

Using Data Envelopment Analysis (D.E.A) Model to Measure and Analyze the Efficiency of Commercial Banks Operating in Algeria

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Abstract:

This study aimed to measure and analyze the efficiency of commercial Banks operating in Algeria using Data Envelopment Analysis (D.E.A) for 2018-2022. The sample consisted of 14 banks, including 6 public and 8 private banks. To evaluate the efficiency scores, the study employed the Variable Returns to Scale (VRS) model with an output-oriented approach. In this model, Operating Expenses (OE) and Total Deposits (TD) were considered as inputs, while Net Bank Income (NBI), Total Loans (TL), and Margin on Interest (MI) were selected as outputs. The results of the study revealed that Algerian banks, overall, exhibit a good level of efficiency, with an average efficiency index of 71,43%. Out of the 14 Banks analyzed, 10 Banks were found to be fully efficient, while the remaining 4 Banks did not reach the efficiency frontier.

Keywords : Commercial banks, Banking efficiency, Efficiency measure, (D.E.A) method.

JEL Classification Codes: C21, G21, L25.

Introduction:

The banking sector is a key pillar in the economic and social life of all countries, significantly impacted by broader changes. It plays a vital role in providing finance by connecting surplus holders with those in deficit, thus stimulating economic activity within the framework of established monetary policies. This contributes to enhancing the economic and social standing of nations.

The challenges facing the banking sector, coupled with increasing competition, have driven Banks to focus more on their efficiency. This focus aims to build strong financial positions and achieve their strategic objectives. Data Envelopment Analysis (D.E.A) has emerged as a crucial tool for measuring banking efficiency.

The diversity in methods for evaluating banking efficiency has led to the development of various tools and approaches, ranging from traditional methods like financial analysis to

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modern quantitative techniques. Among these, DEA stands out as the most important non-parametric method for assessing banking efficiency.

Given the critical role of the banking sector in Algeria, similar to other countries, this research aims to measure and analyze the efficiency of commercial Banks operating in Algeria using the DEA model. Therefore, the research problem, that this study seeks to address, can be formulated as follows: How efficient are the commercial Banks operating in Algeria within the framework of applying the Data Envelopment Analysis (D.E.A) method?

Study Hypotheses: To address this issue, the following hypotheses are proposed:

- ✓ **H1:** There are differences in efficiency levels among commercial Banks operating in Algeria.
- ✓ **H2:** Public Banks in Algeria are more efficient compared to private banks.
- ✓ **H3:** Benchmark Banks are those that have achieved full efficiency by optimally utilizing available resources.
- ✓ **H4:** The efficiency of underperforming Banks can be enhanced through benchmarking comparisons.

Study Objectives: The objectives of this study are as follows:

- ✓ Understand the concept of banking efficiency and the various methods of measuring it.
- ✓ Highlight the Data Envelopment Analysis (D.E.A) model.
- ✓ Assess the current state of the Algerian banking system.
- ✓ Measure the efficiency of commercial Banks operating in Algeria.
- ✓ Suggest necessary improvements for inefficient Banks to enhance their efficiency.
- ✓ Identify Banks that have optimized their input-output combinations to achieve the highest levels of efficiency.

The Scope of Research: Through this study, we seek to study and analyze the efficiency of commercial banks operating in Algeria using the Data Envelope Analysis (DEA) model, within the following scopes:

- The study relied on data from Commercial Banks operating in Algeria during the study period, which numbered 14 Banks, including 6 Public Banks and 8 Private Banks;

- The study covered the period from 2018 to 2022, and was chosen for the availability of data and financial reports for the Banks under study.

Research Approach: Given the nature of the subject and in order to achieve the study objectives and cover its various aspects, the descriptive approach was used in the theoretical aspect, and the case study approach in the practical aspect.

Study Methodology: This study involves conducting a literature review to understand the concepts of banking efficiency and the DEA model. Following this, data will be collected on Algerian commercial banks. The DEA model will be utilized to assess the efficiency of these banks, enabling comparisons and identification of areas for improvement. The findings will be presented, conclusions drawn, and recommendations made based on the analysis.

The organization of the remaining sections of this paper is as follows:

- ✓ **The first section:** Banking efficiency and the DEA method.
- ✓ **The second section:** The Algerian banking sector in statistics.
- ✓ **The third section:** Applying the DEA method on a group of Algerian banks.

I. Banking Efficiency and the DEA Method

Through this section, we will explore concepts related to banking efficiency as well as the Data Envelopment Analysis (D.E.A) method. This discussion will provide a foundation for understanding how these concepts are applied to evaluate the performance of banks.

