depending on the strand and field of economics represented by the author concerned. One of the basic definitions of efficiency derives from the microeconomic approach. Begg et al. (2007) cite the notion of efficiency in the Pareto sense understood as an optimal allocation allowing mutual benefits to be achieved. According to this approach, it is not possible to change the allocation of resources to improve the situation of some actors without worsening the situation of other actors (p. 459). It is therefore a point of equilibrium that provides the best possible combination of resources at which neither party has an incentive to change its preferences. Adopting different proportions of resources than those resulting from the equilibrium point indicates the presence of inefficiency in the Pareto sense. Because the definition of efficiency discussed above refers to the optimal choice of resources, it is referred to as allocative efficiency.

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Fried et al. (2008), on the other hand, present the concept of efficiency in more technical terms. Namely, the authors refer to the concept of achieving the maximum possible effects from the inputs possessed or minimising inputs at a given level of effects (p. 8). Within this approach, efficiency refers to the interrelationship of inputs and effects allowing the highest possible potential returns to be generated. In contrast to allocative efficiency, technical efficiency is mainly concerned with evaluating the financial aspects of a company's operation and management. Efficiency in this sense is described as when the effects exceed the inputs, resulting in a positive financial result.

With regard to the issue of technical efficiency, Capiga also draws attention to the existence of economies of scale. Their general idea refers to a decrease in the level of costs with an increase in production, which can significantly affect the efficiency of enterprises. It is also possible for economies of scale to have a negative impact on their profitability when an increase in production generates significant additional operating costs. There are two types of scale effects, i.e. fixed and variable, for which changes in the level of costs are respectively proportional or disproportional to changes in output (as cited in Harasim, 2009, p. 44).

With regard to the banking sector, the analysis of operational efficiency refers mainly to the issue of technical efficiency, the key determinant of which, as discussed above, is the ability to generate profits. This is relatively intuitive due to the fact that it is this parameter that constitutes the primary objective of banking entities. With the appropriate tools, technical efficiency makes it possible to verify the financial strategy and management methods adopted by banks. Banks are perceived as efficient if they use their inputs correctly while achieving the best results at the lowest possible cost mainly by minimising inputs or maximising profits.

Capiga distinguishes between the basic determinants of bank efficiency. At the most general level, she divides them into internal and external determinants. Internal determinants result from the organisation and management of the bank comprising a subject-oriented approach and a resource-oriented approach. 'Subject-oriented' refers to the key aspects of the bank's business, i.e. products, customers, distribution channels, business lines or organisational units, which are shaped by management, while resource performance refers to the use of inputs and their impact on the results achieved (as cited in Harasim, 2009, p. 49). In addition to internal determinants, external determinants on both macro and microeconomic scales are also important factors in the efficiency of banking entities. Macroeconomic factors refer to the existing economic conditions and the monetary and fiscal policy pursued at the national or international level, while microeconomic factors refer only to conditions within a specific region or banking sector (Harasim, 2009).

The concept of efficiency is often erroneously confused with that of operational effectiveness. Helpful in distinguishing between the above terminology are issues in praxeology, a science that covers all aspects of efficient human action (Kotarbiński, 1976, p. 319). Kotarbiński (1976), in his publication, defines effectiveness as an action that leads to the achievement of a predetermined goal (p. 113). Thus, in contrast to efficiency, which refers to the relationship between inputs and outputs and the need to generate profits in order to achieve it, the concept of effectiveness focuses instead on assessing whether specific actions and adopted strategies make it possible to achieve the set goals. An example of efficiency with simultaneous inefficiency in the operation of banking entities is illustrated, for example, by a situation in which a bank generates positive financial results, but at the same time fails to achieve the set goal of increasing its customer base to the level resulting from the adopted development strategy for a given period. The increase in profitability in this case is the result of an increase in interest margins or commission rates, rather than the acquisition of more customers. Thus, this is an activity that may be efficient, but is not effective.

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3.2. Methods of measuring performance

An extremely important aspect of considering the efficiency of banking entities is the methods of measuring it. The literature describes various approaches to the way efficiency is measured. One of the basic tools in this respect is ratio analysis. It is a key element within the broader issue of financial analysis, which mainly serves to assess the performance of companies on the basis of available financial data. Ratio analysis, as the name suggests, is based on the verification of the performance of enterprises on the basis of various types of financial ratios. As a rule, these ratios make it possible to examine the relationships and dependencies between individual financial data (Pomykalska & Pomykalski, 2017, p. 93). Ratio analysis makes it possible to identify areas in which companies are performing well, as well as those that require improvement and may contribute to a failure to achieve targets and financial benefits. The application of this method can relate to the analysis of the entire enterprise, as well as selected elements of it.

The basic source of data necessary for the analysis under this method is financial statements. Its main components include the balance sheet, the income statement, the statement of changes in equity, the cash flow statement and additional notes which detail selected financial items included in the main tables. Pomykalska and Pomykalski (2017) distinguish five basic types of indicators used in ratio analysis. These include:

- liquidity ratios,
- performance indicators,
- financing structure indicators,
- profitability indicators,
- equity ratios (p. 94).

The breakdown outlined above indicates that financial indicators make it possible to assess a company's performance in all the main spheres of business activity: those relating to its profitability, operability and financing methods. On the other hand, only an analysis of all these indicators provides a complete picture of the financial situation in which a given enterprise finds itself at any given time.

The issue of operating efficiency is mainly addressed by profitability ratios, which focus on the ability of companies to generate the maximum possible profits with the minimum level of input. Kochaniak (2010) lists the main profitability indicators analysed within the banking sector, which include (pp. 57–58):

Return on assets (ROA)

$$ROA = \frac{financial\ result}{assets}$$

Return on equity (ROE)

$$ROE = \frac{financial\ result}{equity\ capital}$$

Return on sales (ROS)

$$ROS = \frac{financial\ result}{income}$$

Cost to Income (C/I)

$$C/I = \frac{cost}{income}$$

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Profit margin (PM)

$$PM = \frac{financial\ result}{operating\ income}$$

In its published analyses of the situation of the banking sector, the Financial Supervision Authority additionally points to the importance of the interest margin indicator (NIM) for assessing the efficiency of banks, expressed as (UKNF, 2019):

$$NIM = \frac{interest\ result}{average\ assets}$$

One of the main advantages of using ratio analysis to assess performance is that it is relatively simple to apply and does not require the construction of complex statistical models or the creation of an extensive database to be analysed. In this case, only knowledge of the basic financial data contained in the financial statements is necessary. At the same time, for the same reason, it may be limited to a certain extent and produce unrealistic results without taking into account, among other things, economies of scale. In addition, the choice of appropriate indicators is often subjective and does not always correspond to the specifics of the company in question. The use of different financial indicators may give different results that do not necessarily reflect the actual situation of the company.

