Revue du Contrôle de la Comptabilité et de l'Audit
ISSN: 2550-469X
Volume 5 : numéro 3

A Review of Measuring the Efficiency of Financial Institutions: A DEA Approach

Revue sur la mesure de l'efficience des institutions financières : Une approche par la méthode DEA

AASRI Ahmed Réda
Phd student
Faculty of Legal, Economic and Social Sciences Souissi
Mohammed V University -RABAT
Research Laboratory in economic competitiveness and managerial performance
Morocco
Ahmedreda.aasri@um5s.net.ma

LKHOYAALI BOUCHRA
Professor of Higher Education
Faculty of Legal, Economic and Social Sciences Souissi
Mohammed V University -RABAT
Research Laboratory in economic competitiveness and managerial performance
Morocco
Blkhoyaali66@gmail.com

Date de soumission: 27/05/2021

Date d'acceptation: 02/07/2021

Pour citer cet article:

AASRI, A. R. & LKHOYAALI, B. (2021) «A Review of Measuring the Efficiency of Financial Institutions: A DEA Approach», Revue du contrôle, de la comptabilité et de l'audit Volume 5 : numéro 3 » pp : 213-234.

Abstract :

The management of a financial institution, like any other company, requires the use of a certain number of indicators. The first indicators to be monitored are activity and profitability indicators, then we move on to ratio analysis. The analysis of ratios has shown a certain number of limitations. Efficiency analysis has just filled in the gaps and especially the use of data envelopment analysis.

This paper seeks to highlight the salient aspects surrounding the study of efficiency in financial institutions. The paper focuses on the works that have mobilized the data envelopment method in different economic spaces. The objective is to highlight the factors that have an impact on the measured efficiency, and whether these factors are common to all the studies analyzed in this paper. The comparative study shows that technical efficiency is positively impacted by the size and history of the financial institution. However, it is not significantly affected by geographic location.

Key-words : Efficiency ; Financial institution ; Data enveloppement analysis ; Bank ; Technical efficiency.

Résumé :

La maîtrise de la gestion d'une institution financière, à l'image de toute firme, nécessite le recours à un certain nombre d'indicateurs. Les premiers indicateurs à suivre sont les indicateurs d'activité et de rentabilité, ensuite on passe à l'analyse par les ratios. L'analyse des ratios a montré un certain nombre de limites dont l'analyse de l'efficience vient de combler les insuffisances et en l'occurrence le recours à l'enveloppement des données.

Ce papier cherche à ressortir les aspects saillants qui entourent l'étude de l'efficience au sein des institutions financières. Le papier s'est focalisé sur les travaux ayant mobilisé la méthode d'enveloppement des données dans différents espaces économiques. L'objectif étant de ressortir les facteurs ayant un impact sur l'efficience mesurée, et si ces facteurs sont communs à toutes les études analysées dans le présent article. L'étude comparative ressort que l'efficience technique est positivement impactée par la taille et par l'antériorité de l'institution financière. Par contre elle est peu significativement impactée par l'emplacement géographique.

Mots-clés : Efficience ; Institution financière ; Enveloppement des données ; Banque ; Efficience technique.

INTRODUCTION

The neoclassical school of thought defended the idea that firms are by nature efficient, but Leibenstein's work demonstrated that efficiency is not a characteristic of every firm. His reasoning was justified by five postulates: the imperfection of markets, the incompleteness of labor contracts, the discretionary character of effort, the selective rationality of individuals and the existence of inert zones. Leibenstein's work led to the advent of the theory he called "X-efficiency theory".

The financial institutions sector represents an important weight at the level of each country, and the financial crises testify to the impact of unhealthy practices on economic stability. Given the resulting difficulties, a regulatory arsenal has been established among the countries of the world to ensure that the stability of the financial system is maintained. Thus, the challenge of the financial firm is to guarantee its profitability and efficiency by complying with different constraints.

The financial firm has asserted its essential position within the economy, following the various limitations of the direct economy which it has been able to overcome. Nevertheless, the financial firm operates in an ecosystem that includes direct and indirect competitors, which requires it to establish rules of good governance and performance monitoring. Traditional indicators have shown their limitations such as partial productivity indicators that hide the effect of compensation of factors of production (Deville & Leleu, 2010), as an example, the ratios do not take into account all variables in the calculated indicator (Paradi, 2011).

