Assessing Efficiency of the European Banking Sectors: an Application of the Network DEA

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Abstract

The global financial crisis, sovereign debt crisis, Covid-19, and the invasion in Ukraine highlighted the need to optimise the production processes in banking sectors in Europe. Data Development Analysis (DEA) is a method used to evaluate the efficiency of production units and to benchmark them. It is an important part of analysing and managing the production processes. The contribution attempts to measure and compare technical efficiency scores of 26 European banking systems in 2020 and 2021 by using Network-Data Envelpment Aanalysis (N-DEA), specifically the two-stage slacked-based model (SBM) by Kaoru Tone and Miki Tsutsui (2009). The methodology of NSBM-DEA allows us to assess the efficiency scores of two sub-processes: the deposit collection process and the intermediation process that reflects the use of deposits for earning assets (loans and purchased bonds). Therefore, by NSBM-DEA the deposit collection efficiency, the intermediation process efficiency and its overall technical efficiency can be gained. Most banking systems in Europe reveal a large inefficiency in collection of deposits and higher efficiency in intermediation of the deposits into earning assets. Our findings show that in 2020 and 2021 only 2 out of 26 European banking sectors were technically efficient in the deposit collection phase, namely Latvia and Malta. In the intermediation phase, the only France was almost technicaly efficient (99.9% in 2020 and in 2021 as well). As to the overall technical efficiency, as the best overal efficiency was reached by the banking systems of France and Germany. The result of our contribution is benefitial to policymakers, regulators, or economists that must assess the performance of the entire banking sectors. The deeper integration of the banking sectors through initiatives like the BankingUnion is inevitable.

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INTRODUCTION

The European banking sector is vital for the European Union (EU) due to several reasons, given its central role in the economy, its influence on financial stability, and its contribution to the EU's integration and development. European banking sectors provide essential credit to businesses, households, and governments, driving economic growth. They support investments, consumption, and infrastructure projects, which are crucial for economic development. In Europe, small and medium enterprises (SMEs) heavily rely on bank financing. These businesses are the backbone of the EU economy, employing a significant portion of the population and contributing to GDP.

The health and efficiency of the banking sector directly impacts financial stability across the EU. A stable banking system helps prevent financial crises, while instability can lead to widespread economic disruptions. Many European banks operate across borders within the EU. This interconnectedness means that banking problems in one country can quickly spread to others, making the stability of the banking sector crucial for the entire region.

The EU has pursued deeper integration of its banking sector through initiatives like the Banking Union. This includes a common framework for bank supervision, a single resolution mechanism, and a deposit insurance scheme. A unified banking sector supports the broader goal of economic and financial integration within the EU. Banks facilitate cross-border trade and investment within the EU's single market. The banking sector is a significant employer in the EU, providing jobs directly within banks and indirectly through related industries like insurance, financial services, and IT. European banking sytems are increasingly involved in financial technology (fintech) innovations, which are crucial for maintaining the EU's competitiveness in the global financial landscape. Banks are also leading in sustainable finance initiatives, aligning with the EU's goals for green growth and the transition to a low-carbon economy.

Technical efficiency is crucial to the banking sector in the European Union (EU) for several reasons, as it directly impacts profitability, competitiveness, stability, and the broader economic objectives of the EU. Technical efficiency is key for banks in managing their resources sustainably. Efficient banks contribute to the goals of the EU's Banking Union by ensuring a more stable and integrated banking sector. This is essential for maintaining confidence in the EU's financial system.

The contribution highlights the difference between technical efficiency of banking systems and technical efficiency of banks. Both concepts are closely related, but they differ in scope and perspective. Technical efficiency of banking systems refers to overall efficiency of the entire country´s banking sector, e. g. to the macro-level of analysis. Results can assess how efficiently banking sectors of countries can convert inputs like labor and capital into outputs like credit extended to the economy. Analysis of banking sectors usually use national banking statistics, such as total number of employees, capital, loans, deposits to evaluate efficiency of the whole system. The outcome of those analysis is benefitial to policymakers, regulators, or economists who have to assess the performance of the entire banking sector. On the other side, technical efficiency of individual banks is assessing how well a specific bank uses its resources to produce its outputs. This a micro-level analysis helps identify in-efficiencies at the level of a specific institutions and is useful for management decision or for benchmarking one banks against others. Bank-specific data are usually driven from individual balance sheets, income statements, and operational metrics. The outcome is used by bank managers, investors, and regulators to evaluate and improve the performance of individual banks. Majority of published literature is devoted to assessment of technical efficiencies of individual banks (branches); therefore, the contribution is focused on technical efficiency of banking systems.

