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ESTIMATING AND ANALYZING THE TECHNICAL EFFICIENCY OF BANKS IN GHANA

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ABSTRACT

This study examined the Technical Efficiency (TE) of commercial banks in Ghana and the determinants of TE in the banking sector. Data Envelopment Analysis (DEA), Random-Effects Tobit regression and Ordinary Least Square (OLS) were the statistical tools used on a sample of 21 banks operating between 2009 and 2013. The results showed that there were more technically inefficient banks in the country than there were technically efficient ones. Another revelation was that, on the average, TE varied directly in proportion to bank size within the two upper quartiles but large banks did not benefit from economy of scales as an edge over small banks. Finally, Gross Domestic Product (GDP) per capita, inflation, credit risk, size and operating cost negatively influenced efficiency while market concentration had a positive influence on efficiency. In our recommendations, we admonished Bank managers to minimize their operating cost and credit risk. Similarly, we recommended that government limit inflation. Finally, we upheld the continuation of the policy of higher capitalization that the Bank of Ghana had been pursuing.

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KEYWORDS: Bank, Technical Efficiency, DEA, Determinants

INTRODUCTION

The role of financial institutions in the development of countries cannot be overemphasized. Efficient Financial institutions are likely to promote economic growth through financial intermediation, investments, employment and taxes to mention but few. Contrarily, inefficiency in the financial sector may lead to credit crunch, recession, financial disintermediation, unemployment etc. It is thus of essence to assess the efficiency of financial institutions in general but particularly that of banks since many studies, including Saka, et al. (2012), identify them as major players in the financial sector.

In Ghana, banks have been rendering financial services prior to independence. After independence, many state-owned banks sprang up with the intention of promoting the drive towards industrialization. Unfortunately, the country traversed severe economic difficulties between 1970 and 1983. This resulted in the accumulation of huge non-performing assets by many banks. Consequently in 1987 the Government of Ghana (GOG) with the assistance of the World Bank, commenced a financial sector reform program to, among other things, establish a sound prudential and regulatory framework for banking operations and liberalize the money and capital markets (Antwi-Asare and Addison, 2000). The liberalization resulted in an increase in the number of commercial banks in the country from 16 in 2000 to 27 in December 2013. However, this also called for extra measures. For example, the Bank of Ghana noted that many of the banks were small in terms of capital base and were therefore highly vulnerable to any adverse but feeble swing in macroeconomic fundamentals. In its opinion, small banks also lacked the capacity to mobilize sizeable equity funds from the international market for investment purposes (Bank of Ghana, 2008). As a result, it resolved to implement a policy that seeks to increase the capital base of banks operating in the country. To obtain a class 1 banking license for instance, the minimum capital requirement was, in 2008, raised to GH¢60 million for all banks and was further augmented to GH¢ 120 million for new entrants in 2013.

This policy corresponds with the requirements of Basel III, which, according to Gual (2011), is an international initiative that provides solutions to some of the inadequacies of the regulatory framework before the banking crisis of 2007 - 2011. In relation to capital requirements, it specifically demands that banks should maintain higher levels of equity in order to be able to deal with potential losses. The initiative also seeks to ensure that financial institutions operate at lower risk levels. There are numerous studies on the efficiency of banks. Many of them are however related to the advanced economies like Canada, United States and member states of the European Union (Allen and Liu (2005), Pasiouras, et al. (2007), Casu and Molyneux (2003), Rozzani and Abdul Rahman (2013) and Wheelock and Wilson (2000)). In Ghana, current researches on the efficiency of banks are very few. Examples thereof include Antwi-Asare and Addison (2000) and Saka, et al. (2012). Given the dynamism of the banking industry (i.e. rapid technological transformation, increased competition, changes in regulatory framework etc.), many of the existing conditions that lead to their findings and recommendations might have changed considerably with time. Therefore, it is likely that the result of these studies may not be relevant contemporarily. That is why it is expedient to conduct new researches on the topic.

