Comparative Analysis of Technical, Allocative and Cost Efficiency of Nigerian Deposit Money Banks

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Abstract

This paper investigated the consistency of technical, allocative and cost efficiency of deposit money banks in Nigeria over the period 2010 to 2017 using non-parametric, data envelopment analysis (DEA) techniques. Among others, the results suggested moderate consistency between cost and technical efficiency and higher allocative efficiency scores rankings. Based on these findings, the paper concluded that the efficiency levels of the sector were relatively strong, implying that as financial deepening improved, the sector's ability to finance real activity grew stronger; further improving banking habits and the efficiency of intermediation. However, technical inefficiency was the major source of inefficiency, which calls for managerial development in order to scale up the efficiency levels.

Keywords: Efficiency, Banks, Data Envelopment Analysis

JEL Classification Numbers: D24, G21, L25, N17

I. Introduction

Globally, the banking sector has witnessed significant developments during the last three decades, as changes in the operating environment have had substantial implications for the way and manner banking services are carried out. Deregulation, globalisation, financial innovation and technological progress have all impacted gradually on their operational efficiency (Dong et al., 2014). However, given the importance of efficiency measures, as a tool for policy makers and market participants in assessing banks' ability to offer value-adding services, both regulators and practitioners rely increasingly on economic theory and empirical analysis to measure the efficiency of banks and compare peers in consolidating market position (Fiorentino et. al., 2006).

Therefore, the measurement of efficiency and productivity in the performance of individual banks and the industry are fundamental to their operational sustainability and economic growth. Banking system assets constitute a substantial proportion of total output. Banks take deposits, create credits, and provide liquidity for a smooth functioning payments system. An efficient banking system is essential for building sustainable economic growth and vibrant economic system. Therefore, the essence of enhanced economic efficiency is to reduce spreads

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between lending and deposit rates, which allows financial and real resources to flow freely to their highest-return uses. This is likely to stimulate both greater mobilisation of savings through the banking system and increase loan demands for small businesses and industrial investment (Karimzadeh, 2012).

According to Ikhide(2000; pp. 4) "Banks in most developing countries, operate with relatively wide spreads. Although, government policies and regulations, as well as, poor state of infrastructure are considered major causes of such wide spreads. However, studies on banking efficiency have pointed at operating inefficiencies as one other possible source that needs to be investigated. Wide spreads affect intermediation and distort prices thus impairing the role of the financial system in contributing to rapid economic growth".

Nevertheless, the Nigerian banking sector has witnessed remarkable reforms in recent decades, given the increasing wave of globalisation, structural and technological changes, and integration of financial markets. These reforms have been channeled towards: achieving further liberalisation of banking business; ensuring competition and safety of the system; and proactively positioning the industry to perform the role of intermediation and playing a catalytic role in economic development (Kama, 2006). Consequently, the Central Bank of Nigeria (CBN), in collaboration with the other stakeholders, has adopted several policies to promote the transformation of Nigerian banking system into market-oriented industry. Policy and regulatory frameworks, including the system of prudential regulation and supervision, were overhauled, including code of conduct and laws on sound transactions. Beyond these, banking consolidation was implemented to position the industry to meet up with the global market and technological progression.

The reforms, among others: ensured the protection of depositors' funds, by ring-fencing banking from other non-banking businesses, as redefined in the licensing model of banks and minimum requirements to guide bank operations, going forward; regulated the business of banks without hindering growth aspirations; and facilitated more effective regulator intervention in public interest entities. The redefined model allows for three categories of banks, as follows: commercial (international, national or regional), merchant (national) and specialised (non-interest-national or regional, primary mortgage, micro-finance, development banks), with their respective capital requirements.

Studies on banks' efficiency have been conducted in several countries. In Nigeria, the studies include Fagge et al., (2012); Ehimare, (2013); Oluitan et al., (2015); Jibrin et al., (2015); Nyong, (2017); Ajayi et al., (2017); and Oke et al., (2017) with varying results and policy implications. For instance, Fagge et al., (2012) conducted a study on the extent to which banks' efficiency has changed over time in Nigeria. The results revealed mixed developments in terms of technical, pure technical and scale efficiencies of banks during the assessment period. Average pure technical efficiency at 39.8 per cent was higher than the scale and technical efficiencies at 30.0 and 24.5 per cent, respectively. Whereas average technical change and efficiency change index were at 1.2 and 2.3 points, respectively.

Ehimare (2013) and Ajayi et al., (2017), conducted similar studies on banks' efficiency, using DEA technique. The results of these studies suggested that while some banks remained efficient throughout the study periods 2006 – 2009, others were inefficient banks.

Specifically, the national licensed banks recorded better mean efficiency scores in 2011, 2012 and 2013, whereas the international licensed banks achieved efficiency scores in 2014 and 2015. The inefficiency scores were attributed to scale inefficiency rather than pure technical inefficiency. The papers called for the regulatory authority to ensure regulatory compliance. Oke et al., (2017), suggested that small banks tend to be more cost-efficient than medium and big banks. Similarly, medium-sized banks tended to be more cost-efficient than big banks, whereas big banks recorded the highest cost efficiency scores in post-consolidation period, due to scale economies. However, cost efficiency of the sector was the highest during consolidation period, followed by pre-consolidation and least in three years after consolidation. Therefore, the study called for improved corporate governance, best managerial practice to achieve efficiency.

Findings from Nyong (2017), revealed high record of inefficiency among the banks, due to waste in utilisation of resources. Inefficiency ranges from 36 per cent in 2001 to 45 per cent in 2002 and from 34 per cent in 2009 to 35 per cent in 2008. The banks' inefficiency is due more to pure technical efficiency rather than scale efficiency. The sources of inefficiency were linked to: low capital-to-asset ratio; high operating expense-to-income ratio; low returns on equity; market share; interest expense-to-deposit ratio; and low liquidity ratio. The results had strong policy implications for banks and called for the regulatory/supervisory authorities to minimise distress and avert bank failure.

