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A DEA Analysis of Bank Performance in Nigeria

Abstract

The recent effort by the Nigerian Central Bank to merge banks, sorely with the aim of increasing shareholders confidence and improved performance, triggered this study. Therefore, the paper measures and decomposes efficiency using the non-parametric approach popularly known as Data Envelopment Analysis (DEA) and productivity growth using Malmquist Productivity index (MPI), in a sample of Nigerian commercial banks over the period of 5 years. Net fixed assets and total deposits were used as the input variables while total loans and advances, other earning assets and net operating income were used as the output variables. Under the Constant Return to Scale assumption, the average efficiency of all the banks over the 5-year period showed a constant improvement. Although the efficiency improvement in the 3rd year seems low, on the average over the years considered the results of all the banks consistently showed improvements. When we considered the variable return to scale we found the efficiency score to still maintain the score significance, although slightly lower in some instances. It is the recommendation of the paper that banks need to do more in terms of maintaining their level of efficiency, especially, when you consider the fact that they have merged with other banks that have somewhat different level of performance and productivity efficiency.

1.0 Introduction

The earliest technique, which was used to measure performance changes, among companies in general and the banking sector in particular, was ratio analysis. This technique simply quantified variables such as return on turnover, return on investment, return on assets. e. t. c. This was considered to be an inappropriate way to measure the performance of sensitive institutions like the banking industry. A part from the impossibility of consistent aggregation, the method does not identify the peculiarities of the banking sector in terms of using multiple inputs to produce multiple outputs. Further limitations of ratio analysis could be seen in Sherman and Gold (1985), Barnes (1987), Smith (1990) and Fernandez-Castro and Smith (1994).

Recent researches on the subject, uses both parametric and the non-parametric approaches to measure the efficiency of banks. For example, Ferrier and Lovell (1990),

Kaparatis *et. al.* (1994) and Altunbas *et. al.* (1995) applied econometric technique, which focus on estimating the characteristics of production or cost functions to measure economics of scale. This resulted to the use of stochastic parametric approach to measure the efficiency of banks. Humphrey (1990) on the other hand used a growth accounting model to measure banks' efficiency. Other researchers used other parametric approach of the "thick frontier" and augmented production function approach. For example, the studies of Baner *et. al.* (1993), and that of Haynes (1991) respectively.

Furthermore, the non-parametric approach, popularly known as the DEA has received the attention of researchers as a tool for measuring efficiency and production changes. Aly *et. al.* (1990) Charnes *et. al.* (1997) Chan and Yeh (2000) are among the users of this method. Similarly, Alam (2001) and Mukherjee *et. al.* (2001) used the Malmquist (MPI) approach to study commercial banks in the USA during the 1980s. Other studies that uses the same approach to study bank productivity includes Avkiran (2000) in his Australian banks study, Chen and Yeh (2000) studies banks in Taiwan and Gilbert and Wilson (2000) studies the Korean banks using the same technique.

In this study, the Data Envelopment Analysis (DEA) and the Malmquist Productivity index MPI) were used to measure the performance of a group of Nigerian commercial banks over a period of 5 years. The paper is structured as follows. The next section discusses the literature review. Section 3 details the methodology while the empirical results are discussed in section 4. Section 5 concludes the paper.

2.0 Literature review

There is the growing need for interest in the performance of financial institutions across economies the world over. Nigeria for example just concluded a merger program among the commercial banks operating in the country. At present, most of the studies on banking efficiency focused on developed economies (Drake and Hall 2003). Tavares (2002) for example, provided a bibliography of DEA analysis, especially, studies on the USA and other developed countries. Among them were the studies of Berger and Humphrey (1997), they surveyed 130 studies that have employed frontier analysis in 21 countries. Of these studies, only 8 were done in developing and Asian countries, with studies on the US financial institutions accounting for 66 out of 116 single country studies. In terms of the findings of these studies, we found that, most of the studies recorded a positive efficiency performance of the banks studied. For instance, Elyasiani and Mehdian (1995) in their study of the large and small banks in the US found that between 1979 and 1986 technical changes among small banks improved more than those of the large banks. Furthermore, Ferrier and Lovell (1990), Kapara Kis *et. al.* (1994), Altunbas *et. al.* (1995) Alam (2001), and Mukheerjee *et al* (2001); using the DEA methodology, studied commercial banks in the USA during the 1980's, their findings reveals a positive productivity growth among the banks studied.