Across the different efficiency analysis frontiers cited in the literature, the data envelopment analysis proves to be the most versatile (Paradi, 2013). The popularity of non-parametric efficiency measurement studies stems primarily from their flexibility. Nevertheless, the advantages provided by this method are its main limitation in terms of their applicability.There are different models of the DEA approach that are used depending on the analysis objective. The most frequently encountered in the literature are: Intermediation (Athanassopoulos, A. D., & Giokas, D., 2000) (Das, and al., 2009), production (Tsolas, 2010) (Paradi & al., 2011) and profitability (Paradi, 2010). Addition we find the market model (Manandhar & Tang, 2002) (Al-Tamimi & Lootah, 2007).

As the name suggests, the data envelopment analysis identifies an envelope that encircles all efficient observations. The observations are referred to as the DMU (The term DMU refers to any entity that is evaluated on its ability to transform inputs into outputs. These evaluations affect any type of organization) decision unit. Observations outside the envelope are considered inefficient. The function thus constituted represents the technological efficiency frontier, and is commonly referred to as the "efficiency frontier". This literature review will attempt to answer the following question: What determines the efficiency of financial institutions under the DEA approach ?

The first section of this paper will be devoted to the theoretical underpinnings of the efficiency concept. Once defined, the second section will address the measurement of this efficiency, first via traditional methods and second via the data envelopment method. The third section will describe the different models of the data envelopment analysis. Finally, the results of the comparative study of the different works will be presented in order to draw lessons from them.

1. Efficiency: a literature review

One of the first founding definitions of the concept of efficiency is that of Koopmans in 1951:

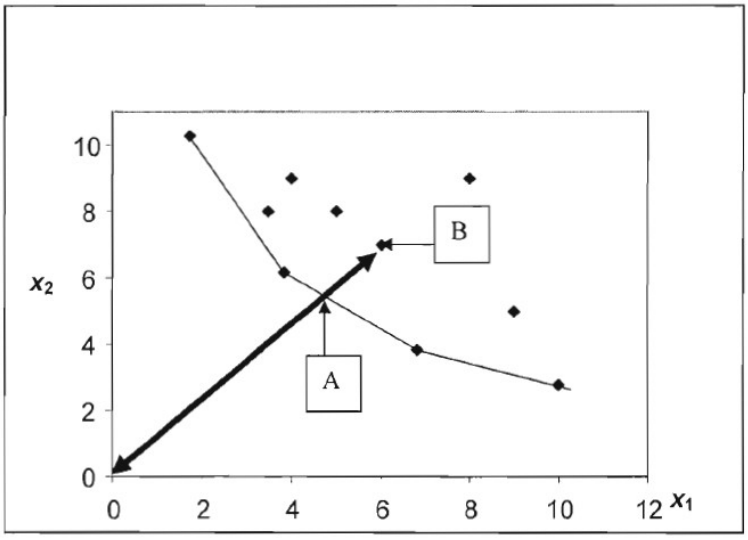
«A DMU (decision-making unit) is fully efficient if and only if it is not possible to improve any input or output without worsening some other input or output (Cooper & al., 2007)»

Efficiency from a holistic point of view, is constituted by some authors as the product of three types of efficiencies (Berger & Bonaccorsi di Patti, 2006):

1.1. Technical efficiency

This concept refers to the technical control of production aspects. In other words, technical efficiency refers to the efficient use of inputs within the bank's technology. In other words, the bank can reduce the quantity of inputs (without substituting inputs) by producing the same quantity of outputs. Thus, if we find that overall efficiency is explained mainly by technical efficiency, we can conclude that it is potentially induced by underutilization or waste of inputs (Staub & al., 2010). Statistically, technical efficiency corresponds to the distance between the observation and the isoquant tracing the decrease in inputs according to a radial movement from point (o) to the efficiency frontier (B →A in Figure N°1).

Figure N°1: Technical efficiency according to the DEA model



Source : (Dominic, 2007)

Technical efficiency is thus the proportion of inputs actually necessary for the production of outputs, and corresponds to the ratio θ= OA / OB. The technical inefficiency will thus be calculated by the formula (1-θ).