1. Banking Efficiency

The concept of efficiency in economic thought is closely linked to the fundamental economic problem, which is how to allocate the available resources within a society to meet the ever-changing needs and desires of individuals. These resources are characterized by scarcity and limitation, and this issue is relevant across various sectors and fields, including the banking sector.

Before addressing banking efficiency, it is important to clarify the concept of efficiency in general. There are many definitions of the term efficiency, but its historical concept primarily dates back to the Italian economist Vilfredo Pareto (1848-1932), who developed the formulation of this concept, which is now known as “Pareto optimality”. According to Pareto, any possible allocation of resources is either efficient or inefficient. An inefficient allocation of resources reflects a state of inefficiency. Efficiency is also defined as a criterion for evaluating an organization’s success rate compared to its competitors by improving the use

of inputs and generating outputs. An organization can be considered efficient if it meets the two following conditions: reducing inputs while maintaining the same level of outputs, and maximizing production using the same inputs (Muarief, 2019, p. 690). Accordingly, efficiency can be defined as the optimal utilization of available resources to achieve the desired objectives. Efficiency also reflects the comparison between inputs and outputs by maximizing outputs at a certain level of inputs or minimizing inputs to achieve a certain level of output.

The term efficiency, particularly in the banking sector, refers to the optimal use of limited resources to achieve maximum output with minimal cost. Evaluating efficiency helps determine how well a bank utilizes its resources and identifies ways to address any inefficiencies. Banks that generate higher returns from the same level of input are considered efficient (Ullah, Abdul, & Jozsef, 2023, pp. 1-2), the concept of efficiency in Banks is not different from that in economic institutions. It relies on comparing inputs and outputs by either maximizing outputs at a certain level of inputs or minimizing inputs to achieve a certain level of outputs. However, these inputs and outputs differ from those in economic institutions due to the specific nature of banking operations.

There are also several types of banking efficiency, which can be categorized as follows:

- **Technical Efficiency:** This is defined as one minus the maximum possible reduction in inputs while still maintaining production. It focuses on minimizing waste by either maximizing output with available inputs (output-oriented) or using the minimum necessary inputs to achieve production goals (input-oriented) (Sandrine, 2007, p. 8).
- **Economic Efficiency:** Economic efficiency refers to the optimal operation of a market, aiming for the lowest production costs, highest output, and maximum market surplus. It encompasses both static and dynamic efficiency as its key components. (Petrou, 2014)
- **Productive Efficiency:** This involves the bank's capability to produce the maximum amount of output from a given set of inputs, or to use the minimum amount of inputs to achieve a specific level of output.

- **Allocative Efficiency:** This involves the bank's ability to allocate its resources in a way that maximizes the value of the output produced. It is about making sure that the resources are used in their most valued application.

2. DEA Method

Data Envelopment Analysis (D.E.A) is a method that uses linear programming to determine the relative efficiency of a set of Decision-Making Units (DMUs) that use a variety of inputs and outputs. This involves dividing the total outputs by the total inputs for each DMU and comparing this ratio with other units. A unit with the highest efficiency ratio is considered to be on the efficient frontier. The inefficiency of other units is measured relative to this efficient frontier using specific linear programming techniques. Efficiency scores range between one (1), representing complete efficiency, and zero (0), indicating total inefficiency (W.COOPER, M.SEIFORD, & TONE, 2007, p. 5). Farrell (1957) developed the fundamental DEA-efficient frontier model, which is outlined in the equation:

$$Efficiency = \frac{Output}{Input}$$

Thus, Data Envelopment Analysis (D.E.A) allows for identifying the best practices among decision-making units and the production frontiers by solving a mathematical model for those frontiers that envelop and surround the decision-making units. It compares their efficiency by measuring the distance from the efficiency frontier, which represents the maximum output that can be produced given a specific combination of inputs, as well as the minimum inputs required to produce a certain level of output. Additionally, DEA can assess the units that have not achieved efficiency (Yüksel, 2012, p. 77). Those units with an efficiency score less than one and greater than or equal to zero can achieve efficiency by following the example of the units on the efficiency frontier.

