



Ministry of Higher Education and Scientific Research

University of Ahmed DRAIA ADRAR – Algeria -

Faculty of Economics, Business and Management Sciences

Department of Management Sciences

Specialty: Financial management

PhD dissertation

Measuring the technical efficiency in Algerian commercial banks

By using Stochastic Frontier Analysis model

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2024/2025

ACKNOWLEDGMENT

By way of recognition, I would like to express my sincere acknowledgment to all those who have contributed directly or indirectly to the development of this modest work.

My sincere gratitude to **Prf. BOUCHRA Abdelghani** for the quality of his advice and his undeniable interest in all students.

I would like to thank **my parents, my brother** for their meaningful advice.

In the impossibility of naming all the names, our sincere thanks go to all those who, near or far, have made it possible by their advice and their skills to carry out this thesis.

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Abstract:

Our topic aims to measure **the technical efficiency** of Algerian commercial banks during the period 2012-2021, taking into account the evolution of the banking sector over significant time periods, including historical developments and reforms within **the banking system**.

To address the research problem, we used the **SFA method** stochastic frontier analysis to estimate the cost and production functions from an economic perspective, given that this model ensures obtaining statistically accurate values and thus reduces the chances of large deviations between the extracted results and the actual reality as a result of global economic changes that directly affect developing countries. In this study, we rely on the analysis of key variables including: **Assets, own funds** and **operating cost** on deposits as inputs for the first stage of the study, as these factors are essential for a deeper understanding of the context surrounding deposit attraction, and short, medium, and long-term **deposits** as inputs for the second stage of the activity of these banks.

Our study made it possible to rank the commercial banks studied based on their technical efficiency, highlighting BEA as the most efficient bank due to better control of costs and production, in contrast to the prevailing situation with CNEP, BADR, and BDL, which were ranked the least efficient.

Key words: The banking system, technical efficiency, SFA method, Assets, own funds, operating cost, deposits.

Résumé :

Notre sujet vise à mesurer **l'efficacité technique** des banques commerciales algériennes au cours de la période 2012-2021, en tenant compte l'évolution du secteur bancaire sur plusieurs périodes importantes, y compris les développements historiques et les réformes au sein du **système bancaire**.

Pour répondre à la problématique de recherche, nous avons utilisé la **méthode SFA** l'analyse de frontière stochastique, pour estimer les fonctions de coût et de production d'un point de vue économique. Ce modèle garantit l'obtention de valeurs statistiquement précises et réduit ainsi les risques d'écarts importants entre les résultats extraits et la réalité, résultant des changements économiques mondiaux qui affectent directement les pays en développement. Dans cette étude, nous nous appuyons sur l'analyse de variables clés, notamment : **les actifs**, les **fonds propres** et **les charges d'exploitation** des dépôts comme intrants pour la première étape de l'étude, car ces facteurs sont essentiels pour une compréhension plus approfondie du contexte entourant l'attraction des dépôts, et les dépôts à court, moyen et long terme comme intrants pour la deuxième étape de l'activité de ces banques.

Notre étude a permis de classer les banques commerciales étudiées en fonction de leur efficacité technique, mettant en évidence la BEA comme la banque la plus efficace en raison d'une meilleure maîtrise de ces coûts et de production, contrairement à la situation qui prévaut avec la CNEP, la BADR et la BDL, qui ont été classées les moins performantes.

Mots clé : Le système bancaire, l'efficacité technique, la méthode SFA, fond propre, charges d'exploitation, les dépôts, actifs

الملخص:

يهدف هذا الموضوع إلى قياس الكفاءة التقنية للبنوك التجارية الجزائرية خلال الفترة 2012-2021، وذلك تبعا للتطور الذي عرفه القطاع البنكي عبر فترات زمنية مهمة، تمثلت في التطور التاريخي والإصلاحات التي شهدتها النظام المصرفي.

لمعالجة إشكالية البحث استخدمنا طريقة SFA تحليل حدود العينة العشوائية لتقدير دالتي التكلفة والإنتاج من منظور الاقتصادي، باعتبار أن هذا النموذج يضمن الحصول على قيم دقيقة احصائيا وبالتالي تقليل فرص الانحرافات الكبيرة بين النتائج المستخرجة والواقع الفعلي نتيجة للتغيرات الاقتصادية العالمية التي تؤثر بشكل مباشر على البلدان النامية، نعتمد في هذه الدراسة على تحليل متغيرات رئيسية تشمل: مصاريف بنكية، تثبيطات، رؤوس أموال على الودائع كمدخلات للمرحلة الأولى من الدراسة، حيث تعد هذه العوامل أساسية لفهم أعمق للسياق الذي يحيط باستقطاب الودائع، والودائع القصيرة والمتوسطة والطويلة الأجل كمدخلات للمرحلة الثانية من نشاط هذه البنوك.

أتاحت دراستنا وضع تصنيف البنوك التجارية المدروسة على أساس كفاءتها التقنية، حيث تم تسليط الضوء على BEA باعتباره البنك الأكثر كفاءة بسبب التحكم الأفضل في التكاليف والإنتاج، على عكس الوضع السائد ب CNEP و BADR و BDL التي صنفت أقل كفاءة.

الكلمات المفتاحية: القطاع البنكي، الكفاءة التقنية، تحليل حدود العينة العشوائية،

مصاريف بنكية، تثبيطات، رؤوس أموال، الودائع.

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Introduction:

Banks are one of the most important sources for financing investment projects in modern economic trends, their goals face a major conflict between achieving profitability, providing liquidity, which makes the banking job difficult and important issue at the same time.

This is explified by the extent of its ability to bring about an effective balance and compatibility between those goals, given that profitability is at the forefront in terms of importance while being hindered by two elements: providing the necessary liquidity and security for depositors.

After having chosen to turn to the market economy, Algeria was forced to launch a process of modernization of its banking sector and try to catch up with the delay in economic adaptation taken on its neighbors in particular Morocco and Tunisia.

The Algerian banking system as it stands today is the result of successive changes dictated by the changing financing needs of the national economy.

Thus, the Algerian State has been forced over the years to undertake a series of reforms whose purpose is underpinned by the objectives below:

- Strengthening the stability and profitability of the financial and banking sector;
- Strengthening the credit market and reducing the cost of intermediation;
- The modernization of information and payment systems to improve the quality of banking services;
- The development of the granting of credit for the financing of the needs of individuals (mortgage and consumer credit).

The nationalization of the banking system in Algeria between 1966 and 1968 provided the state with a significant instrument of development, which was previously dominated by foreign capital. This nationalization was imposed on the Algerian State, which, in addition to the desire to orient its economy towards the socialist pole, was confronted with the refusal of foreign banks to finance the economy of post-independence Algeria.

This is how the public sector was born, which was managed by the State via the Public Treasury and the planning body set up at the time for both the Central Bank and the primary banks.

Thus, between 1966 and 1967, the nationalization of foreign banks began which gave birth to three public commercial banks, namely the National Bank of Algeria BNA, the Algerian Popular Credit CPA & the Exterior Bank of Algeria BEA

GENERAL INTRODUCTION

What was most important for the public authorities at that time was to achieve in the short term the nationalization of the financing structures of the national economy in order to design an authentic Algerian banking system, which would serve the development of the country.

It was then in 1970, through the establishment of a finance law and the application of the first four-year plan 1970-1973 with the sacrament of the definitive choice of centralized planning as the system of organization of the national economy and thus, the establishment of credit distribution planning as an instrument for mobilizing and allocating available resources to finance productive investments in the public sector.

The principle that was applied is that "once the plan, in physical terms, is developed and approved, it remains to adapt a financing plan that allows its realization".

During this period, the Algerian banking system became exclusively public; the sector also became specialized by being organized by activity. Thus, national companies have been forced to concentrate their banking operations with a single bank.

The efficiency of the Algerian banking system varies depending on several factors, including the bank in question, regulatory policies, and economic conditions. Assessing the efficiency of this system also includes several aspects:

- ❖ Algerian banks' reliance on technology and digital banking services in customer service and operational processes.
- ❖ Ensuring the stability of banking systems to prevent financial malpractice through effective regulations.
- ❖ Speed of transaction processing, ease of access to banking services, and clear communication with customers contribute to increasing bank efficiency.
- ❖ Improving internal processes and improving risk management to reduce operating costs.
- ❖ Increasing profitability, asset quality, and capital adequacy take these into account when assessing banks' financial position.
- ❖ Effective credit scoring, effective loan portfolio management, and reducing non-performing loans are essential lending practices for the banking sector.
- ❖ Innovation and improved banking services provide an opportunity to enhance banking efficiency.

GENERAL INTRODUCTION

The efficiency of banks can change over time due to various factors, including changes in management, economic conditions and regulatory developments.

To assess the current efficiency of the Algerian banking system, we need access to updated financial reports and economic data and conduct a detailed analysis of specific banks. In addition, we may need to consult financial experts and regulatory authorities to make a more accurate and up-to-date assessment.

In addition to identifying common input and output variables among the studied banks.

In light of this, our study focused on measuring the extent of technical efficiency in Algerian commercial banks, in order to use the available inputs to reach the maximum outputs.

Our study relied on ' Stochastic Frontier Analysis' as a method of analysis.

➤ **The problem statement:**

The current field of research is a source of complex and diverse challenges that arise in scientific research. These challenges vary from technical to organizational aspects, which highlights the urgent need for a comprehensive study to understand the depths of the problem of measuring the technical efficiency of Algerian commercial banks.

In light of the above, we defined the research problem as follows:

What is the level of technical efficiency in Algerian commercial banks during the period 2012-2021?

➤ **Research questions:**

1. What is the structure of the Algerian banking system?
2. What we mean by the concept of efficiency?
3. How many kind of efficiency are there?
4. What are the different techniques of measurement technical efficiency?
5. What is SFA method?

➤ **Hypotheses:**

When measuring the technical efficiency of Algerian commercial banks, various hypotheses can be used to assess this.

These hypotheses are often used as a basis for building models and conducting empirical analyses.

The following are some hypotheses related to the main problem of our research:

- ❖ Changes and differences in banking systems in Algeria affect the technical efficiency of commercial banks.
- ❖ Strict regulatory requirements may lead to a decrease in technical efficiency due to compliance costs.
- ❖ Economic stability and growth in Algeria positively affect the technical efficiency of commercial banks.
- ❖ Periods of economic crisis or instability can lead to a decrease in technical efficiency due to increased default rates and credit risk.
- ❖ The technical efficiency rate of the Algerian banking system can be high.
- ❖ The technical efficiency rates of Algerian commercial banks vary depending on the size of the bank.

➤ **Aims of the study:**

This study aims to:

- Highlight the importance of banks as an influential factor in the money supply, which leads us to measure their technical efficiency.
 - Optimize the use of a set of inputs to achieve the highest percentage of outputs.
 - Use financial performance analysis (SFA) to measure the efficiency of the Algerian banking sector, enabling analysts to assess how effectively these banks utilize their resources to produce financial services and manage risks.
 - Understand the sources of inefficiency to formulate targeted strategies for improvement.
- Financial performance analysis allows for the analysis of overall inefficiency into its various components. This analysis can reveal sources of inefficiency, whether they result from inadequate management practices, suboptimal resource allocation, or other factors.

GENERAL INTRODUCTION

- Provide insight into the performance of Algerian banks compared to their global peers, allowing researchers and policymakers to use the results to compare the efficiency levels of Algerian commercial banks with international standards.

- Highlight the extent to which banks are successfully managing risk. Banks that operate with high technical efficiency are often better prepared to deal with unexpected shocks and financial crises, making them more resilient.
- Enhancing investor and stakeholder confidence in the banking sector through transparent assessments of Algerian technical competence.

- Providing a case study for researchers and students interested in applying quantitative methods, such as integrated financial performance analysis, to banking and finance.

- Enhancing operational effectiveness and contributing to fostering a culture of continuous improvement within the Algerian commercial banking sector.

➤ **Significance of study:**

Measuring the technical efficiency of Algerian commercial banks is of great importance to various stakeholders, including the government, regulatory bodies, the banks themselves, investors and the broader economy:

- Assessing technical efficiency helps banks identify deficiencies in resource allocation, and thus improve the use of their resources. Banks can redirect funds and manpower to more productive areas, improving profitability and customer service;

- Measuring efficiency can help regulators ensure the stability of the banking sector and reduce the risk of systemic failure;

- Efficient banks tend to provide faster and more cost-effective services to their customers. Improving customer satisfaction can increase customer loyalty and business growth;

- Investors, both local and foreign, are looking for efficient banks to deposit their money. Measuring efficiency provides transparency and helps attract investment, which can support economic development;

- Policy makers can use efficiency measurements to guide regulatory decisions. For example, if certain regulations are found to hinder efficiency, policymakers may consider reforms to encourage a more competitive banking sector;

- Efficient banks are often better at managing credit, operational and other types of risks. This would reduce the likelihood of financial crises and taxpayer-funded bailouts;

GENERAL INTRODUCTION

- Efficient banks generate more outputs (loans and services) from the same amount of inputs (capital and labor). This enhanced productivity can have positive side effects on the broader economy;

- A well-functioning and efficient banking sector is essential for economic growth. Efficient banks can provide the necessary financing to companies and individuals, and stimulate investment and consumption.

- Measuring efficiency allows setting international standards. Comparing the efficiency of Algerian banks with global standards can help identify areas for improvement and modernization.

- Banks that measure and strive to improve efficiency often develop a culture of operational excellence. This culture permeates the organization and can lead to continuous improvement in processes and customer service;

The importance of the study lies in that it examines one of the fundamental issues that preoccupy banking thought in the global financial arena.

It revolves around the way Algerian commercial banks deal with the most important problem facing the real-time gross settlement system, which would generate systemic risks that could lead to the collapse of the local and global banking and financial system. It is the problem of liquidity based on attracting it to employing it more efficiently in the instant gross settlement system.

➤ **Limitation of the study:**

The various difficulties of study can be summarized in three basic points:

- ❖ Difficulties related to measuring technical efficiency;

- ❖ Difficulties related to using the R program;

- ❖ Difficulties related to measuring technical efficiency:

- The difficulty of obtaining accurate and standardized numerical statistics for each commercial bank under study over a long period.

- The availability of accurate and up-to-date financial and operational data is a significant challenge in Algeria, given the lack of a well-established and transparent reporting system.

GENERAL INTRODUCTION

- The impact of the quality of available data on the accuracy of efficiency measurements.
- The difficulty of establishing benchmarks, as it may be difficult to find appropriate groups or reference points, especially in a region with unique economic and regulatory conditions.
- The presence of hidden costs associated with operating in Algeria, such as political and security risks, which are difficult to measure but can significantly impact bank efficiency.
- The instability and performance of the Algerian economy due to factors such as oil prices, political unrest, and government policies. These macroeconomic factors can have a significant impact on the efficiency of commercial banks.
- The adoption of modern banking technologies and practices varies among Algerian banks, which may impact their technical efficiency. However, accurately measuring the impact of technology adoption can be complex.
- The inability to adequately capture the cultural and social factors that influence banking practices and customer preferences in Algeria in traditional efficiency measures. The diversity and number of banks in Algeria are limited, which can make it difficult to conduct a comprehensive analysis of the technical efficiency of each individual bank.
- The impact of short-term fluctuations on the performance of banks' actual efficiency, as efficiency analysis often requires a sufficient time horizon to accurately capture trends and changes.

❖ Difficulties related to using the R program:

Some of the challenges encountered when using R language in our study:

- The R language contains special rules considering that we are using it for the first time.
- Performance issues when working with large sets of data as R stores all data permanently in memory, causing errors or slowing down the code.
- Operations take longer compared to other faster languages.
- The R language contains a large group of packages for various tasks, as some packages were incompatible with each other, which made the troubleshooting process complicated.

GENERAL INTRODUCTION

- Integrating and processing large data sets requires specific skills and can be more difficult compared to other languages.

Analyzing the technical efficiency of banks is a complex task due to various challenges and difficulties:

- During the financial crises in Algeria, it is difficult to access comprehensive and accurate data on the financial performance of banks.

- Different accounting standards and reporting practices prevent the collection and analysis of data.

- It is difficult to establish a unified standard for comparison due to the difference in size, business models and operational strategies of banks, and this difference in the scope of services provided, geographical reach, and customer base has affected the evaluation of efficiency.

- Identifying and measuring the inputs that can include capital, labor, technology, and more and the outputs of banks that can be loans, deposits, income from fees, etc. is not easy, and aggregating these inputs and outputs into useful measures for analyzing efficiency may be subjective and requires careful study.

- Difficulty in choosing the functional form by assuming a specific production or cost function based on the results.

- Regulatory changes, government interventions, and economic conditions greatly affect the operations and efficiency of the bank, which makes it difficult to isolate the impact of the bank's internal operations on efficiency.

- The possibility of internal problems affecting efficiency levels and being affected by them at the same time, which complicates causal inference.

- The impact of economies of scale and scope on bank efficiency. Large banks may benefit from size, while smaller banks may outperform in niche markets, making direct comparisons difficult.

- Our efficiency analysis is based on time series data. Long-term trends and short-term fluctuations make it difficult to draw meaningful conclusions.

- Efficiency is multidimensional, so analyzing all of these dimensions is complex and requires different approaches

➤ **The period of the study:**

The period of study of the technical efficiency of Algerian commercial banks was chosen after considering the periods that witnessed major transformations in the adoption of technology and improvement of banking infrastructure, based on the historical transformations that the banking sector in Algeria has undergone, from digital transformations, strengthening infrastructure, increasing competition, focusing on financial inclusion, and interacting with crises.

Since the period from 2010 to the present is considered the most appropriate for studying the technical efficiency of Algerian commercial banks, this period reflects a great development in adopting technology and modernizing the banking infrastructure, which makes it a period rich in lessons and analyses about the technical efficiency of banks.

Accordingly, our study was limited to calculating the technical efficiency of a type of Algerian banks: commercial banks during the period 2012-2021,

➤ **Methodology of study:**

In our research, we used the descriptive method to clarify the Algerian banking system on the one hand and the analytical econometric method to obtain the results of our data on the other hand

In the applied aspect of the study of technical efficiency, we used the SFA method, as a process of evaluating and examining the results drawn from a random sample represented by Algerian commercial banks, with the aim of generalizing these results to the entire community represented by the banking sector.

Analysis of the limits of the stochastic frontier helped us to enhance good representativeness, by achieving results with high statistical accuracy that reflect the actual situation of the sector, and reducing the possibility of bias and statistical deviations.

Through the method used, we estimated expected values, standard deviations, and other statistical indicators to achieve accurate representation, and examined disparities between the sample groups and the overall population to determine the extent of similarity or difference.

➤ **The diversity of research:**

Our research has been divided into three chapters:

Chapter one: The technical efficiency in Algerian commercial banks;

Introduction of chapter

Section 1: Algerian-banking system

Section 2: technical efficiency

Section 3: The SFA Stochastic Frontier Analysis method

Conclusion of chapter

Chapter two: Study methodology and procedures;

Introduction of chapter

Section 1: Methodology of the study

Section 2: Case study data and stages

Conclusion of chapter

Chapter three: Results and discussion

Introduction of chapter

Section 1: Criteria used to interpret the results of measuring the technical efficiency of commercial banks

Section2: First stage: creation of deposits

Section3: View and test results of the second step

Conclusion of chapter

Chapter one:

**The technical efficiency in Algerian
commercial banks**

CHAPTER ONE: THE TECHNICAL EFFICIENCY IN ALGERIAN COMMERCIAL BANKS

Introduction of chapter:

Efficiency constitutes one of the major foundations of research carried out in management sciences. Correlatively, this quest for efficiency is the basis of the daily practice of banks and constitutes their main objective.

The term "efficiency" is widely used in the field of management but with a multitude of definitions and as Payette (1997) points out: "there is no universal and global definition of efficiency, and it is useful to look for one."

In practice, efficiency is a generic notion, it is based on three main dimensions: economic efficiency, financial efficiency, and competitive efficiency. A fourth dimension linked to informational efficiency has recently been adopted in the literature (Joumady, (2001)).

Accordingly, we shed light during this topic on defining the Algerian banking sector and highlighting the concept of efficiency in general and technical efficiency in particular, in addition to how to measure it.

Section 1: Algerian-banking system

The banks were therefore specialized by sector of activity and developed financial instruments according to the guidelines given by the State.

The financing of the economy was based on budgetary savings, the mobilization of domestic savings not constituting at the time, a priority for the national banks and the private sector was marginalized occupying only a tiny part of the portfolio of these banks.

It was following the financial crisis that occurred in the 1980s that highlighted budgetary constraints leading the State to decide to disengage from financing the national economy with the aim of getting out of the financing crisis through external debt, as a priority, the restoration of balances at the macro-economic level.

In the banking sector, the implementation of this new policy was manifested by the transformation of public banks from 1989 into joint-stock companies subject to the rules of the Commercial Code as well as the start of a program of consolidation and restructuring of the public industrial sector thus enabling the banks to clean up part of their customer portfolios.

In addition to these large-scale transformations, the banks began major projects in 1993 to update their computer systems and adapt their activities to new market requirements.

In the continuity of the reforms in the banking sector, it was the year of 1991 which marked the liberalization of foreign trade in Algeria with thereafter, the institution of the commercial convertibility of the dinar in 1994 in particular thanks to the rescheduling of external debt.

1. Definition of a bank:

According to Walter Leaf : “A bank is a person or corporation which holds itself out to Receive from the public, deposits payable on demand by cheques. ”

Horace White has defined a bank: “as a manufacture of credit and a machine for facilitating exchange.”

According to Prof. Kinley, “A bank is an establishment which makes to individuals such advances of money as may be required and safely made, and to which individuals entrust money when not required by them for use.”

Thus, we can say that a bank is a financial institution which deals in debts and credits.

CHAPTER ONE: THE TECHNICAL EFFICIENCY IN ALGERIAN COMMERCIAL BANKS

It accepts deposits, lends money and also creates money. It bridges the gap between the Savers and borrowers. Banks are not merely traders in money but also in an important sense manufacturers of money

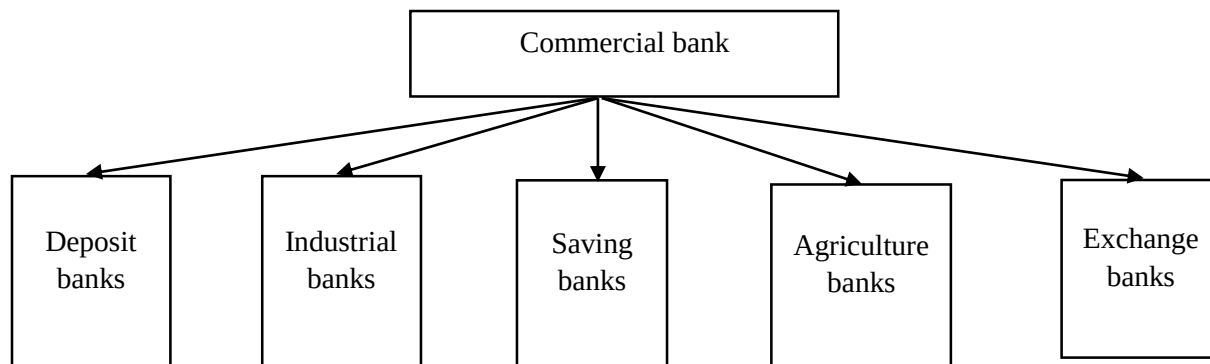
2. Types of banks:

Banks can be classified into commercial banks and central bank,

Commercial banks are those which provide banking services for profit.

The central bank has the function of controlling commercial banks and various other economic activities. There are many types of commercial banks such as deposit banks, industrial banks, savings banks, agricultural banks, exchange banks, and miscellaneous banks.

Fig.1. types of banks



Source: by researcher

✓ Deposit banks:

They are considered one of the most important types of commercial banks, and have a direct connection with the commercial class of people; as they receive the sum of deposits for a short period and provide loans to needy parties, in addition to granting loans for a short period (a period ranging from 3 to 6 months).

✓ Industrial banks:

This type of bank helps industrialists by requesting a large long-term capital for the purpose of purchasing machinery and equipment. In addition to granting long-term industrial loans. Among the most important basic functions of this type of bank, we find:

CHAPTER ONE: THE TECHNICAL EFFICIENCY IN ALGERIAN COMMERCIAL BANKS

- Accepting long-term deposits.
- Granting long-term loans for the purpose of meeting the credit requirements of industries.
- Consultations for industrial companies regarding the sale and purchase of stocks and bonds.

✓ *Savings banks:*

This type of bank helps the poor and the middle class by encouraging them to save, and they also receive deposits in the form of small amounts.

✓ *Agricultural banks:*

These banks are organized on the basis of cooperatives; It meets the credit requirements of farmers through term loans, which are short, medium and long term loans. Its objectives are far from the principle of achieving maximum profit for shareholders.

✓ *Exchange Banks:*

These banks operate on the principle of buying and selling foreign currencies and also help businessmen in their transactions. These banks practice ordinary banking business with the aim of financing the country's foreign trade mostly, they mainly discount, accept and collect foreign bills of exchange. (ABOURA & Dr CHAHIDI , 2019, p. 2)

3. **Objects of banks in Algeria:**

The primary objectives of banks in Algeria, like banks in most countries, revolve around providing essential financial services to individuals, businesses, and the government while contributing to economic development and stability. Here are some of the key objectives of banks in Algeria (ABOURA & Dr CHAHIDI , 2019, p. 2):

✓ **Financial Intermediation:** Banks in Algeria act as intermediaries by accepting deposits from individuals, businesses, and institutions and then using these funds to provide loans and credit to borrowers. This intermediation facilitates the efficient allocation of financial resources and supports economic growth.

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- ✓ **Credit Provision:** Banks aim to provide credit to various sectors of the economy, including individuals seeking consumer loans, businesses looking for working capital or investment financing, and the government requiring funds for public projects.
- ✓ **Savings Mobilization:** Banks encourage individuals and businesses to save by offering a range of deposit products. These deposits provide the banks with funds that can be used for lending and investment purposes.
- ✓ **Payment Services:** Banks offer payment and settlement services, allowing individuals and businesses to conduct transactions, make payments, and transfer funds efficiently. This is essential for facilitating economic activities and trade.
- ✓ **Financial Inclusion:** Banks work toward extending access to formal financial services to underserved and marginalized populations. This can help reduce poverty, improve livelihoods, and foster economic inclusion.
- ✓ **Risk Management:** Banks provide various financial products and services that help clients manage risks, including insurance products, investment diversification options, and hedging services.
- ✓ **Foreign Exchange Services:** Banks facilitate foreign exchange transactions, allowing individuals and businesses to exchange currencies for international trade and transactions.
- ✓ **Government Support:** Banks participate in government financing by purchasing government bonds and providing funds for public projects. This helps the government raise necessary funds for development initiatives and public services.
- ✓ **Investment Services:** Many banks in Algeria offer investment advisory services and financial products to help clients manage their investment portfolios effectively.
- ✓ **Strengthening Financial Stability:** Banks play a role in maintaining financial stability by managing risks, adhering to prudential regulations, and working closely with regulatory authorities to ensure the soundness of the financial system.
- ✓ **Promoting Economic Development:** By providing loans to businesses, funding infrastructure projects, and supporting various economic activities, banks contribute to overall economic development and growth in Algeria.

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✓ **Monetary Policy Implementation:** Banks play a role in transmitting monetary policy set by the central bank. Through their lending and borrowing activities, they help influence money supply, interest rates, and inflation rates.

✓ **Customer Service and Satisfaction:** Banks strive to provide excellent customer service, meeting the financial needs of their clients while building trust and long-term relationships.

✓ **Innovation and Technology:** Modern banks aim to leverage technological advancements to offer innovative financial products and services, enhancing convenience, accessibility, and efficiency for their customers

4. Developments in the Algerian banking sector:

The banking sector is supervised by the Monetary and Credit Council and the Bank of Algeria, where the Monetary and Credit Law of 1990 sets the conditions for banking practices and specifies the rules that banks must adhere to in order to obtain the approval of the Bank of Algeria; which is mainly that bank funds must reach 8% of contracts concluded before December 1999.

