INSTITUT DE FINANCEMENT DU DÉVELOPPEMENT DU MAGHREB ARABE

معهد تمويل التنمية للمغرب العربي

# End of Studies Project

*Topic :*

# "Assessing bank agencies' efficiency by the method Data Envelopment Analysis (DEA): Study case of CNEP-Bank"

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# ABSTRACT

Commercial networks occupy a strategic place, especially in banking organizations. However, setting up a system to control and assess the efficiency of management entities belonging to the same operating network seems delicate, especially in an environment where competitive and technological developments are simultaneous and interdependent. To this end, the internal benchmarking method is presented as an effective and useful tool to guide the behavior of managers and improve the practices adopted within the organization.

This is why we have deemed it particularly judicious to shed light in our brief on a new method based on internal comparison called the Data Envelopment Analysis (DEA) method.

This methodology is dedicated to the assessment of the technical efficiency of bank branches.

Therefore, the use of the DEA methodology has indeed enabled us to go beyond the traditional financial ratios in favor of the notions of input and output and thus to determine from a homogeneous group, the most productive agencies in terms of efficiency.

In our practical case, an empirical application is carried out on a sample of 219 bank branches of the CNEP-Bank, we have developed two DEA models in order to assess the operational performance and the financial performance of this network.

With the help of the results obtained, we were able to distinguish efficient agencies from inefficient agencies as well as their "benchmarks". This allowed us subsequently to deduce the gains from the productivity of the network and the possible savings, and to identify the efforts to be achieved by inefficient agencies in order to improve its efficiency.

Finally, we presented some recommendations that could be taken into account by the CNEP-Bank regarding the use of the DEA tool with a view to improving the performance of its branch network.

**Key words:** DEA, Efficiency, Performance, Bank branch. Benchmark.

# ABVERIATION LIST

**ASD:** Average Stocks of Deposits.

**ASL:** Average Stocks of Loans.

**ATM:** Automated Teller Machine.

**BCC:** Banker, Charnes and Cooper

**CCR:** Charnes, Cooper and Rhodes

**CNEP-Bank :** Caisse Nationale d'Epargne et de Prévoyance-Banque.

**CR:** Commissions Received.

**CRS:** Constant Return to Scale.

**DA:** Dinar Algerien

**DEA:** Data Envelopment Analysis.

**DEAP:** Data Envelopment Analysis Program.

**DMU :** Decision-Making Unit.

**D.R.E. :** « Direction du Réseau d'Exploitation ».

**EBITDA:** Earnings Before interest, Taxes, Depreciation, and Amortization.

**FC:** Financial Charges.

**FR:** Financial Revenues.

**II:** Interest Income.

**KPI:** Key Performance Indicators.

**MCD:** The Management Control Department.

**MDA:** Million Dinar Algerien

**M.C.S.D:** The Management Control and Studies Department by abbreviation.

**NBI:** Net Banking Income.

**NCL:** Number of Clients.

**OGC:** Other General Costs.

**PC:** Personal Costs.

**PMS:** Performance Measurement System.

**SO:** Slack Output.

**SI:** Slack Input.

**SQL:** Structured Query Language.

**VRS:** Variable Return to Scale.

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# SUMMARY

# GENERAL INTRODUCTION

Over the past decades, the international financial environment in general and the banking sector in particular have been marked by profound changes throughout; strong liberalization, a phenomenon of deregulation and a process of disintermediation and globalization of banking activities.

In addition, the financial crisis of 2007 represents one of the most significant events in the history of finance, it firmly embodied the volatility and uncertainty of the environment in which banks and financial institutions operate, which in order to maintain their market shares and preserve their competitive character, they must further strengthen their capacities to cope with them and set themselves apart through a sound commercial and management policy.

Faced with these troubling facts, banks owe themselves a minimum of protection in order to ensure their sustainability and development by setting up an efficient management system that is consistent with environmental conditions and It is in this context that the management control function intervenes and plays a primordial role within banks in particular and companies generally, it comes to respond to the concerns of managers who are the central players in the management process. They are called upon to improve their management practices and adapt their strategies to the current situation to ensure better performance. It became necessary to set up a performance assessment system which makes it possible to assess, among other things, the level of achievement of the objectives previously set by those in charge while taking into account the resources allocated.

In addition, with the phenomenon of decentralization characterizing bank policy, it should be noted that it becomes necessary to also decentralize the performance measurement system (i.e. by profit center) and to judge performance distinctly. of each management entity in order to shed light on the most efficient units which can serve as examples for those facing internal management problems, which makes it possible to develop a benchmarking approach.

the traditional indicators used by management control only ensure the measurement of the efficiency of management entities, they represent a limited view of performance which is rather a combination of effectiveness and efficiency.

Efficiency is the ability to achieve a previously set goal without considering the means to achieve it. As for efficiency, it refers to the ability to achieve an objective with the minimum of means. These two concepts are different despite the strong link between them.

In order to overcome the limits of traditional management control methods and thanks to the Data Envelopment Analysis (DEA) method, we are going to try to provide some answers to the

following problem: **"The use of the DEA method can bring relevant results in the context of measuring the efficiency of bank branches?"**

At the end of a practical internship which was carried out during a period of 45 days at the level of the management control department of the CNEP-Bank, we were able to tackle this problem concretely by breaking it down into several essential questions:

- What is performance and how is it measured?
- What are the tools and indicators that make it possible to understand performance? Which are used by the CNEP-Bank for this purpose?
- What does "Data Envelopment Analysis" consist of? How does it differ from traditional efficiency assessment approaches?
- How will we assess the performance of bank branches in the CNEP-Banque operating network using the DEA method?
- Which production entities represent the best practices of the network (the benchmarks)?
- What efforts must be made by agencies deemed to be inefficient by the method in order to achieve the same level of efficiency as benchmark agencies?

To provide answers to these questions, we have organized our work in two parts, separating the theoretical aspects and the practical application.

The theoretical part is subdivided into two chapters: in the first chapter we will approach the principles and foundations of management control in its first section and then explore the notion of performance and its measurement tools in the second section. In the third section, we are going to discuss the subject of efficiency' measurement.

As for the second chapter of the theoretical part, it will be devoted to the presentation of the DEA method. The first section of this chapter covers the concepts and basic principles of the DEA method. In the second section will expose the general models of the method, after we will discuss the uses of the DEA method, its advantages and its disadvantages.

However, the practical part will be structured in a single chapter, the first section of which will be devoted to the presentation of the host structure and will reveal the existing methodology within the CNEP-Bank for the evaluation of the performance of all its agencies. the second section will be dedicated to the presentation of the choices selected for our study, for the application of the DEA method to the CNEP-Bank branch network in order to emphasize the contributions of the method in the third section.

# CHAPTER 01:

# MANAGEMENT CONTROL AND PERFORMANCE MEASUREMENT

## Introduction:

Changes in the economic world and particularly the banking environment following substantial deregulation, the increased innovation of new financial products, and the resulting financial crises have fostered a climate of fierce competition that shrunk bank margins.

To cope with these new conditions, the banks needed a function that ensures the control of management (rationalization of costs' consumption). Hence, the emergence of management control function as a discipline allowing to foresee changes in the environment, plan actions to be taken and ensure their coordination with its overall objectives to ensure its sustainability.

This chapter aims to offer a synthetic vision of the perimeter and functions of management control and the notion of performance and its measurement tools in banking to integrate with an overview. In the following chapter, we will explore more these different themes.

Thereby, in the first section, we will start with "Generalities about Management Control". In the second section, we are going to discuss the notion of performance. At last, in the third section, we are going to talk about the notion of efficiency.

## Section One: Generalities about Management Control

What is Management Control? What are the primary grounds of this discipline? What is a management control system? These are the kind of questions that we are going to answer in this section.

### 1. The definition of Management Control:

It is necessary to clarify the meaning attributed to the term "control", to define Management control. Indeed, the word carries multiple meanings and sometimes unsuited to the field of management control. As P. Drücker, often considered one of the founding fathers of management control, put it, "*the word control is ambiguous. It signifies the ability to direct oneself and direct one's work. It can also mean the domination of one person over another*"[1]. It is, therefore, useful to specify the general objective of the process as well as its purpose, i.e., "what we are trying to control".

Academics gave several definitions to management control, each developing a particular aspect to this discipline; however, they all pour into the same container contextual.

We will refer to the most widespread and accepted definition, proposed by Anthony R.N. and Dearden J. in the early 1960s: "Management control is a process by which company leaders ensure using resources effectively and efficiently to achieve the objectives set".

We will also cite another important definition, that of Claude GRENIER (1990): "Management Control seeks to design and set up information instruments intended to enable managers to act while achieving overall economic coherence between resources and achievements. It is considered an information system useful for managing the business since it monitors the efficiency and effectiveness of actions and means. But to the extent that management fashions tend to put the organization under tension through strong delegation and increasing accountability of actors, behavioral control becomes essential. Therefore, management control thus becomes an incentive system in which individuals find the company's development".

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[1] François GIRAUD, Olivier SAULPIC, Gérard NAULLEAU, Marie-Hélène DELMOND & Pierre-Laurent BESCOS, « Contrôle de gestion et pilotage de la performance », 2nd édition, Gualino éditeur, Paris, 2005, P.21.

Thereby, Management Control is considered to be, in general, the function that ensures the most efficient combination of financial, technical and human resources to the achievement of the set objectives.

## 2. The Management Control Process:

As Robert N. Anthony said: "Management Control is a process intended to motivate managers and encourage them to carry out activities that contribute to the achievement of the objectives of the organization". This definition highlights the incentive dimension of management control. It underlines that management control is not an isolated action but that it is a process allowing the motivation of managers and the achievement of objectives.

This process is a sequence of actions intended to:

- ✓ **Interpret** the strategic objectives to control the proper execution of operations, take stock of the actions remaining to be carried out and take corrective actions in the event of deviations;
- ✓ **Evaluate and measure** the performance achieved.

Based on the history of the results obtained by the organization and the strategic objectives, management control first defines a benchmark against which the results will be analyzed and compared. Then explanations are given for any discrepancies observed. If the organization deviates from the desired trajectory, it implements the necessary corrective actions. This results in the definition of the recovery plan for each organization's entity, taking into account the feedback.

According to ROUACH M. & NAULLEAU G.[2], the Management Control process revolves around four (04) stages:

- ➢ **<u>Definition of a referential:</u>** the management control process initiates its principle by defining a frame of reference that constitutes a benchmark against which the results will be analyzed and compared. Strategic objectives must inspire that reference, enriched by the history of results obtained by the organization or by comparable entities.

[2] ROUACH M., NAULLEAU G., « Le Contrôle de Gestion Bancaire et Financier », 4th edition, Revue banque Édition, Paris, 2006, P.48.

- **The measurement and evaluation of results:** this step values, on the one hand, the consumption of resources and, on the other hand, the achievement of results while measuring margins for accountability purposes. It turns out to be fundamental because it conditions the relevance of the analyzes and the good based on palliative decisions.
- **Gap analysis and feedback:** it is not enough to measure the "gaps" but rather analyze them and explain their causes and origins. This step is characterized by feedback that promotes the responsiveness of the organization to changes in the environment.
- **Making palliative decisions:** these decisions are made in the event of no correspondence between the reference system and the results obtained in order to bring different entities on the original objectives. Corrective actions can be operational, strategic or at an intermediate level.

The management control process can therefore be schematized as follows:

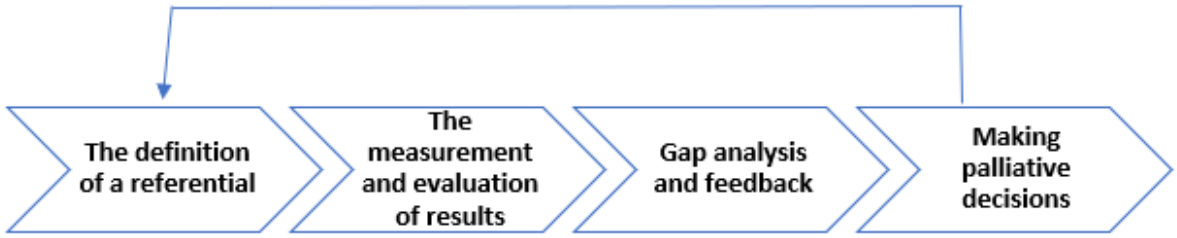


**Figure 1 :** The Management Control process.

## 3. The primary grounds of Management Control:

There exist three fundamental pillars of Management Control, namely:

### 3.1. The objectives:

they must be both realistic, ambitious, and consistent with the organizational strategy. It is crucial to take into account, when setting goals, the entity's environment, structure and capabilities.

### 3.2. The means:

they include the financial, human and technical resources necessary to achieve the objectives, they must be in harmony with the needs and used efficiently. They must not be insufficient nor excessive.

### 3.3. The results:

the results of actions and decisions taken, they must be analyzed effectively.

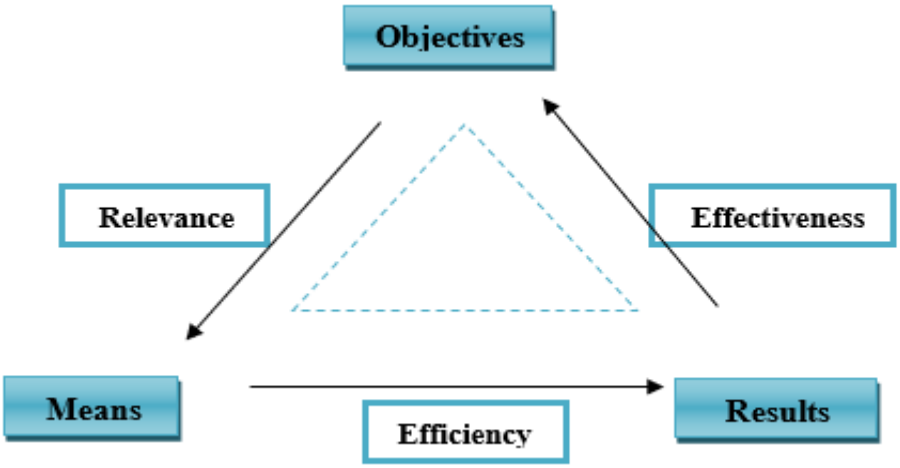


**Figure 2:** The Management Control Triangle[3].

The analysis of the articulations between these three elements gives rise to three fundamental concepts:

- ✓ **Relevance:** this notion qualifies the relationship between the objectives and the means, in other words, the implementation of means adapted in quantity and quality to the goals set.
- ✓ **Effectiveness:** this notion qualifies the relationship between the objectives and the results, in other words, the company's ability to achieve results in accordance with predetermined goals.
- ✓ **Efficiency:** this notion qualifies the relationship between means and results, in other words, the company's ability to maximize results at the lowest cost.

We can therefore conclude that the concept of effectiveness is different from that of efficiency. These are in fact two complementary concepts that must be taken into account when measuring the performance.

[3] LÖNING H., PESQUEUX Y., et al, « Le Contrôle de Gestion : Organisation et mise en œuvre », 2nd édition, Dunod, Paris, 2003, P.3.

## 4. Traditional tools of bank management control:

To properly carry out his mission, the management controller has several of tools enabling him to evaluate and manage activities to optimize performance. The most used tools are mainly:

### 4.1. Forecast Management:

Effective management of distribution and manufacturing activities begins with understanding and anticipating market needs. Forecasting is the process of projecting past sales demand into the future. Implementing a forecasting system enables you to assess current market trends and sales quickly so that you can make informed decisions about the operations. Forecast management's role is to plan in order to adapt to change.

To do that, forecast management is equipped with a certain number of tools such as: Forecasts, Strategic and operational plans, budget monitoring...etc.

### 4.2. The Dashboard and Reporting:

#### 4.2.1. The Dashboard:

The Dashboard is an information management tool that visually tracks, analyzes and displays Key Performance Indicators (KPI), metrics and critical data points to monitor the health of a business, department or a specific process. It is customizable to meet the particular needs of a department and company. Behind the scenes, a dashboard connects to your files, attachments and services, but on the surface displays all this data in the form of tables, line charts, bar charts and gauges. A data dashboard is the most efficient way to track multiple data sources because it provides a central location for businesses to monitor and analyze performance. Real-time monitoring reduces the hours of analyzing and the long line of communication that previously challenged businesses.

