Measuring Technical Efficiency and Productivity Change in the Nigerian Banking Sector: A Comparison of non-parametric DEA and parametric SFA.

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Abstract

This study estimates technical efficiency, technological change and total factor productivity change in the Nigerian banking sector for the period 2005 – 2014, which encapsulates the post consolidation era and subsequent regime of banking reforms aimed at stabilizing the sector from the effects of financial crisis. The study applies both non-parametric Data Envelopment Analysis (DEA) and parametric Stochastic Frontier Approach (SFA), using Malmquist Productivity Index, and error component production function respectively, to ascertain if any significant variation in efficiency exists on a sample of twelve banks covering over 80% of total bank assets in Nigeria. The theoretical intermediation approach is applied for selection of input and output variables for both DEA and SFA. The input variables considered are total deposits, total equity and operating expenses including staff costs, and output variables are loans and operating income, which accounts for off-balance-sheet items such as non-interest or fee-based income. Findings reveal that a high degree of changes in total factor productivity is due to technological change, above all the magnitude of mean technical efficiency and total factor productivity change in DEA decreases as banks output move towards non-interest or fee based income, also inefficiency increases along the same line in SFA. Policy makers should be concerned about arbitrariness in bank's ability to earn fee-based income, which portends high cost of banking services in the long-run.

Keywords: Bank Efficiency; Data Envelopment Analysis (DEA); Malmquist Productivity Index; Stochastic Frontier Approach (SFA); Nigeria Banking

JEL Classification Code: D21, D53, G21

1.0 Introduction

There is a lack of consensus among researchers regarding the preferred choice of frontier model for the estimation of banking sector efficiency. The non-parametric method imposes less restrictions and does not allow for the analysis of random errors that may arise from data, model misspecification, measurement error and environmental factors prevailing against or in favor of the banking system. The presence of random errors which obviously are unobservable to the researcher poses a significant threat to the conclusions reached if not captured adequately. In this case the parametric method seems plausible in order to capture unobservable heterogeneity in decision making process of banks with respect to use of funds and other resources, but the nonparametric method seem to absorb the homogenous nuances that are inherently bank specific such as identifying slacks in inputs and outputs. Berger and Humphrey (1997) posits that the difference between the nonparametric and parametric approaches is important because the two types of methods tend to have different degrees of dispersion and rank the same financial institutions somewhat differently. This study attempts to estimate technical efficiency, technological change and total factor productivity change for the banking sector in Nigeria using both the non-parametric Data Envelopment Analysis (DEA) and the parametric Stochastic Frontier Approach (SFA) on post consolidation data, to ascertain if any significant variations in the efficiency levels exist, due to methodological differences that may affect policy decisions.[1]

In the wake of bank consolidation exercise in Nigeria, the banking sector witnessed a wave of mergers and acquisitions, which brought together many strange bed fellows in the industry. While some scholars argue that the productive efficiency of banks in Nigeria has improved following the consolidation exercise (Assaf, Barros & Ibiwoye, 2012), others argue that consolidation has had no significant effect on the efficiency of banks (Amel, Barnes, Panetta & Salleo, 2004). However, inefficiency in the allocation of resources in a liberalized environment could result in financial crisis, as a result bank's total factor productivity will be hampered (Tanna et al. 2017).[2] To this end, monetary authorities are always concerned about the effect of a policy change on the efficiency and productivity of banks (see Anginer and Demirguc-Kunt, 2014).[3] Because of output loss suffered through banking crises, and the sector-specific inefficiencies that unfolds, a negative productivity change has been observed both in the short and long-term (Oulton and Sebastia-Barriel, 2013). Nevertheless, Mester (2005) posits that consolidation is a positive for the banking industry in the sense that it eliminates inefficient firms and promotes a healthier banking system by diversifying risk and reducing the cost of production since the scale and scope is enlarged.

The intermediation efficiency of banks in both developed and developing economies has been an issue of immense scholarly discourse because to a large extent it determines the efficient

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[1] Technical efficiency is the ability of banks to maximize output from a given set of inputs, and Technological change is the adoption of new methods of productivity. Total factor productivity change is captured by DEA using Malmquist productivity index, while technical efficiency is measured on both DEA and SFA.

[2] Laeven and Valencia (2013) observed that a typical feature of financial crisis is that they are preceded with credit boom and greater financial integration, as was the case in Nigeria in 2009, following bank consolidation exercise of 2005, which seemed like a credit boom to the banking industry because it opened up the banks for investment through the capital market.

[3] Gulamhussen et al., (2014), and Fielding and Rewilak (2015) have documented greater bank risk taking and diversification in a liberalized banking system resulting in a negative effect on bank productivity growth.

allocation of resources required for economic growth and development, since banks play a pivotal role in the intermediation of funds in the economy. However, as macroeconomic factors pose existential threats to the banking industry, policy makers are often confronted with the problem of balancing the efficacy of policy instruments and the efficiency levels at which the banks operate in order to maintain an optimum performance of banks and the sustainability of the financial system. In a bid to make sound decisions there is a need for policy makers to understand how management optimize the use of productive resources in a very competitive industry such as banking. In their intermediation role, banks take deposit from the public, give loans and invest in securities using both skilled and unskilled labor, physical and financial capital. The question that is posed by this study is how efficient are banks in Nigeria in the use of resources, and what are the factors that determine their efficiency levels? To the knowledge of the authors no study has been able to identify the difference between the deterministic efficiency obtained from DEA and the error component productive efficiency on SFA for banks in Nigeria especially arising from the consolidation exercise and the subsequent impact on the technical efficiency of banks. The Malmquist Productivity Index (MPI) proposed by Fare et. al. (1994) is used in this study to measure total factor productivity change; while efficiency measures are obtained through DEA, productivity change is calculated from MPI as the ratio of the efficiency obtained in DEA for two different time periods for a decision making unit (DMU).

The motivation for this study stems from empirical evidence, which posits that the difference between nonparametric and parametric approaches is important because the two types of methods tend to have different degrees of dispersion and rank the same financial institutions somewhat differently.[4] This paper improves on previous bank efficiency studies by including operating income, which accounts for non-interest or fee based income as an output variable in order to ascertain the degree of dispersion in efficiency or productivity change for interest (loan) revenue and non-interest or fee based income.[5] Results show that the degree of technical efficiency and total factor productivity change diminishes as banks revenue portfolio moves towards non-interest or fee based. Policy implications are further identified to limit the arbitrariness of banks in their increasing desire for fee-based income. This study is presented in six sections, the next section is a review of the structure of Nigerian banking system, the third section is a review of related literature and the underlining theories on bank intermediation and productive efficiency, the fourth section is a presentation of data and methods of analyzing efficiency and productivity change, the fifth section presents a discussion of the results, while the sixth section concludes the study and provides direction for future research.

