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Iyo Ipeghan
Ph.D. Post-Doctoral Researcher, Department of Banking and Finance, Rivers State University, Port Harcourt, Nigeria

Adamgbo Suka Lenu Charles
Ph.D. Lecturer, Department of Banking and Finance, Kenule Beeson Polytechnic, Bori, Nigeria

Adolphus J Toby
Professor Lecturer, Department of Banking and Finance, Rivers State University, Port Harcourt, Nigeria

Correspondence
Iyo Ipeghan
Ph.D. Post-Doctoral Researcher, Department of Banking and Finance, Rivers State University, Port Harcourt, Nigeria

Modeling data envelopment analysis and bank-specific determinants of profitability in Nigeria

Iyo Ipeghan, Adamgbo Suka Lenu Charles and Adolphus J Toby

Abstract
This study aims at investigating empirically the overall technical efficiency, x-efficiency and scale efficiency in the Nigerian banking industry. The Data Envelopment Analysis was used to estimate efficiency scores of 15 commercial banks in the Nigerian banking industry during the period of 2007 to 2015. The research also employed regression analysis to estimate the determinant of bank-specific variable. The overall efficiency result suggest that inefficiency across 15 mega banks is small at just over 28.2 percent, which is quite low compare to conventional average. In the case of the theory of efficient-structure, the x-efficiency result showed an industry average of 80.7 percent representing high level of efficiency among the mega banks. The result for scale efficiency in the industry is significantly higher than smaller banks. The empirical results for the tests of efficient-structure hypotheses revealed that x-efficiency and scale efficiency are strongly present in the Nigerian banking industry. Additionally, x-efficiency, which is common in the industry, significantly impact profitability. The significant relationship between technical, scale efficiency and profitability could be viewed as further evidence of the robustness of the estimated efficiency parameters. The banks are efficient within their peer group themselves as they indicate higher efficiency level. This result could suggest that current technology in the financial sector allow efficient growth of the industry.

Keywords: The Nigerian banking industry, data envelopment analysis, commercial banks, overall technical efficiency, efficient-structure hypotheses, x-efficiency and scale efficiency

1. Introduction

The Nigerian banking industry has undergone remarkable changes over the years, in terms of the structural development. Since independence, the banking industry has grown substantially from 8 banks with 160 branches in 1959, to 40 banks with 1316 branches as at December 1985. This era marked the period of strict laws and regulation in managing the banking industry, which inhibited growth, competition and efficiency in the system. During the Structure Adjustment Programme (SAP) and subsequent deregulation of the banking industry, the number of banks has increased. Later, by the end of June, 2004, there were 89 commercial banks operating in Nigeria, comprising institutions of various sizes and degrees of soundness. Structurally, the sector is highly concentrated, as the ten largest banks account for about 50 percent of the industry's total assets/liabilities Bello and Isola (2014) [4]. The issue of number of banks in the banking industry has remained a debatable discourse. While Concentration School of thought, advocates that the fewness of banks (i.e. consolidation, via merger and acquisition) provides a stronger financial market. The Decentralization School of thought considers fewness as a threat to the financial stability of the industry. Vives (2001) observes that the degree of competition in the financial sector enhance efficiency of the production of financial services, the quality of financial products and the degree of innovation in the sector, all of which impact profitability.

The banking system is a key element of the modern market economy. The availability of finance for enterprises, and the potential to restructure and improve competitiveness in transition economies critically depends on the efficiency of the banking system. This methodology of Berger and Humphrey (1998) [5] particularly draw conclusions about the influence of changes in the structure of the financial system and assessment of the effects of government policy on efficiency. Efficiency improves the managerial performance of banks primarily on the basis of the identification of the best-performing firms and best practices in the industry.

There are two broad paradigms used by researchers to analyze efficiency in production stochastic frontier analysis (SFA) and data envelopment analysis (DEA). The former is a fully parameterized model whereas the latter is ''non-parametric.'' Data Envelopment Analysis is currently the conventional approach to deterministic frontier estimation. This is usually carried out by the application of linear programming techniques. The analysis assumes that there is a frontier technology (in the same spirit as the stochastic frontier production model) that can be described by a piecewise linear hull that envelopes the observed outcomes. Most efficient observations will be on the frontier while other (inefficient) individuals will be inside. The technique produces a deterministic frontier that is generated by the observed data, so by construction, some individuals are 'efficient.' This is the fundamental difference between Data Envelopment Analysis and Stochastic Frontier Analysis. Efficiency has often been identified with productivity Siudek (2008) [27]. The fundamental of the theory is that competitive markets are efficient and lead to a unique and optimal allocation of resources (allocative efficiency). Pareto efficiency as a measure of social welfare is used by many scholars as their efficiency goal. According to Samuelson and Nordhaus (1995) [25] denote that competition in a market mechanism assures efficiency and everyone's welfare. According to Drucker, who explain efficiency in term of managerial concerns, efficiency means ''doing things right'' getting the minimum inputs for the most and efficient output. Pure economic concept of efficiency assumes that efficiency is the ratio of total output goods with respect to input resources. Efficiency is regarded to be higher with higher level of the ratio. Rose (1997) [24] defines efficiency as an indicator showing the ability of bank managers and its staff to keep the rate of increase in revenues and income at the level that exceeds the rate of increase in operational costs. Jaworski (2006) [15] also state that, efficient activities are those activities which not only lead to achieving intended goals but also assure economic benefits higher than inputs. Capiga (2003) [7] presents different possible views on bank efficiency, which include distinction between: financial efficiency which examines those items that are financial in nature (included in banks financial statements), for example, by use of financial ratios and cost efficiency which determines how close bank's costs lie to the efficient cost frontier for given inputs and their ratios (technology). Despite considerable development of the Nigerian banking industry, there are still limited studies focusing on the efficiency of Nigerian banks.

The general banking efficiency literature distinguishes two types of efficiency; scale efficiency and X-efficiency. The concept of scale efficiency was first introduced by Farrell (1957) [12], which can be simply defined as the relationship between a bank's per unit average production cost and volume, and thus a bank is said to have economies of scale when the increase in outputs is accompanied by a lower unit cost of production. The x-efficiency concept was popularized by Leibenstein (1966) [17], refers to cost-efficient frontier that depicts the lowest production cost for a given level of output. X-efficiency stems from technical efficiency, which gauges the degree of friction and waste in the production processes, and allocative efficiency, which measures the levels of various inputs. These two are neither scale nor scope dependent and thus X-efficiency is a measure of how well management is aligning technology, human resources management, and other resources to produce a given level of output.

