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Investigation of the efficiency of the Azerbaijan banking system with Data Envelopment Analysis (2015–2019)

Introduction

In the banking efficiency literature, two main approaches are prominent for selecting inputs and outputs for a bank. The first is the production approach, also known as the service delivery or value-added approach, which treats banks as organisations that provide services to customers. This approach offers a framework for evaluating the scope, quality and efficiency of the services provided by banks. The second is the intermediation approach, also known as the asset approach, which assesses banks based on their ability to manage assets and resources effectively. This approach focuses on measuring the financial intermediation functions of banks and the efficiency of these functions. While both approaches apply traditional microeconomic theory to the measurement

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of banking system efficiency, they differ in how they address the characteristics of banking activities (Humphrey, 1985; Hjalmarsson et al., 2000). For instance, the production approach developed by Benston views banks primarily as service providers. It emphasises analysing the scope, quality and efficiency of the services offered by banks, thereby measuring bank performance through the effectiveness and quality of these services (Benston, 1965). According to this approach, output is understood as the scope of services provided to customers and can be most accurately measured by the number and variety of transactions, the volume of documents processed or specialised services provided in a given period. This method provides a comprehensive understanding of both service efficiency and customer loyalty. However, in the absence of detailed process flow data, a measurement based solely on the number of deposit and loan accounts may lead to erroneous results. By focusing on the number of accounts, this approach may ignore important aspects of customer satisfaction and operational efficiency, rather than accurately reflecting the quality or level of service provided. In this approach, inputs include physical variables (such as labour, materials, space or information systems) and their associated costs, focusing solely on operating costs while completely ignoring interest expenses (Kumar, Gulati, 2008).

The brokerage approach proposed by Sealey and Lindley views banks as financial intermediaries that facilitate the transfer of funds between depositors and creditors. In this approach, banks provide brokerage services by collecting deposits and other liabilities and allocating them to interest-bearing assets such as loans, securities and other investments. Unlike the production approach, this method includes deposits as inputs, taking into account both operating costs and interest expenses (Sealey, Lindley, 1977).

Berger and Humphrey argue that no single approach fully captures the dual function of banks, namely their role as both transaction/document processing service providers and financial intermediaries. However, they contend that the intermediation approach is better suited for analysing bank-level efficiency, while the production approach is more appropriate for measuring branch-level efficiency. The reason for this distinction is that bank management aims to reduce not only non-interest expenses, but also total costs – whereas at the branch level, there are numerous customer service activities, and branches generally do not have direct control over the bank's financing and investment decisions (Berger, Humphrey, 1997).

In this context, this study investigates the relative efficiency of banks in Azerbaijan using an intermediation approach with data from 2015 to 2019. The analysis includes 25 banks operating in Azerbaijan for which data is available. The primary objective is to evaluate how the efficiency of Azerbaijan's banking sector has developed over this period and to identify which banks are efficient and which are not. Additionally, the study recommends that inefficient banks adopt best practices from more efficient banks and optimise their input-output strategies to enhance

overall performance. In this study, two different models were used to assess the efficiency of banks: the Charnes, Cooper and Rhodes (CCR) model, with constant returns to scale, and the Banker, Charnes and Cooper (BCC) model, with variable returns to scale. The CCR model operates under the assumption of constant returns to scale, while the BCC model assumes variable returns to scale. These two models provide a comprehensive evaluation of banks' performance. Additionally, the Super Efficiency scores of active banks were calculated in the study. These scores help to analyse the efficiency of banks in more detail compared to other banks. The input variables for the efficiency analysis include interest expenses, personnel expenses, general/special expenses and deposits, while the output variables are loans, interest income and non-interest income. All data is presented in Azerbaijani Manats (AZN), which is important for accurately reflecting local economic conditions and the financial situation of the banking sector. This approach allows for a thorough examination of both the internal and external efficiency performance of banks.

This study provides a comprehensive examination of efficiency analysis. Initially, a literature review was conducted to gather fundamental information about the efficiency of the banking sector based on existing studies. In the second section, the theoretical background of the methods used to analyse banking sector efficiency is explained in detail. This section establishes the theoretical framework necessary for the study by presenting the background of the methodologies employed in the analysis. The third section introduces the banks included in the study and the input and output variables used in the efficiency analysis. This section clarifies the structure of the data set and the criteria used in the analysis. In the fourth section, the results of the efficiency analysis are presented and discussed in detail. The findings include an analytical review of the data obtained to evaluate the performance of the banks, as well as various graphs and tables, to illustrate the implications of the results. Finally, the fifth section includes the discussion and conclusions. This section offers a general evaluation based on the findings, discusses the implications of the results for the banking sector, as well as relevant policies, and presents the limitations of the study along with suggestions for future research.

Literature review

There are many efficiency analyses in the literature to examine the banking sector. Most of these studies focused on the selection of the model and variables to be applied in the research.

In the study conducted by Drake, Hall and Simper (2009), the efficiency of the Japanese banking system was investigated with Data Envelopment Analysis by using total deposits, total operating expenses, total provisions, total non-interest expenses, total other operating expenses as inputs and total loans, total other earning

assets, net commission, fee and trading income, other operating income and net interest income as outputs.

In the study published by Küçükaksoy and Selcan (2013), the balance sheet and income statement data for the years 2004 and 2011 of 10 private capital deposit banks and five foreign capital deposit banks operating in the Turkish banking sector between 2004–2011 were analysed using the Data Envelopment Analysis model. Three input variables (total deposit, interest expenses and personnel expenses) and two output variables (total loan and interest income) were used. As a result of the study, it was determined that seven banks in 2004, 2005, 2008, 2010 and 2011, six banks in 2006, eight banks in 2007 and five banks in 2009 were technically efficient under the assumption of variable returns to scale.

Yuksel, Mukhtarov and Mammadov (2016) measure and compare, using Data Envelopment Analysis, the efficiency of the 10 largest banks operating in Turkey and Azerbaijan between 2010–2014. In their study, five inputs (total assets, total equity, total deposits, number of personnel, interest expenses and number of branches) and three outputs (net income, interest income and non-interest income) were used. As a result of the study, it was determined that Turkish banks are more efficient than Azerbaijani banks. Turkish banks were efficient, except for Turkey Ekonomi Bank in 2011; four Azerbaijani banks were efficient throughout the years, and the other six banks were found to be inefficient for some years.

In the study of Beridze and Anbar (2019), the efficiency of 15 commercial banks operating in the banking sector between 2013–2017 was examined using Data Envelopment Analysis. The variables of total deposits, total capital and total expenses were used as input, while total loans, total income and net profit were used as output variables. As a result, it was determined that the efficiency levels of banks were generally high, with five banks being fully efficient in each year of the analysis period. It was observed that efficiency in the banking sector of Georgia tended to increase in 2013–2015 and decline in 2016–2017.