2.0 Banking Structure in Nigeria

The Nigerian banking system has over the years evolved through the process of restructuring since the Structural Adjustment Program (SAP) of 1986, which introduced a regime of deregulation in the banking sector. The number of banks increased from 29 in 1986 to 89 in 2004 before the consolidation exercise, down to 25 after consolidation in December 2005.

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[4] Berger and Humphrey (1997) observed that the central tendency of efficiency estimates from non-parametric DEA and parametric SFA may be similar but the degree of dispersion differs irrespective of the similarity in the structure of decision making units.

[5] Osuagwu and Nwokoma (2017) finds that banks in Nigeria become less competitive for non-interest revenue or fee-based income, because less technical or skilled manpower is needed. However, it is not known whether low competitiveness for fee based income is driven by increased demand for banking services, which in turn requires managerial effectiveness and technological improvements.

Following recent restructuring of the imbalances arising from the consolidation exercise and global financial crisis the total number of banks in Nigeria settled at 20 as at 2014.[6] Within this period the banking system went through turbulence, albeit structural changes occasioned by internal managerial inefficiencies, industry wide factors and macroeconomic circumstances affecting the overall performance of the sector. Although the regime of deregulation opened the banking space in Nigeria, it also introduced many of the incidental anomalies that the industry is still grappling with.

Since the implementation of bank consolidation exercise in 2005 following an increase in the minimum capital requirement of banks to twenty-five billion Nigerian Naira, academics and policy makers have been pondering on whether the banking sector has actually lived up to expectations or whether the consolidation exercise was an exercise in futility. Assaf *et. al.* (2012) finds a significant improvement in efficiency levels of banks in Nigeria following consolidation for a 3-year data period (2005 – 2007). However, the average performance evaluation ratios for four major selected banks in the Nigerian banking sector do not show any significant improvements after the consolidation exercise; although the total assets and shareholders funds for the four major banks (Zenith Bank, Guarantee Trust bank, First Bank and United Bank for Africa) increased by 1,196% and 2,819% between 2001 and 2010 respectively, the average net profit margin, return on assets and return on capital employed decreased from 17.68%, 2.59% and 29.07% to 16.58%, 1.67% and 9.60% respectively for 2001 and 2010 (see Owolabi and Ogunlalu, 2013). In view of the significant structural changes in the banking system in Nigeria in 2007, the performance indicators were at the lowest level in 2009 with average return on assets for the four major banks dropping to 0.94% and average net profit and return on capital to an all time low (7.60% and 5.28%) since the deregulation of the banking sector in 1986.[7] In any case, the response of monetary authorities to cushion the effect of banking crisis on the macro-economy was the establishment of the Asset Management Company of Nigeria (AMCON) for the management of bank toxic assets. According to Owolabi and Ogunlalu (2013), the performance ratios do not show any improvements despite the huge cost of consolidation; about fourteen banks failed during the process, because of inability to meet the capital requirements. To this end, there is a fervent need to examine the efficiency of banks in Nigeria to know whether structural changes arising from policy directives have had any significant impact on bank productivity since the consolidation exercise.

3.0 **Literature Review and Theoretical Framework**

3.1 Literature Review

The most widely studied area in bank efficiency literature is that of allocative and technical efficiencies using parametric and non-parametric frontier methods.[8] Kourouche (2008) reports that many studies tend to estimate technical efficiency rather than allocative efficiency because

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[6] The bank consolidation exercise and recapitalization policy was part of a home grown economic recovery and poverty reduction strategy tagged Nigerian Economic Empowerment and Development Strategy (NEEDS) introduced in 2003.

[7] The drastic fall in bank performance ratios might have been an aftermath of the global financial crisis coupled with the recklessness of bank management in the process of seeking funds for recapitalization.

[8] Kourouche (2008), Chen (2002), Lee et al. (2010) and Berger and Humphrey (1997) among others provide details of country specific bank efficiency studies.

the later requires input prices, which is difficult to obtain and the presence of technical inefficiencies is more prevalent amongst banks. For this study, we shall be concerned with non-parametric Data Envelopment Analysis (DEA) and the parametric Stochastic Frontier Approach (SFA) in the determination of technical efficiency and total factor productivity change of sampled banks in Nigeria.

Broadly speaking, productivity change is decomposed into technological change (TC) and technical efficiency (TE), while TE is a measure of managerial ability in the use of technology, TC captures the adoption of new methods of productivity. To say the least, improvements in TE emanate from the application of knowledge from experience and training, whereas TC improvements are products of investments in research and technology. However, technical efficiency arises from bank's investment in human capital, and technological change arises from improvements in physical capital such as employing high skilled manpower and acquiring state of the art equipment like Automated Teller Machines (ATM) in banks or improving the cattle feedlots in farms.[9]

Lee et al. (2010) studying the productivity change, technological change and efficiency gains over thee period 1995 – 2005, following bank deregulation in Singapore and using Malmquist Productive Index finds total factor productivity growth and scale efficiency improvements from bank mergers. In the same vein, Angkinand et al. (2010) find that institutional reforms and prudential regulations can mitigate the risk of financial crisis to improve both technical and productive efficiency of the banking sector. On the other hand, Isik and Hassan (2003), using MPI observed that the banking crisis in Turkey arising from excessive regulation affected productivity of the sector causing economic meltdown by reducing loans to firms and financial services to households.

Berg et al. (1993) was one of the first major attempts to determine the technical efficiency of banks in three European countries, namely Norway, Sweden and Finland using Data Envelopment Analysis (DEA). The study specified two input and three output variables; which includes labor and capital as input variables, total loans, total deposits and the number of bank branches as outputs. The results obtained indicate that banks in Sweden were the most technically efficient with a score of 69%, then Finnish banks (50%), and Norwegian banks the least technically efficient at 41%.

In a study of 15 developed countries for the period 1988 – 1992, using the Stochastic Frontier Approach, Allen and Rai (1996) compared the technical efficiency of 194 banks using three input variables – labor, capital and borrowed funds and two input variables – total loans and investments, and found an overall mean technical efficiency score of 84.9%, although the smaller banks (85%) were more technically efficient than large banks (72.5%), indicating that the market share of banks has no bearing on efficiency. Although the overall result was mixed; in some countries like Canada, Italy, Japan and the US large banks were significantly more technically inefficient than small banks, whereas in Austria, Switzerland, Spain and France, the reverse was the case.

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[9] Ghorbani et al. (2010), in a study comparing technical efficiencies of cattle feedlot farms in Iran, obtained through DEA and SFA, indicate low levels of technical efficiency with significant inefficiency differences among farms arising from the SFA parametric estimation.