The research in this paper aims to measure and compare technical efficiency scores of 26 European banking systems in 2020 and 2021 by using the Network-DEA (N-DEA), specifically the two-stage slacked-based model (SBM) by Kaoru Tone and Miki Tsutsui (2009). The methodology of NSBM-DEA allows us to assess the efficiency scores of two sub-processes: the deposit collection process and the intermediation process that reflects the use of deposits for earning assets (loans and purchased bonds). By NSBM-DEA the deposit collection efficiency, the intermediation process efficiency and its overall technical efficiency can be assessed. The paper is structured as follows. The first part contains a brief literature overview, the second part provides description of data and model specifications, the third part reports main research findings that are discussed and in the final one concludes.

1 LITERATURE REVIEW

In their systematic review of the literature on the two-stage technical efficiency evaluation based on the application of the DEA method in the banking industry, the authors Henriques et al. (2020) revealed that the two-stage terminology itself was not consolidated yet. They analysed 59 papers, divided them into ten classes that cover various perspectives of two stage DEA studies, such as the economic context, geographic region of the banking units, methodological characteristics, and type of the models, either internal or external. They included controversial point regarding two-stage DEA models, such as the variable selection approach (production approach, intermediate approach, profit approach), the technique used in the second stage, and the possible impact of non-discretionary variables on efficiency. When the production process is broken down into several suprocesses, these models are categorized in their paper as internal two-stage DEA models. The approaches in which two analysis procedures are used, with DEA in the first stage and some other technique, either parametric or not, in the second stage, are called external two stage DEA models. While the internal models enable the black box problem to be overcome, the external models enable to analyse externalities of DMUs. In our paper we are going to use the internal two-stage DEA model therefore our literature review is going to be concentrated into them. Moreover, Henriques et al. (2020) founded that most frequent objective in the studies was to extend or improve DEA models, whereas the intermediation approach was the most used for variable selection, and the intermediate variables technique was the most popular in the second stage, in which the deposits variable was the most frequently adopted intermediate variable. Therefore, the intermediate variable deposits are used in our contribution as well.

It is important to note that both internal and external two-stage DEA models have been investigated as a response to the limitations of conventional DEA models. Pioneering paper of Färe and Grosskopf (2000) introduced the flexibility of the DEA modelling framework by focusing on the network DEA. Their models allowed the researcher to study the "inside" of the usual black box technology, both in static and dynamic settings. They accomplished this by introducing the idea to "connect processes" changing a single model framework for muti-stage production.

The first attempt to apply internal two-stage DEA models in banks was done by Seiford and Zhu (1999). They aimed to analyse the profitability and marketability of the 55 largest commercial banks in the United States. In the first stage authors measured efficiency of profitability, including three inputs (number of employees, assets and stockholders´ equity) and two outputs (profit and revenues). The variables profit and revenues (outputs of the first stage) were the input variables of the second stage (referred as intermediate variables). The outputs of the second stage were market value, total return to investors, and earnings per share. In this stage authors concluded that banks ´s efficiency in converting its profits and revenues into marketability. Despite of generated value of the study by Seiford and Zhu (1999), according to Kao and Hwang (2008) the two-stage model they used can have problems related to the intermediate variables, given that by seeking maximization of the outputs in the first stage and minimization in the second, the same variables would be minimized and maximized. To solve this problem, researchers such as Färe and Grosskopf (2000), Lewis and Sexton (2004), Kao (2009), Kao and Hwang (2011), Chen et al. (2010), Cook et al. (2010) among others, developed and extended the Network DEA (N-DEA).

Since then, there are several classifications of NDEA models. Authors Fukuyama, Matousek, and Tzeremes (2020) divide them into four main categories: independent, connected, relational, and game theoretic. Independent models investigate each stage of the productive process separately, without any relationship between stages; In Connected models, contrasting with independent models, the interactions between the stages are considered in the calculation of the overall efficiency. Therefore, for a DMU to be overall efficient, it must necessarily be efficient in all stages considered; Relational NDEA models, proposed by Kao (2009), consist of a combination of the two previous models. Relational models make it possible to measure the efficiency of each system and the overall efficiency. This category of models assumes an additive or multiplicative relationship between overall efficiency and the stage efficiencies; Game theoretic models assume each stage of the productive process as a player in a cooperative or a non-cooperative game.