Grifell-tatje and Lovell (1996) using the same technique found that the productivity for savings banks in Spain had declined during the 1980's. Katib and Mathews (1999) in their study of Malaysian banks found that the relative position of

domestic banks as compared to foreign banks is unknown in terms of efficiency and performance.

Furthermore, Berg *et al* (1992), found that the total productivity of the banks in Finland Norway and Sweden has significantly improved. Their results identified technological progress as a major contributing factor to the improved productivity of the large banks in those countries. Gilbert and Wilson (1998) in their study of the performance of banks in Korea, using the non-parametric statistics in their analysis, found that there is improvement in the technical efficiency and managerial performance of the banks.

In another comprehensive study by Grigorian and Manole (2002), using the DEA methodology to estimate the efficiency performance of banks during the period, 1995 to 1998, there study incorporated 17 countries that included Russia and other transitional economies. They found strong evidence that foreign controlling ownership is associated with greater efficiency and some weak evidence that improved prudential rules is also associated with greater efficiency. Philippatotos (2002), estimate bank efficiency among transitional economies, they employed both parametric and the distribution free approach, and incorporated data from 12 transition countries from 1993 to 2000. He found that banks with majority ownership are more cost efficient but less profit efficient than other banks in these transition countries. Fries and Taci (2005) using data from 1996 to 2000 of eleven transition economies in Eastern Europe, they found that costs are lower in countries where foreign owned banks have a large share of assets.

Bonin *et al* (2005) found that foreign owned banks are more cost efficient than other banks and that they also provide better service where there is a strategic foreign

owner. Kraft and Tirtiroglu (1998), examine bank performance in Croatia during 1994 – 1995 and found that the organize-private banks are more efficient relative to their counter parts that are owned by the state. Jemric and Vujcic (2002) also found that foreign banks are more efficient for the same country. They also employ the non-parametric statistical tool in their analysis.

The finding of Philippatotos (2002) has been echoed by the findings of Nikiel and Opiela (2002). They use the distribution free approach, and found that polish banks that are owned by foreign interest are more cost efficient but less profit efficient than the other banks. Isik and Hassan (2003) in their study of the performance of Turkish commercial banks during the deregulation period find that the performance of Turkish private banks after the deregulation exercise was quite commendable. They were able to perform and competed with the other banks that have other forms of ownership.

The empirical literatures on banking in transition countries find relatively strong competitive effects of foreign banks entry. For example, Demirguc Kunt et al (1998) in their examination of factors that determine performance of banks in different economies, they found that countries that are open to foreign entry have their banks performing better than other banks. A further, study by claessens et al (2001), that considered the performance of domestic and foreign banks in eighty countries for the period of eight years (1988 to 1915). They found that foreign banks entry was followed by a reduction in profitability. They also document a significant reduction in the amount expended on overhead expenses of domestic banks. They concluded that foreign participation improves the efficiency of domestic banking.

In Nigeria, although there are studies that try to examine the performance of Nigerian commercial banks over some years and across banks operating in the country, most of the methods employed in the analysis are the ratio analysis. Considering the recent program and government policy of merger of these banks, it will be timely to see a pre-merger performance of these banks using a modern statistical tool. This will provide a base for comparing the performance of the banks with the post merger performance.