In 1978, Charnes, Cooper, and Rhodes enhanced the DEA method by introducing the CCR models, which handle multiple inputs to generate one or more outputs and assume constant returns to scale (CRS). This means that any increase in input results in a proportional increase in output. Later, in 1984, Banker, Charnes, and Cooper revised this approach by developing the BCC model, which incorporates a variable return to scale (VRS) frontier. This adjustment addresses scenarios where an increase in input does not necessarily lead to a proportional change in output (Kraidi, Daneshvar, & Adesina, 2024, p. 2). There are several practical

models of Data Envelopment Analysis, categorized based on different orientations and factors. DEA models are classified into four main types:

- **CCR Model (Charnes, Cooper, and Rhodes, 1978):** what is known as the Constant Returns to Scale (CRS) Model, this model assumes constant returns to scale and helps convert inefficient units into efficient ones by adjusting inputs and outputs, though practical barriers often prevent units from achieving peak capacity (Bourahli & Benzai, 2023, p. 84).
- **BCC Model (Banker, Charnes, and Cooper, 1984):** In 1984, Charnes, Cooper, and Banker developed the BCC model, which assumes variable returns to scale (VRS) rather than constant returns. This model accounts for variations in efficiency based on scale by incorporating a convexity constraint, which changes the efficiency frontier from a conical to a convex shape. The BCC model distinguishes between technical and scale efficiency, providing precise efficiency estimates based on the volume of operations. It identifies gaps in efficiency relative to specific inputs and outputs.
- **Model CHA82 (Charnes & Ai):** Known as the Aggregated Model.
- **Model CHA87 (Charnes & Ai):** Known as the Logarithmic Model.

A set of conditions must be met to measure the efficiency index using Data Envelopment Analysis (D.E.A), which can be summarized as follows (Shahooth & Battal, 2006, p. 142):

- ✓ **Positivity Property:** The DEA method requires that both input and output variables be positive;
- ✓ **Isotonicity Property:** Requires that an increase in any input should lead to an increase in some output, without causing a decrease in any output;
- ✓ **Number of Decision-Making Units:** A general guideline is to have at least three decision-making units (DMUs) for each input and output variable to ensure there are enough degrees of freedom for a meaningful analysis.
- ✓ **Homogeneity of DMUs:** This means that all units included in the evaluation have the same inputs and outputs, with positive values.
- ✓ **Window Analysis:** To track efficiency changes over time, Charnes introduced 'Window Analysis' in DEA, which evaluates a DMU as a separate entity in each

time period, requiring assessment of “nk” units if there are “n” units and “k” periods.

- ✓ **Control of Weights:** Weights or coefficients are determined by solving the Data Envelopment Analysis (D.E.A) method, which calculates them in a way that allows the evaluated units to perform at their best relative to other units.

II. Algerian Banking Sector in Statistics

Like other colonized nations, the Algerian banking system was shaped by colonial influences, functioning as an extension of the colonial banking structure. Since gaining independence, Algeria has navigated several phases of transformation to align its banking system with modern developments and global trends.

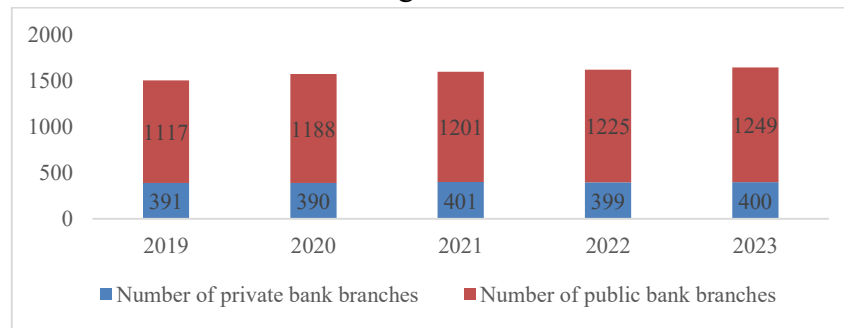
The early 1990’s marked a pivotal period, characterized by significant reforms inspired by Bretton Woods institutions. These reforms aimed to restructure banking activities to adapt to a new economic model and promote the real sector, in line with financial liberalization theories. A key legislative milestone was the enactment of the Law on Currency and Credit, which serves as the foundational reference for the Algerian banking system and has undergone multiple revisions, the latest being Law 23-09 (June 21, 2023). This law emphasizes the Bank of Algeria’s role in maintaining price stability and allows for tailored interventions in Islamic banking and green finance.

Additionally, the establishment of the Financial Stability Committee under this law aims to enhance the resilience of the financial system by managing systemic vulnerabilities and ensuring stability. As of late 2023, the Algerian banking system consists of 28 Banks and financial institutions, including 7 public banks, 13 private Banks (with foreign capital), 2 public financial institutions, 5 financial leasing entities, and 1 agricultural insurance cooperative authorized to conduct banking operations. (Bank of Algeria, 2024, p. 46).