As mentioned above, there are may authors that devoted their research to Network DEA in banking. They are using micro-economic kind of analysis, as they are focussing on the technical efficiency of individual banks. To most important belong Tone and Tsusui (2009, 2014), Thanassoulis (1999), Seiford and Zhu (1999), Färe and Grosskopf (2000), Wang et al. (2014), Ohsato and Takahashi (2015), Grmanov and Weber (2015), among others. As to local authors, the network DEA was used by Grmanová (2013), Palečková (2019), and Kočišová (2020). Kočišová (2020) utilised the dynamic network DEA approach to disaggregate, evaluate, and test the efficiency of 25 European global systematically important banks during the period 2010–2017 with the variable returns to scale setting. Overall technical efficiency consisted of technical efficiency of deposits producing sub-process and earning producing sub-process. Study reveals that in identifying the bank's inefficiency the dynamic network DEA model is more effective than the conventional black-box DEA model as it can optimise both sub-processes simultaneously. Furthermore, the inefficiency of the European global systematically important banks primarily results from the inefficiency of their earning assets producing sub-process. The paper of Palečková (2019) provided an estimation of cost efficiency and its determinants in the Czech and Slovak commercial banks within the period of 2005–2015 by the two-stage DEA. In the first stage the relative cost efficiency was estimated by DEA, in the second phase bank specific and macroeconomic indicators were used to estimate the determinants of cost efficiency. The results showed that the larger banks with higher liquidity risk and with a lower value of the net interest margin were more efficient.

To the best of our knowledge, our contribution is the first empirical study that is assessing the technical efficiency of national financial systems of European union countries by the NSBM-DEA models.

2 DATA AND MODEL SPECIFICATION

Network DEA is an extension of the traditional DEA designed to evaluate the efficiency of systems that have an internal structure composed of inter-connected processes or stages. In the context of banking systems, it is highly relevant because banking systems typically operate as complex systems with multiple divisions or stages, such as gaining deposits, loans, investments which work together to achieve overall performance. In traditional DEA, a Decision-Making Unit (DMU) is treated as a "black box" that transforms inputs into outputs. However, in Network NEA, the internal processes are modelled explicitly, recognizing the inputs are processed through multiple intermediate stages before producing the final outputs. In our case the production process consists of two phases: stage 1 (collecting deposits from customers) and stage 2 (transforming deposits from customers into loans and investments). Network DEA enables the evaluation of the efficiency of each of these stages individually as well as the overall system.

2.1 Data specification

In the cotribution 26 banking systems operating in the European union: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden were assessed. Missing country is Ireland due to lack of data on banking system. To perform the efficiency analysis, we use two different types of variables, financial and physical. The data on number of employees, deposits, loans were gained from the European banking federation statement (Saravia, 2021, 2022), the data on Tier 1 capital and debt securities bought by banks were downloaded from the Statistical Data Warehouse of the European Centra Bank. The selection of inputs and outputs was influenced by availability of the data and by empirical studies of other authors. Table 1 characterizes the selected variables of the model, which represent individual inputs, outputs and intermediate product.

Table 1 Description of variables

Variable	Notation	Description
Employees	E	Total number of employees working in the banking sectors
Capital	C	Capital – Tier 1, in millions of euros
Deposits	D	Deposits of banking systems in millions of euros
Loans	L	Loans provided to customers in millions of euros
Bonds	B	Bonds purchased from the governments in millions of euros

Source: Authors

The data were analyzed separatedly, not pooled. Table 2 presents the descriptive statistics of the variables of the European banking systems for the year 2020, and Tables 3 reveals the descriptive statistics for the year 2021. In 2020, the number of employees in banking systems of analysed countries reaches an average value of approximately 85 244 people. As for the average value of capital, in 2020 it represented 63 494 million euros. The average amount of deposits in 2020 was 878 953 million euros. The average value of loans provided by the national banking sectors to economic subjects in 2020 was 822 506 million euros, that means almost at high as the level of deposits. The average number of debt securities bought by banks was 95 758 million euros in 2020. We can observe higher standard deviations of all variables. There are also considerable differences in the minimum and maximum values for all used variables. In 2020, the range in the number of employees in the banking sectors was ranging from 5 069 people in the banking sector in Malta to 575 508 people in Germany. Median number of employees is lower than average, suggesting that data distribution is skewed towards lower values. This is influenced by countries such as Germany, France and Italy, whose banking sector is several times larger than in other countries. One of the key indicators of strength and stability is Tier 1 capital. In 2020, the minimum level of Tier 1 capital was in Latvia, the highest in France. Value of deposits in 2020 ranged from 18 565 million euros in Latvia to 5 967 587 million euros in France. In Latvia Banks also provided the fewest loans at the level of 18 145 million euros. On the other hand, the same as for deposits, banks in France provided the most loans, on a level of 5 696 791 million euros. The spread of purchased debt securities in 2020 was from 603 million euros to 523 229 million euros. The fewest government debt securities were bought by banks in Latvia, largest amount of bonds bought by banks was in France and it reveals a high indeptedness of the public sector.

