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RESEARCH ARTICLE

Measuring the Efficiency of Banking Services for Saudi Arabia Kingdom Banks Using Data Envelopment Analysis (DEA) During the Period (2017-2022)

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ABSTRACT

Data Envelopment Analysis (DEA) was applied under the assumption of Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS) to measure both technical efficiency and scale efficiency of Saudi banking services during the periods (2017-2019) and (2020-2022). Variables used include shareholders' equity and deposits (as inputs), and loans and total assets (as outputs). It was found that the National Commercial Bank, Alinma Bank, Saudi Investment Bank, and Bank Albilad achieved full relative efficiency scores. Al-Rajhi Bank, Riyadh Bank and Al-Jazira Bank achieved technical efficiency as they achieved score one, but they were not scale-efficient. Meanwhile, the Saudi Fransi Bank, the Saudi British Bank (SABB), and the Arab National Bank were neither technically nor scale efficient during the period (2017-2019). In the period (2020-2022), Riyadh Bank, the Saudi Fransi Bank, the Arab National Bank, the Saudi Investment Bank, and Bank Albilad achieved full relative efficiency scores. The National Commercial Bank, Al-Rajhi Bank and Al-Jazira Bank achieved technical efficiency with the score one but were not scale-efficient. Meanwhile, the Saudi British Bank (SABB) and Alinma Bank were neither technically nor scale efficient. A comparison of the averages shows that efficiency during the period (2020-2022) is lower compared to the period (2017-2019), despite five banks achieved full efficiency in the second period compared to four banks in the first period. It is also noteworthy that the Saudi Investment Bank and Bank Albilad achieved full efficiency in both periods, unlike the other banks.The Saudi Fransi Bank could have achieved full efficiency by reducing its outputs by 0.57% and increasing its shareholders' equity by 3.81%;whereas SABB could have achieved full efficiency by reducing its outputs by 4.29% and increasing shareholders' equity by 24.95%;the Arab National Bank could have achieved full efficiency by reducing its loan volume by 1.95% and total assets by 8.67% for the period (2017-2019). During the period (2020-2022), SABB could have achieved full efficiency by reducing its outputs by 7.19% and increasing shareholders' equity by 14.83%; where as the Arab National Bank could have achieved efficiency by reducing its outputs by 9.27%; and finally, Alinma Bank could have achieved full efficiency by reducing its loan volume by 0.54% and total assets by 6.27%, During the Period (2020-2022).

INTRODUCTION

With the spread of globalization and financial competitiveness, along with the increasing technological advancement in information and communication, the global financial sectors have expanded, introducing new financial tools with rapid and easy execution of financial transactions.

This has affected the banking sector, increased the financial capabilities and activities of banks, which impacted the national economies.

The banking sector is a vital part of national economies for the services it provides, such as financing and financial intermediation. This sector enables the mobilization and utilization of financial surpluses, which, if efficiently managed, leads to increased investments and gross domestic product (GDP). Thus, the importance of measuring the efficiency of banking services and resource allocation has become apparent, as it reflects the banks' ability to sustain and compete. Consequently, Saudi Arabian banks must adapt to the global banking system to achieve the desired efficiency (Jaadi, 2014).

Efficiency represents the optimal use of available resources, either by maximizing output using available resources or achieving a specific output level with the minimum possible inputs. In this context, the banking efficiency of banks could be realized if they can direct their resources to maximize returns by providing diverse banking services. Therefore, this research will focus on measuring the efficiency of banking services in Saudi Arabian banks. Data Envelopment Analysis (DEA) is a mathematical technique that relies on linear programming to measure efficiency among similar units, determining the efficient units that can serve as a reference for the inefficient ones, assuming no measurement errors (Coelli, Rao, O'Donnell, Battese, 2005).

Research Problem

Globalization has led to competitive challenges in the banking sector. Due to the importance of banks in providing financing, they now require a high level of efficiency. This necessitates continuous measurement of banking service efficiency, which is a key method for evaluating the performance of financial institutions. Measuring efficiency is crucial for directing banks to correct inefficiencies. Thus, the research problem can be framed in the following primary question: *What is the level of efficiency of banking services provided by Saudi Arabian banks?* This leads to the following sub-questions: *What is the level of technical efficiency? What is the level of scale efficiency?* and: *Which banks have achieved high levels of efficiency in banking services, and which have not?*

Study Hypothesis

To answer the research problem, the main hypothesis can be formulated as: *There exists a variation between banks in achieving efficiency levels.*

Research Objective

In light of the research problem, the study aims to measure the efficiency of banking services for the most significant banks listed in the Saudi Arabian stock market, totaling 10 banks, during the period (2018-2022). The research applied Data Envelopment Analysis (DEA) to measure both technical and scale efficiency. The goal is to identify which banks have achieved full efficiency, and which have not, while also identifying the input surplus for the less efficient banks and the output deficiency for those banks.