The Nigerian banking industry was aim at increasing revenue and minimizing cost and efficiency is responsible for greater revenue. However, it is not yet fully ascertained that inefficiency significantly account for the fluctuation of banks profit in Nigeria. It is therefore, the burden of this paper to determine the effect of banks profitability in the industry.

The focus of the paper was to measure the level of x-efficiency and scale efficiency in the Nigerian banking industry for the period of 2007-2015 by employing the Data Envelopment Analysis (DEA) approach. It is the purpose of this work to measure the structure of the Nigerian banking industry and its impact on performance.

The study provides additional knowledge for researchers and the general public on factor that will improve performance of the banking industry.

The rest of the paper is structured as follows: section 1 theoretical framework and synthesis of empirical studies. Section 2 presents the methodology. Sections 4 present the empirical results and discussions. Finally, the last section contains the conclusions.

2. Theories and Synthesis of Empirical Literature

In banking literature, there have been many studies on the structure-profit in banking. The common finding of these studies is that there is a positive relationship between profitability and measures of market structure. Various contrasting interpretations for these results are presented.

The systematic efforts to describe the relationship between market structure and market performance originate the development of the structure conduct performance hypotheses, a framework most closely associated with Mason (1939) [18] and Bain (1956) [2]. Although it has been sharply critiqued in the next decades, the SCP literature served to systematically identify and highlight many of the stylized facts and empirical regularities that motivate the market.

The traditional structure-conduct-performance hypothesis (SCP) asserts that this finding reflects the setting of prices that are less favorable to consumers in more concentrated markets and must be in some way collusive or non-competitive to ensure high profit. The relative-market power hypothesis (RMP), on the other hand, asserts that only firms with large market shares are able to exercise market power and earn supernormal profits Shepherd (1982) [26].

An alternative view point, most closely associated with economist from the Chicago school Demsetz (1974) [11] and Peltman (1977), reverses the order by a very important contribution to the structure-conduct-performance studies and proposed the efficient-structure hypotheses. The efficient-structure hypotheses suggest that market structure is determined by efficiency of the operating firms. The researchers who defended the efficient structure hypotheses criticize the traditional market power model since the relationship between market share, concentration and efficiency is excluded. In this alternative model, important profits are generated by large firms since the concentration is the product of efficiency Mensi & Zouari (2011) [19].

Under the X- efficiency version of the efficient-structure hypothesis (ESX), firms with superior management or technologies have lower costs and therefore higher profits. Under the scale-efficiency version of the efficient-structure hypothesis (ESS), some firms produce at more efficient scales than others, and therefore have lower unit costs and higher unit profits.

A lot of studies evaluating efficiencies in diversities of banks or finance houses evolved in Nigeria and other countries of the world. Those studies came up to measure the following efficiencies through the parametric and non-parametric approach; Technical efficiency. Allocative efficiency, Cost efficiency, Scale efficiency, profit efficiency etc. the following researchers came out with peculiar results that were pertinent with the areas in which they carried out the studies and are closely related with this study.

Toby (2006) [30] evaluates the x-efficiencies and scale economies in banking using the traditional stochastic cost frontier and non-parametric approach popularly known as data envelopment analysis (DEA) methodologies. The results support the view that smaller banks are more efficient than larger banks in most countries.

Akeem & Moses (2014) [1] empirically investigated the allocative efficiency of the Nigerian commercial banks for the period of 2002-2011. The Data Envelopment Analysis (DEA) model was used to determine the three input variables deposits, operating expenses, and assets and four output variables loan and advances, investment, Interest income, and non-interest income. The mean allocative efficiency, for the period examined stood at 0.896 (89.6%).

Moses & Ola (2015) [21] they evaluates pure and scale efficiency change consideration of banking industry in Nigeria for the period of 2003 and 2011. The study used Malmquist Productivity Index (MPI) to generate scores for both pure and scale efficiency change. Their results indicate that the average level of the pure efficiency change had gone up in a slight manner significantly from 0.999 in the year 2003 to 1.001 in year 2011 meaning that there is slight relative ability of banking operators to converts inputs into outputs. Reverse is the case for the scale efficiency change where in the year 2003 the score rose a little above the frontier at 1.005 but came down to 1.003 meaning that banking operators have been struggling to make use of the advantage of large scale production.

Yudistira (2004) he investigate technical, pure technical, and scale efficiency measures by utilizing non-parametric technique, Data Envelopment Analysis. Several conclusions emerge. First, the overall efficiency results suggest that inefficiency across 18 Islamic banks is small at just over 10 percent, which is quite low compared to many conventional counterparts. Islamic banks in the sample suffered from the global crisis in 1998-1999 but performed very well after the difficult periods. The findings indicate that there are diseconomies of scale for small-to-medium Islamic banks which suggests that mergers should be encouraged.

Pastory *et al.* (2013) [22] investigate the efficiency of Tanzania banking system. They used paned data from 45 banks for the period of 2006-2011 and employ the measures of financial ratios, parametric approach of Trans log and Cob Douglas and non-parametric approaches. The study revealed that the banks within the peer group were operating at higher level of efficiency but the industry at large still operates at inefficiency level but operate at higher level of profit efficiency due higher level of interest spread, large banks have been more efficient then the medium banks followed by the Non- Banking Financial institutions and finally the medium banks.

3. Methodology

3.1 Data Envelopment Analysis Technique

The different methods of modeling efficiency can be divided into parametric and non-parametric.