Table 2 Descriptive statistics of variables in 2020

2020	E	C	D	L	B
Mean	85 244	63 494	878 953	822 506	95 758
Median	38 873	15 533	271 848	233 135	19 804
Standard deviation	135 638	112 428	1 587 519	1 475 504	156 968
Minimum	5 069	424	18 565	18 145	603
Maximum	575 508	409 762	5 967 587	5 696 791	523 228
Count	26	26	26	26	26

Source: Authors

In 2021, an average number of employees in banking systems of EU countries fell to approximately 81 163 people from approximately 85 244 people in 2020. As for the average value of capital, in 2021 it considerably increased on 81 700 million euros from 63 494 million euros. The average amount of deposits in 2021 increased on 918 538 million euros from 878 953 million euros in 2020. The average value of loans in 2021 increased as well on 981 515 million euros from 822 506 million euros in 2020. The average number of debt securities bought by banks redused on 84 629 million euros from 95 758 in 2020. We can observe high standard deviations of all variables. There are also considerable differences in the minimum and maximum values for all used variables. In 2021, the range in the number of employees in the banking sectors was ranging from 5 193 in the banking sector in Malta to 526 817 in Germany. Median number of employees is lower than average, suggesting that data distribution is skewed towards lower values. Tier 1 capital in 2021 in the minimum level was 622 million euros in Latvia, the highest level was 481 667 million euros in France. Value of deposits in 2021 ranged from 19 350 million euros in Latvia to 5 967 587 million euros in France. In Latvia Banks also provided the fewest loans at the level of 19 767 million euros. On the other hand, the same as for deposits, banks in France provided the most loans, on a level of 7 234 017 million euros. The spread of purchased debt securities in 2021 was from 621 million euros to 492 978 million euros, where fewest government debt securities were bought by banks in Latvia, most in France. The data are rather heterogeneous, but all financial systems perform similar functions as they are mostly banks not market oriented. Reflecting the DEA theory we avoid to use the ratio indicators.

Table 3 Descriptive statistics of variables in 2021

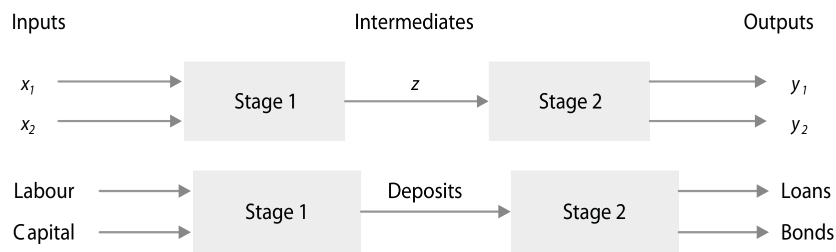
2021	E	C	D	L	B
Mean	81 163	81 700	918 538	981 515	84 629
Median	38 659	15 707	295 725	268 501	21 325
Standard deviation	24 685	27 795	318 960	352 967	29 432
Minimum	5 193	622	19 350	19 767	628
Maximum	526 817	481 667	5 967 587	7 234 017	492 978
Count	26	26	26	26	26

Source: Authors

As mentioned above to analyze the efficiency of banking sectors in the European Union, we use a two-level network structure. The first phase represents the phase of creation of deposits, and the second phase is representing the intermediation of deposits on loans and debt securities bought by banking sectors. In the first phase, based on the theory of production function, the labour and capital are transformed into depostis. In the second phase, the intermediary function of the bank is revealed. In the research, the number of emplyees (E) and capital of Tier 1 (C) of the EU banking systems appear as the inputs of the first phase. The volume of provided loans (L) and the bonds bought by banks (B) are used as outputs in the second phase. The deposits (D) are considered an intermediate product, which is an output in the first phase and an input in the second phase.