The indicators constituting the dashboard must be:

- ✓ **Relevant:** meet the needs of managers at the right time
- ✓ **Obtained quickly**: to carry out corrective actions on time. Priority should be given to securing rapidity over the accuracy of information;
- ✓ **Summary:** all the indicators must provide a global and complete picture of the company or the manager's field of activity;
- ✓ **Contingents:** respond to the situation and current expectations. The dashboard therefore does not have a uniform content between services, nor over time, even if it must have specific stability to make comparisons over time.

### 4.2.2. Reporting:

Reporting refers to "*the regular provision of information to decision-makers within an organization to support them in their work"*[4]. It is a fundamental part of the larger movement towards improved business intelligence and knowledge management. Implementation often involves extract, transform, and load procedures in coordination with a data warehouse and then using one or more reporting tools. This reporting process involves querying data sources with different logical models to produce a human-readable report.

The reporting tool ensures the interrogation of the databases according to the SQL queries prepared during the development of the model. The activity report can then be published on the Intranet, periodically automatically or occasionally on demand.

The tool of course offers specific functions for the development of the report model, calculation and presentation modules (graphics) in order to design particularly timely and relevant reports.

## 4.3. Profitability Measurement:

Establishing a profitability measurement system within the company allows the identification of the sources of value creation and the determination of the key factors of the company in its competitive environment.

Profitability is considered to be the most synthetic performance indicator. Therefore, its measurement constitutes one of the prominent roles entrusted to management control. This measure seeks to determine the margin (Revenue -Costs) generated by the entity that is the analysis' subject. It is then a question of reconstituting the income and expenses attached to the different entities.

[4] Hill, Gregory. "a guide to enterprise reporting". Retrieved Nov. 6, 2013.

## Section Two: the notion of Performance

What is performance? Why do we have to measure it? What are the tools we use in performance measurement? These are the kind of questions we are going to answer in this section.

### 1. Definition of performance:

Trying to define performance is not easy since this notion is polysemic in nature. The meaning of performance is vague, since it is based on two inseparable concepts but fundamentally distinct, i.e., the value-cost pair.

The concept of performance lends itself to an almost infinite variety of definitions, many of which relate to specific contexts or functional perspectives. According to Niculescu (1999), "*performance is the achievement of organizational objectives regardless of the nature and variety*".

As to Didier Noyer (2002), "performance is the achievement of goals that have given in convergence with the company guidelines. Performance is not simply finding a product but rather is the result of a comparison result and objective".
Thereby performance means achieving the wanted results in a manner that is as effective and efficient as possible. Performance management reminds us that being busy is not the same as producing results. It reminds us that training, strong commitment and lots of hard work alone are not results.

To sustain good performance, all parts of the system must be closely integrated and aligned toward actively achieving the desired results. Only then we can say that it is highly performing.

### 2. The components of Performance:

Knowing that performance is the result of an optimal combination of actions consistent with each other and with the means, performance is therefore part of the optimization framework of the "objectives-means-results" triptych, which gives rise to the introduction of the concepts of effectiveness and efficiency which can be summarized by the following diagram:

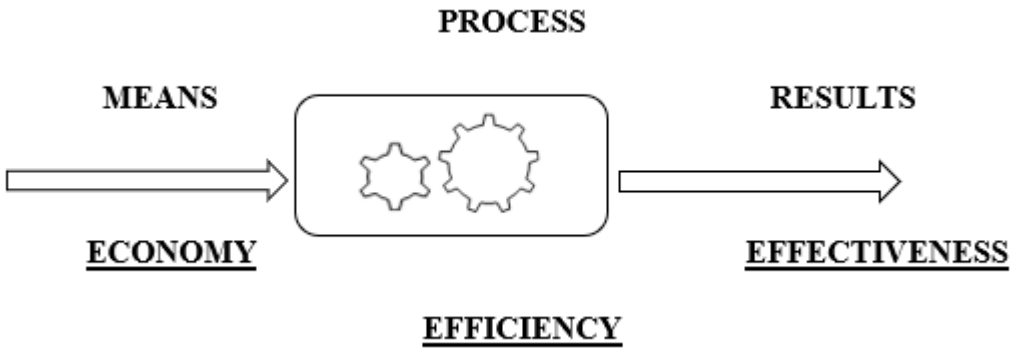


**Figure 3:** Explanatory diagram of performance

from this diagram, we can deduce three main concepts:

- ✓ **The economy:** it consists of obtaining resources at the lowest cost. The economy therefore evokes the notion of efficiency.
- ✓ **Efficiency:** there are two forms of efficiency according to STERN and EL-ANSARY:
- ➢ **Productivity**: it is the ratio of a volume of production (output) obtained at a consumed volume of resources (input). It's about the operational performance measurement;
- ➢ **Profitability:** it is the ratio of the profit generated to the costs generated which made it possible to achieve it.
- ✓ **Effectiveness:** In their actions, managers seek the best value possible between the degree of achievement and the objectives set upstream. It may be quantifiable and measurable but can also sometimes be appreciated only in a qualitative way.

### 3. Performance Measurement System (PMS):

The PMS is an important subsystem within the control systems of organisations, it is central to management control within any organisation.

The term PMS has been discussed in multiple ways in literature. For instance, Marshall et al. (1999)[5], consider a PMS as a development of indicators and a collection of data to describe, analyse, and report organisational performance to management.

According to Amaratunga and Baldry (2003)[6], a PMS is:

"A process of assessing the progress towards achieving pre-determined goals, including information on the efficiency with which resources are transformed into goods and services,

[5] Rahat Munir and Kevin Baired, "Performance measurement systems in banks", routledge, New York, 2019, P.20.
[6] Ibid. P.21.

the quality of those outputs and outcomes, and the effectiveness of organizational operations in terms of their specific contributions to organizational objectives".

Therefore, the establishment of a performance measurement system must obey the principles which condition its proper functioning; these principles are as follows:

### 3.1. Relevance:

"The performance measurement of an entity is considered relevant if it guides the manager's behavior in the direction of the company's objectives"[7]. This means that the relevance of performance measurement is expressed by the convergence of the interests of managers towards the overall interest of the organization.

In a decentralized system where, decision-making power is no longer concentrated at the level of general management, the risk of inconsistency between the actions carried out is high because the members of the organization do not always act in the same direction of collective performance, they can sometimes benefit their personal interests to the detriment of the common interest.

### 3.2. Controllability:

According to GIRAUD F., SAULPIC O. & Al.[8], "The principle of controllability stipulates that the performance measurement of a manager in charge of an entity must be built on the basis of the elements that he can control". This means that the contribution of operational managers is limited to the actions that are under their control, because they are supposed to be able to control everything that occurs at the level of their centers. This principle seems a little difficult to respect in the context of a shared responsibility where a collective result is expected.

### 3.3. Reliability:

This principle is crucial in the implementation of a performance measurement system. the establishment of performance indicators must be done by those in charge who must first collect and process the data necessary for the measurement according to an explicitly and formally determined method. If the measurement is performed objectively by several people who have

[7] GIRAUD F., SAULPIC O., et al., « contrôle de gestion et pilotage de la performance », GUALINO éditeur, Paris, 2002, P.72.
[8] Ibid.

no personal interest in the evaluation, the result must be identical, which will allow us to qualify it as verifiable, objective and therefore reliable.

### 3.4. Stability:

The performance measurement system must be stable over time, in order to be able to establish comparisons between periods. However, it must also be able to adapt and evolve, with changing economic conditions and strategic reforms.

## 4. Why do we need performance measurement?

Performance measurement seeks to guide the behavior of managers in two ways: by clear information on the nature of the required performance and by setting up incentive systems around this measurement. However, it should be noted that there is a third principle, which is measurement for benchmarking purposes.

The figure below illustrates this principle well:

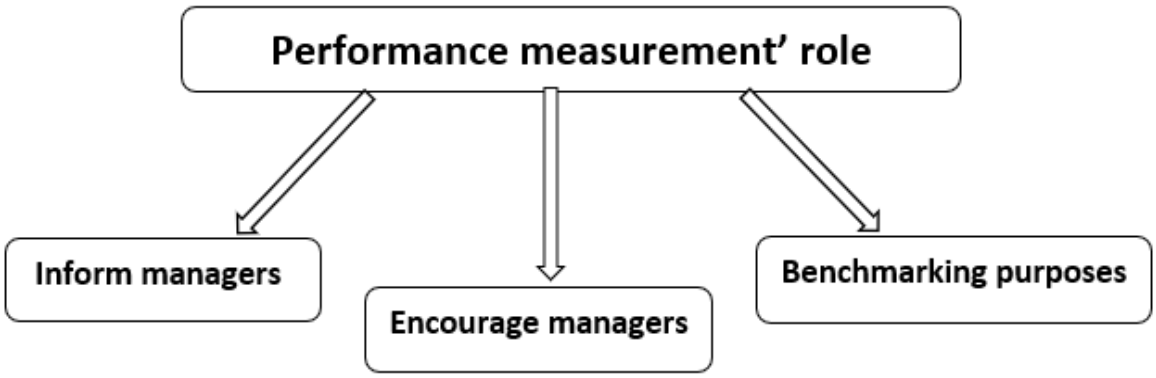


**Figure 4:** Performance measurement' role.

### 4.1. Informing managers:

Above all, performance measurement produces clear information about the situation of the organization. The good communication of information within the bank is constrained by several factors such as: geographic distance, specialization, changes of direction due to the uncertainty of the environment, etc. These also generate risks of inconsistency between the overall goals of the bank and local actions.

This is why the definition of criteria for measuring the performance is proving to be a privileged way of communicating strategic choices at the operational level, by indicating to managers the priorities to be pursued.

### 4.2. Encouraging managers:

It is not enough to orient the behavior of managers in a specific direction by disseminating the necessary information but also to encourage them by integrating incentive mechanisms such as: sanction/reward and variable compensation systems in order to optimize their services.

### 4.3. Benchmarking purposes:

Performance measurement, that is to say, the objectives' achievement degree of a business unit assesses the performance of the units of a network. And since our interest is particularly in measuring the performance of bank branches, relevant measures can represent a symbol of the bank's success. Because comparisons between these agencies will induce competition, and thus challenges can be made to promote a product or best practices. And this way the performance of these units will improve.

## 5. Performance measurement tools of a bank branch:

In order to measure the performance of its agencies, the bank uses traditional tools such as: the budget, the income statement (through Intermediate Management Balances), reporting and the dashboard. Nevertheless, in recent years, we have noticed the emergence of several new tools which come to overcome the shortcomings of the old methods. We will discuss two of them:

### 5.1. Internal benchmarking:

It consists in analyzing and comparing the practices of the different units of the company itself, in order to determine the most efficient entities and those that are less efficient by way of example: the comparison between bank branches belonging to the same operating network.

This practice allows them to compete in order to improve their results. However, it should be used with caution within the organization to avoid internal conflicts. It should be noted that benchmarking can be applied for a practice or a process of an agency, which makes it an agency that performs well in one practice and does not perform well in another.

### 5.2. Quantitative methods:

These methods depend mainly on mathematical and statistical methods such as linear programming, data analysis, modeling, etc. we can mention:

#### 5.2.1. Ascending Hierarchical Classification:

It is a statistical technique to partition a population into subgroups, its purpose is to classify agencies into homogeneous categories according to criteria taken into account during the analysis.

#### 5.2.2. Principal Component Analysis:

It consists of expressing a set of variables as a set of linear combinations of uncorrelated factors in order to remove information redundancy. It allows data to be represented in a lower dimensional space while minimizing the loss of information.

#### 5.2.3. The Data Envelopment Analysis method:

The DEA method measures the efficiency of bank branches. Most precisely, their relative ability to achieve results at the lowest possible cost. In other words, it allows us to learn about the relative level of means' wastage by the agencies compared to other reference agencies which will also be determined for each agency. (We are going to explain this method further in details in the next chapter).

## 6. Obstacles to measuring banking performance:

### 6.1. The definition of inputs and outputs:

Measuring the performance of a company is trying to find the ratio between the factors of production that it uses and its products to compare it with that of competing companies in order to safeguard its existence for guide its evolution. Thereby, knowing the inputs and outputs is the first and one of the most important steps in measuring performance.

### 6.2. The difficulty of dividing expenses:

For a multi-output company, it is essential to divide costs and products before carrying out a performance study. Several reasons make it difficult to separate the charges:

- The bank's products as well as its production factors are of the same nature (monetary).

- For a just division of expenses, exact monitoring is essential, which requires:

    • A developed information system;

    • The establishment of cost accounting.

## Section Three: Efficiency' Measurement

Efficiency is a recent concept; it was not until 1947 that economists began to use this term to distinguish it from effectiveness. Efficiency came to answer the questions: how to choose the best decision? And how to make this best decision happen?

### 1. The notion of efficiency:

Efficiency is a stricter concept than effectiveness, it encompasses more criteria to allow an optimum evaluation of a banking system or banking entities.

According to Farrell[9], efficiency consists of two aspects: technical efficiency and allocative efficiency.

#### 1.1. Technical efficiency:

It is the capacity of the company to achieve the maximum of outputs with a certain level of inputs or to reach a certain level of outputs while using the minimum of inputs.

##### 1.1.1. Pure technical efficiency:

It reflects the capacity of a company to optimize its production for a given level of inputs and, symmetrically, to minimize its consumption of resources for a given level of production. It is independent of the prices of products, inputs and their availability.

##### 1.1.2. Scale efficiency:

It makes it possible to relate the measurement of technical efficiency to the returns to scale obtained for the activity' optimal levels. A company is inefficient of scale if its initial situation is characterized by increasing or decreasing returns to scale.

#### 1.2. Allocative efficiency:

It is making the right decision regarding the inputs used taking into consideration their market price.

- ✓ Illustrative example:

To explain the two concepts of efficiency, we will present the example of Farrell:
It was in his pioneering work dating from 1957 that Farrell proposed the construction of a nonparametric frontier from observations on productive activities. He also introduced the

[9] Farrell M.J. (1957). "The Measurement of Productive Efficiency". Journal of the Royal Statistical Society.

notions of technical and allocative efficiency. Farrell explained his idea by taking a simple example:

A company that uses two inputs to produce an output with a constant return. With the following production function: **Y= f (x1, x2).**

The following graph illustrates the example of Farrell on the efficiency of scale and allocative efficiency:

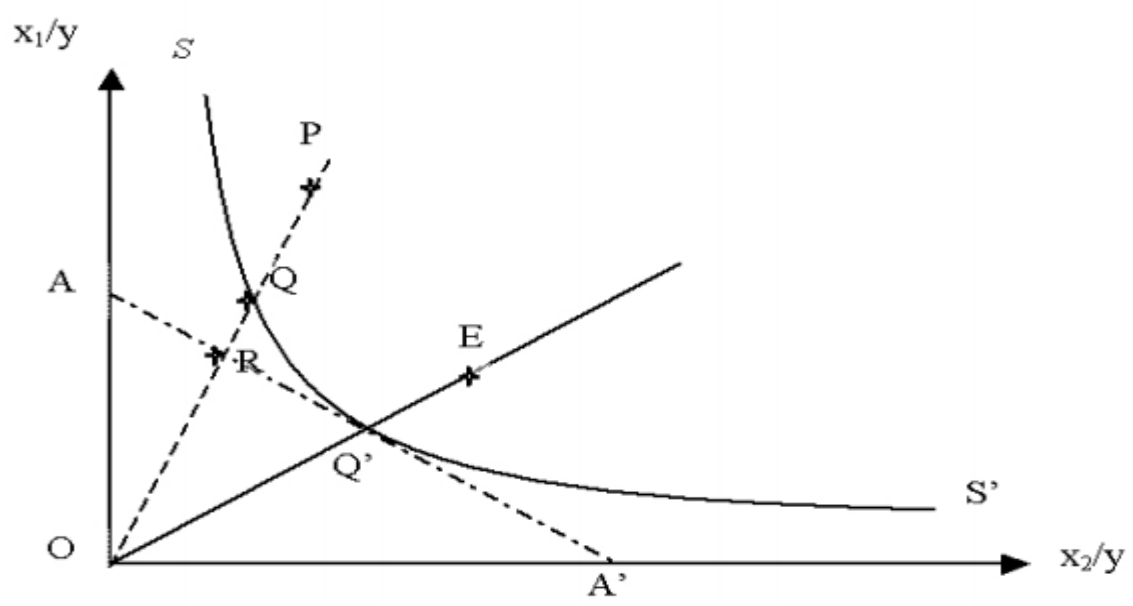


**Figure 5:** Technical and allocative efficiency[10].

- **The explanation of technical efficiency:**

The **SS'** curve represents the set of combinations of the two factors (**X1**, **X2**) for which the firm is said to be technically efficient in producing a unit of **Y**.