1.2. Allocative efficiency

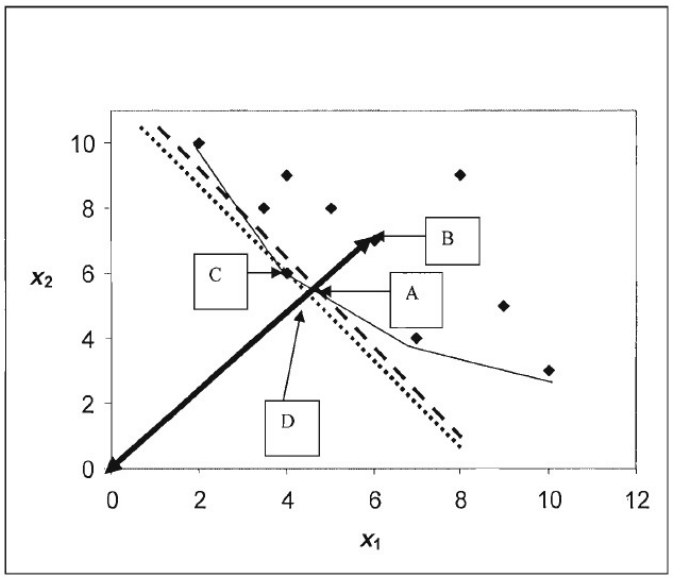
A bank on the efficiency frontier assures that it is making optimal use of its resources, but does not indicate whether its combination of inputs minimizes its costs. To this end, allocative efficiency results from choosing a combination of the least costly inputs and offering the most profitable services (outputs).

Graphically, allocative efficiency corresponds to the displacement following input substitutions, from a technically efficient point to another technically efficient point with a lower cost combination. Shift A →C in Figure N°2

We note EA the allocative efficiency, it represents the ratio of the minimum costs to produce the outputs (point D in figure 2) to the production costs at the technically efficient point A: EA = OD/OA. The allocative efficiency ratio provides information on the percentage of costs actually required to produce the same outputs by changing the combinations of inputs between two technically efficient positions. To this end, the allocative inefficiency is

calculated by the formula (1 -EA) and thus represents the percentage of possible cost reduction.

Figure N°2: Allocative and overall efficiency according to the DEA model



Source : (Dominic, 2007)

1.3. Efficiency of scale

This type of efficiency depends on the concept of economy of scale and measures the effect of size change on banking costs. This type of efficiency determines whether the banking institution operates with increasing or decreasing returns to scale.

Returns to scale are increasing when the output of an additional unit leads to a decrease in unit cost. In other words, when the change in output is more than proportional to the change in inputs. Conversely, when the variation in output is less proportional than the variation in inputs, the marginal cost increases and the result is diminishing returns to scale.

In addition, another concept emerged from the work of (Berger & Mester, 1997), namely economic efficiency, which implies that the notion of economic efficiency arises from the junction of technical efficiency and allocative efficiency (EG = ET * EA = OD/ OB). When these two types of efficiency overlap, the bank is said to be economically efficient. Graphically, it traces the shift of the observation to its point of allocative efficiency that will minimize costs (shift B-C in Figure N°2).

1.4. The concept of X-efficiency

Its contribution consists in explaining the differences in productivity between firms by the existence of inefficiencies other than allocative ones.

His observation is justified by:

1) Production and productivity are influenced by variables other than those derived from classical theory, namely, capital and labor.

2) (Harberger, 1957) demonstrated that the gain in allocative efficiency would only increase by 0.1% in a more intense competitive environment.

3) (Mundell, 1962) indicates that the gains from trade and the benefits from tariff reduction are almost negligible. Unless there is a thorough theoretical re-examination of the validity of the tools on which these studies are based

2. Measuring efficiency

The use of this approach is justified by (Parsons, 1994), who proposed to go beyond the reductive aspect of productivity analysis through ratios to study the technical relationship between inputs and outputs. The production function traces the set of maximum production possibilities (maximum outputs) that can be obtained from a given quantity of inputs. This implies that the approach serves as a benchmark for firms, since each firm will be compared to the best firm in its sector.

The literature highlights two main approaches to measuring efficiency: deterministic techniques and frontier-based methods.

Some authors have pointed out the limitations of using deterministic techniques, which lie in the difficulty of the approach, making its use restricted to specialists. In addition, this approach requires the prior fixing of assumptions on the error term in order to separate the inefficiency from the stochastic noise. In this sense, Berger dealt with panel data and considered that over a long period, these error terms will cancel each other out, and will have no impact on the evaluation of the inefficiency, which is considered to be stable over time (De la Villarmois, 1999).

2.1. Traditional methods of evaluating the activity and profitability of financial institutions

The management of a financial institution requires the use of monitoring indicators in order to control activity, carry out benchmarks and prevent any possible drift. To this end, there is a wide range of indicators to monitor activity, profitability and efficiency.

The first indicator monitored by the management of a financial institution is the net banking income. This is the sum of three balances:

Net banking income = Intermediation margin + Margin on commissions + Result of market activities

The second indicator is gross operating income, which provides information on a financial institution's ability to generate profit after deducting the costs of resources used and operating expenses.

The formula for calculating GOI is as follows:

GOI = Net banking income - (General operating expenses + Depreciation)

At a second level, profitability is calculated. The two most commonly used indicators are ROA and ROE.