The Stochastic frontier Analysis (SFA) is based on maximum likelihood or other classical or Bayesian, parametric econometric techniques. Examples of Parametric techniques are the Stochastic Frontier Approach (SFA), Distribution Free Approach (DFA) and Thick Frontier Approach (TFA), which consider the efficiency frontier as an economic optimization exercise and define the efficient frontier through a functional form (typically a trans logarithmic cost function), which is estimated by econometric techniques. There was a strong controversy on which methodology efficiency-measuring frontier is preferable in general. In contrast, DEA is based on non-parametric, linear programming methods. Both paradigms are based on an underlying construct of the efficient production frontier that relates maximal output to inputs for the 'bank' (decision making unit, or DMU). The dominant non-parametric approach is the DEA which obtains efficiency estimates for the production units considered and creates an efficient frontier through the observed input-output ratios using mathematical programming techniques. In contrast to parametric methods DEA does not allow shocks to production or costs, therefore implying that any deviation from the frontier is inefficiency. However some of the most important advantages of the DEA methodology include the lack of restrictions on the functional form, the types of variables used the possibility of measuring those variables in different units, and the fact that any deviations from the efficiency frontier result to inefficiency. Data Envelopment Analysis (DEA) is a mathematical programming approach for the construction of production frontiers and the measurement of relative efficiency related to the constructed frontiers. The DEA was first used by Charnes *et al.* (1978) [9], and ever since has been a widely used to estimate efficiency in banking. Casu & Molyneux (2003) [8] state that the DEA methodology is based on a concept of efficiency similar to the microeconomic one, differing in that the DEA production frontier is generated by actual data and not by a specific functional form.

Particularly, the DEA frontier is formed by "best-practice observations" yielding a convex Production Possibility Set (PPS). "As a consequence, the DEA efficiency score for a specific Decision-Making Unit (DMU) is not defined by an absolute standard, but it is defined relative to other DMUs in the specific data set under consideration." Casu & Molyneux (2003) [8] one of the main differences of the parametric and non-parametric techniques is that parametric techniques require the estimation of a functional form to measure efficiency. Another main difference is that parametric techniques account for noise created by the estimation whereas the non-parametric technique does not.

There are two approaches when analyzing DEA. The first is the input-oriented model that assumes the minimization of inputs in order to produce the most amount of output. The second is the output oriented approach in which the model assumes the maximization of output subject to the amount of input available. Moreover, there are two variants in both models: Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS).

The CRS model implies that the Decision Making Units (DMUs) are operating at a Pareto-efficient point meaning that the scale of the operation of the DMU has no effect on its productivity. In this manner, there are no decreasing or increasing returns to scale Thanassoulis (2001). While the VRS Banker *et al.* (1984) [3] assumes that there are increasing or decreasing returns to scale meaning that there are imperfections in information, competition and finance, and the lack of constraint allows for the model to pick up these effects.

In banking, a most common approach towards DEA is the input-oriented VRS model to measure technical efficiency. The VRS model yields what is known as local (technical) efficiency scores, whereas the CRS model yields global technical efficiency scores. Hahn (2005) state the difference between the CRS (global technical efficiency) and VRS (local technical efficiency) indicates that a particular firm has scale efficiency. Scale efficiency is defined by the ratio: ESS = CRS/VRS. The value for scale efficiency is bounded by 0 and 1.

The study of Data Envelopment Analysis cum efficiency measurement begins with the notion of the ratio of output to inputs for bank 'I,'

$$Ratio_i = \alpha' y_i, / \beta' x_i, \ i = 1,....K,$$

Where y_i is the vector of M outputs and x_i is the vector of K inputs. The optimal weights are defined by the programming problem,

$$\text{Maximize wrt } \alpha,\beta: \ \alpha' y_i, / \beta' x_i$$
$$\text{Subject to} \quad \alpha' y_i, / \beta' x_i \leq 1, \ s = 1,...K$$
$$\alpha_m \geq 0, \ m = 1,...m$$
$$\beta_k \geq 0, \ k = 1,...k$$

The computer program makes the optimal weights to maximize the efficiency of bank subject to constraint that the efficiencies of all banks are equal to one, and all weights are nonnegative. It is normalized with a restriction such as $\alpha' x = 1$.

In transforming and simplifying the problem it produces the equivalent program.

$$\text{Maximize wrt } \alpha,\beta: \ \alpha' y_i,$$
$$\textit{Subject to} \quad \beta' x_i, = 1$$
$$\alpha' y_i, - \beta' x_i \leq 0, \ s = 1,...N$$
$$\alpha \geq 0$$
$$\beta \geq 0$$

An equivalent type of the problem is the envelopment form.
Minimize wrt θ_i, λ: θ_i

$$\text{Subject to} \quad \textstyle\sum_s y_s - y_i, \geq 0$$
$$\theta_i x_i - \textstyle\sum \lambda_s x_s \geq 0$$
$$\lambda_s \geq 0$$

The value of θ_i is the input oriented technical efficiency score for the ith bank.

$$TE_{input,i} = \theta_i.$$

This measures the extent to which the firm could reduce inputs to attain the same output relative to other banks in the sample. Efficient score will be 1 and 0, otherwise, $\theta_i \leq 1$.

The preceding formulation includes an absolute assumption of constant return to scale (CRS). The assumption is relaxed to variable return to scale (VRS), by adding a constraint.

$$\textstyle\sum_s \lambda_s = 1.$$

Variable return to scale is the standard assumption in current applications. This assumes the means by which the 'scale efficiency' of the firm can be measured. The scale efficiency (SE) may be measured by:

$$SEi = CRS_{ic} / VRS_{iv}$$

Where θ_{ic} represent the technical efficiency obtained assuming constant return to scale, θ_{iv} represent the variable return to scale.

3.2 Data and Model Specification

The secondary data are obtained from balanced cross-sectional time series panel data of the published financial statements of 15 quoted commercial banks in the Nigeria Stock Exchange fact book and the internet between the periods of 2007 – 2015 consisting of 135 observations. The efficiency variables are derived from income statements and balance sheets of commercial banks. In the banking industry, the classification of inputs and outputs is unclear. The numerical measurement of efficiency begins after identifying the inputs and outputs. A review of the studies that have measured banking efficiency generally reveals that the efficiency is calculated relatively. In other words, the calculations are based on comparisons among banks or groups of banks. First, an "efficiency limit" is identified, and the author calculates the relative efficiency levels and the degree to which each business (or group of businesses) deviates from this efficiency limit (or, if a model has been established, from the model values). The amount of deviation from the efficiency limit indicates the level of inefficiency Stavarek (2003) [28]. The relative efficiency can be calculated using parametric or non-parametric methods.