A company whose combination of the production factors **X1** and **X2** positions it at a point **P** or any other point which is not the **SS'** curve is classified as technically inefficient.

The level of technical inefficiency is given by the fraction: **LTI[11]= QP/OP**, and represents the proportion by which it is necessary to reduce the quantities of X1 and X2 for the company to be technically efficient.

The level of technical efficiency of a company is given by: **LTE[12]= 1- QP/OP = OQ/OP.**

[10] TIM. COELLI, « A Guide to DEAP 2.1: Data Envelopment Analysis (computer) Program », University of New England, Australia, p.4.

[11] **LTI**= Level of Technical Inefficiency.

[12] **LTE**= Level of Technical Efficiency.

The level of technical efficiency always belongs to the interval **[0,1].**

- **When LTE< 1:** the firm is technically inefficient.
- **When LTE= 1:** the firm is technically efficient.

➢ **The explanation of allocative efficiency:**

The line of isocosts **AA'** represents the line of the costs relating to the factors of production **X1** and **X2** which give the allocative efficiency. A firm that is not on this line is allocatively inefficient, its production costs can be reduced.
Always taking the example of the company located at point **P**. The latter must make an effort to reduce the quantity used in production factors to position itself at the point **Q** and become technically efficient. By being at point **Q**, the firm is still not economically efficient. It needs an effort to reduce production costs of the order of the proportion: **AI**[13] **= QR/OQ**, for it to become allocatively efficient. Once done, the firm will be at point **R**.

This result proves that allocative efficiency does not imply technical efficiency and vice versa. Because the two points **Q** and **R** correspond respectively to technical and allocative efficiency but they are not located in the same place. Indeed, the combination allowing economic efficiency is that corresponding to the point of intersection between the **SS'** curve and the line of isocosts **AA'**, which means the point **Q'**.

## 2. The approaches to measuring the efficient frontier:

The example brought in 1957 by Farrell in illustrating the concept of efficiency was a benchmark for the work relating to the measurement of efficiency that followed. However, in this same example, Farrell assumed a predefined functional form of the efficient production frontier. In reality, the production function is not known in advance, it must be estimated.
Faced with this shortcoming, Farrell introduced the notion of relative efficiency which is no longer based on a comparison with an ideal and predefined situation. The difference is now measured against the best performance in a homogeneous group with comparable production units. This difference corresponds to the level of technical inefficiency.
To determine the efficiency frontier corresponding to the best practices in a homogeneous group of entities, two approaches are applicable:

[13] **AI**= Allocative Inefficiency

### 2.1. The parametric approach:

This approach is essentially based on a particular specification of the technology of the entity object of the analysis, this means that the form of the production function which links the inputs to the outputs is predefined (Cob-Douglas for example) and the parameters on which it depends are estimated by econometric methods using data from the sample studied. The measurement of efficiency here, can be biased by a bad choice of the production function' form.

### 2.2. The non-parametric approach:

The particularity of this approach is that it does not presuppose any form of the production function beforehand. The determination of the efficient frontier is based on linear programming techniques. Consequently, all the points composing the efficient frontier correspond either to efficient production units (firms, bank agencies, etc.) or to linear combinations of the latter. In this approach, a production unit is said to be efficient if no other unit of the group produces more outputs with the same quantity of inputs as it or the same quantity of outputs with fewer inputs than it.

One of the methods often used in this second approach is the Data Envelopment Analysis (DEA) method which we will explain in details in the next chapter.

## Conclusion:

In this chapter, we have seen that a bank must improve its performance in the short and medium term and thus become more efficient in order to preserve its longevity and meet the numerous requirements of its customers.

We have seen that performance measurement is very important, to enhance various notions of efficiency. Further detailed analysis and possibly inspection of the best and of the worst performers is then necessary in order to understand the production process and derive useful information which may help both the worst and the best performers to make further improvements in efficiency.

Moreover, in the following chapter we will discuss a method of performance measurement which takes into consideration the comparison between bank branches to improve their efficiency, this method is known by the acronym DEA "**Data Envelopment Analysis**".

# CHAPTER 02:

# THE METHOD DATA ENVELOPMENT ANALYSIS (DEA)

## Introduction:

The performance measurement of bank branches refers, not only to a judgment on a result but also to how this result is achieved, taking into account the conditions and the objectives of achievement. It then covers two distinct aspects, in this case, effectiveness and efficiency.

The traditional tools that management control offer to a bank, to measure this performance, such as dashboards, reporting, etc., only consider the "effectiveness" aspect and not "efficiency", hence the need to put in place others methods that meet this need.

One of the performance assessment methods is the "**DEA**" method which offers a multidimensional performance assessment, taking into account the efficiency aspect.

In this chapter, we aim is to introduce in a rigorous but succinct way theoretical aspects of the DEA method; therefore, we will start with the basic principles of the method DEA in the first section, then we are going to discuss the method' general models in the second section. Finally, In the third section, we are going to mention the uses of the method in some fields.

## Section One: Basic principles of the method DEA

In this section we are going to introduce the method DEA and discuss its basic principles, so we can get a general idea about the method, its origin and its technical aspects.

### 1. What is "Data Envelopment Analysis"?

Data Envelopment Analysis (DEA) is a technique based on linear programming for identifying empirical production functions. This method aims to assess the performance (in terms of comparative or relative efficiency) of the decision-making units "DMUs", which transform inputs into outputs. We mentioned relative (comparative) efficiency because the method refers to some set of units to compare to each other to measure their efficiency. Using the DEA method, we cannot derive an absolute measure of efficiency unless we make some predefined assumptions about the compared units (that some of them are efficient in an absolute sense, which we cannot prove). Thus, finding efficient units by DEA may be capable of improving their performance.

DEA offer a measure of the relative efficiency of each DMU and other information useful in managing the performance of these DMUs. Such information contains, some good operating practices which can be spread to all the other units, performance targets per unit can be set, the most productive scale volume at which a unit can operate, exemplar units that an inefficient unit may imitate to improve its performance, and the extent to which a DMU has improved over time.

DEA compares, therefore, all relatively homogeneous units in a population, taking into account several dimensions simultaneously to determine the efficient frontier from the standpoint of the best practice.

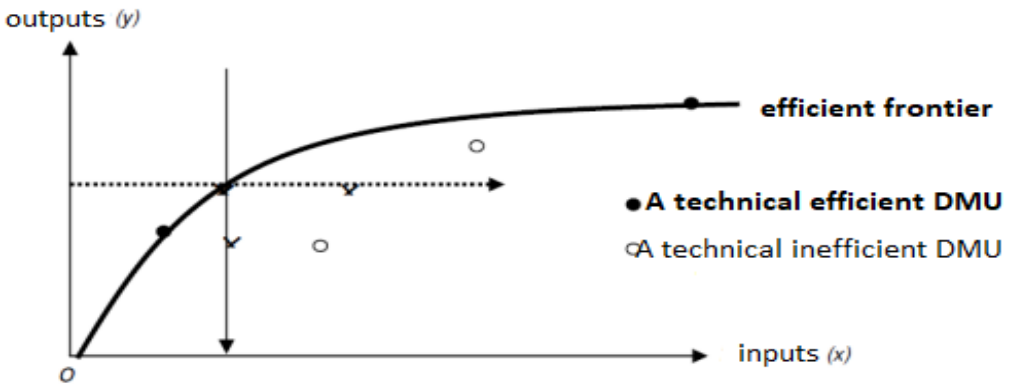


**Figure 6:** The principal of the method DEA.

## 2. Historical facts about DEA:

The DEA method has its origins in the work of Farrell (1957), who for the first time proposes a method for estimating efficiency frontiers from the observation of real production situations. Based on the work of Farrell (1957) the DEA method was born with the doctoral thesis of Edouard Rhodes at the School of Public and Urban Affairs Carnegie Melon University in 1978 under the supervision of W.W COOPER.

In his thesis, Edouard Rhodes sought to assess the performance of the Follow Thought program, an educational program for disadvantaged students undertaken in American public schools. The analysis consisted of a comparison of performance in a group of schools, applying and not applying for the program in question.

In 1978[14], Charnes, Cooper and Rhodes published the first scientific article on the DEA in the journal Management Science. The DEA model is a generalization of Farrell's performance measurement model. It was developed specifically to measure relative efficiency in organizations characterized by the use of several inputs to produce several outputs. In this sense, the relative efficiency of a DMU is defined by the ratio of the total of its weighted outputs by the total of its weighted inputs.

Starting at the CCR model by Charnes, Cooper and Rhodes, many extensions to DEA have been proposed in the literature. They range from adapting implicit model assumptions such as input and output orientation, distinguishing technical and allocative efficiency, adding limited disposability of inputs/outputs or varying returns-to-scale to techniques that use DEA results and extend them for more sophisticated analysis, such as stochastic DEA or cross-efficiency analysis.

Consequently, several works of application of the DEA method have been published in various fields: health, services, banks, etc. The first application of DEA on a network of bank branches was conducted in 1985 by Sherman and Gold.

## 3. The assumptions of the DEA method[15]:

The DEA approach is characterized by its flexibility in using linear programming techniques, which allows it to build performance indicators adapted to the context of analysis and study

[14] Charnes A., W. W. Cooper and E. Rhodes (1978). "Measuring the Efficiency of Decision-Making Units."

[15] Inspired by Emmanual THANASSOULIS, «Introduction to the theory and application of Data Envelopment Analysis », Aston University, Birmingham, Springer-Verlag, 2001, P.89.

objectives. Therefore, the adaptability of performance indicators constructed by the DEA method to the organizational, decision-making and strategic environment is essential for a reliable and original analysis. The definition of the context of the analysis is therefore given from the choice of a series of hypotheses which are broken down into three axes:

### 3.1. The choice of input/output orientation:

Generally, two orientations are possible depending on whether we want to maximize the quantity of outputs with a given number of inputs or minimize the number of inputs for a given number of outputs.

#### 3.1.1. The input orientation:

The input-oriented DEA method measures the amount of input that a DMU must consume to produce a given amount of output. More explicitly, when the analysis DEA highlights that a unit is inefficient, the inefficiency score assigned to it will represent the reduction effort on the resource consumption that the unit must make to become efficient. Therefore, the objective is to verify whether the studied entities manage to minimize their consumption of resources for given levels of volume sold or produced.

#### 3.1.2. The Output orientation:

In an output orientation, the DEA method makes it possible to measure the number of outputs that a DMU must produce by consuming a given quantity of inputs. In other words, when the DEA analysis reveals that a decision-making unit is inefficient, the inefficiency score that will be assigned to it will represent the improvement effort that the unit in question must make on the number of outputs it achieves to achieve the required level of efficiency. Therefore, the objective is to verify whether the DMUs manage to maximize their outputs for a fixed quantity of inputs.

### 3.2. The choice of the measure:

It is an operational tool that allows measuring the gap between the production plan and the frontier of best practices, it is interpreted as a measure of the inefficiency of a production plan. There is a radial measurement and another directional.

- The radial measurement:

The choice of this type of measurement occurs when the objective of efficiency measurement is to perform individual benchmarking for each decision unit in a group of DMUs.

- The directional measurement:

It occurs when the measurement of efficiency aims to benchmark between networks (bank branch networks, for example) and obtain the performance of each network. It is intended to improve the decision-making aspect of general management.

The radial measurement of an output-oriented model makes it possible to indicate at each point of sale the possible increase in outputs given the quantities of inputs used. However, for the directional measure, the indicated increase is no longer proportional and specific to each point of sale but on a basis common to all the points of sale in the network.

### 3.3. The choice of returns to scale:

Returns to scale are useful in qualifying the production technology of the entities being evaluated. A return to scale assumption means the possibility of infinite reduction or increase in the size of the entities being evaluated. There are two types: constant returns to scale and variable returns to scale.

#### 3.3.1. Constant returns to scale:

The assumption of constant returns to scale places the issue in the long term because investment or divestment decisions are planned over several accounting years. This hypothesis considers that the size of the assessed DMU can be infinitely increased or decreased.

#### 3.3.2. Variable returns to scale:

The variable returns to scale hypothesis place the stock in the short term. The latter considers that the assessed DMU has no immediate power over its size, its possibilities of investment or divestment.

## **Section Two:** General Models of the method DEA

the concepts and methodologies of the DEA method have been incorporated into a collection of models. the choice of the model depends on the problem to be solved, the data to be used and the nature of the population to be studied.

The main basic mathematical models are:

- The CCR model (Charnes, Cooper and Rhodes);
- The BCC model (Banker, Cooper and Charnes);
- The multiplicative model;
- The additive model.

These models apply to economic and management issues and provide useful results and their orientations are different.

In what follows, we will develop the first two models which constitute the models most used in most publications relating to the measurement of the performance of bank branches, namely: the CCR model and the BCC model.

In both cases, we distinguish:

- So-called "input-oriented" models, if we study efficiency in terms of inputs, that is to say, if we are interested in inefficiency in terms of excess inputs;
- So-called "output-oriented" models, if we want to analyze efficiency in terms of outputs, that is to say, if we want to apprehend inefficiency through insufficient results.

In addition, we will discuss the different models by making the following assumption:

- There are “n” decision-making units or even DMUs;
- Each DMU consumes different quantities of “m” inputs and produces “s” outputs that are different but of the same nature;
- For a DMUj such as j $\epsilon$ {1, …, n}, it consumes Xij of inputs such as i $\epsilon$ {1, …, m} and produces amounts Yrj of output such as r $\epsilon$ {1, …, s};

With Xij> 0 which assumes that no DMU can produce a positive quantity of outputs without consuming inputs; X is an m × n matrix of inputs and Y is an s × n output matrix;

- v’: the vector (M, 1) of the weights associated with the inputs;
- u’: the vector (S, 1) of the weights associated with the outputs.

## 1. The CCR model:

Charnes, Cooper and Rhodes (1978) developed a model assuming constant returns to scale. It is appropriate when all organizations are operating at their optimum size. This model is characterized by a proposal for a synthetic efficiency measure for each $DMU_i$ in the form of a ratio "outputs weighted by weighted inputs", under the constraint that the similar ratios for each organization are less than or equal to the unit[16]:

$$\begin{cases} Min_{u,v}\ (\frac{u'yi}{v'xi}) \\ Under\ constraints: \\ \frac{u'yj}{v'xj} \leq 1 \\ u, v \geq 0 \\ j = 1,2, \dots, N \end{cases}$$

This linear programming problem can be solved using two approaches. In the first one, the outputs weighted sum is maximized while keeping the inputs constant (model oriented towards the outputs)[17]. In the second one, the weighted sum of the inputs is minimized by keeping the outputs constant (model oriented towards the inputs). It should be noted that the selected model is input orientation; note that by convention, it is established that the number of DMUs must be equal to or greater than 3 times the number of inputs and outputs.

This ratio has made it possible to go from a situation of "multi-outputs and multi-inputs to that of a single virtual output and a single virtual input". However, solving this problem offers an infinite number of optimal solutions. Indeed, if the vector of weights (v *, u *) is an optimal solution then any solution in the form (βv *, βu *) is also such that β> 0.

Faced with this shortcoming, CCR carried out transformations[18] by selecting, among an infinite number of possible solutions, a representative solution for which the denominator of the ratio will be equal to unity ($v'x_i = 1$) to arrive at the formulation of the linear program primal that follows:

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[16] Emmanual THANASSOULIS, op.cit., P.89.

[17] Note that the expressions “orientation input” and “orientation output” are derived from the dual equations of each of the models (and not of the primal equations).