Return On Assets (ROA)

This ratio provides information on the capacity of the financial institution to generate profit from its assets. (Golin, 2001) points out that despite the fact that off-balance sheet assets are not taken into consideration by this ratio, it remains the most widely used.

$$\text{ROA (or ROAA)} = \frac{\text{Net Income or Income Before Taxes}}{\text{Total Balance Sheet or Average Total Balance Sheet}}$$

Return On Equity (ROE)

This indicator provides information on the capacity of the financial institution to generate profit in relation to the capital committed by the shareholders. Indeed, the firm finances its economic assets by a combination of resources (equity + debt). The fact that debt is included in the sources of financing allows the firm to benefit from the leverage effect. Mathematically, the higher the ROE, the more profitable the financial institution is:

$$\text{ROE (or ROAE)} = \frac{\text{Net Income}}{\text{Equity}}$$

Similarly, the formula can also be presented as net income divided by average equity (Ben Naceur & Omran, 2011).

2.2. Data envelopment analysis

Since its conception, the DEA method has become the most widely used approach to measure the efficiency of financial institutions (LaPlante, 2015). Studies have focused more on the efficiency of the financial institution as a whole than on the efficiency of commercial agencies, which is justified by the level of data accessibility. Indeed, consolidated data are available in their quarterly financial disclosures, which are required by regulation for all financial institutions, while agency data remain internal and are not disclosed to third parties.

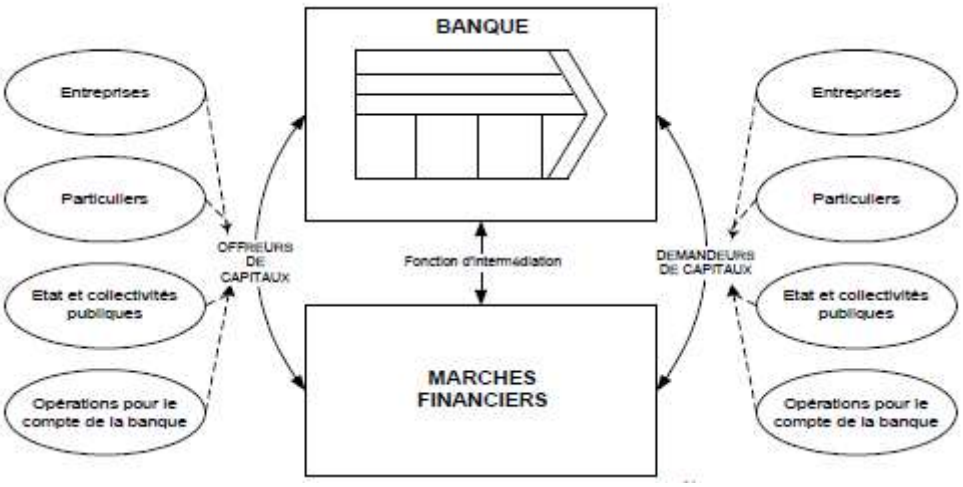
The selection of inputs and outputs is a crucial step in the DEA method. Indeed, this choice conditions the results that emerge from the study and makes it possible to distinguish whether the banking firm under the intermediation approach or the production approach. In the production approach, the financial firm produces loans and deposits using capital, labor and fixed capital. However, in the intermediation approach, banks are responsible for transforming deposits and funds into loans and other assets (Assaf & al., 2013).

On the other hand, a multitude of works have conducted the tests using a two-stage approach to estimate the determinants of bank efficiency (Ismail & al., 2013) and (Saha & al., 2015). In the first stage, the efficiency scores are estimated by the DEA method; in the second stage, the efficiency scoresobtained are used as the dependent variable in the regression analysis, in order to highlight the determinants of efficiency.

There are different models of the DEA approach that are used depending on the analysis objective. The most frequently encountered in the literature are : Intermediation (Athanassopoulos, A. D., & Giokas, D., 2000) (Das & al., 2009), production (Tsolas, 2010) (Paradi and al., 2011) and profitability (Paradi, 2010). Addition we find the market model (Manandhar & Tang, 2002) (Al-Tamimi & Lootah, 2007).

Many studies have focused on the intermediation approach as it is most consistent with the nature of the activity of the financial firm, whose main mission is to overcome the limitations of direct finance by ensuring the optimal allocation of resources from agents with financing capacity to economic agents with financing needs, (Figure 3) below illustrates this economic function performed by the bank.