There are basically two popular approaches that are being used; these are intermediation approach and production approach. On the intermediation approach banks loans and other assets are considered as output since they are used to produce revenue of the banks. Deposit and other liabilities are considered as the inputs, it considers bank primary motive as to borrow funds from the depositors and lends those funds hence loans are considered as the output of the bank and the input includes interest expenses, labour costs, capital costs, operating costs and interest costs expenses. Production approach considers whether the asset and liabilities contribute to the output of the bank. It entails the commercial banks as the institution that uses labour and capital to produce various deposit accounts and loans. The inputs in this category are labour, capital and operating costs

Pastory *et al*. (2013) [22].

Therefore, in modeling bank behavior, this study follows intermediation approach in which Data Envelopment Analysis model consists of 3 outputs and 3 inputs, as follows:

Table 1: Specification of Inputs and Outputs Model

	Outputs		Inputs
Y_1	Loan and advances	X_1	Total deposits
Y_2	Investment	X_2	Operating expenses
Y_3	Non-interest income	X_3	Fixed assets

***Source*:** Adapted from Yudistira (2004), Yang (2012), Chung *et al.* (2001), Akeem & Moses (2014) [1] and Moses & Ola (2015) [21]

3.3 Conceptual Model

Apart from measuring efficiency levels of banks a very important research area is the determination of the factors associated with efficiency and inefficiency. After solving the DEA problem in the first–stage analysis the efficiency scores are regressed upon the bank specific factors.

The next step of the research was to investigate the relationship between efficiency and bank specific factors in the Nigeria banking industry. The coefficients reflect the direction of influence and the strength of the relationship can be assessed by the standard hypothesis. The focus is to measure the efficiencies which is regressed by estimating ordinary least square (OLS) model adapted based on the studies of Berger (1995) [6], Goldberg & Rai (1996) [13], Jian & Jing (2008) [16], Bello & Isola (2014) [4], Mertens & Urga (2001) [20] and Siudek (2008) [27].

$$ROA_{it} = \alpha + \beta_1 XE_{it} + \beta_2 SE_{it} + \beta_3 Z_{it} + \zeta \qquad (2)$$

The subscript *i* refer to the bank and *t* refers to the time period. The dependent variable of ROA represents profitability, XE is the x-efficiency, and SE is scale efficiency. Z = bank specific variables measured by the effect of bank size is the logarithm of total assets (log (A)), Bank cost. i.e. expenses management and ζ is an error term.

4. Empirical Results and Discussion

4.1 Estimation of Banks Efficiency Results

The data envelopment analysis model is used to estimate bank efficiency scores that is x-efficiency and scale efficiency. An efficiency index can be scores from 0 to100. Index equal to 100% represents full efficiency (the production unit belonging to the production frontier), whereas scores below 100% indicate some relative inefficiency (failure to minimize costs for a given output vector). The table below showed the result of bank efficiency ratios.

Table 2A: Overall Technical Efficiency, X-efficiency and Scale Efficiency Scores of Banks

DMU'S-Banks	OBS	Years	Constant Return to Scale or Technical efficiency	Variable Return to Scale or X-Efficiency	Scale Efficiency	Return to Scale
1.Skye Bank	1	2007	0.598	0.759	0.788	Increasing
	2	2008	0.703	0.781	0.9	Increasing
	3	2009	0.744	0.819	0.909	Increasing
	4	2010	0.758	0.809	0.937	Increasing
	5	2011	0.784	0.798	0.983	Increasing
	6	2012	0.826	0.837	0.987	Increasing
	7	2013	0.742	0.743	0.998	Increasing
	8	2014	0.733	0.736	0.996	Increasing
	9	2015	0.73	0.736	0.992	Increasing
Total			6.618	7.018	8.49	
Average			0.735333	0.779778	0.943333	
2. Fidelity	10	2007	0.534	1.000	0.534	Increasing
	11	2008	0.576	0.666	0.864	Increasing
	13	2009	0.701	0.744	0.942	Increasing
	14	2010	0.722	0.736	0.982	Increasing
	15	2011	0.654	0.654	0.999	Decreasing
	16	2012	0.746	0.765	0.976	Increasing
	17	2013	0.743	0.759	0.978	Increasing
	18	2014	0.741	0.762	0.972	Increasing
	19	2015	0.817	0.825	0.99	Increasing
Total			6.234	6.911	8.237	
Average			0.692667	0.767889	0.915222	
3. FCMB	20	2007	1	1.000	1.000	Constant
	21	2008	0.978	1.000	0.978	Decreasing
	22	2009	1	1.000	1.000	Decreasing
	23	2010	0.919	0.938	0.980	Decreasing
	24	2011	0.779	0.809	0.964	Decreasing
	25	2012	0.764	0.853	0.896	Decreasing
	26	2013	0.768	0.969	0.793	Decreasing
	27	2014	0.914	1.000	0.914	Decreasing
	28	2015	1	1.000	1.000	Constant
Total			8.122	8.569	8.525	
Average			0.902444	0.952111	0.947222	

***Source*:** Author's computation from DEAP 2.1 Software

Table 2B: Overall Technical Efficiency, X-efficiency and Scale Efficiency Scores of Banks

DMU'S-Banks	OBS	Years	Constant Return to Scale or Technical efficiency	Variable Return to Scale or X-Efficiency	Scale Efficiency	Return to Scale
4. Diamond	29	2007	0.726	0.726	0.999	Decreasing
	30	2008	0.773	0.818	0.946	Decreasing
	31	2009	0.688	0.715	0.963	Decreasing
	32	2010	0.802	0.835	0.96	Decreasing
	33	2011	0.67	0.724	0.926	Decreasing
	34	2012	0.675	0.759	0.89	Decreasing
	35	2013	0.643	0.744	0.865	Decreasing
	36	2014	0.671	0.857	0.783	Decreasing
	37	2015	0.649	0.844	0.769	Decreasing
Total			6.297	7.022	8.101	
Average			0.699667	0.780222	0.900111	
5. Ecobank	38	2007	0.699	0.908	0.77	Increasing
	39	2008	0.754	0.891	0.847	Increasing
	40	2009	0.739	0.928	0.797	Increasing
	41	2010	0.843	1.000	0.843	Decreasing
	42	2011	1	1.000	1.000	Constant
	43	2012	0.981	1.000	0.981	Decreasing
	44	2013	0.904	1.000	0.904	Decreasing
	45	2014	0.928	1.000	0.928	Decreasing
	46	2015	0.92	0.991	0.928	Decreasing
Total			7.768	8.718	7.998	
Average			0.863111	0.968667	0.888667	
6. Access Bank	47	2007	1	1.000	1.000	Constant
	48	2008	0.902	0.949	0.951	Decreasing
	49	2009	0.795	0.816	0.974	Decreasing
	50	2010	0.858	0.913	0.940	Decreasing
	51	2011	0.883	1.000	0.883	Decreasing
	52	2012	0.651	1.000	0.651	Decreasing
	53	2013	0.654	1.000	0.654	Decreasing
	54	2014	0.724	1.000	0.724	Decreasing
	55	2015	0.345	1.000	0.345	Decreasing
Total			6.812	8.678	7.122	
Average			0.756889	0.964222	0.791333	