[18] Check the demonstration in: Charnes A., Cooper W.W., Rhodes E.L. (1978), “Measuring the Efficiency of Decision-Making Units”, European Journal cf Operational Research, Vol 2, n ° 6, p429-444.

$$\begin{cases} Min_{\mu,\nu}\ (\mu' yi) \\ Under\ constraints: \\ \nu' xi = 1 \\ \mu' yj - \nu' xj \leq 0 \quad j = 1,2,\dots,N, \\ \mu, \nu \geq 0\ , \end{cases}$$

Where u and v have been replaced by μ and ν to indicate that this is a different linear program. Using duality in linear programming, we obtain the following program:

$$\begin{cases} Min_{\theta,\lambda}\ \theta \\ Under\ constraints: \\ -yi + Y\lambda \geq 0 \\ \theta xi - X\lambda \geq 0 \\ \lambda \geq 0 \end{cases}$$

In this problem to be solved N times, θ is a scalar that represents the technical efficiency score of the ith decision unit ($\theta \leq 0$). If $\theta = 1$, the observed decision unit is on the border, i.e., it is efficient in Farrell's sense; on the contrary, if $\theta < 0$, it reveals the existence of technical inefficiency.

λ is a vector (N, 1) of constants called multipliers (weights). These indicate how the decision units combine to form the boundary against which the decision unit will be compared. These multipliers are given the name of peers about the efficient decision units ($\lambda > 0$) which form each segment of the efficiency frontier. These multipliers receive the peer's name (Peers) regarding the effective decision units ($\lambda > 0$) which form each segment of the efficiency frontier.

By integrating the input and output slacks, the linear program will be as follows:

$$\begin{cases} Min\ (\theta, \lambda, SO, SI) \qquad \theta - (\varepsilon \Sigma SO + \varepsilon \Sigma SI) \\ Under\ constraints: \\ -yi + Y\lambda - SO = 0 \\ \theta xi - X\lambda - SI = 0 \\ \lambda, SO, SI \end{cases}$$

Such as:

- ✓ **ε:** it is a non-Archimedean constant (infinitesimal); Which is smaller than any positive real number. Small enough that maximizing the SO and SI deviation variables remains a secondary objective to minimizing the efficiency score.
- ✓ **SO:** the outputs in deficit for each output r (output slacks)[19];
- ✓ **IS:** the excess inputs for each input q (input slacks)

Thereby, a DMU (i) is technically efficient if and only if:

$$\begin{cases} \theta = 1 \\ And \\ SO = 0, and\ SI = 0 \end{cases}$$

If $\theta \neq 1$, therefore, the evaluated DMU is not efficient and must therefore make the necessary modifications to become so, while meeting the two previous conditions.

However, in an analysis, we can get $\theta = 1$ and $SO \neq 0$ and/or $SI \neq 0$. This can be explained by the fact that the DMU is considered technically efficient because of the optimal combinations of inputs and outputs, but since the SO and SI are not zero, then efficiency within the meaning of PARETO-KOOPMANN is not achieved, the assessed firm must proceed either to:

- ✓ The increase in its outputs of SO if SI = 0;
- ✓ The decrease in SI inputs if SO = 0;
- ✓ To both actions simultaneously if SO = 0 and SI = 0.

**2. The BCC model:**

This CCR model is generally performed under the assumption of constant returns which operates at the optimal scale, thereby measuring total efficiency. This is not always the case given the constraints of the market (competitive situation) and the constraints of financial resources. Concerning this situation, BANKER, CHARNES and COOPER (BCC) propose a model which takes into account the hypothesis of variable returns to scale (decreasing or increasing returns). With this assumption, the measured efficiency is pure.

[19] Check the determination of SO and SI in: F. Hosseinzadeh.Lotfi, G.R. Jahanshahloo et M. Alimardani, « A New Approach for Efficiency Measures by Fuzzy Linear Programming and Application in Insurance Organization », Applied Mathematical Sciences, Vol. 1,2007, n°14, p 647-663.

To obtain their model, they consider an additional constraint to the previous program. This constraint, which is the equality between the sum of the weights and a unit vector, is therefore as follows:

$$\Sigma \lambda = 1, \text{ whatever "j"}$$

The BCC model becomes:

$$\begin{cases} Min_{\theta,\lambda}\ \theta \\ Under\ constraints: \\ -yi + Y\lambda \geq 0 \\ \theta xi - X\lambda \geq 0 \\ N1'\lambda = 1 \\ \lambda \geq 0 \end{cases}$$

Where N1 is a unit vector (N, 1).

By retaining the occurrence of slacks, the program becomes:

$$\begin{cases} Min\ (\theta, \lambda, SO, SI) \qquad \theta - (\varepsilon \Sigma SO + \varepsilon \Sigma SI) \\ Under\ constraints: \\ -yi + Y\lambda - SO = 0 \\ \theta xi - X\lambda - SI = 0 \\ \lambda, SO, SI \end{cases}$$

Likewise, a DMU (i) is technically efficient if and only if:

$$\begin{cases} \theta = 1 \\ And \\ SO = 0, and\ SI = 0 \end{cases}$$

Finally, it should be noted that different results can be obtained not only by selecting different models of the DEA method but also by following the different orientations within each model. However, a DMU is characterized as efficient in an input-oriented model if, and only if, it is characterized as efficient in this same output-oriented model. Also, an efficient DMU in a CCR model is necessarily efficient in the corresponding BCC model; the reverse is not necessarily true.

## 3. The specifications of the DEA model applied to a network of bank branches:

The efficiency of financial institutions has been studied many times using the DEA method. The description of the banking production technique comes up against a prerequisite: that of a consensual definition of inputs and outputs. This is indeed the subject of recurring debates; the liveliest, in this matter, concerns the role of deposits. Are they inputs, as the intermediation approach uses, or are they outputs, as the production approach suggests?

- In the intermediation model, the financial institution collects deposits and grants loans intending to make a profit. In the specification of the model, deposits are considered as inputs and loans as outputs;
- In the production model, the financial institution uses resources (capital, labor) to carry out financial transactions (savings and credit activity). In this model, personnel and assets will be considered as inputs and deposits and loans as outputs.

The selection of outputs and inputs depends on our understanding of what a financial institution does. Deposits are an extreme example; they are treated as inputs in the first case; it retains a measure per-flow and as output in the second; it is based on a measure per stock.

## Section Three: Uses of DEA and its advantages and disadvantages

The DEA method consists of calculating relative efficiencies in a non-parametric way, it has been applied in many fields, especially in scientific studies. Indeed, one of the advantages of the DEA is to be able to compare entities producing goods but also services (for which a purely monetary evaluation of performance is impossible).

In this section, we are going to give an outline of some areas where the DEA method has played a role in performance measurement, after that we are going to mention the advantages and disadvantages of the method.

### 1. Uses of DEA in some fields.

#### 1.1. Financial services:

The data envelopment method has many advantages for evaluating performance, in particular for organizations made up of multiple comparable units such as sales networks. An application to the case of a banking network illustrates these interests.

The majority of DEA uses in banking are related to production efficiency at the branch level. To evaluate this type of efficiency, the bank branch is seen as employing inputs such as capital, labor, space to produce outputs such as deposits, loans, insurance applications and so forth. The rest of the reported uses of DEA concerns intermediation efficiency. From a banking perspective, the bank branch is an intermediary collecting deposits to transform them into loans and other income-earning activities. Intermediation efficiency reflects the agency's effectiveness in converting its inputs into sales of its products (outputs).

The determination of the branch's efficiency is the beginning of all analysis, after that comes the determination of input and output targets that would render it efficient if it's not already the most efficient branch comparing to the rest of the DMUs (the wanted levels of efficiency in each branch are the estimated results by the DEA method).

Disentangling the components of the branch's efficiency is one of the issues that analysts address in the DEA applications in the banking sector, Emmanuel Thanassoulis illustrates this point this way[20]: "For example, bank branches may be categorized into those with and those without ATM facilities. Each category is known as a policy under which the units operate. At issue is whether the units operating under a given policy are more effective under that policy.

[20] Emmanual THANASSOULIS, op.cit., P.34.

Caution is needed in addressing this question. If the units are assessed by policy group, the efficiency ratings are not comparable between groups since they relate to different benchmark units for each group. If the units are assessed in a single group regardless of the policy under which they operate, the efficiency rating of each unit will reflect a combination of the performance of its management and of the impact of the policy under which the unit operates".

### 1.2. Education:

Education is also another field where DEA can be applied to measure comparative performance between different units (universities, institutes, classes, teachers' recruitment…etc). It can be harder to determine sources of efficiency and inefficiency in this field (comparing to the banking sector). But a lot of works have been done to measure Educative performance. According to Ahn (1987), three types of outputs are generally retained to characterize the production function of higher education institutions: (1) education, i.e., the transfer of knowledge, (2) research or creation of knowledge, (3) services and activities provided to the community.

### 1.3. Healthcare systems:

The DEA method can be used also in the performance measurement of healthcare systems comparing the performance of different departments. The departments' performance is compared by taking into account, on the one hand, the level of health expenditure of each department and, on the other hand, the state of health of the population that we measure through several morbidity indicators. The objective of the process is to assign each department a score that indicates whether resource savings can be made given the performance achieved by the most efficient departments. At the end of this step, it is possible to establish a hierarchy between the departments.

There are other areas where performance measurement by DEA had been applied: regulation[21], police services[22]…etc.

## 2. Advantages and disadvantages of the DEA method:

### 2.1. Advantages of the DEA method:

The DEA method has several advantages:

[21] The case OFWHAT, the regulator of English and Welsh water companies.

[22] The application was in the context of a wider study of 'crime management' undertaken by the Audit Commission in the UK in 1992-1993.

- The ability to accommodate several inputs and outputs;
- Takes into consideration returns to scale in calculating efficiency, allowing for the concept of increasing or decreasing efficiency based on size and output levels.
- A technology that's not specified by a functional relationship;
- Easy decomposition of technical, allocative and scale inefficiencies.

### 2.2. Disadvantages:

- The results are potentially sensitive to the selection of inputs and outputs;
- The number of efficient DMUs on the frontier tends to increase with the number of inputs and outputs variables;
- if there is no relationship between explanatory factors (within inputs and/or within outputs), DEA views each DMU as unique and fully efficient. In this case, efficient scores are very close to 1, which results in a loss of discriminatory power of the method.

## Conclusion:

To conclude this theoretical part, we can underline the need for the development of managerial practices within any banking establishment operating in a constantly changing environment. To do this, management control now tends to grasp new perspectives of performance evaluation in other dimensions than just the management of profitability. However, the implementation of a performance measurement system requires a good understanding of the strategic challenges of the bank.

In addition, improving organizational performance should not be limited to the search for operational efficiency. It is not a question of creating added value at any cost but of creating value under increasing conditions of efficiency, in other words, the mechanism must aim to optimize the cost / value pair.

It is clear now that DEA is a method that must be taken into account in measuring the performance of companies, including banking establishments. The DEA approach makes it possible to assess the performance of decision-making entities from the frontiers of efficiency. Its major interest lies in the calculation of a synthetic and comprehensive measure of the performance of organizations that use multiple resources (inputs) to generate multiple results (outputs). This is how the multi-criteria analysis of the DEA method makes it possible to determine the factors on which it is necessary to act to reach the level of the best agencies.

In the next part, we will put the DEA method into practice at the level of a commercial bank, that of CNEP-Bank. And try to measure the performance of its operating network.

# CHAPTER 03:

# APPLICATION OF THE DEA METHOD TO THE CNEP-BANK BRANCH NETWORK

## Introduction

After emphasizing the importance of performance within the bank and highlighting the concepts relating to the DEA method. The main objective of this chapter is to measure the efficiency of the CNEP-Bank agencies in order to constitute an efficiency frontier and subsequently carry out an analysis by enveloping the data.

Before we go into the application of the DEA method to the CNEP-Bank branch network, we will try to present the methods used by the CNEP-Bank to assess the performance of its network agencies in the first section, to understand how performance measurement works in the CNEP-Bank and try to criticize this procedure and therefore know precisely what can be the contribution of the DEA method to the bank. In the second section, we will present the choices selected for our study, which requires the selection of the DMUs to assess, the choice of the model and the choice of the approach and the variables.

Finally, we will put our theoretical knowledge into practice after having collected the data needed from the CNEP-Bank to accomplish this study. We will also analyse the results obtained and we will finish our work with recommendations which can be integrated by the CNEP-Bank regarding the use of the DEA method as a tool to assess and improve the performance of its branch network.

## Section One: Performance measurement of CNEP-BANK agencies

This section will be devoted to the presentation of the CNEP-Bank, as well as that of the reception structure "the Management Control Department" (MCD). It will also include a statement of the tools used by the bank to measure the performance of the bank's branches. To conclude, we will take a critical look at the tools that are used.

### 1. Presentation of the CNEP-Bank:

The CNEP-Banque (acronym for `` Caisse Nationale d'Epargne et de Prévoyance-Banque "), is an Algerian public bank specializing in the collection of household savings, housing finance through its mortgage loans to individuals and private and public developers, and also the financing of companies operating upstream in the building sector. It operates within a banking sector managed by legal rules and laws:

- ✓ The Law of Money and Credit
- ✓ The regulations, instructions and notes of the Bank of Algeria;
- ✓ Guiding lines.

To present the CNEP-Bank in a brief way, we have made a technical sheet:

| | |
|---|---|
| |   |
| **Name of the Bank** | CNEP-Bank |
| **Legal status** | Joint-stock company (Sole shareholder being the State) |
| **Share capital** | 46 000 000 000 DZD |
| **Creation** | Aug 10, 1964 |
| **Subsidiaries and Holdings** | • **A.M.N.A.L**<br>• **INSURE-IMMO** |
| **The Head Office** | 61, Avenue SOUIDANI Boudjemaa Cheraga, Alger. |
| **Operating network** | 15 D.R.E. with hierarchical power over the agencies that are 219 distributed across the country |

**Source:** CNEP-BANK documentation.

## 2. Presentation of the host structure:

Hierarchically attached to the Deputy Director General of finance and accounting, The Management Control and Studies Department by abbreviation “M.C.S.D” was created on February 22, 1999 (following Regulatory Decision No. 173/99 of the same date) to meet the following main objectives:

- Assess the bank's activities;
- Make sure that the strategy defined by the General Management is followed;
- Put in place the control and decision-making tools in operational management (dashboard, determination of deviations, etc.);
- Animation of the budget process.

The main missions devolved to the management control department are as follows:

- ✓ Implement the Bank's budget management policy;
- ✓ Set up a budget management and performance measurement process and ensure its continuous improvement;
- ✓ Prepare annual and multiannual provisional budgets resulting from the Bank's strategic plan;
- ✓ Organize and lead budget negotiations with the various structures of the Bank concerned;
- ✓ Develop and implement management and monitoring tools for activities related to management control and ensure their proper use;
- ✓ Ensure the optimization of budget allocations in accordance with the Bank's strategic objectives;
- ✓ Produce, from key and relevant indicators, the dashboards and reports necessary for decision-making;
- ✓ Participate in the process of monitoring the achievement of the objectives of the strategic plan;
- ✓ Design and implement methods for comparing deviations between forecasts and achievements and propose corrective measures, if necessary;
- ✓ Design and set up, in collaboration with the structures in charge of the information system, a statistical database dedicated to the management control activity;
- ✓ Prepare the management report and the annual report of the Bank;
- ✓ Carry out and manage economic and financial analyzes by setting up a panel of reference standards and ratios.

The M.C.S.D consists of the following departments:

- The Budget Department;
- The Analysis, Dashboards and Statistics Department;
- The Studies and Synthesis Department.

Each department of these has its own missions.

## 3. Steering instruments:

### 3.1. The budget realization report:

The Management Control Department has set up a quarterly report in which the status of each agency's achievements is mentioned.

This report is made up of tables each of them showing the quarterly achievements relating to a specific heading and whose lines include: the objective, the achievement of the quarter, the difference between the two, the achievement rate as well as the share by heading and the percentage of achievement in relation to the network. Also, an analysis of the differences is made with an argumentation concerning the reasons for the observed inconsistencies.

### 3.2. The Monthly Income Statement by branch:

The Profit and Loss Account measures the agency's ability to make profits during the month. It then includes all the income and expenses recorded by the latter during the same period and determines the balance which constitutes its result. The main Intermediate Management Balances are highlighted.

