**Determinants of Banks and Financial System Efficiency in Nigeria: A Stochastic Frontier Approach (SFA)**

**Abstract**

This study adopts the relatively novel stochastic frontier analysis approach in examining cost efficiency and its determinants in the Nigerian banking sector, focusing on the dual effects of bank specific factors and macroeconomic variables. The results show that Nigeria banks are generally cost-efficient with asset quality and regulatory quality enhancing the efficiency, while inflation and financial capital undermines it. The efficiency score measures how efficient banks are in the combination of labour, capital, and financial capital to produce an optimal combination of deposits collection and loans creation. The banks are estimated to be efficient at 82 percent given their strategy of transforming deposits into short- and long-term loans, with macroeconomic stability contributing significantly to banks and financial system efficiency.

**Key words:** Banking, cost efficiency, stochastic frontier

**1 Introduction**

The soundness and efficiency of financial institutions is an important element to the health of any economy. This is because banks and other financial institutions play a systemic role in the development of the real sector through the efficient allocation of financial resources within the economy. The most important functions of commercial banks within the economy are savings and deposit mobilization and loan creation, and local and international trade facilitation services. Schumpeter (1911), posits that financial intermediation through the banking system plays a vital role in economic development through efficient allocation of savings, thereby improving productivity, technical change and the rate of economic growth. This is also corroborated by the endogenous growth model, which postulates that financial development has a positive impact on the growth of the economy. That is, efficient financial institutions and financial system are able to mobilize savings, allocate resources efficiently, diversify risk, and enhance the flow of liquidity.

Given the pivotal role of efficient financial institutions in economic development and financial systems stability, considerable research efforts have been made to understand and measure the determinants of the efficiency of financial institutions, particularly commercial banks. These research efforts have focused on estimating an efficient frontier and measuring the average differences between observed banks and banks on the frontier. Efficiency measures how close a production unit gets to its production possibility frontier, which is composed of sets of points that optimally combine inputs in order to produce an output. In relation to banks, it refers to the ability of banks to produce output using a given level of inputs with minimum cost. This definition indicates that banks should allocate inputs and outputs properly with the aim of obtaining maximum result with minimum cost (Erkoc 2013; Kablane, 2010). Many studies find significant differences in cost inefficiencies amongst Nigerian Banks. However, there is no consensus on the sources of the differences in measured efficiency. Berger and Mester (2008) suggest that efficiencies comes from three sources, namely: (i) differences in the concept of efficiency used; (ii) differences in measurement methods used to estimate efficiency within the context of these concepts; and (iii) correlates or determinants of efficiency such as bank specific, macroeconomic, and regulatory characteristics which may explain some of the efficiency differences after controlling for efficiency concept and measurement method.

Nigerian banks present an interesting case as the sector has experienced a cyclical pattern of boom and burst over the past 25 to 30 years (Suleyman, 2016). Prior to the deregulation of the sector in 1986, many banks operated at a level that is less efficient and profitable leading to distress in the industry. Small sized and undercapitalized banks with huge overheads, low capital base, loss making and heavy reliance on government patronage characterized the sector. Consequently, commercial banks were compelled by the Central Bank of Nigeria to raise their capital base from 2 billion naira (US$14million) to 25 billion naira (US$173million) in the 2005. The 1986 recapitalization policy is one of several reforms that have guided the sector to the present time. The financial systems regulator in Nigeria, the Central Bank of Nigeria (CBN) recently described “all” Nigerian banks as safe and healthy (CBN, 2016 Financial Stability Report), notwithstanding the global economic challenges emanating from the collapse of major commodity prices. As such, deposits remain safe in any Nigerian bank.

Notwithstanding the position of the CBN about the stability of Nigerian banks, there are a number of performance and efficiency factors and metrics that require closer examination. The quality of assets in the banking sector declined marginally in the second half of 2015 with the decline in asset quality attributed to the unfavorable macroeconomic environment (Suleyman, 2016). Capital Adequacy Ratio (CAR) also weakened during the period and stood at 17.5% in 2015, versus a required ratio of 15% for systemically important banks. The weakened CAR was attributable to the fall in the level of banks general reserves. Savings deposit rate also fell marginally from 3.59% by January to 3.58% in December 2015. The level of non-performing loans (NPLs) on bank’s balance sheet continues to increase with adverse impact on profitability, liquidity, deposit mobilization and loan creation. Credit Risk Rating indicates that Non-performing loans rose to N649.63 billion at end-December 2015, from N628.54 billion at end-June 2015 (N363.31 billion recorded at end-December 2014). Despite the 30 per cent decline in new loans granted by banks in 2015, 18 of the 22 banks recorded increases in bad loans. The number of banks that exceeded the regulatory limit of five per cent for the ratio of bad loans to total loans rose from three (3) in 2014 to eight (8) in 2015 (CBN, 2016 Financial Stability Report).

Given the rise in global economic and financial challenges in recent times and the need to have sustainable institutions and financial systems, periodic analysis of the performance and efficiency of banks is required. The aim of this regular review and analysis is to understand the determinants and drivers of bank efficiency with a view to measuring and directing policies and actions towards optimizing these determinants and drivers of efficiency. While significant research and regulatory efforts have been directed at this issue in various local and global contexts and jurisdictions, to the best of our knowledge and based on extensive literature review, little effort has been made in this regard with respect to Nigerian banks and the banking and financial system. Furthermore, research effort in this area with respect to the Nigerian banking sector has employed financial ratios as a measure of efficiency and performance, and in relation to firm-specific variables only. This approach has inherent limitations and is not likely to produce robust or conclusive results that can aid operational and policy decisions.