The Algerian banking system includes six public banks (CPA, BNA, BEA, BADR, BDL, CNEP) and the Bank of Facilities (a branch of the Algerian Development Bank).

There are no longer specialized institutions such as deposit banks/development banks, nor, in theory, allocations based on the economic activities of customers, nor restrictions on the duration of credit (without prejudice to the different reserve ratios); (Dr AOUAD Hadjar Soumia & Dr BENZAI, 2018, p. 10)

Chaired by the Governor of the Bank of Algeria, and licensing and regulating the opening of private banking institutions in Algeria under the Monetary and Credit Law, decisions are taken on applications submitted by the Monetary and Credit Council, where BNA, CPA and CNEP have obtained the approval of the Bank of Algeria among the six commercial banks. (Dr AOUAD Hadjar Soumia & Dr BENZAI, 2018, p. 19);

Private banking institutions in Algeria are opened licensed and regulated under the Monetary and Credit Law, where no development of banking activities was recorded between 1990 and 1996, except in two important banking institutions:

- Al Baraka Islamic Bank, in 1991, 50% owned by the Dallah Al Baraka Group, Jeddah.

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- Al Ittihad Bank, established in 1995, owned by a small number of Algerian businessmen.

The Monetary and Credit Council also approved in September 1997 the creation of:

- A subsidiary of Citibank, which has an actual representative office. This required a slight change in name without changing its activities. On January 31, 1999, Citibank became the first foreign institution to obtain approval as a "specialist in treasury assets" (SVT), and to participate in stocks and common stocks.

- A subsidiary of the Arab Banking Corporation (ABC). Arab Banking Corporation - Algeria held its founding assembly in January 1988 and opened its first office on 2nd November, 1998. During its session held on February 8, 1998, the Monetary and Credit Council gave its approval for the creation of Societe Generale Algeria. The second office was opened in Oran at the end of 1999.

Societe Generale Algeria's activities include:

- International trade brokerage for those wishing to have a collective network,
- Commercial clients involved in mergers, acquisitions, privatizations and bond issuances.
- Development of the Algerian financial market,
- Letters of credit or capital, foreign companies and joint ventures established in Algeria,
- Algerian private savings abroad are estimated at around \$ 35 billion by private clients

Final participation in the management of financing granted by the SFI, BAD, BEI or AFD and aimed at supporting the development of the private sector in Algeria.

The Bank Popular Natexis-Banks obtained the approval of the Bank of Algeria in July 1998, enabling it to open a branch in Algiers.

Finally, two financial institutions were established at that time, financed by private Algerian capital: Khalifa Bank (10 branch offices nationwide) and Mona Bank (Algiers and Oran). (Guernane & Slimani , p. 16)

5. Structure of the Algerian banking system:

The Algerian banking system today consists of 29 banks and institutions financial. There are 20 banks, 06 of which are public and 14 private. These are all foreigners. There are also 03 financial institutions (02 public financial institutions and 01 other private), 05 leasing companies (03 public companies and 02 private) and 01 mutual agricultural insurance which, since 2009, has taken on the status of a financial institution.

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➤ **Public banks :**

Public banks in Algeria provide financial intermediation. As it was indicated later, the public banks come close to monopolizing the banking market. The Algerian banking system comprises six public banks, which are:

- ✓ The National Bank of Algeria BNA ;
- ✓ The External Bank of Algeria BEA;
- ✓ The Popular Credit of Algeria CPA;
- ✓ The Bank of Agriculture and Rural Development BADR;
- ✓ The BDL Local Development Bank;
- ✓ The National Savings and Provident Fund (CNEP-BANQUE). (Amina, 2017/2018, p. 158)

➤ **Private banks :**

Although their market share remains low compared to public banks, since 2003, private banks nonetheless experienced a very rapid growth. As confirmed by Bank of Algeria annual reports, private banks are increasingly involved in banking intermediation in Algeria, whether in relation to the collection of resources or the financing of the economy.

They are named as follows:

- Al Baraka Bank Algeria (Bahrain);
- Al Salam Bank-Algeria (Cooperation Council of Arab Golf States);
- Arab Bank Corporation;
- Algeria (subsidiary of ABC-bank Bahrain);
- Arab Bank PLC-Algeria (Jordanian subsidiary);
- BNP Paribas AL Djazair (French subsidiary);
- Calyon Algeria (French subsidiary) ;
- Citibank Algeria (subsidiary of the American group citigroup);
- Fransabank El Djazair SPA (Spanish Subsidiary);
- Gulf Bank Algeria (Kuwait) ;
- HSBC Algeria (subsidiary of the British group Hongkong Shanghai Banking Corporation);

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- Natixis Algeria (French subsidiary of the BPCE group: Banque Populaire Caisse d'économie);
- Societe Generale Algeria (French subsidiary);
- The Housing Bank for Trade and Finance;
- Algeria (Jordanian subsidiary);
- Trust Bank Algeria majority-owned by Trust Algérie Investment Co (don't main investors are members of the Abu Nahl family) and Jordan Expatriates Investment Holding Company. (Amina, 2017/2018, p. 158)

➤ **Financial institutions and leasing companies :**

In addition to state-owned national banks and foreign private banks, the Algerian banking system also includes financial institutions and companies of following leases:

- The Mortgage Refinancing Company (SRH);
- The Financial Company for Investment, Participation and Placement (Sofinance SPA);
- Arab Leasing Corporation (ALC);
- Maghreb Leasing Algeria (MLA Leasing);
- Cetelem Algeria ;
- The National Agricultural Mutual Fund "Financial Institution" (CNMA);
- The National SPA Leasing Company (SNL). (Amina, 2017/2018, p. 159)

6. The importance of the Algerian banking system:

The importance of the Algerian banking system lies in the fundamental role it plays in the country's economy by facilitating economic exchanges and activities, providing basic financial facilities and services, in addition to contributing to comprehensive economic development.

The following is a summary of the main points explaining the importance of the Algerian banking system in the national economy (Amina, 2017/2018, p. 52):

- ✓ Algerian banks play a key role between savers and borrowers, as they collect deposits from individuals and institutions and direct these funds to borrowing operations to encourage investment operations efficiently, with the aim of supporting economic growth;

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- ✓ Helping individuals finance their expenses such as housing and equipment, as banks provide borrowing services to individuals and companies to expand and invest in new projects and create jobs;
- ✓ Contributing to financing major infrastructure projects and development initiatives, and enhancing economic productivity and competitiveness;
- ✓ Providing job opportunities and increasing the employment rate;
- ✓ Providing various savings and deposit products to encourage individuals and companies to save money. Then using deposits to finance loans and investments, and stimulating economic activity;
- ✓ Facilitating transactions and payments, in addition to ensuring effective payment systems for goods and services;
- ✓ Facilitating international trade by providing trade finance services such as export financing;
- ✓ Enhancing investor confidence and attracting foreign investment, by attracting foreign investors and companies by highlighting the stability of the financial sector;
- ✓ Providing diverse financial services to help customers manage risk and diversify investments;
- ✓ Implementing the monetary policy programmed by the Central Bank of Algeria, through adjusting interest rates and other policy tools;
- ✓ Contributing to the embodiment of financial inclusion by providing formal financial services to individuals and companies previously excluded from the financial sector. In addition to increasing economic development;
- ✓ Managing government finances by providing funding for public projects and initiatives.

7. The weight of commercial banks in the Algerian banking system:

Commercial banks play a fundamental role in the financial mediation process, as they constitute the backbone of the Algerian banking sector, providing a range of diverse services, mainly represented in: (BENKHEZNADJI, GAIDI, & BENTOUMI, 2018, p. 9):

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- ✓ Commercial banks occupy an important position in the Algerian banking sector, both in terms of the number of institutions and the total assets they manage;
- ✓ Commercial banks in Algeria meet the financial needs of individuals and businesses, offering a range of services including savings accounts, current accounts, loan facilities, foreign exchange services, and various investment products;
- ✓ Banks expand the infrastructure of investment businesses through their financial intermediation role from savers to borrowers, accepting deposits from individuals and businesses and, in return, lending these funds to borrowers who need capital for various purposes;
- ✓ Commercial banks manage government accounts, process payments, and distribute salaries and pensions;
- ✓ Allocating and extending credit within the economy, thereby promoting economic growth and development;
- ✓ Commercial banks facilitate foreign exchange transactions, which are vital for international trade and investment;
- ✓ The stability and robustness of commercial banks ensures the overall stability of the financial system;
- ✓ Commercial banks in Algeria have enhanced their services by adopting modern banking technologies and digital platforms, which facilitate banking services.

8. Definition of commercial banks:

Commercial banks are defined as financial institutions that provide a wide range of financial services to individuals and institutions. These services include accepting funds, creating deposits, then investing them and granting loans, in addition to facilitating the transfer of funds, providing investment services, and various types of financial products from savings accounts, current accounts, and certificates of deposit. (Amina, 2017/2018, p. 20)

9. Characteristics of commercial banks:

Characteristics of commercial banks include (ABOURA & Dr CHAHIDI , 2019, p. 45):

- ✓ Commercial banks accept deposits from customers, then use them to create loans and financial services.
- ✓ Commercial banks primarily provide loans to individuals and businesses, to finance and expand their projects.
- ✓ Commercial banks facilitate the movement of funds by providing several services
- ✓ Offering financial products that help their applicants manage risks,
- ✓ Providing investment services and helping clients manage their investment portfolios.
- ✓ Providing foreign exchange services, allowing customers to exchange currencies for international transactions.
- ✓ Providing safekeeping services for items such as documents, jewelry, and other assets
- ✓ Making a profit from the difference between interest rates on loans and interest rates on deposits, as commercial banks charge higher interest rates on loans than they do on deposits
- ✓ Ensuring the stability of commercial banks and their compliance with financial regulations is done by subjecting them to strict regulatory supervision by government agencies.

10. Role of Algerian commercial banks:

The role of commercial banks includes several functions that contribute to economic growth, financial stability and comprehensive development, as they play a crucial role in the country's economy by providing financial services to their customers. We summarize this as follows (Guernane & Slimani , p. 17):

- ✓ Commercial banks in Algeria act as intermediaries between depositors and borrowers. They accept deposits and then lend them to borrowers for various purposes;
- ✓ Commercial banks provide credit to various sectors of the economy, by granting loans and facilities to companies to support their operations and promote entrepreneurship;

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- ✓ Provide deposit products, such as savings accounts, fixed deposits, and certificates of deposit, that can be used for lending and investment;
- ✓ Providing payment and settlement services that facilitate the movement of funds within and outside the country, such as wire transfers, electronic transfers, and payment processing to support commercial transactions;
- ✓ Provide trade finance services, facilitating cross-border transactions and mitigating the risks associated with international trade;
- ✓ Providing foreign exchange services, converting currencies for international transactions for travel;
- ✓ Helping clients manage their finances, make investment decisions and plan for the future, by providing investment advice and retirement planning;
- ✓ Assisting clients in diversifying their investment portfolios through the provision of investment products such as mutual funds, stocks, bonds, and other securities;
- ✓ Purchase government bonds and provide funds for public projects to participate in government financing and infrastructure projects;
- ✓ Helping clients manage risks by providing various financial services;
- ✓ Contributing to financial inclusion by providing banking services;
- ✓ Drive economic growth in Algeria, by providing financing, promoting investment, and thus facilitating economic activities;
- ✓ Implementing the monetary policy set by the central bank. By influencing interest rates, money supply, and inflation rates in the economy.

11. Function of Commercial Banks:

“Banking refers to the activity of accepting deposits of money from the public for the purpose of lending or investment, which are repayable on demand or otherwise, and can be withdrawn by cheques, drafts, orders, or other means”.

We can conclude that the functions of banks are accepts deposits and lending of these deposits.

The business of commercial banks is primarily to keep deposits and make loan and advances for short-period up to one or two years made to industry and trade either by the system

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of overdrafts of an agreed amount or by discounting bills of exchange to make profit to the shareholders.

Functions of commercial banks are classified into two main categories (Guernane & Slimani , p. 14):

- Primary functions,
- Secondary functions.

❖ The basic functions of commercial banks:

The main functions of commercial banks are as follows:

- The function of accepting deposits in its two forms: current deposits, savings deposits and fixed deposits, where surplus balances are collected and temporary needs of commercial transactions are financed.

Accordingly, the first task of the bank is to collect savings by accepting deposits from its customers, which are divided into three types:

✓ Current Account Deposits:

These deposits are payable on demand and hence are called demand deposits.

✓ Fixed Deposits (Term Deposits):

Fixed deposits have a fixed maturity period and are referred to as term deposits, which can only be withdrawn after the maturity of the specified fixed period.

✓ Savings Account Deposits:

This type combines the features of both current account and fixed deposits, its main purpose is savings.

- The second main function of a commercial bank is to grant loans and earn interest from them. Accordingly, it represents the main source of income for the bank, as the bank keeps a certain portion of its deposits as a reserve and grants the balance as loans and advances in the form of cash credit, on-demand loans, short-term loans and overdrafts.

✓ Through this function, the commercial bank grants the eligible borrower a credit limit that allows him to withdraw a certain amount from a certain collateral, where the withdrawal capacity of the eligible borrower depends on the borrower's current assets, the inventory statement of which is submitted to the bank as the basis of the collateral, and for this, the bank charges interest on the withdrawn portion (loan).

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✓ In this function, the entire loan amount is deposited in one lump sum into the borrower's loan account, and the loan that can be repaid on demand is called a demand loan and there is no fixed maturity date in this type of loan.

✓ Short-term loans are granted against certain collateral as personal loans to finance working capital or as advances to priority sectors, where the full amount is repaid either in one installment or in a number of installments over the period of borrowing.

❖ Secondary functions:

In addition to the primary functions mentioned above, commercial banks also perform secondary functions, which are mainly:

- The commercial banks provide the facility of discounting of bills to its depositors. A bill of exchange represents a promise to pay a fixed amount of money at a specific point of time in future. It can also be encashed earlier through discounting process of a commercial bank. Alternatively, a bill of exchange is a document acknowledging an amount of money owed in consideration of goods received.

- Credit creation

- Providing foreign trade financing facilities to its customers by accepting and collecting foreign bills from foreign banks, in addition to carrying out foreign exchange business and buying and selling foreign currencies.

- Providing facilities to the depositor to withdraw overdrafts for an amount greater than the amount remaining in his account, where depositors in the current account enter into an agreement with the banks that if they withdraw cheques not covered by the deposit, the bank shall grant them overdrafts and honour the cheques, the difference between overdraft facility and loan is that in case of overdraft it is done without security in the current account, where the borrower is given the facility of borrowing only as much as he needs, but on the other hand loans are granted against security and the borrower has to pay interest on the full approved amount.

- The bank acts as an agent for its clients and gets commission for performing the following agency functions:

✓ Collect and transfer funds

✓ The bank pays taxes, insurance premiums, bills, etc. as directed by its customers.

✓ Buy and sell stocks and securities

- ✓ Collect dividends and interest
- ✓ Provide information about the economic status of its customers

12. Elements of Algerian commercial banks:

Algerian commercial banks consist of different main elements that together form the basis of their operations and services. These elements enable them to provide a wide range of financial services to customers. These elements are mainly represented in (BENKHEZNADJI, GAIDI, & BENTOUMI, 2018, p. 10):

- ✓ **Physical Branches and Locations:** Commercial banks have physical branches and offices where customers can conduct various banking transactions, including deposits, withdrawals, loan applications, and consultations with bank staff.
- ✓ **Management and Staff:** Banks are led by executive management teams that oversee the bank's overall strategy, operations, and risk management. Banks also employ a diverse range of staff, including bankers, customer service representatives, loan officers, financial advisors, and support personnel.
- ✓ **Deposits and Savings Products:** Commercial banks offer various types of deposit accounts, such as savings accounts, checking accounts, time deposits (fixed-term deposits), and certificates of deposit (CDs). These accounts allow customers to save money and earn interest.
- ✓ **Lending and Credit Services:** One of the primary functions of commercial banks is to provide loans and credit to individuals and businesses. They offer various types of loans, including personal loans, business loans, mortgages, and credit lines.
- ✓ **Payment Services:** Banks provide payment services that enable customers to transfer money, pay bills, make purchases, and conduct other financial transactions. These services include wire transfers, electronic funds transfers (EFTs), and payment processing.
- ✓ **Foreign Exchange Services:** Many commercial banks offer foreign exchange services, allowing customers to buy and sell different currencies for international trade, travel, and investment purposes.
- ✓ **Trade Finance:** Commercial banks assist businesses engaged in international trade by providing trade finance services, such as letters of credit, export financing, and foreign exchange services to facilitate cross-border transactions.

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- ✓ **Investment Products and Services:** Banks offer investment options to help customers grow their wealth, including investment funds, stocks, bonds, and other securities.
- ✓ **Risk Management:** Banks provide risk management solutions, such as insurance products, derivatives, and hedging services, to help customers mitigate financial risks.
- ✓ **Technology and Digital Services:** Modern commercial banks in Algeria use technology to provide online banking, mobile apps, and digital services that enable customers to manage their accounts, make transactions, and access information remotely.
- ✓ **Regulatory Compliance:** Banks must adhere to regulations and guidelines set by Algerian financial authorities to ensure their operations are conducted in a safe, sound, and ethical manner.
- ✓ **Customer Support:** Banks offer customer support services to assist customers with inquiries, issues, and concerns related to their accounts and transactions.
- ✓ **ATMs (Automated Teller Machines):** Commercial banks have ATMs that allow customers to perform basic banking transactions, such as withdrawing cash, checking balances, and making deposits, outside of regular banking hours.
- ✓ **Financial Advisory:** Some commercial banks provide financial advisory services, offering expert guidance on managing money, making investments, and planning for retirement or other financial goals.
- ✓ **Monetary Policy Transmission:** Commercial banks play a role in transmitting the effects of monetary policy set by the central bank to the broader economy through their lending and borrowing activities.
- ✓ **Community Engagement:** Many commercial banks engage in corporate social responsibility activities and community outreach to support local development initiatives and social causes.

Section 2: technical efficiency

1. The concept of efficiency:

Efficiency is the dimension most mentioned, whether by researchers or practitioners, in the attempts to define the performance construct. The concept of "efficiency" of a production unit can be considered as new in science of management. Researchers, until 1950, considered resources efficient used under the assumption of full employment. The first works on the concept of efficiency are attributed to Koopmans (1951);

In addition, many factors such as competition, technical progress and the scarcity of riches have influenced theoretical researchers and decision-makers to study closely efficient use of resources. From 1957, this work gave more clarity in the concept by distinguishing technical efficiency from allocative efficiency. (Selcuk & Tuba , 2021, p. 10)

1.1. Differentiation between effectiveness and efficiency:

Before analyzing the concept of efficiency, it is necessary to underline the ambiguity on the notion of effectiveness and efficiency. As indicated, performance covers several concepts including effectiveness, efficiency and productivity. We have noticed that a lot of research and articles find that the terms efficiency and effectiveness are interchangeable (researchers often translate "efficiency" to "effectiveness"). However, the two concepts are distinct;

For March & Sutton (1997), an organization can be very effective without being efficient and it can achieve relatively high levels of efficiency without necessarily being effective;

Therefore, it is essential to pay some attention to the ambiguity that exists between the two concepts. A first explanation for this ambiguity could be the ancestry of the sciences of management. Indeed, management sciences are an emanation of economics and, for the economist, only the concept of efficiency exists, productivity being an indicator. And yet, the term "effectiveness" is widely used in the management literature to measure the performance of any organization (market or non-market organization) to long term. This term can be defined as the ratio between the results achieved by a system and objectives. Therefore, the closer the results are to the objectives, the more system is efficient. We therefore express ourselves in the degree of efficiency to characterize the system performance. In this research, we retain the acceptance of

Marchesnay (2011) on the effectiveness which "Measures the degree of achievement of the targeted objective, compared to previous achievements or external (competition: benchmark) ”;

We recall that more detailed information on efficiency is presented in the remainder of the chapter. (Selcuk & Tuba , 2021, p. 10)

1.2. Definition tests:

In the context of evaluating the performance of a system, whatever its nature (production unit, medical unit, delivery service, etc.), we consider that the efficiency expresses the relationship (link) between the objectives and the means (resources) employed to reach them. In other words, efficiency is concerned with the quantity of factors used to achieve the objectives (number of hours of work, intermediate consumption costs, etc.). Traditionally, certain economic indicators (average cost) and techniques (factor productivity) to measure efficiency.

In general, when we talk about the efficiency of a producer, we have in mind the comparison between the optimal values of the outputs, the inputs and the observed values. The exercise involves either the comparison between the observed output and the maximum potential output that can be obtained from the input. Either that between the observed input and the minimum potential input essential to produce the output, or a certain combination of the two. In these two comparisons, the optimum is defined in terms of production possibilities. He is It is also possible to define the optimum in terms of the objectives targeted by the producer. In this case, efficiency is obtained by comparing "the optimal values of costs, revenues, profits or any objective that the producer can set for himself and the values observed from these under any appropriate constraints on the quantities and price ”. To have a clearer idea on the concept, we offer some tests of definitions;

When we want to define efficiency, we cannot do without the definition of its precursor, Farrell (1957). For the latter, efficiency can be introduced as "success of the company to produce as large an output as possible from a given set of inputs ". (Selcuk & Tuba , 2021, p. 11)

For Johnson and Scholes (1997), the notion of efficiency is essentially linked to "How the company excels in matching its products / services to needs identified of its customers and what skills are needed to achieve this efficiency (or vice versa)”;

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Lusthaus C. et al. (2003) find that efficiency is one of the major key concepts for define organizational performance. For this author, any organization has a certain level of resources to deliver products and services and must operate within the limit of the resulting constraints. Efficiency then becomes: "the ratio which reflects the comparison between the results obtained and the costs incurred to achieve the objectives". Montebello (1976) points out that there is a "consensus on the ultimate measure of efficiency of an organization: its survival". However, we cannot really consider that all companies that have survived are efficient.

Three types of efficiency can be observed at the company level according to Chaffai (1989): technical efficiency which relates to the "technical" management of resources, the efficiency of scale reflecting the adequacy of sectors at their optimal size and efficiency allocative resulting from the possibilities of adapting production processes to the structure of relative prices. Atkinson and Cornwell (1994) 1 find that a production unit (PU) is said to be technically efficient if, from the basket of inputs it holds, it produces the maximum possible outputs, or if, to produce a given quantity of outputs, it uses the most small amounts of inputs possible.

We can then deduce that the level of efficiency of a production unit (PU) allows knowing the capacity of the latter to increase its production without necessarily consume more resources, or reduce the level of inputs used while maintaining its production level.

In summary, we can say that the portmanteau word performance is a construct of several dimensions of which the most cited by researchers and practitioners are productivity and efficiency, which can represent both the aspects, criteria or even the most more relevant to assess the performance of any organization. Efficiency is chosen by many researchers as the best measure of the performance of companies. To better understand this concept, the initial idea proposed by Farrell in 1957 is illustrated in the following section. (Selcuk & Tuba , 2021, p. 12)

1.3. Efficiency: Decomposition and measurement:

The concept of efficiency is new in the literature. Indeed, the neoclassical analysis is based on the assumption of full employment and full exploitation of production resources. There is therefore no waste and all production units are efficient. Gold, when we get closer to reality, we find that companies use different levels of inputs to produce different levels of outputs while recording expenditure (at different degrees) during the production process. In the second part of

the chapter, we first try to dissect efficiency and to present its different components. We then study the Farrell decomposition which disaggregates efficiency into technical efficiency and allocative efficiency. Second, we propose a decomposition of technical efficiency into pure technical efficiency and efficiency of scale. Finally, we introduce the different techniques used to measure efficiency. These techniques are grouped into two approaches: the approach parametric (econometric) and the nonparametric approach which becomes the new trend in estimating the relative efficiency of production units. (Selcuk & Tuba , 2021, p. 13)

1.3.1. Decomposition of efficiency:

➤ Economic efficiency:

According to Farrell Farrell (1957) proposed the construction of a nonparametric boundary to introduce technical efficiency and allocative efficiency as well as their method of calculation. He considered in first, a company that uses two factors of production to produce a single product. The author assumes that the function of efficient production is determined; it is to say that the output of an efficient firm can be produced using combinations different inputs, as shown in the figure below. (Amina, 2017/2018, pp. 67-68)

➤ . Allocative efficiency:

A technically efficient company must also consider how it uses its factors of production in the right proportions vis-à-vis their respective prices. (Amina, 2017/2018, p. 70)

➤ Technical efficiency:

Technical efficiency can be defined as "the ability that has the bank to obtain a given output with a minimum level of inputs ". (Amina, 2017/2018, p. 69)

2. Technical efficiency: orientation and measurement techniques:

Measuring technical efficiency is essential for organizations and industries to understand how well they are using their resources to produce goods and services. There are several methods for measuring technical efficiency, each with its advantages and limitations. Here are some commonly used methods (Amina, 2017/2018, p. 72):

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- Data Envelopment Analysis (DEA): DEA is a non-parametric method used to assess the relative efficiency of multiple decision-making units (DMUs) that convert multiple inputs into multiple outputs. It identifies the most efficient units and sets them as the benchmark for others to emulate. DEA does not require any specific functional form for production or cost functions.
- Stochastic Frontier Analysis (SFA): SFA is a parametric method that estimates a production function or cost function and incorporates a stochastic error term to account for random variation and inefficiencies. It separates observed performance from unobserved technical inefficiency.
- Total Factor Productivity (TFP): TFP measures the overall efficiency of an organization or industry by considering how much output is produced relative to the inputs used, taking into account changes in technology and managerial practices over time.
- Data Envelopment Analysis with Bootstrapping (DEA-Bootstrap): This is an extension of DEA that uses bootstrapping techniques to estimate the confidence intervals for efficiency scores, providing a more robust measure of technical efficiency.
- Parametric Estimation Techniques: Parametric methods, such as regression analysis, can be used to estimate production or cost functions. By analyzing the relationship between inputs and outputs, one can identify inefficiencies and estimate technical efficiency scores.
- Benchmarking: Benchmarking involves comparing an organization's performance to industry or peer benchmarks. It can be a simple yet effective way to gauge technical efficiency, although it may not provide a precise numerical measure.
- Mathematical Programming: Linear or nonlinear programming models can be used to optimize resource allocation and production processes, allowing for the determination of technical efficiency levels by comparing actual and optimal performance.
- Machine Learning and Artificial Intelligence: Advanced machine learning and AI techniques can be employed to analyze large datasets and identify patterns that lead to inefficiencies. These methods can be used in conjunction with traditional approaches to gain deeper insights into technical efficiency.

- Efficiency Ratios: Simple efficiency ratios, such as the ratio of output to input, can provide a quick and straightforward measure of technical efficiency. For example, labor productivity (output per labor hour) is a common efficiency ratio.
- Sensitivity Analysis: By conducting sensitivity analyses, organizations can assess how changes in input levels or other factors impact efficiency. This can help identify areas for improvement

2.1. Guidelines for technical efficiency:

In theory, there are two orientations according to which technical efficiency can be appreciated:

- ❖ Output-oriented technical efficiency: shows the proportion of potential production that produces a unit of output from a certain level of input. In other words, he is the capacity of a production unit to generate as many outputs as possible at starting from a certain level of inputs and a given production technology;
- ❖ Input-oriented technical efficiency: in certain situations, the maximization of outputs (e.g. when production is scheduled) is not as important as reducing inputs. This leads us to present an alternative measure of technical efficiency, which is the minimization of inputs to produce a certain level of outputs. In other words, input-oriented technical efficiency assesses the ability of a production unit to achieve a certain level of output using as little input as possible. (Amina, 2017/2018, p. 74)

2.2. Efficiency measurement techniques:

So far, we have discussed efficiency through a detour on its origins, its beginnings in academic work, its different components, orientations and types of appreciations. In addition, it is necessary to present the methods used to measure efficiency.

A new trend has spread in efficiency measurement production units (UPs). This is the use of border analysis methods (frontier analysis methods).

Boundary analysis makes it possible to separate the entities that have a better efficiency of those who have badly.