Econometric models are another tool for assessing the efficiency of banking entities. They belong to the so-called parametric methods with a precisely specified form which strictly define the relationship between inputs and effects. One of the main models within this approach is the stochastic frontier model SFA (Stochastic Frontier Analysis). It was presented in 1976 by Aiger et al. In their publication, the authors present, among other things, the theoretical basis of the model and its formal form and main assumptions. The general notation of the stochastic limit model is presented below (Aiger et al., 1976, p. 3).

$$y_i = f(x_i; \beta) + \varepsilon_i$$

where
y_i – effect,
$f(x_i; \beta)$ – the form of the boundary function, x_i – the input vector, β – parameter to be estimated,
ε_i – random factor.

One of the most important elements within this model is the adoption of a specific form of the production function necessary to determine the magnitude of the effects. Determining the production function within a given enterprise is very often problematic. Therefore, this tool is sometimes difficult to apply. Equally important is the assumption of random factors. They are an important element of the model that can significantly influence the results of the analyses in this area. They can contribute both to making the results more realistic and to distorting them significantly. In the context of operational efficiency, a company is assumed to be operating efficiently if the results of the analysis fall within the boundary area. If they do not meet this assumption then they are seen as inefficient.

The efficiency of the banking sector can also be measured using non-parametric methods. The primary non-parametric tool in this respect is the DEA method. It was first presented by Charnes et al. in 1978. In their publication, the authors present concepts for measuring the efficiency of given decision-making units referred to as DMUs (Decision-Making Units) using only knowledge of individual inputs and outputs (p. 431). In this type of model, unlike those described above, the relationships between inputs and effects are not strictly defined. Consequently, knowledge of the production function is not required, and no random factor is taken into account in the

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analysis. The selection of appropriate inputs and effects is made on the basis of the professional judgement of those carrying out the study, depending on the specific characteristics of the company in question or the industry in which it operates. According to the concept presented by the authors, efficiency is expressed as the maximum of the quotient of weighted effects to the quotient of weighted inputs. The solution to this optimisation problem, which indicates the full efficiency of the facilities, is a value of one (p. 430). This is the most desirable level to which the facilities should aspire. However, if they take values below one, it indicates inefficient use of inputs at a given level of effects or the possibility of not achieving the best possible effects at a given level of inputs. A detailed description and form of the non-parametric DEA method is presented in the next chapter of this article.

3.3. Review of empirical studies on bank efficiency

The issue of the efficiency of banking entities is an area of interest for many researchers. This is understandable given the fact that they are an extremely important element of the financial system, as well as the economy as a whole. The occurrence of possible instabilities caused by inadequate functioning of banks may lead to negative economic consequences and worsening of the financial situation of many entities. The main focus of analysis in this area is the measurement of bank efficiency. There are many tools available to measure their efficiency. Based on the literature review, selected studies in this area are presented below.

The application of the Stochastic Frontier Approach (SFA) in studies on bank efficiency was presented, among others, by Bonanno (2014) in his publication on the Italian banking sector. The analysis focused on the banking sector, divided into the main groups of banks, i.e. CCB, LTD and Popolari, the size of their business and their geographical location in the years 2006–2011 (p. 287). For the analysis, the author used the following dependent variables: the level of loans, non-interest income and securities. The size of employment, capital, liabilities to customers, labour costs, capital and deposits were used as independent variables (p. 289). The results of the study indicate that the efficiency of banks in the CCB group is dominant over other types of banks throughout the analysed period. In addition, small and medium-sized banks are more efficient, which may be due to the fact that they are easier to manage properly owing to the relatively smaller scale of their operations (p. 303).

Sathye (2001), on the other hand, conducted a study on the efficiency of Australian banks using the DEA method. His study referred to the performance evaluation of 29 banks (19 domestic and 12 foreign) in 1996. The author based his analysis on three inputs, i.e. labour, capital and loan funds, and two outputs, i.e. loans and deposits (pp. 618–619). The final results obtained show that, on average, domestic banks are more efficient than foreign banks taking into account both technical efficiency, allocative efficiency and overall efficiency which is the product of the previous two. Sathye, quoting from Williams (1998), points out that an explanation for this phenomenon could be the greater propensity of foreign banks to use more resources to expand their branch network, which is much smaller in size than that of domestic banks, thus potentially achieving lower profits (pp. 624–626).

A similar study was conducted by Novickytė and Droždz (2018) relating to the Lithuanian banking sector. The study analysed 7 banks operating in different forms, including as local banks and foreign branches, in 2012–2016 (p. 7). The authors analysed 5 DEA models with different assumptions on inputs and effects. The value of deposits, labour costs, liabilities to banks and other credit institutions were used as inputs, while operating profit, loans, profit before tax or net interest income were used as effects (p. 6). The analysis showed that under the assumption of variable scale effects, local banks are more efficient than foreign branches, while with fixed scale effects the relationship is reversed (p. 13).

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Ghaeli (2017) also presents the application of the DEA method to the analysis of the banking sector. The subject of the study is 26 banks operating in the US market in 2016. In the DEA method, the author considers only three parameters. He takes the size of total assets and employment as inputs while net income is taken as an effect. As a result of optimising the functions of the model in question, Ghaeli demonstrates that most banks operating in the United States are characterised by low operating efficiency. Only Santander Bank is a fully efficient bank during the period under review. Bank of America, JPMogran Chase and Wells Fargo, despite having the highest net revenues, incur correspondingly high expenses that reduce their profitability and profit potential (pp. 225–226).

It is also worth mentioning studies relating to the Polish banking sector presented by Polish authors. Pawłowska (2003) used the DEA method to analyse changes in the size structure of banks in Poland in 1997–2001. In the first half of the 1990s, the mechanism of mergers and acquisitions shaped this structure. The conclusion was that all banks involved in the M&A process significantly improved their efficiency measures and productivity indexes. The primary factor affecting efficiency is their size. Most efficient banks are «very large» banks; most extremely inefficient banks are in the «small» group.