In another study covering 530 banks from five European countries – France, Germany, Italy, Spain and the UK for the period 1993 – 1997, Casu and Molyneux (2003) using DEA on a two input (total costs and short term funding) and two output (total loans and other earning assets) model sought to find whether there has been an improvement in technical efficiency across banks in the region since the single market was created. The study revealed a relatively low level of technical efficiency for banks in the sampled countries, but the method employed was able to show the trend in mean technical efficiency over time, and as a result banks in UK (78.2%) and Germany (71.3%) had the most technically efficient banks, while Italy (53.8%) had the least technically efficient.

Using a sample of 31 Polish banks and 16 Czech banks, Weill (2003) applied the Stochastic Frontier Approach (SFA) to ascertain whether foreign bank entry had any significant influence on the technical efficiency of banks in transition countries for the year 1997. The study adopted a three input (personnel expenses, interest expenses and non-interest expenses) and two output (total loans and investment assets) model, and finds that foreign banks were more technically efficient than domestic banks in both countries, the mean technical efficiency for foreign banks in Poland and Czech Republic was 70.4%, and that of domestic banks was 62.0%.

Grigorian and Manole (2006) measures the technical efficiency of banks in 17 transition economies for the period 1995 – 1998 using DEA on two distinct models 'A' (specifying inputs of labor, fixed assets and interest expense and outputs of revenues, net loans and liquid assets) and 'B' (same inputs as model A, but with outputs of total deposits, net loans and liquid assets), findings show that the technical efficiency scores for Model A ranged between 23.7% (Belarus) and 79.9% (Czech Republic) and for Model B technical efficiency scores ranged between 15.5% (Belarus) and 84.3% (Slovenia). The change in efficiency scores for both models could be attributed to the difference in output variables.

In another two-model analysis, Attaullah et al. (2004) in examining the technical efficiency of banks in India and Pakistan for the period 1988 – 1998, using DEA and two input variables (interest expense and operating expense) for both Model 'A' and 'B' and different output variables for Model 'A' (total loans and investment) and Model 'B' (interest and non-interest income) findings show that the mean technical efficiency of banks in India was 72.8% and 63.0% for models A and B respectively, and for Pakistan the mean technical efficiency score was 42.4% for Model A and 54.1% for Model B. These findings in Grigorian and Manole (2006) and Attaullah et al. (2004) demonstrate that the choice of inputs and outputs strictly determines the efficiency scores to be obtained. Problems that may be envisaged in cross-country studies stem from the difference in banking systems, regulatory and macroeconomic environment where the bank exists. However, Kourouche (2008) opined that the findings in these studies show that countries with higher levels of inefficient banks tend to have more restrictive regulatory banking systems.

Isik and Uysal (2006) in a study of Turkish banks observe that productivity growth was fastest amongst foreign banks and slower in public banks, however, the productivity growth in public banks is a result of scale efficiency changes, but foreign banks operated at the best-practice frontier because of innovation and technical know how imported from parent countries, which set a high standard for domestic banks. The poor performance of domestic banks in Turkey could be attributed to exogenous factors related to poor managerial skills and very restrictive legal framework, despite all the technological investments put in place as a result of the liberalization.

Chen (2002) estimates the technical efficiency of 39 banks in Taiwan, findings show that there are significant differences in efficiency scores between the chance-constrained DEA and the stochastic frontier production function. The study further asserts that for the Taiwanese banking sector the same variable (ownership) still provides the explanation for technical efficiency in both models. A number of papers have investigated whether there is significant difference in parametric and non-parametric approach to efficiency analysis (Bjurek et al. 1990; Giokas, 1991; Resti, 1997 and 2000; Ferrier and Lovell, 1990; Cooper and Tone, 1997) with differing results. While Bjurek et al. (1990) and Giokas (1991) did not find any difference between deterministic DEA and log-linear model, Resti (1997) similarly finds that some models of DEA and stochastic cost function do not differ at all, but the findings in Ferrier and Lovell (1990) show that deterministic DEA and stochastic cost function differ both in structure and in implementation. On the other hand, Cooper and Tone (1997) observed significant bias in SFA in comparison to the DEA model applied in the estimation.

Since this study is about the determination of technical efficiency for banks in Nigeria following the consolidation exercise, there is a need to look briefly at the literature on efficiency with respect to bank mergers and consolidation. Mester (2005) argues that consolidation is a positive exercise for the industry and the economy if the average cost of production declines as the size of the bank increases. Studies that consider both profit and cost efficiency (Berger and Mester 1997; Berger 1998; Berger and DeYoung 2001; Al-Sharkas et al. 2008) are all able to show profit efficiency gains for the merged institutions vis-à-vis non-merging peers. Berger and Mester (1997) and Al-Sharkas et al. (2008) find improvements in cost efficiency for the combined entity, which seem to be mainly driven by technological advances. The studies that center on profit efficiency are also able to show improvements. [10]

In the case of Europe, dynamic efficiency studies mostly concentrate on a specific country, such as the UK or Germany, rather than Europe as a whole. Altunbas and Molyneux (1996) and Altunbas et al. (2001) show that economies of scale and scope exist for most European banks and that consolidation can be an appropriate way of realizing this potential. Especially for small banks, potential improvements from economies of scale seem to be high when they merge (Altunbas et al. 2001).

The existing literature on productive efficiency of banks in sub-Saharan Africa show mixed results depending on whether profit or cost efficiency is estimated and the analytical technique applied. Mwega (2011) investigates the competitiveness and efficiency of the financial services sector in Kenya using DEA and SFA, findings show that the average efficiency score in the banking sector was 0.58(DEA constant returns to scale), 0.65(DEA variable returns to scale) and 0.84(SFA). The evidence from this study suggests that the banking sector in Kenya experienced reduced concentration and became more competitive between 1998 and 2007.

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[10] Akhavein et al. (1997) show that the profit efficiency improvements are mainly due to the ability of banks to shift their outputs from securities to higher yielding loans.

Oke and Poloamania (2012) in analyzing the efficiency correlates of Nigerian banks deduced from the Random effects Tobit regression model indicates that the correlates of cost efficiency obtained from DEA show net assets as a better index for measuring bank size efficiency other than total assets, and credit risk being the most significant variable that negatively affects efficiency as opposed to foreign ownership that has a positive effect on efficiency for the period 2001 – 2008.