This research work was carried out to fill the gaps on the basis of the issues raised in some of the previous studies. Specifically, this study expanded the scope of the study by Fagge et al., (2012) by examining technical, allocative and cost efficiency of Nigerian deposit money banks. The choice for this scope covers the period of economic crisis and its effect on the baking system as well as the policy measures taken to address the issues.

The objective of this paper, therefore, is to assess the efficacy of Nigeria's banking system by examining the developments in technical, allocative and cost (economic) efficiency of deposit money banks. The paper is divided into five sections. Following the introduction, Section 2 presented a brief review of the related literature, while Section 3 examined the empirical model and methodology. Sections 4 contained model specification and analysis of data, while Section 5 provided the conclusion and policy recommendations.

II. Related Literature

A number of studies have been conducted on banks' efficiency. This paper seeks to enrich the existing literature on economic efficiency of the banking sector. Mamonov and Vernikov (2015) conducted a study comparing efficiency of public, private and foreign banks in Russia, using stochastic frontier analysis (SFA) of bank-level using quarterly data spanning 2005 to 2013. The results suggested that foreign banks appeared to be the least cost-efficient, while the core state banks were, on the average, nearly as efficient as domestic private banks. The results further showed that foreign banks were capable of being more cost-efficient than others, if they increase loans-to-assets ratios above the sample median level. Conversely, core state banks led in terms of cost efficiency, if their loans-to-assets ratio fell below the sample median level.

Jreisat and Al-Barghouthi (2015) examined cost efficiency for 17 Jordanian banks (2 large, 8 medium, 4 small and 3 foreign) for the period 1996-2007, using the parametric stochastic frontier analysis (SFA) technique, based on the measures or indicators of cost efficiency identified by Papke and Wooldridge (1996). The research findings showed that both the domestic and foreign banks had shown slight improvements. In addition, the paper investigated whether or not ownership structure, size, number of branches and automated teller machine (ATM), bad loan and age of the bank significantly affected the cost efficiency levels of Jordanian banks. The results showed that differences in ownership structure significantly affected Jordanian banks performance in terms of cost efficiency.

Zhao and Kang (2015) examined the cost efficiencies of 18 Chinese commercial banks, divided into state-owned and the joint-stock banks, using stochastic frontier analysis (SFA) technique. The findings revealed that there was an upward trend in the overall mean of cost efficiencies of the sample banks. The cost efficiencies of the state-owned banks had improved greatly, while the cost efficiency gap between the state-owned banks and the joint-stock banks decreased. Overall, the economic (cost) efficiency of the 18 Chinese commercial banks increased.

Raina and Sharma (2013) examined the cost efficiency of Indian commercial banks, using data envelopment analysis (DEA) over the period 2005:06 to 2010:11. They specifically incorporated interest and non-interest income measures in their estimation. The result showed that despite the existence of enabling environment, which served as a catalyst in improving the level of cost or economic efficiency, there was noticeable record of inefficiency among the banks, due to the regulatory challenge, rather than the managerial difficulties.

Raphael (2013) used data envelopment analysis (DEA) technique to assess the relative efficiency of 58 selected commercial banks operating within the East African Community, which include Tanzania, Kenya, Uganda, Rwanda and Burundi, from 2008 to 2011. The estimation results were mixed indicating a sharp decline of technical efficiency from 0.81 in 2008 to 0.56 in 2009. It, however, showed an increasing trend afterwards, reaching 0.73 in 2011. The result further revealed that most commercial banks in the Zone were operating at a decreasing return to scale, implying inefficient utilisation of input. The study recommended that banks should make use of their underutilised resources and reduce operating expenses In order to be relatively efficient in the production frontier.

Tabak et al., (2011) studied the influence of banks' concentration on cost and profit efficiency, using a sample of 495 Latin American banks over the period 2001-2008. The results indicated that: scale efficiency of the banks were close to their optimal size; banks were more inefficient in profits than in costs; concentration impaired cost efficiency; larger banks had higher performance, but this advantage decreased in concentrated markets; private and foreign banks were the most efficient; and most banks were operating with increasing returns of scale.

Xianga et al., (2011) employed a mixed two-stage approach to estimate and explain differences in the cross-country efficiency of 10 Australian, 5 UK and 8 Canadian banks over the period 1988 to 2008, using stochastic distance, cost and profit frontiers. Their results showed that Australian banks exhibited superior efficiency, compared with their Canadian and UK counterparts. Key factors found to have affected efficiency positively included the level of intangible assets and the loans-to-deposits and loans-to-assets ratios. In contrast, key factors found to affect efficiency negatively included bank size and the ratios of loan loss provisions-to-total loans and the debt-to-equity ratios.

Brack and Jimborean (2010) investigated the economic efficiency of French banks vis-a-vis their European (Germany, Italy, Spain, and the United Kingdom) and the United States' 10 biggest counter-parts over the period 1994-2006 using DEA technique. The results showed improvement in cost-efficiency of French and Spanish banks, while there was deterioration in the other countries. Further tests of convergence suggested that inefficient banks had reduced the gap during the period. They also applied censured Tobit model and proved that capitalised, newly-established banks, with tighter ratios of Tier 1 capital and operating in a country with a lower GDP per capita recorded the highest cost-efficiency scores.

Isik and Hassan (2002) employed both parametric and non-parametric data envelopment analysis (DEA) techniques to examine technical, pure technical, scale, allocative, cost and profit efficiency measures in the Turkish banking industry over the period 1988 - 1996. The findings revealed that the heterogeneous characteristics of banks had significantly impacted on their efficiency. Cost and profit efficiency had exacerbated over time. The results also indicated that the dominant source of inefficiency was technical, rather than allocative inefficiency, which was mainly attributed to diseconomies of scale. The study recommended that government should implement financial reforms that would foster competition in the sector and devise incentive schemes to improve managerial efficiency.