3.0 Methodology

Data envelopment analysis (DEA) is a non-parametric statistical tool that measures the productivity of a given organization, which is referred to as the decision-making unit (DMU). For the purpose of this study, each bank used in the sample is represented as a DMU. DEA considers the efficiency of the banks using the different inputs they employ to produce different outputs. A production frontier is said to represent the maximum level of output attainable for a given level of inputs. Therefore, a bank that is technically efficient would operate at the production frontier, which means it produces the maximum output for a given level of inputs. This implies that a technically inefficient bank would operate at a level beneath the frontier. This is because the bank's output would be less than the maximum attainable. Alternatively, a bank can be said to be technically efficient if it uses minimum inputs to produce a given level of output, and this implies that where a bank uses more than the minimum inputs it would be considered to be technically inefficient.

Furthermore, the paper tested productivity changes using the Malmquist productivity indices (MPI). The MPI is a valuable tool for measuring productivity. It has

the ability to separate technical efficiency, which is a movement towards the production frontier from changes in technology, which is a shift of the production frontier, and scale changes, which is movement towards or away from the optimal scale point of operation on the production frontier. The methodology has been documented by a lot of researchers; for example, Koopmans (1951), Caves et al (1982) Zhu (2003) Canhoto and Dermine (2003) Casu *et al* (2004). Icatib (1999) and Alam (2001). They all commended the use of MPI as it has the advantage of inherent flexibility and allows for substantial annual variation in the data.

This paper therefore, measures the productivity of a group of commercial banks operating in Nigeria over a 5-year period. Malmquist productivity measure using the DEA approach was used to analyze the data based on both the constant return to scale (CRS) approach and the variable return to scale approach (VRC) approach. This was prompted by the quest to identify performance measure based on changes in efficiency (catch-up) and changes in technology (innovation).

3.1 The DEA Model.

Assuming each bank used in the sample to be a decision-making unit (DMU) and each producing s different outputs with r different inputs. Using this relationship we can model the efficiency ratio to be:

$$E_i = \frac{\sum_{i=1}^{s}}{\sum_{j=1}^{r}}$$

Where

E_i = relative efficiency of the DMU
s = number of outputs produced by the DMU
r = number of inputs employed by the DMU
y_i = i th output produced by the DMU
x_j = the j the input employed by the DMU
u_i = s x 1 vector of output weights and
v_j = r x 1 vector of input weights.
i runs from 1 vector to s and j runs from 1 to r.

This when converted to fractional programming and then transformed into a linear programming as done by Charnes *et. al.* (1978) and Mahadzir (2005), we arrive at:

$$\text{Max } E_i = \sum_{i=1}^{s} u_i y_i$$

Subject to

$$\sum_{j=1}^{r} v_i x_{ji} = 1$$

$$\sum_{i=1}^{s} u_i y_{im} - \sum_{j=1}^{r} v_i x_{jm} \leq 0,\ m = 1,\text{-----}n.$$

To simplify the computation, we can use the Efficiency Measurement System Software version 1.3 developed by Holger (2000); Pioneer 2 version 2.0 developed by Thomas and Richard (2001) and the DEA Excel solver developed by Joe (2002).

3.2.2 Malmquist Productivity Index

Malmquist Productivity Index is defined using distance functions. Suppose the function that describes the technology of production is given as: F (X, Y) = 0, Where X= (X_1, X_2, -----X_m) is the input vector and Y = (Y_1, Y_2, -------Y_s) is the output vector. Although, Caves *et al* (1982), provided an alternative interpretation of production

technology using the concept of "distance function". They defined the output function as $D_0 (X, Y) = \text{Min}_{\mu}[\mu : F(X, Y/\mu) = 0]$. Where μ_y is the minimum equi-proportional change in the output vector. The output distance function measures the maximum proportional change in output required to place (X, Y) on the efficiency frontier. If the evaluated production unit is efficient, $D_0 (X, Y) = 1$ otherwise, $D_0 (X, Y) < 1$. Distance function may also be computed with input orientation, reference technology in a certain time period and CRS or VRS specification Caves *et al* (1982); Galagedera and Edirisriya (2002); Fare *et al* (1994); Coelli, (1998); and Kent and Mahadzir (2005). Let $D_0^{\ t}$ (CRS) and $D_0^{\ t}$ (VRS) specification respectively. The distance function can be determined using the DEA methodology.