A similar study was conducted by Pawłowska and Kozak (2008) in the context of Poland›s possible accession to the eurozone. The effects on efficiency, the level of competition and the performance of the Polish financial sector were examined. The results of the efficiency analysis obtained by the DEA and SFA methods showed an increase in the efficiency of Polish commercial banks, and the average efficiency was similar to that of selected eurozone countries.

Perek (2014) used the DEA method to study the technical efficiency of cooperative banks in 2005–2011. The analysis was based on models: BCC and CCR targeting inputs and effects. The study conducted on a sample of all cooperative banks showed a large discrepancy between the minimum and maximum values of efficiency ratios. The distribution of banks by efficiency ratio level also suggests that the cooperative bank sector is highly diversified. Analysing changes in efficiency over time, it was found that banks recorded a decline in total productivity in 2009–2010 and 2010–2011, which was mainly due to a decrease in relative efficiency.

Mielnik and Ławrynowicz (2002) conducted an analysis of efficiency measures for commercial banks in Poland (data for 1999) using the DEA method. The results reveal a relatively high value of average efficiency. A significant number of banks show decreasing and constant economies of scale, which results in the fact that further expansion of the business by means of increasing inputs will not bring greater effects, only less or equal. On the other hand, the number of bank branches (taken as a business effect) strongly influences the explanation of the efficiency of the banks studied. This may mean that the managements are pursuing an additional strategic goal – the development of the branch network. Such a goal is strategically significant, which will increase the bank›s potential in the future and may generate additional revenue the bank›s owners are looking forward to.

4. EXAMINING THE EFFICIENCY OF THE BANKING SECTOR IN POLAND AGAINST THE BACKGROUND OF SELECTED COUNTRIES IN THE REGION

4.1. Description of the research sample

The authors' study described in this chapter concerns the assessment of the efficiency of the banking sector in Poland against the background of selected countries of the region using the non-parametric DEA method in the years 2014–2018. The selected countries of the region should be understood as countries from the area of Central and Eastern Europe belonging to the European Union. Those are: Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania,

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Romania and Slovakia. The sample was restricted to countries within the European Community due to the greater availability of financial data published by various European institutions. However, Slovenia was excluded from the analysis because it had numerous data gaps during the period under consideration. The above countries were selected because they have relatively recently undergone a major overhaul of the banking system as a consequence of the 1989 systemic transformation. The present analysis refers to the period from 2014 to 2018. This is mainly due to the desire to present the current functioning of the banking sectors in the countries of the region and to omit the period of the recent global financial crisis of 2007–2009 as well as some years immediately before and after this crisis in order to avoid possible distortions in the data that could translate into misinterpretation. The empirical data on banking sectors on which the study is based comes from data published by the World Bank, the European Central Bank and the European Banking Federation. The inputs and effects analysed in this study using the non-parametric DEA method are presented below.

Table 6
Inputs and outputs analysed as part of the banking sector efficiency study carried out

No.	Inputs	Outputs
1	Salaries	Gains or losses
2	Employment	Loans
3	Number of branches	Interest income
4	Number of ATMs	Commission revenue
5	Interest costs	
6	Commission costs	
7	Total assets	
8	Liabilities and provisions	
9	Equity	
10	Deposits	
11	Administrative costs	

Source: own elaboration.

Inputs and effects represent both financial data from the banking sector aggregated income statement and balance sheet presented in the European currency and non-financial data expressing, in this case, employment, number of branches or ATMs. Eleven inputs were selected for this study, i.e. salaries, employment, number of branches and ATMs, interest expenses, commission expenses, total assets, liabilities and provisions, equity, deposits and administrative expenses. In our opinion, the above parameters best illustrate the outlays incurred by banks, as they take into account all aspects of their functioning, i.e. the assets held, the main operating costs, the bank's operating costs, the sources of its financing, namely equity and debt capital, as well as the size of the network of branches and ATMs, which affects the availability of banking products and the size of the workforce, which translates, inter alia, into the efficiency of the execution of banking operations. The performance of banking sectors, on the other hand, is illustrated by four effects: profits and losses, loans, interest income and commission income. These are the main parameters expressing the potential profitability and viability of banks.

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4.2. Characteristics of selected countries in the region and the banking sector

A GDP level indicator has been selected to present a brief macro-economic overview of the selected countries in the region. Between 2014 and 2018, all countries surveyed recorded a systematic increase in GDP levels. The highest GDP levels in 2018 were recorded in Poland (USD 1 208.9 billion), Romania (USD 565.7 billion), the Czech Republic (USD 429.3 billion) and Hungary (USD 308.7 billion). These countries also saw the highest value growth in the index with USD 235.3 billion or 24% in Poland, USD 155.1 billion or 38% in Romania, USD 89.6 billion or 26% in the Czech Republic and USD 56.1 billion or 22% in Hungary. The rest of the countries, however, did not exceed a GDP of USD 200 billion in the analysed period. The lowest growth in value terms was recorded in Estonia (USD 9.8 billion or 25%) and Latvia (USD 11.5 billion or 24%) (OECD, 2023).

The main parameter characterising the banking sectors in the countries of the region is the level of assets held, which illustrates the size of the sectors. The sizes of the banking sectors in the countries concerned are quite diverse (Chart 1). In particular, Poland and the Czech Republic stand out for their very high level of assets compared to the other countries in the region. In the analysed period, they increased by EUR 83 billion or 23% to EUR 443.7 billion in Poland and by EUR 89.1 billion or 49% to EUR 270.8 billion in the Czech Republic. These are both the largest asset values and their changes over the period under review. The remaining countries in the region do not exceed banking assets of EUR 130 billion. One country that recorded a reduction in the size of the banking sector over the period of EUR 8.4 billion or 27% is Latvia. According to the European Banking Federation, this is due, among other things, to a reduction in foreign customer deposits (EBF, 2020).

An equally important parameter illustrating the banking sector is the number of banking entities operating within it. In this case, disproportions between individual countries are also visible. The largest number of banking entities is found in Poland. In 2018, 647 of them were recorded, a decrease of 32 entities compared to 2014, which is due to the numerous bank mergers and acquisitions carried out in recent years. In comparison, the Croatian banking sector is made up of only 22 entities. During the period under consideration, a systematic downward trend in the number of banking entities in the different countries of the region is visible. The largest decrease occurred in Hungary. Between 2014 and 2018, as many as 129 banks disappeared from the sector, which, according to the European Banking Federation, is the result of consolidation processes affecting credit and savings cooperatives in particular (EBF, 2020). Only in the Czech Republic, 3 new banks appear during the same period.