Assaf et al. (2012) in assessing the performance of Nigerian banks using post consolidation data for 2005 - 2007 finds that the efficiency of Nigerian banks has increased post consolidation to reach a highest average of 91.2% in 2007 based on the Bayesian stochastic frontier model applied. Given the earlier observation by Berger and Humphrey (1997) that parametric and non-parametric methods yield significantly different results, and corroborated by Chen (2002) showing that there are significant differences in efficiency scores between the chance-constrained DEA and stochastic frontier approach estimated for the Taiwanese banking sector. The motivation for this study is rife from literature because none of the studies reviewed has incorporated non-interest or fee-based income to determine the technical efficiency and total factor productivity change for post consolidation Nigerian banking sector, and comparing the parametric and the non-parametric efficiency scores to ascertain if any significant difference could be ascertained. The empirical evidence in Assaf et al. (2012), which shows that Nigerian banks have become cost efficient following consolidation is contestable because of the short period of data. This study therefore extends the data period, and innovates by considering non-interest or fee-based revenue as bank output in the analysis of non-parametric DEA and parametric SFA models for the assessment of post consolidation technical efficiency and total factor productivity change in the Nigerian banking sector.

3.2 Theoretical Framework

There are two major underlining theories to support bank productivity and performance based on the choice of input and output variables; the intermediation approach and the production approach. Although there are some other conceptualizations of modelling bank production behavior apart from the production and intermediation approach, namely user-cost approach and value added approach. The two latter approaches are not very popular because they are bereft of microeconomic foundations, and hence will not be discussed in this study. The production approach is analogous to the manufacturing firm where one production department produces and supplies an output which is used directly as an input in another process. However, there are intermediate outputs, which build up the production process to earn the final product. In the case of a banking firm the final output is produced with capital, labor and materials, which produce loanable funds. Berger and Humphrey (1997) states that under the production approach financial institutions perform transactions and process customer's loan applications and check payments, so output is best measured by the number of transactions processed over a given time period, but such transactions flow data always fall short of detailed bank productive output, as a result stock data of the number of accounts prevail.

The Intermediation approach made popular by Sealey and Lindley (1977) considers financial institutions as intermediary between savers and investors, the input of funds and their interest cost is considered and funds are considered the major instrument of the intermediation process. Berger and Humphrey (1997) does not consider any of these two approaches to be perfect, however, recommends different circumstances for the application of either of the theories based on the choice of input and output in the analysis. They posit that production approach may be suitable for the estimation of efficiencies of branches of financial institutions, because branches process customer documents and managers at the branch level make little or no investment decisions. However, Berger and Humphrey (1997) also suggests that the intermediation approach is most appropriate for evaluating the entire financial institutions because it takes into account interest expenses, which incorporates costs, and since minimization of total costs and not production costs is considered in profit maximization, it becomes relevant in the estimation of frontier efficiency of profitability.

Sealey and Lindley (1977) had earlier criticized the production approach stating that it failed to take account of the technical and economic aspects of the production of financial services, hence they proposed a theory where a bank functions as the intermediary between depositors and investors, and various types of earning assets such as loans are treated as outputs and deposits along with capital and labor as inputs.

The input and output variables to be considered in this study are drawn from the intermediation role of banks. The advantage of the intermediation approach is that it allows for the inclusion of off balance sheet (OBS) instruments like non-interest income and expenses in the analysis of bank productive efficiency. OBS activities, which includes trading financial instruments and generating income from fees and loan sales are increasingly seen as potential dependable income source for banks.

4.0 Methodology

4.1 Data

The data employed for this study is drawn from the annual reports (2005 to 2014) of selected banks, which constitute over 80% of the total market size. The banks not included in the sample are new banks formed out of the restructuring exercise of 2010 and lack the requisite data for this study. The financial year of all banks in the sample is assumed to begin in January and end in December. The banks in the sample are – Access Bank, Diamond Bank, Eco-Bank, Fidelity Bank, First Bank, Guaranty Trust Bank (GTB), Skye Bank, Sterling Bank, United Bank for Africa (UBA), Union Bank of Nigeria, Wema Bank and Zenith Bank.

4.2 Measures of Bank Efficiency

Efficiency is a measure of deviation between actual performance and desired performance, and must be measured relative to an objective function (Mester, 2005). Farrell (1957) was one of the earliest studies that proposed the decomposition of bank overall efficiency into technical efficiency (TE) and allocative efficiency (AE). While the former is the ability of a firm to obtain maximal output from a given set of inputs; the later is the ability of a firm to use its input in optimal proportions. In a broader sense technical efficiency can be decomposed into scale efficiency (SE) and pure technical efficiency, which reflects the optimal or most productive scale size and the implementation of the production plan in converting inputs into outputs. When assessing efficiency especially for the banking industry, the interest is largely on the determination of managerial efficiency or X-efficiency; whether banks use their available inputs efficiently. A bank is cost efficient if it maximizes profits for a given combination of inputs and outputs (Kapopoulos and Siokis, 2005). X-efficiency is about the optimization of existing resources, taking size and technology as given and the combination of production factors. In a broad sense, scale efficiency is about whether banks produce the right amount of output and scope efficiency looks at whether banks choose the optimal combination of products. In this study we shall be concerned with the scale efficiency of banks only, the consideration of scope efficiency would require a lot more complex data.

4.3 **Frontier Methods of Estimating Bank Efficiency**

A frontier estimation is a combination of factors, along which all efficient firms would operate. The distance of each bank from the frontier is taken as a measure of its inefficiency. Large deviation from the frontier of X-efficiency indicates managerial incompetence, although small deviations from the cost frontier may be attributed to random effects, which is beyond the control of bank management. For scale efficiency we determine whether the performance of banks on the frontier would improve by changing their size, if that is the case then economies of scale is evaluated. On the other hand, scale (in)efficiency is a measure of the distance between the minimum of the cost function and an actual cost of a bank on the cost frontier.

The estimation of efficiency scores using sample data requires the use of either parametric or non-parametric methods. The non-parametric method requires linear programming, while the parametric employs the specification of functional econometric and statistical methods (Berger and Humphrey, 1997). The two widely used non-parametric methods are Data Envelopment Analysis (DEA) and Free Disposal Hull (FDH), and three widely used parametric methods are Stochastic Frontier Approach (SFA), Thick Frontier Approach (TFA) and Distribution Free Approach (DFA). For the purpose of this study, we shall limit our discussion to the non-parametric Data Envelopment Analysis (DEA) and the parametric Stochastic Frontier Approach (SFA).

4.4 **Model Specification:**

There are two basic models employed in this analysis, based on the dependent variables. In the first model, the dependent variable is total loans, which represents the output of banking firms and the explanatory variables are inputs – total deposit, staff cost and equity capital. In the second model, the dependent variable or output function is operating income, which incorporates non-interest or fee-based income, and the input variables or explanatory variables are total deposit, staff cost, total equity and operating expense. Both DEA and SFA are analyzed using the same output and input variables. The study assumes constant returns to scale and input orientation in DEA.[11]

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[11] This means the orientation in DEA is examining how much the input levels is reduced, while maintaining the output levels of each bank (see Kourouche, 2008).