1. Evolution of the Number of Public and Private Banks

With the addition of a new bank, Bank of Housing, in 2022, the number of Banks at the end of 2023 was 20, all headquartered in Algiers. The number of Banks has remained relatively stable from 2019 to 2020, with private Banks numbering 14 and public Banks 6. In 2021 and 2022, the number of private Banks was 13, while the number of public Banks in 2023 was 7. The following figure will illustrate the evolution of the number of bank branches in Algeria from 2019 to 2023:

Figure 1: Evolution of the Number of Algerian Bank Branches from 2019 to 2023



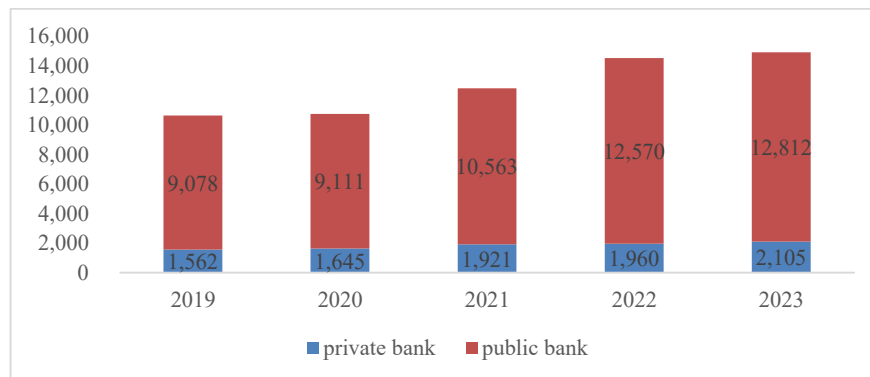
Source: Prepared by the researcher based on the Bank of Algeria's Annual Report (2023)

Based on the above figure, we observe that by the end of 2023, the number of bank branches was projected to be around 1649, with 400 belonging to private Banks and 1249 to public banks. The latter thus holds a significant share of the total number of branches, at 75.74%, largely due to the expansion of public Banks and their nationwide presence. Additionally, there has been an increase in the number of branches from year to year, with the total number of branches rising by approximately 21% between 2019 and 2023.

2. Evolution of Aggregate Deposits in the Algerian Banking System

The total value of aggregate deposits in the Algerian banking system was estimated at approximately 14 917 billion DZD at the end of 2022. The evolution of these deposits between public and private Banks can be illustrated by the following figure:

Figure 2: Evolution of Aggregate Deposits in the Algerian Banking System from 2019 to 2023



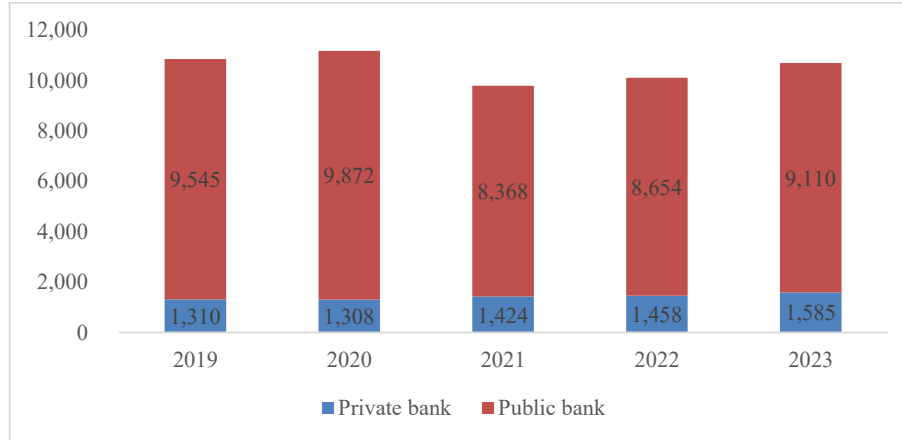
Source: Prepared by the researcher based on the Bank of Algeria's Annual Report (2023)

The figure above shows that aggregate deposits in the Algerian banking system increased by 28.68% between 2019 and 2023, amounting to 4 278 billion DZD. It also highlights that public Banks dominate the total aggregate deposits, accounting for 85.32% in 2023, compared to 14.68% held by private banks.

3. Evolution of Loans in the Algerian Banking System

The value of loans within the Algerian banking system, across all types, was estimated at approximately 10 695 billion DZD at the end of 2023. The evolution of these loans between public and private Banks can be illustrated in the following figure:

Figure 3: Evolution of Loans in the Algerian Banking System from 2019 to 2023



Source: Prepared by the researcher based on the Bank of Algeria's Annual Report (2023)

The growth in loans granted to the economy, which began in 2022, continued, reaching 5.8% by the end of 2023, an increase of 2.6 % compared to the end of 2022 (3.2%). In terms of value, the outstanding loans to the economy amounted to 10 694.9 billion DZD at the end of December 2023, compared to 10 112.3 billion DZD the previous year. This notable growth was observed in both public banks, which recorded an increase of 5.3%, and private banks, which recorded an increase of 8.7%, compared to 3.4% and 2.4%. Respectively, at the end of 2022, in terms of contribution, public Banks accounted for 78.4% of the increase in loans granted to the economy within the banking sector, while the contribution of private Banks doubled from 10.9% in 2022 to 21.6% in 2023.