Oluitan et al., (2015) conducted a study on cost efficiency of some deposit money banks (DMBs) in Nigeria. The work involved a sample of 15 banks using the stochastic frontier model with data spanning 2002 to 2013. The findings showed that the efficiency of the banks examined varied between 0.97 and 0.99 with an average value of 0.98. The study established that these banks were highly efficient with cost in determining their non-interest revenue at 99.9 per cent, which represented the highest level of cost efficiency attained.

III. Methodology

The literature distinguishes two main approaches in measuring banking efficiency; parametric and non-parametric approach in which the specifications of a production function is required in both methods. The parametric approach involves the specification and econometric estimation of a statistical or parametric function, such as stochastic frontier analysis (SFA), while the non-parametric technique offers a linear boundary by enveloping the experimental data points, known as “Data Envelopment Analysis” (DEA) (Karimzadeh, 2012).

This study adopts the non-parametric technique of DEA because it allows the assessment of the performance of banks as homogeneous decision making units (DMUs). The key advantage of DEA is that it allows for a specification of multiple outputs and inputs unlike the SFA. This study, thus, estimates technical, allocative and cost (economic) efficiency of banks. The main objective of DEA is to establish which firms are operating on their efficient frontier and which firms are not. If the firm's input-output combination lies on the DEA frontier, the firm is considered efficient; but the firm is considered inefficient if the firm's input-output combination lies inside the frontier.

As cited by Tahir et al., (2009: PP 99) "the evaluation of bank efficiency creates several problems, which arise as a result of the nature and function of financial intermediaries, especially as banks are multi-product firms that do not produce or market physical products. One of the major problems in the study of bank efficiency is the specification of bank inputs and outputs. There has been long-standing disagreement among researchers over what banks produce. The most debatable issue is the role of deposits and, more specifically, whether they should be treated as inputs and/or outputs. Some researchers, such as Elyasiani and Mehdian (1990) and Lang and Welzel (1996) treat them as inputs, but researchers such as Berger and Humphrey (1991) and Ferrier and Lovell (1990), treat deposits as outputs, while other researchers, such as Humphrey (1990) and Aly et. al., (1990) treat them simultaneously as inputs and outputs"(pp 99).

Thus, these studies as highlighted above indicate two ways of measuring bank outputs; the production approach and the intermediation approach. Under the production approach, banks create accounts and process deposits and loans, and acquire operating costs. Under the intermediation approach, banks are treated as financial intermediaries that combine deposits, labour and capital to produce loans and investments. The values of loans and investments are treated as output measures; labour, deposits and capital are inputs; and operating costs and financial expenses comprise total cost.

III.1 Data Envelopment Analysis

DEA has been identified as a linear programming technique that provides a means of calculating apparent efficiency levels within a group of organisations. The efficiency of a firm is calculated, relative to the group's observed best practice. Thousands of DEA studies have been reported in areas, including agriculture, education, financial institutions, health care, transportation, public sector firms, sports, armed forces, market research, among others. (Fagge et al., 2012).

As highlighted above, DEA is a deterministic technique for examining relative efficiency, based on the data of selected inputs and outputs of a number of entities, called decision making units (DMUs). From the set of available data, DEA identifies relatively efficient DMUs (that are used as reference points), which define the efficiency frontier, and also evaluates the inefficiencies of other DMUs, which lie below that frontier (Karimzadeh, 2012). It also identifies for inefficient DMUs, the sources and level of inefficiency for each of the inputs and outputs (Charnes et al., 1995; Repkova, 2015).

Similarly, DEA serves as an alternative analytic technique to regression analysis.

Regression analysis approach is characterised as a central tendency approach and it evaluates DMUs relative to an average. In contrast, DEA is an extreme point method and compares each DMU with the only best DMU. The main advantage of DEA is that, unlike regression analysis, it does not require an assumption of a functional form to relate inputs and outputs. Instead, it constructs the best production function solely on the basis of observed data; hence, statistical tests for significance of the parameters are not necessary (Chansan, 2008; Karimzadeh, 2012).

According to Cook and Seiford (2009), the DEA approach has its origins in Farrell (1957) who applied it to a production unit, employing a single input with which to produce a single output. It was later generalised by Charnes et al. (1978), with the assumption of constant returns to scale (CRS) to handle DMUs facing multiple inputs and multiple outputs. In contrast to CCR model, the BCC's model (Banker et al., 1984) assumes a variable output with respect to the scale. The model showed that the concept of efficiency measurement can be divided into two components, technical efficiency (TE) and allocative efficiency (AE). Furthermore, the technical efficiency is decomposed to pure technical efficiency and scale efficiency in order to measure the output to scale as well as efficiency itself.

Similarly, Farrell (1957) describes technical efficiency as the firm's ability to obtain maximal output from a given set of inputs, while allocative efficiency means the firm's ability to use inputs in optimal proportions, given its respective prices and production technology. The most conjoint concept is technical efficiency, which transforms physical inputs (services of employees and machines) into outputs, relative to best practice. Technical efficiency happens when there is no possibility to increase the output without increasing the input. Thus, it is really a prerequisite for economic efficiency. Economic efficiency occurs when the production cost of an output is as low as possible. In order to achieve economic efficiency, technical efficiency must have been achieved. An organisation operating at best practice is said to be 100 per cent technically-efficient. However, if the organisation operates below best practice levels, then the organisation's technical efficiency is expressed as a percentage of best practice (Darrat et al., 2002). Managerial practices and the scale or size of operations affect technical efficiency. Allocative efficiency occurs when there is an optimal distribution of goods and services, taking into account consumer's preferences. Thus, it is at an output level where the price equals the marginal cost (MC) of production.