### 3.3. The Daily Dashboard:

The dashboard is a reduced sample of indicators allowing the manager to follow the evolution of results, deviations from reference values (set objectives, internal or external standards, statistical references), as much as possible in real time. , focusing on those he considers most significant.

It is for this purpose that the bank has set up this tool since a simple analysis of the balance of the income statement does not lead to a precise diagnosis of the situation of the bank because it does not make it possible to identify and therefore to analyze the elements which contributed to the constitution of this result.

The management control department establishes a daily dashboard which includes details of the activity in terms of assets, liabilities and results.

### 3.4. Calculation of some ratios:

In order to highlight the financial performance of the agencies in its operating network, the management control department calculates a few ratios for each agency such as:

- ✓ **Return on Assets** = Net Income / Total Assets;
- ✓ **Cost / income ratio** = Management costs / NBI;
- ✓ Profitability coefficient = Net income / Equity.

## 4. The limits of the performance measurement system of the management control department:

The traditional tools used by the Management Control Department present some constraints. Indeed:

- ✓ The Monthly Income Statement allows only one classification against a criterion and does not identify the sources of inefficiencies. It therefore only deals with one-dimensional performance, which is the classification of bank branches against the EBITDA. The latter gives an idea of the most profitable agencies in the network, but not of the performance of the agencies. This classification excludes the characteristics of the business environment of the performance appraisal process which can lead to diagnostic bias; the agencies are not subject to the same difficulties / facilities.
- ✓ Financial performance indicators (for example: EBITDA / Total balance sheet, EBITDA / Workforce) are summary indicators of the financial performance of the commercial activity of bank branches, but the scope of interpretation is limited. Indeed, while they allow benchmarking practices that are relatively easy to make operational, they do not indicate how to achieve an improvement in measured financial performance: is good / bad financial performance due to financial costs or costs of low operating or rather a high financial margin or large financial savings commissions? Thus, these indicators do not tell the less performing agencies on which position (s) the efforts are being made.
- ✓ Finally, the partial productivity ratios, calculated from accounting information, have three major limitations from a decision-making point of view:
    1. They are multiple since the banking agency uses several inputs to produce several outputs, which does not facilitate decision-making. Indeed, how to compare an agency that has a good performance on the outstanding deposit ratio per employee and a poorer performance on the outstanding savings ratio

financial per employee at another agency that presents an inverse performance on these two ratios?

2. Partial productivity indicators are difficult to interpret because they do not proceed from "all other things being equal" reasoning. Indeed, the variation of one of the indicators over time, for example an increase in the apparent productivity of labor, cannot be unambiguously attributed to the efforts of the employees because it is possible that the increase in activity is linked to other resources that we do not control in the definition of a partial productivity indicator. So, could we believe that staff productivity increases when in reality it decreases, if it is masked by the greater increase in the productivity of other resources mobilized? Thus, this second limit can lead to diagnostic errors and therefore to erroneous decisions.
3. The third limitation relates to the role of size in the performance appraisal process. Partial productivity ratios implicitly assume constant returns to scale since they are defined as a ratio. Indeed, to say that a large agency with an average outstandings per employee of (2000/20) = 100 is less productive than a small agency whose ratio (250/2) = 125, is to say that the any activity can be scaled up and the possibility of economy or de-economy of scale in production is not taken into account in the evaluation process.

The Data Envelopment Analysis (DEA) approach that we adopt below addresses these limitations.

## Section Two: Presentation of the choices selected for our study

The DEA approach is based on the definition of a production set made up of all the practices observed. Best practices define the frontier of this set called the efficiency frontier. The efficiency of a practice is evaluated by a score, calculated as the difference between the observed practice and the best practice located on the border. Note that the concept of efficiency here is relative since it is based on the best practices observed and not on a theoretical benchmark. The variable return to scale assumption is made to take into account the effect of the size of the agency on its productivity.

Therefore, the main steps in building a DEA model are the selection of the DMUs to be evaluated as well as the choice of the model and the approach to be applied.

### 1. The selection of DMUs

It is necessary to respect a certain working methodology in the DEA method. Indeed, the latter requires the determination of a homogeneous group of DMU activating in comparable environments in terms of opportunities and constraints**.**

### 2. Choosing the model and the orientation

Our analysis will be carried out according to the BCC model (Banker, Cooper, Charnes; 1984) with variable return to scale because this is the model that most closely matches the reality of the context studied. Indeed, the CCR hypothesis (CHARNES, COOPER, RHODES, 1978) with constant return to scale is only adequate when all the DMUs operate at an optimal scale. However, this is not always the case due to environmental constraints (imperfect competition, financial constraints, etc.). This choice can also be justified by the fact that the size of bank branches cannot be increased indefinitely, in other words the production capacity of the branches is fixed in the short term.

Our model is an output-oriented model, the goal is to maximize the agency's output for a given level of inputs. Inefficiency is understood in the light of insufficient output.

This choice is consistent with the decision-making power of the agencies: they do not decide on the prices of products, their location or their allocation of resources. On the other hand, they have an obligation to optimize the volume of sales.

Our analysis will focus on a radial efficiency measure (inputs compared to the volume of outputs initially produced by the assessed agency) because the simplest measure of efficiency

is based on the assumption of a proportional reduction of all factors. The objective is to determine an individual benchmarking between a set of agencies of a single operating network.

## 3. Choosing the approach

As already underlined in the theoretical part of our work, two approaches oppose to determine the inputs and outputs of banks. Essentially, the opposition relates to taking bank deposits into account as inputs (the intermediation approach) or as outputs (the production approach). In several DEA studies carried out in the banking context, it is the intermediation approach that is used.

For our study, we also opted for an intermediation approach because the main activity of the CNEP-Bank is financial intermediation through the collection of deposits to granting loans.

## 4. Selection of inputs and outputs

To build our study, we have retained two types of variables: monetary unit and physical unit, depending on the objective that we will pursue through each model that we are going to build.

Two new performance indicators were introduced by the DEA approach: operational performance and financial performance. Unlike the measurement of operational performance marked by certain divergences between the authors as to the choice of inputs and outputs, the design of financial performance seems to be more consensual knowing that it is based on income from the activities of the points of sale. Information that can be easily pulled from branch accounting which is supposed to be implemented in all banks.

We relied on certain research work in the same context as our work as well as on what is retained in the measurement of the performance of branches by our bank to select the inputs and outputs necessary for our study.

### 4.1. The table of inputs and the justification for their choice:

| Variable | Definition and Justification | Documentary reference |
|---|---|---|
| PC | **Personnel Costs** are used to measure the cost of the human resources employed by each agency. This is a very large charge which can represent up to 70% of the total costs | Akther et al., 2013<br>Bangladesh |
| OGC | **The Other General Costs** include: depreciation, rents, maintenance, deposit | "A Study of the Relative Efficiency of Bank Branches: An |

| | | |
|---|---|---|
| | guarantee premium, depreciation and impairment of assets, taxes and duties, …etc. | Application of Data Envelopment Analysis"<br><br>M. Vassiloglou and D. Giokas |
| FC | **Financial Charges** represent the interest paid by each branch on customer deposits. The cost of "customer capital" is measured by customer deposits. | "A Study of the Relative Efficiency of Bank Branches: An Application of Data Envelopment Analysis"<br><br>M. Vassiloglou and D. Giokas |
| ISC | **Interest and Similar Charges:** These are the costs borne by the company on its loans, on its foreign exchange transactions (losses or negative exchange differences), or even on the disposal of financial securities (capital losses resulting from the disposal of financial securities). | "A Data Envelopment Analysis of the Operational Efficiency of Bank Branches "<br><br>B. Golany and J. E. Storbeck |
| ASD | **The Average Stock Deposits** represents the average monthly stock deposits for the year 2020. This calculation was made so as not to judge the branches on the only outstanding amounts at the end of the year, which would be penalizing and unfair | « Mesure de la performance globale des agences bancaires : une application de la méthode DEA »<br><br>HUBRECHT.A et GUERRARA (2005) |
| NCL | The **Number of Clients** allows the agency to reach a significant level of activity in terms of value and volume, so the more active clients of an agency, the more it carries out various operations and therefore the turnover... The activity of bank branches consists, through the maintenance of customer relations and prospecting for the sale of banking products: (deposit and credit activities) and non-banking | Wanke and Barros, 2014<br><br>Brazil |

| | | |
|---|---|---|
| | products: (damage insurance and financial savings products) | |

**Table 1:** Inputs table

### 4.2. The table of outputs and the justification for their choice

| | Variable | Documentary reference |
|---|---|---|
| II | **The Interest Income** constitutes the major part of the branches' NBI. It is calculated on the basis of the difference between the interest received and the interest paid. | Al-Tamimi and Lootah, 2007<br>UAE |
| CR | **Commissions Received** constitute the margin on bank commissions received on the provision of services offered to customers; they are insensitive to changes in interest rates. | Ohsato and Takahashi, 2015<br>Japan |
| FR | **Financial Revenues:** it is integrated to consider the deposit collection activity. It remunerates agencies with a surplus of resources and sanctions those which are short of resources. | « Mesure de la performance globale des agences bancaires : une application de la méthode DEA »<br>HUBRECHT.A et GUERRARA (2005) |
| NBI | **The Net Banking Income** constitutes the net profit from operations carried out by financial institutions. It represents the difference between a bank's operating income and its operating costs. | "Comparative efficiency analysis of Portuguese bank branches"<br>Maria Conceição A. Silva Portela, Emmanuel Thanassoulis |
| ASL | **The Average Stock of Loans** reflects the level of activity of a bank branch. | "A Study of the Relative Efficiency of Bank Branches: An Application of Data Envelopment Analysis" |

| | | |
|---|---|---|
| | | M. Vassiloglou and D. Giokas |

**Table 2:** Outputs table

After the justification of the variables necessary for our analysis, we will try to combine them in the form of different models reflecting the production process within the bank.

## 5. The construction of models

The models we have built are established so that we obtain two types of performance indicators. The first indicator will concern the financial performance of the agencies. To this end, we are directly interested in the components of gross operating income (GOI) as indicators of resources and activities. Income from activities is considered as output and the cost of resources consumed as input. As for the second indicator, it will concern operational performance: it takes as input the resources consumed and as output the banking activities produced in volume. It is a model that verifies whether agencies are optimizing their resource consumption in relation to their business volumes.

The objective behind the adoption of this working approach is to allow an analysis of the relationship that exists between operational performance, agency productivity, and financial performance, agency profitability. Two performance indicators as important as the other but not considered in the same way during the current measurement of the performance which is more concerned with the financial performance than with the operational performance.

For a better explanation, the table below displays the details, inputs and outputs, of the models that we have developed.

| | **Financial Performance** | **Operational Performance** | |
|---|---|---|---|
| | 1st Model | 2nd Model | 3rd Model |
| INPUTS | Personnel Costs | Personnel Costs | Personnel Costs |
| | Financial Charges | Interest and Similar Charges | Other General Charges |
| | Other General Charges | Average Stock of Deposits | Number of Clients |
| OUTPUTS | The Interest Income | Average Stock of Loans | Financial Revenues |
| | Net Banking Income | Commissions Received | Net Banking Income |
| | Financial Revenues | Financial Revenues | Commissions Received |

**Table 3:** Developed models

We have opted for a single model of financial performance which will subsequently reflect inefficiency " EBITDA ". The latter alone brings together the most important costs of the points of sale and the most important revenues from their activities.

We have also grouped variables measured in volume (stocks) in the last two models of operational performance. One of them contains the average outstanding deposits and commitments (balance sheet and off-balance sheet) while the other contains the number of customers and the number of accounts opened. This latest model will reflect the attractiveness of our group of agencies.

## 6. The program to optimize

We will summarize in the following table all the variables that will be used in the program to be optimized before moving on to the formulation of the latter:

| Variable description | The agency's data (j) | The network's data |
|---|---|---|
| Personnel Costs | PC (j) | PC |
| Other General Costs | OOC (j) | OOC |
| Financial Charges | FC (j) | FC |
| Interest and Similar Charges | ISC (j) | ISC |
| Number of Clients | NCL (j) | NCL |
| The Interest Income | II (j) | II |
| Commissions Received | CR (j) | CR |
| Net Banking Income | NBI (j) | NBI |
| Financial Revenue | FR (j) | FR |

**Table 4:** Description of the variables used

As a reminder, we have chosen a BCC type model in an output orientation. The objective is to maximize the production of outputs while not exceeding the level of resource allocation.

Two models need to be formulated: one for financial performance and another for operational performance.

The DEA program for the agency (j) under the first model gives:

$$\begin{cases} \boldsymbol{Max}_{\boldsymbol{\theta,\lambda,OS,IS}} \quad \theta + \varepsilon\Sigma OS + \Sigma IS \\ \theta\ II(j) - II\ \lambda + OS = 0 \\ \theta\ NBI(j) - NBI\ \lambda + OS = 0 \\ \theta\ FR\ (j) - FR\ \lambda + OS = 0 \\ PC\ (j) - PC\ \lambda + IS = 0 \\ FC\ (j) - FC\ \lambda + IS = 0 \\ OGC(j) - OGC\ \lambda - IS = 0 \\ \Sigma\ \lambda = 1 \\ \lambda, OS, IS > 0 \\ \text{with:} \end{cases}$$

- **θ:** the technical efficiency score of the DMU j;
- **λ:** the vector of weights;
- **OS, IS:** the Output and Input Slacks respectively.

The DEA program for an agency (j) under the 2nd model gives:

$$\begin{cases} \boldsymbol{Max}_{\boldsymbol{\theta,\lambda,OS,IS}} \quad \theta + \varepsilon\Sigma OS + \Sigma IS \\ \theta\ ASL(j) - ASL\ \lambda + OS = 0 \\ \theta\ CR\ (j) - CR\ \lambda + OS = 0 \\ \theta\ FR\ (j) - FR\ \lambda + OS = 0 \\ PC\ (j) - PC\ \lambda + IS = 0 \\ ISC\ (j) - ISC\ \lambda + IS = 0 \\ ASD(j) - ASD\ \lambda - IS = 0 \\ \Sigma\ \lambda = 1 \\ \lambda, OS, IS > 0 \\ \text{with:} \end{cases}$$

- **θ:** the technical efficiency score of the DMU j;
- **λ:** the vector of weights;
- **OS, IS:** the Output and Input Slacks respectively.

The DEA program for an agency (j) under the 3rd model gives:

$$
\begin{cases}
\boldsymbol{Max}_{\boldsymbol{\theta,\lambda,OS,IS}} & \theta + \varepsilon\Sigma OS + \Sigma IS \\
\theta\ FR\ (j) - FR\ \lambda + OS = 0 \\
\theta\ NBI\ (j) - NBI\ \lambda + OS = 0 \\
\theta\ CR\ (j) - CR\ \lambda + OS = 0 \\
PC\ (j) - PC\ \lambda + IS = 0 \\
OGC\ (j) - OGC\ \lambda + IS = 0 \\
NCL\ (j) - NCL\ \lambda - IS = 0 \\
\Sigma\ \lambda = 1 \\
\lambda, OS, IS > 0 \\
\text{with:}
\end{cases}
$$

- **θ:** the technical efficiency score of the DMU j;
- **λ:** the vector of weights;
- **OS, IS:** the Output and Input Slacks respectively.

## 7. Analysis of the models' sensitivity in relation to the choice of inputs and outputs:

In order to test the sensitivity of the models with respect to the choice of inputs and outputs, we calculated the correlation of the three models with the "EViews 9" software from the vectors of efficiency scores obtained using the "DEAP" software version 2.1 ":

| | First Model | Second Model | Third Model |
|---|---|---|---|
| First Model | 1 | 0.4374 | 0.9924 |
| Second Model | 0.4374 | 1 | 0.4376 |
| Third Model | 0.9924 | 0.4376 | 1 |

**Table 5:** Correlation table for selected models.

In order to be able to choose the model that we will use in our practical case, we start by analyzing and interpreting the correlation coefficients calculated between the three models proposed above:

When this coefficient is for example high (close to unity) between two models, the efficiency scores obtained by them vary in the same direction and in the same way. And so, if a branch gets a high efficiency score in the first model, it will have a high score in the second as well.

This will allow us to say that the choice of inputs and outputs does not significantly influence the results.