III. Applying the DEA Method to a Group of Algerian Banks

In this section, we will apply the Data Envelopment Analysis (D.E.A) method to a sample of commercial Banks operating in Algeria, specifically 14 banks, using data from the years 2018-2022 obtained from their financial statements and annual reports. We will follow two main phases: the first phase involves presenting and analyzing the study data, while the second phase involves calculating efficiency indicators and analyzing the results obtained.

1. Data Presentation and Analysis

The study data consists of the previously mentioned sample of banks, the study variables, the selected model, and the descriptive analysis of these variables.

1.1. Study Sample

As previously discussed, the study sample consists of 14 commercial Banks operating within the Algerian banking system. We focused on traditional commercial Banks and excluded Al Baraka Bank and Essalam Bank as they are Islamic banks. Additionally, branch offices were not considered. The Banks were divided into two groups: public Banks and private banks, as follows:

Table 01: Banks in the study sample

Public Banks	Private Banks
BEA, BNA, BADR, BDL, CPA, CNEP	AGB, ABC, Trust, SGA, FRANSABANK (FSB), BNP, HBTF, NATIXIS.

Source: Prepared by the researcher

1.2. Tools and Study Variables

To measure efficiency indicators, we used the output-oriented Data Envelopment Analysis (D.E.A) model, which means increasing banking outputs while maintaining a certain level of inputs, within its two main models: The Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS) models, to obtain results that are more reflective of reality. We used the DEAP 1.2 software to obtain efficiency indicators.

Regarding the study variables, we relied on a set of inputs and outputs based on the available data and used an intermediation approach. In banking, production requires financial intermediation, as Banks collect capital and then provide these funds in the form of loans. Thus, the bank acts as an intermediary between those with surplus financial resources (savers) and those with financial deficits (investors). Therefore, dealing with deposits as inputs is similar to labor and capital, as they form the essential material that turns into financial investments. The study variables can be presented in the following table:

Table 02: Study variables

Inputs		Outputs	
Variable	Abrv	Variable	Abrv
Operating Expenses	OE	Net Bank Income	NBI
Total Deposits	TD	Total Loans	TL
		Margin on Interest	MI

Source: Prepared by the researcher

1.3. Measuring the Correlation Between Study Variables

To ensure the credibility of the study, there must be a relationship between the study variables (inputs and outputs). For example, an increase in one of the inputs should result in an increase in one or more of the outputs. To clarify this relationship, we calculated Pearson's correlation coefficient. It is worth noting that we relied on the average values from 2018 to 2022 for the calculation. The results obtained are as follows:

Table 03: Pearson correlation coefficient between study variables

Variables		Inputs		Outputs		
		OE	TD	NBI	MI	TL
Inputs	OE	1,000				
	TD	0,872	1,000			
Outputs	NBI	0,825	0,980	1,000		
	MI	0,850	0,989	0,990	1,000	
	TL	0,882	0,999	0,976	0,989	1,000

Source: Prepared by the researcher using Excel

From the table above, we observe that the Pearson correlation coefficients between the variables indicate a positive linear relationship. This means that any change in one variable will necessarily lead to a change in the other variable.

1.4. Robustness of the Model

To demonstrate the robustness of the data used in applying the Data Envelopment Analysis (D.E.A) method in our study, we will compare the calculated efficiency score (ES) with other efficiency indicators, specifically the Return on Equity (ROE) and the Return on Assets (ROA). This comparison will involve sensitivity analysis using Pearson correlation coefficients. Note that we relied on average values from 2018 to 2022 for these calculations, and the results obtained are as follows:

Table 04: Pearson correlation coefficient between the efficiency score and performance indicators

	ES	ROE	ROA
ES	1,000		
ROE	0,292	1,000	
ROA	0,478	0,767	1,000

Source: Prepared by the researcher using Excel

As expected, the table above shows a positive correlation between the calculated efficiency score and various performance indicators, indicating the robustness of the studied model. However, this correlation is weak because the efficiency score measures overall

efficiency, whereas other indicators measure only partial aspects of efficiency. Thus, it can be said that Data Envelopment Analysis (D.E.A) is complementary to other indicators.