This work will be beneficial to bank managers, governments, researchers and bank clients. To bank managers, this study enables them to gauge their efficiency against the best practice and provide them with clues on the determinants of TE in order to guide them on how to keep performance at peak. For researchers, this work contributes to the pool of literature and facilitates comparative surveys or the study of trends in different research works. Burger and Humphrey (1997) is a typical example. To the government, the result of this study provides a feedback on the appropriateness of its policy of increasing the minimum capital requirement. In the event that large banks are better than small ones concerning TE and/or economy of scale, then this result will be a vindication of government's policy. This work seeks to estimate and to analyze the TE of banks in Ghana. In specific terms, it will examine i.) The TE of commercial banks in Ghana ii.) Whether big banks were technically more efficient than small banks, iii.) Whether large banks in Ghana benefited from economy of scale as an advantage over small ones, and iv.) The determinants of TE of commercial banks in Ghana There are five sections in this work. The next section involves a review of theoretical and empirical literature on the efficiency of banks. Section 3 considers issues of methodology whilst section 4 entails an analysis of data and presentation of results therefrom. The final section encompasses conclusions, recommendations and limitations of the study.

LITERATURE REVIEW

The Financial Sector Reform Programs in Ghana

The financial sector of Ghana comprises of insurance companies, banks, savings and loan firms, Ghana Stock Exchange, discount houses, leasing firms, credit unions, foreign exchange bureaus and mortgage financing companies. There had been numerous financial reforms in the country since independence in 1957. However, the most significant among them occurred in the late nineties. According to BOG, 1998/1999 report, cited by Antwi-Asare and Addison (2000) these reforms took place between 1988 and 1990. They sought to among other things: establish a sound prudential and regulatory framework for banking operations, ensure uniform accounting and auditing standards for all banks, and put in place a more effective Banking Supervision Department (BSD) endowed with the requisite personnel and skills to enforce the rules and regulations as well as a code of conduct for the banking sector. Pursuant to this, there was an authorization for the operation of foreign-exchange bureaus in 1988 and there was equally the establishment of the Ghana Stock Exchange in 1989. In that same year, a new banking law was enacted which shunned the imposition of entry or exit restrictions in order to foster competition. The country abandoned Credit ceiling and credit allocation policies in favor of indirect instruments of monetary control. This resulted in the liberalization of interest rates and the relaxation of direct control over bank charges. Moreover, the government recapitalized banks in financial distress by offsetting their non-performing loans with interest-bearing bonds issued by the Non-Performing Asset Recovery Trust (NPART). The latter was

responsible for the retrieval of these loans. The change also led to the replacement of top management of many state-owned banks and the reconstitution of many Board of Directors.

The reforms led to a rapid increase in the number of banks in the sector (from 16 in 2000 to 27 in 2007). A development that compelled BOG to institute further measures because of the conviction that the numerous banks springing up had low capital base and were unable to provide high levels of lending, notably on the international platform. Again, the Central Bank was worried that small banks were highly susceptible to the slightest adverse swing in macroeconomic fundamentals. More importantly, BOG considered the domestic commercial banks as lacking the requisite capacity to enable them raise mammoth equity finance through the capital market. Consequently, over the past few years, BOG has been pushing for larger minimum capital for financial institutions within its jurisdiction. For example, in order to obtain a Class 1 license, commercial banks had their minimum capital requirement raised to GH¢60 million while banks in operational existence were obliged to meet that same level latest by the end of December 2009. Local banks were provided with an extended period to enable them increase their capital to GH¢ 25 million latest by the end of 2010 and to further augment it to GH¢60 million by 2012 (Bank of Ghana, 2008). This minimum capital requirement was further raised to GH¢ 120 million for new entrants seeking the class 1 banking license while existing class 1 banks were advised to take steps to enhance their capital in line with their business strategy and risk profile to avoid requesting for single obligor exposure waivers (Bank of Ghana, 2013).