RESEARCH METHODOLOGY

The research employed the quantitative analytical approach, using Data Envelopment Analysis (DEA) to measure the efficiency of banking services in the Saudi banking sector. For comparison purposes,the analysis relied on annual reports published by the study banks during the periods (2017-2019) and (2020-2022). DEA was applied using two models: **CCR model** (based on Constant Returns to Scale - CRS), and **BCC model** (based on Variable Returns to Scale - VRS). The two models were applied in an output-oriented manner (CCR-O, BCC-O), aiming to maximize outputs while maintaining current input levels, which aligns with the objectives and nature of banking activities. The software **DEAP**was used, as it is specialized in DEA analysis. Due to the complementary nature of the CCR and BCC models, the results of both models were integrated to serve the purpose of the current research.

Research Boundaries

Spatial Boundaries: Saudi Arabia Kingdom.

Temporal Boundaries: The research was applied to the Saudi stock market data for the period (2018-2022).

Variables and Research Sample

Since banks operate with multiple inputs and outputs, it is difficult to address all inputs and outputs in one study. Therefore, the study will focus on variables that reflect the core activities of the banks. The research variables include loans (Y_1) and total assets (Y_2) as outputs, and shareholders' equity (X_1) and deposits (X_2) as inputs. The research sample consists of 10 major banks operating in Saudi Arabia. According to (Debasish, 2006), the sample size must be at least twice the sum of the number of inputs and outputs, which in this case is 8, to ensure the DEA analysis has sufficient distinguishing power.

Chronological evolution of Saudi banks, definitions, model used and previous studies

- Chronological Evolution of Saudi Banks

<table>
<tr><th>Original Name</th><th>Transformed To</th><th>Then To</th><th>Then To</th><th>Then To</th><th>Currently</th></tr>
<tr><td>Currency exchange company owned by Kaaki and Bin Mahfouz</td><td colspan="3">The National Commercial Bank (NCB), the first Saudi commercial bank</td><td>The Saudi National Bank</td><td rowspan="6">The Saudi National Bank (founded in 1953)</td></tr>
<tr><td>Bank of Lebanon and Overseas (1375 AH/1955 AD)</td><td rowspan="3">Merged with the last three remaining foreign banks in 1982 to form: The United Saudi Commercial Bank</td><td rowspan="3">Merged in 1997 under the name: The United Saudi Bank</td><td rowspan="4">The Saudi American Bank, merged in July 1999</td><td rowspan="4">Samba Financial Group (name changed on January 4, 2004)</td></tr>
<tr><td>National Iranian Bank</td></tr>
<tr><td>United Bank</td></tr>
<tr><td>Bank of Cairo (1374 AH/1954 AD)</td><td>Cairo Saudi Bank</td></tr>
<tr><td>First National City Bank (1375 AH/1955 AD)</td><td>Citibank</td><td>Saudi American Bank (1980)</td></tr>
<tr><td>National Bank of Pakistan</td><td colspan="4">Bank Al-Jazira (founded on 12 Jumada Al-Thani 1395 AH/June 21, 1975)</td><td>Al-Jazira Bank (founded in 1975)</td></tr>
<tr><td>Dutch Commercial Company (1345 AH/1926 AD)</td><td>General Bank of Holland</td><td colspan="2">Saudi Dutch Bank (October 21, 1976, until November 27, 2016)</td><td>The First Bank (from November 27, 2016, until June 15, 2019)</td><td rowspan="2">Saudi British Bank (from June 16, 2019, founded in 1978)</td></tr>
<tr><td>Gellatly Hankey& Co. Limited</td><td>The British Bank of the Middle East (1949)</td><td colspan="2">Saudi British Bank</td><td>SABB</td></tr>
<tr><td>Banque de l'Indochine (Indochina)</td><td>Fransi Bank for Indochina (1367 AH / 1947 AD)</td><td colspan="3">Saudi Fransi Bank</td><td>Saudi Fransi Bank (founded in 1977)</td></tr>
<tr><td>Arab Bank Limited (1368 AH / 1949 AD)</td><td colspan="4">Arab National Bank</td><td>Arab National Bank (Founded in 1991)</td></tr>
<tr><td>Saudi Investment Banking Corporation (1396 AH / 1976 AD)</td><td colspan="4">Saudi Investment Bank</td><td>Saudi Investment Bank (Founded in 1977)</td></tr>
<tr><td colspan="5">Riyadh Bank (since 1376 AH / 1956 AD, the first Saudi joint-stock banking company)</td><td>Riyadh Bank (Founded in 1958)</td></tr>
</table>