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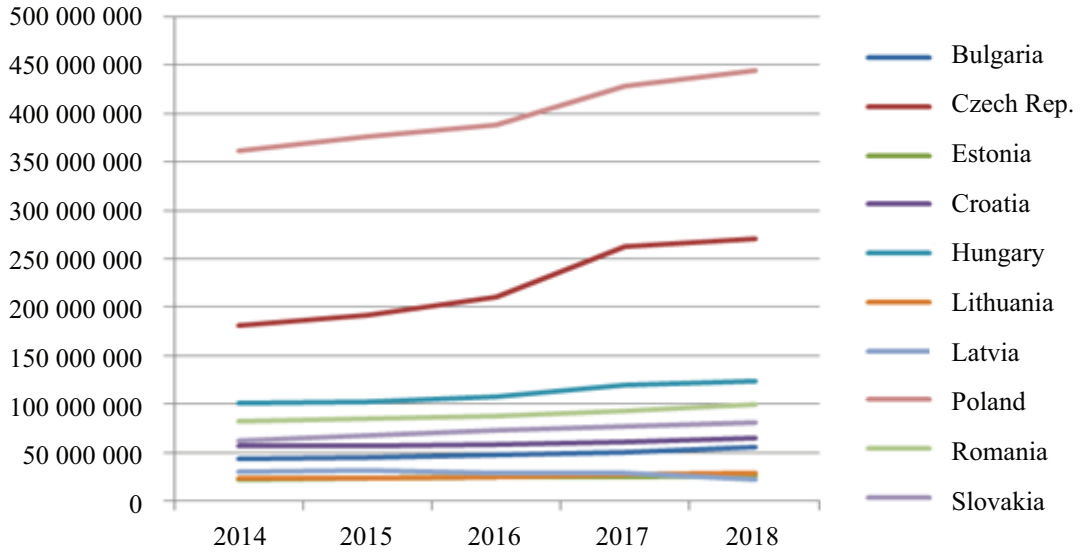
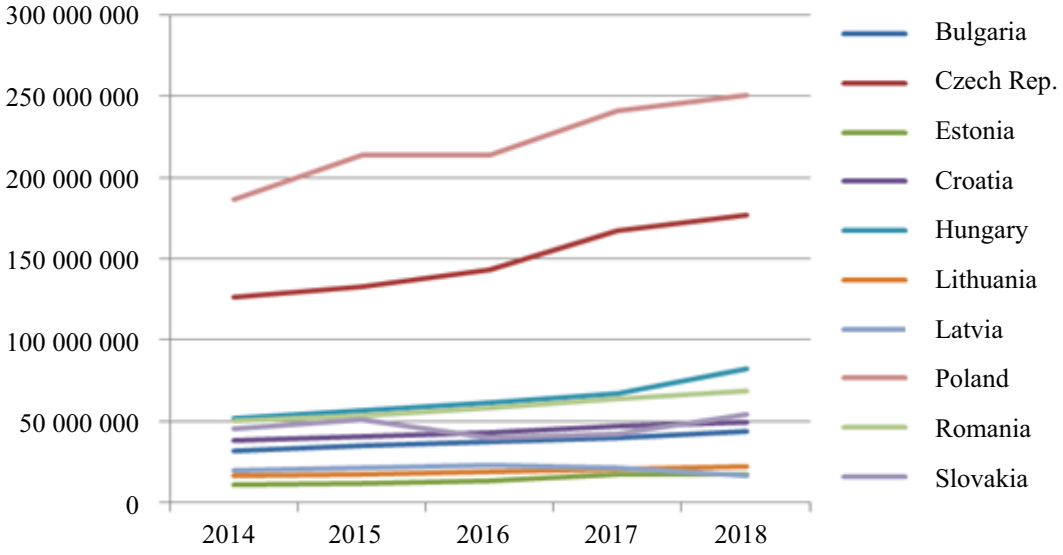
Chart 1
Assets of the banking sector from 2014 to 2018 (in thousands of euros)



Source: ECB (2019).

The main source of funding for banks' activities is deposits. As with assets, their highest level remains in Poland and the Czech Republic. In 2018, this was EUR 250.7 billion and EUR 177.1 billion, respectively. These countries also saw the highest growth in deposits in value terms between 2014 and 2018, by EUR 64.4 billion in Poland and EUR 51.1 billion in the Czech Republic. In the other countries of the region, with the exception of Latvia, cash exposures also gradually increased throughout the period under consideration, but did not exceed EUR 83 billion. In Latvia, there was a decrease of EUR 2.7 billion in bank deposits compared to 2014, which, as mentioned above, is the result of a decrease in foreign customer exponentiations.

Chart 2
Banking sector deposits in 2014–2018 (in EUR thousand)



Source: ECB (2019).