There are two approaches to boundary analysis:

Literature Review

➤ The parametric approach or also called the econometric approach which brings together the methods:

- The stochastic frontier method widely known by its name English Stochastic Frontier Approach (SFA), this method has been used in several studies, including:

❖ **(Mesure de l'EfficiencE Economique des banques commerciales Algériennes: Application de la Méthode d'Analyse des Frontières Stochastiques SFA, Dr AOUAD Hadjar Soumia, Dr BENZAI Yassine 2018):**

In this study, the researchers apply the stochastic frontier method (SFA), to estimate the cost efficiency of Algerian commercial banks during the period (2003-2015), and identify the source of inefficiency in banking practices, in order to attribute this either to a misallocation of production factors or simply judge that banks are experiencing external shocks that can negatively affect their performance.

The method makes it possible to estimate a frontier function that simultaneously takes into account random error and an inefficiency component specific to each bank evaluated. Although traditional econometric estimation methods such as regression take into account random error, but, they estimate an average function and not a frontier function.

Therefore, they are unable to decompose the gap between the estimated function and the observations in terms of inefficiency and random error.

In order to overcome some imperfections related to the basic model research adopted the specification of Battese & Coelli (1995). In this model, the bank's cost inefficiency scores are determined by a simultaneous equation system based on the variables characterizing the banking activity. The model also has the advantage of estimating efficiency from a dynamic perspective.

The empirical results of the parametric analysis show that the average level of cost efficiency of Algerian commercial banks are relatively lower than those of banks in the MENA region.

Thus, all banks obtained a very modest score of 45.74% on average, indicating that if banks use available inputs efficiently, they can reduce production costs by more than half (54.26%) while maintaining the same level of production. This shows that banks have not managed to maximize

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their outputs given these available inputs (technical inefficiency). Similarly, they use production factors in incorrect proportions given their costs on the market (input allocative inefficiency).

The researchers also found that the scores diverge according to ownership and size.

Indeed, in terms of efficiency, large public banks outperform medium-sized and small private banks by around 12.25% and 33.04% respectively. On the other hand, dynamic analysis shows that efficiency has deteriorated considerably from 65.72% in 2003 to 39.26% in 2015.

The investigation of the factors responsible for inefficiency using the one-step analysis approach was not (statistically) successful in this study. Due to the static nature of the panel data in the study sample. Indeed, Algerian banks do not experience a structural evolution over time.

Under these conditions, the stochastic parametric method is not able to identify the sources of inefficiency of our estimated model.

Indeed, the inefficiency of Algerian banks is mainly due to the quality of assets and the importance of operating expenses, particularly staff costs. Most public banks remain penalized by overstaffing, which weighs on productivity.

The deterioration in efficiency is also due to the slow pace of structural reforms, which hinders the development of the private sector, a regulatory framework for the financial sector that is still evolving, an underdeveloped infrastructure (including a credit risk center with limited coverage) and the predominance of directed credit and other forms of support and subsidies. In addition to the criticisms raised, other organizational and functional failures can be mentioned, such as:

- The inadequate distribution of the banking network;
- The management deficit (organization, supervision, adaptation to change);
- Banks suffer from structural weaknesses that tarnish their brand image and call into question their operating methods, even their viability;
- The inadequacies of the information system, marketing and telecommunications;
- The weakness of innovation in monetary and financial instruments and even the inability to effectively adapt traditional instruments;
- A monetary circulation outside the banking circuit and that the banking system cannot capture;

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As a result, public banks will have to face several imperatives in the coming years, namely the diversification of products, the modernization of information systems, the management of skills and the reduction of costs, in addition to the movements of concentration and rapprochement between banks to reach competitiveness thresholds.

❖ **(Efficience des banques commerciales Tunisiennes: etude par l'approche de frontière stochastique, Bannour Boutheina, Labidi Moez, 2011):** During this study, the researchers propose to evaluate the production efficiency degrees of 20 Tunisian commercial banks were evaluated during the period 1990-2009, and the variables that illustrate the level of efficiency were determined, using a border method called the border stochastic approach (SFA), where important changes were recorded after the government adopted different standards for financial liberalization.

The results of the study highlighted that the banks with the best proficiency scores are BT (99.5%), BH (98.5%) following AB (94.9%) and de ATB (94, 5%).

Discussion of method:

✓ The parametric stochastic efficiency model tries to estimate the efficiency of a group of studied units by distinguishing between statistical random error and lack of efficiency in the sample data;

✓ It gives an inference to the functional model of the parametric efficiency and the statistical significance of the independent variables in the model;

✓ This method is the best method for studies with a single input or the pre-estimated average of multiple inputs. As for the bandwidth analysis of the data, it is characterized by addressing many inputs and outputs without pre-estimating the average of the estimates - weight - by analyzing;

- The Thick Frontier Approach (TFA) method

- The free distribution method, in English, Distribution Free Approach (DFA).

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➤ **The non-parametric approach which itself includes two methods:**

- Analysis by data envelopment, known under the name of Data Envelopment Analysis (DEA)

❖ **(Measuring efficiency of commercial banks in a developing economy: the case of turkey, Selcuk Percin, Tuba Yakici Ayan 2006):** In order to restructure the financial system, especially the banking system, some important steps were taken that brought about developments in the Turkish economy and banking system in the period 2002-2004 in accordance with the objectives of the Banking Restructuring Reforms.

Accordingly, the effectiveness of banking supervision was increased in addition to the exclusion of banks with weak financial structures from the banking system, and banking rules and regulations were significantly harmonized with international standards.

Banks and financial structures have shown great importance in their efficiency (BRSA, 2004).

Most studies on bank efficiency are generally focused on banks in developed countries. On the other hand, the economic and political environments surrounding financial institutions or banks vary greatly across countries. In this study, the comparative performance of 31 commercial banks was evaluated using data envelopment analysis. For this purpose, two outputs and four inputs were used in the analysis. According to the results, for 2004, the efficiency of 11 (35.5%) of the 31 banks was calculated according to the CRS while the efficiency of 16 (51.6%) of them was calculated according to the CRS assumption. Also, for 2003, the efficiency of 16 (51.6%) of the 31 banks was calculated according to the CRS assumption while that of 23 (74.2%) was calculated according to the CRS assumption. Our results also show that state-owned banks are more efficient than privately owned and foreign banks in the commercial banking industry in Turkey. It is shown that the use of input sources enhances the technical efficiency of public banks compared to private and foreign banks. These results are consistent with the results of Zaim (1995) and Isik and Hassan (2002). Inefficiency is more prevalent among privately owned banks (76.4%) than foreign banks (54.5%) and state-owned banks (33.3%). Therefore, most of the privately owned and foreign banks need to improve their efficiency. Furthermore, the sensitivity of inefficient banks in 2004 and the changes in banks' efficiency during 2003-2004 were analyzed using the multidimensional performance index approach. Sensitivity analysis shows how to modify the input and output

variables of banks to eliminate inefficiencies in the commercial banking industry in Turkey. For this purpose, reducing inputs or increasing output is generally used to improve inefficient banks.

❖ **(Estimating and analyzing the technical efficiency of banks in Ghana, Y. Abdul Karimu Tossa, Ministry of Gender, Children and Social Protection, 2016):** This study mainly deals with the efficiency of banks in Ghana and its determinants. In particular, it looks at the variation in efficiency of banks by bank size including large banks and the extent to which they enjoy economies of scale as an advantage over their small counterparts. Using balanced panel data for a sample of twenty-one (21) banks from 2009 to 2013, various analyses show that at most eight (8) banks were technically efficient according to the output approach of the DEA-BCC model. Consequently, at least 61.9% of banks in the country were inefficient. The analyses also indicate that the average bank in the country was 63.89% to 80.48% as efficient as the “best” banks. This means that given the same output level, the average bank used 19.52% to 36.11% more inputs than the technically efficient bank. The largest banks had the most technically efficient banks, followed by the largest banks. Even when the number of technically efficient banks was similar between the largest banks and the other class of banks (the case of the mediation approach, DEA–CCR model), the largest banks had the highest relative TE. Thus, there is sufficient evidence to support the assertion that TE, on average, varied directly in proportion to bank size within the top two quartiles. It was also evident that large banks did not benefit from economies of scale as an advantage over small banks.

All regression models show that INFL, GDPPC, and MKTC significantly affect TE. While the effect of INFL and GDPPC is negative, the effect of MKTC is positive. This means that increases in INFL and GDPPC lead to a decrease in efficiency while increases in MKTC lead to an improvement in efficiency.

With regard to firm-specific variables, both the Tobit regression and the random-effect OLS regression indicate that OPRC has a negative effect on TE; that is, increases in OPRC constrain TE. According to the random effect OLS, size negatively affects SE while Tobit regression suggests that CRED has a negative effect on TE. By inference, SE tends to suffer as banks become larger and CRED increases leading to lower TE. None of the regression models demonstrate any significant association between OWNRR and efficiency.

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❖ **(Technical efficiency and its determinants: an empirical study on banking sector of Oman, Dharmendra Singh, Bashir Ahmad Fida, 2015):** The objective of this study is to assess the degree of technical efficiency and scale efficiency in commercial banks in Oman using Data Envelopment Analysis (DEA). The results concerning returns to scale indicated that underreporting of returns to scale was the primary source of scale inefficiency. The study found that Bank Dhofar and Al Ahli Bank were the most technically efficient banks during the examined period, while Bank Muscat showed evidence of declining returns. Furthermore, the estimated efficiency scores were regressed (using a Tobit model) on bank size, capital adequacy, liquidity, and profitability. The latter two were considered important positive explanatory variables

❖ **(Measuring the efficiency of commercial banks operating in Palestine using the envelope data analysis "DEA", Mohamedr AL Raee, Shreen Tayeh et Mohamed El Harazin, 2020):** This study aimed to measure the technical efficiency and the scope efficiency of commercial banks operating in Palestine, to determine the efficient and inefficient banks, and identify the required improvements that ineffective banks must apply to reach optimal relative efficiency.

In this study, data envelopment analysis (DEA) was relied on to measure the efficiency of commercial banks operating in Palestine using financial data from 2008 to 2017. This study concluded that the Arab Bank was the only one with relative efficiency during the average study period, while no bank reached Post to this level in average proficiency during the study period.

This study recommended the banks that did not achieve the required relative efficiency to examine the reasons that prevent this so that they can make better use of the available resources, in addition to studying the internal work environment of competing banks, which achieved relative efficiency and following them to introduce new work methods to ensure that these banks reach efficiency relativity required.

The study reached the following results:

- Lack of internal efficiency in most Palestinian commercial banks, which is evident from the lack of combination between the input elements represented by debts, depreciation of fixed assets, general expenses to achieve a certain volume of outputs, loans, net banking income, i.e. they are considered;

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- Achieving a degree of complete relative efficiency on average during the study period by the Arab Bank, without other banks;
- The results showed the banks that achieved complete relative efficiency during the year 2017, represented by: Arab Bank, National Bank, Bank of Jerusalem, Arab Egyptian Real Estate Bank, while other banks were unable to reach this degree of efficiency;
- The results showed that foreign banks were equal to local banks in terms of total efficiency during the mentioned year;
- The results indicate that eight commercial banks are considered inefficient in terms of volume due to external factors that these banks could not control;
- The improvements required from the inefficient unit are to reduce the volume of private debts and the volume of fixed assets depreciation, reduce general expenses and increase the volume of lending, assuming that the current net banking income remains constant.

➤ **Discussion of method:**

Despite the importance of data envelopment analysis in measuring the efficiency of industrial enterprises, this method has many advantages and shortcomings as well. We can provide it in the following:

- ✓ High sensitivity to data quality, any small error in the relationship between input and output can change the results of the study;
- ✓ The large number of calculations resulting from the size of the linear programs that must be solved for each production unit;
- ✓ This method is considered relative and therefore it is not possible to reach accurate results that show the efficiency of the studied units;
- ✓ The contribution of the various variables cannot be known, because the various parameters of the function are not estimated as in the parametric methods;
- ✓ This method considers that the error is equal to zero, unlike the parametric methods that take into account the error in the estimated function of the efficiency, and therefore this hypothesis can affect the quality of the results and therefore the interpretations, especially if the studied environment is characterized by random shocks

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✓ The absence of prices means that DEA gives us an analysis of a measure of technical efficiency rather than economic efficiency, because it reveals how efficient the inputs are used to produce the outputs, but does not give us indications of whether efficient units can reduce their costs or improve the value of their outputs by choosing combinations of different from the inputs or outputs.

However, the technical efficiency information obtained using this type of analysis remains of great use for evaluating and improving the efficiency of decision-making units when price information is absent or limited.

It should be noted that the choice of the optimal method depends on the objectives of the research and the available data, and the results of measuring efficiency remain subject to the choice of inputs and outputs.

The following table summarizes the main differences between the stochastic frontier method and the data envelopment analysis method:

Table.1. comparison between SFA and DEA method

SFA	DEA
Instructor style	non instructor style
Statistical input	selective input
Takes into account random noise	Does not include random noise
Statistical hypothesis is allowed to be heterogeneous	Statistical hypotheses are not allowed to be covariant
Performs assumptions about the inefficiency period distribution	The assumptions on the inefficiency period distribution are not implemented
Include compound expression error	Does not include expression error
Requires defining the function model	Does not include defining the function model
Possibility of inefficiency with poor model selection	Sensitive with the number of variables error and anomaly in the scale
Estimation method: econometrics	Estimation method: linear programming

Source: by the researcher

- Free Disposal Hull (FDH), which is only an extension of the analysis method by wrapping the data.

Each of the above methods has advantages and disadvantages.

3. Basic measures of efficiency:

In any industry, performance measurement is an important topic, and as efficiency presents the fundamental component of performance, its measurement remains a concern for managers, given that it provides managers with guidance to compare their structures costs both among themselves and over time, as well as to governments in the debate on regulatory issues.

In fact, identifying the most efficient units within a homogeneous group amounts to finding methods to identify the “best” units and to measure the distance of others from these “best practices”. », Since Koopmans (1951) and Farrell (1957), economists have sought to measure the “relative” efficiency of comparable decision units.

If the study of banking performance is traditionally based on the analysis of financial ratios; today, with the massive development of banking networks and the availability of information; new approaches have emerged to evaluate the performance of banks, approaches which are part of a Benchmarking approach and which are assessed using efficiency criteria.

In order for us to estimate the efficiency of banks, it is essential, first, to identify the approach to adopt for the efficiency analysis.

3.1. Fundamental approaches to banking production:

Measuring the efficiency of a bank requires determining the most appropriate approach to modeling banking activity. There are now different ways to simulate the bank's production process. We generally find:

the production approach emanating from Benston in 1965 and developed by Berger in 1991 and the intermediation approach developed by Sealey and Lindley in 1977, the profitability model introduced by Berger and Mester in 1997, the marketing model developed by Seiford and Zhu in 1999 and finally the portfolio model applied by Fama in 1980 (cited by OheneAsare, 2011).

Two main conceptions are generally retained to characterize the banking firm: the conception of production and the conception of intermediation. The production approach considers the bank as a producer of services. However, the so-called intermediation approach considers the

bank as a financial intermediary. The main oppositions distinguishing these two models concern the taking into account of financial costs and the specification of deposits.

Overall, in the empirical literature, the two most adopted approaches are the production approach and the intermediation approach.

3.1.1. Production approach:

In practice, this model highlights the commercial behavior of banks in providing services to account holders, hence its name "service delivery approach".

Thus, the present approach considers the bank as a service company. The latter are divided into two categories: those which generate resources (demand deposits, term deposits and savings, etc.); and those which constitute jobs (commercial loan, real estate loan; installment loan, etc.), using different physical factors in particular the physical capital K and the labor factor.

According to this approach, the total cost borne by the bank does not take into account interest charges paid on deposits since the latter are considered as outputs, and only physical inputs are necessary to carry out transactions or offer other types Services.

However, the production's approach received a lot of criticism. In fact, for economists of portfolio management theory, the hypothesis of independence between the bank's liabilities and assets, which the production approach posits as a principle, affects the activity of the bank.

3.1.2. The intermediation approach:

Following the shortcomings of the production approach, which revealed its deficiencies in the conception of the real activity of the bank, the intermediation approach appeared, also known as the value approach. This approach is part of the spirit of a renewal of reflection on the nature of banking activity, a question which is often at the heart of a very dense literature since the beginning of the 1980s.

This approach is called intermediation in the sense that the bank is no longer considered as a firm which offers independent products, but rather as a financial intermediary which collects resources, essentially in the form of deposits in order to grant credits. . Indeed, the intermediation model of Sealey & Lindley (1977) considers financial institutions as agents who pass funds between the sources of demand 'investors' and the sources of supply 'savers', using inputs.

According to this approach, banking inputs are composed of the labor factor L , the physical capital factor. Consequently, the total cost includes operational costs as in the production approach,

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but also interest charges, since deposits are treated as inputs. However, the outputs generated by the production process take the form of credits and investments (cited by Ohene-Asare, 2011).

Section 3: The SFA Stochastic Frontier Analysis method

1. Definition of The SFA Stochastic Frontier Analysis method:

Stochastic frontier analysis (SFA) is a statistical technique used to estimate the production function and measure technical efficiency in the presence of inefficiency and random error. It is commonly applied to study the cost and production functions of various activities; the production function represents the relationship between inputs (such as labor, capital, and raw materials) and output in a production process.

It describes how the inputs are combined to produce a given level of output. The production function can be estimated using SFA to determine the factors that contribute to production inefficiency and to measure technical efficiency relative to the production frontier; (Feng , Arabinda , Jane , & Xiaoli , 2019, p. 44)

The cost function, on the other hand, represents the relationship between the inputs and the cost of production. It helps in understanding the cost structure and estimating the cost efficiency of firms. SFA can be used to estimate the cost function and measure cost efficiency, taking into account inefficiencies and random variations;

In SFA, the production or cost function is modeled as a combination of a deterministic component (the production or cost frontier) and a stochastic component (the error term). The stochastic component captures the inefficiency and random variations in the data that cannot be explained by the deterministic component. The inefficiency term represents factors such as managerial inefficiencies, technical inefficiencies, or external shocks that affect the production or cost process;

The estimation of the production or cost frontier involves estimating the parameters of the production or cost function and the inefficiency term. Various econometric techniques, such as maximum likelihood estimation or Bayesian estimation, can be used to estimate these parameters; (Feng , Arabinda , Jane , & Xiaoli , 2019, p. 44)

The estimated production or cost frontier allows for the measurement of technical efficiency, which represents how close a firm operates to the best-practice frontier given its inputs. Technical efficiency measures the ability of a firm to produce the maximum output for a given set of inputs or to minimize costs for a given level of output;

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Stochastic Frontier Analysis is widely used in economics and applied fields to analyze productivity, cost efficiency, and technical efficiency in different industries. It provides valuable insights into the factors affecting production and cost inefficiencies, helping policymakers and managers identify areas for improvement and resource allocation; (Feng , Arabinda , Jane , & Xiaoli , 2019, p. 45)

The "SFA" method is based on classical econometric regression approaches to estimate a production, cost or profit function. It requires a specification of a functional form of the efficient frontier which can be of Cobb-Douglas, Translog or Fourrier type. This border can then take three forms: that of a stochastic border, that of a thick border or that of a free border, this one is then estimated from the data of the sample by a method of the maximum likelihood. . This analysis essentially consists of breaking down the residual value into a random error and a non-negative inefficiency term

Stochastic frontier analysis (SFA) was introduced independently by Aigner, Lovell, and Schmidt (1977), Battese and Corra (1977), and Meeusen and Van den Broeck (1977), as a model for measuring production efficiency;

The original SFA model included a production function with two components: one to account for random effects; the other to account for technical inefficiency. This model can be expressed in the equation (DONp. 81):

$$y_i = x_i \beta + \varepsilon_i, \varepsilon_i = (v_i - u_i), i=1, 2, 3, \dots, N, \text{ where,}$$

- y_i : is the production (or the logarithm of the production) of the i -th organization;
- x_i : is a $k \times 1$ vector of (transformations of the) input quantities of the i -th organization;
- β : is an vector of unknown parameters;
- v_i : is random variables which are assumed to be iid $N(0, \sigma_v^2)$, and u_i is non-negative random variables which are assumed to account for technical inefficiency in production and are often assumed to be iid $|N(0, \sigma_u^2)|$.

The SFA model assumes a composite disturbance ϵ_i , which is the sum of two independent components v_i and u_i . The error component v_i is a normally distributed random disturbance representing specification or measurement errors. Thus, v_i is the counterpart of the ordinary least squares disturbance. The error component u_i is a one-sided disturbance, often assumed to follow a semi-normal or truncated normal distribution;

It represents any type of inefficiency. It is assumed to be distributed independently of v_i and the regressor x_i . This original SFA model has been used in such a vast number of empirical applications as the following: the manufacturing industry (Suh 1992); the agricultural industry (Chiao 1986; Pitt and Lee 1981; Ramirez 1987; Rawlins 1984); the banking industry (Kaparakis et al. 1994; Yang 1990); the airline industry (Bauer 1986; GallegosMonteagudo 1992); the health and mental health area (Toren 1993; Vitaliano and Toren 1994); hospitals (Zuckerman et al. 1994); and the insurance industry (Cummins and Weiss 1993; Gardner and Grace 1993; Kumbhakar and Hjalmarsson 1995);

These extensions of the SFA model include a specification of more general distributional assumptions for the u_i , such as the truncated normal or two-parameter gamma distributions; the consideration of panel data and time-varying technical efficiencies; the extension of the methodology to cost functions, and also to the estimation of system of equation; etc (Forsund et al. 1980; Schmidt 1986; Bauer 1990). (DONp. 82)

2. Advantages of the Stochastic Frontier Analysis Method:

The Stochastic Frontier Analysis (SFA) method is an accurate measurement tool through (Feng , Arabinda , Jane , & Xiaoli , 2019, p. 24):

- SFA allows for the measurement of technical efficiency, providing insights into how well inputs are being used or costs are being reduced. By comparing actual performance with best practices, SFA helps identify inefficiencies and areas for improvement. This information is essential for improving resource allocation, enhancing productivity, and achieving cost reductions;
- Provides a benchmark against which efficiency levels can be compared, by identifying the most efficient elements. SFA helps in setting performance targets and facilitating performance evaluation. It also helps in determining the relative position of agencies, leading to better decision-making and increased competitiveness;

- SFA is used to assess the impact of different interventions on efficiency levels, by comparing the efficiency of institutions before and after policy changes, enabling decision makers to determine the effectiveness of specific measures on resource allocation;
- Strategic performance analysis helps identify areas of low efficiency, by targeting resources towards inefficient elements, which enables policymakers to work on improving productivity and reducing the use of wasteful resources, leading to better economic outcomes;
- Detailed strategic performance analysis of different activities by identifying the factors that contribute to inefficiency, and helping policymakers understand the factors that determine productivity and cost efficiency, such as technological advances, management practices, and market conditions, as this information helps in the planning and restructuring process;
- It acts as a diagnostic tool by identifying the sources of inefficiency, by breaking down inefficiency into its components (such as technical inefficiency and random error), strategic performance analysis helps identify specific areas for improvement, and highlights factors that hinder cost improvement, allowing. (Feng , Arabinda , Jane , & Xiaoli , 2019, p. 25)

3. Importance of SFA method:

The Stochastic Frontier Analysis (SFA) method holds significant importance in several domains (Dr AOUAD Hadjar Soumia & Dr BENZAI, 2018, p. 51):

- SFA allows measuring technical efficiency to assess how effectively resources are used to produce output or reduce costs, by identifying differences between actual performance and best practices. This model provides valuable insights into areas of improvement and resource allocation;
- SFA is a powerful tool for assessing the effectiveness of policies aimed at improving efficiency. It enables policymakers to assess the impact of different measures on productivity and cost efficiency, facilitating evidence-based policy decisions and promoting economic growth;
- SFA provides a benchmark against which efficiency levels can be compared, by identifying better performing entities, enabling benchmarking exercises that help set and evaluate relative performance targets and enhance competitiveness;

- SFA helps improve resource allocation by identifying inefficiencies, which decision makers can use to strategically allocate resources, focusing on areas of low efficiency to boost productivity;
- SFA enables comprehensive analysis of industries by identifying the factors contributing to inefficiency. This information helps in understanding the determinants of productivity, identifying areas for improvement, and developing targeted strategies for industry development and competitiveness;
- SFA serves as a diagnostic tool, allowing specific sources of inefficiency to be identified and addressed, by identifying the factors that contribute to technical inefficiency, and facilitating performance improvement initiatives;
- SFA has been widely used in research to analyze efficiency, productivity, and cost structures across various sectors, and has contributed to the development of economic theories, understanding of market dynamics, and empirical evidence supporting policy recommendations. (Dr AOUD Hadjar Soumia & Dr BENZAI, 2018, p. 52)

4. Principles of SFA method:

Stochastic frontier analysis (SFA) is an econometric technique used to estimate production efficiency and productivity by modeling the relationship between inputs and outputs in the presence of inefficiencies. It is often applied to study the performance of converting inputs into outputs, as the method takes into account both random variations and inefficiencies that can affect the production process. The basic principles of stochastic frontier analysis are as follows (Feng , Arabinda , Jane , & Xiaoli , 2019, p. 51):

- ✓ Production function framework based on the concept of production function, which represents the relationship between inputs and outputs, with the aim of estimating the efficiency of converting inputs into outputs, taking into account the possibility of inefficiency;
- ✓ The random nature represented by random factors affecting the production process, which can lead to variations in output even when inputs are constant, and these random variations are captured by the random component of the model;

- ✓ Inefficiency component that takes into account deviations from the production frontier, as this component reflects other factors that affect the efficiency of the production process;
- ✓ The production frontier function for the maximum possible level of output that can be obtained given the input levels, where it represents the difference between the actual output and the frontier to inefficiency;
- ✓ Decomposing the error term into two parts, the random component and the inefficiency component, this analysis allows separating the differences due to randomness and those due to inefficiency;
- ✓ Parametric and non-parametric approaches where parametric methods assume a functional form for the production frontier and inefficiency distribution, while non-parametric methods avoid imposing specific functional forms;
- ✓ Estimating the production frontier and inefficiency scores for each observation, which involves maximizing the likelihood function, taking into account the observed data and the assumed structure of the model;
- ✓ Panel data analysis allows for interpretation of efficiency trends and the identification of factors influencing them over time, as observations are collected over multiple time periods or entities.
- ✓ SFA results provide insights into the sources of inefficiency within the production process, enabling policymakers to use this information to identify areas for improvement, allocate resources effectively, and enhance overall productivity;
- ✓ Economic interpretation using estimated inefficiency scores to compare the performance of different units within a unit, where units with lower inefficiency scores are more efficient at converting inputs into outputs. CITATION Fen19 \p 52 \l 1033 (Feng , Arabinda , Jane , & Xiaoli , 2019, p. 52)

5. The advantages of stochastic frontier analysis method:

Stochastic Frontier Analysis (SFA) is an econometric technique used primarily in estimating the production or cost frontier, which can help in assessing the relative efficiency of units. Here are

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some advantages of using the Stochastic Frontier Analysis technique: (Feng , Arabinda , Jane , & Xiaoli , 2019, p. 30):

- ✓ Measures efficiency by comparing its actual performance to a bounded one, taking into account random noise or inefficiency in the data;
- ✓ Random factors that affect the production process or cost structure, where this randomness is explicitly modeled, making it a powerful tool for dealing with variability and uncertainty in the real world;
- ✓ The SFA method is flexible in that it can be applied to different types of data, such as cross-sectional or time series data, and can be adapted to suit different research questions and data structures;
- ✓ SFA helps to account for unobserved variation that affects efficiency;
- ✓ SFA separates technical inefficiency from random noise or measurement errors, it can identify areas where performance is poor due to inefficiency rather than external factors;
- ✓ SFA is used to evaluate the impact of policies or interventions on efficiency, which helps industry analysts when assessing the effectiveness of policy measures;
- ✓ SFA provides a benchmark that helps identify areas where efficiency can be improved and costs reduced;
- ✓ SFA can provide valuable insights into the determinants of efficiency, which can be useful for academic research, business strategy, and policy formulation;
- ✓ SFA can be applied to longitudinal analysis data, allowing analysis of efficiency changes over time;
- ✓ The SFA method is robust to different assumptions and data conditions compared to other efficiency measurement methods, making it a reliable choice in many applications. (Feng , Arabinda , Jane , & Xiaoli , 2019, p. 31)

6. inconvenience of stochastic frontier analysis method:

Despite the advantages of stochastic frontier analysis (SFA), it also has some disadvantages and limitations that researchers and analysts should be aware of, including (Feng , Arabinda , Jane , & Xiaoli , 2019, p. 31):

- ✓ SFA relies on several assumptions, which can significantly affect the results, and may not always accurately represent the true production or cost structure;
- ✓ SFA requires detailed, high-quality data on inputs and outputs. Data errors or measurement problems can lead to biased efficiency estimates. In addition, collecting such data can be time-consuming and expensive;
- ✓ SFA models can be complex, especially when dealing with multiple input and output variables. This complexity can make the results difficult to implement and interpret, especially for non-specialists;
- ✓ Difficulty in estimating SFA models, especially for large data sets or when dealing with nonlinear models;
- ✓ SFA assumes that the inefficiency term follows a specific distribution, these distributional assumptions may not always hold true in practice, and misspecification may affect the results; (Feng , Arabinda , Jane , & Xiaoli , 2019, p. 32)
- ✓ Interpreting SFA results can be difficult, especially for those unfamiliar with the intricacies of this method;
- ✓ SFA assumes that inputs are exogenous and not affected by the inefficiency term, which can lead to biased estimates;
- ✓ Choosing the appropriate SFA model specification (Cobb-Douglas, translog) can be difficult, which can lead to inaccurate efficiency estimates;
- ✓ SFA may suffer from sample selection bias, which can bias efficiency estimates;
- ✓ Scarcity of data, making it difficult to apply job performance analysis effectively;
- ✓ Sharing detailed data for job performance analysis may raise privacy and confidentiality concerns, especially when dealing with sensitive industries;
- ✓ Data aggregation problem that results in loss of valuable information and concealment of individual variation;

CHAPTER ONE: THE TECHNICAL EFFICIENCY IN ALGERIAN COMMERCIAL BANKS

- ✓ Misspecification of the model that may lead to biased and inconsistent efficiency estimates;
- ✓ Job performance analysis focuses primarily on measuring efficiency rather than establishing causal relationships, and cannot identify the causes of inefficiency, which may require additional research methods. (Feng , Arabinda , Jane , & Xiaoli , 2019, p. 32)

Conclusion of chapter:

In the context of commercial banks, technical efficiency ultimately boils down to how well a bank converts its inputs (such as labor, capital, and deposits) into outputs (such as loans and other financial services).