The first stage shows how efficiently the banking systems can gain deposits by minimizing human and capital sources, and the second stage shows how the banking systems utilize deposits to finance private economic subjects by providing loans and the public subjects by bonds. Figure 1 represents the given network model.

Figure 1 Two stage network DEA model



Source: Authors

When using the network SBM model, it is important to assign weights to individual divisions. We consider both phases to be equally important, so we decided to give them the same weight of 0.5 and 0.5, since the process of gaining deposits and the process of financing economic subjects are the basic tasks of banking systems. An equally important issue is determining the connection between individual divisions. According to Tone and Tsutsui (2009), there are 4 types of links: a free link, in which connected activities are under the control of the company while maintaining continuity between input and output. Another type is a fixed link, where the linked activities are unchanged, and the intermediate product is not under the control of the company. There are two more types of less used links, so called good link and bad link. In our analysis, we use a free link, as each water company can guide the length of the water network.

2.2 Model specification

Authors Jablonský (2010), Jablonský and Dlouhý (2015) categorized the stages of the production process into serial, parallel or their combination. The serial model assumes a multi-stage production process in which a certain output represents the input to the next stage.

In our study, a two-stage network DEA model is used. The efficiency of the 1st and 2nd level is defined as follows:

$$\max \theta_0^1 = \frac{\vec{w}'\vec{z}_0'}{\vec{v}'\vec{x}_0'} \qquad \max \theta_0^2 = \frac{\vec{u}'\,\vec{y}_0}{\vec{w}'\vec{z}_0}\ , \tag{1}$$

under conditions:

$$\vec{w}'\vec{z} - \vec{v}'x \leq \vec{0}' \quad \vec{u}'\vec{y}_0' - \vec{w}'\vec{z} \leq \vec{0}'$$
$$\vec{v}' \geq \vec{0}', \vec{w}' \geq \vec{0}'; \vec{u}' \geq \vec{0}'$$
$$\vec{w}'\mathrm{z} - \vec{v}'\mathrm{x} \leq \vec{0}' \quad \vec{u}'\vec{y}_0 - \vec{w}'\vec{z} \leq \vec{0}'$$
$$\vec{v}' \geq \vec{0}', \ \vec{w}' \geq \vec{0}'; \ \vec{u}' \geq \vec{0}'.$$

The overall efficiency can be expressed as:

$$\max \theta_0^0 = \frac{\vec{u}'\vec{y}_0}{\vec{v}'\vec{x}_0'}, \tag{2}$$

under conditions:

$$\vec{u}'Y - \vec{v}'X \leq \vec{0}'$$
$$\vec{v}' \geq \vec{0}, \vec{u}' \geq \vec{0}.$$

Assuming that the output of the 1st stage is also the input of the 2nd stage, the overall efficiency is expressed by the following Formula:

$$\theta_0^0 = \frac{\vec{w}'\vec{z}_0}{\vec{v}'\vec{x}_0} \times \frac{\vec{u}'\vec{y}_0}{\vec{v}'\vec{x}_0} = \frac{\vec{u}'\vec{y}_0}{\vec{v}'\vec{x}_0}, \tag{3}$$

under conditions:

$$\vec{u}'Y - \vec{w}'Z \leq \vec{0}'$$
$$\vec{w}'Z - \vec{v}'X \geq \vec{0}'$$
$$\vec{v}' \geq \vec{0}, \vec{u}' \geq \vec{0}, \vec{w}' \geq \vec{0}.$$

In the case of writing the model as a linear programming problem, we get the following form:

$$\max \theta_0^0 = \vec{u}' y_0, \tag{4}$$

under conditions:

$$\vec{v}'\vec{x}_0 = 1$$
$$\vec{u}'Y - \vec{w}'Z \leq \vec{0}'$$
$$\vec{w}'Z - \vec{v}'X \geq \vec{0}'$$
$$\vec{v}' \geq \vec{0}, \vec{u}' \geq \vec{0}.$$