Dutta, Jain and Gupta (2020) analysed the performance of non-banking financial companies (NBFCs) in the Indian context by using data envelopment analysis. In the first stage, panel data for the years 2014–2018 were taken to calculate super efficiencies, and in the second stage, in order to find exogenous factors significantly affecting the model, Tobit regression analysis was used. As a result of the study, where total assets and employee cost are considered as input, interest income, non-interest income and operating profit as output, according to traditional models, the total number of efficient decision-making units is eight out of 43, and considering the Super Efficiency algorithm, 15 units were found. Malmquist Indices, productivity indices of NBFCs over five years, were found to have a maximum productivity increase of 8.53%.

Hammami *et al.* (2022) applied Data Envelopment Analysis and Euclidean common set of weights (ECSW) ranking to the banking sector in the Euro Area

from 2014 to 2018. A data set for 59 of 67 banks traded in 17 countries was obtained. In the study, deposits, number of employees and operating costs are used as input variables, while operating income and total assets are used as output variables. As a result of the ECSW approach, it was observed to perform better than other common weight approaches in terms of ranking consistent with banks' credit ratings, as well as in both numerical and real-life examples.

Tsionas (2020) measured the efficiency of 285 banks in the USA by using the DEA method. In the study, consumer loans, property loans, commercial and industrial loans and securities are considered as input variables, and the labour force (number of full-time equivalent employees), physical capital, funds purchased, interest-bearing transaction accounts and non-transaction accounts are considered as output variables.

Čiković, Keček and Cvetkoska (2023) investigated the impact of the COVID-19 pandemic on the performance of banking systems in Western Balkan countries using Data Envelopment Analysis (DEA) based on the data of commercial banks in six developing Western Balkan countries (North Macedonia, Serbia, Montenegro, Bosnia and Herzegovina, Kosovo and Albania) for the period 2016–2020. The output-oriented DEA model was implemented using interest expenses and non-interest expenses as inputs, and interest income and non-interest income as outputs. According to the results of the analysis, the average efficiency of the banks in the six Western Balkan countries included in the analysis has varied across these years, with Kosovo banks exhibiting the highest performance and Bosnia and Herzegovina banks the lowest. The COVID-19 pandemic had a negative impact on the banking sector in the six Western Balkan countries, except Kosovo (Čiković et al., 2023).

In the study conducted by Li *et al*. (2020), the efficiency of 32 banks operating in China between 2014–2018 was analysed by using three inputs – number of employees, fixed assets and operational cost(s), and two outputs – interest income and non-interest income.

Balci and Ayvaz (2020) measured the efficiency of 15 deposit banks operating in the Turkish banking sector between 2014–2018 using Data Envelopment Analysis on three public, six private and six foreign deposit banks, along with the Malmquist index. As inputs, personnel expenses/total assets (%), total loans/total assets (%), equity/total assets (%) and total deposits/total assets (%) were used, and as outputs, earning power of assets (net profit/total assets) and earning power of equity (net profit/equity) (%) were used to analyse the efficiency of banks. As a result of the study, four banks were found to be efficient under the assumption of constant returns to scale, and eight banks were found to be efficient under the assumption of variable returns to scale between 2014–2018.

S. Yagubov and U. Yagubov (2020) investigated the efficiency of 10 commercial banks with the highest total number of assets in Azerbaijan in 2016,

using the Data Envelopment Analysis method for the period 2011–2016. Three inputs (total assets, total equity and interest expenses) and two output variables (interest income and net profit) were used in the study, employing the CCR (Charnes, Cooper and Rhodes) model. As a result of the study, it was determined that only Turan Bank was efficient in the period before the devaluation that took place in 2015, while the banks in the post-devaluation period were generally efficient, with Pasha Bank achieving the highest efficiency.

The reviewed literature provides an overview of CCR, BCC and Super Efficiency models used in banking sector efficiency analysis. It highlights that variations in efficiency levels among banks are influenced by economic conditions, regulatory changes and internal management practices. The current research emphasises the importance of selecting appropriate models and variables in context and aims to develop a deeper understanding of banking efficiency dynamics and contribute to the existing literature.

Research methodology

The subject of the study is to evaluate the efficiency of 25 banks operating in Azerbaijan between 2015–2019 and to determine the efficiency of these banks. In addition, based on the results of the analysis, the aim is to identify efficient and inefficient banks and to assess whether the Azerbaijani banking system operated efficiently and effectively during these years. Therefore, in this study, three Data Envelopment Analysis (DEA) models – the CCR model, BBC model and Super Efficiency model – were used to measure the efficiency of the banks.

CCR Model

The CCR model used in the analysis was the first tool that provided the development of the DEA approach by Charnes, Cooper and Rhodes in 1978. In this method, the variable weight method is used, and the weights are created directly from the data obtained as a result of multiple assumptions, with fixed weights being avoided (Kutlar, Salamov, 2016, pp. 5–6). In determining these weights with three constraints through linear programming:

1. All data and weights included in the analysis must be positive;
2. The ratio of weighted outputs to weighted inputs should take a value between zero and one;
3. Weights must be used for all DMUs included in the model (Cooper et al., 2011, p. 13).

In the literature, these weight values are called *virtual input-output* or *virtual weights*. The weights are determined in order to maximise the efficiency rate through linear programming. The mathematical representation of the model is shown below (Cooper et al., 2011, p. 13):

$$Weights = \frac{\text{virtual output}}{\text{virtual input}} = \frac{u_1 y_{1o} + u_2 y_{2o} + \ldots + u_s y_{so}}{v_1 x_{1o} + v_2 x_{2o} + \ldots + v_m x_{mo}} \tag{1}$$

Any DMU that is efficient in the analysis made with the input-oriented CCR model is definitely efficient in the output-oriented analysis. This model is divided into two as input-oriented CCR model and output-oriented CCR model according to the control of inputs and outputs. In this analysis, the input-oriented CCR model will be discussed. The input-oriented CCR model is a model solution aimed at minimising the input level by determining the most appropriate input set to bring a certain output set to the most efficient rate (Torun, 2020, p. 47). The purpose of the CCR model is the ratio of a single virtual output to virtual input for a DMU by maximising the ratio of output and input. It provides the efficiency measure which is a function of the factors. If j is the efficiency of the decision unit h_j, the goal should be to maximise this value.