Mathematically, relative efficiency of a DMU is defined as the ratio of weighted sum of outputs to weighted sum of inputs. However, CRS efficiency scores will never be higher than that of VRS efficiency scores. Similarly, in the CRS model, the input-oriented efficiency scores are exactly equal to the inverse of the output-oriented efficiency scores (Karimzadeh, 2012).

According to Karimzadeh (2012), allocative efficiency is expressed as a percentage score, with a score of 100 per cent, indicating that the organisation is using its inputs in the proportions that minimises its costs, given relative input prices. Finally, cost efficiency (total economic efficiency) refers to the combination of technical and allocative efficiency. An organisation will only be cost-efficient, if it is both technically and allocatively efficient. Thus, cost efficiency is calculated as the product of the technical and allocative efficiency scores, expressed as a percentage. So an organisation can only achieve a 100 per cent score in cost efficiency if it has achieved 100 per cent in both technical and allocative efficiency.

According to Darrat et al., (2002) to compute cost efficiency for a particular bank(x), we first find the minimum cost of producing outputs, given input prices(y). Suppose that there are (*n*) banks, utilising (*m*) different inputs, to produce (*s*) different outputs, cost minimisation is calculated by the following linear programming problem:

$$\text{Min}_{1i} \sum_{i=1}^{m} w_i I_i, \quad \textit{subject to} \quad \sum_{j=1}^{n} \lambda_j O_{rj} \geq O_{rjo},$$
$$\sum_{j=1}^{n} \lambda_j I_{ij} \leq I_{ijo}, \qquad (1)$$
$$\sum_{j=1}^{n} \lambda j = 1, \qquad \lambda j \geq 0.$$

Where for bank *j*, λ_j and w_j are the intensity variable and input prices, respectively. O_{rj} is the r^{th} output variable of the bank; I_{ij} is the i^{th} input variable of the bank; O_{rjo} is its observed output vector; and I_{ijo} is its observed input vector. Cost efficiency for bank *j* is measured by the ratio of minimum cost to actual cost incurred by the bank. In order to calculate technical efficiency (TE) for bank j, we solve the following linear programming problem:

$$\text{Min} \quad \Theta, \ \text{subject to} \ \sum_{j=1}^{n} \lambda_j O_{rj} \geq O_{rjo}$$
$$\sum_{j=1}^{n} \lambda_j I_{ij} \leq \Theta . I_{ijo}, \qquad (2)$$
$$\lambda j \geq \text{O}.$$

As highlighted above, technical efficiency (TE) can be decomposed into pure technical efficiency (PTE) and scale efficiency (SE). Scale efficiency occurs if the bank does not operate at constant return to scale, while pure technical efficiency accounts for efficient input utilisation.

IV. Analysis of Data and Model Specification

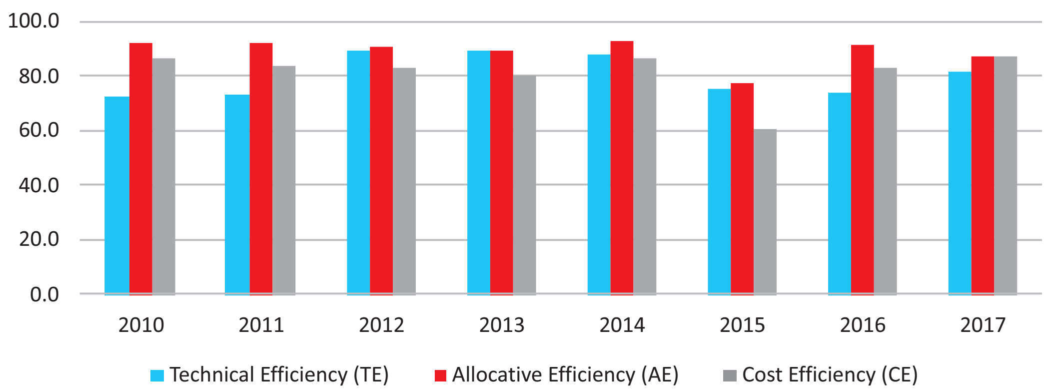
This paper relied on the intermediation approach, given the financial intermediary role banks play in the economy, to define bank inputs and outputs. Accordingly, four inputs were used consisting of average total assets; total deposits; capital employed; other operating expenses, while the four outputs included profit before tax; gross earnings; total loans and advances; and value-added.

IV.1 Empirical Findings

In this section, we present the estimated results of the technical, allocative and cost efficiency scores for the examined banks, using performance improvement measurement PIM-DEA software. DEA provides an efficiency rating that generally ranges between 0 and 1, which will interchangeably be referred to as an efficiency percentage ranging between zero and 100 per cent. The upper limit is set as 1 or 100 per cent to reflect the view that a DMU cannot be more than 100 per cent efficient. However, where it's more than 100 per cent, it's called super-efficient.

Figure 1 (Appendix 1: Tables 1 - 4) showed the respective technical, allocative and cost efficiency scores of the banking sector for the reference period 2010 – 2017. The average technical efficiency results for 2010,2011,2012,2013,2014,2015,2016 and 2017 were 72.6, 73.3, 89.7, 89.4, 88.5, 75.8, 74.0 and 81.8 per cent, respectively. Similarly, the average allocative and cost efficiency scores for these periods were 92.5, 92.4, 91.4, 89.5, 93.3, 77.5, 91.8 and 87.5 per cent; and 87.0, 83.8, 83.4, 80.4, 86.8, 61.0, 83.7 and 87.5 per cent, respectively. While the mean technical, allocative and cost efficiency indices were 80.6, 89.5 and 81.7 per cent, respectively.