If $\vec{v}'^*, \vec{u}'^*, \vec{w}'^*$ represent an optimal solution, we express the overall efficiency of the 1st and 2nd stages as follows:

$$\theta_0^1 = \frac{\vec{w}'^*\vec{z}_0}{\vec{v}'^*\vec{x}_0}$$
$$\theta_0^2 = \frac{\vec{u}'^*\vec{y}_0}{\vec{w}'^*\vec{z}_0} \tag{5}$$
$$\theta_0^0 = \frac{\vec{u}'^*\vec{y}_0}{\vec{v}'^*\vec{x}_0},$$

where: X = input matrix, Y = output matrix, Z = intermediate product matrix, $\vec{x}_0$ = input´s vector of DMU, $\vec{y}_0$ = output´s vector of DMU, $\vec{z}_0$ = intermediate product vector of DMU, $\vec{v}'$ = input weight vector, $\vec{u}'$= output weight vector, $\vec{w}'$ = intermediate product weight vector, θ_0^0 total efficiency of DMU, θ_0^1 efficiency of the first stage of DMU, θ_0^2 efficiency of the second stage of DMU.

While the traditional DEA model cannot systematically analyze the relationship between the overall efficiency and the efficiency of each stage, the Network SBM model considers the interactions between different stages and can integrate the efficiency evaluation of each network node in the system with the overall efficiency evaluation of the system. Tone and Tsutsui (2009) pointed out that it is one of the methods applicable to the comprehensive assessment of structural efficiency within the DMU.

3 RESULTS AND DISCUSSION

Table 4 shows the technical efficiency of banking systems in EU countries measured by the Network SBM model (VRS) for the years from 2020 and 2021. The first part of the table represents the efficiency of the 1st phase, which represents the efficiency of deposit collection process. In the 1st phase, the inputs were labor and capital. These imputs serve to ensure the functionality of the network and gain deposits. The deposits are thus the output of the stage 1. The results shown in Table 4 indicate that in Phase 1, majority of financial systems of EU countries did not perform their operations efficiently. Most of the banking systems were identified as deposit-collection-inefficient under Phase 1. Based on the results, we observe that in 2020 and 2021 only 2 out of 26 production units were technically efficient, namely Latvia and Malta. It was followed by Estonia (80.69% in 2020 and 80.9% in 2021). Other banking systems in EU achieved a technical efficiency of 77.7% and less. This result suggests that most banking systems in EU should better use their human and financial resources by improving day-to-day operations and catching up with the most efficient banking systems in EU countries. In the second phase, the technical efficiency of the intermediation process of banking systems in EU countries is accessed. Deposits represents the input of the 2nd phase and volume of loans provided to households and private sectors and the volume of purchased bonds from the public sector are the outputs of the second phase. In this phase, the only France was almost technicaly efficient (99.9% in 2020 and in 2021 as well). It was followed by Germany (72.5% in 2020 and 66.4% in 2021). The overall efficiency scores reveal the technical efficiencies of both phases of the production process in the banking systems in the EU countries. The best technical efficiency was achieved by the banking system of France (50.4% in 2020 and in 2021), followed by the banking system of Germany (42.3% in 2020 and 40.2% in 2021). Other banking systems in EU achieved in analyzed period a technical efficiency of 36.6% and less.

Table 4 Technical efficiency of banking systems in EU countries assessed by two-stage DEA model

Contries	Phase I.		Phase II.		Overall score		Rank	
	2020	2021	2020	2021	2020	2021	2020	2021
Austria	0.048	0.047	0.116	0.12	0.109	0.112	7	6
Belgium	0.073	0.071	0.109	0.107	0.106	0.104	8	7
Bulgaria	0.253	0.247	0.004	0.006	0.005	0.008	24	21
Croatia	0.652	0.645	0.003	0.003	0.006	0.006	23	24
Cyprus	0.459	0.446	0.008	0.007	0.012	0.011	18	18
Czechia	0.182	0.178	0.017	0.026	0.019	0.029	17	15
Denmark	0.064	0.067	0.207	0.071	0.182	0.071	6	8
Estonia	0.806	0.809	0.002	0.002	0.003	0.004	25	25

Table 4 (continuation)