 This present study will contribute to our knowledge and existing literature by looking at the determinants of the efficiency of deposit money banks in Nigeria using both bank specific and macro-economic variables. Banks operate under changing macroeconomic and regulatory environment that impacts their efficiency and performance. Hence, it is plausible and useful to perform an analysis based on both micro (bank-specific) and macro (macroeconomics) environment (Anbar and Alper, 2011; Raphael, 2013). Emphasis is also placed on the use of frontier analysis methods in measuring bank efficiency instead of using financial ratios. This method makes it possible to determine the cost frontier while taking into account factors related to both the technological process of banks and the environment in which they operate.

Following the introduction, the rest of the paper is organized into four sections. Section 2 gives a brief review of the empirical literature on the determinants of the efficiency of banking sector. Section 3 presents the data and methodology. Section 4 presents the results and discussion and section 5 provides the conclusions.

**2. Brief Empirical Review**

From a review of extant literature, previous studies and investigations of the determinants of the efficiency of banking sector have been country-specific or cross-country studies, with most of these studies based on developed economies with very little focus on developing economies like Nigeria. In addition, these studies have produced mixed results due perhaps to differences in methodology, data choice and sample period, and measures of efficiency adopted. Some of these studies include the earlier work of Berger and Humphrey (1992), Berger et al. (1993), Miller and Noulas (1996), Berger and Hannan (1998), Evan and Dogan (1998) to the recent studies of Berger and Mester (2008), Berger, Hasan and Zhou (2009), Ramona and Estelle, (2010), Dong, Abul, and Andrew (2011), Alin (2011), Pessarossi and Weill (2013), Małgorzata and Patrycja (2014), Hakan and Dilem (2016), Majed (2016) among others.

Using econometric techniques, Oyedokun (2014) examined the main determinants of efficiency of Nigerian Commercial Banks and the effect of changes in capital base on efficiency. The study finds that while bank performance and efficiency is strongly affected by capital base, changes in capital requirements are ineffective in reducing distress in the banking industry. A similar study by Olarewaju (2016) on the influence of banks capital base on the level of operational efficiency of banks in Nigeria for the period 2004- 2013 was evaluated. Using descriptive statistics and two-way fixed effect regression technique, this author found that debt to total equity, core capital ratio and bank risk was significant in evaluating the influence of capital adequacy on operational efficiency of the Nigerian money deposit banks.

Ubesie and Okwy-Nwangwu (2013) assessed bank specific factors that determine financial performance. Using linear multiple regression model and Ordinary Least Square (OLS) on pooled data to estimate the parameters, they found that banks performance in Nigeria is only affected by the operating expenses and firm size when performance is measured by return on asset (ROA) and return on equity (ROE). The coefficients representing operating expenses, in ROA and ROE are negative and statistically significant. Moreover, the size of the banks is positively and statistically significant in the models. However, performance of commercial banks in Nigeria is not influenced by capital strength as its coefficient is not statistically significant. Haruna (2015) examined the determinants of financial performance of listed mega banks in Nigeria for a period of seven years. The result of his random effect regression analysis provides evidence that capital adequacy, bank size, cost-to-income ratio and income diversification have significant impact on financial performance of the banks under study. Furthermore, Idialu and Yomeru (2010) analyzed the efficiency of the Nigerian banks using the Stochastic Frontier Analysis (SFA) over the sample period of 2000 and 2004. Their result showed that there is inefficiency in the Nigerian banking system ranging between 0 and 19 percent of the total cost while the level of efficiency of individual bank ranged between 81 to 100 percent. With respect to the determinants of efficiency, they found that customer loans, other earning assets, salaries, interest, other overheads, capital and non-performing loans are capable of determining the efficiency of the banking system in Nigeria. (See Eriki and Osagie (2015), Olaoye and Olarewaju (2015), Omankhanlen (2013), David and Poloamina (2012) and Ekwueme et al., (2010) for more on bank-specific variables).

Mergers and acquisitions in the Nigerian banking sector are reform strategies recently adopted to reposition the banking sector and to achieve improved financial efficiency. As a result, Owolabi and Ajayi (2013) made a comparative analysis on the financial efficiency of banks in the pre-and post-merger and acquisitions era in Nigeria. They used gross earnings, profit after tax and net asset of the selected bank as indices to determine financial efficiency. Data were collected from the published annual reports of the selected banks and was analyzed applying t-test statistics. Their results suggest that the post-mergers and acquisitions period was more financially efficient. In addition, Martina and David (2015) examined the impact of Nigerian banking sector reforms on Nigerian banks’ performance and efficiency in two-time periods, pre -consolidation and post-consolidation period. These authors adopted a non-parametric (Data Envelopment Analysis) approach and their findings revealed varying levels of efficiency in both periods. They also reported that some banks still remained inefficient but there was a general improvement in efficiency in the post-consolidation period though this improvement was not entirely attributed to the consolidation policy as two immediate years after the consolidation exercise still recorded poor levels of efficiency among many banks. (See Michael (2017), Frances et al. (2013) and Aliyu (2010) for more on reforms and consolidation effect on efficiency of banks in Nigeria).