In this case, the input-oriented function can be expressed in the formula below (Charnes et al., 1978, p. 430):

$$\text{Max} h_j = \frac{\sum_{s=1}^{n} u_s y_s}{\sum_{i=1}^{m} v_i x_i} \tag{2}$$

The following constraint was imposed so that the efficiency rate of DMU does not exceed 1 (Charnes et al., 1978, p. 430):

$$\frac{\sum_{s=1}^{n} u_s y_s}{\sum_{i=1}^{m} v_i x_i} \leq 1 \tag{3}$$

The following constraint was introduced so that the weights of the inputs and outputs to be used are not negative:

$u_r \geq 0$; $v_i \geq 0$;

where:
j: DMU number, *j* = 1,2.., *r*;
s: output number, *s* = 1,2...*n*;
i: input number, *i* = 1,2...*m*;
y_s : j'th, the value of the s'th output produced by the DMU;

x_r : j'th the value of the r'th input produced by the DMU;
u_r : weight given to r'th output;
v_i : weight given to the i'th input (Yeşilyurt, Salamov, 2017, p.130).

If the efficiency scores are 1, the KVB included in the analysis is efficient; if it is less than 1, it indicates that it is not efficient (Kutlar, Babacan, 2008, p. 150).

BCC Model

In 1984, Banker, Charnes and Cooper conducted studies based on the assumption of returns to scale and called the BCC formulation. This model was developed on the basis of the CCR model, which is based on the assumption of constant returns to scale, and a model based on the assumption of variable returns to scale was created (Cooper et al., 2007, p. 87). The BCC method measures efficiency by considering only technical efficiency. The BCC model's efficiency score limits will always be less than or equal to the CCR efficiency score limits. As in the CCR model, the BCC model also uses two methods: input-oriented and output-oriented (Banker et al., 1984, p. 1079). In this study, the input-oriented BCC model will be used. The input-oriented BCC model was created to provide the intended output and determine the best amount of input.

The function of input-oriented BCC model is as follows (Banker et al., 1984, p. 1079):

$$MaxZ = \sum_{r=1}^{s} u_r y_{r0} - \mu_0 \tag{4}$$

According to the following conditions:

$$\sum_{i=1}^{m} v_i x_{i0} = 1 \text{; j = 1, ... , n: } \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} - \mu_0 \le 0 \text{; r = 1, ... , p; i = 1, ..., m;}$$

$u_r \ge \varepsilon$; $v_i \ge \varepsilon$, μ_0 : unrestricted

where:
u_r : the weight given to the *r*'th output by DMU;
v_i : the weight given to the *i*'th input by DMU;
y_{r0} : *i*'th input used by DMU;
y_{rj} : *r*'th output produced by the *j*'th DMU;
x_{ij} : *i*'th input used by the *j*'th DMU;
ε : a small enough positive number;
μ_0 : the return to the scale is defined as variable.

The efficiency value of the efficient DMUs in the Input Oriented BCC model is equal to 1. In the case of efficiency, it is impossible to make any changes to the

input and output vectors. The efficiency value of inefficient DMUs is less than 1 (Cooper et al., 2007, p. 89).

SUPER EFFICIENCY

In DEA model analysis, Super Efficiency (SE) is a model that is measured in cases where a DMU gets a value higher than 1, as not every company allows it to be used as an equal. With the assumption of n number of DMU, each DMU_j (j = 1, 2, ..., n) consumes X_j input to produce Y_j output. The input-oriented Super Efficiency DEA model, created on the basis of the basic DEA models predicted by Seiford and Thrall (1990), can be expressed as follows (Seiford, Thrall, 1990, p. 9):

Max ρ
Restrictions

$$\sum_{\substack{j=1 \\ j\neq 0}}^{n} \lambda_j x_j \leq \rho x_0; \qquad \sum_{\substack{j=1 \\ j\neq 0}}^{n} \lambda_j y_j \geq y_0; \qquad \rho, \lambda_j \geq 0, \qquad j \neq 0; \tag{5}$$

With this linear programming, no plug-ins are needed when Super Efficiency is used for the CCR model, but when BCC is used for model, $\sum_{\substack{j=1 \\ j\neq 0}}^{n} \lambda_j = 1$ is added to the model.

Here, x_0 and y_0 represent DMU_0. The model was created for the firm "j", which is the linear programmatic-input-oriented fixed-scale return DEA expressed by the above formula. In order to calculate the Super Efficiency scores of the "j" company, the data of the "j" DMU is extracted from the X (N*I) and Y (M*I) matrices. As a result, the matrices take the form of *Nx (I-1)* and *Mx* (*I-1*). In this case, when linear programming is run, it cannot be part of the *j*-th firm's reference boundary and, therefore, if it is a DMU that is at full efficiency limit in the original standard DEA model, now its efficiency score is expected to be more than one. This linear programming is calculated for each firm in the sample, and each linear programming contains a reference set of (*I-1*) DMU (Coelli et al., 1998).

DETERMINATION OF DECISION UNITS AND VARIABLES

In order to meet the minimum conditions of the analysis and to reach a clear conclusion, all banks operating in the Republic of Azerbaijan were included in the analysis and accepted as a Decision-Making Unit (DMU). The input and output data used in this study was collected on the basis of the banks' year-end independent audit reports. In the analysis, efficiency scores of DMUs were calculated without making any distinction between banks. In the study, input-oriented Data Envelopment

Analysis (DEA) was conducted for 25 banks in Azerbaijan using data from 2015–2019. One of the main objectives of this study is to analyse the banks operating in Azerbaijan as a whole. With this approach, in order to include all banks in the analysis, data from some banks after 2019 could not be accessed. In other words, the lack of post-2019 data from some banks constitutes a limitation in this analysis.

The input-oriented analysis method is to calculate how much the inputs are minimised to produce the current outputs of DMUs. Fixed-return-to-scale Charnes, Cooper and Rhodes (CCR) and variable-return-to-scale Banker, Charnes and Cooper (BCC) models were used in the analysis, and as a result of these models, the Super Efficiency scores of the efficient banks were obtained. The names of the banks included in the study are shown in the table.

Table 1. List of banks included in the analysis

No.	Bank Names	No.	Bank Names	No.	Bank Names
1	Capital Bank	10	Pasha Bank	19	Bank of Baku
2	AccessBank	11	Premium Bank	20	Bank Respublika
3	AFB Bank	12	Bank Melli Iran	21	Bank VTB
4	Azer-Turk Bank	13	TuranBank	22	RabiteBank
5	Bank BTB	14	UniBank	23	Azerbaycan Industry Bank
6	ExpressBank	15	Xalq Bank	24	International Bank
7	Bank Avrasiya	16	Yapi Kredi Bank	25	National Bank of Pakistan
8	Gunay Bank	17	Yelo Bank		
9	MughanBank	18	Ziraat Bank		

Source: own study.