Figure 1: Average Efficiency Scores for Banks (2010-2017)



The efficiency estimates indicated that the efficiency levels of the sector were relatively strong and the banking habit and efficiency of intermediation improved. Thus, these factors helped in building up the efficiency levels for the Nigerian banking system over the years. At micro level, in 2010, the technical efficiency measurement showed that 10 out of 22 DMUs recorded relative efficiency rating of 100 per cent each. These 10 banks comprised the best practice set or best efficiency frontier. In other words, their input-output combinations lie on the efficiency frontier, while the remaining 12 banks had their input-output conditions inside the frontier showing the remaining levels of inefficiency. This implied that there were more inefficient banks in operation with other less-efficient banks. Despite being inefficient, efforts were made by bank 03, bank 09, bank 12, bank 05 and bank 19, having scored 97.2, 91.2, 88.1, 85.8 and 84.5, per cent, respectively, to operate on their frontier (Table 1).

Similarly, in 2011 and 2012, 9 out of 22 DMUs recorded relative efficiency rating of 100 per cent, lower than the preceding period by 10 percentage points. Also, these 9 banks comprised best efficiency frontier, which implied that their input-output combinations lied within the efficiency frontier. Comparable analysis holds for the 2013, 2015 and 2016, respectively, as 8 out of 22 DMUs were found to have operated on the frontier points. However, in 2014 and 2017, the sector recorded the highest performance with 11 out of 22 banks and 17 out of 22 banks, each attaining 100 per cent relative efficiency level, respectively.

The overall ratings of the industry suggested that 36.4 per cent of the DMBs were efficient in 2013, 2015 and 2016; 40.9 per cent in 2011 and 2012; 45.5 and 50.0 per cent in 2010 and 2014; and 77.3 per cent in 2017. Similarly, an average of 19.5 per cent was required for overall technical efficiency. This result further suggests that an average Nigerian bank, if producing its output at 72.6 per cent on the efficiency frontier, instead of its current (virtual) location, would need only 27.4 per cent of the input currently being used in 2010. This interpretation of efficiency frontier scores could be extended to subsequent periods in the sample analysis.

This result connotes that the magnitude of overall average technical inefficiency in the banking sector would also need an index to the tune of 26.7 per cent in 2011; 10.3 per cent in 2012; 10.6 per cent in 2013; 11.5 per cent in 2014; 24.2 per cent in 2015; 26.0 per cent in 2016; and 19 per cent in 2017, to scale up the efficiency levels.

This analysis further revealed that, by adopting best practice technology, deposit money banks could, on the average, reduce their inputs of average total assets, total deposits, capital employed and other operating expenses by at least the levels of overall technical inefficiencies for the respective periods, under review and still produce the same levels of outputs. However, the potential reduction in inputs for adopting best practices varied, from bank to bank.

IV.2 Comparing Technical, Allocative and Cost Efficiency Scores

According Batir et al., (2017) technical efficiency measures the proportional reduction in input usage, while allocative efficiency measures the proportional reduction in costs if the right mix of inputs are chosen by banks. In addition, cost efficiency is equal to the product of allocative and technical efficiency as cited in (Cooper, Seiford, & Tone, 2007, pp. 258-260; Isik & Hassan, 2002a, pp. 723,724).

They further maintained that cost efficiency as a measure of proportional reduction in costs, which can be acquired if the bank is technically and allocative efficient while the allocative efficiency is the measure of proportional reduction in costs when the bank chooses the right mix of inputs and technical efficiency is the measure of proportional reduction in input usage that can be obtained if the bank operates efficiently (Isik & Hassan, 2002a, p. 719).

Therefore, efficiency scores are used to benchmark banks against the most efficient banks operating under the same environment. As earlier mentioned, the average technical, allocative and cost efficiency scores of the banking sector for the period 2010 – 2017 were 80.6, 89.5 and 81.7 per cent, respectively. This result showed that an average bank operated at a technical efficient level of 80.6 per cent of the best performing bank in the sample. This implied that the best performing bank used fewer resources in producing the same amount of output as compared to the average bank in the sample. It indicated that the average bank could have used 19.4 per cent less resources, if it had used the method adopted by the most efficient bank. In other words, had the average bank operated at the same efficient level as the most efficient bank in the sample, it could have saved 19.4 per cent of the resources in producing the same amount of output.

The average allocative efficient score for the banking sector was 89.5 per cent, indicating that the average bank could have applied the same amount of input using 10.5 per cent less resources, if they had produced following the most efficient bank in the sample. The results implied that using the same amount of resources, the average bank could have used a relatively low volume of resources, if it had adopted the standard of the best performing bank in the sample. Similarly, the average cost efficiency of the banking sector for the period 2010 - 2017 stood at 89.5 per cent, indicating that an average bank operated at an efficient level of 89.5 per cent of the best performing bank in the sample. This means that the best performing bank used fewer resources in producing the same amount of output, compared to the average bank in the sample. It implied that the average bank could have used 10.5 per cent less resources if it had used the method adopted by the best practice bank. In other words, had the average bank operated at the same efficient level as the most efficient bank in the sample, it could have saved 10.5 per cent of the resources in producing the same amount of output.

Given that technical, allocative and cost inefficiency scores were low at an average of 19.4, 10.5 and 18.3 per cent, respectively, suggested that banks experienced low levels of wastage in the intermediation process. The banks had substantial room for significant technical, allocative and cost savings, if they had operated at the level of best practice, performing bank in the sample (Table 4). Theoretically, a bank is fully-efficient, if it produces the output level and mix that maximises profits and minimises possible costs. Therefore, this result revealed that most banks were economically-efficient, indicating profit maximisation at a given costs. According to Batir et al., (2017) as cited in Isik & Hassan (2002a), technical efficiency is related to managerial issues, while allocative efficiency is explained by regulatory factors.