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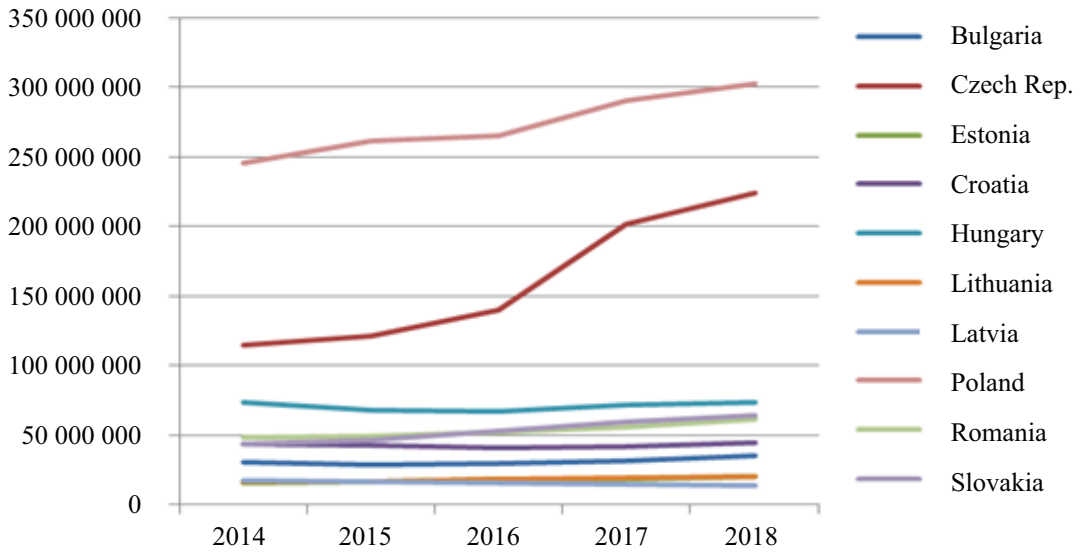
With regard to the level of lending within the individual countries of the region, a continuing positive trend between 2014 and 2018 is evident in most of them, with the largest increases in lending in the Czech Republic (of EUR 110 billion or 96%), Poland (of EUR 56.6 billion or 23%) and Slovakia (of EUR 20.6 billion or 47%). The only country with a decrease in lending during this period is Latvia. Here, its decrease reached EUR 4.5 billion, i.e. 25%. According to the European Banking Federation, this mainly affected the non-resident corporate client segment (EBF, 2020). In 2018, the highest level of loans was recorded in Poland (EUR 302.4 billion), the Czech Republic (EUR 224.4 billion) and Hungary (EUR 74.1 billion), while the lowest level was recorded in the Eastern European countries, namely Latvia (EUR 13.6 billion), Lithuania (EUR 20 billion) and Estonia (EUR 20.1 billion), which is correlated with the amount of assets and deposits in these countries.

Chart 3
Banking sector loans from 2014 to 2018 (in EUR thousand)



Source: ECB (2019).

Banks' profitability is expressed, among other things, by the profits and losses they generated. In 2018, the highest level of banking sector profits was achieved by Poland (EUR 3.4 billion), the Czech Republic (EUR 3 billion) and Hungary (EUR 2 billion) while the lowest was recorded by Latvia (EUR 275.8 million), Lithuania (EUR 355.8 million) and Estonia (EUR 377.4 million). The dynamics of change of the parameter in question throughout the analysed period varied across the countries of the region. The highest increase in profitability between 2014 and 2018 was achieved by Hungary and Romania at EUR 4 billion or 196% and EUR 2.6 billion or 245%, respectively. This is mainly due to these countries recording significant losses from their banking activities in 2014–2015, caused, in the case of Hungary, by the high cost of converting Swiss franc mortgages into domestic currency (Zsebesi, 2015) while in Romania, by a decrease in income and a persistently high level of net provisions (Deloitte, 2014). At the same time, Poland and Latvia recorded a fall in profitability of EUR 325.8 million and EUR 26.9 million in the period under review. The decrease in profitability in Poland is due, inter alia, to the gradual decrease in interest rates set by the Monetary Policy Council, the introduction of the bank tax in 2016 and, in 2018, the new IFRS 9 standard assuming changes in the classification of financial assets and the amount of write-downs on them, which may significantly reduce the potential profits of banks. The decrease in profit in Latvia is mainly due to the decrease in banking activity, i.e. both loan and deposit levels, as described above.

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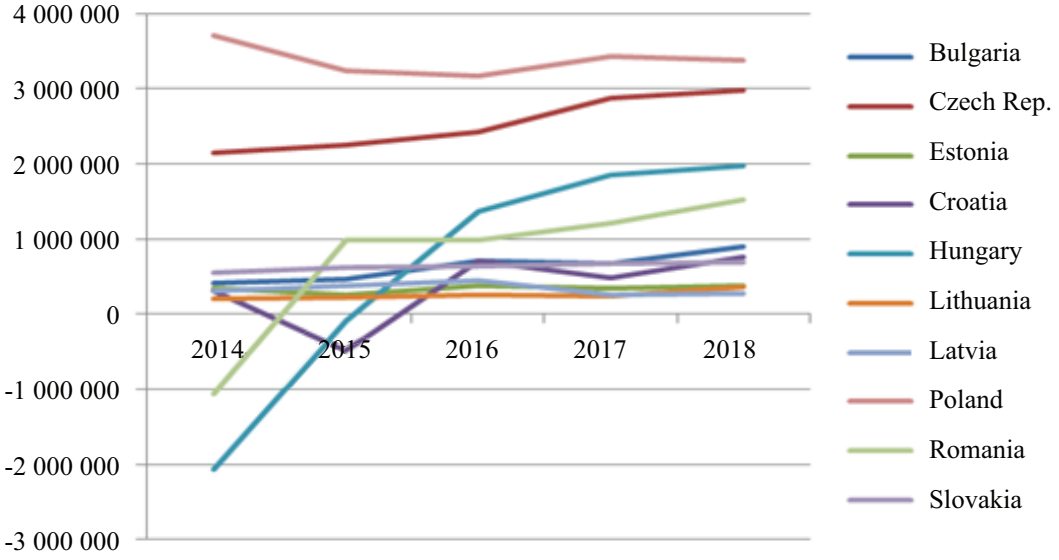
Chart 4
Profits and losses of the banking sector from 2014 to 2018 (in EUR thousand)



Source: ECB (2019).

4.3. Description of the research method

As mentioned, the Data Envelopment Analysis (DEA) method is an example of non-parametric tools most commonly used to measure the performance of data objects referred to in the literature as DMUs (Decision Making Units). Its authors, Charnes, Cooper and Rhodes, in their publication, indicate that the level of efficiency of objects can be determined based on knowledge of individual inputs and outputs under appropriate constraints (Charnes et al., 1978, p. 429). The DEA method identifies the optimum ratio of effects and inputs based on the available data, which it then compares with the actual results obtained. If the two do not coincide and the results deviate from the best possible values determined by the model, then the subject is seen as inefficient. With this method, it is possible to analyse multiple inputs and outputs at the same time, which means that the method can more accurately reflect the actual situation of the facility in question, as efficiency is, by definition, the resultant of a number of factors. These can refer to both financial and non-financial data, as the DEA method does not impose strict requirements in this respect.

The following is a form of the DEA model developed by Charnes et al. (1978, p. 430).

$$\max h_0 = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}}$$

where

$$\frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}} \leq 1$$

$$u_r, v_i \geq 0 \qquad j = 1,\ldots, n \qquad r = 1,\ldots, s \qquad i = 1,\ldots, m$$

y_{r0} – effects,
x_{i0} – inputs,
u_r, v_i – the weighting of effects and inputs.