2. Measuring the Efficiency Score and Analyzing the Results

To measure the efficiency score, we relied on the average values during the period 2018-2022 using the Variable Returns to Scale (VRS) model. We collected and organized the data related to inputs and outputs, and by using the DEAP 1.2 software. We obtained the following results:

Table 05: Measuring the efficiency score for the average values

Banks	CRS	VRS	Scale	Returns to scale
ABC	1,000	1,000	1,000	-
AGB	0,877	1,000	0,877	drs
BADR	0,921	0,976	0,944	drs
BDL	1,000	1,000	1,000	-
BEA	1,000	1,000	1,000	-
BNA	1,000	1,000	1,000	-
BNP	0,759	0,957	0,793	drs
CNEP	0,899	0,899	1,000	-
CPA	0,959	0,960	0,999	irs
FBA	0,931	1,000	0,931	irs
HTBF	0,874	1,000	0,874	irs
NATIXIS	1,000	1,000	1,000	-
SGA	0,826	1,000	0,826	drs
Trust	1,000	1,000	1,000	-

Source: Prepared by the researcher using the outputs of the DEA method

Considering that the second column of the above table represents the overall technical efficiency score according to the Constant Returns to Scale (CRS) model, and the third column represents the overall technical efficiency score according to the Variable Returns to Scale (VRS) model. the fourth column represents scale efficiency, which is the result of dividing the score efficiency according to the VRS model by the efficiency score according to the CRS model. Finally, the fifth column represents the returns to scale for each bank, which can be either increasing (irs) or decreasing (drs). Decreasing returns to scale means that

the increase in outputs is less than the increase in inputs, and therefore it is advisable to reduce inputs, and vice versa for increasing returns to scale.

Through this table, we observe that the overall efficiency score according to the output-oriented Variable Returns to Scale (VRS) model was estimated at 71.43%, where 10 Banks out of 14 achieved efficiency, while 4 Banks did not, representing 28.57%. The Banks ABC, AGB, BDL, BEA, BNA, FBA, HTBF, NATIXIS, SGA, and Trust managed to achieve an efficiency score equal to one, indicating full efficiency. In contrast, the Banks BADR, BNP, CNEP, and CPA, did not achieve efficiency, with their score ranging from 89.9 %, the lowest value achieved by CNEP, to 97.6%, the highest value achieved by BADR, which was close to achieving efficiency. The average efficiency score according to the output-oriented VRS model was estimated at 98.5%. Among the inefficient banks, there is one private bank representing 7.14% of the 14 Banks and three public Banks representing 21.43% of the 14 banks.

It can also be concluded that the average efficiency score according to the Constant Returns to Scale (CRS) model was estimated at 93.2%. As for the overall efficiency score, it was estimated at 42.86 %, meaning that 6 Banks out of 14 managed to achieve efficiency, which is a weak score. The Banks ABC, BDL, BNA, BEA, NATIXIS, and Trust achieved full efficiency with an efficiency score equal to one. Meanwhile, the Banks BADR, CPA, and FBA were close to achieving full efficiency with indices estimated at 92.1%, 95.9%, and 93.1%, respectively. The lowest efficiency score was recorded by the bank BNP, with an index estimated at 75.9 %. For the remaining banks, it can be observed that four Banks had efficiency score between 80% and 90%, which are AGB, CNEP, HTBF, and SGA.

The fourth column shows the scale efficiency scores, where we observe that 7 banks, representing 50% of the sample, achieved full-scale efficiency, we also notice that the lowest efficiency score was recorded by BNP, with an estimated rate of 79.3%. Additionally, three Banks had efficiency scores ranging between 80% and 90%, namely AGB, HTBF, and SGA, with scores of 87.7 %, 87.4 %, and 82.6 %, respectively. The remaining 4 Banks were close to achieving efficiency, with scores exceeding 90% and nearing 100%.

On the one hand, in terms of returns to scale, there was a dominance of decreasing returns to scale, with 57.14% of the sample, representing 4 banks, operating under this scale. On the other hand, 42.85% of the sample, or 3 banks, operated under increasing returns to scale. The

remaining banks, which make up the efficient frontier, operated under constant returns to scale, representing 50% of the sample, or 7 banks.

3. Diagnosing Inefficient Banks

After measuring the efficiency scores and identifying both efficient and inefficient banks, we will now proceed with diagnosing and analyzing the inefficient Banks to pinpoint areas of inefficiency. It is important to note that our analysis will be based on the Variable Returns to Scale (VRS) model with an output orientation. We have identified 4 inefficient banks, namely BADR, BNP, CNEP, and CPA.