Contries	Phase I.		Phase II.		Overall score		Rank	
	2020	2021	2020	2021	2020	2021	2020	2021
Finland	0.153	0.154	0.055	0.056	0.06	0.062	12	10
France	0.008	0.008	0.999	0.999	0.504	0.504	1	1
Germany	0.006	0.006	0.725	0.664	0.423	0.402	2	2
Greece	0.109	0.109	0.043	0.037	0.045	0.039	14	14
Hungary	0.112	0.105	0.019	0.021	0.021	0.023	16	16
Italy	0.013	0.013	0.565	0.527	0.366	0.35	3	3
Latvia	1	1	0.003	0.003	0.006	0.006	21	22
Lithuania	0.627	0.601	0.002	0.002	0.003	0.003	26	26
Luxembourg	0.147	0.139	0.048	0.047	0.053	0.051	13	13
Malta	1	1	0.004	0.004	0.009	0.009	20	20
Netherlands	0.049	0.048	0.255	0.244	0.213	0.205	5	5
Poland	0.033	0.033	0.066	0.058	0.064	0.057	9	12
Portugal	0.077	0.076	0.061	0.061	0.062	0.061	10	11
Romania	0.777	0.149	0.015	0.016	0.026	0.018	15	17
Slovakia	0.351	0.347	0.004	0.004	0.006	0.005	22	23
Slovenia	0.457	0.449	0.007	0.007	0.01	0.009	19	19
Spain	0.019	0.019	0.408	0.403	0.295	0.293	4	4
Sweden	0.071	0.065	0.06	0.064	0.061	0.064	11	9

Source: Authors

Results of our research revealed that the best and the second-best evaluation of technical efficiency by NSBM-DEA models was reached by French and German banking sectors. According Saravia (2021, 2022), French banks continued to play their full role in financing the economy, providing a robust supply of credit. In 2021, the activity in France rebounded sharply: GDP increased by 6.8%, after –7.9% in 2020 and +1.9% in 2019. The output of various industries and components of demand rebounded, albeit with important differences in intensity. Furthermore, with the strong recovery in activity, labour income contributed to the dynamism of household disposable income. Thus, despite rising prices, household purchasing power per consumption unit increased by 1.9. With the rebound in consumption spending, the savings rate decreased but remained at a historically high level, at 18.7%. The banking sector is one of France's six main economic assets, according to the OECD. As of January 2022, the French banking industry counted 334 banks. According to the Financial Stability Board, four French banks are among the eight euro area Global Systemically Important Banks (G-SIBs). Financial activities accounted for 3.9% of total value added in France in 2021, of which approximately 60% for the banking industry. The banking industry employed 350 400 people at the end of 2021 – accounting for more than 20% of the sector's workforce in the euro area – and recruited 40 300 people in 2021. Their network of bank branches providing access to banking services and cash is among the densest in Europe (almost one out of three bank branches in the eurozone is in France).

German banks continue to be quite robust in this very difficult macroeconomic environment (Saravia, 2021, 2022). The German economy is in a very challenging environment, and it is influenced by the energy crisis that has developed because of the Russian war on Ukraine and the extraordinarily high inflation rate. Added to this there are the major challenges posed by the transformation of the economy towards sustainability and a readjustment of cross-border production and supply chains to strengthen resilience to crises. The ECB has reacted to the rising inflation rates. In July 2022, it ended the eight-year phase of the negative interest rate policy. The end of the negative interest rate policy improved earnings prospects. However, the strong and rapid increase in capital and money market interest rates is associated with certain risks for the value of assets. In addition, significantly increased costs (especially material costs driven by high inflation) are deteriorating economic outlook. Germany's banking system comprises three pillars (private commercial banks, public-sector banks, and cooperative banks) distinguished by the legal form and ownership structure. The private-owned commercial banks represent the largest segment by assets, accounting for around 40% of total assets in the banking system. An important feature of the private banks is that they compete keenly not only with banks in other sectors of the industry, but also among themselves. The private banks play a key role for the German export economy, they are involved in 88% of German exports and maintain almost three quarters of the German banking industry's foreign network. The public banking sector comprises savings banks (Sparkassen), Landesbanken, and DekaBank, which acts as the central asset manager of the Savings Banks Finance Group, representing just over a quarter of total banks' assets. There are currently 371 savings banks. They are normally organised as public law corporations with local governments as their guarantors/owners. Their business is limited to the area controlled by their local government owners. Other than this regional focus, their business does not differ in any way from that of the private commercial banks. As a result of the so-called regional principle, savings banks do not compete with one another. Landesbanken were originally designed to act as central banks for the savings banks. In recent years, however, they have been increasingly involved in wholesale funding, investment banking, and international business activities, thus directly competing with commercial banks. The six Landesbanken at present are owned by the federal states and the regional associations of the savings banks. The cooperative sector consists of 773 cooperative banks (Volks- und Raiffeisenbanken) and one central cooperative bank (DZ Bank AG). It accounts for 53% of all institutions by number and around 12% of total bank assets. The cooperative banks are owned by their members, who are usually their depositors and borrowers as well. By virtue of their legal form, cooperative banks have a mandate to support their members, who represent about half of their customers. But cooperative banks also provide banking services to the public. Like the savings banks, cooperative banks have a regional focus and are subject to the regional principle. The number of banks in Germany has dropped sharply in recent years, and by 60% since 1995. Consolidation to achieve economies of scale has taken place largely within the existing pillars. In most cases in the savings bank and cooperative sectors (contrary to mergers in the private sector), consolidation has been the result of stress rather than proactive business considerations.