More so, as indicated in Table 4, choosing the proper input mix and given the prices as well as employing all factor inputs, the analysis showed that the average technical efficiency index in 2010, at 72.6 per cent, was lower than allocative efficiency at 92.5 per cent. The result implied that the main source of technical inefficiency was the cost inefficiency at 13.0 per cent, which called for regulatory and managerial advice to scale up the efficiency levels. Similarly analysis holds for all the remaining periods, except in 2013, where the allocative efficiency was marginally higher than the technical efficiency by 0.01 percentage points.

V. Conclusion

In Nigeria, the banking sector has witnessed significant developments over the last three decades, as changes in the environment had substantial implications for their business activities. Deregulation, consolidation, globalisation, financial innovation and technological progress, all have gradually impacted on efficiency and performance of the industry, propelled by investment in corporate and good governance, better supervision, risk management, new information technology (IT innovation) and competition. The banks have also improved on their functional attitude, strategies and policies. Applying a non-parametric DEA approach, this study examined efficiency measures (technical, allocative and cost efficiency) of Nigerian deposit money banks. Industry-wise, the trends showed an average cost efficiency scores of 72.6, 73.3, 89.7, 89.4, 88.5, 75.8, 74.0, and 81.8 per cent, respectively, in 2010, 2011, 2012, 2013, 2014, 2015, 2016 and 2017, with a conforming average inefficiency of 27.4, 73.3, 10.3, 10.6, 11.5, 24.2, 26.0 and 18.2 per cent, respectively, which served as their sources to capture both cost (managerial) and allocative (regulatory) efficiencies.

Rationally, this inefficiency, though tolerable, has to be reduced in order to provide better services to the customers and supply adequate financial resources to the needs of the growing economy. The result also revealed that the Nigerian banking sector reforms of 2004 and 2009 had impacted on the banks' size, profitability, technological advancement, service delivery and, above all, economic efficiency, as evidenced by the improvement in the measure of efficiency of the sector, which averaged, 80.0 per cent in the review period.

References

Ajayi, M. A., Nageri, I. K., Abogun, S. & Abdulmumin, B. A. (2017). Evaluation of Deposit Money Bank's Efficiency in Nigeria: Data Envelopment Analysis. *Oshogbo Journal of Management* (OJM), 2(1), 68 – 83.

Aly, H. Y., Grabowski, R., Pasurka, C., & Rangan, N. (1990). Technical, Scale and Allocative Efficiencies in US Banking: An Empirical Investigation. *The Review of Economics and Statistics*, 72: 211-218.

Banker, R. D., Charnes, A. & Cooper, W. W. (1984). Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis. *Management Science*. Vol. 30 No. 9, September.

Batir, T., Eyceyurt, D., Volkman, A. & Gungor, B. (2017). Determinants of Bank Efficiency in Turkey: Participation Banks versus Conventional Banks. *Istanbul Review*, 17 – 2, pp 86 – 96.

Berger, A. N. & Humphrey, D. B. (1997). Efficiency of Financial Institutions: International Survey and Directions for Future Research. *European Journal of Operational Research*. Volume 98, Issue 2, April 16, Pages 175 – 212.

Brack, E. & Jimborean, R. (2010). The Cost-efficiency of French Banks. Published in*:* *Bankers, Markets and Investors* No. 105: pp. 21- 38.

Chansarn, S. (2008). Cost Efficiency Measurement with Price Uncertainty: A DEA Application to Bank Branch Assessments. *The Economic Journal*, 73-86.

Charnes, A., Cooper, W. W., & Rhoades, E. (1978). Measuring the Efficiency of Decision-making Units. *European Journal of Operational Research, No. 2, pp 429-444*.

Cooper, W. W., Seiford, L. M., & Tone, K. (2007) Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA Solver Software (Vol. 2). *Springer Science & Business Media*.

Cook, D. W. & Seiford, L. M. (2009). Data Envelopment Analysis (DEA) – Thirty Years On. *European Journal of Operational Research* 192 (1), pp 1 – 17.

Darrat, F. A., Topuz, C. & Yousef, T. (2002). Assessing Cost and Technical Efficiency of Banks in Kuwait. Being a Paper Presented at the *EFR's 8th Annual Conference*, held in Cairo, January.

Dong, Y., Hamilton, R., & Tippett, M. (2014). Cost Efficiency of the Chinese Banking Sector: A Comparison of Stochastic Frontier Analysis and Data Envelopment Analysis. *Economic Modelling*, *36*, 298-308.

Ehimare, O. A. (2013). Nigerian Banks' Efficiency Performance: A Post 2004 Banking Reforms Evaluation, Ph.D. Thesis, *Department of Banking and Finance*, Covenant University, Ota, Ogun State.

Elyasiani, E. & Mehdian, S. M. (1990). A Non-parametric Approach to Measurement of Efficiency and Technological Change: The Case of Large U.S. Commercial Banks. *Journal of Financial Services Research, 4 (2): 157-68.*

Fagge, A. I., Adamgbe, E. T. & Evbuomwan, O. O. (unpublished) Assessing

Technical and Scale Efficiency in Nigerian Banks.

Fagge, A. I., Hogan E. B. & Odey, L. I. (2012). How far has Banks' Efficiency Changed Overtime in Nigeria? An Empirical Investigation. *CBN Economic and Financial Review*, Vol. 50, No. 3, (Part A), September.

Farrell, M. J. (1957). The Measurement of Productive Efficiency. *Journal of Royal Statistical Society, 120(3), 253-281*.

Ferrier, G. D. & Lovell, C. K. (1990). Measuring Cost Efficiency in Banking: Econometrics and Linear Programming Evidence. *Journal of Econometrics, 46: 229-245*.