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According to the above formal notation of the model, efficiency under this approach is calculated by maximising the ratio of the weighted product of effects to the weighted product of inputs. According to the assumption, the results of the efficiency analysis should take values in the range from 0 to 1. Those decision-making units whose results take the value of 1 are considered fully efficient, while those whose results are closer to 0 are considered inefficient. The model also assumes that the weights for individual inputs and effects are included in the analysis. These should take on positive values. The weights are set automatically by the model when solving an optimisation problem to achieve the best possible result.

In the literature, Cooper et al. (2011) distinguish between two types of DEA model, i.e. input-oriented and effect-oriented (p. 13). The form of the input-oriented and effect-oriented model in question is presented below.

Input-oriented model

$$\min \theta - \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right)$$

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta x_{i0}$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = y_{r0}$$

Effects-oriented model

$$\max \varphi + \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right)$$

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = x_{i0}$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = \varphi y_{r0}$$

$$\lambda \geq 0 \qquad j = 1,\ldots, n \qquad r = 1,\ldots, s \qquad i = 1,\ldots, m$$

where
s_r^+, s_i^- – clearance values for optimisation,
ε – fixed parameter,
φ, θ – performance parameters.

From the above formal notations of the different types of DEA model, it follows that the input-oriented model is concerned with minimising the efficiency parameter relating to inputs, while the effects-oriented model refers to maximising the efficiency parameter relating to effects. Thus, depending on the efficiency analysis objective adopted, a specific optimisation problem needs to be solved. An input-oriented model assesses a company's use of inputs at a given level of outputs, while an effects-oriented model allows verification that a company is achieving the best possible results at a given level of inputs. For each of the types of DEA model discussed above, it is possible to make the assumption of fixed or variable scale effects (Cooper et al., 2011, p. 12). The form of the DEA model presented by Charnes et al. (1978) is the so-called CCR model with fixed scale effects. The concept of variable scale effects, on the other hand, is introduced in the publication by Banker et al. (1984) and referred to in the literature as the BCC model. The form of this model adopts most of the assumptions originally included in the CCR model. The basic assumption differentiating the fixed and variable scale effects model introduced by Banker et al. is the constraint that the sum of input and effect weights should be equal to 1 (p. 1082). Its formal notation is presented below.

$$\sum_{j=1}^{n} \lambda_i = 1$$

The general concept of variable scale effects assumes that a change in inputs causes a disproportionate change in effects. The authors of the BCC model indicate that in its initial phase, an increase in inputs translates into an increase in output or profits of a given entity (these

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are increasing economies of scale). On the other hand, at a certain point, further increases in inputs cease to be profitable and do not result in the expected increase in effects (these are declining economies of scale). In this case, the facility's output or profits start to decline and it is desirable to reduce inputs to get to a point where better results can be achieved (Banker et al., 1984, pp. 1087–1088). According to the concept of Banker et al., economies of scale are expressed by the following parameter, which is contained in the form of the BCC model (p. 1082).

$$u_j = k\lambda_j$$

The non-parametric DEA method, in addition to its undoubted advantages, i.e. no need to know the production function and take into account the random factor, the relatively simple form of the model and the possibility of analysing multiple inputs and effects, also has its weaknesses. Guzik (2009) points to a significant problem with regard to the practical application of this method, i.e. redundancy, that is an excessive number of efficient entities, which significantly limits the possibility of comparing the analysed entities (p. 8). Guzik, referring to Banker and Gilford as well as Andersen and Petersen, presents in his publication the basic assumptions of the SE-CCR super-efficiency model. This model assumes the introduction of a so-called ranking index in place of the existing efficiency parameter. Other assumptions regarding inputs and effects remain unchanged. According to the author, the use of a ranking index simultaneously excludes the object under study from the analysis. If it takes on values greater than 1, the entity in question is perceived as efficient, while if it is less than 1, it is considered inefficient. The general formal form of the SE-CCR super-efficiency model is presented below, which can be adapted accordingly depending on the orientation of the model (p. 8).

$$\min \rho_o$$

where

$$\sum_{j \neq o} \lambda_{oj} y_{rj} \geq y_{r0}$$

$$\sum_{j \neq o} \lambda_{oj} x_{nj} \geq \rho_o x_{n0}$$

$$\rho_o, \lambda_{oj} \geq 0$$

ρ_o – ranking factor.

Then, in order to differentiate between the good of the objects perceived as efficient on the basis of the ranking index, Guzik indicates the need to calculate a new efficiency index expressed as the quotient of the ranking index of a given object to the maximum ranking index among all analysed entities. In this way, it is relatively easy to indicate which entities perform better than others even though they may all be perceived as efficient. The new coefficient of efficiency, like the original one, can take values from 0 to 1 (p. 9). We used the SE-CCR model in this study of the efficiency of the banking sector in Poland against the background of selected countries in the region.

Performance analysis using the non-parametric DEA method can be carried out by means of various analytical tools. One of these is to solve an optimisation problem in an Excel spreadsheet using the Solver add-in, where the objective cell returns a value identified with the level of efficiency of the unit under study while specifying the exact assumptions regarding the individual

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inputs, effects and their weights. Technically, this method can also be applied using relevant programs, i.e. EMS and DEAP, which in principle will work in the same way. Within these tools, it is also possible to specify the orientation of the model and the scale effects to be analysed.

4.4. Results of the DEA study

Presented below are the results of the analysis of the efficiency of the banking sector in Poland compared to selected countries in the region using the non-parametric DEA method in 2014–2018. The analysis was performed within the framework of the SE-CCR model oriented to both inputs and effects. Formal calculations of the model were performed using the Solver add-in in an Excel spreadsheet.

On the basis of the application of inputs and outputs described in the preceding subsections and characterising the individual countries of the region in the initial phase of the study, we obtained results indicating full efficiency of all the banking sectors in question over the entire period, i.e. efficiency ratios took the value of 1. The above results did not allow us to single out the more and less efficient countries, as they all showed the same values. A review of the literature on methods of measuring the efficiency of the entities concerned allowed us to conclude that the above results may indicate the existence of the phenomenon of over-efficiency, or so-called redundancy, in our analysis. Therefore, a modification to the CCR model used so far was introduced with assumptions derived from the SE-CCR super-efficiency model described in the previous subsection assuming the introduction of a ranking factor and then calculating a new efficiency factor on its basis.