The DEA method suggests a set of improvements that inefficient Banks can undertake to achieve efficiency, these improvements can be illustrated in the following table:

Table 06: Results of diagnosing BADR bank on Million DZD

Variable	BADR	BNP	CNEP	CPA
NBI	1 336	726	4 366	3 273
MI	1 060	572	3 791	2 882
TL	30 999	7 094	124 593	81 376

Source: Prepared by the researcher using the outputs of the DEA method.

Based on the table above, the DEA method suggests a set of improvements that inefficient Banks can make to increase their outputs while maintaining the same level of inputs. Concerning the BADR bank can increase Net Bank Income by 1,336 million DZD, increase the interest margin by 1,060 million DZD, and raise the loan volume by 30,999 million DZD. The bank can follow a marketing strategy by offering loans at rates that allow it to achieve a higher interest margin compared to the available deposits, thereby increasing the Net Bank Income. The same applies to the other inefficient banks, which can implement the improvements suggested by the DEA method as indicated in Table 6 above, while maintaining the same level of inputs.

To enable the inefficient Banks to implement these improvements, they can benchmark against their reference banks, as detailed in the table below:

Table 07: List of benchmark banks

Bank	Benchmark banks		
BADR	BNA	BEA	BDL
	0,103	0,156	0,741
	Trust	SGA	-

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BNP	0,411	0,589	-
CNEP	BNA	Trust	BDL
	0,319	0,156	0,525
CPA	BEA	BNA	FBA
	0,247	0,635	0,118

Source: Prepared by the researcher using the outputs of the DEA method.

The table above shows the benchmark Banks for inefficient banks, where the benchmark bank is a virtual bank that combines a group of the best banks, which constitute the efficiency frontier and operate at the same level as the inefficient bank, but with different weights. For the BADR bank, its benchmark bank consists of three banks: BNA, BEA, and BDL, with weights of 10.3 %, 15.6 %, and 74.1 % respectively. As for BNP Bank, which had an efficiency score of 95.7 %, meaning an inefficiency of 4.3 %, its benchmark bank is composed of Trust Bank with a weight of 41.1 % and SGA Bank with a weight of 58.9%. For CNEP Bank, its benchmark bank is composed of BNA, Trust, and BDL Banks with weights of 31.9%, 15.6 % and 52.5 %, respectively. Additionally, BEA, BNA, and FBA Banks appeared as reference Banks for CPA Bank with weights of 24.7%, 63.5%, and 11.8% respectively.

IV. Conclusion

The banking sector is a critical part of the economy, as it connects those with financial deficits to those with financial surpluses. Given the intense competition in this sector, Banks must focus on improving their efficiency compared to their peers to keep up with industry developments and ensure their survival and success in the market. To monitor and enhance efficiency, scientific methods are used, including Data Envelopment Analysis (D.E.A) , which relies on linear programming to measure banking efficiency accurately and objectively. In our study, we applied Data Envelopment Analysis (D.E.A) to a sample of 14 Algerian Banks using the Variable Returns to Scale (VRS) model with an output-oriented approach. The study variables included Operating Expenses (OE) and Total Deposits (TD) as inputs, and Net Bank Income (NBI), Total Loans granted (TL), and Margin on Interest (MI) as outputs. Based on this empirical study, the research concluded with a set of results and recommendations as follows:

1. Results of the Study

The results of this study are:

- ✓ Data Envelopment Analysis (D.E.A) is a quantitative method that uses linear programming to measure the efficiency of decision-making units, such as commercial banks.
- ✓ DEA can be applied to commercial Banks using two models: The Constant Returns to Scale (CRS) model and the Variable Returns to Scale (VRS) model.
- ✓ Data Envelopment Analysis (D.E.A) does not provide results contrary to activity indicators; rather, it is complementary and offers more accurate information.
- ✓ Commercial Banks operating in Algeria demonstrate good efficiency according to the Variable Returns to Scale (VRS).
- ✓ The average efficiency score, according to the Variable Returns to Scale (VRS) model, was estimated at 71.43%. Ten Banks achieved efficiency, while four Banks did not.
- ✓ Private Banks are considered more efficient than public banks, as 3 out of 4 public Banks that are inefficient, struggled to optimize the combination of inputs and outputs despite holding advanced positions in terms of their level of activity compared to other banks.
- ✓ Inefficient Banks can achieve efficiency by optimizing their combination of inputs and outputs by emulating benchmark banks, which are a group of efficient Banks with activities similar to those of the inefficient banks.
- ✓ Data Envelopment Analysis (D.E.A) suggests a range of improvements that inefficient Banks can use to enhance their efficiency.