Figure N°3: The economic function of the bank



Source : (Vettori, 2000)

3. The DEA models

3.1. The CCR[1] Model of Charnes, Cooper and Rhodes, 1978:

Charnes, Cooper and Rhodes (1978) developed a model that operates under the assumption of constant returns to scale and an input orientation, which amounts to minimizing inputs for a

[1] Also known as (CRS) Constant Return to Scale.

given level of outputs. The corresponding efficiency frontier is presented in a linearly fragmented form. The model can be input-oriented or output-oriented.

The design of the CCR model puts forward three conditions on the production technology frontier. First, constant returns to scale; second, the convexity of the set of combinations of inputs and outputs that can be realized; and third, the free availability of inputs and outputs.

We consider there are "n" decision-making units, and each unit has "m" input and "s" output, the efficiency score of a DMUp is obtained by solving the program proposed by Charnes, Cooper and Rhodes (1978).

3.2. The BCC Model of Banker, Charnes and Cooper, 1984

The CCR model of (Charnes & al., 1978), detailed above, operates under the fundamental assumption of the existence of constant returns to scale, but this assumption can only be met when all the decision units are operating at their optimal scale. To this end, a situation of imperfect competition can eventually break the DMU from reaching its optimal scale. To take this into account, (Banker, Charnes & Cooper, 1984) developed a variant of the CCR model that takes into account the context of variable returns to scale (VRS). In the CRS model, when DMUs do not operate at their optimal scale, technical efficiency is confounded with scale efficiency. To do this, the use of the VRS specification will result in a purely technical efficiency calculation excluding the scale effect. Mathematically, this is done by incorporating a convexity constraint. $\sum_{j=1}^{n} \lambda j = 1$.

3.3. The Additive Model of Charnes, Cooper, Golany, Seiford and Stutz, 1985

In the previous models, a choice had to be madeconsidering the orientation of the model (input/output). The additive model is unique because it is "unoriented model" since the objective function allows both maximizing and minimizing the outputs and inputs.We note θ which represented inefficiency, is no longer present in this model since inefficiencies are detected at the level of the slack values. This being the case, the efficiency test is limited to finding out whether the slacks are present or zero.

This simultaneous optimization is made possible by the integration of a new variable ($\hat{Y}_{ro}$ and $\hat{X}_{io}$) to the initial formula. The optimal situation is said to be reached when it is impossible to

increase an output $\hat{Y}_{ro}$ or decrease an input $\hat{X}_{io}$ without decreasing another output element or adding another input element.

3.4. The Multiplicative Model of Charnes , Cooper , Seiford and Stutz . 1983

The multiplicative model has the particularity of substituting the classic additive combinations of inputs and outputs with multiplicative combinations. Graphically, this model gives a log-linear or Cobb-Douglas function, in the form of fragments along the envelope frontier. The scale efficiency used is an assumption that depends on the interpretation given to the production process to determine the frontier.

The use of the function depends on the type of return to scale, in the situation of constant return to scale, the function is of the log-linear type; on the other hand, in the case of a VRS situation, the Cobb-Douglas form is more appropriate.

4. Summary of empirical studies in the banking sector

In order to better understand the study of efficiency in a banking environment, (Table 1) illustrates a set of practical cases studied.

Table 1: Synthesis of empirical studies in the banking sector

Auteur	Inputs	Outputs	Country	Sample	Study period	Results
(Berg & al., 1993)	- Labor - Capital	-Loans -Deposits -Number of branches	Nordic countries	Banks - 503 Finnish - 150 Norwegian - 126 Swedish	1990	Most of the banks on the Nordic border with the best practices were Swedish. The average Swedish bank was also significantly more efficient than the average Finnish and Norwegian banks, while the average Norwegian bank was more efficient than the average Finnish bank.
(Favero & Papi, 1995)	- Labor - Capital - Savings deposits and net funds borrowed from other banks.	- Loans to other banks and non-financial institutions, - Securities and bond investments, - Non-interest income	Italy	174 banks	1991	Existence of both technical and allocative inefficiency. Inefficiency is explained by productive specialization, size and, to a lesser extent, by location. The importance of size is an indication of greater efficiency in large banks. However, the relationship between size and efficiency is not interpreted as an indicator of increasing returns to scale.