Apart from the fact that the above studies are limited in scope, their findings are also mixed. Therefore, following Berger and Mester (2008), this present effort is an attempt to contribute empirically to the literature by updating the data and the scope of most of the earlier studies on the efficiency of Nigerian banking sector and its determinants.

**3 Methodology**

Measuring efficiency in banking has been extensively researched over the past decades. The analysis has developed along two separate streams, the parametric (econometrics) and the non-parametric approaches. In this study, the parametric approach is adopted. Different econometric methods such as Stochastic Frontier Analysis (SFA), Thick Frontier Approach (TFA) and Distribution Free Approach (DFA) have been employed in recent studies, but only a handful of them have focused on the estimation of efficiency in the developing countries, most especially, the Nigerian banking sector. To the best of our knowledge, only one of the previous studies on the Nigerian banking system has employed a stochastic frontier functional form. Specifically, and in line with the study of Girardone et al. (2004) on Italian banks that was adopted by Indialu and Yomeru (2010) for the Nigerian banking sector, this present study uses the stochastic cost frontier approach to generate estimates of X-efficiencies for each bank over the study period. A fundamental element of stochastic frontier analysis is that each bank potentially produces less than it might produce because of a degree of inefficiency modeled as an additional stochastic term. For the $ith$ firm at time $t$, the single equation cost function model is represented in natural logs as:

$$ lnTC\_{it}=lnTC\left(W\_{it},Y\_{it};Z\right)+ε\_{it} i=1,…I;t=1,…T 3.1$$

where $TC\_{it}$, is the observed logarithm of the total costs of production for bank $i$ at time $t$, $Y\_{it}$ is the vector of banking output for bank $i$ at time $t$, $W\_{it}$ is the vector of input prices for bank $ith$ at time $t$, and Z is a vector of unknown parameters of bank-specific and macroeconomics variables for the associated output and input price in efficiency estimation. The stochastic cost frontier model used in this empirical study implies that a banking firm's observed total cost will deviate from the cost-efficient frontier because of random noise, v, and possible inefficiency, u. Thus, using data from sixteen Nigerian banks covering the period 2006 to 2016 organized in a panel template, a single Cob-Douglas form stochastic frontier cost function model is expressed as:

$$lnTC\_{it}=β\_{0}+X\_{it}β+V\_{it}+U\_{it} U\_{it}\geq 0; i=1,…I;t=1,…T 3.2$$

$TC\_{it}$, is as defined above, $X\_{it}$ is a k x 1 vector of input prices and output quantities of the $ith$ firm in the $t th$ time period. For the $ith$ bank at time $t$:

 $ε\_{it}=v\_{it}+u\_{it}$

$u\_{it}$ is time-variant cost inefficiency, and $v\_{it}$ is the random variables of $ith$ unit in year $t$ reflecting the effect of statistical noise. A detailed version of this model is provided by Kumbhakar and Lovell (2000) as:

$$lnTC\_{it}=β\_{0}+β\_{y}lnY\_{it}+ \sum\_{n}^{}β\_{n}lnW\_{nit}+V\_{it}+U\_{it} U\_{it}\geq 0; i=1,…I;t=1,…T 3.3$$

All parameters are as defined above. Given the multiplicity of bank functions, the trans-logarithmic functional form is used to estimate the cost function. The trans-logarithmic function seems to be best adapted compared to other functional forms because it takes into account the numerous complementarities between explanatory factors. Besides, it does not impose any restriction on the functional form (Kablane, 2010). Thus, the model to be estimated for this study, that is, the multi-period cost function is of the form:

$$lnTC\_{it}=α\_{O}+\sum\_{i}^{ }α\_{i}lnY\_{i}+\sum\_{j}^{ }β\_{j}lnW\_{j}+½\sum\_{i}^{ }\sum\_{k}^{ }α\_{ik}lnY\_{i}lnY\_{k}+½\sum\_{h}^{ }\sum\_{j}^{ }β\_{hj}lnW\_{j}lnW\_{h}+\sum\_{i}^{ }\sum\_{j}^{ }δ\_{ij}lnY\_{i}lnW\_{j}+Z\_{it}+V\_{it}+U\_{it} 3.4$$

with: $W\_{i}$: the inputs price vector, $Y\_{j}$: the outputs’ value vector, $Z\_{it}$ : the vector of variables that explain efficiency including risk and quality variables, $V\_{it}$: statistical noise with the independent normal distribution $N(0,δ\_{v}^{2})$, $U\_{it}$: the positive inefficiency term, assumed to be distributed independently of $V\_{it}$

**3.1 Techniques of estimation**

The technique of analysis employed in the estimation process is the Maximum Likelihood (ML) with the parameterization of Battese and Corra (1977). This process, as emphasized by Battese and Coelli (1988, 1992, 1995 etc.) replaced $σ\_{v}^{2}$ and $σ\_{u}^{2}$ with $σ^{2}=σ\_{v}^{2}+σ\_{u}^{2}$ and $γ={σ\_{u}^{2}}/{(σ\_{v}^{2}+σ\_{u}^{2})}$. The $γ$ parameterization has an advantage in seeking to obtain the maximum likelihood estimates because the parameter space can be searched for with a suitable starting value for the iterative maximization algorithm involved. In particular, a value of zero for $γ$ indicates that the deviations from the frontier are due entirely to statistical noise, while a value of one would mean that all deviations are due to inefficiency. We obtained our maximum-likelihood estimates by estimating the multi-product trans-logarithm cost in 3.4 with Stata 12.0.