High technical efficiency indicates that a bank is operating close to its optimal production frontier that is, making the most of its resources. Conversely, low technical efficiency indicates that the bank can produce more output with the same level of inputs, or the same output with fewer inputs.

Therefore, assessing technical efficiency provides a critical perspective for banks to understand their operational performance, identify areas for resource optimization, and ultimately enhance their competitiveness and profitability. It is not just about getting things done; it is about getting them done right.

This will be dealt with practically in the next chapter.

Chapter two:

Study methodology and procedures

CHAPTER TWO: study methodology and procedures

Introduction of chapter:

The weight of commercial banks in the banking system varies from country to country depending on economic conditions and regulatory changes.

Accordingly, commercial banks play a key role in the banking system in most countries:

- Commercial banks benefit from government-backed deposit insurance programs, which provide a safety net for depositors in the event of bank failure. This safety net helps build confidence in commercial banks and encourages people to deposit their money with them.
- Commercial banks act as a source of liquidity;

During this chapter, we dealt with a presentation of the method of processing the collected data represented in a number of inputs and outputs derived from statistical tables of the Central Bank of Algeria to measure the technical efficiency of Algerian commercial banks during the period from 2012 to 2021

We used a random sampling analysis method based on using a set of inputs classified by two stages: The stage of attracting deposits; and the stage of granting loans.

Section 1: Methodology of the study

Studying the technical efficiency of Algerian commercial banks is a complex and comprehensive research endeavor; as such, a study requires data analysis, econometric modeling, and a deep understanding of the dynamics of the banking sector.

The following is a general summary of the steps we took to conduct our study:

1. Research Objectives:

Through our study, we tried to evaluate the technical efficiency of Algerian commercial banks as an essential part of the Algerian banking sector, to measure the extent of their contribution to supporting the sector, taking into account the impact of some factors on this efficiency.

2. Data Collection:

Data on the technical efficiency of Algerian commercial banks were collected and extracted from the statistical data of these banks and the Central Bank.

3. The Efficiency Measurement Method:

Among the known methods for measuring the technical efficiency of banks, the stochastic frontier analysis (SFA) method was chosen to assess the efficiency of banks in converting inputs (deposits) into outputs (loans and profits).

4. Model specifications:

We have constructed an econometric model that links the inputs and outputs of commercial banks, and it helps us explore the relationship between economic factors and bank efficiency, and thus the possibility of a correct interpretation of technical efficiency.

5. Data analysis:

To perform data analysis we used the R statistical program

6. Interpretation of the results:

The results of the analysis obtained were interpreted by highlighting the extent of the relationship between the influencing factors and the bank's efficiency on the one hand, and the extent of the continuous impact of some variables on efficiency on the other hand.

7. Highlighting the implications of the adopted economic policy:

Through the results obtained, we discuss the variation in technical efficiency among a sample of Algerian commercial banks and determine its effects on monetary policy, and thus consider how policy makers can use this information to improve the efficiency of the Algerian banking sector.

❖ The importance of using periodic variables to measure the technical efficiency of commercial banks:

Cyclical variables are critical to measuring the technical efficiency of commercial banks, as they support banks' strategic planning and resource allocation that contributes to their long-term success and competitiveness in the financial industry.

Cyclical variables are often used to measure the technical efficiency of commercial banks for several important reasons:

- Commercial banks' efficiency varies over time due to market changes, economic cycles, and internal factors, allowing for time-based analysis, which enables researchers to track efficiency trends and assess the impact of economic and political changes.
- Periodic data provides a consistent basis for measuring and comparing commercial banks' efficiency to identify where banks may need to improve their operations.
- Using periodic data to measure efficiency helps banks make decisions to achieve greater overall efficiency, and accordingly allocate resources, including capital investment, employee hiring, and branch expansion.
- Periodic efficiency measures are essential inputs to strategic planning, enabling banks to set performance targets and develop strategies to strengthen their competitive position in the market.
- Periodic financial statement reports of commercial banks are used to measure efficiency and, therefore, compliance with regulatory requirements.

CHAPTER TWO: study methodology and procedures

- Use periodic reports of banks to inform customers about their performance, and they provide valuable insights into the operational health of banks and can influence investment decisions.

- Periodic efficiency analysis helps banks identify weaknesses and thus address issues that may impact their long-term stability and profitability.

- Periodic efficiency measures are part of performance evaluation, using consistent data points over specific time periods.

- Periodic efficiency measurements help banks evaluate their resource allocation strategies against desired outcomes in a competitive environment.

- Regular efficiency measurements help track progress towards long-term goals and ensure that the bank is on track to achieve its strategic objectives.

8. Study's spam:

The size of our sample remains subject to the availability of data collected from the Central Bank of Algeria and commercial banks from annual reports, statistical bulletins, and monetary position.

Our sample is limited to commercial banks to overcome statistical problems related to the heterogeneity of banking products.

The study period extends from 2012 to 2021, and the choice of this period was imposed on us by the fact that the reforms of the banking system were announced through the promulgation of the law on money and credit in 1990. However, Algerian banks, especially public banks, did not begin to really feel the effects of these reforms on their practices until the first decade of the twenty-first century.

There are some periods that may be more appropriate than others to study the efficiency of banks, due to the changes that the banking system has experienced, including:

-  Periods of economic stability, as these periods are considered appropriate to study the operational efficiency of banks, as performance can be measured without being greatly affected by economic turmoil;

-  Periods of financial crises, which can reveal the extent of banks' ability to deal with pressures and challenges;

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✚ Periods following the implementation of new laws or reforms, especially after the introduction of new banking regulations or laws, such as capital or liquidity requirements;

✚ Periods of economic growth, where banks' efficiency can reflect their ability to take advantage of available opportunities and enhance their profits;

✚ Major technological transformations such as digitization, as this period can be important for studying how technological innovations affect banks' efficiency.

By linking the developments of the banking system to the optimal periods for studying the efficiency of banks, the time periods can be divided into main stations that represent important stages in the development of the banking system, which we have summarized in:

✓ *Financial stability stage (before major crises):*

In this period, banking systems are relatively stable with clear and known regulatory rules. Banking systems operate efficiently in stable economic conditions, as this period is considered suitable for studying the efficiency of banks' internal operations, as the data is not distorted by economic turmoil. The focus is on measuring operational efficiency and the ability to achieve profits under normal conditions.

✓ *Financial crisis stage:*

Banking systems are exposed to great pressures during financial crises, and this period is considered ideal for studying the ability of banks to adapt to pressures and evaluate efficiency under abnormal conditions. Government and central bank policy responses can also be analyzed.

✓ *Post-crisis and reorganization stage:*

After crises, new regulatory reforms are usually introduced, such as increased capital and liquidity requirements. This period is ideal for studying the impact of these reforms on bank efficiency. Performance before and after the implementation of these regulations can be compared to measure their success in improving financial stability without negatively affecting efficiency.

✓ *Technological innovation stage (such as digitization):*

The emergence of financial technology and digitization is changing the shape of the banking industry, by improving services and increasing efficiency, as well as increasing competition, which makes this period suitable for studying how technological innovations affect the efficiency of banks.

CHAPTER TWO: study methodology and procedures

✓ *Economic recovery and growth stage:*

Banking systems are well positioned to take advantage of economic opportunities. The ability of banks to achieve sustainable growth in a favorable economic environment is demonstrated. During this stage, it is possible to study how banks benefit from the positive economic environment to enhance efficiency and increase profits.

✓ *Geopolitical or major economic changes stage:*

During this period, the efficiency of banks is studied to reveal the extent to which they are affected by external factors and how they deal with fluctuations.

Based on the above, and to obtain an accurate study of the data, we divided the study period according to the development witnessed by the banking sector in Algeria, represented by the historical development of the banking system and the reforms witnessed by the country.

This can be summarized in the following stages:

- (2012 - 2016): The period of strengthening the infrastructure and technology

During this period, the Algerian banking sector witnessed several developments and reforms aimed at modernizing it and keeping pace with global technological changes. This is evident through:

Digitization and development of electronic banking services, expansion of electronic payment services, improvement of networks,

Automation of internal operations.

To achieve the above, the Algerian banking sector faced a number of challenges, mainly represented by:

The weakness of some banks in terms of traditional infrastructure, which may lead to delays in implementing some digital operations, the traditional banking culture represented by the difficulty of convincing customers to abandon traditional transactions with liquidity and switch to digital systems due to weak confidence in the modern banking system or lack of awareness about the benefits of these transformations, and enhancing foreign investments

- (2017 - 2021): The period of strengthening financial inclusion

This period witnessed the emergence of the Covid-19 pandemic, which greatly affected Algerian commercial banks, as it did with many financial institutions around the world, through the main challenges and adaptations faced by Algerian banks during this period of reduced

CHAPTER TWO: study methodology and procedures

economic activity, liquidity challenges, economic slowdown and reduced activity, loan defaults and credit risks, reduced oil revenues, adoption of digital banking services, intervention by the Central Bank, challenges in foreign exchange operations, impact on investment and development projects due to the postponement and cancellation of many development and infrastructure projects, government support and recovery measures.

With regard to defining the inputs and outputs of banking work, we follow the mediation approach, which sees that the bank collects **deposits**, as well as all other resources, to convert them into **loans** or other **productive assets**, using the **operating cost rate** as an internal variable, and **assets** and **own funds** as external variables.

Section 2: Case study data and stages

1. Procedures of study:

The practical steps of our study are summarized in the following two stages:

a. Phase one:

Deposits in commercial banks represent an essential element for stimulating the economic system, through: (Mukhtorovna, 2018, p. 50):

- Banks act as intermediaries between savers and borrowers, which is the essential function of channeling funds from surplus units to deficit units, and this process helps to promote economic growth and development;
- Banks can lend out a portion of the deposits they hold, effectively doubling the money supply, which stimulates credit creation by financing investment, consumer spending, and business expansion;
- Banks facilitate the transfer of funds, making transactions more efficient and secure, as these transfers rely on the funds deposited to process payments;
- Depositors earning interest on their savings provides an incentive to save and keep their money in banks, which in turn helps finance lending and investment activities;
- Banks provide a safe place for depositors to store their money;
- Central banks can influence the money supply, interest rates, and general economic conditions, by using reserves held by commercial banks. (Mukhtorovna, 2018, p. 51)
- Deposits provide a source of available funds that are used to meet withdrawal requests and cover short-term liabilities;
- Deposits allow banks to lend money, invest in assets, and provide a wide range of financial services to their customers;
- The stability of the banking system helps absorb economic shocks by providing a buffer of liquidity and availability of credit during times of financial distress;
- Deposits contribute to the development of infrastructure and public services. (Mukhtorovna, 2018, p. 51)
- Commercial banks are involved in mobilizing deposits of various types, such as savings accounts, current accounts, fixed deposits, and certificates of deposit, by encouraging customers to deposit their money with the bank;

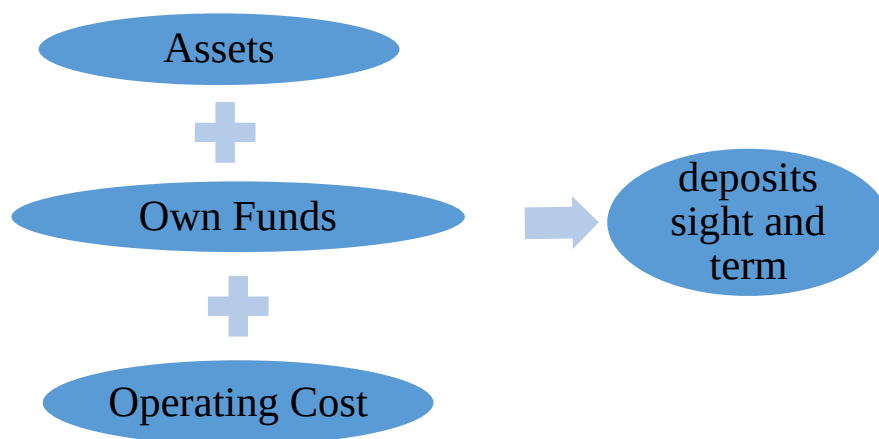
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- Banks often offer additional benefits, such as online banking, mobile banking, and rewards programs, to enhance customer satisfaction and loyalty;
- Commercial banks are responsible for ensuring the safety and security of deposited funds; (Usmonovich, 2020, p. 206)
- Deposits are a source of funding for commercial banks and must therefore be managed effectively to meet depositors' withdrawal requests while ensuring that they have sufficient funds for lending and investment activities;
- Deposits provide a reliable source of funding for commercial banks to extend loans, as the funds deposited by customers are used to finance various lending activities;
- Commercial banks are subject to regulatory requirements relating to deposits that require them to comply with reserve requirements, liquidity ratios, capital adequacy standards, and requirements relating to deposit-taking activities;
- Commercial banks set interest rates on deposits based on various factors, such as market conditions, competition, cost of funds, and regulatory guidelines. (Usmonovich, 2020, p. 207)

In general, deposits are an essential element in the operations of commercial banks, as they provide a source of funding and allow for lending, but this requires effective management of customer relationships and compliance with regulatory rules to ensure the maintenance of financial stability.

Accordingly, the following figure summarizes this stage as follows:

Fig.2. Inputs and outputs of banks during the first phase of their activity



Source: by the researcher

CHAPTER TWO: study methodology and procedures

We classified deposits according to the study into:

❖ **Short Term Deposits Current Account:**

These deposits are payable on demand and can be withdrawn by depositors according to the balance in the account. The bank does not pay any interest on these deposits, but it does provide check facilities.

❖ **Time or fixed deposits:**

They are called term deposits because they cannot be paid on demand, as they do not have check facilities, and they cannot be withdrawn except after the maturity of the specified period. They also carry a higher interest rate and are not treated as part of the money supply.

In this phase, we distinguish:

➤ **Internal and endogenous variable:**

It represents the total cost of cash transfers that includes operating cost consisting of own funds and Assets.

➤ **External variables:**

- Banking inputs: We considered that the production of banking products is mainly linked to two basic factors, namely: the bank Assets factor and the own funds factor, which form the basis for attracting deposits that constitute the financing capital as an output,

Inputs are generally presented as explanatory variables according to total cost in order to be able to account for differences in risk preferences. , we prefer to use the interest rate and inflation as the net output in one of the models that we will have to estimate according to the table below.

- Banking outputs: The combination of banking inputs results in the following outputs: Total Deposits: Deposits deposited with banks include both current deposits and medium and long-term deposits.

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First period :(2012 – 2016): The period of strengthening the infrastructure and technology:

This period indicates the beginning of implementing reforms aimed at modernizing and improving the banking sector, where commercial banks focused on adopting modern technology to enhance the efficiency of banking services, improve security, and provide digital banking services that better meet customer needs, through:

Updating technological systems, digital transformation by creating platforms for online banking services, training and professional development to ensure providing distinguished services to customers, expanding infrastructure and enhancing cloud computing capabilities to meet the growing demand for digital services, in addition to establishing a legal and regulatory framework to support digital transformation in the banking sector, which helped create a favorable environment for growth and development.

Tabl.2. inputs and outputs of the first stage first period Million DA

	2012	2013	2014	2015	2016
DEPOSITS (output)					
BNA	1 325 198 500	1 498 338 492	1 742 545 916	1 732 218 308	1 673 844 881
BEA	2 234 045 113	2 122 364 125	2 273 213 124	2 075 512 143	1 867 120 414
CPA	3 433 963 516	3 221 070 468	3 058 163 670	3 267 583 016	3 268 408 677
BADR	5 342 766 925	5 226 253 336	5 432 436 901	5 644 717 011	5 772 434 515
CNEP	3 239 943 044	3 007 592 605	3 109 211 267	3 535 365 530	3 338 138 546
BDL	2 821 542 763	2 933 011 992	2 257 123 099	2 747 218 438	2 164 266 456
ASSET (input 1)					
BNA	2 267 779 263	2 183 564 663	2 223 056 995	2 144 915 767	2 284 337 118
BEA	4 166 607 176	3 154 689 248	3 262 369 202	3 297 324 992	3 122 177 722
CPA	3 115 800 752	2 689 134 245	2 514 024 452	2 258 543 699	1 922 533 695
BADR	1 849 299 926	1 645 197 114	1 575 914 095	1 477 179 232	1 347 945 606
CNEP	1 798 625 483	1 568 378 742	1 538 450 076	1 481 693 504	1 421 684 523
BDL	1 347 934 483	1 211 334 030	1 112 152 958	1 048 881 260	902 281 828
OWN FUNDS (input 2)					
BNA	416000000	430420914	42315009	44523197	43512000

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BEA	550 360 120	540 121 326	536 218 550	594 633 104	526 240 225
CPA	427 124 980	418 917 142	397 234 926	352 675 421	324 568 218
BADR	197 456 338	180 831 211	166 413 520	154 453 864	122 609 454
CNEP	145 519 651	141 640 318	139 452 240	134 467 793	129 640 320
BDL	128 412 826	125 116 324	125 809 223	125 671 208	123 588 765
OPERATING COST % (input 3)					
BNA	11,02	09,12	10,33	12,46	12,91
BEA	19,45	18,16	18,90	19,06	19,20
CPA	24,18	20,52	21,52	20,42	23,07
BADR	25,40	25,26	23,11	21,67	20,55
CNEP	26,30	26,12	25,45	26,43	28,19
BDL	28,96	27,30	25,53	27,31	25,77

Source: by the researcher from statistical bulletins of the Algerian commercial banks

Second period : (2017 – 2021): The period of strengthening financial inclusion:

Financial inclusion has contributed to increasing deposits in Algerian commercial banks, as more citizens have started saving and using banking services, which enhances the financial and economic stability in the country. Accordingly, commercial banks have witnessed an increase in deposits thanks to several key factors, including: Increasing financial awareness, expanding access to financial services, increasing government incentives, introducing microfinance programs, and integration with digital payment systems.

Tabl.3. inputs and outputs of the second stage first period Million DA

	2017	2018	2019	2020	2021
DEPOSITS (output)					
BNA	94 617 409	87 782 431	94 076 648	95 704 941	78 281 823
BEA	111 132 794	131 844 093	124 213 273	143 512 075	120 867 414
CPA	81 542 763	83 648 070	81 059 059	76 995 810	68 840 487
BADR	54 388 259	53 336 462	52 331 909	54 440 658	58 727 646
CNEP	39 943 044	37 361 952	41 600 276	35 682 365	38 138 546
BDL	33 693 156	33 299 011	35 375 757	47 438 812	40 364 662
ASSET (input 1)					
BNA	4 481 253 481	3 440 270 872	3 491 982 968	3 082 299 350	2 828 633 272
BEA	4 166 607 176	3 154 689 248	3 262 369 202	3 297 324 992	3 122 177 722
CPA	3 115 800 752	2 689 134 245	2 514 024 452	2 258 543 699	1 922 533 695
BADR	1 849 299 926	1 645 197 114	1 575 914 095	1 477 179 232	1 347 945 606

CHAPTER TWO: study methodology and procedures

CNEP	1 798 625 483	1 568 378 742	1 538 450 076	1 481 693 504	1 421 684 523
BDL	1 347 934 483	1 211 334 030	1 112 152 958	1 048 881 260	902 281 828
OWN FUNDS (input 2)					
BNA	713 326 607	677 917 183	658 830 550	634 444 249	591 315 849
BEA	616 234 024	577 648 489	520 235 837	481 366 601	422 166 175
CPA	340 043 220	324 709 970	284 169 824	259 865 643	229 703 091
BADR	180 306 569	167 210 830	157 857 533	159 354 468	144 069 844
CNEP	123 935 700	137 622 589	133 324 240	130 534 808	120 177 936
BDL	134 344 223	131 536 134	126 178 935	125 762 158	111 761 906
OPERATING COST % (input 3)					
BNA	12,82	10,08	11,30	10,35	14,91
BEA	21,40	20,15	20,90	19,63	23,26
CPA	27,25	21,47	23,13	23,01	24,07
BADR	29,48	27,87	38,63	38,88	44,02
CNEP	35,91	38,97	35,45	36,44	38,27
BDL	35,69	36,25	41,62	39,27	43,96

Source: by the researcher from statistical bulletins of the Algerian commercial banks

b. Phase two:

The stage of loans in commercial banks involves several key aspects (Rahmon, 2018, p. 13):

✓ Commercial banks engage in the process of loan origination, which involves evaluating loan applications, assessing the creditworthiness of borrowers, and determining the terms and conditions of the loan. Banks have established loan underwriting standards and procedures to ensure that loans are granted to borrowers who meet the bank's criteria for creditworthiness;

✓ Banks perform credit risk assessments to evaluate the likelihood of loan repayment. This includes analyzing the borrower's financial history, income sources, collateral (if any), and assessing the overall risk associated with the borrower and the proposed loan. Credit risk assessment helps banks make informed decisions about approving or rejecting loan applications and determining appropriate interest rates and loan terms;

✓ Upon approval of a loan application, commercial banks disburse funds to borrowers. The loan amount is transferred to the borrower's account or provided in the form of a check or other payment instruments. Disbursement may occur in a lump sum or in installments, depending on the terms of the loan agreement;

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✓ Commercial banks monitor the loans they have disbursed to ensure that borrowers are complying with the terms and conditions of the loan agreement. This includes tracking repayment schedules, monitoring collateral (if applicable), and assessing the borrower's financial health. Regular monitoring helps banks identify any potential signs of financial distress or non-compliance and take appropriate actions, such as initiating collections or restructuring loans;

✓ Commercial banks earn revenue from loans through the collection of interest and fees. They set interest rates based on factors such as the borrower's creditworthiness, prevailing market rates, and internal pricing policies. Banks also charge fees for loan processing, documentation, and other services. Managing interest rates and fees is crucial for banks to ensure profitability while remaining competitive in the lending market. (Rahmon, 2018, p. 14)

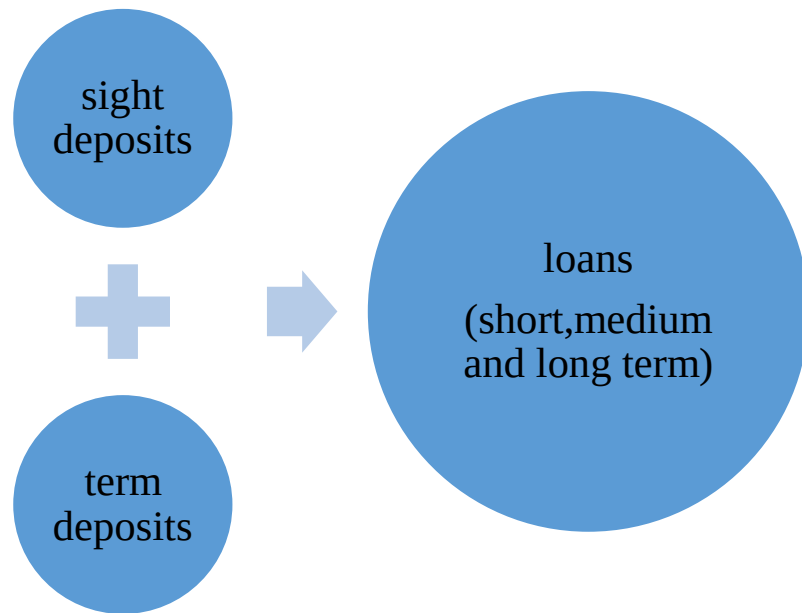
✓ In cases where borrowers fail to make loan repayments as per the agreed-upon terms, loans become non-performing. Commercial banks actively manage non-performing loans by initiating collection efforts, negotiating loan restructurings, or, in extreme cases, pursuing legal actions. Effective non-performing loan management is important for minimizing losses and maintaining the bank's financial stability;

✓ Commercial banks engage in loan portfolio management to ensure a balanced and diversified portfolio of loans. This involves monitoring the overall composition of loans in terms of sectors, types of loans, and geographic distribution. Banks assess the risk exposure of their loan portfolio and make strategic decisions to mitigate risks, such as adjusting lending practices or diversifying into different loan categories. (Rahmon, 2018, p. 13)

✓ Commercial banks are subject to regulatory guidelines and reporting requirements related to lending activities. They must adhere to prudential regulations, reserve requirements, and consumer protection laws. Compliance with regulations is essential for ensuring the safety and soundness of the banking system and protecting the interests of borrowers.

Accordingly, the following figure summarizes this stage as follows:

Fig.3. Inputs and outputs of banks during the second phase of their activity



Source: by researcher

The second main function of commercial banks is to provide loans and thus earn interest. This represents the main source of income for the bank.

The bank keeps a certain portion of deposits with itself as reserve and gives (lends) the balance to borrowers as loans and advances in the form of cash credit, demand loans, short term loans and overdraft as given below.

❖ **Cash credit:**

The eligible borrower is first imposed on a credit limit, within which limit he is allowed to draw a certain amount on a certain security. The drawing power depends on the borrower's current assets, the inventory of which is submitted to the bank as a basis for collateral. The bank charges interest on the withdrawn or used portion of the credit (loan).

❖ **Demand Loans:**

A loan that can be refunded on demand is called a demand loan. There is no specific maturity. The entire loan amount is paid in one go by depositing it into the borrower's loan account. Those such as stock brokers whose credit needs generally fluctuate, take such loans on personal collateral and financial assets.

❖ **Short-term loans:**

Short-term loans are given against some collateral as personal loans to finance working capital or as an advance for priority sectors. The full amount is paid either in one payment or in several installments during the loan term

In this phase, we distinguish:

➤ **Internal and endogenous variable:**

It represents the total production of cash deposits, which includes sight deposits and medium and long term deposits.