(Ayadiand al., 1998)	- Interest paid on deposits, - Personnel costs, - Administration - Total deposits	- Total loans - Interest income - Non-interest income	Nigeria	10 banks	1991-1994	- The weakness of Niger's banks is mainly due to poor management, manifested in excessive credit risk and liquidity, poor loan quality, and a weak ability to generate capital internally. - The banks that were found to be relatively efficient in this study are those that have been in existence for a long time.
(Chen & Yeh, 1998)	- Staff employed - Bank assets - Number of bank branches - Operating costs - Deposits - Interest expense	- Loans -Investment - Interest income - Non-interest income	Taiwan	34 commercial banks	1996	15 commercial banks are relatively efficient and the overall level of efficiency is quite high. Inefficient banks can effectively promote resource use efficiency by better managing their workforce and operational capital efficiency and by expanding the bank investment function

(Ho & Zhu, 2004)	Stage 1: - capital, - assets, - branches - employees Stage 2: - Sales - Deposits	Stage 1: - Sales - Deposits Stage 2: - Net income, - Non-interest income - Interest Income	Taiwan	41 banks listed on the Taiwan Stock Exchange	2001	- Stage 1 efficiency shows only 12 efficient banks. - The stage 2 efficiency model shows only 10 efficient banks. - Inefficient banks can effectively promote efficiency in resource use by better managing their workforce and operational efficiency of their capital.
(Wu & al., 2006)	- Employees - Other general expenses	- Deposits - Income - Loans	Canada (Toronto)	142 banks	Oct-Nov-Dec2001	The results are comparable to the normal DEA results overall. However, the DEA-NN approach produces a more robust frontier and identifies more efficient units as better performance patterns are explored. In addition,

						the DEA-NN approach provides guidance to underperformers on how to improve their performance at different efficiency scores.
(Anouze, 2010)	- Fixed assets - Non-productive assets - Deposits	- Investments - Loans - Net income	Gulf	60 banks	1998-2007	- Only 10 banks are efficient. - The lowest efficiency score is found in 2005, two years after the second Gulf crisis. - The Kruskal-Wallis test shows that there is no statistically significant relationship between the geographical location of the bank and its efficiency on the 2007 results.
(Fadzlan & Kamarudin, 2016)	-Total dépôts-Capital-Travail	-Prêt-Investissements -Revenu autre qu'intérêts	Malaisie	Toutes les banques commerciales de la Malaisie	1999-2008	-Technical efficiency increases with bank size; - Increase in efficiency of Malaysian banking sector over the sample period. Productive efficiency is positively related to size, non-interest income and capitalization. - Positive impact of banking sector concentration and risk on the efficiency of banks operating in the Malaysian banking sector.

	- Negative impact of market capitalization on the technical efficiency of Malaysian banks, implying that the Malaysian stock market provides substitution opportunities rather than complementing the products and services offered by banks to borrowers in Malaysia. -Banks in Asian countries are relatively more efficient than foreign banks in other regions and their domestic counterparts, rejecting the home field advantage hypothesis, but supporting the "limited form" of aggregate advantage.

Source: Author

The results of the (table °1) show that:

-One of the salient findings that several authors have found is that technical efficiency increases with bank size (Favero & Papi, 1995); (Hauner, 2005) and (Fadzlan & al., 2016).

- Typically, empirical studies of efficiency using the DEA method consider three categories of inputs: Fixed capital, labor, and financial capital. In contrast to the output approach, outputs are measured here by the volume (monetary unit) of credit extended and portfolio investments, regardless of the number of accounts managed by the financial firm. This implies the assumption that the stocks of loans and deposits taken from balance sheet positions are proportional to the flows (Joumady, 2001).

- Loans are the common output in the majority of the studies plus other variables that vary from one study to another such as investments in securities and bonds, number of branches, interest income, non-interest income and net income.

- For the geographic location variable, the results were mixed, but did not reveal a strong positive correlation between the variable and efficiency. Indeed, some authors have shown that efficiency is explained very minimally by the location variable (Favero & Papi, 1995). Similarly, (Anouze, 2010) found that there was no statistically significant relationship between geographical location and the results observed.

- The anteriority effect is important in some ecosystems, since it was found, for example, in the study by (Ayadi & al., 1998) that the oldest Nigerian banks were those that recorded the best efficiency scores.

- The samples taken are always large in relation to the number of inputs and outputs considered in the study. Indeed, the robustness of the results obtained in the DEA approach are conditioned by the number of variables taken into account. For example, (Dyson & al., 2001) suggest that the sample size should be at least twice the number of inputs multiplied by the number of outputs. In the above study by (Ayadi & al., 1998), following the constraint of (Dyson & al., 2001), the sample size had to be at least 24 (2*(4 inputs*3 outputs) = 24) banks instead of 10.

CONCLUSION

This paper has reviewed the concept of efficiency and its application in the financial institutions sector. Indeed, the monitoring of the firm's performance in terms of efficiency was done through a number of classical indicators which showed some limitations and do not allow to synthesize the result through a single indicator. The DEA method proves to be the most suitable for this field of study and is the most consistent with the activity of financial institutions when studied through the intermediation prism.