CONCLUSION

The European banking sectors play multifaceted role in supporting economic growth, ensuring financial stability, and driving innovation. Their efficiency, health and functionality are directly linked to the broader success and stability of the European Union. There is a vast literature on technical efficiency of the individual banks, but the analyses on technical efficiency of the whole banking systems are missing. Therefore, the contribution partially filles this gap. Technical efficiency of individual banks is assessing how well a specific bank uses its resources to produce its outputs. This a micro-level analysis helps identify in-efficiencies at the level of a specific institutions and is useful for management decision or for benchmarking one bank against others. Bank-specific data are usually driven from individual balance sheets, income statements, and operational metrics. The outcome is used by bank managers, investors, and regulators to evaluate and improve the performance of individual banks. In the case of this contribution, technical efficiency of banking systems refers to overall efficiency of entire country´s banking sector, e.g. to the macro-level of analysis. Results can assess how efficiently banking sectors of countries can convert inputs like labor and capital into outputs like credit and investment extended to the economy. Analysis of banking sectors use national banking statistics, such as total number of employees, capital, loans, deposits to evaluate efficiency of the whole system. The oucome of our analysis is benefitial to policymakers, regulators, or economists that must assess the performance of the entire banking sector.

In the contributiom, the methodology of Network DEA (invented by Tone and Tsusui, 2009) allowed us to assess the efficiency scores of two sub-processes: the deposit collection process and the intermediation process that reflected the use of deposits for earning assets (loans and purchased bonds). Overall technical efficiency is a combination of technical efficiencies of both sub-processes. Our findings show that in 2020 and 2021 only 2 out of 26 European banking sectors were technically efficient in the deposit collection phase, namely Latvia and Malta. Majority of banking systems in European Union should improve their deposit collection performance by allocating their human sources and capital more efficiently and creating new practices. In the second phase, representing intermediation function of banking, the only France was almost technicaly efficient (99.9% in 2020 and in 2021 as well) and it was followed by Germany (72.5% in 2020 and 66.4% in 2021). Most banking systems in Europe reveal a large inefficiency in collection of deposits and higher efficiency in intermediation of the deposits into earning assets. As to the overall technical efficiency, as the best overal efficiency was reached by the banking systems of France and Germany. The least overal efficiency was gained by the Latvia and Estonia.

As mentioned above, the results of our analysis can be benefitial to policymakers, regulators, or economists that must assess the performance of the entire banking sector. The EU has pursued deeper integration of its banking sector through initiatives like the Banking Union. This includes a common framework for bank supervision, a single resolution mechanism, and a deposit insurance scheme. A unified banking sector supports the broader goal of economic and financial integration within the EU. Our outcomes could enrich the regulatory institutions as well as management of the banks that form the banking systems of European countries.

Modern banking systems face a variety of challenges as they navigate rapid technological advances, regulatory pressures, and evolving customer expectations. As to cybersecurity threats, with growing digitalization, banks are prime targets for cybercriminals aiming for data breaches, ransomware, and phishing attacks. Moving to cloud-based systems comes with integration and security challenges. Regulatory compliance is increasingly complex including global (Basel I–III), European (Banking union) and national rules. Failure to meet regulatory standards can cead to reputational damage. Startups challenge traditional banks in areas like payments, lending, and wealth management. Banks face uncertainty in how to integrate blockchain technology and deal with the rise of cryptocurrencies. Customers expect tailored products and services based on their preferences and behavior. Younger generations prefer digital banking solutions over traditional branches, requiring significant investment in digital platforms. Inflation, interest rate changes, and economic downturns challenge profitability. Banks are under pressure to support environmentally and socially responsible initiatives, which may conflict with short-term profitability goals.

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