***Source*:** Author’s computation from DEAP 2.1 Software

Table 2B: Overall Technical Efficiency, X-efficiency and Scale Efficiency Scores of Banks

DMU'S-Banks	OBS	Years	Constant Return to Scale or Technical efficiency	Variable Return to Scale or X-Efficiency	Scale Efficiency	Return to Scale
7. Firstbank	56	2007	0.746	0.769	0.971	Increasing
	57	2008	0.768	0.778	0.987	Increasing
	58	2009	0.831	0.836	0.994	Increasing
	59	2010	0.649	0.651	0.997	Increasing
	60	2011	0.742	0.743	1.000	Constant
	61	2012	1	1.000	1.000	Constant
	62	2013	0.705	0.726	0.970	Decreasing
	63	2014	0.663	1.000	0.663	Decreasing
	64	2015	0.709	0.794	0.893	Decreasing
Total			6.813	7.297	8.475	
Average			0.757	0.810778	0.941667	
8. Gtbank	65	2007	0.8	0.816	0.980	Decreasing
	66	2008	0.867	0.947	0.916	Decreasing
	67	2009	0.769	0.883	0.870	Decreasing
	68	2010	0.864	1.000	0.864	Decreasing
	69	2011	0.836	1.000	0.836	Decreasing
	70	2012	0.76	1.000	0.760	Decreasing
	71	2013	0.842	1.000	0.842	Decreasing
	72	2014	0.779	1.000	0.779	Decreasing
	73	2015	0.831	1.000	0.831	Decreasing
Total			7.348	8.646	7.678	
Average			0.816444	0.960667	0.853111	
9. Stanbic IBTC	74	2007	1	1.000	1.000	Constant
	75	2008	0.885	0.926	0.956	Increasing

	76	2009	0.85	0.858	0.991	Increasing
	77	2010	1	1.000	1.000	Constant
	78	2011	0.923	0.938	0.985	Increasing
	79	2012	1	1.000	1.000	Constant
	80	2013	1	1.000	1.000	Constant
	81	2014	0.908	0.921	0.986	Decreasing
	82	2015	0.868	0.882	0.984	Decreasing
Total			8.434	8.525	8.902	
Average			0.937111	0.947222	0.989111	

***Source*:** Author's computation from DEAP 2.1 Software

Table 2C: Overall Technical Efficiency, X-efficiency and Scale Efficiency Scores of Banks

DMU'S-Banks	OBS	Years	Constant Return to Scale or Technical efficiency	Variable Return to Scale or X-Efficiency	Scale Efficiency	Return to Scale
10. Sterling	83	2007	0.976	1.000	0.976	Decreasing
	84	2008	0.778	0.944	0.824	Decreasing
	85	2009	0.751	0.901	0.833	Decreasing
	86	2010	0.712	0.828	0.859	Decreasing
	87	2011	0.573	0.636	0.900	Decreasing
	88	2012	0.723	1.000	0.723	Decreasing
	89	2013	0.771	1.000	0.771	Decreasing
	90	2014	0.756	1.000	0.756	Decreasing
	91	2015	0.759	0.940	0.807	Decreasing
Total			6.799	8.249	7.449	
Average			0.755444	0.916556	0.827667	
11. UBA	92	2007	0.692	0.708	0.977	Increasing
	92	2008	0.565	0.577	0.980	Increasing
	93	2009	0.636	0.636	1.000	Constant
	94	2010	0.547	0.563	0.970	Increasing
	95	2011	0.66	0.673	0.980	Increasing
	96	2012	0.627	0.627	1.000	Constant
	97	2013	0.618	0.626	0.987	Increasing
	98	2014	0.634	0.638	0.994	Increasing
	99	2015	0.655	0.658	0.995	Increasing
Total			5.634	5.706	8.883	
Average			0.626	0.634	0.987	
12. Union Bank	100	2007	0.478	0.506	0.944	Increasing
	101	2008	0.497	0.504	0.987	Increasing
	102	2009	0.473	0.478	0.99	Increasing
	103	2010	0.709	0.710	0.998	Decreasing
	104	2011	0.732	0.733	0.999	Decreasing
	105	2012	0.674	0.674	1.000	Constant
	106	2013	0.721	0.722	0.998	Decreasing
	107	2014	0.7	0.700	0.999	Constant
	108	2015	0.608	0.613	0.991	Increasing
Total			5.592	5.64	8.906	
Average			0.621333	0.626667	0.989556	

***Source*:** Author's computation from DEAP 2.1 Software

Table 2D: Overall Technical Efficiency, X-efficiency and Scale Efficiency Scores of Banks

DMU'S-Banks	OBS	Years	Constant Return to Scale or Technical efficiency	Variable Return to Scale or X-Efficiency	Scale Efficiency	Return to Scale
13. Unity Bank	109	2007	0.949	0.950	0.999	Decreasing
	110	2008	0.606	0.721	0.841	Decreasing
	111	2009	0.501	0.502	0.999	Decreasing
	112	2010	0.609	0.628	0.971	Decreasing
	113	2011	0.642	0.654	0.981	Decreasing
	114	2012	0.717	0.729	0.984	Decreasing
	115	2013	0.656	0.662	0.991	Decreasing
	116	2014	0.709	0.711	0.997	Decreasing
	117	2015	0.882	0.882	1.000	Constant
Total			6.271	6.439	8.763	
Average			0.696778	0.715444	0.973667	
14. WEMA	118	2007	0.512	0.530	0.967	Decreasing