**3.2 Data and Variables**

Choosing the appropriate definition of bank output is an issue that continues to challenge many researchers in the study of bank efficiency. However, we follow leading scholars like Mester (1996) and Berger and Mester (1997) to adopt the intermediation approach to banks’ variables definition. The approach posits that total loans and total securities are outputs, whereas deposits are inputs to the production process of banking firms. In this study, banks’ total cost which is the addition of personnel expenses, interest expenses and other operating expenses is our dependent variable while the output and input variables as well as macroeconomic variables served as explanatory variables. Table 1 gives the variables used with their respective definition as well as their source.

 **Table.1: Variables, Measurement and Data Sources**

|  |  |  |  |
| --- | --- | --- | --- |
| **Variables** | **Symbol** | **Measurement** | **Source** |
| **Dependent Variable** |
| Operating expenses  | TC | Personnel expenses + Interest expenses + Other operating expenses | Bank Annual Financial Statements |
| **Output Variables** |
| Loans | $$Y\_{1}$$ | Loans and advances to Credit institutions and to Customer | $$√$$ |
| Assets | $$Y\_{2}$$ | Other Earning Assets | $$√$$ |
| **Inputs Variables** |
| Deposits  | $$W\_{1}$$ | Amounts owed to credit institutions and to customers | $$√$$ |
| Staff expenses | $$W\_{2}$$ | Staff cost per employee | $$√$$ |
| Interest expenses | $$W\_{3}$$ | Interest payable on any borrowing |  |
| **Risk and Quality Variables** |  |  |  |
| Financial capital | $$K\_{ }$$ | Total equity attributed to owners of the bank + non-controlling interest | $$√$$ |
| Non-performing loans (Asset quality) | $$S\_{ }$$ | Non-Performing Loans/Total Loans | $$√$$ |
| **Macroeconomic Variables** |
| Gross Domestic Product (GDP) | $$Z\_{1}$$ | GDP per capital (constant 2010 US$) | World Development Indicators (WDIs), 2015 edition |
| Inflation rate | $$Z\_{2}$$ | Inflation rate is measured by consumer price index (annual %) | $$√$$ |
| Regulatory quality | $$Z\_{3}$$ | Regulations that promote private sector development | World Governance Indicators (WGIs), 2015 edition |

**3.2.1 Variable Definition and A priori Expectation**

The coefficients of the estimated variables in the inefficiency model are of particular interest to this study. Positive coefficients indicate more inefficiency and less efficiency while negative coefficients mean less inefficiency and more efficiency (Battese and Coelli, 1995). Generally, our methodology implies that factors that reduce banks operating cost will affect efficiency positively while factors that tend to increase operating cost will affect efficiency negatively. This section defines the variables and states the a priori expectations accordingly.

1. Gross Domestic Product: Real GDP is a measure of a country's total economic output, adjusted for price changes. It affects numerous factors related to demand for and supply of banking services (Kablane, 2010). Theoretically, it is believed that banks in a country with higher per capita income operate in a better environment, resulting in more competitive interest rates and profit margins. Therefore, since the trend of Nigeria GDP over the study period is positive and rising, it is expected to have an inverse relationship with total operating cost and affect cost efficiency positively.
2. Inflation: It is the constant rise in the general level of prices where a unit of currency buys less than it did in prior periods. Inflation indicates a decrease in the purchasing power of a nation’s currency. We expect a positive relationship between inflation and operating cost i.e., higher and unstable inflation is associated with higher costs and inefficiency.
3. Financial Capital: It is a term for financial assets, such as funds held in deposit accounts and funds obtained from special financing sources. Financial capital is usually associated with a cost. It is therefore expected that it affects operating cost positively and cost efficiency negatively. The availability of capital usually aids insolvency risk of banks as it serves to absorb portfolio risks, it should therefore be considered in efficiency analysis.
4. Asset Quality: Asset quality is a measure of the likelihood of default of a loan or lease, combined with a measure of its marketability. We measure asset quality as the ratio of banks’ non-performing loans to total loans. Asset quality goes up with high non-performing loans and tends to place financial burden on banks. Thus, we expect a positive relationship between asset quality and operating cost and a negative relationship with efficiency, when non-performing loan is high, otherwise, a negative relationship is expected with operating cost thereby enhancing efficiency.

**4. Empirical results and discussion**

4.1 Descriptive statistics and Correlation Analysis

 Our descriptive statistics gives information about the sample statistics such as the mean and the variation of the sample measured by the standard deviation with the minimum and maximum value for each statistic. Table 2 show the summary statistics of data used in the model with the standard deviation showing three variations (i.e., overall, between and within). The overall statistics indicates a relatively low average value of operating expenses (TC) 18.06 with between variation (across individual banks) more than the within variation (over time). The overall standard deviation is 0.87, suggesting less fluctuation in the value of the variable for the commercial banks in Nigeria over the study period. Similarly, the statistics of all the variables used are reported, while loans, assets and deposits have between variation more than the within variation, all the other variables have within variation more than the between variation. In all, the relatively low statistic values obtained for inflation and regulatory quality show high degree of macroeconomic uncertainty in Nigeria.