Caves et al (1982) defined the output based Malmquist productivity index to compare performance of a production unit in time t and t+1 with reference to period t technology as:

$$M_0^{\ t}(X_{t+1}, Y_{t+1}, X_t Y_t) = \frac{D_0^{\ t}(X_{t+1}, Y_{t+1})}{D_0^{\ t}(X_t Y_t)}$$

Alternatively we may define output based Malquist productivity index with reference to period t+1 technology as

$$M_0^{\ t+1}(X_{t+1}, Y_{t+1}, X_t Y_t) = \frac{D_0^{\ t+1}(X_{t+1}, Y_{t+1})}{D_0^{\ t+1}(X_t Y_t)}$$

$M_0 > 1$ indicates higher productivity in period t than in period t +1

Fare *et al* (1994) defines an index that incorporates Malmquist indices in both periods. This they suggest to avoid choice of the time period arbitrarily. They specify the index to be

$$M_0\ (X_{t+1}, Y_{t+1}, X_t\ Y_t\ ) = \left[\left(\frac{D^t_0\ (X_{t+1}, Y_{t+1})}{D_0\ (X_t\ Y_t\ )}\right)\left(\frac{D_0{}^{t+1}(X_{t+1}, Y_{t+1}}{D_0{}^{t+1}\ (X_t\ Y_t\ )}\right)\right]^{1/2}$$

$$= \left(\frac{D^{t+1}{}_0\ (X_{t+1}, Y_{t+1})}{D_0{}^{t}\ (X_t\ Y_t\ )}\right)\left[\left(\frac{D^t_0\ (X_{t+1}, Y_{t+1})}{D_0\ (X_t\ Y_t\ )}\right)\left(\frac{D_0{}^{t}\ (X_{t+1}, Y_{t+1}}{D_0{}^{t+1}\ (X_t\ Y_t\ )}\right)\right]^{1/2}$$

Where $\frac{D^{t+1}{}_0\ (X_{t+1}, Y_{t+1})}{D_0{}^{t}\ (X_t\ Y_t\ )}$

is the change in relative technical efficiency between periods t and t+1. and

$$\left[\left(\frac{D^t_0\ (X_{t+1}, Y_{t+1})}{D_0\ (X_t\ Y_t\ )}\right)\left(\frac{D_0{}^{t}\ (X_{t+1}, Y_{t+1}}{D_0{}^{t+1}\ (X_t\ Y_t\ )}\right)\right]^{1/2}$$

Captures the shift in technology (technological change) between the two time periods evaluated at (X,Y) and (X_{t+1}, Y_{t+1}). Now for each production unit, define five malmquist indices for period t+1 relative to period t.

Total factor productivity change index (TFPCI)

$$\left(\frac{D^{t+1}{}_0\ (CRS)(X_{t+1}, Y_{t+1})}{D_0{}^{t}\ (CRS)\ (X_t\ Y_t\ )}\right)\left[\left(\frac{D^t_0\ (CRS)\ (X_{t+1}, Y_{t+1})}{D_0{}^{t+1}\ (CRS)\ (X_{t+1}Y_{t+1}\ )}\right)\left(\frac{D_0{}^{t}\ (CRS)\ (X_{t+1}, Y_{t+1}}{D_0{}^{t+1}\ (CRS)\ (X_t\ Y_t\ )}\right)\right]^{1/2}$$

= (Technical Efficiency Change Index)(Technological change index)

Technical change index = $\frac{D^{t+1}{}_0\ (CRS)(X_{t+1}, Y_{t+1})}{D_0{}^{t}\ (CRS)\ (X_t\ Y_t\ )}$

Pure technical change index = $\frac{D^{t+1}{}_0\ (VRS)(X_{t+1}, Y_{t+1})}{D_0{}^{t}\ (VRS)\ (X_t\ Y_t\ )}$

Scale Efficiency Change = $\frac{\text{Technical Efficiency Change Index}}{\text{Pure technical change index}}$

A value of less than 1 in the index indicates a decline in efficiency, equal to 1 indicates stagnation and greater than 1 indicates a growth between period *t* and *t+1* from the perspective of period *t* technology.