From the table above we notice that the coefficients reflect a positive correlation between the three models:

- We see an almost perfect correlation between the first and the third model (99.24 %) and this following the similarity of the variables of the two models, except that the third model contains two different variables “the number of clients” and “the commissions received”.
- However, the score between the first and the second model shows a weak and positive correlation (43.74%). That’s why we are going to keep the third model.

Therefore, the table below resume the models that we are going to take into consideration for our study:

| | **Financial Performance** | **Operational Performance** |
|---|---|---|
| | 1st Model | 2nd Model |
| **INPUTS** | Personnel Costs | Personnel Costs |
| | Financial Charges | Other Operational Charges |
| | Other Operational Charges | Number of Clients |
| **OUTPUTS** | The Interest Income | Financial Revenues |
| | Net Banking Income | Net Banking Income |
| | Financial Revenues | Commissions Received |

**Table 6:** Table of the chosen models.

## **Section Three:** Application and analysis of the results of the DEA method.

One of the requirements of the DEA method is that the number of observations must be greater than or equal to twice the product of the number of inputs and the number of outputs used. We have chosen three inputs and three outputs for the financial performance model, three inputs and three (03) outputs for the operational performance model.

Our study will focus on a sample of all CNEP-Bank branches. i.e. a sample of 219 branches thus respecting the condition for a correct empirical application. The data we used correspond to the 2020 financial year and which are taken from the database of the Management Control Department, the location of our internship.

### 1. Presentation of the results:

Using DEAP 2.1 software, we obtained the efficiency scores of the two models under variable return to scale (BCC) in order to be able to assess the pure technical efficiency and the efficiency of scale of each of the branches. The results obtained from the two models selected are presented in **Annex N°1.**

The results we obtained in the two models and under variable return to scale are summarized in the following table:

| | First Model | Second Model |
|---|---|---|
| % Of efficient branches | 11.87% | 12.79% |
| % Of inefficient branches | 88.13% | 87.21% |
| Average network efficiency score | 0.887 | 0.888 |
| Minimum efficiency score | 0.744 | 0.744 |

**Table 7:** Summary of the results of the two models in VRS.

It emerges from the above results that in the first model, twenty-six (26) branches are technically efficient, i.e. 11.87% of the network. These branches show no signs of waste.

They represent the best practices (benchmark branches) within the analyzed sample and form the efficiency frontier.

We also find that the efficiency scores vary between: 0.7 and 0.99 for the rest of the branches that are less efficient than those with an efficiency score of 1.00, which leads us to appreciate

the average efficiency score that amounts to 88.7%, a very good score that puts the bank in a comfortable position.

The branch 368 had the two lowest scores in the two models: its result is affected by non-performing loans. Its portfolio quality confirms this.

In addition, we have twenty-five (25) agencies whose score is equal to unity in both models, or 11.42% of the network. They are the best agencies in the group since they are successful financially and operationally.

**2. The Benchmark branches:**

The benchmarks are determined on the basis of the coefficients of efficiency under the VRS model, they constitute the reference models for other branches showing pure technical inefficiency. A technically inefficient branch is automatically compared to the closest group of reference branches representing the most similarity in the combination of inputs and outputs. To be on the frontier of efficiency, the latter must imitate their behavior and adopt their way of managing.

The branches with the highest peer count in the groups of "peers" determined by the DEAP 2.1 software are called "Benchmarks". The information thus obtained is relevant both for decision-makers in the branches and for those in the regional network.

| AGENCE | First Model | Second Model |
|---|---|---|
| 101 | 7 | 6 |
| 126 | 122 | 123 |
| 129 | 64 | 74 |
| 131 | 5 | 6 |
| 132 | 2 | 1 |
| 201 | 27 | 27 |
| 271 | 12 | 10 |
| 354 | 50 | 52 |
| 366 | 19 | 19 |
| 371 | 16 | 16 |
| 401 | 3 | 3 |
| 402 | 70 | 76 |
| 455 | 33 | 29 |
| 551 | 2 | 2 |
| 107 | 92 | 76 |
| 115 | - | 4 |
| 602 | 1 | - |
| 603 | - | 2 |
| 652 | - | 4 |
| 654 | 124 | 121 |
| 426 | 20 | 19 |
| 458 | 134 | 134 |
| 363 | 29 | 31 |
| 364 | 2 | 2 |

**Table 8:** Peer count summary.

We observe that: the branches: 126, 129, 354, 402, 107, 654,458 are the “referral” branches which display the highest number of peer counts, they represent the benchmark for most of the group's agencies thanks to their high performance and the similarity of combinations of their inputs and outputs with those of inefficient branches.

### 3. Assessment of the impact of economies of scale:

As a reminder, overall technical efficiency consists of pure technical efficiency and efficiency of scale. The integration of scale effects will allow a performance measurement which aims to neutralize the size effect because it is a question of comparing agencies as fairly as possible. The underlying idea is to reach the optimal size which will allow economies of scale.
In order to assess the impact of returns to scale on overall technical efficiency, we will use the results given by DEAP 2.1 software under constant returns to scale (CRS).
It should be noted that the efficiency of the scale is calculated by the ratio of the CRS score to the VRS score of each branch.

The results obtained under constant return to scale are summarized in the table below:

| | First Model | Second Model |
|---|---|---|
| % Of efficient branches | 7.76% | 8.68% |
| % Of inefficient branches | 92.24% | 91.32% |
| Average network efficiency score | 0.874 | 0.874 |
| Minimum efficiency score | 0.738 | 0.738 |

**Table 9:** Summary of the results of the two models in CRS

Regarding the first model, the number of efficient branches has decreased to seventeen (17), or 7.76% of the network. The impact of returns to scale is therefore important. The other nine (9) branches are inefficient of scale because of the increasing returns to scale they experience. Their goal is to increase their activities. Indeed, the economy of scale allows the agency to make more profits, because it can multiply its outputs by a factor greater than the factor increasing inputs. The remaining agencies which number one hundred and ninety-three (193) recorded a double inefficiency: pure technical inefficiency and inefficiency of scale.

As for the second model, the impact of returns to scale is also important. The number of efficient branches has decreased to nineteen (19), or 8.68% of the network. The nine (09) agencies that

have become inefficient to scale show increasing returns to scale. The one hundred and ninety-one (191) remaining agencies recorded double inefficiency, pure technical inefficiency and inefficiency of scale.

So there seems to be a problem with the volume of business. Indeed, there is a dominance of inefficiency of scale over pure technical inefficiency. In the first model, we have 88.13% of agencies in the pure inefficiency class versus 92.24% in the inefficiency of scale class. In the second model, 91.32% of the branches are inefficient of scale compared to 87.21% for pure technical inefficiency.

## 4. The share of efficient and inefficient branches in the bank's revenues and expenses:

### 4.1. The financial performance model:

The results from the DEA method revealed twenty-six (26) technically efficient agencies and one hundred and ninety-three (193) technically inefficient agencies. In order to verify these results and to analyze the overall performance of our branch network, we have highlighted the consumption and products of these two groups of branches:

| | | Efficient Branches | Inefficient Branches | Total Network | % Of Efficient Branches | % Of Inefficient Branches |
|---|---|---|---|---|---|---|
| REVENUES | Interest Income | 16 662 936 761 | 28 911 607 621 | 45 574 544 382 | 36.56% | 63.44% |
| | Net Banking Income | 14 470 178 952 | 18 893 503 462 | 33 363 682 413 | 43.37% | 56.63% |
| | Financial Revenues | 1 485 147 293 | 6 296 475 657 | 7 781 622 950 | 19.09% | 80.91% |
| EXPENSES | Personnel Costs | 638 091 714 | 3 735 220 631 | 4 373 312 346 | 14.59% | 85.41% |
| | Financial Charges | 134 315 866 | 1 113 260 854 | 1 247 576 720 | 10.77% | 89.23% |
| | Other General Charges | 847 055 579 | 2 561 255 026 | 3 408 310 604 | 24.85% | 75.15% |

**Table 10:** Summary of the contribution of efficient and inefficient agencies in the expenses and revenues of the network under the first model.

We can see that the contribution of efficient agencies in the Bank's financial result is significant. Efficient Branches (26) contribute in 36.56% of the global amount of interest income. They also contribute in 43.37% of the net banking income (NBI) which is very significant. This reflects the importance of credit activity at their level.

Even though these branches are very significant in the contribution of the bank's NBI, they contribute in less than 15% of the bank's financial and personnel costs, which confirms their efficiency.

These results are consistent with those of the DEA method which classified the twenty-six branches as efficient and the others as inefficient from the point of view of their revenues and their expenses.

### 4.2. The operational performance model:

The results of the DEA analysis revealed twenty-eight (28) technically inefficient and one hundred ninety-one (191) technically efficient agencies. The table below highlights the contribution of each group in the consumption and income of the network:

| | | Efficient Branches | Inefficient Branches | Total Network | % Of Efficient Branches | % Of Inefficient Branches |
|---|---|---|---|---|---|---|
| REVENUES | Financial Revenues | **1 553 067 739** | **6 228 555 210** | **7 781 622 949** | **19.96%** | **80.04%** |
| | Net Banking Income | **14 650 876 442** | **18 712 805 971** | **33 363 682 413** | **43.91%** | **56.09%** |
| | Commissions Received | **702 066 851** | **1 278 515 061** | **1 980 581 913** | **35.45%** | **64.55%** |
| EXPENSES | Personnel Costs | **686 672 956** | **3 686 639 389.17** | **4 373 312 346** | **15.70%** | **84.3%** |
| | Other General Charges | **866 394 783.14** | **2 561 255 026** | **4 600 460** | **25.42%** | **74.58%** |
| | Number of Clients | **578 504** | **4 021 956.00** | **3 408 310 604** | **12.57%** | **87.43%** |

**Table 11:** Summary of the contribution of efficient and inefficient agencies in the expenses and revenues of the network under the second model.

The first observation that we can make is that the consumption of inefficient branches is greater than that of efficient agencies because of their greater number, while their revenues are much less.

In fact, efficient branches collected 35.45% of the commissions received by the network, i.e. more than the third of the overall commissions received from the bank, which reflects significant portfolio-fund activity.

These results confirm those of the DEA method which classified the twenty-six (26) branches as benchmarks in terms of productivity.

What emerges from the comparison of the operational and financial results of the branches is the weakness of the credit activity of inefficient branches. Indeed, the share of loans granted by the latter remains poor, which influences their financial income such as: the interest income, financial revenues...

A priori, the urgency seems to be in improving the credit portfolio of these agencies but to better understand the problem, we will, in the rest of our work, carry out a more detailed study of two inefficient agencies in order to highlight their strengths and weaknesses and thus identify the activity in which efforts will have to be made.

## 5. Analysis and diagnosis of technically inefficient branches:

In order to have a global vision of the shortfall and waste recorded by the group of inefficient agencies, we have drawn up the table below which highlights the waste of each input and the shortfall for each output:

| | Original Value | Target Value | Shortfall | Total Network | % of the Shortfall |
|---|---|---|---|---|---|
| II | 27 911 607 621 | 31 139 806 026 | 3 228 198 405 | 45 458 777 139 | 7.10% |
| NBI | 16 093 503 462 | 20 387 789 619 | 4 294 286 158 | 33 363 682 413 | 12.87% |
| FR | 4 596 475 657 | 6 108 812 674 | 1 512 337 017 | 6 666 266 457 | 22.69% |
| CR | 928 555 210 | 1 256 398 765 | 327 843 555 | 1 980 581 913 | 16.55% |
| PC | 3 765 220 631 | 3 681 720 282 | 83 500 350 | 4 373 312 346 | 1.91% |
| FC | 1 113 260 854 | 1 013 639 349 | 99 621 505 | 1 247 576 720 | 7.99% |
| OGC | 2 561 255 026 | 1 887 154 264 | 674 100 762 | 3 408 310 604 | 19.78% |

**Table 12:** The efforts to be made by efficient agencies

From this table, we can see that our branch network could reduce its Personnel Costs by more than 83.5 MDA, or 1.91% of the observed Personnel Costs. In practice, this could be achieved through redeployment of excess staff. For example, we suggest the transfer of this staff to the new branches which will be opening (internal recruitment and transfer) or to the central structures of the bank which show a need for personnel.

In addition, the Other General Costs must be reduced by 674.1 MDA, or 19.78% of the observed amount of Other General network Costs. These costs may be less of a problem than those of staff but must be taken into account in order to avoid waste. These can be reduced by sifting through suppliers, educating staff about the use of paper and other supplies, or negotiating better rental terms for certain agencies.

As for the Financial Charges, the decrease that must be achieved is of the order of 99.6 MDA, or 7.99 % of the observed charges. The solution available to the bank is to increase the volume of loans caused or to lower interest rates in order to discourage deposits.

In the same perspective, our network recorded a shortfall of more than 9 MDA. This amount includes the Interest Income, the Net Banking Income, the Commissions Received and the Financial Revenues. This lack can be compensated, first, by the increase in credit activity.
As a reminder, credit risk must always be controlled and the increase in credit activity should only affect caused loans. Suffice to say that these are increases that must be taken into consideration since they could allow the network to make a significant gain.
In addition, the bank must step up its efforts in terms of marketing to attract new customers.

## 6. Exploitation of the results of the DEA method:

In order to better understand the problems behind the inefficiency of some branches, we opted for the analysis of two (02) of these branches in order to determine the causes of their inefficiency and to propose solutions to improve them.
Our choice fell on the branch "368" which obtained the lowest efficiency scores in both models, financial and operational, and on the branch "603" which, for its part, is financially inefficient and operationally efficient.

### 6.1. Diagnosis of the branch "368":

In what follows, we will develop a table which will relate the consumption of inputs and the production of outputs of agency "368", identify its sources of inefficiency and finally propose corrective actions allowing an improvement in the efficiency of this branch as part of a benchmarking.

| Variable | Original value | Radial movement | Slack movement | Projected value |
|---|---|---|---|---|
| II | 20 854 327.71 | 7 170 528.55 | 142 084 159.5 | 170 109 015.7 |
| NBI | 16 222 355 | 5 577 876.26 | 43 364 303.37 | 65 164 534.62 |
| FR | 17 263 104 | 5 935 726.19 | 0 | 23 198 830.07 |
| PC | 12 287 372.53 | 0 | 0 | 12 287 372.53 |
| FC | 14 012 139.9 | 0 | -4 296 005.49 | 9 716 134.41 |
| OGC | 4 530 425.18 | 0 | 0 | 4 530 425.18 |

**Table 13:** DEA analysis results for agency "368" according to the 1st model in VRS.

| Variable | Original value | Radial movement | Slack movement | Projected value |
|---|---|---|---|---|
| FR | 17 263 104 | 5 935 726.19 | 0 | 23 198 830.07 |
| NBI | 16 222 355 | 5 577 876.27 | 43 364 303.37 | 65 164 534.62 |
| CR | 1003698.48 | 345 110.55 | 7 424 613.27 | 8 773 422.31 |
| PC | 12 287 372.53 | 0 | 0 | 12287372.53 |
| NCL | 51 670 | 0 | -15 841.592 | 35 828.41 |
| OGC | 4 530 425.18 | 0 | 0 | 4 530 425.18 |

**Table 14:** DEA analysis results for agency “368” according to the 2nd model in VRS.

| Indicateur | Branch "368" | Benchmarking Branch | Network Average |
|---|---|---|---|
| II | 20 854 327.71 | 208 895 770.29 | 154 574 324.83 |
| NBI | 16 222 355.00 | 78 427 576.39 | 62 345 581.80 |
| FR | 17 263 104.00 | 26 832 517.41 | 23 532 524.88 |
| CR | 1 003 698.48 | 10 622 450.31 | 9 043 753.03 |
| PC | 12 287 372.53 | 14 453 116.45 | 19 969 462.77 |
| FC | 14 012 139.90 | 11 893 098.65 | 10 696 697.35 |
| OGC | 4 530 425.18 | 12 379 400.96 | 15 563 062.12 |
| NCL | 51 670 | 53 856 | 41 007 |

**Table 15:** The agency's partial activity indicators.

We note that the quantity of outputs produced by the branch “368” is very low compared to the benchmark agency which is made up of the the branch “402”. However, this quantity remains significant compared to the group average. Regarding its expenses, they are higher in terms of overheads and personnel costs.