 In the same vein, the correlation analysis gives information on the degree and direction of relationship between pairs of variables used in the model. Table 3 shows the correlation coefficients among the variables in the model. The results indicate that, with the exception of asset quality (S), all other variables are positively correlated. Asset quality does not only show a negative association with operating expenses but consistently show a negative linear relationship with other explanatory variables, pointing out that the quality of assets may have significant negative effect on efficiency of banks in Nigeria. Interest expenses and total equity (i.e., W3 and K) show substantial association with operating expenses (TC), suggesting their importance in the model. In sum, all the variables included in the model show significance at 5% level with the exception of inflation rate albeit theoretical guidance preclude its inclusion as an important macroeconomic variable.

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| **Table 2: Summary Statistics** dddddd |
|  | Mean | Standard Deviation | Minimum | Maximum |
|  |  | Overall | Between | Within |  |  |
| **Dependent Variable** |  |  |  |  |  |  |
| Operating expenses (TC) | 18.069 | 0.874 | 0.641 | 0.597 | 15.419 | 19.649 |
| **Output Variables** |  |  |  |  |  |  |
| Loans (Y1) | 18.800 | 1.943 | 1.533 | 1.209 | 11.725 | 22.314 |
|  Assets (Y2) | 18.447 | 2.743 | 2.406 | 1.407 | 13.062 | 21.971 |
| **Input variables** |  |  |  |  |  |  |
| Deposits (W1) | 18.879 | 2.242 | 2.086 | 0.850 | 12.712 | 21.461 |
| Staff costs (W2) | 8.512 | 0.541 |  0.343  | 0.475 | 6.907 | 9.615 |
|  Interest expenses (W3) | 17.015 | 0.946 |  0.580 | 0.757 | 14.613 | 18.743 |
| **Potential correlates** |  |  |  |  |  |  |
| Financial capital (K) | 18.428 | 1.200 | 0.746 | 0.942 | 10.790 | 20.372 |
|  Asset quality (S) | -2.944 | 0.848 | 0.438 | 0.726 | -5.541 | -0.913 |
| Gross Domestic Product (Z1) | 7.745 | 0.088 | 0.023 | 0.087 | 7.584 | 7.843 |
| Inflation rate (Z2) | 2.257 | 0.249 | 0.009 | 0.249 | 1.683 | 2.618 |
| Regulatory quality (Z3) | -0.762 | 0.068 | 0.004 | 0.068 | -0.887 | -0.669 |

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| --- |
| **Table 3: Correlation Matrix** |
| Variable | Oexp (TC) | Lo(Y1) | Ast(Y2) | Dep(W1) | Sc(W2) | Iexp(W3) | Teq(K) | Aq(S) | GDP(Z1) | Ir(Z2) | Regq(Z3) |
| Operating expenses (TC) | 1.000 |  |  |  |  |  |  |  |  |  |  |
| Loan(Y1) | 0.273\* | 1.000 |  |  |  |  |  |  |  |  |  |
| Asset(Y2) | 0.196\* | 0.587\* | 1.000 |  |  |  |  |  |  |  |  |
| Deposits(W1) | 0.208\* | 0.635\* | 0.859\* | 1.000 |  |  |  |  |  |  |  |
| Staff costs(W2) | 0.340\* | 0.195\* | 0.358\* | 0.285\* | 1.000 |  |  |  |  |  |  |
| Interest expenses(W3) | 0.882\* | 0.248\* | 0.184\* | 0.249\* | 0.337\* | 1.000 |  |  |  |  |  |
| Teq(K) | 0.884\* | 0.238\* | 0.205\* | 0.201\* | 0.362\* | 0.828\* | 1.000 |  |  |  |  |
| Asset quality(S) | -0.292\* | -0.138 | -0.120 | -0.088 | -0.240\* | -0.313\* | -0.299\* | 1.000 |  |  |  |
| GDP(Z1) | 0.456\* | 0.310\* | 0.319\* | 0.416\* | 0.617\* | 0.582\* | 0.431\* | -0.387\* | 1.000 |  |  |
| Inflation rate(Z2) | 0.057 | 0.046 | 0.011 | -0.038 | 0.139 | -0.039 | 0.045 | 0.179\* | 0.104 | 1.000 |  |
| Regulatory quality(Z3) | 0.235\* | 0.211\* | 0.155\* | 0.162\* | 0.394\* | 0.188\* | 0.189\* | -0.111 | 0.517\* | 0.607\* | 1.000 |
| Note:(\*) indicate significance at 5% level. |

**4.2 Estimation results of the stochastic cost frontier model**

The analysis of the cost frontier estimations were performed using the maximum likelihood function incorporated into Stata 12. After a small number of iterations, convergence of the single stage frontier estimation and cost inefficiency model was achieved. For consistency, alternative specifications and assumptions about the distribution of the error term were also carried out. Specifically, a more restrictive half-normal distribution of the inefficiency effects and a specification assuming heteroscedasticity (e.g., truncated fixed effect of Greene, 2005a and Battesse and Coelli, 1988) were estimated and reported. The results of the estimations are shown in Table 4.