Due to the lack of data on personnel expenditures and general and disciplinary expenditures, which are among the input variables of Rabitabank for 2015 and 2016, these were not included in the analyses for those years.

Table 2. Input and output variables

Input				Output		
Interest Expenditures	Personnel Expenditures	General and Retained Expenditures	Deposits	Loans	Interest Income	Non-Interest Income Income

Source: own study.

As in most of the empirical literature, the input and output variables shown in Table 2 were used to analyse the efficiency of banks operating in the Azerbaijani banking sector. In the study, four inputs (interest expenditures, personnel expenditures, general and private expenditures and deposits) and three outputs (loans, interest income and non-interest income) were used for efficiency analysis.

All the data included in the analysis is given on the basis of the Azerbaijani national currency (manat) and analysed with the DEA-Solver program.

RESEARCH FINDINGS

CCR MODEL

Efficiency scores and averages for 24 banks in 2015–2016 and 25 banks in other years with a fixed return CCR model of input-oriented DEA to scale are shown in Table 3. The ranking is based on the annual performance averages of the banks.

Table 3 shows that three banks: Gunay Bank, Bank VTB and Bank Melli Iran were fully efficient, and except for 2015, AFB Bank, Halk Bank and Bank Eurasia, and except for 2016, National Bank of Pakistan achieved a fully efficient score between 2015–2019. The efficiency score of most of the banks included in the analysis was above 50%. The banks with an efficiency rate of less than 50% in 2015 were Bank Respublika (46%), Yapı Kredi Bank (45%) and Azer-Turk Bank (33%). According to Table 3, the number of fully efficient banks increased from seven banks to 18 banks in 2019 compared to 2015; that is, seven banks in 2015, nine banks in 2016, 12 banks in 2017, 13 banks in 2018 and 16 banks in 2019 were efficient.

The banks that got the closest to the full efficiency score in 2015 were Premium Bank (0.93), AccessBank (0.92) in 2016, Unibank and Muğanbank (0.96) in 2017, TuranBank (0.95) in 2018 and Unibank (0,98). The efficiency score average of the 25 banks included in the analysis between 2015 and 2019 is shown in Figure 1.

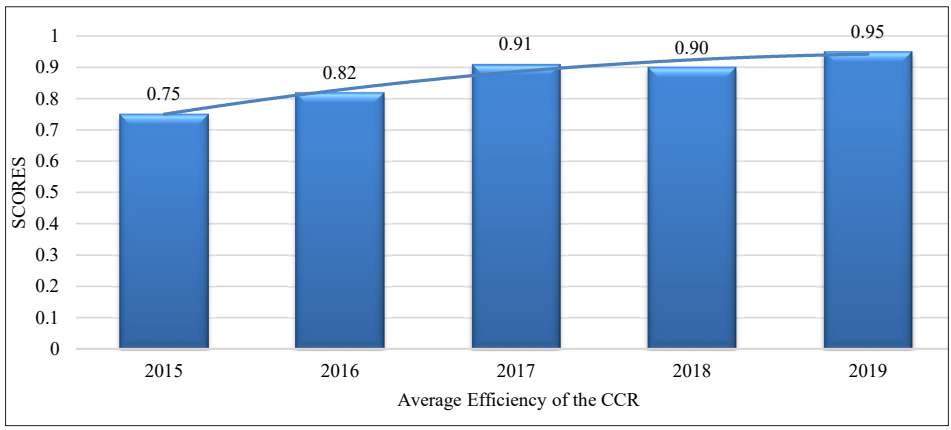

Figure 1. Average efficiency of the CCR model of banks by year (%)

Source: own study.

Table 3. CCR Efficiency Scores between 2015–2019

Bank Names	2015	2016	2017	2018	2019	Average	Bank Names	2015	2016	2017	2018	2019	Average
Gunay Bank	1	1	1	1	1	**1**	MughanBank	0.74	0.83	0.96	0.92	0.89	**0.87**
Bank VTB	1	1	1	1	1	**1**	Ziraat Bank	0.80	0.84	0.80	0.89	1	**0.87**
Bank Melli Iran	1	1	1	1	1	**1**	Uluslarası Bank	0.57	0.76	1	1	1	**0.87**
Bank Avrasiya	0.85	1	1	1	1	**0.97**	Yapi Kredi Bank	0.45	0.61	1	1	1	**0.81**
Bank of Baku	1	1	0.83	0.88	1	**0.94**	Expressbank	0.77	0.89	0.81	0.71	0.88	**0.81**
Premium Bank	0.93	0.76	1	1	1	**0.94**	TuranBank	0.50	0.69	0.90	0.95	1	**0.81**
AFB Bank	0.67	1	1	1	1	**0.93**	Kapital Bank	0.51	0.60	0.92	1	1	**0.81**
AccessBank	1	0.92	1	0.91	0.77	**0.92**	Pasha Bank	0.72	0.75	0.88	0.83	0.78	**0.79**
National Bank of Pakistan	1	0.59	1	1	1	**0.92**	Rabitebank	-	-	0.82	0.71	0.73	**0.75**
Xalq Bank	0.57	1	1	1	1	**0.91**	Bank BTB	0.64	0.54	0.75	0.88	0.84	**0.73**
Yelo Bank	0.67	1	1	1	0.86	**0.91**	Bank Respublika	0.46	0.51	0.74	0.63	1	**0.67**
Azerbaycan Industry Bank	1	0.57	0.81	1	1	**0.88**	Azer-Turk Bank	0.33	0.76	0.66	0.56	0.95	**0.65**
Unibank	0.78	1	0.96	0.65	0.98	**0.87**	Average score	**0.75**	**0.82**	**0.91**	**0.90**	**0.95**	

Source: own study.

Between 2015 and 2019, a linear progression in the average efficiency scores of banks was observed. The efficiency score increased from 75% in 2015 to 95% in 2019, reflecting a 27% improvement in average efficiency over this period. This trend suggests a significant enhancement in operational efficiency among banks in Azerbaijan, indicating progressive optimisation of their performance.

BCC Model

For 24 banks in 2015–2016 and 25 banks in other years, the variable return BCC model of input-oriented DEA is used to scale the efficiency score, and the averages are shown in Table 4. The ranking is based on the annual performance average of the banks.