➤ **External variables:**

- Banking inputs: We considered that the production of banking products is mainly linked to two basic factors, namely: the sight deposits and medium and long term deposits, which form the basis for producing loans that constitute outputs,

- Banking outputs: The combination of banking inputs results in the following outputs: Total loans: short-term loans and medium and long-term loans.

First period :(2012 – 2016): The period of strengthening the infrastructure and technology:

Improving the infrastructure and technology in Algerian commercial banks has greatly contributed to increasing the efficiency of the loan creation process, which supports economic growth and contributes to the development of the banking sector in Algeria, through: improving banking operations, enhancing technical infrastructure, using digitization to increase the efficiency of granting loans, expanding the scope of services, data analysis and risk management, which reduces the likelihood of default, increasing the ability to analyze customer data to facilitate the provision of customized loan offers that suit the customer's needs and ability to repay, enhancing security and regulatory compliance, improving customer relationship management, which increases the chances of retaining existing customers and attracting new customers.

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Tabl.4. inputs and outputs of the first stage second period Million DA

	2012	2013	2014	2015	2016
LOANS					
BNA	39 558 320	34 435 970	33 890 234	35 845 130	26 542 618
BEA	53 776 580	51 567 123	48 514 290	49 666 610	46 423 789
CPA	24 345 620	22 907 456	21 974 446	31 556 314	26 389 690
BADR	5 334 019	4 246 345	4 102 932	9 453 924	5 845 379
CNEP	4 426 515	3 672 459	3 456 123	4 642 321	3 456 819
BDL	2 877 908	2 484 621	2 430 673	7 225 654	3 661 872
DEPOSITS					
BNA	1 325 198 500	1 498 338 492	1 742 545 916	1 732 218 308	1 673 844 881
BEA	2 234 045 113	2 122 364 125	2 273 213 124	2 075 512 143	1 867 120 414
CPA	3 433 963 516	3 221 070 468	3 058 163 670	3 267 583 016	3 268 408 677
BADR	5 342 766 925	5 226 253 336	5 432 436 901	5 644 717 011	5 772 434 515
CNEP	3 239 943 044	3 007 592 605	3 109 211 267	3 535 365 530	3 338 138 546
BDL	2 821 542 763	2 933 011 992	2 257 123 099	2 747 218 438	2 164 266 456

Source: by the researcher from statistical bulletins of the Algerian commercial banks



Second period : (2017 – 2021): The period of strengthening financial inclusion:

During the period of enhancing financial inclusion, creating loans is one of the main means that contribute to providing financing, and creating a favorable environment for increasing loan granting activity through: expanding the customer base, which provides an opportunity to create new loans, developing the small and medium enterprises sector, which is a major driver of economic growth, using financial technology to innovate new financing solutions such as digital loans or crowdfunding, reducing financial disparity, increasing financial awareness with the aim of increasing demand for loans, and complying with government policies.

CHAPTER TWO: study methodology and procedures

Tabl.5. inputs and outputs of the second stage second period Million DA

	2017	2018	2019	2020	2021
LOANS					
BNA	46 690 479	23 047 665	19 064 195	35 832 184	29 986 747
BEA	71 812 607	68 620 095	62 548 353	76 775 610	57 365 645
CPA	30 440 730	20 603 163	21 974 446	40 981 379	32 937 968
BADR	7 267 000	5 021 388	4 836 459	13 647 831	6 753 536
CNEP	5 451 627	3 596 301	6 692 266	9 316 123	8 746 716
BDL	3 919 889	2 568 758	1 667 941	16 310 150	13 801 709
DEPOSITS					
BNA	94 617 409	87 782 431	94 076 648	95 704 941	78 281 823
BEA	111 132 794	131 844 093	124 213 273	143 512 075	120 867 414
CPA	81 542 763	83 648 070	81 059 059	76 995 810	68 840 487
BADR	54 388 259	53 336 462	52 331 909	54 440 658	58 727 646
CNEP	39 943 044	37 361 952	41 600 276	35 682 365	38 138 546
BDL	33 693 156	33 299 011	35 375 757	47 438 812	40 364 662

Source: by the researcher from statistical bulletins of the Algerian commercial banks

2. Statistical methods used in the study:

During the two stages of the study, we used the cost equation for the deposit attraction stage and the production equation for the loan production stage.

a. SFA Coast function:

Stochastic Frontier Analysis (SFA) can be applied to estimate cost functions using the stochastic frontier approach. In this context, the SFA cost function represents the relationship between costs and inputs used in a production process, taking into account random errors and inefficiencies. (Bao Hoang Nguyen, Robin C. Sickles, & Valentin Zelenyuk, 2021, p. 10)

The SFA cost function takes the following general form:

$$C = f(X, Z; \beta) * \exp(v - u),$$

where:

- C represents the cost incurred by the entity.
- X represents the vector of inputs.

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- Z represents other factors that affect costs but are not under the control of the entity.
- β represents the vector of parameters to be estimated, which captures the relationship between inputs and costs.
- v represents a random error term that accounts for random shocks that cannot be controlled.
- u represents an inefficiency term, which accounts for deviations from best practice limits due to factors that are within the control of the firm

The term $f(X, Z; \beta)$ represents the deterministic component of the cost function, which captures the underlying relationship between inputs and costs. This can be specified using various functional forms, such as Cobb-Douglas, Translog, or flexible functional forms;

The exponential term $\exp(v - u)$ represents the stochastic component of the cost function. The term v captures random shocks or factors that affect costs but are beyond the control of the firm, such as fluctuations in input prices. The term u captures inefficiency or deviations from the best-practice frontier, which can arise due to factors such as managerial inefficiencies, suboptimal resource allocation, or technological inefficiencies;

Estimating the SFA cost function involves simultaneously estimating the parameters β , the inefficiency term u , and the random error term v . This estimation allows for the identification of factors that contribute to cost inefficiencies, the measurement of technical efficiency, and the comparison of firms' cost performance;

The SFA cost function is a valuable tool for analyzing cost efficiency, identifying areas for improvement, benchmarking cost performance, and informing resource allocation decisions. It helps firms and policymakers understand the cost dynamics, improve cost management practices, and enhance overall operational efficiency. (Bao Hoang Nguyen, Robin C. Sickles, & Valentin Zelenyuk, 2021, p. 12)

 Example:

Let's say we have a cost function for the company of the following form:

$$TC=f(Q,X)+\epsilon$$

Where:

- **TC:** is the total costs
- **Q:** is the quantity of production.
- **X:** represents a set of other variables that affect costs (such as raw material prices, wages, etc.)
- **ϵ :** is the random error that can be divided into two components: one that represents inefficiency and another that represents natural random factors.

In stochastic frontier analysis (SFA), we split the error ϵ into two components:

$$\epsilon = v + u$$

Where:

- **v :** It is a random term representing natural noise (normally distributed with mean zero and standard deviation σ_v)
- **u :** It is an efficiency term (it is distributed non-negatively, such as the semi-normal distribution).

Suppose we have a random sample of 10 firms, and each firm provides data on its output and costs. The data could be as follows:

Tabl.X. Digital data for the application example

TC	Q	The company
500	100	1
650	150	2
800	200	3
900	250	4
1100	300	5
1300	350	6
1500	400	7
1600	450	8
1700	500	9
2000	550	10

Source: by the researcher

The cost function is estimated using the Maximum Likelihood Estimation method to obtain the model parameters, which will allow us to estimate the efficiency.

$$\ln(TC) = \beta_0 + \beta_1 \ln(Q) + v + u$$

- `data = pd.DataFrame`
`({'Q': [100, 150, 200, 250, 300, 350, 400, 450, 500, 550],`
`'TC': [500, 650, 800, 900, 1100, 1300, 1500, 1600, 1700, 2000]}`
- Natural logarithm of production quantity and costs:
`data['ln_Q'] = np.log(data['Q'])`
`data['ln_TC'] = np.log(data['TC'])`

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- Dependent and independent variable:

`X = sm.add_constant(data['ln_Q'])`

`y = data['ln_TC']`

`data['Efficiency'] = np.random.uniform(0.7, 1, size=len(data))`

Firms with efficiency close to 1 operate more efficiently, while firms with low efficiency face greater inefficiency.

b. SFA Production function:

Stochastic frontier analysis (SFA) is used to estimate production functions using the stochastic frontier approach. In this context, the SFA production function represents the relationship between the inputs used in a production process and the resulting output, taking into account random errors and inefficiencies. (Federico Belotti, Silvio Daidone, Giuseppe Ilardi, & Vincenzo Atella, 2013, p. 20)

The SFA production function takes the following general form:

$$Y = f(X, Z; \beta) * \exp(v - u),$$

where:

- Y represents the output produced by the entity.
- X represents the vector of inputs.
- Z represents other factors that affect output but are not under the entity's control.
- β represents the vector of parameters to be estimated, which captures the relationship between inputs and outputs.
- v represents a random error term that represents uncontrollable random shocks to output.
- u represents an inefficiency term, which accounts for deviations from best practice limits due to factors within the entity's control.

The term $f(X, Z; \beta)$ represents the deterministic component of the production function, which captures the fundamental relationship between inputs and outputs, which can be specified

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using different functional forms, such as Cobb-Douglas, Translog, and elastic functional forms; The exponential term $\exp(v - u)$ represents the stochastic component of the production function, The term v captures random shocks or factors that affect production but are outside the entity's control, such as fluctuations in the availability of inputs, The term u captures inefficiencies or deviations from best practice boundaries, which may arise due to other factors. (Federico Belotti, Silvio Daidone, Giuseppe Ilardi, & Vincenzo Atella, 2013, p. 21)

The estimation of the SFA production function involves the simultaneous estimation of the parameters β , the inefficiency term u and the random error term v . This estimation allows identifying the factors that contribute to production inefficiency, measuring technical efficiency and comparing firms' production performance;

The SFA production function is a useful tool for analyzing production efficiency, identifying areas for improvement, comparing production performance and informing resource allocation decisions. It helps firms and policy makers understand production dynamics, improve production management practices and enhance overall operational efficiency. (Federico Belotti, Silvio Daidone, Giuseppe Ilardi, & Vincenzo Atella, 2013, p. 21)

Example:

In our example we will use the Cobb-Douglas production function as follows:

$$\ln(Y_i) = \beta_0 + \beta_1 \ln(L_i) + \beta_2 \ln(K_i) + v_i - u_i$$

Where:

- **Y_i** : total output of the firm
- **L_i** : amount of labor used
- **K_i** : capital used
- **$\beta_0, \beta_1, \beta_2$** : model parameters to be estimated
- **v_i** : random error term (represents unobserved random factors, normally distributed

with mean zero)

- **u_i** : inefficiency term (non-negative, reflects technical inefficiency)

Assume data for a sample of 10 companies as follows:

Tabl.Y. Digital data for the application example

K	L	Y	The company
100	50	500	1
110	60	600	2
105	55	550	3
120	65	700	4
115	60	650	5
130	70	800	6
125	68	750	7
140	80	900	8
135	75	850	9
150	85	950	10

Source: by the researcher

➤ Steps:

- Data preparation: Take the natural logarithm of the variables to apply the Copas-Douglas logarithmic model.

- Model estimation: Use linear regression to estimate the model coefficients.
- Efficiency analysis: Calculate the technical efficiency of each firm.

- data = pd.DataFrame:

({ 'Y': [500, 600, 550, 700, 650, 800, 750, 900, 850, 950],

'L': [50, 60, 55, 65, 60, 70, 68, 80, 75, 85],

'K': [100, 110, 105, 120, 115, 130, 125, 140, 135, 150]

- Taking the natural logarithm of variables:

data['ln_Y'] = np.log(data['Y'])

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```
data['ln_L'] = np.log(data['L'])
```

```
data['ln_K'] = np.log(data['K'])
```

- Independent and dependent variables:

```
X = data[['ln_L', 'ln_K']]
```

```
X = sm.add_constant(X)
```

```
y = data['ln_Y']
```

We assume that the results extracted from the model are as follows:

- **Constant (β_0) = 0.0500:** refers to the basic level of output when the values of the independent variables equal 1 (considering the natural logarithm).
- **Labor coefficient (β_1) = 0.6000:** means that a 1% increase in labor leads to a 0.6% increase in output, with capital constant.
- **Capital coefficient (β_2) = 0.4000:** means that a 1% increase in capital leads to a 0.4% increase in output, with labor constant.

➤ Results with technical efficiency:

Tabl.Z. Digital data for the application example

Yp	TE	Yr	The company
526.32	0.95	500	1
652.17	0.92	600	2
585.11	0.94	550	3
777.78	0.90	700	4
698.92	0.93	650	5
909.09	0.88	800	6

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842.70	0.8	750	7
1058.82	0.85	900	8
934.07	0.91	850	9
1091.95	0.87	950	10

Source: by the researcher

➤ Technical Efficiency Analysis:

- **Company 1:** Its technical efficiency is 95%, which is the highest in the sample. Its actual output is very close to its potential output.
- **Company 8:** It has the lowest technical efficiency (85%). It can increase its output by about 158.82 units without increasing inputs, just by improving efficiency.
- **Average Efficiency:** The average efficiency of all companies can be calculated to assess the overall performance of the sector.

➤ Conclusions and Recommendations

- **Improving Efficiency:** Less efficient companies can focus on improving production processes, training, and adopting new technologies to increase their efficiency.
- **Benefiting from Best Practices:** Less efficient companies can benefit from the expertise of highly efficient companies.
- **Strategic Planning:** Understanding the sources of inefficiency helps management make strategic decisions to improve efficiency.

3. R language:

R is a programming language designed specifically for statistical computing and data analysis, providing a wide range of tools and libraries that make it popular among statisticians, data scientists, and researchers. It is characterized by:

- Data analysis and visualization with extensive processing and analysis capabilities, and provides a rich set of libraries, such as ggplot2 and dplyr, that allow users to perform their tasks.
- Statistical modeling through a comprehensive set of functions and packages for statistical modeling and inference.
- Data import and export, including CSV, Excel, JSON, XML, and databases.
- Reproducible search through the use of scripts and notebooks, by writing code or using tools such as R Markdown.
- Highly extensible as it allows users to create their own functions, packages, and libraries. This enables the R community to develop and share a wide range of user-contributed packages.
- It contains a large and active community of users and developers, contributing to the development of packages, and providing support through forums and mailing lists.
- Integration with other programming languages and tools.
- Free to download, use and modify.

4. Evolution of R:

R first appeared in 1993, written by Ross Ihaka and Robert Gentleman in the Department of Statistics at the University of Auckland, New Zealand. A large group of individuals contributed to its development by submitting code and bug reports, and since mid-1997, there has been a core group whose job is to edit the R source code archive.

5. Importance of R language:

R is a versatile programming language primarily used for statistical computing and data analysis. It is known for its comprehensive libraries and packages specifically designed for data analysis and statistical modeling. It is particularly notable for its data visualization, with packages such as ggplot2 allowing users to create complex and customizable data visualizations. R has a

vibrant and active user community, resulting in a broad ecosystem of user-contributed packages. These packages extend the capabilities of the programming language in various fields, from machine learning to data processing and time series analysis. It also facilitates reproducible research by enabling users to document and share their analysis workflows. As it is open source, it promotes collaboration, innovation, and integration, allowing seamless integration with other programming languages and tools. R offers a wide range of tools for developing and implementing statistical models, from simple linear regressions to complex machine learning algorithms, and is widely used in academia and research across disciplines. Its flexibility and broad statistical capabilities make it an essential tool for researchers to analyze and interpret data, and business analytics. It is an excellent language for teaching and learning data analysis and statistics, and many educational institutions integrate it into their curricula to prepare students for careers in data science and related fields.

6. Advantages and disadvantages of R language:

The advantages and disadvantages of the R programming language can be explored on :

✓ Advantages of R:

- R is an open source programming language, meaning it is freely available to use, which has contributed to its widespread adoption.
- R offers a comprehensive set of statistical functions, making it the preferred choice for statisticians and researchers.
- R has a vast ecosystem of packages for data processing, and users can easily access and leverage these packages to extend the functionality of this language.
- R is known for its highly customizable graphics and publishing quality, and is widely used to create informative charts and graphs.
- R supports reproducible research through tools that enable the creation of dynamic and interactive reports, enhancing transparency.
- R has a large and active user community, making it easy for users to find solutions to their problems and stay up to date with the latest developments.
- The R programming language is available on systems that ensure it works in a better operating system environment.

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- The R programming language can be easily integrated with other programming languages, making it versatile.
- The R programming language is used for data analysis and statistics, making it a popular choice in educational settings.

✓ **Disadvantages of R:**

- The data handling of R may be less intuitive than some other languages.
- R may not be as memory efficient as some other languages, which can be a limitation when working with large datasets.
- Speed issues with the R programming language, it may not be the best choice for real-time applications.
- Data cleaning and preprocessing in R can be cumbersome and less user-friendly than some other tools.
- The R programming language's GUI options are somewhat limited compared to other languages, which makes it less attractive to some users.
- There may be compatibility issues or inconsistencies between packages in the programming language, which requires careful management.
- The quality and coverage of documentation for some packages may vary within the R programming language.

7. Practical steps to use R language:

To be able to start coding, we need to install two essential tools:

- The R software,
- Rstudio software.

The first is essential for translating text (R code) into machine language (binary). The second offers a set of tools that facilitate the use of R (writing code, executing it, debugging it, etc.).

We will typically use R via RStudio. We can compare this situation to that of driving a car in which R is the engine and RStudio the dashboard. (Enseignement à distance, 2020, p. 9)

After installing R and RStudio on our computer, we will have two new applications.

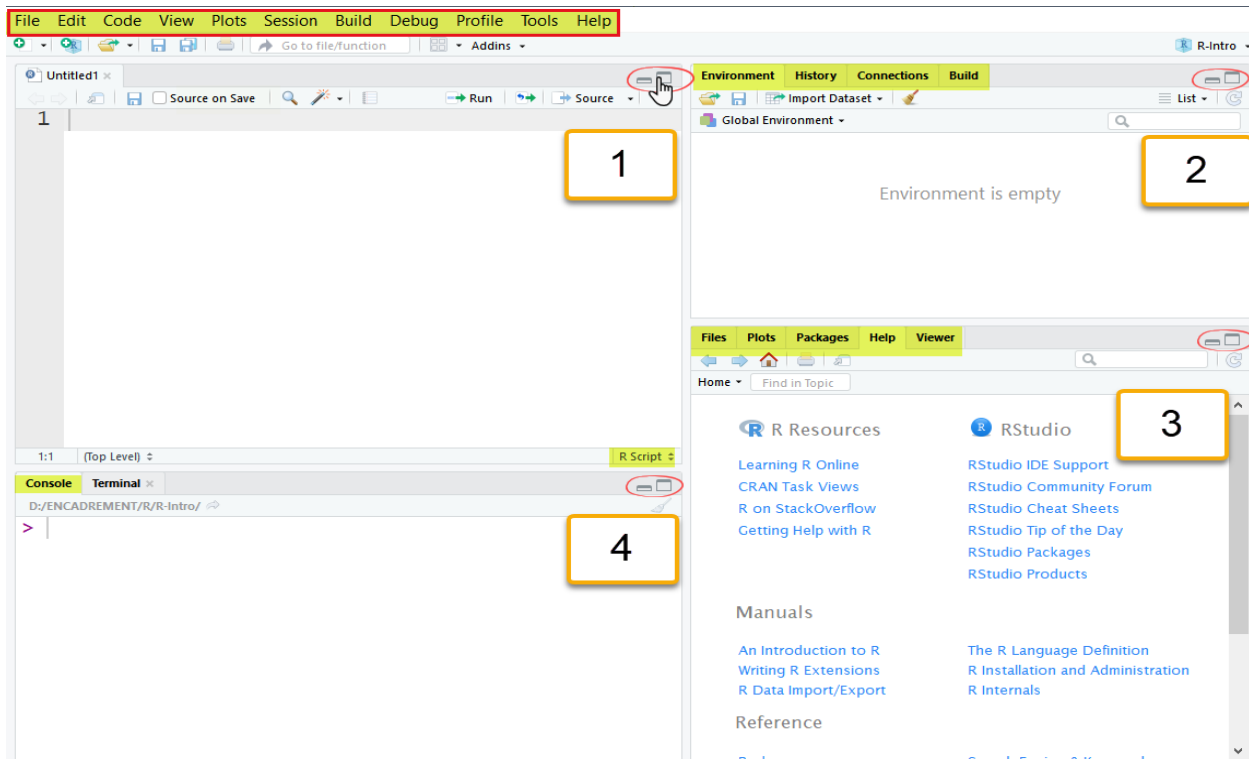
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We will always work with RStudio and not with R (directly).

In other words, we must always open RStudio, which is the latter that will automatically call R to execute our codes and display the results.

Once Rstudio is running, you will have an interface in the form of a single window divided into several areas that can be resized, hidden or maximized according to your preferences as shown in the following figure (Enseignement à distance, 2020, p. 12):

Fig.4. interface of R language



Source: by researcher from R program

1. The top-left quadrant is the pane dedicated to source files, It is used to write and save lines of code (script). This is where we spend most of our time in RStudio.
2. The top-right quadrant provides, among other things, information about your objects and data in memory (Environment) and your command history (History).
3. The bottom-right quadrant allows you to browse your working directory (Files tab), display help (Help), display your graphics (Plots) and the available extensions (Packages). The last Viewer tab will not be useful to us (yet).

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4. Finally, the Console is displayed at the bottom left. This is where we will be able to enter/execute instructions in R and see the results displayed.

Conclusion of chapter:

Technical efficiency is used to study the relationship between the inputs and outputs of banks' decision-making units. Either the bank increases its inputs within the limits of the level of outputs it desires to obtain, or it increases its outputs at a certain level of inputs, and if we take into account the two basic stages of the activity stages Commercial banks, which represent the stage of attracting deposits and the stage of granting loans

Accordingly, there are two approaches to determining the inputs and outputs of banks: the production approach and the mediation approach.

After addressing the program and the statistical method for processing the available data, we can present and discuss the obtained results, which will be dealt with during the third chapter.

Chapter three:
Results and discussion

CHAPTER THREE: RESULTS AND DISCUSSION

Introduction of chapter:

Our objective in this chapter is therefore to compare the technical efficiency of Algerian public commercial banks, Accordingly, a sample of six Algerian commercial banks was selected.

For this, we use a data sample including six commercial banks operating in Algeria over the period 2012–2021, by choosing different variables according to the two stages of cost and production study, It was mainly represented by assets, private funds and operating costs on deposits as inputs for the first stage on the one hand, and short-, medium- and long-term deposits as inputs for the second stage of the activity of these banks.

During this section, we present the results obtained from data processing using SFA method through R program

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Section 1: Criteria used to interpret the results of measuring the technical efficiency of commercial banks:

To interpret the results of measuring the technical efficiency of commercial banks, we took a systematic approach to understanding what efficiency scores mean and how they can inform decision-making, using the stochastic frontier analysis (SFA) method. Below we review the standard steps followed to interpret the results of technical efficiency measurements:

❖ Understanding degrees of proficiency:

Efficiency scores typically range from **0** to **1**, where 1 represents ideal efficiency (best possible performance) and values less than 1 indicate relative inefficiency.

❖ Determine the years with effective and ineffective units:

- Sorting or classifying units by year into efficient and ineffective groups based on their efficiency degrees.
- Years in which units are efficient receive a score of 1, indicating that they make optimal use of resources.
- While the years in which the units are characterized by ineffectiveness receive scores less than 1 and resources are not used efficiently.

❖ Analysis of differences between years of efficiency calculation:

- Comparing the effective and ineffective years of the studied units with the aim of identifying the main differences in their operations, practices or characteristics during the years of study.
- Study what distinguishes the effectiveness of the units in terms of best practices or strategies.

❖ Interpretation of proficiency scores:

- Scores close to **1** indicate high efficiency, while scores less than 1 indicate room for improvement.
- Efficiency scores can help identify areas that need adjustments or changes to improve performance.

❖ Benchmarking:

- Use efficiency scores to benchmark units against each other over time and against industry standards.

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- Benchmarking allows for setting efficiency targets and identifying areas where poor performing years can improve.

- ❖ Sensitivity analysis:

Conducting sensitivity analysis is used to assess the strength of efficiency scores on input or output variables, which helps in assessing the stability of results.

- ❖ Root causes of inefficiency:

Investigate the root causes of inefficiency of underperforming units, including specific factors such as resource allocation, production processes or management decisions.

- ❖ Policy Implications:

Efficiency scores can inform interventions and regulatory changes to improve overall sector performance.

- ❖ Continuous improvement:

Efficiency is not a static measure; it can change over time due to factors such as market conditions, technological advances, and changes in management. Therefore, a culture of continuous improvement based on efficiency analysis should be encouraged.

- ❖ Feedback to decision makers:

Communicate the potential benefits of addressing shortcomings and improving resource use, by presenting results and insights to relevant decision makers,

- ❖ Long-term strategy:

- Use efficiency measurement as part of a long-term strategy to improve performance.

- Efficiency scores can guide resource allocation, investment decisions, and process improvement efforts. View and test results of the first step:

1. Command syntax:

The specific syntax can vary depending on the programming language used in which the commands are issued.

For that, our rules and conventions that govern how commands are organized and written bellow:

✓ Command Name:

Command syntax SFA: which is represented the name of the command or program to be run;

✓ Options:

Options can be single-letter abbreviations or entire words. These are usually preceded by hyphens or double hyphens..

Through our study, the following options were adopted:

-sc or --sciviews

-f or --frontier

✓ Arguments:

Arguments represents the inputs (parameters) that the command operates on. It usually comes after the command and any options, it was determined according to the study as follows:

- file.txt: File name.
- Directory/: Directory path.
- 123: A numerical value, derived from an Excel table containing study statistics

✓ Syntax rules:

Commands are usually case sensitive, which means that it may have different meanings, spaces or tabs were used to separate commands, options, and arguments.

We also used quotes in order to group arguments or options that contain spaces or special characters together.

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✓ Pipes (|) and (>) Redirection:

The pipe symbol (|) was used to pass the output of one command as input to another command in many command-line interfaces.

Redirection (>) has also been used to redirect output to a file. For example:

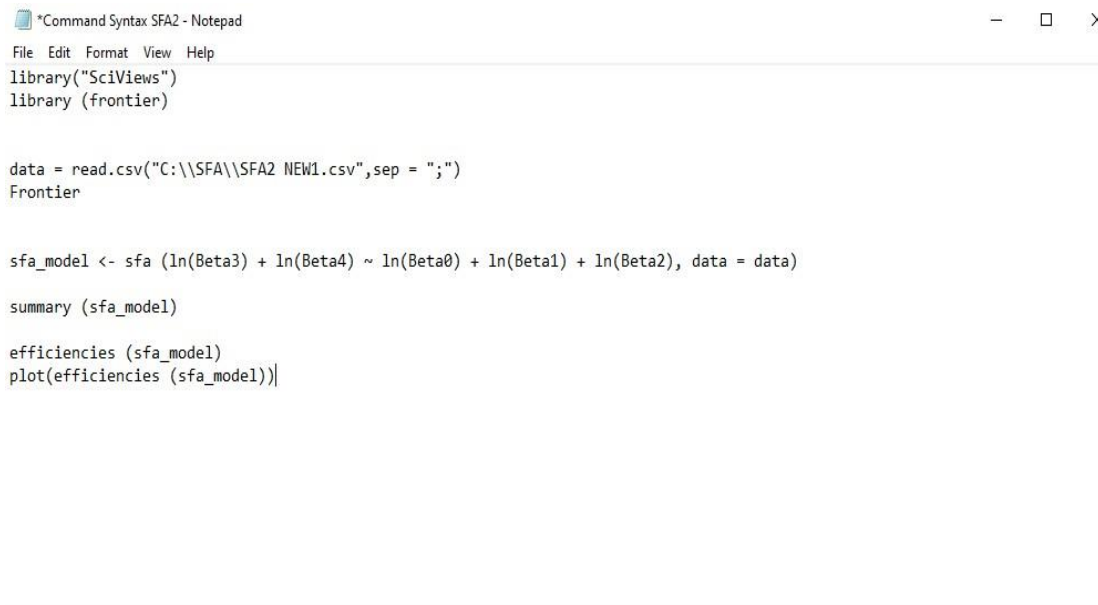
✓ Command1 | Command2:

|: Route the output of Command1 to Command2.

>: Redirects the command output to a file called output.txt.

Wildcards: Some command line interfaces support wildcards to represent multiple files or directories.

Fig.5. command syntax SFA coast function