<table>
<tr><td colspan="3">Alinma Bank</td><td>Alinma Bank (Founded in 2008)</td></tr>
<tr><td>Al Rajhi Exchange and Trade Company</td><td>Al Rajhi Banking and Investment Corporation</td><td>Al Rajhi Investment Bank (1987)</td><td>Al Rajhi Bank (Founded in 1957)</td></tr>
<tr><td rowspan="8">Merging the activities of eight exchange companies into one banking company</td><td colspan="2">Mohammad and Abd-Allah Ibrahim Al-Subeihi Exchange Company (42%)</td><td rowspan="8">Bank Albilad (Founded in 2004)</td></tr>
<tr><td colspan="2">Heirs of Abd El-Aziz bin Soleiman Al-Moqayrin (17%)</td></tr>
<tr><td colspan="2">Al Rajhi Trading Foundation (14%)</td></tr>
<tr><td colspan="2">Al Rajhi Commercial Exchange Foundation (13%)</td></tr>
<tr><td colspan="2">Mohammad Saleh Sirfi Foundation (5%)</td></tr>
<tr><td colspan="2">Yousef Abd El-Wahhab Ne'maht Allah Exchange Company (Injaz Exchange) (3%)</td></tr>
<tr><td colspan="2">Abd El-Mohsen Saleh Al-Omari Foundation (1%)</td></tr>
<tr><td colspan="2">Ali Hazaa & Partners Trading and Exchange Company (0.5%)</td></tr>
<tr><td colspan="3">Gulf International Bank</td><td>Gulf International Bank/Meem (GIB-SA)</td></tr>
</table>

Source:https://web.archive.org/web/20201018105325/https://alphabeta.argaam.com/article/detail/100531

- http://www.sama.gov.sa/en-US/BankingControl/Pages/LocalBanks.aspx

Definitions Related to the Research Subject

Efficiency: Refers to achieving maximum extent of objectives with inducing improvement and development as needed and based on future vision, using the least amount of resources (human, material, or financial) and reducing waste in production capacity without affecting production quality. Another definition focuses on the success of the relationship between resources used (inputs) and outputs, aiming to increase outputs while minimizing inputs (Othman, Mohd-Zamil, Rasid, Vakilbashi & Mokhber, 2016).

Economic Efficiency: Defined as the allocation of resources among various alternative uses in such a way that it is impossible to increase outputs by changing resource allocation. It can be achieved by getting the maximum output using a certain amount of resources, or achieving a specific output volume using the least amount of resources (Sharmaa, Rainab & Singhc, 2012).

Banking efficiency: A combination of technical and economic efficiency. A bank is considered highly efficient if it manages to direct its available economic and technical resources to achieve the highest possible returns with minimal material and human capabilities, achieving optimal size while providing more financial products (Rayece and Al-Zahra, 2012).

Technical Efficiency: Refers to the bank's ability to produce a certain level of outputs with the least amount of inputs. It includes two approaches: first, the bank's ability to maximize its outputs using fixed inputs, known as output-oriented technical efficiency (Output orientation). Second, the bank's ability to minimize inputs while producing the same level of outputs, known as input-oriented technical efficiency (Input orientation) (Farrell, 1957).

Size Efficiency: refers to the extent of change in outputs resulting from changes in inputs basedon the production stage in which the bank operates. If the bank operates in the stage of increasing return to scale, any increase in the percentage of inputs will lead to a larger percentage increase in outputs. If the increase in outputs is equal to the increase in inputs, the bank is operating in the stage of constant return to scale. However, if the increase in the percentage of inputs results in a smaller percentage of outputs, it means the bank is operating in the stage of diminishing return to scale (Cooper, Seiford, and Zhu, 2011, Cooper, and Tone, 2006).

Methods to Improve Efficiency

Constant output using less inputs: This means maintaining the final product's value while reducing the resources used, i.e., eliminating excess and unused input elements, which will not affect the achieved output.