	119	2008	0.425	0.429	0.992	Decreasing
	120	2009	0.698	0.703	0.994	Decreasing
	121	2010	0.701	0.722	0.971	Decreasing
	122	2011	0.596	0.598	0.997	Decreasing
	123	2012	0.54	0.544	0.993	Decreasing
	124	2013	0.584	0.584	1.000	Constant
	125	2014	0.566	0.566	1.000	Constant
	126	2015	0.604	0.604	1.000	Constant
Total			5.226	5.28	8.914	
			0.580667	0.586667	0.990444	
	127	2007	0.883	0.903	0.978	Increasing
	128	2008	0.644	0.655	0.984	Increasing
	129	2009	0.618	0.621	0.995	Increasing
	130	2010	0.578	0.588	0.983	Increasing
	131	2011	0.589	0.597	0.987	Increasing
	132	2012	0.574	0.579	0.991	Increasing
	133	2013	0.647	0.650	0.996	Increasing
	134	2014	0.822	0.834	0.986	Decreasing
	135	2015	0.849	0.854	0.995	Decreasing
Total			6.204	6.281	8.895	
Average			0.689333	0.697889	0.988333	
Industry Average			0.742	0.807	0.928	

Source: Author’s computation from DEAP 2.1 Software

The Data envelopment analysis estimate produced mixed results for all the banks as they are efficient in some years and inefficient in other years and those banks with scores of 100 are efficient as they are profitable and successful in the use of their minimum inputs to achieved maximum outputs. While those banks with scores less than 100 are inefficient as they are not profitable and unsuccessful in the use of their minimum inputs to achieved lower outputs in both x-efficiency and scale efficiency estimates. However, the industry average for x-efficiency was 80.70% while that of scale efficiency was 92.80% for the entire Nigerian banking industry.

In overall, scale efficiency scores are better than x-efficiency; over the sampling period, the industry averages were 92.80% for scale-efficiency while 80.70% for x-efficiency, respectively

The result from table 1 revealed that within the period of 2007 to 2015 the United Bank for Africa PLC had constant return to scale as well as increasing return to scale efficiencies indicating that this bank will optimally attain the scale efficiency level based on our expectation. Again, Skye Bank PLC had a continuous increasing return to scale signaling the expected scale efficiency level in the subsequent periods as it maintained the return to scale to this period.

Table 3: Overall Technical Efficiency, Pure Technical Efficiency and Scale Efficiency of Banks

S/N	Banks	CRS TE	VRS TE	Scale TE
1	Skye Bank	0.735	0.780	0.943
2	Fidelity Bank	0.693	0.768	0.915
3	Fcmb	0.902	0.952	0.947
4	Diamond	0.700	0.780	0.900
5	Ecobank	0.863	0.964	0.889
6	Access Bank	0.757	0.964	0.791
7	First Bank	0.757	0.811	0.942
8	GT Bank	0.816	0.961	0.853
9	Stanbic IBTC	0.937	0.947	0.989
10	Sterling	0.755	0.917	0.828
11	UBA	0.626	0.634	0.987
12	Union Bank	0.621	0.627	0.990
13	Unity Bank	0.697	0.715	0.974
14	Wema Bank	0.581	0.587	0.990
15	Zenith Bank	0.689	0.698	0.988
	Industry Average	0.742	0.807	0.928

Source: Author's Computation from data obtained from the bank’s annual reports from 2007 to 2015

Based on the results discussed above we infer the existence of global/overall efficiency, technical efficiency and scale efficiency of the mega commercial banks.

Table 2 shows the average overall efficiency according to Charnes, Cooper and Rhodes (CCR) model as it assumes constant return to scale (CRS). The efficiency score determine the mean constant return to scale technical efficiency of the Nigeria banking industry from 2007-2015.

The industry average from CCR-DEA model of overall technical efficiency is 74.2%. While the 28.2% indicating inefficiency (failure to minimize cost for a given output vector).

The CRS model yields global technical efficiency scores and this satisfied those Nigerian banks that can compete globally such as Stanbic IBTC bank is the highest with an average score of 0.937, FCMB recorded efficiency average score of 0.902, Eco bank recorded efficiency level average score of 0.863, GT Bank recorded efficiency level average score of 0.816, followed by First Bank with average score of 0.757 and Access bank with the efficiency level of 0.756, Sterling bank recorded efficiency score of 0.755 and finally Skye bank which recorded efficiency level of 0.735.

The result for x-efficiency revealed that the industry average of the sector during the period 2007 to 2015 is estimated at 80.7%. This is reflected by the fact that inefficiency cost is at 19.3%. In other words, the inefficiency score reflects a waste of resources (inputs) of 19.3% without altering its vector in the industry.

The VRS model yields what is known as local (technical) efficiency or x-efficiency. From the results in table.1, the banks that score the highest average x-efficiency are Ecobank with average score of 0.964, follow by Access bank and GTbank with average scores of 0.961, FCMB with average score of 0.952, next is Stanbic with average score of 0.947 and finally Sterling bank with average score of 0.917.

The scale efficiency aim at determining the contribution of a change in size to reduce banking costs. The industry average result suggests that banks in the industry have a degree of scale efficiency that is relatively large showing 92.8%. This means that banks can reduced their costs on average by 7.2% increase in their size i.e. inefficiency (failure to operate at the minimum efficient scale).

The scale efficiency shows the average performance of banks as they are operating at their optimal scale of operations. The banks were ten (10) with average scale efficiency of 0.99 to 0.915 such as, Wema bank, Union Bank, Zenith Bank, Stanbic IBTC, UBA, Unity bank, FCMB, Skye bank, First Bank and Fidelity bank

4.2 Econometric analysis results

The econometric analysis of model (2) confronts the following issues: First, we test for stationarity of the panel, using a unit root test for balanced panel data. Second, we used the ordinary least square estimation to analyze the multiple regressions on table 5 below.