The intermediation approach refers to the role that the financial firm plays in the interface between depositors and borrowers (Sealey & Lindley, 1977). In this approach, financial firms have the role of transforming deposits and funds into loans and other assets (Assaf & al., 2013).Generally, proponents of this approach (Berger & al., 1987), (Mester, 1987), (Weill, 2004)...) take into account three inputs: fixed capital, labor input and financial capital. If we look further into this approach, it turns out that loans are not only the result of deposits, but can also be converted into inputs via the securitization process, thus becoming an additional resource to the deposits collected. Moreover, the consideration of customers' needs through the supply of deposits indicates that they appear as an output (The Van, 1993).

The comparative study conducted in different economic areas shows that efficiency is positively affected by the size and history of the financial institution. However, for some authors it is not significantly affected by geographical location, while for others it is not significant. These results deserve to be compared with the results of efficiency tests carried out using parametric methods in order to see whether changing the measurement approach leads to the same results or to different conclusions.

BIBLIOGRAPHY

Al-Tamimi, H. A. H., & Lootah, A. M. (2007). Evaluating the operational and profitability efficiency of a UAE-based commercial bank. *Journal of Financial Services Marketing*, *11*(4), 333-348.

Anouze, A. (2010). Evaluating productive efficiency: comparative study of commercial banks in Gulf countries (Doctoral dissertation, Aston University).

Assaf, A. G., Matousek, R., &Tsionas, E. G. (2013). Turkish bank efficiency: Bayesian estimation with undesirable outputs. *Journal of Banking & Finance*, *37*(2), 506-517.

Assaf, A. G., Matousek, R., & Tsionas, E. G. (2013). Turkish bank efficiency: Bayesian estimation withundesirable outputs. *Journal of Banking & Finance*, *37*(2), 506-517.

Athanassopoulos, A. D., & Giokas, D. (2000). The use of data envelopment analysis in banking institutions: evidence from the commercial bank of Greece. *Interfaces*, *30*(2), 81-95.

Ayadi, O. F., Adebayo, A. O., & Omolehinwa, E. (1998). Bank performance measurement in a developing economy: An application of data envelopment analysis. *Managerial Finance*.

Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some models for estimating technical and scale inefficiencies in Data Envelopment Analysis. Management Science, 30, 1078-1092.

Ben Naceur, S., Omran, M., 2011. The effects of bank regulations, competition, and financial reforms on banks' performance. Emerging Markets Review 12, 1–20.

Berg, S. A., Førsund, F. R., Hjalmarsson, L., & Suominen, M. (1993). Banking efficiency in the Nordic countries. Journal of Banking & Finance, 17(2-3), 371-388.

Berger, A. N., & Di Patti, E. B. (2006). Capital structure and firm performance: A new approach to testing agency theory and an application to the banking industry. *Journal of Banking & Finance*, *30*(4), 1065-1102.

Berger, A. N., Hanweck, G. A., & Humphrey, D. B. (1987). Competitive viability in banking: Scale, scope, and product mix economies. *Journal of monetary economics*, *20*(3), 501-520.

Berger, A.N., & Mester, L.J. (1997), "Inside the Black Box: What Explains Differences in the Efficiencies of Financial Institutions? ", Journal of Banking and Finance, vol. 21, pp. 895-947.

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research*, 2, 429-444.

Chen, T. Y., & Yeh, T. L. (1998). A study of efficiency evaluation in Taiwan's banks. International Journal of Service Industry Management.

Cooper, W. W., Seiford, L. M., Tone, K., & Zhu, J. (2007). Some models and measures for evaluating performances with DEA: past accomplishments and future prospects. Journal of Productivity Analysis, 28(3), 151-163.

D'Aoust, D. (2007). Comparaison des efficiences technique, allocative et globale des hôpitaux québécois et californiens par le biais du modèle Data Envelopment Analysis (DEA).

Das, A., Ray, S. C., & Nag, A. (2009). Labor-use efficiency in Indian banking: A branch-level analysis. *Omega*, *37*(2), 411-425.

De la Villarmois, O. (1999). Le contrôle du réseau bancaire : Exploration de la faisabilité et de la pertinence d'une démarche de comparaison des unités opérationnelles. Thèse de Doctorat en sciences de gestion, université IAE, Lille

Deville, A. & Leleu, H. (2010). De nouvelles mesures pour comparer la performance opérationnelle et financière des agences bancaires. *Comptabilité - Contrôle - Audit*, tome 16(2), 97-126. https://doi.org/10.3917/cca.162.0097

Dyson, R.G., Allen, R., Camanho, A.S., Podinovski, V.V., Sarrico, C.S. & Shale, E.A. (2001), "Pitfalls and protocols in DEA", European Journal of Operational Research, vol. 132, no. 2, pp. 245-259.