```
*Command Syntax SFA2 - Notepad
File Edit Format View Help
library("SciViews")
library (frontier)

data = read.csv("C:\\SFA\\SFA2 NEW1.csv",sep = ";")
Frontier

sfa_model <- sfa (ln(Beta3) + ln(Beta4) ~ ln(Beta0) + ln(Beta1) + ln(Beta2), data = data)

summary (sfa_model)

efficiencies (sfa_model)
plot(efficiencies (sfa_model))
```

Source: by researcher from R program

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Section2: First stage: creation of deposits:

The above image represents the form of equation used in processing the data of the first stage, which includes : “**Assets, own funds and operating cost**” as inputs on the one hand, and the various deposits **banking products** obtained by banks as outputs on the other hand.

➤ **First variable: assets of banks**

Assets represent all the resources controlled by a company and capable of generating future profits. They are classified into two main categories: non-current assets (or fixed assets) and current assets.

Tabl.06. ASSETS (INPUT 1) *(million DA)*

	2012	2013	2014	2015	2016
BNA	2 267 779 263	2 183 564 663	2 223 056 995	2 144 915 767	2 284 337 118
BEA	4 166 607 176	3 154 689 248	3 262 369 202	3 297 324 992	3 122 177 722
CPA	3 115 800 752	2 689 134 245	2 514 024 452	2 258 543 699	1 922 533 695
BADR	1 849 299 926	1 645 197 114	1 575 914 095	1 477 179 232	1 347 945 606
CNEP	1 798 625 483	1 568 378 742	1 538 450 076	1 481 693 504	1 421 684 523
BDL	1 347 934 483	1 211 334 030	1 112 152 958	1 048 881 260	902 281 828
	2017	2018	2019	2020	2021
BNA	4 481 253 481	3 440 270 872	3 491 982 968	3 082 299 350	2 828 633 272
BEA	4 166 607 176	3 154 689 248	3 262 369 202	3 297 324 992	3 122 177 722
CPA	3 115 800 752	2 689 134 245	2 514 024 452	2 258 543 699	1 922 533 695
BADR	1 849 299 926	1 645 197 114	1 575 914 095	1 477 179 232	1 347 945 606
CNEP	1 798 625 483	1 568 378 742	1 538 450 076	1 481 693 504	1 421 684 523
BDL	1 347 934 483	1 211 334 030	1 112 152 958	1 048 881 260	902 281 828

Source by researcher from statistical bulletins of the Algerian commercial banks

The table presented above includes statistics related to the six banks under study, which relate to the first input (ASSETS).

➤ **Testing the first variable:**

This represents the rate of return on assets shows the result obtained by employing the bank's resources for assets, and reflects the efficiency of the bank's management in utilizing total

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assets, and it measures net income result of the investment of a unit of assets. The return on assets ratio is calculated with the following formula:

$$\text{Profitability of Assets} = \text{Banking Products} / \text{Assets}$$

Tab.07. Testing the first input

		2012	2013	2014	2015	2016
BNA	AU	0.58%	0.68%	1.28%	1.24%	0.73%
	PM	31,25%	34,30%	32,20%	28,35%	29,41%
	RAO	1,86%	1,65%	1,45%	1,36%	1,44%
BEA	AU	0.53%	0.67%	0.69%	0.63%	0.59%
	PM	42,20%	46,37%	45,42%	49,08%	56,34%
	RAO	3,25%	2,92%	2,45%	2,60%	2,98%
CPA	AU	1.10%	1.2%	1.22%	1.45%	1.70%
	PM	35,45%	40,36%	41,11%	36,8%	39,24%
	RAO	1,09%	1,56%	1,34%	0,99%	1,18%
BADR	AU	2.89%	3.18%	3.48%	3.82%	4.28%
	PM	13,48%	20,36%	8,17%	8,72%	12,342%
	RAO	0,50%	0,92%	0,31%	0,31%	0,39%
CNEP	AU	1.81%	1.92%	2.02%	2.39%	2.35%
	PM	19,50%	24,31%	18,80%	12,20%	15,65%
	RAO	0,52%	0,54%	0,43%	0,36%	0,25%
BDL	AU	2.09%	2.42%	2.03%	2.62%	2.4%
	PM	45,20%	42,15%	26,3%	18,67%	10,66%
	RAO	1,63%	1,76%	1,05%	0,83%	0,34%
Average.AU		1.5%	1.69%	1.79%	2.025%	2%
Average.PM		31.18%	34.64%	28.67%	25,63%	27.27%
Average.RAO		1.48%	1.59%	1.17%	1.075%	1.09%
		2017	2018	2019	2020	2021
BNA	AU	2,77%	3,10%	2,69%	2,55%	2,11%
	PM	38,31%	37,44%	20,26%	26,26%	49,35%
	RAO	1,06%	1,16%	0,55%	0,67%	1,04%
BEA	AU	3,87%	4,35%	3,81%	4,18%	2,67%
	PM	47,46%	53,50%	50,36%	52,05%	64,62%
	RAO	1,84%	2,33%	1,92%	2,18%	1,72%
CPA	AU	3,58%	3,41%	3,22%	3,11%	2,62%
	PM	47,85%	53,23%	27,11%	24,63%	37,33%
	RAO	1,71%	1,81%	0,87%	0,77%	0,98%
BADR	AU	4,36%	3,69%	3,32%	3,24%	2,94%
	PM	11,50%	25,07%	9,24%	9,41%	13,36%
	RAO	0,50%	0,92%	0,31%	0,31%	0,39%
CNEP	AU	2,68%	2,41%	2,70%	2,38%	2,22%

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	PM	22,93%	26,11%	16,09%	9,63%	13,65%
	RAO	0,62%	0,63%	0,44%	0,23%	0,30%
BDL	AU	4,47%	4,52%	3,18%	2,75%	2,50%
	PM	34,19%	34,38%	4,71%	7,71%	11,63%
	RAO	1,53%	1,56%	0,15%	0,21%	0,29%
Average.AU		3.51%	3,59%	3,18%	3,12%	2.48%
Average.PM		36.92%	42.50%	27.24%	28.89%	39.87%
Average.RAO		1.30%	1.53%	0.87%	0.90%	0.99%

Source by researcher from statistical bulletins of the Algerian commercial banks

➤ **Second variable: own funds**

Equity is important because it represents the part of the business financed by the owners and not by debt. They play a key role in the financial strength of the company and its ability to withstand economic difficulties. A company with high equity is often perceived as more stable and reliable by investors and creditors.

Tabl.08. OWN FUNDS (INPUT 2) *(million DA)*

	2012	2013	2014	2015	2016
BNA	416000000	430420914	42315009	44523197	43512000
BEA	550 360 120	540 121 326	536 218 550	594 633 104	526 240 225
CPA	427 124 980	418 917 142	397 234 926	352 675 421	324 568 218
BADR	197 456 338	180 831 211	166 413 520	154 453 864	122 609 454
CNEP	145 519 651	141 640 318	139 452 240	134 467 793	129 640 320
BDL	128 412 826	125 116 324	125 809 223	125 671 208	123 588 765
	2017	2018	2019	2020	2021
BNA	713 326 607	677 917 183	658 830 550	634 444 249	591 315 849
BEA	616 234 024	577 648 489	520 235 837	481 366 601	422 166 175
CPA	340 043 220	324 709 970	284 169 824	259 865 643	229 703 091
BADR	180 306 569	167 210 830	157 857 533	159 354 468	144 069 844
CNEP	123 935 700	137 622 589	133 324 240	130 534 808	120 177 936
BDL	134 344 223	131 536 134	126 178 935	125 762 158	111 761 906

Source by researcher from statistical bulletins of the Algerian commercial banks

The table presented above includes statistics related to the six banks under study, which relate to the second input (OWN FUNDS).

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➤ Testing the second variable:

To measure the return on shareholders' investments, it is calculated as follows:

The profitability of equity = Banking Products / Equity capital

Tabl.09. Testing the first input

		2012	2013	2014	2015	2016
BNA	ROA	1,15%	1,09%	1,22%	0,90%	1,11%
	ME	3,25	3,39	4,30	4,77	5,50
	ROE	6,67%	6,56%	4,23%	3,65%	5,35%
BEA	ROA	1,82%	2,09%	2,11%	2,86%	1,57%
	ME	7,40	6,85	6,27	5,46	6,76
	ROE	13,59%	15,95%	12,02%	11,88%	11,65%
CPA	ROA	1,71%	1,81%	0,87%	0,77%	0,98%
	ME	8,37	8,69	8,85	8,28	9,16
	ROE	14,34%	15,77%	7,73%	6,35%	8,95%
BADR	ROA	0,50%	0,92%	0,31%	0,31%	0,39%
	ME	9,36	9,27	9,98	9,84	10,26
	ROE	4,69%	8,56%	3,06%	3,00%	4,03%
CNEP	ROA	0,62%	0,63%	0,44%	0,23%	0,30%
	ME	11,83	11,35	11,54	11,40	14,51
	ROE	8,28%	8,15%	8,42%	9,61%	9,31%
BDL	ROA	1,58%	1,42%	1,60%	1,65%	1,67%
	ME	10,07	10,56	10,42	11,19	11,03
	ROE	11,20%	11,56%	10,32%	10,25%	12,13%
Average.ROA		1.23%	1.33%	1.09%	1.12%	1.003%
Average.ME		8.38%	8.35%	8.56%	8.49%	9.54%
Average.ROE		9.79%	11.09%	7.63%	7.46%	8.57%
		2017	2018	2019	2020	2021
BNA	ROA	1,06%	1,16%	0,55%	0,67%	1,04%
	ME	4,78	4,86	5,30	5,07	6,28
	ROE	5,07%	5,65%	2,89%	3,40%	6,55%
BEA	ROA	1,84%	2,33%	1,92%	2,18%	1,72%
	ME	7,40	6,85	6,27	5,46	6,76
	ROE	13,59%	15,95%	12,02%	11,88%	11,65%
CPA	ROA	1,71%	1,81%	0,87%	0,77%	0,98%
	ME	8,37	8,69	8,85	8,28	9,16
	ROE	14,34%	15,77%	7,73%	6,35%	8,95%
BADR	ROA	0,50%	0,92%	0,31%	0,31%	0,39%
	ME	9,36	9,27	9,98	9,84	10,26
	ROE	4,69%	8,56%	3,06%	3,00%	4,03%
CNEP	ROA	0,62%	0,63%	0,44%	0,23%	0,30%
	ME	11,83	11,35	11,54	11,40	14,51

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	ROE	7,28%	7,14%	5,02%	2,61%	4,35%
BDL	ROA	1,53%	1,56%	0,15%	0,21%	0,29%
	ME	8,07	8,34	8,81	9,21	10,03
	ROE	12,35%	12,97%	1,32%	1,95%	2,91%
Average.ROA		1.30%	1.53%	0.87%	0.90%	0.99%
Average.ME		7.13	7.06	7.18	6.80	7.95
Average.ROE		9.24%	10.77%	6.21%	6.12%	7,85%

Source by researcher

➤ **Third variable: operating cost**

Operating costs (operating expenses) represent all expenses incurred by a company in the course of its day-to-day activities.

These expenses are necessary to produce goods or services and sell them; they are recorded in the income statement and directly impact the profitability of the company.

Tabl.10. OPERATING COST (INPUT 3) (%)

	2012	2013	2014	2015	2016
BNA	11,28	8,10	10,20	10,45	13,38
BEA	31,34	30,12	28,5	23,42	26,39
CPA	23,18	19,33	21,40	22,04	23,30
BADR	30,52	28,80	34,40	36,9	38,23
CNEP	35,34	36,70	34,15	37,31	30,28
BDL	34,18	33,15	30,28	32,33	37,50
	2017	2018	2019	2020	2021
BNA	12,82	10,08	11,30	10,35	14,91
BEA	21,40	20,15	20,90	19,63	23,26
CPA	27,25	21,47	23,13	23,01	24,07
BADR	29,48	27,87	38,63	38,88	44,02
CNEP	35,91	38,97	35,45	36,44	38,27
BDL	35,69	36,25	41,62	39,27	43,96

Source by researcher

The table presented above includes rates related to the six banks under study, which relate to the third input (OPERATING COST).

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➤ fourth variable (output): banking products

Banking products represent the different sources of income of a bank. These products are diverse and can be classified into several categories, depending on their nature and their method of generation.

Tabl.11. BANKING PRODUCTS (output)

(million DA)

	2012	2013	2014	2015	2016
BNA	1 325 198 500	1 498 338 492	1 742 545 916	1 732 218 308	1 673 844 881
BEA	2 234 045 113	2 122 364 125	2 273 213 124	2 075 512 143	1 867 120 414
CPA	3 433 963 516	3 221 070 468	3 058 163 670	3 267 583 016	3 268 408 677
BADR	5 342 766 925	5 226 253 336	5 432 436 901	5 644 717 011	5 772 434 515
CNEP	3 239 943 044	3 007 592 605	3 109 211 267	3 535 365 530	3 338 138 546
BDL	2 821 542 763	2 933 011 992	2 257 123 099	2 747 218 438	2 164 266 456
	2017	2018	2019	2020	2021
BNA	94 617 409	87 782 431	94 076 648	95 704 941	78 281 823
BEA	111 132 794	131 844 093	124 213 273	143 512 075	120 867 414
CPA	81 542 763	83 648 070	81 059 059	76 995 810	68 840 487
BADR	54 388 259	53 336 462	52 331 909	54 440 658	58 727 646
CNEP	39 943 044	37 361 952	41 600 276	35 682 365	38 138 546
BDL	33 693 156	33 299 011	35 375 757	47 438 812	40 364 662

Source by researcher from statistical bulletins of the Algerian commercial banks

Applying the previous data to the following equation of SFA cost:

$$\ln Ci = f(X_i, \beta) + v_i + u_i$$

We find the mean following results:

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Tabl.12. results of R language A1

Bank		estimate	Std. error	Z value	Pr z
BNA	Intercept	-17.24454	7.48889	-2.3027	0.0212966*
	Ln input1	4.13147	1.21007	3.4142	0.0006396***
	Ln input2	0.65720	0.48423	1.3572	0.1747130
	Ln input3	-1.30343	0.75956	-1.7160	0.0861555
	Sigma sq	0.53532	0.16433	3.2575	0.0011241**
	gamma	1.00000	0.11273	8,8705	2.2e-16***

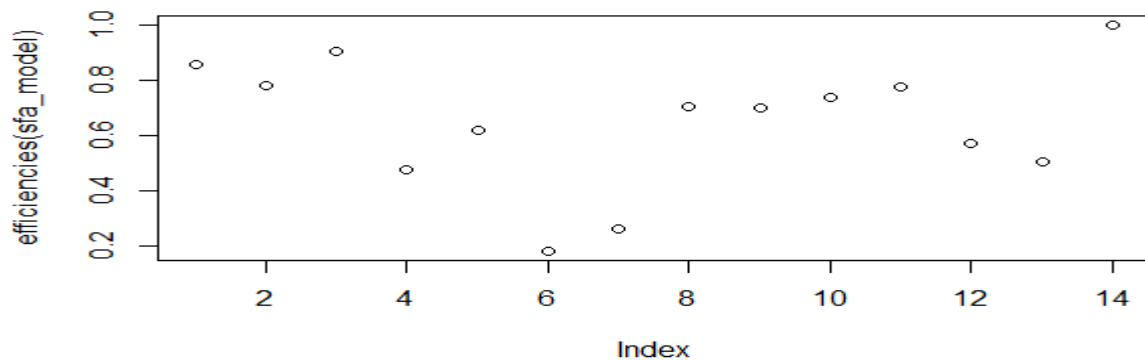
Source: by researcher from appendice 1

Through the result of the table above, by analyzing the evolution of technical efficiency for the BNA during the period 2012-2021 we note that:

- the BNA showed a very slight decline in 2017;
- In 2019 we see negative growth;
- positive growth in return on equity;

The results obtained in the table above are summarized in the following figure:

Fig.6. results of R language A3



Source: by researcher from R language

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Tabl.13. results of SFA by using R language B1

Bank		estimate	Std. error	Z value	Pr z
BEA	Intercept	10.316319	0.996682	10.3507	2.2e-16***
	Ln input1	0.032438	0.140817	0.2304	0.8178
	Ln input2	1.359540	0.211669	6.4229	1.337e-10***
	Ln input3	-0.160935	0.120293	-1.3379	0.1809
	Sigma sq	0.147735	0.168913	0.8746	0.3818
	gamma	0.998142	0.052935	18.8561	2.2e-16***

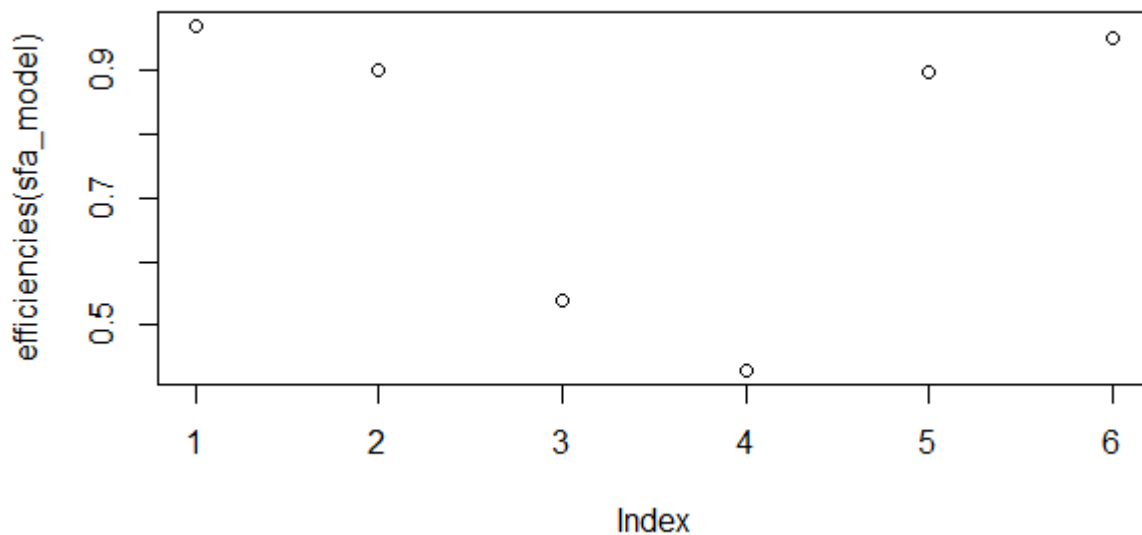
Source: by researcher from appendice 3

According to the result of the table above, by analyzing the evolution of technical efficiency for the BEA during the period 2012-2021 we note that:

- the efficiency of the bank in the use of its assets and the control of these costs in 2018;
- difficulty in achieving positive growth in the rate of return on assets in 2021;
- the bank achieved positive growth;

The results obtained in the table above are summarized in the following figure:

Fig.7. results of R language B3



Source: by researcher from R language

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Tabl.14. results of R language C1

Bank		estimate	Std. error	Z value	Pr z
CPA	Intercept	18.10495	0.99835	18.1348	2.2e-16***
	Ln input1	0.25204	0.19908	1.2660	0.2055
	Ln input2	0.42951	0.66405	0.6468	0.5178
	Ln input3	0.10392	0.74767	0.1390	0.8895
	Sigma sq	2.10135	0.99940	2.1026	0.0355*
	gamma	1.00000	0.21781	4.5912	4.408e-06***

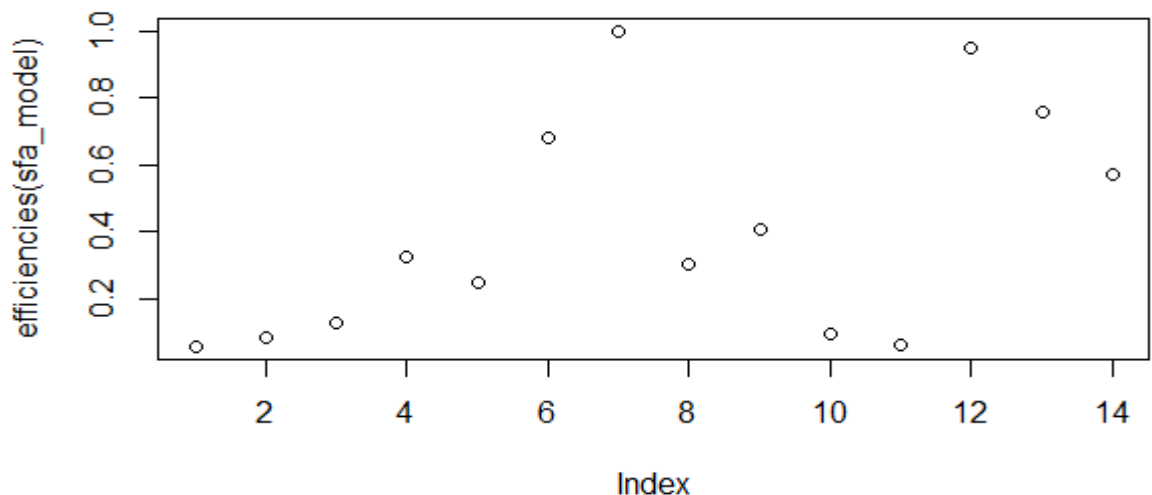
Source: by researcher from appendice 5

According to the result of the table above, by analyzing the evolution of technical efficiency for the CPA during the period 2012-2021 we note that:

- In 2018, the bank experienced an evolution compared to 2017;
- the bank was able to increase the efficiency rate to varying degrees during the five years;
- General operating expenses constitute lower percentages compared to its net banking income;

The results obtained in the table above are summarized in the following figure:

Fig.8. results of R language C3



Source: by researcher from R language

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Tabl.15. results of R language D1

Bank		estimate	Std. error	Z value	Pr z
BADR	Intercept	-32.4384821	0.9973355	-32.5251	2.2e-16***
	Ln input1	4.3315492	0.2605509	16.6246	2.2e-16***
	Ln input2	0.9670803	0.2786586	3.4705	0.0005195***
	Ln input3	-0.2091878	0.1234334	-1.6947	0.0901244
	Sigma sq	0.4604047	0.2708458	1.6999	0.0891540***
	gamma	1.0000000	0.0044526	224.5899	2.2e-16***

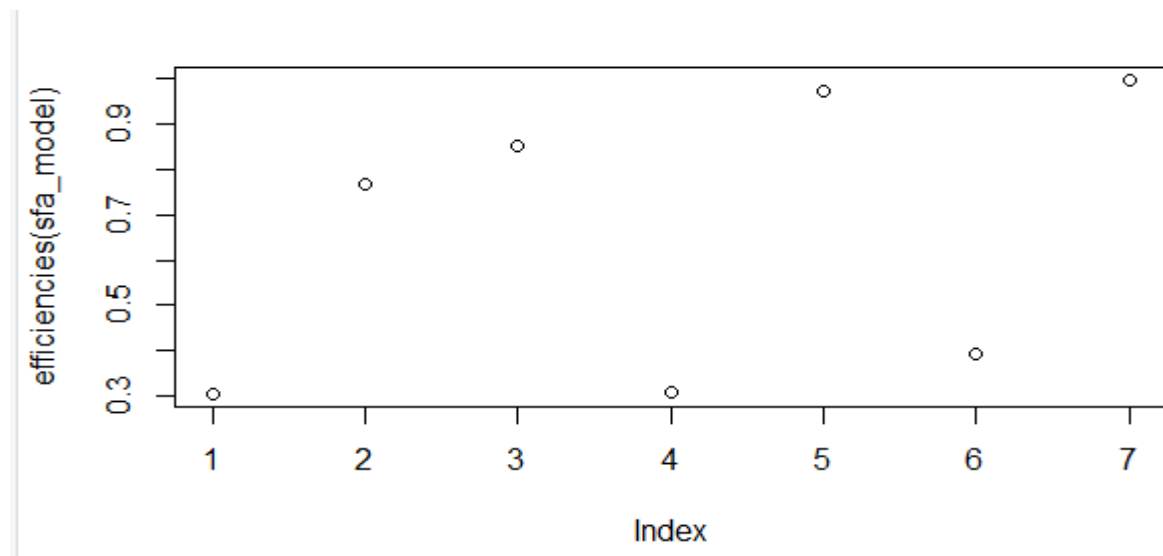
Source: by researcher from appendice 7

According to the result of the table above, by analyzing the evolution of technical efficiency for the BADR during the period 2012-2021 we note that:

- General operating expenses at BADR constitute high percentages compared to their net banking income, which explains the low percentage of the profit margin.;
- the bank's efficiency in the use of its assets and the control of these costs is the lowest in 2017;

The results obtained in the table above are summarized in the following figure:

Fig.9. results of R language D3



Source: by researcher from R language

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Tabl.16. results of R language E1

Bank		estimate	Std. error	Z value	Pr z
CNEP	Intercept	-1.7689e+02	3.7468e+00	-47.2123	2.2e-16***
	Ln input1	1.5569e+01	1.5238e-01	102.1690	2,2e-16***
	Ln input2	1.9485e-01	2.4706e-01	0.7887	0.4303
	Ln input3	1.2118e+00	2.1470e-01	5.6443	1.658e-08***
	Sigma sq	3.6501e-01	2.0655e-01	1.7672	0.0772
	gamma	3.5372e-05	7.1161e-02	0.0005	0.9996

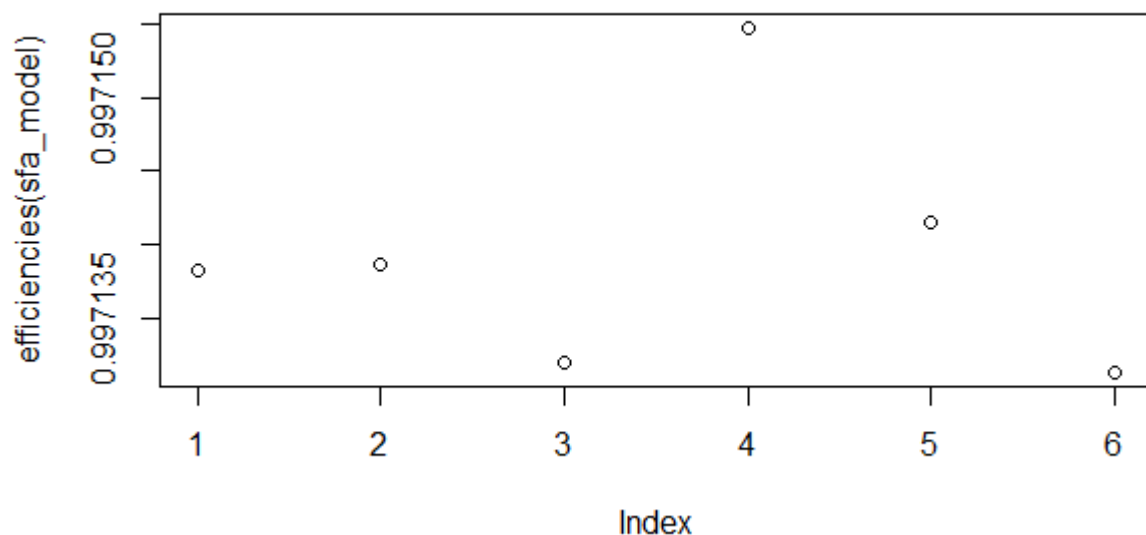