Table 4: Unit Root Test Result

Variables	ADF Statistics	5% Critical values	Probability Values	Order of Integration	Recommendation
ROA	-9.296079	-2.883073	0.0000	1(0)	Stationarity
XE	-4.852705	-2.883073	0.0001	1(0)	Stationarity
SE	-6.582563	-2.883073	0.0000	1(0)	Stationarity
BS	-3.286179	-2.883073	0.0176	1(0)	Stationarity
EXM	-5.245912	-2.883073	0.0000	1(0)	Stationarity

***Source*:** Eviews 9 output

The Augmented Dickey-Fuller test was used to check for stationarity of the variables. The decision rule is that the ADF test statistic value must be greater than the Mackinnon critical value at 5% (in absolute value). Table 4 showed that all the variables were stationary at their level, indicating that they are all integrated of order zero i.e. 1(0). This is in confinement with other researches that economic variables are stationary at their level or at their first difference. Since all the variables have their respective ADF statistic greater than the Mackinnon critical value at 5%. As evidenced from the unit root test, the variables would have a long run relationship.

Table 5: Estimated Regression Result

Dependent Variable: ROA				
Method: Least Squares				
Date: 01/29/18 Time: 15:04				
Sample (adjusted): 2 135				
Included observations: 134 after adjustments				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-6.220893	7.360913	-0.845125	0.3997
XE	-13.73555	3.798441	-3.616102	0.0004
SE	-5.307486	4.999521	-1.061599	0.2905
LOG_BS	-0.215773	0.222488	-0.969820	0.3340
EXM	-4.01E-05	0.000699	-0.057381	0.9543
ROA(-1)	0.224640	0.081722	2.748820	0.0069
XE(-1)	16.71724	3.835589	4.358455	0.0000
SE(-1)	12.87800	4.956194	2.598364	0.0105
LOG_BS(-1)	0.154116	0.225456	0.683574	0.4955
EXM(-1)	-0.000186	0.000690	-0.269250	0.7882
R-squared	0.192174	Mean dependent var		2.742575
Adjusted R-squared	0.133542	S.D. dependent var		4.872676
S.E. of regression	4.535669	Akaike info criterio++-n		5.933518
Sum squared resid	2550.964	Schwarz criterion		6.149774
Log likelihood	-387.5457	Hannan-Quinn criter.		6.021397
F-statistic	3.277607	Durbin-Watson stat		1.915847
Prob(F-statistic)	0.001301			

***Source*:** Eview 9 output 2018

From table 5 above the regression result provided statistically significant relationship between x-efficiency and profitability confirming the present of x-efficient hypothesis version of the efficient-structure hypothesis in the Nigerian banking industry. Furthermore, scale efficiency has shown a statistically significant positive relationship between scale efficiency and profitability verifying the present of scale efficient hypothesis thereby supporting the scale efficiency version of the efficient-structure hypothesis in the industry. The regression result provided statistical evidence for the relationships of technical and scale efficiency with profitability. The bank specific control variable such as bank size was not able to provide evidence for significant relationship with profitability. There is absence of interdependence between the bank size and profitability. Bank cost i.e. expense management (raw efficiency parameter) is negative and not statistically significant; this suggests that the advantage of the performance of the Nigerian banking industry is not influence by bank cost.

Statistically, the overall goodness fit of the model as shown by the adjusted coefficient of determination was 0.19, and this indicates a poor relationship between banks profitability and the independent variables.

Appendix 1: Panel data for Return-on-Assets ROA; X-Efficiency XE; Scale Efficiency SE; Log of Bank Size BS; Expenses Management EXM.

OBS	ROA	TE	SE	Log BS	EXM
1	0.468	0.759	0.788	13.008	4.62
2	2.041	0.781	0.900	13.573	3.58
3	0.016	0.819	0.909	13.620	5.34
4	1.240	0.809	0.937	13.668	5.98
5	1.247	0.798	0.983	13.887	5.26
6	1.435	0.837	0.987	13.926	3.91
7	0.685	0.743	0.998	14.167	3.14
8	0.824	0.736	0.996	14.197	4.19
9	1.037	0.736	0.992	14.228	4.32
10	1.916	1.000	0.534	12.288	4.16
11	2.436	0.666	0.864	13.187	2.97
13	0.326	0.744	0.942	12.981	3.64
14	1.172	0.736	0.982	13.117	5.88
15	0.530	0.654	0.999	13.511	4.93
16	1.960	0.765	0.976	13.726	5.55
17	0.714	0.759	0.978	13.894	5.02
18	1.162	0.762	0.972	13.987	4.81
19	1.129	0.825	0.990	14.024	5.20
20	3.233	1.000	1.000	19.963	2.32
21	0.775	1.000	0.978	20.061	3.86
22	0.122	1.000	1.000	19.955	5.84
23	1.473	0.938	0.980	20.104	5.85
24	1.277	0.809	0.964	20.215	5.46
25	1.664	0.853	0.896	20.627	1.20
26	1.580	0.969	0.793	20.732	1.59
27	1.887	1.000	0.914	20.880	0.97
28	0.403	1.000	1.000	20.871	1.06
29	1.959	0.726	0.999	20.218	3.01
30	1.065	0.818	0.946	20.294	3.77
31	0.809	0.715	0.963	20.219	6.04
32	1.189	0.835	0.960	20.123	7.86
33	3.203	0.724	0.926	20.386	7.05
34	2.179	0.759	0.890	20.781	3.23
35	2.196	0.744	0.865	21.027	3.21
36	1.260	0.857	0.783	21.283	3.01
37	0.247	0.844	0.769	21.165	3.38
38	2.392	0.908	0.770	12.649	4967.7
39	0.001	0.891	0.847	12.977	6012.5
40	1.290	0.928	0.797	12.782	8.61
41	1.259	1.000	0.843	16.164	0.29
42	1.205	1.000	1.000	16.658	0.12
43	1.438	1.000	0.981	16.808	0.15
44	0.656	1.000	0.904	16.930	0.14
45	1.628	1.000	0.928	17.004	0.18
46	0.456	0.991	0.928	16.975	0.16
47	1.556	1.000	1.000	20.755	1.27
48	3.287	0.949	0.951	20.330	4.97
49	0.136	0.816	0.974	20.289	4.05
50	1.779	0.913	0.940	20.404	5.34