Table 4. BCC Efficiency Score between 2015–2019

Banks Names	2015		2016		2017		2018		2019		Average
	Score	Scale	Score	Scale	Score	Scale	Score	Scale	Score	Scale	
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
AccessBank	1	C	1	D	1	C	1	D	1	D	1
AFB Bank	1	D	1	C	1	C	1	C	1	C	1
International Bank	1	D	1	D	1	C	1	C	1	C	1
Bank Melli Iran	1	C	1	C	1	C	1	C	1	C	1
Bank Avrasiya	1	D	1	C	1	C	1	C	1	C	1
Bank VTB	1	C	1	C	1	C	1	C	1	C	1
Gunay Bank	1	C	1	C	1	C	1	C	1	C	1
National Bank of Pakistan	1	I	1	I	1	C	1	C	1	C	1
Pasha Bank	1	D	1	D	1	D	1	D	1	D	1
Premium Bank	1	D	1	D	1	C	1	C	1	C	1
Unibank	1	D	1	C	1	D	1	D	1	D	1
Xalq Bank	1	D	1	C	1	C	1	C	1	C	1
Expressbank	1	D	1	D	1	D	0.93	D	1	D	0.99
Yelo Bank	0.97	D	1	C	1	C	1	C	0.92	D	0.98
Kapital Bank	0.76	D	1	D	1	D	1	C	1	C	0.95
Mughanbank	0.85	D	0.89	D	1	D	1	D	1	D	0.95
Bank of Baku	1	C	1	C	0.83	D	0.90	C	1	C	0.95
Ziraat Bank	1	D	0.87	D	0.81	I	0.92	I	1	C	0.92

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Industry Bank	1	C	0.65	C	0.86	I	1	C	1	C	0.90
TuranBank	0.72	D	0.85	D	0.93	D	1	D	1	C	0.90
Yapı Kredi Bank	0.63	D	0.74	D	1	C	1	C	1	C	0.87
Rabitebank	-	-	-	-	0.86	I	0.72	I	0.76	D	0.78
Bank BTB	0.72	D	0.57	D	0.75	I	0.89	D	0.91	D	0.77
Bank Respublika	0.65	D	0.59	D	0.74	I	0.77	D	1	C	0.75
Azer-Turk Bank	0.57	D	0.85	D	0.66	I	0.57	D	0.95	I	0.72
Average efficiency	0.91		0.92		0.94		0.95		0.98		

"C" – Constant Return to Scale Feature; "I" – Increasing Return to Scale Feature; "D" – Increasing Return to Scale Feature

Source: own study.

In Table 4, according to the results of the analysis made with the variable return to scale BCC model, 12 banks: National Bank of Pakistan, International Bank, Bank VTB, Xalq Bank, Bank Melli Iran, Premium Bank, Paşa Bank, Gunay Bank, Bank Avrasiya, AFB Bank, AccessBank and Unibank were seen to be efficient between 2015–2019. Eight banks: Expressbank, Yelo Bank, Kapital Bank, Muğanbank, Bank of Baku, Ziraat Bank, Azerbaycan Industry Bank and TuranBank had efficiency scores between 90% and 99%, Yapı Kredi Bank Azerbaijan 87%, while the other six banks received efficiency scores between 72% and 78%. Express Bank (except 2018) and Kapital Bank (except 2015) were efficient in other years. Yelo Bank, Muğanbank, Bank of Baku, Azerbaijan Industry Bank and Yapı Kredi Bank were efficient in three different years. According to Table 4, in 2019, compared to 2015, the number of efficient banks increased from 16 to 20. The efficiency scores of all banks included in the analysis achieved above 50%. The four banks with the lowest average scores were Rabitabank (78%), Bank BTB (77%), Bank Respublika (75%) and Azer-Turk Bank (72%).

The efficiency analysis shows that Azer-Turk Bank (2015, 2017 and 2018), the Bank BTB (2016) and Rabitabank (2019) received the lowest efficiency scores. As a result of the analysis conducted with the CCR and BCC method in Table 4, the characteristics of banks' returns to scale are also presented. The number of banks with constant returns to scale and without scale inefficiency was six banks in 2015, 10 banks in 2016, 12 banks in 2017, 14 banks in 2018 (Bank of Baku) and 16 banks in 2019. In both CCR and BCC analyses, it can be said that most of the banks with constant returns to scale are efficient and there is no need to change the

input and output variables. In the analysis performed by the Industry Bank in 2016 and the Bank of Baku in 2018 with the CCR and BCC method, it was determined that although they were not efficient, their scales did not change. The number of banks with increasing returns to scale was one in 2015, 2016 and 2019, six in 2017 and two in 2018. The banks with increasing returns to scale show that they produce less output while they should produce more output with current inputs. As the cause of this situation, the economic structure of the country, political decisions taken, the country being at war, as well as the geographical situation and climate, can be shown as external factors. In the analysis conducted with the CCR method, it is seen that most of the inefficient banks in all years have the feature of decreasing returns to scale. The average efficiency score of 25 banks included in the analysis between 2015 and 2019 is shown in Figure 2.

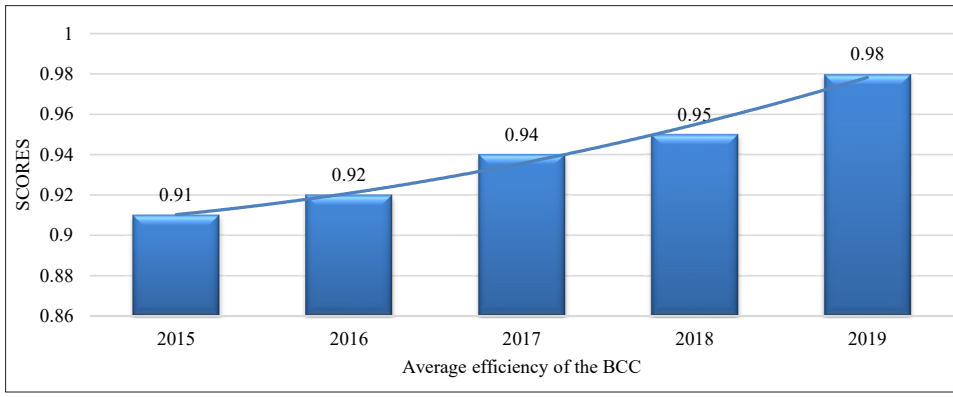

Figure 2. Average efficiency of the BCC model of banks by year (%)

Source: own study.

According to Figure 2, between 2015 and 2019, there was a linear increase in the average efficiency scores of banks. Specifically, the average efficiency score rose from 91% in 2015 to 98% in 2019. This represents an approximate 8% improvement in average efficiency over this period. These results indicate that banks operating in Azerbaijan are progressively enhancing their performance and operating with greater efficiency.