Each of the columns (i - iii) represents different frontier model which are named accordingly. The gamma coefficient as presented in column (i) is significantly different from zero indicating the existence of the cost frontier function. Likewise, the lambda coefficients in the (ii) and (iii) columns portray the existence of the frontier function. The value of gamma suggests that the random error is less than 5 percent. Comparably, lambda is statistically significant at 10 percent and 5 percent respectively. This enables us to reject the assumption according to which the variance of inefficiency term is null. Consequently, we cannot isolate the $u\_{it}$ term from the regression and the estimate of the parameters by Ordinary Least Squares (OLS) which disregards the bank-specific inefficiency component is inadequate. The results imply that deviations from the frontier of best practice are largely driven by bank-specific inefficiency effects. Our results validate the importance attached to bank-specific variables for the efficiency of the banking system and are in concinnity with the previous works of Haruna (2015); Munyambonera (2013); Gwahula (2013) and Malgorzata and Patrycia (2014).

Regarding the coefficients of the model, the results indicate a complementarity role for loans (lnY1) and assets (lnY2) as their elasticities are negative i.e., Nigerian banks use these outputs as complementary products in their activities as financial services providers. The negative sign of loans indicates that the collected funds from customers and lend afterward, serve to decrease the costs of financial intermediation and consequently increases the efficiency level of banks. The result is in congruence with that of Kablane (2010) who found complementarity role for loans and equities for banks in sub-Saharan African countries. The price of deposits (lnW1) is significant with positive value. This is expected since the increase in deposits rate raises the costs of banks and consequently their levels of inefficiency. In the same vein, interest expenses (lnW3) give a positive significant coefficient and because real interest rate usually has a negative effect on loans demand, interest expenses would have an adverse effect on cost efficiency of the commercial banks in Nigeria. Lastly, the price of labor (lnW2) give a positive but insignificant effect which indicates the low level of wages and salaries paid for employees in the country’s banking system. On the interaction between the variables, the parameters represent the joint effect of the production of outputs on total operating costs. When they are statistically significant and negative, they indicate shared costs; otherwise, there is an absence of such an advantage.

 **Table 4: Results of the Trans-Logarithmic Cost Frontier Function**

|  |  |  |  |
| --- | --- | --- | --- |
| Variables |  |  | Frontiers |
| Operating expenses (TC) log | Name | Parameters | (i) BC88[t-normal] | (ii) Normal/h-normal] | (iii) TFE [h-normal] |
| Intercept | b0 | $$α\_{0}$$ | 8.542 [1.25] | 11.656 [1.56] \* | 11.993 [0.04] |
| ln $Y\_{1}$ | b1 | $$α\_{1}$$ | -0.740 [1.93] \*\* | -0.783 [1.80] \* | -0.738 [1.96] \*\* |
| ln$Y\_{2}$ | b2 | $$α\_{2}$$ | -4.363 [5.32] \*\*\* | -3.005 [3.91] \*\*\* | -4.8649 [6.20] \*\*\* |
| ln$W\_{1}$ | b3 | $$β\_{1}$$ | 3.392 [3.70] \*\*\* | 2.074 [2.26] \*\* | 4.064 [4.62] \*\*\* |
| ln$W\_{2}$ | b4 | $$β\_{2}$$ | 0.989 [0.91] | 0.960 [0.86] | 0.611 [0.57] |
| ln$W\_{3}$ | b5 | $$β\_{3}$$ | 1.787 [3.00] \*\*\* | 1.413 [2.18] \*\* | 1.463 [2.41] \*\* |
| ln$Y\_{1}$ln$Y\_{1}$ |  b6 | $$ α\_{11}$$ | 0.044 [2.86] \*\*\* | 0.029 [1.79] \* | 0.045 [2.95] \*\*\* |
| ln$Y\_{1}$ln$Y\_{2}$ | b7 | $$α\_{12}$$ | 0.015 [0.37] | 0.019 [0.47] | 0.028 [0.72] |
| ln$Y\_{2}$ln$Y\_{2}$ | b8 | $$α\_{22}$$ | -0.123 [7.49] \*\*\* | 0.085 [3.47] \*\*\* | 0.127 [7.89] \*\*\* |
| ln$W\_{1}$ln$W\_{1}$ | b9 | $$β\_{11}$$ | 0.078 [0.35] | 0.021 [0.36] | 0.012 [0.25] |
| ln$W\_{1}$ln$W\_{2}$ | b10 | $$β\_{12}$$ | -0.057 [1.35] | 0.057 [1.50] \* | -0.069 [1.50] \* |
| ln$W\_{1}$ln$W\_{3}$ | b11 | $$β\_{13}$$ | -0.099 [2.74] \*\*\* | -0.085 [2.27] \*\* | -0.089 [2.47] \*\* |
| ln$W\_{2}$ln$W\_{2}$ | b12 | $$β\_{22}$$ | -0.000 [0.01] | -0.041 [0.54] | 0.018 [0.24] |
| ln$W\_{2}$ln$W\_{3}$ | b13 | $$β\_{23}$$ | -0.006 [0.12] | 0.049 [0.82] | -.011 [0.20] |
| ln$Y\_{1}$ln$W\_{1}$ | b14 | $$δ\_{11}$$ | -0.050 [1.19] | -0.018 [0.42] | -0.069 [1.69] \* |
| ln$Y\_{1}$ln$W\_{2}$ | b15 | $$δ\_{12}$$ | -0.032 [0.77] | -0.031 [0.65] | -0.024 [0.61] |
| ln$Y\_{2}$ln$W\_{1}$ | b16 | $$δ\_{21}$$ | -0.061 [1.18] | -0.041 [0.76] | -0.068 [1.38] |
| ln$Y\_{2}$ln$W\_{2}$ | b17 | $$δ\_{22}$$ | 0.053 [2.41] \*\*\* | 0.036 [1.56] \* | 0.067 [3.15] \*\*\* |
| ln$Y\_{2}$ln$W\_{3}$ | b18 | $$δ\_{23}$$ | 0.028 [0.87] | 0.009 [0.29] | 0.036 [1.17] |
| Wald chi square | b19 | X2 | 1181.29 | 1378.89 | 1068.21 |
| likelihood ratio | b20 | l.l.f | 12.5590 | -23.2253 | 13.5369 |
| sigma2 | b21 | $$σ^{2}$$ | 0.027 [0.027] \*\* | 0.144 [0.035] |  |
| Gamma | b22 | $$γ$$ | 0.763 [0.041] \*\* |  |  |
| Lambda | b23 | $$λ$$ |  | 1.605 [0.07] \* | 0.611 [0.03] \*\* |