51	0.553	1.000	0.883	20.671	4.10
52	2.363	1.000	0.651	21.139	2.24
53	1.538	1.000	0.654	21.256	3.32
54	2.015	1.000	0.724	21.407	2.80
55	2.731	1.000	0.345	21.604	3.46
56	1.616	0.769	0.971	13.969	6.53
57	2.103	0.778	0.987	14.327	4.85
58	0.072	0.836	0.994	14.388	3.95
59	1.637	0.651	0.997	14.490	5.47
60	1.927	0.743	1.000	14.717	5.47
61	0.302	1.000	1.000	12.510	0.30
62	22.652	0.726	0.970	12.650	0.37
63	1.975	1.000	0.663	12.570	0.74
64	0.771	0.794	0.893	12.553	1.63
65	2.892	0.816	0.980	20.411	4.11
66	3.735	0.947	0.916	20.682	4.28
67	2.221	0.883	0.870	20.788	5.15
68	3.329	1.000	0.864	20.865	5.54
69	3.390	1.000	0.836	21.144	1.07
70	5.262	1.000	0.760	21.206	1.27
71	4.492	1.000	0.842	21.367	1.21
72	4.193	1.000	0.779	21.478	2.23
73	4.141	1.000	0.831	21.546	2.13
74	2.281	1.000	1.000	12.626	3.26
75	2.670	0.926	0.956	12.752	7.11
76	1.891	0.858	0.991	12.710	8.97
77	2.096	1.000	1.000	12.828	8.17
78	0.746	0.938	0.985	13.204	7.51
79	1.452	1.000	1.000	11.191	0.01
80	11.05	1.000	1.000	11.231	1.22
81	17.36	0.921	0.986	11.234	1.88
82	18.415	0.882	0.984	11.241	10.23
83	0.425	1.000	0.976	18.799	6.81
84	2.761	0.944	0.824	19.281	5.91
85	3.239	0.901	0.833	19.142	9.45
86	1.610	0.828	0.859	19.375	5.84
87	1.371	0.636	0.900	20.038	4.06
88	1.198	1.000	0.723	20.179	3.45
89	1.169	1.000	0.771	20.378	3.81
90	1.092	1.000	0.756	20.530	1.20
91	1.287	0.940	0.807	20.499	1.46
92	1.799	0.708	0.977	13.913	4.03
92	2.632	0.577	0.980	14.234	3.82
93	0.920	0.636	1.000	14.153	7.81
94	0.151	0.563	0.970	14.175	3.94
95	0.478	0.673	0.980	14.326	6.12
96	2.451	0.627	1.000	14.475	3.90
97	2.096	0.626	0.987	14.612	3.87
98	1.714	0.638	0.994	14.665	4.24
99	2.150	0.658	0.995	14.611	4.66
100	0.552	0.506	0.944	13.718	3.56
101	0.374	0.504	0.987	13.917	5.59
102	0.087	0.478	0.990	13.733	15.38
103	8.350	0.710	0.998	13.647	7.60
104	9.274	0.733	0.999	13.626	8.85
105	0.358	0.674	1.000	13.695	7.10
106	0.581	0.722	0.998	13.690	6.43
107	2.226	0.700	0.999	13.732	6.22
108	1.775	0.613	0.991	13.814	5.61
109	0.355	0.950	0.999	19.130	6.42
110	3.637	0.721	0.841	19.713	7.34
111	6.174	0.502	0.999	19.364	14.22
112	4.083	0.628	0.971	19.533	9.89
113	0.722	0.654	0.981	19.737	8.67
114	1.562	0.729	0.984	19.796	7.50
115	5.595	0.662	0.991	19.816	12.85

116	2.587	0.711	0.997	19.840	7.55
117	1.058	0.882	1.000	19.910	2.95
118	44.791	0.530	0.967	18.675	8.54
119	10.514	0.429	0.992	18.525	13.04
120	1.467	0.703	0.994	18.777	9.31
121	7.994	0.722	0.971	19.129	8.96
122	1.912	0.598	0.997	19.214	7.85
123	2.051	0.544	0.993	19.320	3.14
124	0.483	0.584	1.000	19.617	2.76
125	0.620	0.566	1.000	19.762	2.59
126	0.587	0.604	1.000	19.799	2.87
127	1.981	0.903	0.978	13.692	5.10
128	2.769	0.655	0.984	14.334	4.84
129	1.167	0.621	0.995	14.269	6.57
130	1.863	0.588	0.983	14.397	4.98
131	1.904	0.597	0.987	14.590	5.00
132	3.931	0.579	0.991	14.706	4.58
133	2.898	0.650	0.996	14.873	4.82
134	2.701	0.834	0.986	15.046	4.45
135	2.634	0.854	0.995	15.137	4.14

5. Conclusion

In this paper, overall technical efficiency, pure technical efficiency and scale efficiency measure are calculated by utilizing the non-parametric technique, Data Envelopment Analysis. The overall efficiency result suggest that inefficiency across 15 mega banks is small at just over 28.2 percent, which is quite low compare to conventional average. In the case of the theory of efficient-structure, in particular, the scores of x-efficiency and those of scale efficiency were obtained using the non-parametric method for estimating the efficiency DEA. The x-efficiency result showed an industry average of 80.7 percent representing high level of efficiency among the mega banks. The results showed that there is scale efficiency in the Nigerian banking industry, with larger banks in general being more likely to have higher scale efficiency than smaller ones.

The empirical results for the efficient-structure hypotheses revealed that the x-efficiency and scale efficiency are strongly present in the Nigerian banking industry. Additionally, x-efficiency, which is common in the industry, significantly impact profitability.

The significant relationship between technical, scale efficiency and profitability could be viewed as further evidence of the robustness of the estimated efficiency parameters. The banks are efficient within their peer group themselves as they indicate higher efficiency level.

From the results obtained its entails that the industry had the chance to increase their performance level because the whole industry average for x-efficiency i.e. pure technical efficiency is 80.7% and this reflect that inefficiency cost is at 19.3 percent. While, scale efficiency is relatively large with industry average of 92.8% meaning that banks can reduce their costs on average by 7.2 percent. In general it has been characterized on average with inefficiency level hence the banking industry can increase their performance by increasing productions at a lower unit cost, alternatively the banks can reduce the input ratio to maintain the same output level.

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