More output using constant inputs: Increasing the final product value while keeping the value of the used resources constant.

More output using more inputs: Increasing the final product value with an increase in resources used at a lesser rate, provided that the increase in outputs is higher.

Less output using less inputs: Reducing the final product value while reducing the value of resources used at a higher rate, provided that the input reduction is greater.

More output with less inputs: Increasing the final product value while reducing the resources used. This is considered the best approach, as it achieves greater outputs with fewer inputs (Abd El-Qadir, 2011-2012), (Sharmaa, Rainab & Singhc, 2012).

Measuring the Banking Efficiency through Quantitative Methods

Quantitative methods used to measure banking efficiency can be divided into two types. The first relies on **non-parametric models**, such as **Data Envelopment Analysis (DEA)**, which assumes no random errors during measurement. The second approach is **parametric** and involves statistical estimation, including methods like **Thick Frontier Analysis (TFA)**, **Stochastic Cost Frontier Analysis (SFA)**, and **Distribution-Free Analysis (DFA)**. These methods are as follows:

Data Envelopment Analysis (DEA): This is a linear programming method based on **Frontier Methodology**, originally developed by Farrell in 1957. DEA has several advantages, such as identifying inefficiency levels, determining its sources, and ease of use (Farrell, 1957). This method uses cost data, outputs and input prices for a sample of banks to identify the bank that produces at the lowest cost (given a specific output level at certain input prices). This bank is considered the most efficient and forms the **Efficiency Frontier** that envelops other banks in the sample. Banks located on the frontier are efficient, while those outside are inefficient. This method is flexible and adaptable, and doesn't impose a specific cost function for the best bank (Mester, 1994).

Stochastic Cost Frontier Analysis (SFA): This method uses regression analysis to estimate a total cost function, where total costs are dependent variables,whereas other factors, such as output levels and input prices, are independent variables. The expected total cost forms the frontier representing the best practice. A bank is considered efficient if its current costs equal its expected costs. Conversely, a bank is inefficient if its current costs are higher than expected. The difference between current and expected costs is known as the **stochastic disturbance frontier**, which consists of two parts: inefficiency errors (distributed half-normally) and random regression errors (distributed normally) (Qureshi, 2005-2006), (Charnes, Cooper, Lewin, & Seiford, 1994).

Thick Frontier Analysis (TFA): This method divides the bank sample into four groups based on average cost (total cost/total assets). By estimating the total cost function for the sub-sample, the group or quartile with the lowest average cost represents what is called the "thick frontier". This frontier serves as the best practice for measuring banking efficiency in the other banks (Mester, 1994).

Distribution-Free Analysis (DFA): This method is applied when data is available for multiple years. It assumes that inefficiency remains stable over time, while random errors average out over the same period. Since the stochastic disturbance consists of two parts: inefficiency and random error, the average stochastic disturbance over several years serves as a measure of inefficiency across the entire period.

Model Used in the Research

The Data Envelopment Analysis (DEA) was introduced by Edwardo Rhodes in his 1978 doctoral dissertation, in collaboration with his supervisors, Cooper and Charnes. It became known as the

CCR model after them (Ibrahim, 2022). DEA is a non-parametric linear programming technique used to measure the relative efficiency of decision-making units by determining the optimal mix of multiple inputs and outputs. The concept is based on the idea that a unit is inefficient if another can produce the same output with fewer inputs. The efficiency score for each unit is calculated as the ratio of the weighted sum of outputs to the weighted sum of inputs. This method is called DEA because the efficient units "envelop" the inefficient ones (Ibrahim, 2022).

DEA has many advantages, including the ability to summarize each unit's performance in a single efficiency score. It can handle multiple inputs and outputs and focuses on the best performance frontier. Each production unit is compared to the most efficient unit or combination of efficient units, identifying the sources of inefficiency for less efficient units. It can determine which units are on the efficiency frontier, the amount of unused input resources for less efficient units, and the excess energy or potential to increase output in less efficient units. It also identifies the nature of returns to scale at the efficiency frontier. DEA does not require a mathematical formulation to link the dependent variables (outputs) with the independent variables (inputs). Some conditions that must be met for DEA include: Inputs and outputs must be non-negative variables (values ≥ 0), The units must be relatively homogeneous, the sample size should be larger than the product of the number of inputs and outputs, or at least twice the total number of inputs and outputs (Abd El-Qadir, 2011-2012).