 *Figures in parentheses are /z-values/. \*\*\*, \*\* and \* indicates significance at 1%, 5% and 10% respectively.*

**4.3 Determinants of Banking Efficiency**

The estimation results of determinants of bank efficiency are based on the conditional mean model approach of SFA. Conditional mean model allows the single step estimation of maximum likelihood estimates (MLE) of the parameters of the stochastic cost frontier function and the inefficiency variables. Table 5 shows the empirical results of the determinants of bank cost efficiency where regression model (i) served as the baseline model. In models (ii - vi) regressions, other variables were added one after the other to the baseline specification that include only the bank-specific attribute variables. Our results show that the coefficients of the baseline variables stay mostly the same, they keep the same sign and order of magnitude, they remain significant as they were so in the baseline regression albeit sometimes at different levels of significance. Therefore, for models (ii - vi) regressions; the discussion is focused on the result of the new variables added to the baseline specification.

The inefficiency variables as shown in the Table 5 (i.e., financial capital, asset quality, gross domestic product per capita, Inflation rate and regulatory quality) are supposed to have an effect on the total operating cost and consequently on the cost efficiency of the Nigerian banks. Our results show significant coefficient for financial capital, asset quality and inflation rate. GDP though not significant (probably owing to the low growth rates in the countries) have an expected negative coefficient. This suggests that an increase in the economic activity increases the demand for financial services thereby improving the efficiency of banks. Similar result for this variable is found in the studies of Daley and Mathews (2009), Albertazzi and Gambacorta (2009), Athanasoglou, and Pasiouras and Kosmidou (2007) who found a positive impact of GDP on efficiency albeit with a different models and approach.

For the measure of governance, the parameter estimate indicates that regulatory quality has an expected negative sign and significant at 5 percent level. The results suggest that operating costs decline with good and stable institutions. This is suggestive of the importance of institutional factors for the costs of intermediation and efficiency of banks in Nigeria. Similar result is reported for banks in sub-Saharan African countries by Williams and Tomaszk (2014). Further, inflation is used as the measure of macroeconomic uncertainty and policy stance in the country, we obtain a clear positive impact on operating cost and banks’ inefficiency since inflation may increase input prices used in banking production. This result is similar to the one found by (Shen et al., 2009; Musonda, 2008) and indicates that an unstable macroeconomic environment is a hindrance to banks’ efficiency. In particular, the magnitude of the estimate on the log of inflation calls for a more stable macroeconomic environment as a pre-requisite for an efficiently functioning banking system in the country.

With particular reference to the estimates for the ratio of non-performing loans to total loans (asset quality) and equity level (financial capital), the results show that while the former is statistically significant at the 10 per cent level, the latter is significant at 1%. The elasticity of financial capital (K) is positive while that of asset quality also give an expected negative coefficient. The positive coefficient of financial capital shows that a 1% increase in capital will increase total cost by 19.4% which contributes to lower the banks’ efficiency in Nigeria. Clearly, a high level of capital reduces the risk of insolvency and the cost of capital and banks tend to reduce their use of capital as the average price increases. Our result is consistent with that of Agbeja, 2014 and Kablane, 2010. In the same vein, the negative coefficient of asset quality implies that this variable has a negative effect on operating cost and a positive effect on cost efficiency, implying that the Nigeria banks have been able to manage risk to enhance their efficiency over the study period.