3.2.3 Bank Input and Output

Although there is upsurge in research on the subject, what constitute input and output of a bank is still a controversy in the literature. Principally, there are three approaches in identifying the input and output of a bank. Intermediation, value added and user cost methods. For the purpose of this study the intermediation approach, which, views back to operate as final intermediaries, was use. The method was first used by Sealey and Lindley (1977), to analyze financial institutions. We therefore, used net fixed assets and total deposits as the input variables while total loans and advances, other earning assets and operating income were used as the output variables. Other studies that used this measures in their analysis include the studies of Kent and Mahadzir (2005), Mandos and Pastor (2003), Yildirim (2002), and Siems and Barr (1998).

4.0 Empirical Results

The results from the analysis are presented in 2 forms. First, we present the results of the DEA and in the end we present the result of the Malmquist index. We further compressed the results into ownership differential, especially as it relates to private and government ownership.

Under the Constant Return to Scale assumption, the average efficiency of all the banks over the 5-year showed a constant improvement. Although the efficiency improvement in the 3rd year seems low, on the average over the years considered the results of all the banks consistently showed improvements. This result is consistent with the findings of other studies, for example, Mathews and Mahadzir (2005), documented an average efficiency score of about 56.57 percent. In another study Favero and Papi (1995) found average efficiency score for Italian banks to be 91 percent. Katib and Mathews (1999) found average efficiency score to be 82 percent in 1995. Leavan (1999) found that the average efficiency score was 70 percent. Casu and Malyneyx (1999) found the efficiency score to be 66 percent.

One important observation to note here is that we are not comparing the efficiency performance over years, but each year for all the observations or DMU's. This is because the analyses in data envelopment do not consider absolute efficiency. It only measures the relative efficiency of the observations.

When we considered the variable return to scale we found the efficiency score to still maintain the score significance although slightly lower in some instances.

To compare the performance across various ownerships, the banks were categorized into 2. Those owned by the state and those privately owned. The result shows that the private banks' performance is superior to the state owned banks. In one of the years the privately owned banks have their efficiency score more closely to 1, indicating that they are located on the best practice frontier. To further identify whether the differences in efficiency scores of the 2 groups of the banks is statistically significant we computed the one-sample Kolmogorov – Smirnov test (using SPSS output). The results

showed that the differences in efficiency score are statistically significant. Although, we found private banks to perform better than the state owned. This is in contrast to the findings of Ismail (2004), Yildirim (2002), and Sathye (2001).

Ismail (2004) found foreign owned banks to have highest efficiency score of 98 percent, followed by the state-owned banks with 96 percent and the private owned banks with 88 percent. Yildirim (2002) found the rank as follows; first the state-owned banks 99 percent, followed by the foreign banks 97 percent and the private banks 96 percent. While Sythye (2001), found local banks to be more efficient than their foreign counter parts.

5.0 Conclusion and recommendation

This paper measures the productivity of a group of commercial banks operating in Nigeria over a 5-year period. The DEA approach was used to analyze the data based on both the constant return to scale (CRS) approach and the variable return to scale approach (VRC) approach. This was prompted by the quest to identify performance measure based on changes in efficiency (catch-up) and changes in technology (innovation).

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It is the recommendation of the paper that banks need to do more in terms of maintaining their level of efficiency, especially, when you consider the fact that they have merged with other banks that have somewhat different level of performance and productivity efficiency.

Table 1: Data Used in the Computations

S/N	Variables	Mean	Std. dev.	Max	Min
1	FA	2328320	1629930	4555427	12108
2	TD	31491234	24188489	61600622	265378
3	LAD	12549615	7983704	21350818	114673
4	OEA	12534239	9037554	27213502	12184
5	OPI	113064.3	365582.9	967514	-55245

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