There are several models for Data Envelopment Analysis (DEA)**,** including:

- CCR Model considering Constant Returns to Scale: This model assumes that changes in the amount of inputs used by an inefficient unit will have a proportional effect on the outputs produced as it moves towards the efficiency frontier. An inefficient unit can become efficient under the CCR model by projecting its coordinates onto the efficiency frontier. From an **input-oriented** perspective, the unit can improve by reducing inputs, while from an **output-oriented** perspective it can improve by increasing outputs. The improvement of inefficient units depends on their position relative to the efficiency frontier, whether input-oriented or output-oriented. In the **CCR model**, efficiency scores are equal for both the input and output orientations (Abd El-Qadir, 2011-2012).

- BCC Model considering Variable Returns to Scale: This model was proposed by Banker, Cooper and Charnes (1984). The **BCC model** is similar to the CCR model but includes a **scale constraint**, ensuring that the reference units for inefficient units are similar in size, neither larger nor smaller. This leads to an efficiency score that reflects the firm's scale returns, whether increasing, decreasing, or constant. The BCC model distinguishes between two types of efficiency: **technical efficiency** and **scale efficiency**. When comparing efficiency scores from the **CCR model** and **BCC model** for the same unit, any difference indicates that the unit is **scale inefficient**. If the scores are equal, it means the evaluated unit exhibits **constant returns to scale**.

- REVIEW OF LITERATURE

- Study by Nisreen and Mohamed (2002) Banker, Cooper, Seiford, Thrall, and Zhu (2004): This study measured and compared the efficiency levels of the Algerian banking sector using Data Envelopment Analysis (DEA) during the period 2006-2017, based on a sample of 9 public and private commercial banks operating in Algeria. The study concluded that both public and private commercial banks in Algeria achieved low efficiency levels. However, public banks achieved higher levels of technical efficiency compared to private banks, which was attributed to the excessive control of the state over this sector, positively reflecting its efficiency. This indicates lack of competition in the Algerian banking sector and a near-monopoly by public banks, suggesting the need for the state to continue reforming the banking sector to improve its efficiency.

- Study by Khatto and Qureshi (2013): This study aimed to measure the banking efficiency of a group of national, Arab and foreign banks in Algeria, using DEA. It covered 10 banks: 3 national, 4 Arab and 3 foreign banks, for the year 2010. Results showed that most of the banks under study had an abundance of resources, which reflected weak banking investments. The efficiency scores were largely consistent with the classification of the sample into groups, with foreign banks being

more efficient than Arab and national banks. The study also found that efficiency scores were not related to bank size.

- Study by Al-Subeihi (2017): This study measured the efficiency of Islamic banks in Jordan during the period 2010-2015, using DEA. Results showed that the amount of waste in banking inputs was 14%, and 44% of Islamic banks achieved 100% efficiency. Jordan Dubai Islamic Bank achieved the highest level of efficiency with an average of 98%, while Arab Islamic International Bank had the lowest average at 67%. The study recommended that other banks should benefit from the experience of Jordan Dubai Islamic Bank as it had the best performance and achieved the highest efficiency levels.

- Study by Badawe (2017), Sathya (2006): This study aimed to measure the efficiency of Islamic banks in several Arab countries during the period 2005- 2010, using DEA. The study included 14 Islamic banks in 9 Arab countries. Results showed a relative decline in the cost efficiency rankings (economic efficiency) for the countries under study. Analysis of cost efficiency components (technical efficiency and allocative efficiency) revealed that technical efficiency was the main reason for the decline in cost efficiency of Islamic banks.

- Study by Al-Humaid (2017), Banker, Charnes, and Cooper (1984): This study measured the efficiency of private commercial banks in Syria during the period 2010-2015. The study included all private commercial banks, totaling 11 banks, using DEA. Results revealed that all private commercial banks achieved 100% technical efficiency in 2015, except for Bank Audi, indicating that these banks had benefited from each other's experiences over time, leading to convergence in their technical efficiency levels, as technical efficiency indicators reflect the management expertise of each bank.

- Study by Al-Wabil (2019), Aghimien, Kamarudin, Hamid, and Noordin (2016), Akhtar (2010).: This study measured the efficiency of the Saudi banking sector during the period 2013-2017, using DEA. The achieved results indicated an excess of available resources in inefficient banks, meaning that there were more resources than those being used, and that increased banking investments were needed to achieve full efficiency. Saudi British Bank, Arab National Bank, Alinma Bank and Bank Al-Jazira made optimal use of available resources, achieving full efficiency. Samba Financial Group, Riyadh Bank, the First Bank, Al Rajhi Bank, Saudi Investment Bank and Saudi Fransi Bank could achieve full efficiency by reducing their inputs. National Commercial Bank and Bank Albilad could achieve full efficiency by reducing both their outputs and inputs.