Favero, C. A., & Papi, L. (1995). Technical efficiency and scale efficiency in the Italian banking sector: a non-parametric approach. Applied economics, 27(4), 385-395.

Golin, J., 2001. The Bank Credit Analysis Handbook: A Guide for Analysts, Bankers and Investors. John Wiley& Sons, Asia.

Harberger A.C. 1957, "Some Evidence on the International Price Mechanism", The Journal of Political Economy, vol. 65, no. 6, pp. 506-521.

Hauner, D. (2005). Explaining efficiency differences among large German and Austrian banks. Applied Economics, 37 , 969–980 .

Ho, C. T., & Zhu, D. S. (2004). Performance measurement of Taiwan's commercial banks. International Journal of Productivity and Performance Management.

LaPlante, A. E., &Paradi, J. C. (2015). Evaluation of bank branch growth potential using data envelopment analysis. *Omega*, *52*, 33-41.

Manandhar, R., & Tang, J. C. (2002). The evaluation of bank branch performance using data envelopment analysis: A framework. *The Journal of High Technology Management Research*, *13*(1), 1-17.

Mester, L. J. (1987). A multiproduct cost study of savings and loans. *The Journal of finance*, *42*(2), 423-445.

Mundell, R., 1962. Review of L.H. Janssen, "free trade, protection and customs union", American Economic Review, vol. 52, pp. 621–622.

Nguyen The Van. (1993). Inputs, outputs et fonctions de coût bancaire: critiques et reformulation. *Revue d'économie financière*, 155-168.

Otman Joumady, (2001), Déréglementation du marché des capitaux et efficiences de l'intermédiation bancaire au Maroc. Université Lumière Lyon 2.

Paradi, J. C., & Zhu, H. (2013). A survey on bank branch efficiency and performance research with data envelopment analysis. *Omega*, *41*(1), 61-79.

Paradi, J. C., Rouatt, S., & Zhu, H. (2011). Two-stage evaluation of bank branch efficiency using data envelopment analysis. *Omega*, *39*(1), 99-109.

Paradi, J. C., Vela, S. A., & Zhu, H. (2010). Adjusting for cultural differences, a new DEA model applied to a merged bank. *Journal of Productivity Analysis*, *33*(2), 109-123.

Parsons, L. J. (1994). Productivity versus relative efficiency in marketing: Past and future. In T. Laurent., G. Lilien, G.L. Pras (Eds.), Research traditions in marketing (pp.169-200). Boston: Kluwer Academia Publisher.

Saha, A., Ahmad, N. H., &Dash, U. (2015). Drivers of technical efficiency in Malaysian banking: a new empirical insight. *Asian-Pacific Economic Literature*, *29*(1), 161-173.

Said, J., Hasnan, S., Ismail, F., Majid, M. S. A., & Rahim, R. A. (2013). Efficiency of Islamic and conventional banks in Malaysia. *Journal of Financial Reporting and Accounting*.

SEALEY C. et J. LINDLEY, 1977, 'Inputs, outputs, and a theory of production and cost at depository financial institutions', *Journal of Finance*, 32, 1251-1266.

Staub, R. B., e Souza, G. D. S., & Tabak, B. M. (2010). Evolution of bank efficiency in Brazil: A DEA approach. *European journal of operational research*, *202*(1), 204-213.

Sufian, F., & Kamarudin, F. (2016). Determinants of efficiency in the Malaysian banking sector: Does bank origins matter?. *Intellectual Economics*, *10*(1), 38-54.

Tsolas, I. E. (2010). Modeling bank branch profitability and effectiveness by means of DEA. *International Journal of Productivity and Performance Management*.

Tsolas, I. E. (2010). Modeling bank branch profitability and effectiveness by means of DEA. *International Journal of Productivity and Performance Management*.

Varian, H.R. (1997). Introduction à la Microéconomie (4ed.). Paris: De Boeck Université.

Vettori, G. A. F., & Jarillo, J. C. (2000). Les Economies d'Echelle: Du concept à l'application, le secteur bancaire suisse.

Weill, L. (2004). Measuring cost efficiency in European banking: A comparison of frontier techniques. *Journal of Productivity Analysis*, *21*(2), 133-152.

Wu, D. D., Yang, Z., & Liang, L. (2006). Using DEA-neural network approach to evaluate branch efficiency of a large Canadian bank. Expert systems with applications, 31(1), 108-115.