CCR Super Efficiency

In the efficiency analysis conducted with the CCR method, in order to determine which of the efficient banks is the most efficient, the results of the Super Efficiency analysis are presented in Table 5 below by year.

Table 5. Super Efficiency Analysis Predictions (CCR)

N	2015		2016		2017		2018		2019	
	Bank Names	Score	Bank Names	Score	Bank Names	Score	Bank Names	Score	Bank Names	Score
1	Industry Bank	227.89	Bank Melli Iran	11.70	National Bank of Pakistan	17.64	National Bank of Pakistan	21.01	National Bank of Pakistan	96.25
2	Bank Melli Iran	11.82	Unibank	4.63	International Bank	3.59	Bank VTB	2.31	Premium Bank	2.64
3	Gunay Bank	4.68	Gunay Bank	3.70	Bank VTB	3.30	Premium Bank	2.05	Xalq Bank	2.13
4	National Bank of Pakistan	1.53	Bank VTB	2.03	Premium Bank	2.09	Gunay Bank	1.96	Bank VTB	2.05
5	Bank VTB	1.13	AFB Bank	1.40	AFB Bank	1.87	Xalq Bank	1.95	Industry Bank	1.78
6	AccessBank	1.08	Bank of Baku	1.40	Bank Melli Iran	1.76	Bank Melli Iran	1.58	Bank Melli Iran	1.73
7	Bank of Baku	1.02	Yelo Bank	1.37	Xalq Bank	1.76	Industry Bank	1.54	AFB Bank	1.34
8			Bank Avrasiya	1.07	Gunay Bank	1.70	AFB Bank	1.50	Bank Avrasiya	1.31
9			Xalq Bank	1.01	Bank Avrasiya	1.36	Yelo Bank	1.27	International Bank	1.27
10					Yelo Bank	1.19	International Bank	1.26	Gunay Bank	1.21
11					Yapi Kredi Bank	1.12	Bank Avrasiya	1.18	Bank of Baku	1.13
12					AccessBank	1.04	Kapital Bank	1.16	Kapital Bank	1.12
13							Yapi Kredi Bank	1.05	Yapi Kredi Bank	1.11
14									Bank Respublika	1.06
15									Ziraat Bank	1.03
16									TuranBank	1.03

Source: own study.

Banks with the highest Super Efficiency scores obtained by the CCR method were Industry Bank in 2015 (227.89), Bank Melli Iran in 2016 (11.70) and National Bank of Pakistan in 2017–2019 (17.64, 21.01, 96.25). Banks with the least Super Efficiency scores by years were Bank of Baku (1.02), Halk Bank (1.01), AccessBank (1.04), Yapi Kredi Bank (1.05), Ziraat Bank (1.03) and TuranBank (1.03), respectively.

BCC Super Efficiency

The results of the Super Efficiency analysis conducted to determine which of the banks that are efficient in the efficiency analysis conducted with the BCC method is more efficient are presented in Table 6.

In Table 6, according to the results of the Super Efficiency analysis conducted using the variable return to scale BCC method, Bank Melli Iran achieved the highest scores (16.29 and 33.76) in 2015 and 2016, and the National Bank of Pakistan achieved scores of 27.00, 56.00 and 100.99 in 2017–2019. International Bank in all years, Industry Bank in 2015, Kapital Bank in 2018 and Pasha Bank in 2019 received the lowest Super Efficiency score (1.00). Furthermore, five banks in 2015 and 2018, nine banks in 2016, seven banks in 2017 and six banks in 2019 obtained a score of 2 or more.

The banks that were a reference for those that are not efficient in the input-oriented, constant returns efficiency analyses conducted for the years 2015–2019 of banks operating in Azerbaijan are presented in Table 7.

Table 7 illustrates that Bank Melli Iran, Bank VTB and Gunay Bank during the period were fully efficient and were shown as references for the inefficient banks. Although National Bank of Pakistan in 2015, Access Bank in 2017 and in 2018, AFB Bank, Bank Respublika, Premium Bank, TuranBank & Ziraat Bank in 2019 were efficient, these banks have not been referenced.

According to Table 7, Bank Avrasiya, Bank VTB, Gunay Bank and Xalq Bank were efficient during the years and are shown as a reference to the inefficient banks. Although AccessBank, Bank Melli Iran and Industry Bank in 2018 and 2019, AFB Bank and Ziraat Bank in 2015 and 2019, Bank Respublika in 2019, Expressbank and Muğanbank in 2017 and 2019, Kapital Bank in 2016 and 2017, Pash Bank in 2016–2019, Premium Bank, Turan Bank and Yapı Kredi Bank in 2018, International Bank in 2016, 2018 and 2019, and Unibank in 2017 were efficient, these banks have not been referenced.

As a result of the input-oriented analyses conducted with both CCR and BCC methods, it is observed that inefficient banks use existing outputs and input variables more efficiently than reference banks. It can be said that in order for inefficient banks to become efficient, they should use each variable efficiently and the variables should be reduced at approximately the same rate.

Table 6. Super Efficiency Analysis Predictions (BCC)

No.	2015		2016		2017		2018		2019	
	Bank Names	Score	Bank Names	Score	Bank Names	Score	Bank Names	Score	Bank Names	Score
1	Bank Melli Iran	16.29	Bank Melli Iran	33.76	National Bank of Pakistan	27.00	National Bank of Pakistan	56.00	National Bank of Pakistan	100.99
2	National Bank of Pakistan	7.46	Unibank	15.16	Bank Melli Iran	7.22	Premium Bank	3.11	Premium Bank	5.18
3	Gunay Bank	5.81	Gunay Bank	4.30	Bank VTB	3.34	Bank VTB	2.74	Bank VTB	2.56
4	AccessBank	2.50	National Bank of Pakistan	3.54	Xalq Bank	2.71	Xalq Bank	2.02	Xalq Bank	2.52
5	Xalq Bank	1.71	Bank VTB	2.64	Pasha Bank	2.56	Gunay Bank	1.97	Bank Melli Iran	2.00
6	Bank VTB	1.62	Bank of Baku	2.44	Premium Bank	2.09	Yelo Bank	1.93	Industry Bank	1.80
7	Premium Bank	1.61	Xalq Bank	2.25	AFB Bank	1.95	Bank Melli Iran	1.89	Bank Respublika	1.77
8	Pasha Bank	1.53	AFB Bank	2.20	Yelo Bank	1.77	AFB Bank	1.74	Kapital Bank	1.60
9	Bank of Baku	1.42	AccessBank	1.86	Gunay Bank	1.71	Industry bank	1.58	Gunay Bank	1.42
10	Expressbank	1.29	Yelo Bank	1.62	AccessBank	1.56	AccessBank	1.41	Expressbank	1.42
11	AFB Bank	1.11	Premium Bank	1.50	Bank Avrasiya	1.37	Pasha Bank	1.40	Unibank	1.38
12	Ziraat Bank	1.07	Pasha Bank	1.45	Yapi Kredi Bank	1.35	Bank Avrasiya	1.25	AFB Bank	1.35
13	Bank Avrasiya	1.06	Expressbank	1.16	Unibank	1.19	Muganbank	1.23	Bank Avrasiya	1.32
14	Industry Bank	1	Kapital Bank	1.13	Kapital Bank	1.16	Yapi Kredi Bank	1.15	AccessBank	1.30
15	International Bank	1	Bank Avrasiya	1.12	Expressbank	1.12	Unibank	1.11	Yapi Kredi Bank	1.29
16			International Bank	1	Muganbank	1.05	TuranBank	1.01	Muganbank	1.24
17					International Bank	1	Kapital Bank	1	Bank of Baku	1.15
18							International Bank	1	TuranBank	1.14
19									Ziraat Bank	1.07
20									Paşha Bank	1
21									International Bank	1