- Study by Hassan (2019): This study measured the technical and scale efficiency of commercial banks listed on the Egyptian Stock Exchange to identify efficient banks during the period 2014-2017. The study concluded that most of the commercial banks listed on the Egyptian Stock Exchange did not achieve technical efficiency, meaning that they were not optimizing the combination of inputs to achieve a certain level of output. The banks that managed to achieve full efficiency in 2017 were the Export Development Bank of Egypt, the National Bank of Kuwait, and Qatar National Bank, making them the efficiency frontier for the sample.

- Study by Fetiha (2020/2021), Almumani (2013): This study measured the relative efficiency of a sample of 10 Islamic banks in 2020 using DEA. Results revealed variations in efficiency scores among banks, with an average relative efficiency of 86.5%. This means that these banks were using their inputs to obtain 86.5% of the outputs, suggesting that thebanks under studyshould be able to maximize their outputs using their current inputs to achieve full efficiency. In other words, they need to increase their outputs by 13.5% with the same inputs to reach full efficiency.

- Study by Yassad and AbdEl-Salam (2022), Alsharif, Nassir, Kamarudin and Zariyawati (2019): This study measured the efficiency of Islamic banks operating in Algeria and Sudan in 2018, selecting 2 Islamic banks from Algeria and 8 Islamic banks from Sudan, using DEA. Results showed that 3 Sudanese Islamic banks achieved full efficiency (100%), while the efficiency of the remaining Islamic banks, including the Algerian banks, was less than 100%.

RESEARCH RESULTS:

From Table (1), it is clear that National Commercial Bank, Alinma Bank, Saudi Investment Bank, and Albilad Bank achieved full relative efficiency scores (score of 1) according to the output-oriented **CCR model**, meaning that they achieved 100% efficiency and met the condition thatthe values of the slack variables equal zero. These banks formed the efficient frontier for the study sample during the period 2017-2019. Additionally, these banks achieved both scale and technical efficiency according to the output-oriented **BCC model**, indicating that their returns to scale are constant. They achieved the optimal and efficient scale under both CCR and BCC models and can continue operating with their current mix of inputs and outputs.

It was also found that Al Rajhi Bank, Riyadh Bank and Bank Aljazira achieved technical efficiency, as they scored 1 on the technical efficiency scale and had zero slack values, placing them on the efficient frontier of the **BCC model** with an output orientation. However, they did not achieve scale efficiency because their scale efficiency scores were less than one. Meanwhile, Saudi Fransi Bank, Saudi British Bank and Arab National Bank were neither technically nor scale-efficient, as they scored less than one on both efficiency measures and had non-zero slack values. This suggests that banks that are not technically or scale-efficient under the **CCR** or **BCC** models have either increasing or decreasing returns to scale and, therefore, are experiencing negative or positive economies of scale. These banks were unable to achieve the optimal scale with the resources available and can only do so by improving inputs, outputs, or both.

Table (1): Efficiency of Saudi Arabia Kingdom banks during the period (2017-2019).

No.	Bank	Relative Efficiency	Technical Efficiency	Volumetric Efficiency	Source of Inefficiency	Returns to scale
1	National Commercial Bank	1	1	1.000	None	Constant
2	Al Rajhi Bank	0.903	1	0.903	Volumetric	Decreasing
3	Riyadh Bank	0.994	1	0.994	Volumetric	Decreasing
4	Saudi Fransi	0.99	0.994	0.995	Volumetric and Technical	Decreasing
5	Saudi British	0.932	0.959	0.972	Volumetric and Technical	Decreasing
6	Arab National	0.94	0.981	0.959	Volumetric and Technical	Decreasing
7	Alinma Bank	1	1	1.000	None	Constant
8	Saudi Investment	1	1	1.000	None	Constant
9	Albilad Bank	1	1	1.000	None	Constant
10	Aljazira Bank	0.932	1	0.932	Volumetric	Increasing
	average	0.969	0.993	0.976		

Source: Prepared by the researcher from the analysis of the research data using the DEAP program.