This unit obtained a score of 0.774 in both the financial and operational performance models. Which means that it only achieves 77.4% of the performance of which it is technically capable. It must therefore reduce its costs and increase its resources to become efficient and therefore be on the efficiency frontier.

To do this, it must increase its II, NBI, FR, CR products with the respective amounts of (7 170 528.55; 5 577 876.27; 5 935 726.19; 345 110.55) as highlighted in the second column of the tables 14 and 15, while keeping the same level of inputs.

In addition, the DEA estimates the inefficiency of scale of agency “368” at 26.2% explained by the decreasing returns to scale recorded by the latter. This is due to the under-utilization of production and the over-consumption of resources.

In order to eliminate the size effect, agency “368” must therefore increase its II and NBI by 142084159.5 and 43364303.37 DA. in addition to the decrease in personnel costs amounting to 4 296 005.49 DA.

Finally, managers should be guided by projected values when setting future goals and allocating resources.

### 6.2. Diagnosis of the branch “603”:

We are now interested in the results of the “603” agency which is inefficient financially.

| Variable | Original value | Radial movement | Slack movement | Projected |
|---|---|---|---|---|
| II | 169 674 439.3 | 3 720 714.116 | 80 951 220.4 | 254 346 374 |
| NBI | 214 572 239 | 4 705 257.68 | 0 | 219 277 497 |
| FR | 37 233 873.59 | 816 484.79 | 0 | 38 050 358.4 |
| EE | 22 083 148.89 | 0 | 0 | 22 083 148.9 |
| FC | 12 019 929.4 | 0 | 0 | 12 019 929.4 |
| OGC | 13 674 267.93 | 0 | 0 | 13 674 267.9 |

**Table 16:** DEA analysis results for agency “603” according to the 1st model in VRS.

| Variable | Original value | Radial movement | Slack movement | Projected |
|---|---|---|---|---|
| FR | 37 233 873.59 | - | - | 37 233 873.59 |
| NBI | 214 572 239 | - | - | 214 572 239 |
| CR | 16 025 717.10 | - | - | 16 025 717.10 |
| EE | 22 083 148.89 | - | - | 22 083 148.89 |
| OGC | 13 674 267.93 | - | - | 13 674 267.93 |
| NCL | 34 286 | - | - | 34 286 |

**Table 17:** DEA analysis results for agency “603” according to the 2nd model in VRS.

| Indicateur | Branch "603" | Benchmarking Branch | Network Average |
|---|---|---|---|
| II | 169 674 439.3 | 221 874 937.62 | 154 574 324.83 |
| NBI | 214 572 239 | 202 490 247.44 | 62 345 581.80 |
| FR | 37 233 873.59 | 55 145 878.79 | 23 532 524.88 |
| CR | 16 025 717.10 | 14 810 595.75 | 9 043 753.03 |
| PC | 22 083 148.89 | 16 453 116.45 | 19 969 462.77 |
| FC | 12 019 929.4 | 11 893 098.65 | 10 696 697.35 |
| OGC | 13 674 267.93 | 12 379 400.96 | 15 563 062.12 |
| NCL | 34 286 | 32 856 | 41 007 |

**Table 18:** The agency's partial activity indicators.

This difference between the results obtained and the internal ranking of branches at the bank level is one of the added values of the DEA method. Indeed, the “603” branch is compared with branches that are similar to it in terms of volume of activity, results obtained and consumption recorded.

We can see that the branch "603" recorded results above the network average but a little lower than those of the benchmark agency constituted by the branch "364". The problem lies mainly in the revenue portfolio of this branch. Indeed, we can see the difference in terms of II, NBI, FR between the branch "603" and the benchmarking branch.

Nevertheless, besides the fact that the “603” branch is operationally efficient, it also shows a financial efficiency score of 0.979, which is close to unity, this means that it is almost technically efficient in terms of financial performance.

it must increase its II, NBI, FR products with the respective amounts of (3 720 714.116; 5 577 876.27; 4 705 257.68) as highlighted in the second column of the table 16, while keeping the same level of inputs.

### 7. The limits and contributions of the DEA method:

There are some limitations to the application of the DEA method. Indeed, the latter depends essentially on the sample chosen, the data used and the period observed. Indeed, the efficiency scores given by the DEAP 2.1 software are sensitive to the number of variables used, inputs and outputs. In addition, the latter improve when the number of variables used is increased or

the sample is small. We were able to avoid this limit as long as the constraint of the minimum number of branches to be used was respected in our study.

Saying that all the factors influencing agency activity are identifiable and from time to time practically modelable; something that can be contested because taking, for example, the quality of the reception of each agency significantly influences its activity (output) despite this the modeling of such a factor by the DEA approach remains difficult for not to say impossible.

Despite the limitations of this method, its contributions remain indisputable. Indeed, the results obtained help to facilitate decision-making by managers both at the level of the points of sale and at the level of general management.

We strongly recommend the use of the DEA method at the CNEP-Bank to measure the performance of its bank branches since it allows:

- Enhance dashboards with indicators systematically comparing the performance of entities (functions, processes) with internal performance;
- Increase customer satisfaction and competitive advantages. Indeed, by detecting wastage, the bank can reuse it in the launch of new products or already existing products and services provided to customers;
- Finally, to increase the opportunities for management success at the level of the Finance and Accounting Department.

## Conclusion:

At the end of this chapter, we manage to classify all the branches evaluated in each group thanks to the individual efficiency coefficients obtained by the DEA method.
From this arises the possibility of identifying the reference branches which constitute the efficiency frontier and against which other branches suffering from technical inefficiency are compared.

The DEA methodology helps us to identify the strengths and weaknesses of each entity and therefore to outline the strategic objectives to be followed in order to improve its performance thereafter. This method has proven its importance in many fields, since it is capable of being used with any input-output measurement. The DEA method can analyse and qualify the sources of inefficiency of every assessed unit and therefore can contribute in development of these units' efficiency. Which lead us to think that the DEA method can contribute in the optimization of productivity of production units in many fields and therefore the prosperity of the economy.

# GENERAL CONCLUSION

Since efficiency is one of the factors that can explain the overall performance of the bank production unit, it would be appropriate to integrate into the traditional dashboard of each branch a new indicator characterized by being a synthetic and comprehensive measure of efficiency. This is the coefficient of efficiency that can be obtained using the data envelopment analysis (DEA) methodology.

The integration of the DEA approach into management control systems could only be beneficial for our Algerian banks. The major advantage of this approach lies in its ability to understand the sources of inefficiency of the decision-making units but moreover to shed light on best practices in order to be able to take corrective actions. It also makes it possible to assess the performance of organizations that use multiple resources (inputs) to generate multiple results (outputs). This is why we decided to respond to our problem by adopting this method.

Our empirical analysis was carried out on a homogeneous sample of two hundred and nineteen (219) bank branches of the CNEP-Bank. In order to assess the financial and operational performance of this network, we have developed two DEA models.

It emerges from the results obtained under the two models that 54% of the branches are technically efficient with average efficiency scores of 0.887 financially and 0.888 operationally, reflecting a very good performance of the network.

The use of the DEA method favors an internal benchmarking application which has made it possible to position each agency in relation to best “benchmark” practices. This led us to make an individual diagnosis of one agency classified as inefficient and another financially inefficient, in order to determine the efforts to be made by managers to improve their performance.

At the end of our work, we made some recommendations regarding the contribution of the DEA method to the performance measurement system of the CNEP-Bank, the improvement of the decision-making of managers-directors and consequently the piloting system.