Data Envelopment Analysis - Malmquist Productivity Index

This study employs the non-parametric Malmquist Total Factor Productivity (TFP) model of DEA to measure total factor productivity change in panel data and to decompose this change into technical efficiency change and technological change. According to Fare et al. (1994), a Malmquist TFP index greater than 1 indicates a positive growth from period t to period t+1, and on the other hand, being less than 1 indicates a decline. In other words, technical efficiency index being more than 1 implies that the organization has been able to fill its production units, in the same vein, technological change index being more than 1 implies a positive leverage of its efficiency levels. A negative change in technological index means a reduction in output amount produced by a similar amount of input. However, technical efficiency is decomposed into pure technical efficiency and scale efficiency change. Pure technical efficiency stem from managerial competence, and seeks to answer the question of whether the organization is producing within the appropriate scale. A decrease in pure technical efficiency is an indication of managerial incompetence. A decrease in scale efficiency mirrors into the organization's scale problem.

The productivity change in the Malmquist index is measured as a component of four different distance functions in efficiency change, technical change, scale efficiency change and output and input mix effect. According to Fare et al (1994), the Malmquist TFP index between the base period s and the next period t, given a change in technology, is stated as follows;

$$\mathrm{TFPC}^{s,t}(Xs, Xt, Ys, Yt) = \frac{d_0^t(Xt,\ Yt)}{d_0^s\ (Xs,\ Ys)}\left[\frac{d_0^s(Xt,\ Yt)}{d_0^t(Xt,\ Yt)} X \frac{d_0^s(Xs,\ Ys)}{d_0^t(Xs,\ Ys)}\right]^{0.5} \qquad [1]$$

$$\text{Technical Efficiency Change} = \frac{d_0^t(Xt,\ Yt)}{d_0^s\ (Xs,\ Ys)} \qquad [2]$$

$$\text{Technological Change} = \left[\frac{d_0^s(Xt,\ Yt)}{d_0^t(Xt,\ Yt)} X \frac{d_0^s(Xs,\ Ys)}{d_0^t(Xs,\ Ys)}\right]^{0.5} \qquad [3]$$

where TFPC is the Malmquist Total Factor Productivity Change index, X is the input variable and Y is the output variable, s and t stands for two different periods as stated earlier. The above is the input-orientated Malmquist index, which converges to the output-orientated index if technology exhibits constant returns to scale. Input orientation measures how much inputs can be reduced while maintaining the output levels of each bank.

The Malmquist total factor productivity index is calculated assuming a constant return to scale model. The first component of equation 1, measures technical efficiency change from period s to the next period t, while the second part measures the technological change that has taken place in the bank between the period s and the next period t. The Malmquist index has two distinct features; there is no behavioral assumption and prices of resources and services provided are not required, the sources of productivity change are based on the Malmquist Productivity Index (MPI) decomposed into changes in productive efficiency.

For DEA efficiency scores, values between 0 and 1 or 0 and 100% indicate the efficiency levels of decision making units (dmu). In contrast, the MPI assigns values greater than 1 for positive productivity growth or progress and a value less than 1 for productivity decline or regress. The mean aggregate efficiency scores are reported based on weighted geometric mean efficiency scores, using the shares of individual banks in total banking output. In the same vein, technical efficiency changes greater than 1 indicates a positive change in relative technical efficiency, given bank's approximation to the efficient productive frontier. A technical change less than 1 is a movement away from the frontier, which does indicate a fall in the productivity of a given bank, but can be caused by a positive shift of the frontier. If technical efficiency change is equal to 1, then the bank has retained the same relative position with respect to the frontier.

Stochastic Frontier Approach – Error Component model

The stochastic frontier model assumes a given functional form for the relationship between inputs and outputs. Stochastic frontier models introduced by Aigner, Lovell, and Schmidt (1977) and Meeusen and van den Broeck (1977), made popular by Kumbhakar and Lovell (2000), fits both production and cost frontier models with distinct specifications of the inefficiency term. The inefficiency and random error components of the composite error term are disentangled by making explicit assumptions about their distributions. The random error term, vi, is assumed to be two-sided (usually normally distributed), and the inefficiency term, ui, is assumed to be one-sided (usually half-normally distributed). The parameters of the two distributions are estimated and can be used to obtain estimates of firm-specific inefficiency.

A stochastic frontier model follows a production function $f(z_{it}, \beta)$. Assuming there is no disturbance term, error or inefficiency in time t, the ith firm would produce

$$q_{it} = f(z_{it}, \beta) \quad [4]$$

Secondly, assuming that each firm in the industry operates at less than optimum; that is producing less, given available resources. In this case

$$q_{it} = f(z_{it}, \beta)\xi_{it} \quad [5]$$

Where ξ_{it} is the efficiency level for firm i at time t; ξ_i lies in the interval (0, 1]. If $\xi_{it} = 1$, the firm is producing optimal output, when $\xi_{it} < 1$, the firm is not making the most of its inputs z_{it} given the level of technology in the production function $f(z_{it}, \beta)$.

Because output is assumed to be positive $q_{it} > 0$, the degree of technical inefficiency is also assumed to be strictly positive, $\xi_{it} > 0$

Since output is assumed to be subjected to random shocks, the production becomes,

$$q_{it} = f(z_{it}, \beta)\xi_{it} \exp(\nu_{it}) \quad [6]$$

Taking the natural log of both sides yields

$$\ln(q_{it}) = \ln\{f(z_{it}, \beta)\} + \ln(\xi_{it}) + \nu_{it} \quad [7]$$

If the production function is linear in logs and assuming there are k inputs,

then $\mu_{it} = -\ln(\xi_{it})$, which yields

$$\ln(q_{it}) = \beta_0 + \sum_{j=1}^{k} \beta_j \ln(z_{jit}) + v_{it} - u_{it} \qquad [8]$$

Subtract uit from $\ln(q_{it})$, and restricting uit ≥ 0, implies that $0 < \xi_{it} \leq 1$ as stated earlier.

The Stochastic Frontier Analysis to be applied in this study is based on Battese and Coelli (1992) error component specification for a production function, which is expressed as follows:

$$\ln(y_{it}) = f(x_{it}, t, \beta) + v_{it} - u_{it} \qquad [9]$$

$$\ln(y_{it}) = \beta_0 + \sum_n \beta_n \ln X_{it} + v_{it} - u_{it} \qquad [10]$$

where y_{it} is the output (total loans, operating income) of the i-th (i = 1, 2, …, 12) bank firm in the t–th (t = 1, 2, …, 10) year; x_{it} denotes a (1 X K) vector of inputs (total deposit, staff cost, total equity and operating expense); $f(\cdot)$ is the functional form; t is a time trend for technological change; β is a vector of parameters to be estimated; v_{it} are random errors, assumed to be iid. and follows N(0, δ_v^2) distribution, independent of u_{it}; and u_{it} are non-negative random variables assumed to account for technical efficiency effects in production, which are iid as truncations at zero of N(0, δ_u^2) distribution.