It is also clear from Table (2) that Riyadh Bank, Saudi Frensi Bank, Arab National Bank, Saudi Investment Bank and Albilad Bank achieved full relative efficiency scores (score of 1) according to the output-oriented **CCR model** applied to the period 2020-2022, meaning that they achieved 100% efficiency and met the condition of zero slack values. These banks also achieved both scale and technical efficiency under the output-oriented **BCC model**, indicating that their returns to scale are constant.They also achieved the optimal and efficient scale under both CCR and BCC models. They can continue operating with their current mix of inputs and outputs.

In addition, it was found that the National Commercial Bank, Al Rajhi Bank and Aljazira Bank achieved technical efficiency, as they scored 1 on the technical efficiency scale and had zero slack values, placing them on the efficient frontier of the **BCC model** with an output orientation. However, they did not achieve scale efficiency because their scale efficiency scores were less than one. Meanwhile, Saudi British Bank and Alinma Bank were neither technically nor scale-efficient, as they scored less than one on both efficiency measures and had non-zero slack values. This indicates that banks that are not technically or scale-efficient under the **CCR** or **BCC** models either have increasing or decreasing returns to scale, experiencing negative or positive economies of scale, and were unable to achieve the optimal scale with the resources available. They can only do so by improving inputs, outputs, or both.

A comparison of the averages shows diminishing efficiency during the period (2020-2022) compared to the period (2017-2019), despite five banks achieving full efficiency in the second period compared to four banks in the first period. It is also noted that Saudi Investment Bank and Albilad Bank achieved full efficiency in both periods, unlike the other banks.

Table (2): Efficiency of Saudi Arabia Kingdom banks during the period (2020-2022).

No.	Bank	Relative Efficiency	Technical Efficiency	Volumetric Efficiency	Source of Inefficiency	returns to scale
1	National Commercial Bank	0.962	1	0.962	Volumetric	Decreasing
2	Al Rajhi Bank	0.953	1	0.953	Volumetric	Decreasing
3	Riyadh Bank	1	1	1	None	Constant
4	Saudi Fransi	1	1	1	None	Constant
5	Saudi British	0.901	0.933	0.965	Volumetric and Technical	Decreasing
6	Arab National	0.915	0.915	1	Technical	Constant
7	Alinma Bank	0.987	0.995	0.992	Volumetric and Technical	Decreasing
8	Saudi Investment	1	1	1	None	Constant
9	Albilad Bank	1	1	1	None	Constant
10	Aljazira Bank	0.971	1	0.971	Volumetric	Increasing
	average	0.969	0.984	0.984		

Source: Prepared by the researcher from the analysis of research data using the DEAP program.

Table (3) shows the required improvements in the outputs and inputs of the banks for the period 2017-2019. For Saudi Fransi Bank to achieve full efficiency, it needs to reduce its loan output by 0.57% and total assets by 0.57%. By doing so, it can achieve the optimal scale as specified by the proposed values in Table (3) for these two outputs, and increase its shareholder equity by 3.81%. The reference banks for this improvement (the efficient comparison units) include the Saudi Investment Bank and Riyadh Bank.

Similarly, Saudi British Bank can achieve full efficiency by reducing its loan output by 4.29% and total assets by 4.29%. To achieve the optimal scale as specified by the proposed values in Table (3) for these two outputs, it would also need to increase its shareholder equity by 24.95%. The reference banks for this improvement include the National Commercial Bank and the Saudi Investment Bank.

Arab National Bank can achieve full efficiency by reducing its loan output by 1.95% and total assets by 8.67%. To achieve the optimal scale, as specified by the proposed values in Table (3) for these outputs, the reference banks for this improvement include the National Commercial Bank and Albilad Bank.

Table (3): Levels of improvement required from inefficient banks in the Saudi Arabia Kingdom during the period (2017-2019).