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# ANNEXES

## Annex 01 :

| | FIRST MODEL | | | | SECOND MODEL | | | |
|---|---|---|---|---|---|---|---|---|
| AGENCE | crste | vrste | scale | | crste | vrste | scale | |
| 101 | 0.962 | 1 | 0.962 | drs | 0.926 | 1 | 0.926 | drs |
| 102 | 0.902 | 0.903 | 1 | - | 0.903 | 0.916 | 0.986 | drs |
| 103 | 0.871 | 0.891 | 0.978 | irs | 0.871 | 0.891 | 0.978 | irs |
| 104 | 0.956 | 0.958 | 0.998 | drs | 0.956 | 0.958 | 0.998 | drs |
| 105 | 0.91 | 0.918 | 0.992 | irs | 0.91 | 0.918 | 0.992 | irs |
| 106 | 0.892 | 0.911 | 0.979 | irs | 0.892 | 0.911 | 0.979 | irs |
| 110 | 0.902 | 0.92 | 0.98 | drs | 0.896 | 0.915 | 0.979 | drs |
| 112 | 0.856 | 0.858 | 0.997 | irs | 0.856 | 0.858 | 0.997 | irs |
| 126 | 1 | 1 | 1 | - | 1 | 1 | 1 | - |
| 127 | 0.851 | 0.856 | 0.994 | irs | 0.851 | 0.856 | 0.994 | irs |
| 129 | 1 | 1 | 1 | - | 1 | 1 | 1 | - |
| 130 | 0.859 | 0.865 | 0.993 | irs | 0.859 | 0.865 | 0.993 | irs |
| 131 | 1 | 1 | 1 | - | 1 | 1 | 1 | - |
| 132 | 0.993 | 1 | 0.993 | drs | 0.994 | 1 | 0.994 | drs |
| 151 | 0.881 | 0.931 | 0.946 | drs | 0.881 | 0.932 | 0.946 | drs |
| 152 | 0.844 | 0.859 | 0.982 | irs | 0.847 | 0.859 | 0.987 | irs |
| 153 | 0.837 | 0.838 | 1 | - | 0.838 | 0.841 | 0.997 | drs |
| 154 | 0.804 | 0.819 | 0.981 | irs | 0.804 | 0.819 | 0.981 | irs |
| 155 | 0.811 | 0.813 | 0.998 | drs | 0.811 | 0.813 | 0.998 | drs |
| 158 | 0.777 | 0.786 | 0.989 | irs | 0.775 | 0.783 | 0.989 | irs |
| 159 | 0.768 | 0.784 | 0.979 | irs | 0.763 | 0.779 | 0.98 | irs |
| 160 | 0.786 | 0.818 | 0.961 | irs | 0.786 | 0.818 | 0.961 | irs |
| 161 | 0.815 | 0.821 | 0.993 | irs | 0.815 | 0.821 | 0.993 | irs |
| 162 | 0.827 | 0.833 | 0.993 | irs | 0.827 | 0.833 | 0.993 | irs |
| 117 | 0.832 | 0.835 | 0.996 | irs | 0.832 | 0.835 | 0.996 | irs |
| 201 | 0.96 | 1 | 0.96 | drs | 0.96 | 1 | 0.96 | drs |
| 202 | 0.907 | 0.907 | 1 | - | 0.907 | 0.907 | 1 | - |
| 203 | 0.914 | 0.915 | 0.999 | drs | 0.914 | 0.915 | 0.999 | drs |
| 204 | 0.968 | 0.987 | 0.981 | irs | 0.947 | 0.963 | 0.983 | irs |
| 205 | 0.961 | 0.961 | 1 | - | 0.961 | 0.961 | 1 | - |
| 206 | 0.918 | 0.922 | 0.996 | drs | 0.918 | 0.929 | 0.989 | drs |
| 207 | 0.919 | 0.926 | 0.992 | drs | 0.919 | 0.926 | 0.992 | drs |
| 208 | 0.911 | 0.914 | 0.997 | irs | 0.911 | 0.914 | 0.997 | irs |
| 214 | 0.862 | 0.891 | 0.968 | drs | 0.871 | 0.899 | 0.969 | drs |
| 215 | 0.838 | 0.858 | 0.977 | irs | 0.839 | 0.858 | 0.978 | irs |
| 216 | 0.748 | 0.762 | 0.982 | irs | 0.748 | 0.762 | 0.982 | irs |
| 217 | 0.891 | 0.916 | 0.972 | irs | 0.891 | 0.916 | 0.972 | irs |
| 218 | 0.848 | 0.864 | 0.982 | irs | 0.848 | 0.864 | 0.982 | irs |
| 219 | 0.912 | 0.918 | 0.993 | irs | 0.908 | 0.916 | 0.991 | irs |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 251 | 0.875 | 0.926 | 0.945 | drs | 0.875 | 0.926 | 0.945 | drs |
| 252 | 0.987 | 0.99 | 0.997 | irs | 1 | 1 | 1 | - |
| 253 | 0.863 | 0.865 | 0.998 | drs | 0.863 | 0.865 | 0.998 | drs |
| 254 | 0.855 | 0.868 | 0.985 | irs | 0.855 | 0.868 | 0.985 | irs |
| 256 | 0.866 | 0.869 | 0.996 | irs | 0.866 | 0.869 | 0.996 | irs |
| 257 | 0.823 | 0.832 | 0.99 | irs | 0.823 | 0.832 | 0.99 | irs |
| 258 | 0.896 | 0.91 | 0.984 | irs | 0.896 | 0.91 | 0.984 | irs |
| 259 | 0.874 | 0.89 | 0.982 | irs | 0.872 | 0.888 | 0.982 | irs |
| 267 | 0.869 | 0.895 | 0.972 | drs | 0.869 | 0.895 | 0.972 | drs |
| 268 | 0.91 | 0.935 | 0.974 | irs | 0.91 | 0.935 | 0.974 | irs |
| 269 | 0.856 | 0.858 | 0.998 | irs | 0.856 | 0.858 | 0.998 | irs |
| 270 | 0.912 | 0.912 | 1 | - | 0.912 | 0.912 | 1 | - |
| 271 | 1 | 1 | 1 | - | 1 | 1 | 1 | - |
| 272 | 0.836 | 0.843 | 0.992 | irs | 0.836 | 0.843 | 0.992 | irs |
| 273 | 0.913 | 0.917 | 0.996 | irs | 0.913 | 0.917 | 0.996 | irs |
| 274 | 0.93 | 0.931 | 0.999 | drs | 0.93 | 0.931 | 0.999 | drs |
| 301 | 0.868 | 0.937 | 0.926 | drs | 0.856 | 0.937 | 0.913 | drs |
| 302 | 0.817 | 0.821 | 0.995 | irs | 0.817 | 0.821 | 0.995 | irs |
| 303 | 0.905 | 0.918 | 0.986 | drs | 0.905 | 0.918 | 0.986 | drs |
| 304 | 0.874 | 0.881 | 0.992 | irs | 0.874 | 0.881 | 0.992 | irs |
| 305 | 0.844 | 0.862 | 0.979 | irs | 0.844 | 0.862 | 0.979 | irs |
| 306 | 0.805 | 0.807 | 0.998 | irs | 0.81 | 0.811 | 1 | - |
| 307 | 0.83 | 0.856 | 0.969 | drs | 0.83 | 0.858 | 0.967 | drs |
| 308 | 0.808 | 0.838 | 0.964 | irs | 0.812 | 0.841 | 0.966 | irs |
| 309 | 0.807 | 0.815 | 0.99 | irs | 0.807 | 0.815 | 0.99 | irs |
| 310 | 0.863 | 0.885 | 0.975 | irs | 0.863 | 0.885 | 0.975 | irs |
| 311 | 0.93 | 0.956 | 0.973 | drs | 0.93 | 0.959 | 0.969 | drs |
| 312 | 0.793 | 0.821 | 0.966 | irs | 0.793 | 0.821 | 0.966 | irs |
| 313 | 0.819 | 0.833 | 0.983 | irs | 0.819 | 0.833 | 0.983 | irs |
| 314 | 0.841 | 0.847 | 0.993 | irs | 0.841 | 0.847 | 0.993 | irs |
| 315 | 0.853 | 0.855 | 0.998 | drs | 0.853 | 0.855 | 0.998 | drs |
| 316 | 0.808 | 0.824 | 0.981 | irs | 0.808 | 0.824 | 0.981 | irs |
| 317 | 0.877 | 0.88 | 0.996 | irs | 0.877 | 0.88 | 0.996 | irs |
| 318 | 0.792 | 0.799 | 0.991 | irs | 0.792 | 0.799 | 0.991 | irs |
| 319 | 0.875 | 0.877 | 0.998 | irs | 0.875 | 0.877 | 0.998 | irs |
| 351 | 0.965 | 0.971 | 0.994 | drs | 0.965 | 0.971 | 0.994 | drs |
| 352 | 0.87 | 0.873 | 0.996 | irs | 0.858 | 0.858 | 1 | - |
| 353 | 0.806 | 0.821 | 0.982 | irs | 0.806 | 0.82 | 0.983 | irs |
| 354 | 1 | 1 | 1 | - | 1 | 1 | 1 | - |
| 355 | 0.792 | 0.812 | 0.975 | irs | 0.792 | 0.811 | 0.976 | irs |
| 356 | 0.855 | 0.878 | 0.973 | irs | 0.843 | 0.866 | 0.973 | irs |
| 357 | 0.932 | 0.95 | 0.981 | irs | 0.932 | 0.95 | 0.981 | irs |
| 358 | 0.835 | 0.872 | 0.957 | irs | 0.835 | 0.872 | 0.957 | irs |
| 366 | 0.998 | 1 | 0.998 | drs | 0.998 | 1 | 0.998 | drs |
| 367 | 0.904 | 0.923 | 0.979 | irs | 0.904 | 0.923 | 0.979 | irs |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 368 | 0.738 | 0.744 | 0.991 | irs | 0.738 | 0.744 | 0.991 | irs |
| 369 | 0.98 | 1 | 0.98 | drs | 0.972 | 0.999 | 0.973 | drs |
| 370 | 0.856 | 0.861 | 0.994 | irs | 0.856 | 0.861 | 0.994 | irs |
| 371 | 1 | 1 | 1 | - | 1 | 1 | 1 | - |
| 373 | 0.873 | 0.881 | 0.992 | irs | 0.873 | 0.881 | 0.992 | irs |
| 374 | 0.838 | 0.845 | 0.991 | irs | 0.838 | 0.845 | 0.991 | irs |
| 401 | 1 | 1 | 1 | - | 1 | 1 | 1 | - |
| 402 | 1 | 1 | 1 | - | 1 | 1 | 1 | - |
| 403 | 0.949 | 0.953 | 0.996 | drs | 0.953 | 0.961 | 0.992 | drs |
| 404 | 0.846 | 0.85 | 0.996 | irs | 0.846 | 0.85 | 0.996 | irs |
| 405 | 0.774 | 0.777 | 0.996 | irs | 0.769 | 0.772 | 0.997 | irs |
| 406 | 0.793 | 0.797 | 0.995 | irs | 0.793 | 0.794 | 0.998 | irs |
| 407 | 0.844 | 0.85 | 0.993 | irs | 0.844 | 0.849 | 0.993 | irs |
| 408 | 0.851 | 0.865 | 0.984 | irs | 0.851 | 0.865 | 0.984 | irs |
| 409 | 0.846 | 0.856 | 0.989 | irs | 0.846 | 0.855 | 0.989 | irs |
| 410 | 0.905 | 0.919 | 0.984 | irs | 0.905 | 0.919 | 0.984 | irs |
| 411 | 0.915 | 0.919 | 0.995 | irs | 0.915 | 0.919 | 0.995 | irs |
| 412 | 0.978 | 0.988 | 0.991 | irs | 0.982 | 0.992 | 0.99 | irs |
| 417 | 0.871 | 0.871 | 1 | - | 0.871 | 0.871 | 1 | - |
| 418 | 0.867 | 0.872 | 0.994 | irs | 0.867 | 0.872 | 0.994 | irs |
| 421 | 0.955 | 0.958 | 0.997 | drs | 0.955 | 0.958 | 0.997 | drs |
| 422 | 0.815 | 0.838 | 0.972 | irs | 0.815 | 0.838 | 0.972 | irs |
| 423 | 0.85 | 0.851 | 0.999 | - | 0.85 | 0.851 | 0.999 | - |
| 428 | 0.951 | 0.958 | 0.992 | irs | 0.951 | 0.958 | 0.992 | irs |
| 451 | 0.839 | 0.867 | 0.967 | drs | 0.839 | 0.867 | 0.967 | drs |
| 452 | 0.826 | 0.835 | 0.99 | irs | 0.826 | 0.835 | 0.99 | irs |
| 453 | 0.827 | 0.832 | 0.994 | irs | 0.827 | 0.832 | 0.994 | irs |
| 454 | 0.854 | 0.858 | 0.996 | drs | 0.854 | 0.858 | 0.996 | drs |
| 455 | 1 | 1 | 1 | - | 1 | 1 | 1 | - |
| 456 | 0.991 | 0.994 | 0.997 | irs | 0.991 | 0.994 | 0.997 | irs |
| 457 | 0.887 | 0.891 | 0.996 | drs | 0.887 | 0.891 | 0.996 | drs |
| 459 | 0.873 | 0.913 | 0.956 | drs | 0.873 | 0.913 | 0.956 | drs |
| 460 | 0.797 | 0.805 | 0.99 | irs | 0.797 | 0.805 | 0.99 | irs |
| 461 | 0.842 | 0.843 | 0.999 | drs | 0.842 | 0.843 | 0.999 | drs |
| 462 | 0.871 | 0.899 | 0.968 | irs | 0.871 | 0.899 | 0.968 | irs |
| 463 | 0.909 | 0.931 | 0.976 | drs | 0.909 | 0.931 | 0.976 | drs |
| 465 | 0.805 | 0.807 | 0.998 | irs | 0.805 | 0.807 | 0.998 | irs |
| 466 | 0.804 | 0.808 | 0.996 | drs | 0.804 | 0.808 | 0.996 | drs |
| 467 | 0.869 | 0.874 | 0.994 | drs | 0.869 | 0.874 | 0.994 | drs |
| 468 | 0.917 | 0.917 | 1 | - | 0.917 | 0.917 | 1 | - |
| 469 | 0.847 | 0.852 | 0.994 | irs | 0.847 | 0.852 | 0.994 | irs |
| 470 | 0.841 | 0.841 | 0.999 | irs | 0.841 | 0.841 | 0.999 | irs |
| 471 | 0.955 | 0.956 | 1 | - | 0.955 | 0.956 | 1 | - |
| 501 | 0.827 | 0.92 | 0.899 | drs | 0.809 | 0.92 | 0.88 | drs |
| 502 | 0.802 | 0.811 | 0.989 | irs | 0.802 | 0.811 | 0.989 | irs |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 503 | 0.836 | 0.845 | 0.988 | irs | 0.836 | 0.845 | 0.989 | irs |
| 504 | 0.819 | 0.866 | 0.946 | drs | 0.805 | 0.866 | 0.929 | drs |
| 505 | 0.799 | 0.833 | 0.959 | irs | 0.799 | 0.833 | 0.959 | irs |
| 506 | 0.853 | 0.856 | 0.996 | irs | 0.853 | 0.856 | 0.996 | irs |
| 507 | 0.837 | 0.849 | 0.985 | irs | 0.837 | 0.849 | 0.985 | irs |
| 508 | 0.807 | 0.812 | 0.994 | irs | 0.807 | 0.812 | 0.994 | irs |
| 509 | 0.861 | 0.881 | 0.977 | drs | 0.861 | 0.881 | 0.977 | drs |
| 510 | 0.778 | 0.787 | 0.989 | irs | 0.778 | 0.787 | 0.989 | irs |
| 511 | 0.798 | 0.799 | 0.998 | irs | 0.798 | 0.799 | 0.998 | irs |
| 512 | 0.833 | 0.838 | 0.994 | irs | 0.833 | 0.838 | 0.994 | irs |
| 517 | 0.819 | 0.821 | 0.997 | irs | 0.819 | 0.821 | 0.997 | irs |
| 551 | 0.913 | 1 | 0.913 | drs | 0.913 | 1 | 0.913 | drs |
| 552 | 0.767 | 0.77 | 0.996 | irs | 0.767 | 0.77 | 0.996 | irs |
| 553 | 0.826 | 0.908 | 0.91 | drs | 0.826 | 0.908 | 0.91 | drs |
| 554 | 0.796 | 0.821 | 0.969 | irs | 0.796 | 0.821 | 0.969 | irs |
| 555 | 0.861 | 0.868 | 0.991 | irs | 0.861 | 0.868 | 0.991 | irs |
| 556 | 0.793 | 0.81 | 0.979 | irs | 0.793 | 0.81 | 0.979 | irs |
| 557 | 0.769 | 0.773 | 0.994 | drs | 0.769 | 0.773 | 0.994 | drs |
| 558 | 0.824 | 0.824 | 1 | - | 0.824 | 0.824 | 1 | - |
| 559 | 0.827 | 0.844 | 0.98 | irs | 0.827 | 0.844 | 0.98 | irs |
| 560 | 0.807 | 0.81 | 0.997 | drs | 0.807 | 0.81 | 0.997 | drs |
| 562 | 0.861 | 0.876 | 0.982 | irs | 0.861 | 0.876 | 0.982 | irs |
| 107 | 1 | 1 | 1 | - | 1 | 1 | 1 | - |
| 108 | 0.946 | 0.949 | 0.997 | drs | 0.946 | 0.949 | 0.997 | drs |
| 109 | 0.906 | 0.911 | 0.994 | irs | 0.906 | 0.911 | 0.994 | irs |
| 111 | 0.932 | 1 | 0.932 | drs | 0.934 | 1 | 0.934 | drs |
| 114 | 0.865 | 0.999 | 0.866 | drs | 0.865 | 0.999 | 0.866 | drs |
| 115 | 0.984 | 1 | 0.984 | drs | 0.984 | 1 | 0.984 | drs |
| 116 | 0.9 | 0.922 | 0.976 | drs | 0.9 | 0.922 | 0.976 | drs |
| 118 | 0.906 | 0.953 | 0.951 | drs | 0.906 | 0.957 | 0.947 | drs |
| 601 | 0.85 | 0.86 | 0.988 | drs | 0.85 | 0.86 | 0.988 | drs |
| 602 | 1 | 1 | 1 | - | 1 | 1 | 1 | - |
| 603 | 0.973 | 0.979 | 0.994 | drs | 1 | 1 | 1 | - |
| 604 | 0.994 | 0.998 | 0.996 | drs | 0.994 | 0.998 | 0.996 | drs |
| 605 | 0.938 | 0.941 | 0.997 | irs | 0.938 | 0.941 | 0.997 | irs |
| 606 | 0.95 | 0.951 | 1 | - | 0.95 | 0.951 | 1 | - |
| 119 | 0.882 | 0.977 | 0.902 | drs | 0.882 | 0.977 | 0.902 | drs |
| 120 | 0.848 | 0.848 | 1 | - | 0.848 | 0.848 | 1 | - |
| 121 | 0.852 | 0.86 | 0.991 | drs | 0.852 | 0.86 | 0.991 | drs |
| 122 | 0.965 | 0.997 | 0.969 | drs | 0.961 | 0.979 | 0.982 | drs |
| 123 | 0.84 | 0.847 | 0.992 | irs | 0.84 | 0.847 | 0.992 | irs |
| 124 | 0.831 | 0.833 | 0.997 | irs | 0.83 | 0.833 | 0.997 | irs |
| 125 | 0.856 | 0.893 | 0.959 | drs | 0.856 | 0.894 | 0.958 | drs |
| 651 | 0.972 | 0.972 | 0.999 | irs | 0.957 | 0.958 | 0.999 | irs |
| 652 | 1 | 1 | 1 | - | 1 | 1 | 1 | - |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 653 | 0.983 | 1 | 0.983 | drs | 0.983 | 1 | 0.983 | drs |
| 654 | 1 | 1 | 1 | - | 1 | 1 | 1 | - |
| 413 | 0.861 | 0.865 | 0.996 | drs | 0.861 | 0.865 | 0.996 | drs |
| 414 | 0.833 | 0.835 | 0.998 | irs | 0.833 | 0.835 | 0.998 | irs |
| 415 | 0.785 | 0.793 | 0.991 | irs | 0.785 | 0.793 | 0.991 | irs |
| 416 | 0.806 | 0.817 | 0.986 | irs | 0.806 | 0.817 | 0.986 | irs |
| 420 | 0.83 | 0.852 | 0.975 | irs | 0.83 | 0.852 | 0.975 | irs |
| 424 | 0.883 | 0.887 | 0.996 | irs | 0.883 | 0.887 | 0.996 | irs |
| 425 | 0.841 | 0.856 | 0.983 | irs | 0.841 | 0.856 | 0.983 | irs |
| 426 | 1 | 1 | 1 | - | 1 | 1 | 1 | - |
| 427 | 0.805 | 0.819 | 0.983 | irs | 0.805 | 0.819 | 0.983 | irs |
| 458 | 1 | 1 | 1 | - | 1 | 1 | 1 | - |
| 464 | 0.815 | 0.832 | 0.98 | irs | 0.815 | 0.832 | 0.98 | irs |
| 513 | 0.857 | 0.893 | 0.959 | drs | 0.905 | 1 | 0.905 | drs |
| 514 | 0.875 | 0.902 | 0.97 | irs | 0.876 | 0.903 | 0.971 | irs |
| 515 | 0.855 | 0.869 | 0.984 | irs | 0.855 | 0.869 | 0.984 | irs |
| 516 | 0.885 | 0.913 | 0.969 | irs | 0.885 | 0.913 | 0.969 | irs |
| 701 | 0.814 | 0.833 | 0.978 | irs | 0.814 | 0.833 | 0.977 | irs |
| 209 | 0.852 | 0.914 | 0.932 | drs | 0.853 | 0.912 | 0.936 | drs |
| 210 | 0.856 | 0.859 | 0.996 | irs | 0.856 | 0.859 | 0.996 | irs |
| 211 | 0.895 | 0.897 | 0.998 | irs | 0.895 | 0.897 | 0.998 | irs |
| 212 | 0.849 | 0.861 | 0.987 | irs | 0.849 | 0.861 | 0.987 | irs |
| 213 | 0.862 | 0.862 | 1 | - | 0.862 | 0.862 | 1 | - |
| 260 | 0.889 | 0.893 | 0.996 | drs | 0.889 | 0.893 | 0.996 | drs |
| 261 | 0.829 | 0.853 | 0.972 | irs | 0.829 | 0.853 | 0.972 | irs |
| 262 | 0.921 | 0.937 | 0.983 | irs | 0.921 | 0.937 | 0.983 | irs |
| 263 | 0.834 | 0.852 | 0.979 | irs | 0.834 | 0.852 | 0.979 | irs |
| 264 | 0.836 | 0.85 | 0.983 | irs | 0.836 | 0.85 | 0.983 | irs |
| 265 | 0.816 | 0.832 | 0.98 | irs | 0.816 | 0.832 | 0.98 | irs |
| 266 | 0.811 | 0.864 | 0.939 | irs | 0.811 | 0.864 | 0.939 | irs |
| 801 | 0.854 | 0.854 | 0.999 | drs | 0.854 | 0.854 | 0.999 | drs |
| 802 | 0.858 | 0.858 | 1 | - | 0.858 | 0.858 | 1 | - |
| 803 | 0.839 | 0.84 | 0.999 | irs | 0.839 | 0.84 | 0.999 | irs |
| 804 | 0.811 | 0.817 | 0.992 | irs | 0.811 | 0.817 | 0.992 | irs |
| 805 | 0.934 | 0.934 | 1 | - | 0.934 | 0.934 | 1 | - |
| 255 | 0.831 | 0.833 | 0.998 | irs | 0.831 | 0.833 | 0.998 | irs |
| 359 | 0.94 | 0.941 | 1 | - | 0.922 | 0.924 | 0.998 | irs |
| 360 | 0.839 | 0.862 | 0.973 | irs | 0.839 | 0.862 | 0.973 | irs |
| 361 | 0.818 | 0.832 | 0.983 | irs | 0.803 | 0.82 | 0.979 | irs |
| 362 | 0.761 | 0.771 | 0.987 | irs | 0.761 | 0.771 | 0.987 | irs |
| 363 | 1 | 1 | 1 | - | 1 | 1 | 1 | - |
| 364 | 1 | 1 | 1 | - | 1 | 1 | 1 | - |
| 365 | 0.833 | 0.834 | 0.999 | irs | 0.833 | 0.834 | 0.999 | irs |
| 372 | 0.855 | 0.855 | 0.999 | drs | 0.855 | 0.855 | 0.999 | drs |
| 375 | 0.774 | 0.778 | 0.996 | irs | 0.774 | 0.778 | 0.996 | irs |

# TABLE DES MATIERES