Fiorentino, E., Karmann, A. & Koetter, M. (2006). The Cost Efficiency of German Banks: A Comparison of SFA and DEA. Bundesbank Series 2, *Discussion Paper* No. 10.

Humphrey, D. B. (1990). Why do Estimates of Bank Scale Economies Differ? *Economic Review*, Federal Reserve Bank of Richmond, September/October: 38-50.

Ikhide, S. (2000). Efficiency of Commercial Banks in Namibia. Research Department, Bank of Namibia, *Occasional Paper* No. 4.

Isik, I. & Hassan, M. K. (2002a). Technical, Scale and Allocative Efficiencies of Turkish Banking Industry. *Journal of Banking and Finance*, Vol. 26, No. 4, April, pp 719 – 766.

Jibrin, M. A., Okorie, G., Okoro, A. S., Dada, E. A., Chiemeke, C., & Owolabi, O. H. (2015). Strategies for Lowering Banks' Cost of Funds in Nigeria, *CBN Working Paper Series* (CBN/WPS/01/2015/05).

Jreisat, A. & Al-Barghouthi, S. (2015). An Investigation into the Determinants of Cost Efficiency in the Jordanian Banks: An Application of Stochastic Frontier Methods. *Researchers World*, Vol. 6, ISS 1, January. Pp 73 -87.

Kama, U. (2006). Recent Reforms in the Nigerian Banking Industry: Issues and Challenges. The Dynamics of Exchange Rate in Nigeria. *CBN Bullion Publication*, Volume 30, No. 3.

Karimzadeh, M. (2012). Efficiency Analysis by using Data Envelopment Analysis Model: Evidence from Indian Banks. *International Journal of Latest Trends in Finance & Economic Sciences*, Vol. 2, No. 3, September.

Mamonov, M. & Vernikov, A., (2015). Bank Ownership and Cost Efficiency in Russia, Revisited. *Higher School of Economics Research Paper* No. WP BRP 46/FE/June.

Nyong, M. O. (2017). Relative Efficiency of Commercial Banks in Nigeria: A Nonparametric Mathematical Optimisation Analysis, *Noble International Journal of Economics and Financial Research*, Vol. 2, No. 2, pp: 27-49.

Oke, D. A., Ogbuji, I. A. & Bokana, K. G. (2017). Deposit Money Banks' Efficiency in Three years after, during and before the 2004–2005 Consolidation in Nigeria: The Puzzle on Size, *Banks and Bank Systems*, Volume 12, Issue 3, pp. 193-203.

Oluitan, R., Michael, B. & Onyebuchi, J., (2015). Cost Efficiency of Nigerian Banks an

Empirical Analysis, *International Journal of Development Strategies in Humanities, Management and Social Science,* Volume 5, Number 1, July.

Papke, I. E. & Wooldridge, J. M. (1996). Econometric Methods for Fractional Response Variables with an Application to 401(K) Plan Participation Rates. *Journal of Applied Econometrics* 11, pp. 619 – 632.

Raphael, G. (2013). Efficiency of Commercial Banks in East Africa: A Non Parametric Approach. *International Journal of Business and Management*. Vol. 8, No. 4.

Tabak, B. M., Fazio, D. M. & Cajueiro, D. O. (2011). Profit, Cost and Scale Efficiency for Latin American Banks: Concentration-Performance Relationship. *Central Bank of Brazil*, *Working Paper Series* no. 244, May.

Tahir, I. M., Abu Bakar, N. M. & Haron, S. (2009). Evaluating Efficiency of Malaysian Banks Using Data Envelopment Analysis. *International Journal of Business and Management.* Vol. 4, No. 8, August. Pp 96 – 106.

Xianga, D., Shamsuddinb, A. & Worthingtona, A. C. (2011). A Comparative Technical, Cost and Profit Efficiency Analysis of Australian, Canadian and UK Banks: Feasible Efficiency Improvements in the Context of Controllable and Uncontrollable Factors. *Griffith University, Business School Discussion Papers Finance,* No. 19, ISSN 1836 – 8123.

Zhao, H. & Kang, S. (2015). Cost Efficiency of Chinese Commercial Banks. *International Journal of Finance and Accounting,* Vol. 4, No. 3, pp 180-186.

APPENDIX 1

Appendix 1: Technical, Allocative, Cost and Industry Average Efficiency Scores

Table 1

Charnes, Cooper and Rhodes (CCR) Technical Efficiency (TE) Percent

DMUs	2010	2011	2012	2013	2014	2015	2016	2017
Bank01	100	100	100	100	100	100	100	100
Bank02	100	100	100	100	100	100	100	100
Bank03	97.2	98.64	91.8	79.73	95.78	100	100	100
Bank04	100	100	98.74	85.43	99.32	71.77	69.17	100
Bank05	85.78	100	94.96	87.26	86.16	78.81	97.69	100
Bank06	100	100	78.72	89.26	100	83.16	81.66	100
Bank07	79.01	81.36	91.22	86.42	92.79	58.9	98.18	100
Bank08	100	80.52	92.07	84.73	82.95	67.33	100	100
Bank09	91.22	100	91.57	88.95	92.46	81.3	0	0
Bank10	100	100	99.85	100	100	100	100	100
Bank11	0	0	74.31	67.75	56.39	70.28	55.86	100
Bank12	88.08	61.92	87.4	86.21	100	58.97	0	0
Bank13	100	100	100	100	100	100	100	100
Bank14	0	0	8.07	56.5	82.87	32.27	78.8	100
Bank15	100	96.08	100	96.1	100	73.69	100	100
Bank16	100	85.84	77.06	76.78	73.09	72.49	63.53	100
Bank17	100	100	100	98.15	100	100	90.93	100
Bank18	71.64	76.9	87.13	100	100	100	95.95	100
Bank19	84.55	91.49	100	100	100	100	95.7	100
Bank20	0	0	100	84.37	85.82	37.83	0	0
Bank21	0	39.65	100	100	0	79.74	100	100
Bank22	0	0	100	100	100	0	0	0
Average	72.6	73.3	89.7	89.4	88.5	75.8	74.0	81.8