An error component production function is applied and results will indicate sigma-squared (δ^2) = $\delta_v^2 + \delta_u^2$, gamma (γ) = $\frac{\delta_u^2}{\delta_v^2 + \delta_u^2}$, $0 \leq \gamma \leq 1$.

A fundamental difference between the DEA model and the SFA is that the former generates a deterministic frontier that is an outcome of the observed data, which implies that some efficient firms or decision making units are on the frontier and other inefficient firms are inside, while the latter is based on maximum likelihood estimates or classical or Bayesian parametric techniques to define a relationship amongst firms. DEA efficiency score of 1 indicate full efficiency within a technology set, and this may occur for one or more decision making units in the sample, but for SFA, an efficiency score of 1 does not occur except when $\mu = 0$, and the distribution is continuous indicating a probability of 0.

Some advantages of SFA over DEA includes tests of hypotheses, which can ascertain the existence of inefficiency and determines the structure of the production function. SFA is more relevant where data is prone to disturbances from seasonal factors, measurement errors, macroeconomic disturbances and managerial or administrative inefficiencies. The methodology of DEA differs from SFA, although both measure efficiency. A change in input for an inefficient firm will not change the efficiency of other firms in DEA, but it might change the efficiency of other firms in SFA because it might influence the random error component.

In general, the models for estimating both DEA and SFA are specified above, but the table below is a presentation of the input and output variables in a simplified form. It is noteworthy that the variables for analyzing both DEA and SFA are the same:

Variable Identification

	Model I	Model II
Output (Dependent variables)	Total Loans	Operating Income
Input (Explanatory variables)	Total Deposit, Staff Cost and Total Equity.	Total Deposit, Staff Cost and Total Equity, Operating Expense

The model specification for this study follows the intermediation approach, where a bank uses inputs such as deposits, labor (staff cost), capital (equity) and other expenses to produce loans and generate revenue (operating income – interest income and non-interest income accounts).

5.0 Discussion of Empirical Results

This study employs a panel of 12 banks from 2005 – 2014, in 120 observations as stated in Table 1 of summary statistics for bank level data. The non-parametric Malmquist Productivity index is applied using the software DEAP version 2.1 developed by Coelli (1996). From Table 2, we observe that Nigerian banks were more productive during the period 2006-07 and 2013-14 with Total Factor Productivity Change (TFPC) of 34.1% and 70.5% respectively, reflecting the years immediately after recapitalization and when the banks seem to be recovering from the effects of the financial crisis following the establishment of the Asset Management Corporation of Nigeria (AMCON) for the management of toxic assets in the banking system. Worthy of note, is that this increase in productivity change is accounted for by technological change, which is as a result of banks acquiring new product lines or applying new techniques for the efficient allocation of resources aligning with the findings in Ghorbani *et al*. (2010) and Lee *et al*. (2010) on the improvements in total factor productivity due to technological efficiency. On the other hand, the worst performance in terms of productivity of loan assets was the period between 2010 and 2012, which is indicative of when the banking industry witnessed the most difficult years after the consolidation exercise and average TFPC dropped from 26% to 7% in 2010-11 and 2011-12 respectively supporting the observation in Laeven and Valencia (2013), which predicts a decline in productivity following a credit boom as was the case during the consolidation exercise.[12] It is noteworthy to state that technological change accounts for changes in total factor productivity for the period in question.

[12] In the same vein, Gulamhussen et al., (2014), and Fielding and Rewilak (2015) have observed a negative effect on bank productivity due to greater risk and diversification in periods of liberalization and restructuring, which is evident of the recapitalization process and subsequent consolidation of banks in Nigeria.

Table1: Summary statistics of bank level data

Variable	Obs	Mean	Std. Dev.	Min	Max
TL	120	465206.3	437267.9	1723	2178980
OPINC	120	86152.08	76973.84	2596	360065
SC	120	22282.61	20106.53	1139	102542
OE	120	55210.97	44119.78	5008	234087
TE	120	156031.1	127897.7	1278	522890
TD	120	766584.2	668022	12380	3050853

Data Source: Bank Annual reports 2005 – 2014. Authors' computation using Stata 14

Note: TL – total loans, OPINC – operating income, SC – staff cost, OE – other operating expense, TE – total equity (shareholders' capital), TD – total deposits.

Table 2: DEA Malmquist Index Summary of Annual Means – Model I

Year	Efficiency Change	Technological Change	Pure efficiency Change	Scale efficiency Change	Total factor productivity Change
2005-06	1.036	1.153	1.018	1.018	1.194
2006-07	0.941	1.426	0.881	1.068	1.341
2007-08	0.977	1.051	1.068	0.914	1.026
2008-09	0.992	1.182	0.959	1.034	1.173
2009-10	1.022	1.168	1.063	0.961	1.193
2010-11	0.991	0.743	1.009	0.983	0.736
2011-12	1.072	0.869	0.921	1.164	0.931
2012-13	1.043	1.129	1.083	0.962	1.177
2013-14	1.071	1.593	1.040	1.029	1.705

Mean	1.015	1.120	1.003	1.012	1.137

Data Source: Bank Annual Reports 2005 – 2014. Author's computation with DEAP 2.1

In Table 3, we observe that the bank with the highest improvements in TFPC is UBA with an average of 51.1% and the least performing was Wema Bank with a drop of .02% below the frontier. The improvements in the productivity of loanable funds at UBA is attributable to changes in technology, while the poor performance of Wema Bank is attributed to a decline in technical efficiency which culminates into a fall in scale efficiency for the period under review.