Source: own study.

Table 7. Reference Numbers of Efficient Banks (CCR and BCC)

Bank Names	CCR					BCC				
	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019
AccessBank	3	-	0	0	-	2	1	1	0	0
AFB Bank	-	6	4	3	0	0	5	3	2	0
Bank Melli Iran	1	-	-	-	1	2	5	2	0	0
Bank of Baku	-	-	5	-	1	7	6	-	-	4
Bank Respublika	16	12	8	2	3	-	-	-	-	0
Bank Avrasiya	5	7	-	-	6	1	1	6	3	3
Bank VTB	-	-	-	-	0	3	3	2	3	2
Expressbank	-	5	9	5	6	4	3	0	-	0
Gunay Bank	6	5	4	5	1	5	3	7	7	2
Halk Bank	17	12	11	11	3	4	7	3	3	2
Kapital Bank	-	-	-	3	3	-	0	0	2	2
Muğanbank	0	-	3	3	6	-	-	0	1	0
National Bank of Pakistan	-	-	2	2	0	0	0	1	3	1
Pasha Bank	-	-	-	-	0	3	0	0	0	0
Premium Bank	-	4	-	-	-	5	0	5	3	2
Industry Bank	-	2	4	5	4	5	-	-	0	0
TuranBank	-	-	-	-	1	-	-	-	0	1
International Bank	-	2	2	5	-	4	0	3	0	0
Unibank	-	-	-	-	0	-	0	1	1	3
Yapı Kredi Bank						-	-	2	0	1
Yelo Bank						-	2	2	5	-
Ziraat Bank						0	-	-	-	0

"-" banks that are not efficient in the current year.

Source: own study.

CONCLUSION

The importance of the banking sector is increasing day by day in the globalising world. In this study, the comparison of selected decision-making units with the CCR, BCC and Super Efficiency model measurements of input-oriented DEA for the period 2015–2019 was analysed. In the input-oriented DEA model, the aim is to minimise the level of inputs in order to produce the available outputs. In the selection of decision-making units, inputs and outputs that meet the

minimum conditions for the analysis were investigated, and all 25 banks operating in Azerbaijan were selected as decision-making units. To analyse the efficiency of banks, 24 banks in 2015–2016 and 25 banks in 2017–2019 were included in the study. In other words, Rabitabank was not included in the analysis in 2015 and 2016. The limitation of the study is the unavailability of Rabitabank's data for the years 2015–2016 from the Statistical Institute of the Republic of Azerbaijan and the annual reports of the bank. The study uses four variables as inputs – interest expenditures, personnel expenditures, general/special expenditures and deposits – and three variables as outputs – loans, interest income and non-interest income in thousands (manat). Super Efficiency analyses were conducted to determine which year was more efficient in CCR and BCC models, and improvement suggestions were developed for inefficient years.

According to the analysis results of the input-oriented CCR and BCC models, Azerbaijan's banking system exhibited expected improvements from 2015 to 2019. This enhancement is likely due to amendments made by the Central Bank of Azerbaijan to the banking regulations, which aimed to promote bank development. Furthermore, the analysis of input-oriented CCR and BCC Super Efficiency models indicates that the efficiency scores of banks in Azerbaijan increased from 2005 to 2019. These findings suggest that the development of banks in Azerbaijan was positively influenced by the reforms implemented by the Central Bank of Azerbaijan.

According to the results of the four model analyses, the average efficiency scores of banks increased from 2015 to 2019, indicating that banks are operating more efficiently. As a result of the analysis, it is recommended that inefficient banks learn the transaction systems of efficient banks and adjust the inputs and outputs of their banks in accordance with their capacities.

Bibliography

Balci, E., Ayvaz, B. (2020). Efficiency and productivity analysis in Turkish banking sector with Data Envelopment Analysis and Malmquist index. *Southeast Europe Journal of Soft Computing, 9*(1), 9–23. DOI: 10.21533/scjournal.v9i1.185.

Banker, R.D., Charnes, A., Cooper, W.W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science*, *30*(9), 1078–1092. DOI: 10.1287/mnsc.30.9.1078.

Benston, G.J. (1965). Branch Banking and Economies of Scale. *Journal of Finance, 20*(2), 312–331. DOI: 10.1111/j.1540-6261.1965.tb00212.x.

Berger, A., Humphrey, D. (1997). Efficiency of Financial Institutions: International Survey and Directions for Future Research. *European Journal of Operational Research, 98*(2), 175–212. DOI: 10.1016/S0377-2217(96)00342-6.

Beridze, J., Anbar, A. (2019). Efficiency Analysis in Georgian Banking Sector: An Application of Data Envelopment Analysis. *Business & Management Studies: An International Journal*, *7*(2), 1076–1096. DOI: 10.15295/bmij.v7i2.1127.

Charnes, A., Cooper, W.W., Rhodes, E. (1978). Measuring the Efficiency of Decision Making Units. *European Journal of Operation Research*, *2*, 429–444. DOI: 10.1016/0377-2217(78)90138-8.

Coelli, T., Prasada, D.S., Battese, G.E. (1998). *An introduction to efficiency and productivity analysis*. Boston: Kluwer Academic Publisher. DOI: 10.1007/b136381.

Cooper, W.W., Lawrence, W., Seiford, M., Zhu, J. (2011). *Handbook on Data Envelopment Analysis. Second Edition*. London: Springer New York Dordrecht Heidelberg.