No.	Bank	Output						Inputs						Comparative Efficient Units
		Loans			Assets			Shareholders' Equity			Deposits			
		Suggested Values	Actual Values	Improvement	Suggested Values	Actual Values	Improvement	Suggested Values	Actual Values	Improvement	Suggested Values	Actual Values	Improvement	
1	National Commercial Bank	265.380	265.380	0.00	467.621	467.621	0.00	58.397	58.397	0.00	327.011	327.011	0.00	
2	Al Rajhi Bank	235.677	235.677	0.00	362.054	362.054	0.00	50.864	50.864	0.00	293.566	293.566	0.00	
3	Riyadh Bank	154.615	154.615	0.00	237.324	237.324	0.00	38.656	38.656	0.00	172.902	172.902	0.00	
4	Saudi Fransi	123.460	122.766	0.57	188.168	187.109	0.57	30.611	31.823	-3.81	137.602	137.602	0.00	8 3
5	Saudi British	131.893	126.469	4.29	218.407	209.426	4.29	30.470	40.602	-24.95	154.305	154.305	0.00	1 8
6	Arab National	120.445	118.139	1.95	193.251	177.833	8.67	26.399	26.399	0.00	140.078	140.078	0.00	1 9
7	Alinma Bank	85.918	85.918	0.00	122.794	122.794	0.00	21.447	21.447	0.00	93.752	93.752	0.00	
8	Saudi Investment	58.705	58.705	0.00	96.894	96.894	0.00	12.949	12.949	0.00	66.564	66.564	0.00	
9	Albilad Bank	51.109	51.109	0.00	74.282	74.282	0.00	8.283	8.283	0.00	57.355	57.355	0.00	
10	Aljazira Bank	46.370	46.370	0.00	65.243	65.243	0.00	10.554	10.554	0.00	54.926	54.926	0.00	

Source: Prepared by the researcher from the analysis of the research data using the DEAP program.

Table (4) shows the required improvements in the outputs and inputs of the banks for the period (2020-2022). Saudi British Bank can achieve full efficiency by reducing its loan output by 7.19% and total assets by 7.19%, and by increasing its shareholder equity by 14.83%. The reference banks for this improvement includethe Saudi Investment Bank and the National Commercial Bank.

Arab National Bank can achieve full efficiency by reducing its loan output by 9.27% and total assets by 9.27%. To achieve the optimal scale, as specified by the proposed values in Table (4) for these outputs, the reference banks for this improvement includethe Saudi Investment Bank, Saudi Fransi Bank, and Riyadh Bank.

Alinma Bank can achieve full efficiency by reducing its loan output by 0.54% and total assets by 6.27%. To achieve the optimal scale as specified by the proposed values in Table (4) for these outputs, the reference banks for this improvement include Albilad Bank and the Saudi Fransi Bank.

From the previous discussion, it can be concluded that:

Some of the banks under study achieved full efficiency, indicating that other banks can improve their efficiency by following the example of these more efficient banks.

To increase the efficiency of less efficient banks, they must reduce outputs and increase resources, particularly shareholders' equity.

The source of inefficiency was either due to scale, or both scale and technical factors, indicating technical problems in output production and scale issues in the mix of inputs and outputs.

Table (4): Levels of improvement required from inefficient banks in the Saudi Arabia Kingdom during the period (2020-2022).

No.	Bank	Output						Inputs						Comparative Efficient Units
		Loans			Assets			Shareholders' Equity			Deposits			
		Suggested Values	Actual Values	Improvement	Suggested Values	Actual Values	Improvement	Suggested Values	Actual Values	Improvement	Suggested Values	Actual Values	Improvement	
1	National Commercial Bank	463.195	463.195	0.00	819.695	819.695	0.00	123.235	123.235	0.00	524.425	524.425	0.00	
2	Al Rajhi Bank	445.627	445.627	0.00	618.279	618.279	0.00	69.709	69.709	0.00	486.543	486.543	0.00	
3	Riyadh Bank	217.001	217.001	0.00	331.826	331.826	0.00	47.086	47.086	0.00	218.241	218.241	0.00	
4	Saudi Fransi	145.797	145.797	0.00	213.985	213.985	0.00	34.022	34.022	0.00	142.218	142.218	0.00	
5	Saudi British	180.049	167.977	7.19	308.446	287.766	7.19	44.933	52.759	-14.83	196.717	196.717	0.00	81
6	Arab National	139.818	127.959	9.27	213.265	195.175	9.27	31.056	31.056	0.00	139.979	139.979	0.00	843
7	Alinma Bank	128.674	127.986	0.54	188.016	176.930	6.27	25.672	25.672	0.00	128.561	128.561	0.00	94
8	Saudi Investment	60.585	60.585	0.00	103.525	103.525	0.00	13.902	13.902	0.00	63.736	63.736	0.00	
9	Albilad Bank	81.409	81.409	0.00	112.050	112.050	0.00	12.040	12.040	0.00	82.502	82.502	0.00	
10	Aljazira Bank	62.331	62.331	0.00	103.588	103.588	0.00	11.706	11.706	0.00	77.464	77.464	0.00	

Source: Prepared by the researcher from the analysis of the research data using the DEAP program.

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