Considering operating income as the output variable in the banking industry and the results presented in Tables 4 and 5, we find that the most productive period was 2013 – 14, when TFPC improved by 41.6% above the frontier of optimum performance, and the worst period was 2010 – 11 with a decline of 16.6% below the production frontier, which conforms with the findings in DEA estimation in Tables 1 and 2 using the Malmquist Productivity Index (MPI). We have earlier stated that a bank does not only produce loans but also generate income from interest and non-interest services which is ploughed back into its operations. UBA was the most productive for the period with an average TFPC increase of 32.1%, and the least performing bank is Skye bank, with an average decline in TFPC of 0.034% for the period. It is noteworthy that the improvements in TFPC for the period is a result of technological change and the decline stem from scale efficiency change. We find here that overall mean total factor productivity change decreases from 13.7% to 8.9% as bank's productivity or output tend towards the inclusion of non-interest or fee based income. This supports the finding in Grigorian and Manole (2006), studying the technical efficiency of banks in India and Pakistan for the period 1988 - 1998, with mean technical efficiency for Model A at 72.8% and 63.0% for Model B, which includes non-interest revenue accounts. The implication is that as banks move from the traditional intermediation services of collecting deposit and issuing loans to fee based non-interest income accounts, the productive efficiency declines.[13]

Table 3: Malmquist Index Summary of Firm Means – Model I

Firms	Efficiency Change	Technological Change	Pure efficiency Change	Scale efficiency Change	Total factor productivity Change
Zenith Bank	0.985	1.093	0.991	0.995	1.077
GTB	1.009	1.089	1.002	1.007	1.099
Access Bank	1.000	1.053	1.000	1.000	1.053

[13] This assertion corresponds with the findings in Osuagwu and Nwokoma (2017) regarding competitiveness of banks in Nigeria for interest and non-interest or fee-based revenue accounts. As banks revenue portfolio tends toward non-interest income, the competitiveness among banks decrease, the empirical evidence in this study equally suggests that mean technical efficiency of banks decline as they seek fee-based income.

Skye Bank	1.039	1.075	1.000	1.039	1.117
Diamond Bank	0.960	1.063	0.979	0.980	1.020
Fidelity Bank	1.001	1.035	1.003	0.998	1.036
Sterling Bank	1.164	1.087	1.000	1.164	1.266
EcoBank	0.998	1.223	0.998	1.000	1.220
First Bank	1.036	1.323	1.000	1.036	1.371
UBA	1.078	1.402	1.075	1.002	1.511
Union Bank	0.968	1.042	0.986	0.982	1.008
Wema Bank	0.961	1.019	1.000	0.961	0.980
mean	1.015	1.120	1.003	1.012	1.137

Data Source: Bank Annual Reports 2005 – 2014. Author's computation with DEAP 2.1

Table 4: Malmquist Index Summary for Annual Means – Model II

Year	Efficiency Change	Technological Change	Pure efficiency Change	Scale efficiency Change	Total factor productivity Change
2005-06	0.959	1.270	1.001	0.958	1.217
2006-07	1.022	1.134	0.979	1.043	1.159
2007-08	0.887	0.984	1.021	0.869	0.873
2008-09	0.962	1.075	0.916	1.050	1.034
2009-10	1.034	1.220	1.023	1.010	1.262
2010-11	0.981	0.850	1.010	0.971	0.834
2011-12	1.054	1.004	0.970	1.087	1.058
2012-13	1.057	1.014	1.059	0.998	1.072
2013-14	1.026	1.380	1.015	1.011	1.416
Mean	0.997	1.093	0.999	0.998	1.089

Data Source: Bank Annual Reports 2005 – 2014. Author's computation with DEAP 2.1

Table 5: Malmquist Index Summary of Firm Means – Model II

Firm	Efficiency change	Technological Change	Pure efficiency Change	Scale efficiency Change	Total factor productivity Change
Zenith Bank	0.988	1.097	0.991	0.996	1.084
GTB	1.000	1.026	1.000	1.000	1.026
Access Bank	0.992	1.052	0.993	0.999	1.044
Skye Bank	0.963	1.014	0.996	0.967	0.976
Diamond Bank	0.973	1.042	0.983	0.990	1.014
Fidelity Bank	0.967	1.020	1.000	0.967	0.986
Sterling Bank	1.016	1.009	1.000	1.016	1.025
EcoBank	1.000	1.180	1.000	1.000	1.180
First Bank	1.000	1.273	1.000	1.000	1.273
UBA	1.014	1.303	1.021	0.993	1.321
Union Bank	1.009	1.102	1.000	1.009	1.112
Wema Bank	1.039	1.042	1.000	1.039	1.083
mean	0.997	1.093	0.999	0.998	1.089

Data Source: Bank Annual Reports 2005 – 2014. Author's computation with DEAP 2.1

The results presented in Tables 6 and 7 are the Stochastic Frontier Analysis of Model I and Model II, generated from the FRONTIER version 4.1 developed by Coelli (1996). For Table 6, we observe that Mu which is a measure of inefficiency in the error component model, indicates that the degree of inefficiency in the sampled banks decreases by 32% in their use of inputs to generate output (loans) within the period. Worthy of note is that all the input variables in both models were insignificant in the determination of output, however this insignificance stems from the inefficiency in the use of input resources in both model specifications. The results in Model I for the SFA show that UBA was the least technically efficient bank for the period under study given that the bank only utilized an average of 76.9 percent of the input resources (total deposit, staff cost, and total equity) to generate output (total loans). On the other hand, Ecobank was the most technically efficient because it used 98.2 percent of input resources to generate output (total loans).

Table 6: Error Component Production Function Frontier OLS – Model I

Output (Dependent Variable): Total Loans	Coefficient	Standard Error	t-ratio
Constant	-0.4406	0.2191	-0.2011
Total Deposit	0.1172	0.6207	0.1888
Staff Cost	-0.1338	0.6121	-0.2188
Total Equity	-0.2998	0.1961	-0.1529
sigma-squared	0.3593	0.5838	0.6154
Gamma	0.7045	0.5027	0.1401
Mu	-0.3182	0.9684	-0.3286
Eta	0.7524	0.3552	0.2118
Log likelihood function	0.9189		

Technical Efficiency Estimates:

Firm	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Mean
Zenith Bank	0.836	0.847	0.857	0.867	0.876	0.884	0.892	0.899	0.906	0.913	0.878
GT Bank	0.956	0.959	0.962	0.965	0.967	0.969	0.972	0.974	0.976	0.977	0.968
Access Bank	0.971	0.973	0.975	0.976	0.978	0.980	0.981	0.982	0.984	0.985	0.979
Skye Bank	0.957	0.960	0.963	0.965	0.968	0.970	0.972	0.974	0.976	0.977	0.968
Diamond Bank	0.958	0.961	0.963	0.966	0.968	0.971	0.973	0.975	0.977	0.978	0.969
Fidelity Bank	0.946	0.950	0.954	0.957	0.960	0.963	0.965	0.968	0.970	0.972	0.961
Sterling Bank	0.797	0.810	0.822	0.834	0.845	0.855	0.865	0.874	0.883	0.890	0.848

EcoBank	0.976	0.977	0.979	0.980	0.982	0.983	0.984	0.985	0.987	0.988	0.982
First Bank	0.932	0.937	0.941	0.945	0.949	0.953	0.956	0.959	0.962	0.965	0.950
UBA	0.695	0.714	0.731	0.748	0.764	0.779	0.793	0.806	0.819	0.831	0.769
Union Bank	0.839	0.850	0.860	0.869	0.878	0.886	0.894	0.901	0.908	0.915	0.880
Wema Bank	0.873	0.881	0.890	0.897	0.904	0.911	0.917	0.923	0.928	0.933	0.906
Mean	0.895	0.902	0.908	0.914	0.920	0.925	0.930	0.935	0.939	0.944	0.922