In line with the concept of the SE-CCR model presented in the publication by Guzik, a new parameter known as the ranking index was introduced in place of the existing efficiency ratio. It allows ranking of the analysed banking sectors from the most efficient to the least efficient. Based on assumptions arising from the model, it can take values both above and below 1, with values above 1 indicating full efficiency of the sectors under consideration. When calculating the ranking indicators for individual sectors, it is also important to exclude a given sector from the analysed set forming the technology common to that sector (Guzik, 2009, p. 8). Detailed results for the ranking indicators in the input-effect-oriented SE-CCR model are presented in Tables 7 and 8.

Table 7
Ranking coefficients of banking sectors in the SE-CCR model in the surveyed countries of the region from 2014 to 2018 in the input-oriented model

Country	2014	2015	2016	2017	2018
Bulgaria	2.2237	1.9773	1.8100	1.6944	1.6379
Czech Republic	2.2279	2.4093	2.0418	2.3259	2.4836
Estonia	2.6059	2.0513	2.3815	1.7796	1.5505
Croatia	1.3038	1.3740	1.3797	1.3335	1.1037
Hungary	1.8363	1.8422	1.9206	2.0807	2.1465
Lithuania	1.1317	1.1797	1.3089	1.2754	1.3290
Latvia	1.8753	1.5348	1.4937	1.3353	1.3271
Poland	1.6806	1.6317	1.4581	1.7301	1.5235
Romania	1.1396	1.2571	1.1418	1.1484	1.2331
Slovakia	1.2256	1.1910	1.4802	1.7209	1.4138

Source: own elaboration.

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Table 8
Ranking coefficients of banking sectors in the SE-CCR model in the surveyed countries of the region from 2014 to 2018 in the effects-oriented model

Country	2014	2015	2016	2017	2018
Bulgaria	0.4497	0.5057	0.5525	0.5902	0.6105
Czech Republic	0.4488	0.4151	0.4898	0.4299	0.4026
Estonia	0.3837	0.4875	0.4199	0.5619	0.6450
Croatia	0.7670	0.7278	0.7248	0.7499	0.9060
Hungary	0.5446	0.5428	0.5207	0.4806	0.4659
Lithuania	0.8836	0.8477	0.7640	0.7841	0.7524
Latvia	0.5332	0.6515	0.6695	0.7489	0.7535
Poland	0.5950	0.6129	0.6858	0.5780	0.6564
Romania	0.8775	0.7955	0.8758	0.8708	0.8110
Slovakia	0.8159	0.8396	0.6756	0.5811	0.7073

Source: own elaboration.

The above ranking coefficients in the input-oriented model indicate that the banking sectors in all analysed countries of the region are fully efficient throughout the considered period, as they take values above 1. This means that in order to achieve the effects of a given banking sector, the other banking sectors of the CEE countries would have to consume the same or more inputs. It is therefore apparent that banks in the individual countries of the region are geared towards minimising their inputs. They want to reduce the amount of costs generated as much as possible in order to achieve a certain level of effects. Between 2014 and 2018, the highest value of the ranking index (above 2) within this model was recorded in the Czech Republic. Its high values, i.e. above 1.87 on average, are also found in Estonia, Bulgaria and Hungary, which may indicate a high level of efficiency ratios within the above countries. On the other hand, the lowest values are found in Romania, Croatia and Lithuania, whose coefficients do not exceed 1.3 on average throughout the period. The value of the ranking coefficient for Poland is in the middle of the pack, recording an average of 1.6 over the whole period. With regard to the above ranking indicators, high variability over time can be observed, without, however, a clear unambiguous trend for all countries analysed.

In contrast, different conclusions can be drawn from the analysis of the results from the effects-oriented model. The results show that none of the banking sectors of the countries in the region surveyed gets the best possible results from their inputs throughout the period. The ranking indicators within this type of model show the inefficiency of all banking sectors, as they take values below 1. Thus, they do not fully perform optimally and do not fully exploit the potential from the inputs. The increase in input costs does not translate into a correspondingly high result. The highest ranking indices during the period under study, i.e. above 0.78 on average, were recorded in Romania, Croatia and Lithuania, which is the opposite of the results obtained from the input-oriented model. Thus, their activities compared to the other countries analysed are more oriented towards achieving the best possible results rather than minimising inputs. The lowest ratios, i.e. below 0.54 on average, are achieved by Bulgaria, the Czech Republic, Estonia and Hungary. In relation to the above countries, there are banking sectors in the region that are able to generate greater results on the basis of their technology and the same level of costs. Poland and Latvia also record intermediate ranking indices averaging 0.63 and 0.67, respectively, over the entire period under consideration. From the above analysis of the ranking indicators, it can be

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concluded that, depending on the model adopted, i.e. input-oriented or output-oriented, its results may differ significantly and lead to different conclusions on the efficiency of the banking sectors.

In line with the assumptions of the SE-CCR model, new efficiency ratios were determined on the basis of the ranking ratios for each banking sector throughout the period under consideration. They are calculated as the quotient of the ranking ratio for a given banking sector to the maximum ranking ratio among all the banking sectors surveyed. Detailed results for the new efficiency ratios in the input-output oriented SE-CCR model are presented in Tables 9 and 10.

Table 9
Efficiency ratios of banking sectors in the SE-CCR model in the studied countries of the region from 2014 to 2018 in the input-oriented model

Country	2014	2015	2016	2017	2018
Bulgaria	0.8533	0.8207	0.7600	0.7285	0.6595
Czech Republic	0.8549	1.0000	0.8573	1.0000	1.0000
Estonia	1.0000	0.8514	1.0000	0.7651	0.6243
Croatia	0.5003	0.5703	0.5793	0.5733	0.4444
Hungary	0.7047	0.7646	0.8065	0.8946	0.8643
Lithuania	0.4343	0.4897	0.5496	0.5483	0.5351
Latvia	0.7196	0.6370	0.6272	0.5741	0.5343
Poland	0.6449	0.6772	0.6123	0.7438	0.6134
Romania	0.4373	0.5218	0.4795	0.4937	0.4965
Slovakia	0.4703	0.4943	0.6216	0.7399	0.5693

Source: own elaboration.