Source: by researcher from appendix 9

According to the result of the table above, by analyzing the evolution of technical efficiency for the CNEP during the period 2012-2021 we note that:

- In 2020, the bank failed to achieve positive growth in asset management efficiency.;
- The return on equity saw a slight decline in 2019;
- General operating expenses at CNEP constitute a high percentage compared to its net banking income, which explains the low percentage of the profit margin.

The results obtained in the table above are summarized in the following figure:

Fig.10. results of R language E3



Source: by researcher from R language

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comparison between the technical efficiency of banks in the first stage :

In the table below, we present the variation of TF during the first stage:

Tabl.17. VAR Cost TF in the first stage

	Years	Cost TF	Means TF
BNA	2012	0.6415044	0.68888105
	2013	0.7645141	
	2014	0.8910658	
	2015	0.7166412	
	2016	0.5355882	
	2017	0.8558518	
	2018	0.7804783	
	2019	0.6047596	
	2020	0.4786253	
	2021	0.6197818	

Source: by researcher from R language

Reading the table above is based on the marketing strategy adopted by the National Bank to attract deposits and savings, where BNA has introduced the "Magnetic Strip Savings Account", in addition to the features of the regular bank savings account, the possibility of conducting all banking transactions on the National Bank's ATMs. This new product allows customers to automate transactions on their bank savings account and access it at any time, and provides convenience to customers, as it allows withdrawals from ATMs, payment of banknotes to the account of the holder of the passbook and payment of banknotes to a third party account.

BNA offers the "Interest-Free Savings Account". It allows you to save excess money safely and make it available at any time for those who do not wish to receive interest. BNA offers the interest-free savings account product.

Another product is offered by BNA. It consists of the "My Future" Junior Savings Booklet, which is a safe and flexible investment product, intended for children (aged 0 to 15 years), this product allows them to build savings that will be used to finance their studies, buy a car or start a project. This booklet qualifies you for a special reward. Moreover, the National Bank of Algeria offers the possibility of choosing an interest-free formula according to the convenience of the customers. This account is compensated at a very competitive fixed rate of up to 3% per annum (for the interest-bearing formula).

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Tabl.18. VAR Cost TF in the first stage

	Years	Cost TF	Means TF
BEA	2012	0.8877551	0.87254538
	2013	0.9103494	
	2014	0.9105635	
	2015	0.8627682	
	2016	0.8968227	
	2017	0.7620506	
	2018	0.8246210	
	2019	0.8673170	
	2020	0.8759472	
	2021	0.9272591	

Source: by researcher from R language

The results obtained through the table above, especially for the fiscal year 2018, prove the effectiveness of the adopted strategy. During the fiscal year 2018, the British Environment Agency increased its development work in line with the objectives set in the three-year plan 2017-2019. In terms of commercial activity, the bank focused its activities on developing and promoting electronic payment products as well as banking products for new customers and intensifying the branch network. In terms of resource collection, BEA moved towards diversifying its clients in order to anticipate the contraction in oil and gas revenues. Thus, emerging sectors and certain segments of the economy contributed to reducing the deficit in hydrocarbon revenues. Indeed, the decline in hydrocarbon resources, since 2014, was compensated by the development of resources in other sectors such as some companies in the traditional sectors of the bank's portfolio (cement factories, insurance) and other emerging sectors (mining, steel industry, manufacturing industries). Fertilizers). In this context, the bank's total resources developed at the end of the fiscal year 2018 compared to the previous year 2017 despite the difficult economic situation. This progressive trend was recorded for both deposits in dinars and foreign currencies.

Assets in dinars thus showed a positive difference between 2017 and 2018. In terms of account opening, approximately 65,000 new accounts were opened, compared to 33,000 accounts at the end of 2017. It is worth noting that the marketing of the MasterCard, which requires opening a deposit account and a foreign currency account, boosted this efficiency.

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Tabl.19. VAR Cost TF in the first stage

	Years	Cost TF	Means TF
CPA	2012	0.7737166	0.8089805
	2013	0.7745925	
	2014	0.8026699	
	2015	0.8175715	
	2016	0.8209443	
	2017	0.8237166	
	2018	0.8254925	
	2019	0.8029966	
	2020	0.8177551	
	2021	0.8303494	

Source: by researcher from R language

The results of the table above highlight the increase in the collection of resources in savings accounts at a steady growth rate, as these deposits, given their relative stability, constitute a source of financing investments and contribute to improving the ratio of capital to permanent resources.

As for the public sector, its share has witnessed a clear development, thanks to the mitigation measures and facilities granted by the public authorities within the framework of reviving and modernizing the public economic sector, in a highly competitive context and an environment characterized by the contribution of new information and communication technologies, the bank seeks, as part of its modernization policy, progressive measures that adapt to market requirements and the expectations of its customers.

As such, the electronic banking service, which is of particular interest to customers, records a constantly increasing number of subscribers.

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Tabl.20. VAR Cost TF in the first stage

	Years	Cost TF	Means TF
BADR	2012	0.6227186	0.54478321
	2013	0.6356815	
	2014	0.7293234	
	2015	0.6643234	
	2016	0.5805656	
	2017	0.4227302	
	2018	0.5399769	
	2019	0.4193146	
	2020	0.4326312	
	2021	0.4005667	

Source: by researcher from R language

From the results presented above, it is clear to us that the bank has been affected by several structural and economic factors, as it tried to rationalize its expenses and attract a larger number of deposits while continuing to support the agricultural sector through subsidized credit policies, which led to an increase in its costs in the short term.

Like other Algerian commercial banks, the Bank of Agriculture and Development benefited from the process of modernizing and digitizing the system, but the full implementation of this process did not bear fruit in terms of significant cost reduction, which led to facing major challenges related to its operating structure and a difficult economic environment.

Accordingly, the efficiency ratio, which measures the ratio of operating costs to revenues, was affected by the structural rigidity of the bank, as a result of the bloated workforce and the decline in automation of operations, which limited the rapid improvement in cost efficiency.

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Tabl.21. VAR Cost TF in the first stage

	Years	Cost TF	Means TF
CNEP	2012	0. 4532907	0.41248256
	2013	0.4599626	
	2014	0. 4415294	
	2015	0. 4720647	
	2016	0. 5137333	
	2017	0. 5230479	
	2018	0. 4269596	
	2019	0.3753133	
	2020	0.2064747	
	2021	0.2524494	

Source: by researcher from R language

Referring to the results recorded above, we find that CNEP's production and cost effectiveness were affected between 2012 and 2021 by several economic and institutional factors. Its ability to improve its costs was limited by high operating costs, a cumbersome structure, and a slow transition to real estate financing. However, the bank has made progress in modernizing its services, especially since 2017, but accelerating the digital transformation and more rigorous risk management could have improved its efficiency. Despite these challenges, the bank has been able to play its social role and contribute to the development of the real estate sector in Algeria.

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Tabl.22. VAR Cost TF in the first stage

	Years	Cost TF	Means TF
BDL	2012	0.3659113	0.34901687
	2013	0.3548972	
	2014	0.3821447	
	2015	0.3731838	
	2016	0.3712130	
	2017	0.3916513	
	2018	0.3497582	
	2019	0.2471384	
	2020	0.3171388	
	2021	0.3371320	

Source: by researcher from R language

The table above explains the bank's low cost efficiency, with its large employee base, traditional banking infrastructure, and low initial adoption of technology, which affected the bank's profitability and limited its ability to quickly improve its efficiency.

Starting in 2017, the bank made efforts to improve cost efficiency by reducing staff costs, improving infrastructure management, and gradually integrating digital technologies to reduce processing costs. However, these reforms took time to become fully operational, and efficiency gains were more modest than expected in the early years.

The bank also faced an increase in bad debts, especially after 2014 when the decline in oil prices affected the ability of many customers to repay. This forced the bank to increase its provisions for loan losses, which increased its operating costs and reduced its financial efficiency.

3. Discuss the results:

Through Table above, the cost technical efficiency before 2019 was increasing for all public commercial banks with the exception of CNEP Bank, which experienced a slight decline. In 2019 we see negative growth in all public commercial banks at varying rates, the largest impact was recorded by BDL, which fell from 35.80% to 24.71%, due to the significant impact on net income, which decreased by 90%. During 2020, despite the slight improvement in results, negative growth in return on equity continued for all public banks, with the exception of BNA and BDL, the continuation of this Negative growth is due to the fact that banks have increased reserves at a higher rate than the growth rate of results.

As we mentioned previously, the technical efficiency of commercial banks in Algeria in using their assets and controlling these costs recorded positive growth in 2018 compared to 2017, ranging between 2.33%, which is the highest rate of increase achieved by the Central Bank of Algeria in 2018, and 0.50%, which is the lowest rate recorded. BADR Bank in 2017. In 2019, the rate of technical efficiency decreased in all public commercial banks, with different percentages affected by the effects of the political and economic crisis, which negatively affected the resulting results. It also highlights weak cost control and low efficiency in managing Assets. In 2020, all public banks were able to achieve positive growth at this rate, with the exception of CNEP and CPA.

In 2021, the studied banks obtained better results than the previous year, and thus achieved positive growth in the rate of return on assets, with the exception of BEA Bank, and although it obtained better results than in 2020, it obtained a technical efficiency rate, due to the increase in its assets by 32%, while the results did not exceed a growth of 4.7% compared to 2020.

By analyzing the development of the efficiency of public commercial banks during the period 2012-2021, we note:

- All public commercial banks witnessed development in 2018 compared to 2017, with the exception of BDL, which showed a very slight decline.

In 2019, only the BADR Association was able to maintain its percentage, while all colleagues suffered from the most severe decline recorded by the BDL at 4.71%.

After 2019, banks were able to increase this rate to varying degrees.

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In order to find out the reason for this low rate in most public commercial banks, and to deepen the analysis, we will present a table that allows us to compare general operating expenses in relation to net banking income, and the impact of these fees on the efficiency of banks.

We can conclude:

A) General operating expenses at BDL, CNEP, and BADR represent high percentages compared to their net banking income, which explains the low profit margin ratio.

b) Operating costs alone do not fully explain the decline between 2018 and 2019, which is also due to the political and economic situation that led to a general increase in the net cost of risk (credit risk provisions) of large Algerian private groups and a tightening of restrictions. From public markets.

Section3: View and test results of the second step:

Command syntax refers to the rules and conventions that govern how commands are organized and written. The specific syntax can vary depending on the programming language or program being used or the context in which the commands are issued.

There are some common elements and conventions that apply in many cases and that have been adopted in the syntax of study orders:

✓ Command Name:

The name of the command or program to be run, which is represented by: command syntax SFA;

✓ Options or flags:

These are usually preceded by hyphens or double hyphens and modify the behavior of the command. Options can be single-letter abbreviations or entire words.

Through our study, the following options were adopted:

-sc or –sciviews

-f or –frontier

✓ Arguments:

These are the inputs or parameters that the command operates on. It usually comes after the command and any options.

It was determined according to the study as follows:

file.txt: File name.

directory/: Directory path.

123: A numerical value, derived from an Excel table containing study statistics

✓ Syntax rules:

Commands and options are usually case sensitive, which means that command and command may have different meanings.

Spaces or tabs were used to separate commands, options, and arguments.

We also used quotes (single or double) to group arguments or options that contain spaces or special characters together. For example: “The file contains space.txt”.

CHAPTER THREE: RESULTS AND DISCUSSION

✓ Pipes | > Redirection:

In many command-line interfaces, the pipe symbol (|) was used to pass the output of one command as input to another command. > has also been used to redirect output to a file. For example:

✓ Command3 | Command4:

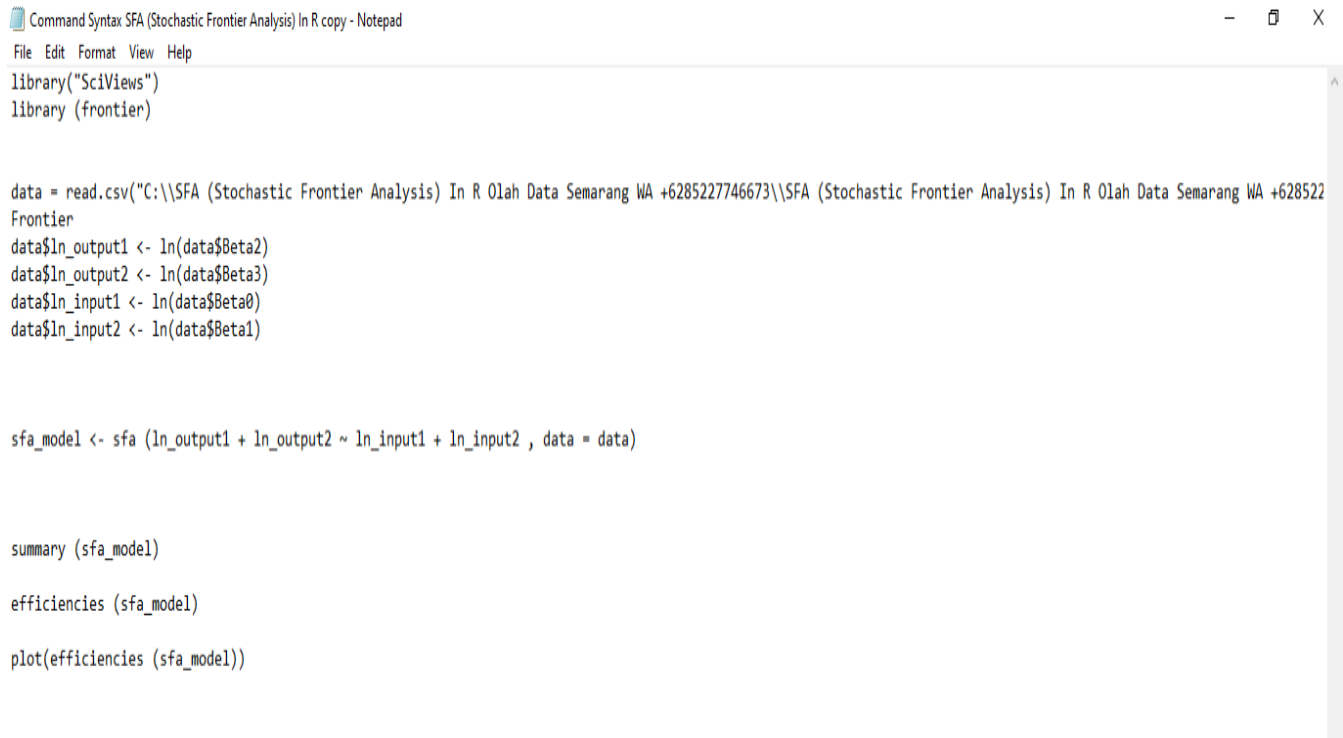
Route the output of Command3 to Command4.

Command > output.txt: Redirects the command output to a file called output.txt.

✓ Wildcards:

Some command line interfaces support wildcards to represent multiple files or directories.

Fig.11. command syntax SFA