Data Source: Bank Annual Reports 2005 – 2014. Authors' computation with FRONTIER 4.1

Table 7: Error Component Production Function Frontier OLS Result – Model II

Output (Dependent Variable): Operating Income	Coefficient	Standard Error	t-ratio
Constant	-0.634	0.3200	-0.1980
Total Deposit	0.6504	0.8708	0.7469
Staff Cost	0.2864	0.1311	0.2185
Operating Expense	0.8139	0.1505	0.5410
Total Equity	0.4950	0.2334	0.2121
sigma-squared	0.2071	0.6646	0.3116
Gamma	0.3618	0.2005	0.1804
Mu	0.1379	0.1646	0.8378
Eta	0.4814	0.3857	0.1248
Log likelihood function	0.7894		

Technical Efficiency Estimates:

Firm	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Mean
Zenith Bank	0.859	0.860	0.860	0.861	0.861	0.862	0.863	0.863	0.864	0.865	0.862
GT Bank	0.966	0.966	0.966	0.967	0.967	0.967	0.967	0.967	0.967	0.967	0.967

Access Bank	0.931	0.931	0.931	0.932	0.932	0.932	0.933	0.933	0.933	0.933	0.932
Skye Bank	0.879	0.880	0.880	0.881	0.881	0.882	0.882	0.883	0.883	0.884	0.882
Diamond Bank	0.902	0.903	0.903	0.904	0.904	0.905	0.905	0.905	0.906	0.906	0.904
Fidelity Bank	0.831	0.832	0.831	0.834	0.834	0.835	0.836	0.836	0.837	0.838	0.834
Sterling Bank	0.849	0.850	0.851	0.851	0.852	0.852	0.853	0.854	0.854	0.855	0.852
EcoBank	0.871	0.872	0.873	0.874	0.874	0.875	0.875	0.876	0.876	0.877	0.874
First Bank	0.892	0.893	0.893	0.894	0.894	0.895	0.895	0.896	0.896	0.897	0.895
UBA	0.806	0.807	0.808	0.809	0.809	0.810	0.811	0.812	0.813	0.814	0.810
Union Bank	0.801	0.802	0.803	0.804	0.804	0.806	0.806	0.807	0.808	0.809	0.805
Wema Bank	0.723	0.724	0.725	0.726	0.727	0.728	0.730	0.731	0.732	0.733	0.728
Mean	0.859	0.860	0.861	0.861	0.862	0.862	0.863	0.864	0.864	0.865	0.862

Data Source: Bank Annual Reports 2005 – 2014. Authors' computation with FRONTIER 4.1

In the case of Model II, sampled banks inefficiency factor increased by 13.8 percent in the use of inputs to generate operating income, which includes non-interest or fee-based revenue. None of the input variables was significant in explaining changes in the output variable (operating income). The least technically efficient bank in the use of inputs (total deposit, staff cost, operating expense and total equity) to generate output (operating income) was Wema Bank with an average technical efficiency score of 72.8 percent, and the most technically efficient was GTB with a mean technical efficiency score of 96.7 percent for the period under study. The implication of this finding is that mean technical efficiency scores vary with respect to the input and output variables under consideration. However, evidence from this analysis indicate that in the SFA model, the mean technical efficiency of banks decreases from 0.922 (92.2%) in Model I to 0.862 (86.2%) in Model II, which implies that as output changes from interest (loan) income to non-interest or fee-based income, the mean technical efficiency score decreases, the value of the log likelihood function decreases from 0.9189 in Model I to 0.7894 in Model II, also the magnitude of inefficiency increases from (negative) -31.8% in Model I to (positive) 13.8% in Model II, which corroborates the finding in the DEA model for a decline in mean total productivity change as bank output tend towards operating income, which is largely non-interest or fee based. From all indications, this empirical evidence supports what Aghion et al. (2005) referred to as incomplete financial markets, where bank firms face tight credit constraints and are likely to reduce long-term investments because of its relatively less pro-cyclical return and a higher liquidity risk.

6.0 Conclusion

This study has applied Malmquist Productivity Index and error component production function in the estimation of total factor productivity change and technical efficiency in Data Envelopment Analysis (DEA) and Stochastic Frontier Approach (SFA) respectively, for a sample of selected banks in Nigeria, to ascertain if any significant variation exists in the choice of input and output variables, and the methods of estimation, that may affect policy decisions. From the empirical results, we find that technological change is a major determinant of changes in total factor productivity in the Nigerian banking sector for the period under study. Technological change may be interpreted as employing new methods of banking services such as automated teller machines and improved skilled manpower that is ready to adapt to the application of new technologies for the improvement of banking services. It is also observed that bank's total factor productivity improved under DEA immediately after the consolidation exercise; which to a large extent is a boom period for the banking sector in Nigeria emerging from recapitalization.

In the determination of technical efficiency and total factor productivity change in the Nigerian banking sector with respect to output variables; interest (loan) and non-interest revenue (operating income), the study reveals that mean total factor productivity change in DEA decreases for non-interest accounts. In the same vein, the mean technical efficiency of banks under the SFA estimation also decreases as bank revenue tends toward non-interest or fee-based services. In comparison, both DEA and SFA yield similar results in the determination of technical efficiency and total factor productivity change for bank's output portfolio. Inefficiency term in the error component model of SFA decreases for interest (loan) output and increases in the case of non-interest or fee-based income. In other words, banks become laxer or inefficient when they desire to improve off-balance sheet assets, because some of these fee-based charges are already fixed and determined by industry specifications.

A major implication of this finding is that it corroborates the results in recent studies that banks' revenue portfolio in Nigeria is increasingly becoming more of non-interest income or fee-based accounts, because it is less competitive to earn. This study supports this assertion by showing that banks become less efficient when they seek non-interest income. Nonetheless, since non-interest or fee-based transactions are gradually becoming a cheap or easy source of revenue, policy makers need to monitor the arbitrariness that is exhibited by bank management in the provision of these services. Because arbitrariness may increase the cost of services in the banking sector in the long-run., and reduce the potency of the intermediation role of banks in the economy. Although, the magnitude of total factor productivity change and technical efficiency scores for DEA and SFA respectively, differs, the direction of productive efficiency for both the non-parametric and parametric estimation are similar for our choice of input and output variables. The direction for future research is to determine the profit and cost efficiency profile of Nigerian banks in a bid to generate non-interest and fee-based income. This will provide the analytical framework for understanding whether bank's desire to increase their revenue through off balance sheet instruments and fee based services would be sustainable or not.

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