Cooper, W.W., Seiford, L.M., Tone. K. (2007). *Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software*. Boston: Kluwer Academic Publishers. DOI: 10.1007/978-0-387-45283-8.

Čiković, K.F., Keček, D., Cvetkoska, V. (2023). The Impact of COVID-19 on Bank Efficiency in the Western Balkans: A DEA Approach. *Naše gospodarstvo/Our Economy, Sciendo, 69*(1), 29–42. DOI: 10.2478/ngoe-2023-0004.

Drake, L., Hall, M.J.B., Simper, R. (2009). Bank Modelling Methodologies: A Comparative Non-parametric Analysis of Efficiency in the Japanese Banking Sector. *Journal of International Financial Markets, Institutions and Money, 19*(1), 1–15. DOI: 10.1016/j.intfin.2007.05.002.

Dutta, P., Jain, A., Gupta, A. (2020). Performance analysis of non-banking finance companies using two-stage data envelopment analysis. *Annals of Operations Research, 295*, 91–116, DOI: 10.1007/s10479-020-03705-6.

Hammami, H., Ngo, T., Tripe, D., Vo, D.T. (2022). Ranking with a Euclidean common set of weights in data envelopment analysis: with application to the Eurozone banking sector. *Annals of Operations Research, 311*, 675–694. DOI: 10.1007/s10479-020-03759-6.

Hjalmarsson, L., Andersson, I., Mlima, A. (2000). *Swedish Banking Efficiency and Productivity in an International Perspective*, Estocolmo: Supplement Number 28 to the Government Inquiry on the International Competitiveness of the Swedish Financial Sector.

Humphrey, D.B. (1985). Costs and scale economies in bank intermediation. In: R.C. Aspinwall, R.A. Eisenbeis (eds.), *Handbook for Banking Strategy* (pp. 745–783). New York: John Wiley and Sons.

Kumar, S., Gulati, R. (2008). An examination of technical, pure technical, and scale efficiencies in Indian Public Sector Banks using data envelopment analysis. *Eurasian Journal of Business and Economics, 1*(2), 33–69.

Kutlar, A., Babacan, A. (2008). A Comparison of the Effectivity of Cumhuriyet University with State Universities: An Application of DEA Technique. *KOSBED*, *15*, 148–172.

Kutlar, A., Salamov, F. (2016). Evaluation of Effectiveness of Azerbaijan Public Hospitals with Data Envelopment Analysis. *KOSBED*, *31*, 1–17.

Küçükaksoy, I., Selcan, O. (2013). Türk bankacılık sektöründe faaliyet gösteren bankaların etkinliklerinin veri zarflama analizi yöntemi ile ölçülmesi: 2004–2011 yılları uygulaması. *Ekonometri & İstatistik e-Publisher*, *18*, 56–80.

Li, F., Wu, L., Zhu, Q., Yu, Y., Kou, G., Liao, Y. (2020). An Eco-inefficiency dominance probability approach for Chinese banking operations based on data envelopment analysis, *Complexity in Economics and Business*, *3780232*, 1-14. DOI: 10.1155/2020/3780232.

Sealey, C.W. Jr., Lindley, J.T. (1977). Inputs, Outputs, and a Theory of Production and Cost at Depository Financial Institutions. *Journal of Finance, 32*(4), 1251–1266.

Seiford, L.M., Thrall, R.M. (1990). Recent Developments in DEA: The Mathematical Programming Appoach to Frontier Analysis. *Journal of Econometrics*, *46*(1–2), 7–38. DOI: 10.1016/0304-4076(90)90045-U.

Torun, N. (2020). *Sağlık Hizmetlerinde etkinlik* ölçümü. Ankara: Gazi.

Tsionas, M.G. (2020). A coherent approach to Bayesian data envelopment analysis. *European Journal of Operational Research, 281*(2), 439–448, DOI: 10.1016/j.ejor.2019.08.039.

Yagubov, S., Yagubov, U. (2020). The efficiency of Azerbaijani banks: an empiric analysis. In: *55th International Scientific Conference on Economic and Social Development, 3*, Jun 18/Jun 19, 2020, Baku/Azerbaijan, pp. (581–587). Varazdin: Book of Proceedings.

Yeşilyurt, Ö., Salamov, F. (2017). Evaluation of Efficiency and Factors influencing the Efficiency in the Health Systems of Turkic States with Super-efficiency and Tobit Models. *Balkan and Near Eastern Journal of Social Sciences*, *3*(2), 128–138.

Yuksel, S., Mukhtarov, S., Mammadov, E. (2016). Comparing the efficiency of Turkish and Azerbaijani banks: An application with data envelopment analysis. *International Journal of Economics and Financial Issues, 6*(3), 1059–1067.

Summary

The primary objective of this research was to assess the efficiency of banks within the Azerbaijani banking system, identifying and comparing both efficient and inefficient banks. To this end, the efficiency of 25 banks operating in Azerbaijan from 2015 to 2019 was analysed using input-oriented CCR, BCC and Super Efficiency models. The results provide insights into the efficiency levels of the banks and highlight the distinctions between efficient and inefficient institutions. Furthermore, recommendations for improving inefficient banks were developed, with the expectation that these suggestions could enhance the effective use of resources within the banking system. The study estimates a significant increase in banking system efficiency over the years, and this improvement is believed to reflect the positive impact of reform and enhancement efforts.

Keywords: DEA, BCC model, CCR model, super efficiency, Azerbaijan banking system.

Badanie efektywności systemu bankowego Azerbejdżanu za pomocą analizy DEA (2015–2019)

Streszczenie

Głównym celem niniejszego badania jest ocena efektywności banków w systemie bankowym Azerbejdżanu, zidentyfikowanie i porównanie banków efektywnych i nieefektywnych. W tym celu, efektywność 25 banków działających w Azerbejdżanie w latach 2015–2019 została przeanalizowana

przy użyciu modeli CCR, BCC oraz modelu Super Efektywności opartego na danych wejściowych. Wyniki analizy dostarczyły informacji na temat poziomów efektywności banków i uwypukliły różnice między bankami efektywnymi a nieefektywnymi. Ponadto, opracowano rekomendacje mające na celu poprawę efektywności banków nieefektywnych, z nadzieją, że sugestie te przyczynią się do bardziej efektywnego wykorzystania zasobów w systemie bankowym. Badanie szacuje, że w ciągu lat efektywność systemu bankowego znacznie wzrosła, a ten wzrost uważa się za odzwierciedlenie pozytywnego wpływu reform i działań usprawniających.

Słowa kluczowe: DEA, model BCC, model CCR, super efektywność, system bankowy Azerbejdżanu.

JEL: D61, D70, E42, E50, G24.