Table 10
Efficiency ratios of banking sectors in the SE-CCR model in the studied countries of the region from 2014 to 2018 in the effects-oriented model

Country	2014	2015	2016	2017	2018
Bulgaria	0.5089	0.5966	0.6308	0.6778	0.6739
Czech Republic	0.5080	0.4897	0.5592	0.4937	0.4444
Estonia	0.4343	0.5751	0.4795	0.6453	0.7119
Croatia	0.8680	0.8586	0.8276	0.8612	1.0000
Hungary	0.6163	0.6404	0.5945	0.5519	0.5142
Lithuania	1.0000	1.0000	0.8724	0.9004	0.8305
Latvia	0.6035	0.7686	0.7644	0.8600	0.8317
Poland	0.6734	0.7230	0.7831	0.6638	0.7245
Romania	0.9930	0.9385	1.0000	1.0000	0.8951
Slovakia	0.9233	0.9905	0.7714	0.6673	0.7807

Source: own elaboration.

Analysing the values of the new efficiency indicators in the input-oriented model, it can be concluded that the most efficient banking sector compared to the countries of the region operates in the Czech Republic. Throughout the period under consideration, its efficiency indicator averaged

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0.94. In 2015 and 2017–2018, the Czech Republic was the leading country in terms of banking sector efficiency, while in 2014 and 2016 the indicator oscillated around 0.85. The high efficiency of the Czech Republic under this model can be mainly attributed to the significant growth in the level of loans granted, the dynamics of which is higher than the growth of key inputs, i.e. deposits or total assets, among others, throughout the period. Significant values of the efficiency ratio were also recorded in Bulgaria, Estonia and Hungary, which exceed 0.81 on average over the analysed time period. Estonia had the highest bank efficiency in 2014 and 2016 compared to other countries in the region due to, among other things, a significant increase in profit levels and a decrease in interest expenses in 2016. On the other hand, the lowest value of the efficiency ratio was recorded in Romania, Croatia and Lithuania, not exceeding the level of 0.53 on average. The data also shows that Poland is characterised by the average efficiency of banks compared to other countries in the region, which remains at a relatively stable level adopting the value of the ratio equal to 0.66 on average. Thus, it is clear that there are better performing banking sectors that can achieve the same amount of effects with fewer inputs. The reasons for the lower efficiency of Polish banks can be found, inter alia, in the Monetary Policy Council's systematic reduction of interest rates, which are currently at a record low level. Similar levels of banking sector efficiency are also found in Lithuania and Slovakia, whose index does not exceed an average of 0.62. Based on the above data, there is also no strong correlation between the level of economic development and the banking sector efficiency index. Large countries of the region in terms of GDP size, i.e. Poland, the Czech Republic, Hungary and Romania (GDP over USD 200 billion), do not record significantly higher bank efficiency during the period under review, compared to small countries, i.e. Bulgaria, Estonia, Croatia, Lithuania, Latvia or Slovakia (GDP under USD 200 billion). While the Czech Republic and Hungary show some of the highest bank efficiencies in the entire period under consideration, Poland and Romania perform much worse on the indicator than, among others, Bulgaria or Estonia classified as small countries in the region.

In the performance-oriented DEA model, the most efficient banking sectors in 2014–2018 are Romania, Lithuania and Croatia, which achieve an average index value of 0.97, 0.92 and 0.88, respectively. The above countries are therefore able to generate the greatest results from their inputs, i.e. profits, revenues or loan volumes. In 2014–2015, Lithuania was characterised by the best performance of banks compared to the other countries in the region, while in 2016–2017 it was Romania. Slovakia, Poland and Latvia also record intermediate magnitudes of the efficiency index of banking entities within the range of 0.71–0.88 on average over the whole period within the model. In the case of the Polish banking sector, an upward trend in its efficiency is visible in 2014–2016, which was, however, halted in 2017 mainly as a result of the introduction in 2016 of a bank tax paid as a percentage of total assets generated. Thus, in the effects-oriented model, the Polish banking sector is also not the most efficient compared to other countries in the region. In Slovakia, a decline in the efficiency ratio of banks was recorded from 2017 mainly due to a systematic reduction in interest income. Its lowest level in the analysed period is in Bulgaria, the Czech Republic, Estonia and Hungary. Bulgaria and Estonia show an increasing trend in banking sector efficiency, in contrast to the Czech Republic and Hungary, which show a decreasing trend. On average, within the above countries, the efficiency indicator value is 0.62. Large countries of the region in terms of GDP size, i.e. Poland, Romania, the Czech Republic and Hungary, are not significantly better performing banking entities in the analysed period in comparison to countries considered as small, either. The best performance of the bank efficiency index among the large havens of the region is shown by Romania (0.97), while the worst by the Czech Republic (0.50) and Hungary (0.58). Thus, it is clear that the disparity in efficiency levels within these countries is relatively high. At the same time, some of the highest efficiency indicators in comparison to other countries were recorded by small countries, i.e. Lithuania (0.92) and Croatia (0.88).

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5. CONCLUSION

The aim of this paper was to examine the efficiency of the banking sector in Poland and then compare the obtained results with selected countries in the region, i.e. Bulgaria, the Czech Republic, Estonia, Croatia, Hungary, Lithuania, Latvia, Romania and Slovakia in 2014–2018 using the non-parametric DEA method. The study used the SE-CCR super-efficiency model due to the presence of redundancy and different sizes of banking sectors. Efficiency analysis was carried out in both input-oriented and effect-oriented models. The parameters selected as inputs were salaries, employment, number of branches and ATMs, interest costs, commission costs, total assets, liabilities and provisions, equity, deposits and administrative costs, while the parameters selected as effects were profits and losses, loans, interest income and commission income.

The results show that regardless of the DEA model considered (i.e. input-oriented and effect-oriented), the Polish banking sector is not the most efficient among the selected countries in the region in the period 2014–2018. In the input-oriented model, the highest efficiency ratio was recorded in the Czech Republic, Estonia, Bulgaria and Hungary adopting values above 0.76 on average throughout the period. The Polish banking sector ranks in the middle of the pack in terms of efficiency, reaching an average of 0.66.

Also in the performance-oriented model, there were countries with better performing banking entities than Polish banks, i.e. Romania, Lithuania and Croatia, for which the efficiency indicator took values above 0.88. Poland, too, had an average banking sector efficiency of 0.71.

The analysis also shows that large countries of the region in terms of GDP size (above USD 200 billion), i.e. Poland, Romania, the Czech Republic and Hungary, do not have significantly higher banking sector efficiency compared to smaller countries during the period under review.

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