**Table 5: Estimation results of the efficiency correlates**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Operating expenses (TC) log |  |  | Frontiers |  |  |
| **Panel A** | Parameter | (i) | (ii) | (iii) | (iv) | (v) | (vi) |
| Loans (Y1) log | b1 | 0.027 [1.18] | 0.022 [1.01] | 0.026 [1.17] | 0.040\* [1.78] | 0.016 [0.74] | 0.014 [0.72] |
| Assets (Y2) log | b2 | -0.024\* [1.58] | -0.016 [1.16] | -0.022 [1.49] | -0.020 [1.44] | -0.025 \* [1.73] | -0.013 [0.98] |
| Deposits(W1) log | b3 | -0.061\*\*\* [3.01] | -0.056\*\*\* [2.66] | -0.068 \*\*\* [3.08] | -0.067 \*\*\* [3.16] | -0.056 \*\* [2.52] | -0.060 \*\*\* [3.24] |
| Staff cost (W2) log | b4 | 0.237\*\*\* [3.68] | 0.181\*\*\* [2.86] | 0.243 \*\*\* [3.75] | 0.321 \*\*\* [4.63] | 0.209 [3.27] | 0.106 \* [1.71] |
| Interest expenses (W3) log | b5 | 0.706\*\*\* [18.31] | 0.599 \*\*\* [12.16] | 0.719 \*\*\* [17.52] | 0.733 \*\*\* [19.27] | 0.723 \*\*\* [18.73] | 0.713 \*\*\* [20.72] |
| Financial capital (K) log | b6 |  | 0.194\*\*\* [3.38] |  |  |  |  |
| Asset quality (S) log | b7 |  |  | -0.545 \* [1.87] |  |  |  |
| Gross domestic product (Z1) log | b8 |  |  |  | -3.328 [0.46] |  |  |
| Inflation rate (Z1) log | b9 |  |  |  |  | 0.497 \* [1.86] |  |
| Regulatory quality (Z2)  | b10 |  |  |  |  |  | -0.057\*\* [1.91] |
| Constant | b11 | 5.222\*\*\* [7.33] | 7.012\*\*\* [7.90] | 4.941 \*\*\* [6.60] | 3.627\*\*\* [4.22] | 5.132 \*\*\* [7.61] | 6.405 \*\*\* [9.77] |
| Observation | b12 |  176 |  176 |  176 |  176 |  176 |  176 |
| Log likelihood | b13 |  88.75 |  73.58 |  88.37 |  86.29 |  86.27 |  76.79 |
| Prob>chi2 | b14 | 0.000\*\*\* | 0.000\*\*\* | 0.000\*\*\* | 0.000\*\*\* | 0.000\*\*\* | 0.000\*\*\* |
| Wald Chi2 | b15 | 657.08 | 188.88 | 557.04 | 635.39 | 682.05 | 675.58 |

*Figures in parentheses are /z-values/. (\*\*\*), (\*\*) and (\*) indicates significance at 1%, 5% and 10% respectively.*

**5. conclusion**

 Efficient financial institutions are critical for economic growth and development and as a result, considerable research effort across the world has been made to measure the efficiency of financial institutions and its determinants. Most of the studies are however from developed economies with mixed results due to difference in methodology, choice of sample period, measures of efficiency correlate used etc. This paper examines the determinants of cost efficiency of Nigerian banks with a view to bridging the gap in the literature with respect to a focus on developing economies (Nigeria) and application of robust methodology. To the best of our knowledge, a previous study on developing economies has explored the determinants of the efficiency of banks in Nigeria through the stochastic frontier approach. Our empirical model is based on the intermediation approach of choosing outputs and inputs variables for banks and the technique of analysis employed in the estimation process is the Maximum Likelihood (ML) with the parameterization of Battese and Corra (1977). The scope of the study extends between 2006 and 2016 and covers 16 Nigerian commercial banks based on data availability.

For consistency and robustness, three frontier models were estimated to ascertain the existence of our cost frontier equation after which we estimate six models to determine the effects of the efficiency correlates. The effects of financial capital and inflation rate on total operating cost are positive, indicating that banks’ cost efficiency will be adversely affected by the increase in these variables. Nonetheless, evidence shows that strong economic activities (GDP), asset and regulatory qualities are positively related to banks efficiency in Nigeria. Our findings support the view that policy makers in developing countries like Nigeria should pursue policies that promote macroeconomic growth and stability, while bank operators should focus on cost efficiencies, asset quality and deposit conversion ratios, as these have positive impact on bank efficiency and sector stability.

**COMPETING INTERESTS DISCLAIMER:**

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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**Table 6: Mean cost efficiency by bank and year**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Bank/Year | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Average |
| Access | 0.83 | 0.83 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 |
| Citibank | 0.83 | 0.83 | 0.83 | 0.84 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 |
| Diamond | 0.84 | 0.83 | 0.83 | 0.82 | 0.83 | 0.83 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 |
| Ecobank | 0.83 | 0.83 | 0.82 | 0.82 | 0.82 | 0.82 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 |
| FCMB | 0.84 | 0.83 | 0.83 | 0.83 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 |
| Fidelity | 0.84 | 0.84 | 0.83 | 0.82 | 0.83 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 |
| First bank | 0.82 | 0.82 | 0.81 | 0.81 | 0.81 | 0.82 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 |
| GTB | 0.83 | 0.83 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.81 | 0.81 | 0.81 | 0.81 |
| Skye | 0.84 | 0.83 | 0.83 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 |
| Stanbic  | 0.84 | 0.83 | 0.82 | 0.83 | 0.83 | 0.83 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 |
| Sterling | 0.84 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 |
| UBA | 0.82 | 0.82 | 0.82 | 0.81 | 0.81 | 0.82 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 |
| Union bank | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 |
| Unity bank | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.82 | 0.83 | 0.82 | 0.82 | 0.82 |
| WEMA | 0.84 | 0.84 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.82 | 0.82 | 0.83 | 0.82 | 0.82 |
| Zenith | 0.83 | 0.82 | 0.82 | 0.81 | 0.82 | 0.82 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 |
| Average | 0.83 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 | 0.82 |