2. Recommendations of the Study

Based on the above, we can draw a set of recommendations, which are as follows:

- ✓ Inefficient Banks should reconsider their outputs and benefit from the suggested improvements to achieve efficiency.
- ✓ Algerian Banks can use quantitative methods to measure efficiency.
- ✓ Algerian Banks can rely on benchmarking methods, such as Data Envelopment Analysis (D.E.A), to assess their efficiency and compare it with other Banks operating in the Algerian banking system.

- ✓ The study recommends that Algerian Banks include efficiency indicators in their dashboards for better decision-making.
- ✓ Algerian Banks should use Data Envelopment Analysis (D.E.A) to compare their efficiency with Banks in other countries, such as Maghreb or African banks.

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VI. Appendices

Appendix 01: Outputs of the DEAP 1.2 Software for Calculating the Efficiency Score

```

Results from DEAP Version 2.1

Instruction file = eg1-ins.txt
Data file      = EG1-dta.txt

Output orientated DEA

Scale assumption: VRS

Slacks calculated using multi-stage method

EFFICIENCY SUMMARY:

firm  crste  vrste  scale
1    1.000  1.000  1.000  -
2    0.877  1.000  0.877  drs
3    0.921  0.976  0.944  drs
4    1.000  1.000  1.000  -
5    1.000  1.000  1.000  -
6    1.000  1.000  1.000  -
7    0.759  0.957  0.793  drs
8    0.899  0.899  1.000  -
9    0.959  0.960  0.999  irs
10   0.931  1.000  0.931  irs
11   0.874  1.000  0.874  irs
12   1.000  1.000  1.000  -
13   0.826  1.000  0.826  drs
14   1.000  1.000  1.000  -

mean  0.932  0.985  0.946

Note: crste = technical efficiency from CRS DEA
      vrste = technical efficiency from VRS DEA
      scale = scale efficiency = crste/vrste

```

Appendix 02: Outputs of the Data Envelopment Analysis (D.E.A) for BADR Bank

```

Results for firm:      3
Technical efficiency = 0.976
Scale efficiency      = 0.944 (drs)
PROJECTION SUMMARY:
  variable            original      radial      slack      projected
                        value         movement  movement  value
output  1  53777109.000  1336988.579  0.000  55114097.579
output  2  42660690.000  1060615.871  1195647.590  44916953.460
output  3  1246863493.000  30999105.014  0.000  1277862598.014
input   1  22056167.000    0.000  -7171245.807  14884921.193
input   2  1480774841.000    0.000  0.000  1480774841.000
LISTING OF PEERS:
peer  lambda weight
6     0.103
5     0.156
4     0.741

```

Appendix 03: Outputs of the Data Envelopment Analysis (D.E.A) for BNP Bank

```
Results for firm:      7
Technical efficiency = 0.957
Scale efficiency      = 0.793  (drs)
PROJECTION SUMMARY:
  variable            original      radial      slack      projected
                        value        movement  movement  value
output      1      16104189.000    726654.791    0.000    16830843.791
output      2      12679041.000    572104.928    906308.268    14157454.197
output      3      157229004.000    7094502.499    1856208.970    166179715.469
input       1       6727633.000        0.000    -857842.611    5869790.389
input       2      221970344.000        0.000    0.000    221970344.000
LISTING OF PEERS:
peer  lambda weight
  14    0.411
  13    0.589
```

Appendix 04: Outputs of the Data Envelopment Analysis (D.E.A) for CNEP Bank

```
Results for firm:      8
Technical efficiency = 0.899
Scale efficiency      = 1.000  (crs)
PROJECTION SUMMARY:
  variable            original      radial      slack      projected
                        value        movement  movement  value
output      1      38906136.000    4366290.385    6287985.522    49560411.906
output      2      33780760.000    3791088.572    6826682.638    44398531.210
output      3      1110198485.000    124593430.969    0.000    1234791915.969
input       1      14568016.000        0.000    0.000    14568016.000
input       2      1410094722.000        0.000    0.000    1410094722.000
LISTING OF PEERS:
peer  lambda weight
   6    0.319
  14    0.156
   4    0.525
```

Appendix 05: Outputs of the Data Envelopment Analysis (D.E.A) for CPA Bank

```
Results for firm:      9
Technical efficiency = 0.960
Scale efficiency      = 0.999  (irs)
PROJECTION SUMMARY:
  variable            original      radial      slack      projected
                        value        movement  movement  value
output      1       78678788.000    3273440.220    5844506.963    87796735.182
output      2       69274107.000    2882157.361    5434140.402    77590404.764
output      3      1955915694.000    81376102.270    0.000    2037291796.270
input       1      17656402.000        0.000    0.000    17656402.000
input       2      2429389106.000        0.000    0.000    2429389106.000
LISTING OF PEERS:
peer  lambda weight
   5    0.247
   6    0.635
  10    0.118
```