```
Command Syntax SFA (Stochastic Frontier Analysis) In R copy - Notepad
File Edit Format View Help
library("SciViews")
library (frontier)

data = read.csv("C:\\SFA (Stochastic Frontier Analysis) In R 01ah Data Semarang WA +6285227746673\\SFA (Stochastic Frontier Analysis) In R 01ah Data Semarang WA +628522
Frontier
data$ln_output1 <- ln(data$Beta2)
data$ln_output2 <- ln(data$Beta3)
data$ln_input1 <- ln(data$Beta0)
data$ln_input2 <- ln(data$Beta1)

sfa_model <- sfa (ln_output1 + ln_output2 ~ ln_input1 + ln_input2 , data = data)

summary (sfa_model)

efficiencies (sfa_model)

plot(efficiencies (sfa_model))
```

Source: by researcher from R program

The above image represents the complete form of the equation used in processing the data of the second step, which includes the deposits as inputs on the one hand, and the various loans as outputs on the other hand.

CHAPTER THREE: RESULTS AND DISCUSSION

➤ first variable (input):

Tabl. 23. Banking products (input)

(million DA)

	2012	2013	2014	2015	2016
BNA	1 325 198 500	1 498 338 492	1 742 545 916	1 732 218 308	1 673 844 881
BEA	2 234 045 113	2 122 364 125	2 273 213 124	2 075 512 143	1 867 120 414
CPA	3 433 963 516	3 221 070 468	3 058 163 670	3 267 583 016	3 268 408 677
BADR	5 342 766 925	5 226 253 336	5 432 436 901	5 644 717 011	5 772 434 515
CNEP	3 239 943 044	3 007 592 605	3 109 211 267	3 535 365 530	3 338 138 546
BDL	2 821 542 763	2 933 011 992	2 257 123 099	2 747 218 438	2 164 266 456
	2017	2018	2019	2020	2021
BNA	94 617 409	87 782 431	94 076 648	95 704 941	78 281 823
BEA	111 132 794	131 844 093	124 213 273	143 512 075	120 867 414
CPA	81 542 763	83 648 070	81 059 059	76 995 810	68 840 487
BADR	54 388 259	53 336 462	52 331 909	54 440 658	58 727 646
CNEP	39 943 044	37 361 952	41 600 276	35 682 365	38 138 546
BDL	33 693 156	33 299 011	35 375 757	47 438 812	40 364 662

Source: by researcher from

Banking products or **Deposits** are the most common form of financial investment. They are measured from the balance sheets provided by these institutions, included in the monetary aggregates and savings accounts or investments.

CHAPTER THREE: RESULTS AND DISCUSSION

➤ **Second variable (output):**

Tabl. 24. Loans (output)

(million DA)

	2012	2013	2014	2015	2016
BNA	39 558 320	34 435 970	33 890 234	35 845 130	26 542 618
BEA	53 776 580	51 567 123	48 514 290	49 666 610	46 423 789
CPA	24 345 620	22 907 456	21 974 446	31 556 314	26 389 690
BADR	5 334 019	4 246 345	4 102 932	9 453 924	5 845 379
CNEP	4 426 515	3 672 459	3 456 123	4 642 321	3 456 819
BDL	2 877 908	2 484 621	2 430 673	7 225 654	3 661 872
	2017	2018	2019	2020	2021
BNA	46 690 479	23 047 665	19 064 195	35 832 184	29 986 747
BEA	71 812 607	68 620 095	62 548 353	76 775 610	57 365 645
CPA	30 440 730	20 603 163	21 974 446	40 981 379	32 937 968
BADR	7 267 000	5 021 388	4 836 459	13 647 831	6 753 536
CNEP	5 451 627	3 596 301	6 692 266	9 316 123	8 746 716
BDL	3 919 889	2 568 758	1 667 941	16 310 150	13 801 709

Source: by researcher from

Loans encompass the various money lending activities by commercial banks.

Expression the following function of SFA production:

$$\ln Y_i = f(X_i, \beta) + v_i - u_i$$

Tabl.25. results of R language F1

Bank		estimate	Std. error	Z value	Pr z
BNA	Intercept	2.328388	1.000000	2.3284	0.01989*
	Ln input1	1.303020	1.000000	1.3030	0.19257
	Ln input2	0.423333	1.000000	0.4233	0.67205
	Sigma sq	0.030359	1.000000	0.0304	0.97578
	gamma	0.050000	1.000000	0.0500	0.96012

Source: by researcher appendice 11

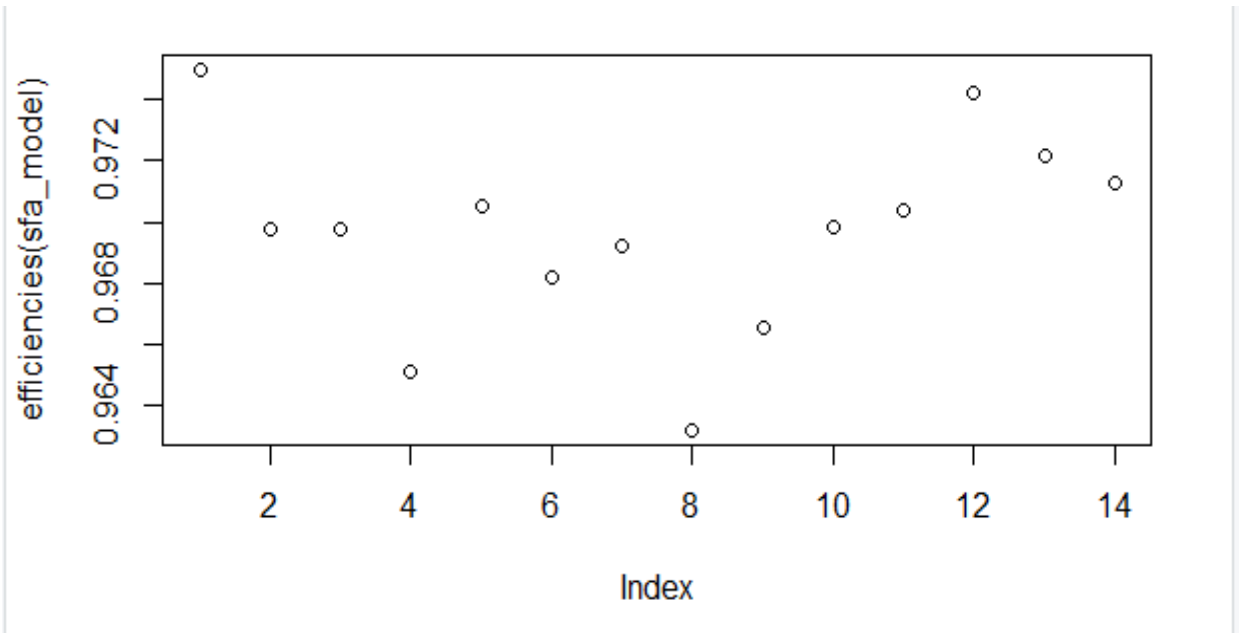
CHAPTER THREE: RESULTS AND DISCUSSION

Across the table, Deposit yields were up overall

During the year 2020, despite the slight improvement in results, the positive growth in yield continued for the BNA, the continuation of this slight growth is due to the fact that the bank carried out increases in reserves at a pace higher than the growth rate of results.

The results obtained in the table above are summarized in the following figure:

Fig.12. results of R language F3



Source: by researcher from R language

Tabl.26. results of R language G1

Bank		estimate	Std. error	Z value	Pr z
BEA	Intercept	-1.6125e+01	1.3504e+01	-1.1941	0.23245
	Ln input1	3.4215e+00	1.9527e+00	1.7522	0.07974
	Ln input2	-8.6529e-02	9.6172e-02	-0.0900	0.92831
	Sigma sq	1.2786e-01	6.9720e-02	1.8340	0.06666
	gamma	1.7827e-06	7.3083e-03	0.0002	0.99981

Source: by researcher appendice 12

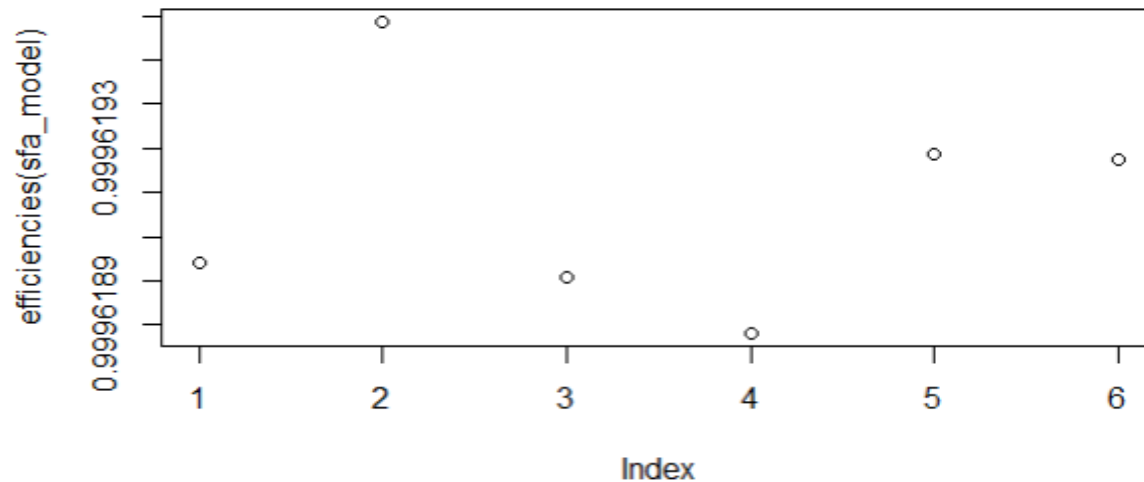
CHAPTER THREE: RESULTS AND DISCUSSION

As mentioned in the table above, the bank's efficiency rate in the exploitation of its assets and the control of these costs recorded higher growth in 2018,

In 2021, the bank performed poorly than the previous year, it achieved a lower rate of return on assets,

The results obtained in the table above are summarized in the following figure:

Fig.13. results of R language G3



Source: by researcher from R language

Tabl.27. results of R language H1

Bank		estimate	Std. error	Z value	Pr z
CPA	Intercept	5.3479e+00	4.1154e+00	1.2995	0.193779
	Ln input1	1.0159e-01	2.4082e-01	0.4219	0.673123
	Ln input2	1.4383e+00	2.5036e-01	5.7450	9.194e-09***
	Sigma sq	2.9950e-01	9.7026e-02	3.0868	0.002023**
	gamma	6.9405e-05	9.4269e-02	0.0007	0.999413

Source: by researcher appendice 13

CHAPTER THREE: RESULTS AND DISCUSSION

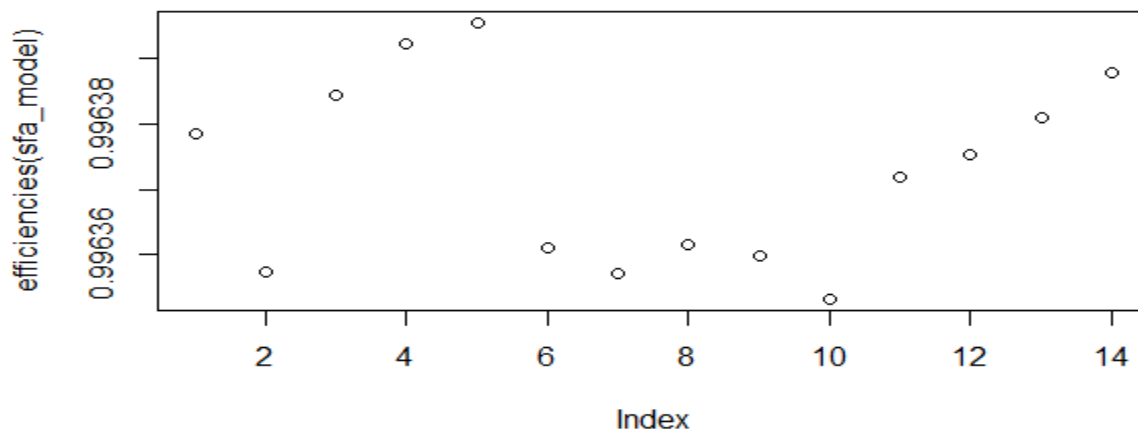
from the results mentioned above, the efficiency rate of the CPA bank in the production of loans from the correct exploitation of its assets recorded positive growth in 2018 compared to 2017,

In 2019, this rate decreased overall, affected by the effects of the political-economic crisis, which negatively impacted the results generated. This also highlights a weakness in cost control, and low efficiency in asset management.

In 2020, the entire bank recorded weak growth due to a decline in results caused by the pandemic.

The results obtained in the table above are summarized in the following figure:

Fig.14. results of R language H3



Source: by researcher from R language

Tabl.28. results of R language I1

Bank		estimate	Std. error	Z value	Pr z
BADR	Intercept	35.2814097	1.1641738	30.3060	2.2e-16***
	Ln input1	-4.2767771	0.4405143	-9.7086	2.2e-16***
	Ln input2	3.5253607	0.4329070	8.1435	3.841e-16***
	Sigma sq	0,1620142	0.0876515	1.8484	0.06455
	gamma	1.0000000	0.0035923	278.3744	2.2e-16***

Source: by researcher appendice 14

CHAPTER THREE: RESULTS AND DISCUSSION

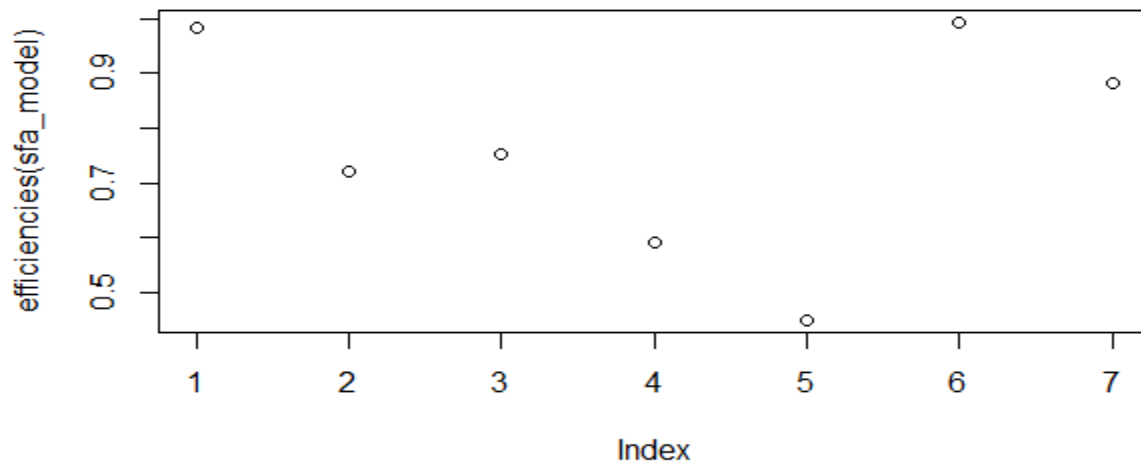
By analyzing the evolution of the TF for the BADR bank during the period 2017-2021 we note:

- In 2018, the bank experienced an evolution compared to 2017,
- In 2019, the bank suffered a drop, in order to know the reason for this low rate in , and to deepen the analysis, we can deduce:

General operating expenses at BADR constitute high percentages compared to their net banking income, which explains the low percentage of the profit margin.

The results obtained in the table above are summarized in the following figure:

Fig.15. results of R language I3



Source: by researcher from R language

Tabl.29. results of R language J1

Bank		estimate	Std. error	Z value	Pr z
CNEP	Intercept	-12.7438473	0.4298423	-29.6477	2.2e-16***
	Ln input1	-1.2714298	0.9798000	-1.2976	0.1944103
	Ln input2	3.4039058	0.9880714	3.4450	0.0005711***
	Sigma sq	0.0139895	0.0090255	1.5500	0.1211420
	gamma	1.0000000	0.0169277	59.0748	2.2e-16***

Source: by researcher appendice 15

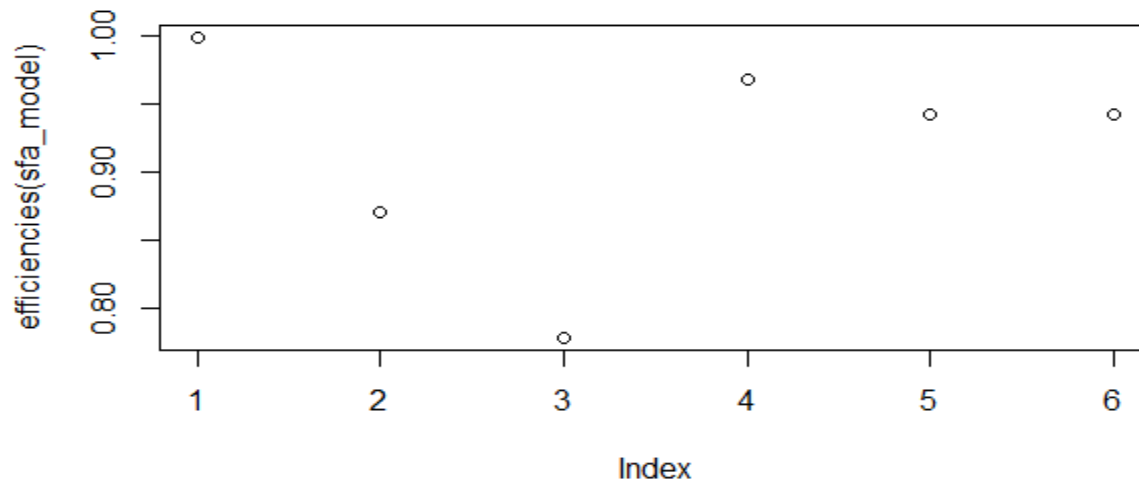
CHAPTER THREE: RESULTS AND DISCUSSION

We analyze the evolution of the TF of CNEP bank during the period from 2012 to 2021. We note the following:

- During the 2017-2018 period, CNEP had the lowest rate.
- In 2019, the CNEP increased slightly due to the increase of net banking income driven upwards by the increase in interest received and its low exposure to the corporate market which had experienced a significant tightening following the crisis leading to an increase in provisions for payment defaults and a drop in activity.
- In 2020 the TF decreased in banking,

The results obtained in the table above are summarized in the following figure:

Fig.16. results of R language J3



Source: by researcher from R language

CHAPTER THREE: RESULTS AND DISCUSSION



comparison between the technical efficiency of banks in the second stage :

In the table below, we present the variation of TF during the first stage:

Tabl.30. VAR production TF in the first stage

	years	Production TF	Means TF
BNA	2012	0.9100341	0.85841999
	2013	0.8500784	
	2014	0.8917190	
	2015	0.9282642	
	2016	0.9739751	
	2017	0.8549674	
	2018	0.8697347	
	2019	0.6697820	
	2020	0.7651325	
	2021	0.8705125	

Source: by researcher

The results obtained in the table above explain the fact that the National Bank of Algeria has made available to its customers a new financing product, the consumer credit "Crédit Auto". The car credit finances the purchase of a car produced or assembled in Algeria for customers without affecting their savings. The peculiarity of this financing method is that the files are processed in a maximum of 5 days and gives the customer the possibility of benefiting from up to 85% of the price of the car at a competitive price, with repayments made over a period ranging from 12 to 60 months. In addition to the old range of financing products of: mortgage, specific loan, financial leasing, cash credits and long and medium-term loans, the National Bank of Algeria also offers a new formula, the credit (Med-solution). Its purpose is to finance the creation of a new medical practice (new creation) or the expansion of an existing practice, it is a medium or long-term investment credit (CMT/CLT) intended for doctors, surgeons, dentists or anyone else. Other people working in the medical field in general who want to create their own practice or renew an old one, BNA has found the solution thanks to its new product "Med-solution".

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Tabl.31. VAR production TF in the first stage

	years	Production TF	Means TF
BEA	2012	0.8603847	0.896044118
	2013	0.8642492	
	2014	0.8721668	
	2015	0.8712530	
	2016	0.8796190	
	2017	0.8691981	
	2018	0.8972176	
	2019	0.9162080	
	2020	0.9665654	
	2021	0.9698330	

Source: by researcher

The results of the table above show that BEA, originally dedicated to financing the hydrocarbons sector, has succeeded in recent years in diversifying its client portfolio by financing large companies and small and medium-sized enterprises, whose financing has almost doubled during this period. Thus, BEA includes among its clients state-owned companies in heavy industries, companies in the agro-industry sector, tourism, packaging, pharmaceuticals, agriculture, as well as the most advanced medical-surgical structures. Without forgetting the young leaders of innovative projects in the field of information and communication technologies and renewable energies.

BEA is thus no longer limited to financing energy and industry, which represent 30% of its portfolio, but is now financing several projects in other sectors of activity, in accordance with the directives of the public authorities, which has enabled it to develop rapidly.

Previously, it financed refineries, petrochemicals and LNG carriers for the international transport of hydrocarbons.

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Tabl.32. VAR production TF in the first stage

	years	Production TF	Means TF
CPA	2012	0.8773074	0.86123122
	2013	0.8742924	
	2014	0.8768216	
	2015	0.8653120	
	2016	0.8649061	
	2017	0.8563847	
	2018	0.8542492	
	2019	0.8421668	
	2020	0.8412530	
	2021	0.8596190	

Source: by researcher

The results obtained in the table above confirm the performance achieved by the Bank, which was characterized by strong participation in financing the economy, especially through supporting and assisting productive investment.

These efforts resulted in additional financing, 97% of which was directed towards the business sector in all its sizes and sectors combined. This approach, in addition to indicating the Bank's desire to intervene effectively in all investment projects that achieve growth and profitability, in implementing various regulatory measures aimed at encouraging the establishment and development of small enterprises.

While the Bank expanded its area of expertise to include new areas of activity, the majority of the Bank's assistance was allocated to investment, representing 89% of the total direct commitments.

The policy advocated by the bank regarding credit allocation has had a positive impact on the efficiency of the bank's portfolio, which has remained balanced and diversified, covering various sectors and branches of activity. This structure allows the bank to protect itself against concentration risks.

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Tabl.33. VAR production TF in the first stage

	years	Production TF	Means TF
BADR	2012	0.6322248	0.57039909
	2013	0.6197633	
	2014	0.5998999	
	2015	0.6099993	
	2016	0.4530257	
	2017	0.5286169	
	2018	0.5437190	
	2019	0.5476918	
	2020	0.5684309	
	2021	0.6006193	

Source: by researcher

Through the results obtained in the table above, which include the bank's production efficiency during the period between 2012 and 2021, we find that the banking institution's production efficiency has witnessed some development thanks to the modernization of its services and increased support for the agricultural sector, through the bank's efforts to rationalize its costs while increasing its productivity through digitization and expanding its branch network. However, the challenges of risk management, especially in light of bad debts and difficult economic conditions, have sometimes hindered this improvement, which has made the increase in production efficiency still limited by some structural and economic factors.

The fluctuation in the bank's production efficiency is due to the decline in hydrocarbon prices, especially during the period after 2014, which led to a decrease in state revenues and indirectly affected the financing capabilities of public banks, in addition to the Covid-19 pandemic, which had a significant impact on the Algerian banking sector, forcing the bank to adjust its operations to deal with health restrictions and disruption of agricultural supply chains.

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Tabl.34. VAR production TF in the first stage

	years	Production TF	Means TF
CNEP	2012	0.5378563	0.49792017
	2013	0.5257634	
	2014	0.5283436	
	2015	0.5192163	
	2016	0.5165339	
	2017	0.5276835	
	2018	0.4967435	
	2019	0.4734638	
	2020	0.4396321	
	2021	0.4139653	

Source: by researcher

The above results on CNEP's technical cost efficiency are explained by the fact that it faces high staffing costs, a cumbersome infrastructure and therefore a high cost structure despite efforts to reduce costs, which could have improved further with the acceleration of digital transformation and improved bad debt management.

The National Housing Fund, which plays an important social role in housing finance, has benefited from public support to keep interest rates low, especially for loans under social programs. These subsidies have helped the bank keep costs moderate for its clients, but have also limited its profit margins and thus its ability to achieve high profits.

Although CNEP has managed to maintain a stable level of activity, profit margins have remained relatively low due to high operating costs and the constraints imposed by state policies to support interest rates. The COVID-19 pandemic has also disrupted the Algerian banking sector, forcing CNEP to adjust its operations in the face of health restrictions and economic turmoil. The decline in incomes of some households has affected the ability to repay loans, leading to an increase in bad debts and pressure on cost efficiency.

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Tabl.35. VAR production TF in the first stage

	years	Production TF	Means TF
BDL	2012	0.2452611	0.31881837
	2013	0.2665731	
	2014	0.2761356	
	2015	0.2966030	
	2016	0.3533423	
	2017	0.3525161	
	2018	0.3524671	
	2019	0.3693165	
	2020	0.3396090	
	2021	0.3363599	

Source: by researcher

From the above results, we find that the bank's production efficiency during the first half of this period (2012-2016) witnessed a decline, as a result of the slow updating of operations, which led to inefficiency in processing loan files and managing banking operations. Since 2017, the bank began to shift towards digitizing some services, with the introduction of online services and more automated management tools, but this shift took time and did not immediately allow for a significant improvement in production efficiency. The Corona pandemic also disrupted the financing of small and medium-sized enterprises, which slowed down the bank's production and increased the financial risks associated with delays in loan repayments. Although the bank put in place support measures for its customers, this had a negative impact on its production efficiency in 2020 and 2021.

1. Discuss the results:

Several banks went through a very difficult period, due to the scale of the shock it caused and which disrupted the entire economy. The Bank of Algeria called on banks and financial institutions to implement support measures on the ground.

Despite these measures, some public banks have experienced a disruption in certain financial indicators, this is due to several factors, mainly the lack of control over asset management, as well as poor cost control, which has affected results.

The technical efficiency of banks remains low and poses risks to financial stability. The volume of resources held by banks and the nature of their structures as well as cost management have considerable repercussions on banking efficiency and productivity.

The application of the SFA method on the fabric of Algerian public banks allowed us to draw a ranking which highlights the BEA as being the most efficient bank due to better control of these costs and asset management. Conversely, the CNEP, BADR and BDL are positioned at the bottom of the scale.

Despite an appreciation of the profit margin from 2020, it remains low for the entire public banking network due to the lack of cost control; however, CNEP, BDL and BADR display the highest relative costs. Asset turnover shows a negative trend due to the drop in banking products following rescheduling measures and the capping of excessive rates and the increase in assets of certain banks. Asset efficiency shows a general evolution over the period studied, with BEA and BDL at the top and CNEP at the bottom of the list.

The efficiency of capital showed a negative evolution over the period studied for all banks with the exception of the BNA, however the BEA displays the best rate, unlike the BADR, the BDL and the CNEP which display the lowest rates, the latter must put in place strategies to restructure their assets and work on commercial strategies which will allow them to increase their banking products as well as improve cost and production management.

Conclusion of chapter:

The study aimed to measure the technical efficiency of a sample of Algerian commercial banks, consisting of six banks for the period 2012-2021, using the SFA model to determine the factors affecting them, by dividing the banks' activity into two basic stages: the stage of attracting deposits and the stage of granting loans.

The inputs of the first stage were fixed assets and operational costs, while the outputs were total deposits,

While the inputs of the second stage are represented in the total deposits, while the outputs of this stage are represented in the total loans and financing.

Through the previous results, we reached that, the average technical efficiency ratio of the Algerian commercial banks the synthesis of input elements (deposits) to achieve the maximum volume of outputs (loans) is low

To increase this efficiency, several policy modifications can be considered.

Conclusion:

Through our research, we applied the stochastic frontier method (SFA) to estimate the technical efficiency of Algerian commercial banks during the period (2012-2021).

It is important to point out that the results and conclusions identified during the research, related to technical efficiency in Algerian commercial banks, will require a detailed analysis of available data and research on the Algerian banking sector.

Assessing technical efficiency in Algerian commercial banks can provide insights for policy makers and regulatory authorities. The results can guide the formulation of policies aimed at enhancing efficiency, encouraging competition, encouraging innovation, and ensuring financial stability within the banking sector.

Different methodologies, such as data envelopment analysis (DEA) and stochastic frontier analysis (SFA), can be used to measure technical efficiency in commercial banks. These techniques compare a bank's actual performance against a benchmark or limits, taking into account inputs, outputs and various variables.

The SFA method makes it possible to estimate the boundary function while simultaneously taking into account the random error and the inefficiency component of the evaluated banks. Although traditional econometric estimation methods such as regression take into account random error, they estimate a mean function and not a marginal function.

The practical results of the parametric analysis show that the volume of resources held by banks and the nature of their structures as well as cost management have considerable repercussions on banking efficiency.

The application of the “SFA” analysis method on the fabric of Algerian public commercial banks during the period 2012-2021 allowed us to draw a ranking which highlights the BEA as being the most efficient bank due to a better control of these costs and asset management, on the contrary, CNEP, BADR and BDL are positioned at the bottom of the scale.

Despite an appreciation of the profit margin from 2020, it remains low for the entire public banking network due to the lack of cost control; however, CNEP, BDL and BADR display the highest relative costs. Technical cost efficiency shows a general evolution over the period studied, with BEA and BDL at the top and CNEP at the bottom of the list. Production efficiency showed a negative evolution over the period studied for all banks with the exception of the BNA, however the BEA displays the best ratio, unlike the BADR, the BDL and the CNEP which display the rates

GENERAL CONCLUSION

the lowest, the latter must put in place strategies to restructure their assets and work on commercial strategies which will allow them to increase their banking products as well as improve cost management.

The low percentage of technical efficiency in Algerian commercial banks can be attributed to several factors:

- Algerian commercial banks have generally lagged behind in adopting advanced technologies and digital solutions. Outdated or inefficient technology infrastructure can hinder operational processes, data management, customer service, and overall efficiency.

Non-optimal exploitation of resources, insufficient investment in technology, and lack of competence of employees lead to a decrease in technical efficiency

- The absence of innovative practices and automation in operational processes can hinder efficiency. Manual and time-consuming tasks, paperwork, and outdated systems can create bottlenecks and prevent banks from operating at full capacity.

- Complex and restrictive regulatory frameworks can hinder the efficiency of Algerian commercial banks. Excessive paperwork, burdensome reporting requirements, and bureaucratic procedures can divert resources and time away from core banking activities.

- The lack of intense competition and limited market dynamics in the Algerian banking sector may reduce the incentive for banks to improve their efficiency. Without strong market pressures, banks may have less incentive to invest in technology, streamline operations, or enhance customer service.

- Poor risk management practices can lead to high operating costs and inefficiency. Inadequate assessment and management of credit risk, liquidity risk and operational risk can result in increased expenses, non-performing loans and decreased overall efficiency.

- Inadequate skills, training and talent management within the banking workforce can impact efficiency. A lack of specialized knowledge, inadequate employee development programs, and talent retention challenges can limit banks' ability to improve their operations.

- Broader economic and political conditions can also affect the technical efficiency of commercial banks. Macroeconomic instability, currency fluctuations, policy uncertainties, and changes in the regulatory environment can create challenges for banks and hamper their efficiency.

Addressing these factors requires a comprehensive approach that includes regulatory reforms, investing in technology and infrastructure, enhancing competition, encouraging

GENERAL CONCLUSION

innovation, strengthening risk management frameworks, and prioritizing workforce development. By addressing these challenges, Algerian commercial banks can improve their technical efficiency and enhance their overall performance.

Other reasons for the decline in the technical efficiency ratio of commercial banks include the following:

- Poor combination of input elements to achieve a certain size of output;
- Poor management of the movement of funds as a result of the lack of independence in the decision to grant loans at banks.
- Using the banking economic field as a tool to embody political decisions, thus rendering the decision irrelevant.

Based on the results, our study recommended the need for bank officials to study the reasons that prevent them from making the most of the inputs represented by deposits by knowing the weak points and reaching full levels of technical efficiency, and thus increasing the volume of outputs.

In conclusion, assessing the technical efficiency in Algerian commercial banks is crucial for evaluation

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Appendices

Appendices. Results of R language A

final maximum likelihood estimates

	Estimate	Std. Error	z value	Pr(> z)	
(Intercept)	-17.24454	7.48889	-2.3027	0.0212966	*
ln(Beta0)	4.13147	1.21007	3.4142	0.0006396	***
ln(Beta1)	0.65720	0.48423	1.3572	0.1747130	
ln(Beta2)	-1.30343	0.75956	-1.7160	0.0861555	.
sigmaSq	0.53532	0.16433	3.2575	0.0011241	**
gamma	1.00000	0.11273	8.8705	< 2.2e-16	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

log likelihood value: -5.046534

cross-sectional data

total number of observations = 14

```
<
> efficiencies (sfa_model)
  efficiency
1    0.8558518
2    0.7804783
3    0.9047596
4    0.4786253
5    0.6197818
6    0.1837275
7    0.2646210
8    0.7020506
9    0.6973170
10   0.7359472
11   0.7737166
12   0.5734925
13   0.5029966
14   0.9977551
> plot(efficiencies (sfa_model))
```

Appendices. results of R language B

```
final maximum likelihood estimates
      Estimate Std. Error z value Pr(>|z|)
(Intercept) 10.316319   0.996682 10.3507 < 2.2e-16 ***
ln(Beta0)    0.032438   0.140817  0.2304  0.8178
ln(Beta1)    1.359540   0.211669  6.4229 1.337e-10 ***
ln(Beta2)   -0.160935   0.120293 -1.3379  0.1809
sigmaSq      0.147735   0.168913  0.8746  0.3818
gamma        0.998142   0.052935 18.8561 < 2.2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
log likelihood value: 0.5318912

cross-sectional data
total number of observations = 6

mean efficiency: 0.7818246
>
> efficiencies (sfa_model)
  efficiency
1  0.9703494
2  0.9027682
3  0.5399769
4  0.4293146
5  0.8979749
6  0.9505635
> plot(efficiencies (sfa_model))
>
```

Appendices. Results of R language C

```
final maximum likelihood estimates
              Estimate Std. Error z value Pr(>|z|)
(Intercept) 18.10495    0.99835 18.1348 < 2.2e-16 ***
ln(Beta0)    0.25204    0.19908  1.2660  0.2055
ln(Beta1)    0.42951    0.66405  0.6468  0.5178
ln(Beta2)    0.10392    0.74767  0.1390  0.8895
sigmaSq      2.10135    0.99940  2.1026  0.0355 *
gamma        1.00000    0.21781  4.5912 4.408e-06 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
log likelihood value: -17.44443

cross-sectional data
total number of observations = 14
```

```
mean efficiency: 0.4047264
>
> efficiencies (sfa_model)
  efficiency
1  0.05734040
2  0.08157208
3  0.12657642
4  0.32616352
5  0.25006286
6  0.68184989
7  0.99844958
8  0.30213933

9  0.40556425
10 0.09540133
11 0.05937496
12 0.95098156
13 0.75936304
14 0.57133019
> plot(efficiencies (sfa_model))
>
```

Appendices. Results of R language D

```
      Estimate Std. Error z value Pr(>|z|)
(Intercept) -32.4384821   0.9973355 -32.5251 < 2.2e-16 ***
ln(Beta0)    4.3315492   0.2605509  16.6246 < 2.2e-16 ***
ln(Beta1)    0.9670803   0.2786586   3.4705 0.0005195 ***
ln(Beta2)   -0.2091878   0.1234334  -1.6947 0.0901244 .
sigmaSq      0.4604047   0.2708458   1.6999 0.0891540 .
gamma        1.0000000   0.0044526 224.5899 < 2.2e-16 ***
---
signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
log likelihood value: -2.976677

cross-sectional data
total number of observations = 7

mean efficiency: 0.656767
>
> efficiencies (sfa_model)
  efficiency
1  0.3045729
2  0.7695496
3  0.8524494
4  0.3064747
5  0.9753133
6  0.3916513
7  0.9973582
> plot(efficiencies (sfa_model))
>
```

Appendices. Results of R language E

```
final maximum likelihood estimates
      Estimate Std. Error z value Pr(>|z|)
(Intercept) -1.7689e+02 3.7468e+00 -47.2123 < 2.2e-16 ***
ln(Beta0)    1.5569e+01 1.5238e-01 102.1690 < 2.2e-16 ***
ln(Beta1)    1.9485e-01 2.4706e-01  0.7887  0.4303
ln(Beta2)    1.2118e+00 2.1470e-01  5.6443 1.658e-08 ***
sigmaSq      3.6501e-01 2.0655e-01  1.7672  0.0772 .
gamma        3.5372e-05 7.1161e-02  0.0005  0.9996
---
signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
log likelihood value: -5.490101

cross-sectional data
total number of observations = 6

mean efficiency: 0.9971395
>
> efficiencies (sfa_model)
  efficiency
1  0.9971384
2  0.9971388
3  0.9971320
4  0.9971547
5  0.9971416
6  0.9971314
> plot(efficiencies (sfa_model))
>
```

Appendices. Results of R language F

*Command Syntax SFA - Notepad

File Edit Format View Help

library("SciViews")

library (frontier)

```
data = read.csv("C:\\SFA\\SFA NEW1.csv", sep = ";")
Frontier
```

```
sfa_model <- sfa (ln(Beta3) + ln(Beta2) ~ ln(Beta0) + ln(Beta1) , data = data)
```

```
summary (sfa_model)
```

```
efficiencies (sfa_model)
plot(efficiencies (sfa_model))
```

final maximum likelihood estimates

	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	2.328388	1.000000	2.3284	0.01989 *
ln(Beta0)	1.303020	1.000000	1.3030	0.19257
ln(Beta1)	0.423333	1.000000	0.4233	0.67205
sigmaSq	0.030359	1.000000	0.0304	0.97578
gamma	0.050000	1.000000	0.0500	0.96012

signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
log likelihood value: 4.823768

cross-sectional data

total number of observations = 14

mean efficiency: 0.9696576

>

> efficiencies (sfa_model)

efficiency

1 0.9749674

2 0.9697347

3 0.9697820

4 0.9651342

5 0.9705125

6 0.9681981

7 0.9692176

8 0.9632080

9 0.9665654

10 0.9698330

11 0.9703847

12 0.9742492

13 0.9721668

14 0.9712530

> plot(efficiencies (sfa_model))

Appendices. Results of R language G

```
final maximum likelihood estimates
      Estimate Std. Error z value Pr(>|z|)
(Intercept) -1.6125e+01 1.3504e+01 -1.1941 0.23245
ln(Beta0)    3.4215e+00 1.9527e+00  1.7522 0.07974 .
ln(Beta1)   -8.6529e-02 9.6172e-01 -0.0900 0.92831
sigmaSq     1.2786e-01 6.9720e-02  1.8340 0.06666 .
gamma       1.7827e-06 7.3083e-03  0.0002 0.99981
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
log likelihood value: -2.343257

cross-sectional data
total number of observations = 6

9  0.40556425
10 0.09540133
11 0.05937496
12 0.95098156
13 0.75936304
14 0.57133019
> plot(efficiencies (sfa_model))
>
mean efficiency: 0.9996192
>
> efficiencies (sfa_model)
efficiency
1  0.9996190
2  0.9996196
3  0.9996190
4  0.9996189
5  0.9996193
6  0.9996193
> plot(efficiencies (sfa_model))
>
```

Appendices. Results of R language H

```
final maximum likelihood estimates
      Estimate Std. Error z value Pr(>|z|)
(Intercept) 5.3479e+00 4.1154e+00 1.2995 0.193779
ln(Beta0)    1.0159e-01 2.4082e-01 0.4219 0.673123
ln(Beta1)    1.4383e+00 2.5036e-01 5.7450 9.194e-09 ***
sigmaSq      2.9950e-01 9.7026e-02 3.0868 0.002023 **
gamma        6.9405e-05 9.4269e-02 0.0007 0.999413
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
log likelihood value: -11.42513

cross-sectional data
total number of observations = 14
```

```
mean efficiency: 0.9963726
>
> efficiencies (sfa_model)
  efficiency
1    0.9963785
2    0.9963574
3    0.9963843
4    0.9963921
5    0.9963953
6    0.9963611
7    0.9963571
8    0.9963615

9    0.9963600
10   0.9963533
11   0.9963720
12   0.9963753
13   0.9963810
14   0.9963878
> plot(efficiencies (sfa_model))
```

Appendices. Results of R language I

```
final maximum likelihood estimates
      Estimate Std. Error  z value  Pr(>|z|)
(Intercept) 35.2814097  1.1641738  30.3060 < 2.2e-16 ***
ln(Beta0)   -4.2767771  0.4405143  -9.7086 < 2.2e-16 ***
ln(Beta1)    3.5253607  0.4329070   8.1435 3.841e-16 ***
sigmaSq      0.1620142  0.0876515   1.8484 0.06455 .
gamma        1.0000000  0.0035923 278.3744 < 2.2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
log likelihood value: 1.342653

cross-sectional data
total number of observations = 7

mean efficiency: 0.7678864
>
> efficiencies (sfa_model)
  efficiency
1  0.9843159
2  0.7221001
3  0.7536708
4  0.5915112
5  0.4496053
6  0.9925885
7  0.8814132
> plot(efficiencies (sfa_model))
```

Appendices. Results of R language J

```
      Estimate Std. Error z value Pr(>|z|)
(Intercept) -12.7438473   0.4298423 -29.6477 < 2.2e-16 ***
ln(Beta0)    -1.2714298   0.9798000  -1.2976 0.1944103
ln(Beta1)     3.4039058   0.9880714   3.4450 0.0005711 ***
sigmaSq       0.0139895   0.0090255   1.5500 0.1211420
gamma         1.0000000   0.0169277  59.0748 < 2.2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
log likelihood value: 8.204245

cross-sectional data
total number of observations = 6

mean efficiency: 0.9159856
>
> efficiencies (sfa_model)
  efficiency
1  0.9980003
2  0.8695732
3  0.7780256
4  0.9674477
5  0.9414334
6  0.9414334
> plot(efficiencies (sfa_model))
\ |
```