Table 2

Allocative Efficiency Ratings

DMUs	2010	2011	2012	2013	2014	2015	2016	2017
Bank01	100	100	100	100	100	92.84	100	91.09
Bank02	90.83	93.53	92.44	87.56	100	100	100	77.5
Bank03	90.67	91.01	93.22	96.28	97.42	65.58	100	81.83
Bank04	100	100	88.46	87.71	92.98	72.96	93.04	93.06
Bank05	89	89.26	95.59	94.32	96.95	74.77	94.84	76.29
Bank06	92.75	100	83.44	84.86	95.68	60.88	88.94	72.48
Bank07	92.81	86.87	91.02	87.57	87.15	88.91	91.06	81.69
Bank08	100	89	94.77	88.89	92.42	71.42	89.72	86.64
Bank09	98.94	100	98.41	95.55	92.12	66.03	NaN	NaN
Bank10	100	99.71	95.92	94.3	92.28	64.14	91.43	88.75
Bank11	NaN	NaN	69.37	86.32	86.53	57.27	62.27	57.87
Bank12	91.6	81.04	89.93	81.66	83.02	92.13	NaN	NaN
Bank13	78.3	100	95.21	100	93.46	60	96.74	100
Bank14	NaN	NaN	63.98	78.59	82.97	80.31	96.8	80.22
Bank15	100	95.27	96.97	89.7	100	95.57	100	142.02
Bank16	68.71	73.49	88.93	82.9	92.3	71.61	86.43	85.24
Bank17	100	100	100	87.49	93.22	52.87	93.1	79.01
Bank18	90.36	94.21	92.87	75.12	87.81	100	93.94	81.59
Bank19	88.79	94.65	96.42	100	100	100	92.79	99.87
Bank20	NaN	NaN	82.77	89.67	92.57	95.41	NaN	NaN
Bank21	NaN	75.79	100	90.57	NaN	64.48	80.56	100
Bank22	NaN	NaN	100	90.32	100	NaN	NaN	NaN
Average	92.5	92.4	91.4	89.5	93.3	77.5	91.8	87.5

Table 3

Cost Efficiency Ratings

DMUs	2010	2011	2012	2013	2014	2015	2016	2017
Bank01	100	100	100	100	100	92.84	100	91.09
Bank02	90.83	93.53	92.44	87.56	100	100	100	77.5
Bank03	88.14	89.78	85.58	76.77	93.31	65.58	100	81.83
Bank04	100	100	87.34	74.93	92.35	52.37	64.36	93.06
Bank05	76.35	89.26	90.78	82.3	83.54	58.92	92.64	76.29
Bank06	92.75	100	65.68	75.75	95.68	50.63	72.63	72.48
Bank07	73.33	70.68	83.03	75.68	80.86	52.37	89.41	81.69
Bank08	100	71.67	87.25	75.32	76.66	48.09	89.72	86.64
Bank09	90.26	100	90.12	84.99	85.18	53.68	NaN	NaN
Bank10	100	99.71	95.78	94.3	92.28	64.14	91.43	88.75
Bank11	NaN	NaN	51.55	58.48	48.8	40.25	34.78	57.87
Bank12	80.68	50.18	78.59	70.4	83.02	54.33	NaN	NaN
Bank13	78.3	100	95.21	100	93.46	60	96.74	100
Bank14	NaN	NaN	5.16	44.41	68.76	25.91	76.27	80.22
Bank15	100	91.54	96.97	86.21	100	70.43	100	142.02
Bank16	68.71	63.08	68.53	63.65	67.46	51.91	54.91	85.24
Bank17	100	100	100	85.87	93.22	52.87	84.66	79.01
Bank18	64.73	72.45	80.91	75.12	87.81	100	90.13	81.59
Bank19	75.07	86.59	96.42	100	100	100	88.8	99.87
Bank20	NaN	NaN	82.77	75.65	79.44	36.1	NaN	NaN
Bank21	NaN	30.05	100	90.57	NaN	51.41	80.56	100
Bank22	NaN	NaN	100	90.32	100	NaN	NaN	NaN
Average	87.0	83.8	83.4	80.4	86.8	61.0	83.7	87.5

Table 4

Industry Average Efficiencies	2010	2011	2012	2013	2014	2015	2016	2017	Overall Mean
Technical Efficiency (TE)	72.6	73.3	89.7	89.4	88.5	75.8	74.0	81.8	**80.6**
Allocative Efficiency (AE)	92.5	92.4	91.4	89.5	93.3	77.5	91.8	87.5	**89.5**
Cost Efficiency (CE)	87.0	83.8	83.4	80.4	86.8	61.0	83.7	87.5	**81.7**
Number of Efficient DMUs/Banks									
Technical Efficiency (TE)	10	9	9	8	11	8	8	17	**10.0**
Allocative Efficiency (AE)	6	6	4	3	5	3	4	**1**	**4.0**
Cost Efficiency (CE)	6	5	4	3	5	3	4	**1**	**3.9**
Industry (%)									
Technical Efficiency (TE)	45.5	40.9	40.9	36.4	50.0	36.4	36.4	**77.3**	**45.5**
Allocative Efficiency (AE)	27.3	27.3	18.2	13.6	22.7	13.6	18.2	4.5	**18.2**
Cost Efficiency (CE)	27.3	22.7	18.2	13.6	22.7	13.6	18.2	4.5	**17.6**

Note: In 2017, bank15 recorded Efficiency and Super-efficiency scores in both AE and CE levels.

Source: Author's Computation