Efficiency in Literature

The notion of efficiency crisscrosses numerous disciplines such as Economics, Physics and Medicine. Heyne (2008) explained that efficiency is the rapport between ends and means. A condition is not efficient if it could not attained its targeted end with fewer resources or if the resources used yielded less than the expected results. Farrell (1957) and De Borge, et al. (1994) added that a firm achieves efficiency when it succeeds in turning out the largest feasible output from the inputted resources. They then distinguished between price efficiency and TE. The former refers to an entity's accomplishment in selecting the best combination of inputs while the latter gauges its achievement in turning out the highest level of output from a given collection of inputs Economists distinguish among allocative efficiency, productive efficiency, TE, x-efficiency, dynamic efficiency, and static efficiency. This study focuses on TE but details on other types are obtainable from Kolasky and Dick (2003) and Economics Online (2014). Maidamisa, et al. (2012) mentioned that it is possible to divide TE into pure TE and scale efficiency. Pure TE measures how a producer utilizes its resources under exogenous environments and scale efficiency is the percentage of TE to pure TE. How do we measure TE?

In 1951, Koopmans and Debreu initiated the efforts to measure efficiency and Farrell made his input in 1957. Thereafter, researchers developed numerous techniques on the measurement of efficiency. Mandl, et al. (2008) mentioned that TE improvements are drifts towards the Production Possibility Frontier (PPF), which other literature also refer to as efficiency frontier. However, not all forms of TE have economic significance because TE ignores costs and benefits resulting from the optimum arrangement of inputs. This implies that the achievement of a high level of TE is not economically sensible so long as alternative permutation of inputs would lead to higher outputs. The measurement of allocative efficiency addresses the weaknesses of TE. Allocative efficiency examines the connection between optimum arrangements of inputs taking on board not only costs and benefits, but also the output achieved. In the next paragraph, we will examine the techniques used in estimating the efficiency frontier.

Parametric and non-parametric approaches are the two major techniques used in estimating the efficiency frontier. . Mandl, et al. (2008) maintained that parametric frontier functions require an assumption of a particular form of association between input and output. There is equally an assumption that data or population under study has a specific structure (i.e. normal distribution, F-distribution or Chi-Square

distribution). Contrarily, a non-parametric procedure has little or no a priori assumption. In order words, presumption about data or population having a specific characteristic structure is almost inexistent. Consequently, non-parametric procedures tend to be flexible and susceptible to several alternative formulations. Berger and Humphrey (1997) concluded that efficiency estimates from non-parametric studies are akin to those from parametric frontier model. However, the nonparametric methods normally turn out lower average efficiency scores and appear to have larger variations than the results of parametric models. Murillo-Zamorano and Vega-Cervara (2000) also distinguished between deterministic and stochastic models. Deterministic models envelop all the observations, with reference to the gap separating the observed output and the highest possible output. On the other hand, stochastic approaches facilitate the distinction between TE and statistical noise.

For example, the Free Disposable Hull (FDH) is a deterministic and non-parametric tool for estimating productive efficiency while the DEA is a stochastic and non-parametric approach. Examples of parametric frontier approaches are the Stochastic Frontier Approach (SFA), Distribution Free Approach (DFA), and the Thick Frontier Approach (TFA) (Berger and Humphrey, 1997). Within the banking sector, literature on the composition of input and output, used in measuring efficiency focuses mainly on two models, which are the intermediation approach and the production approach. The production approach, as explained by Berger and Humphrey (1997), considers financial institutions as producing services for account holders. These services include, but not limited to processing of loan applications, credit reports, honoring of checks or other payment instruments. Consequently, with the production approach, the inputs considered are only physical inputs such as labor and capital as well as the costs thereof. On the other hand, the measurement of output encompasses factors such as the numerical size and category of documents or transactions processed over a time interval. However, due to the challenges in obtaining vivid details of this data, alternatives such as the number of deposit or loan accounts serviced are used. Now it is important to consider the determinants of efficiency in the banking sector.

Previous works identified profitability ratio, average capital ratio, bank size, market share, credit risk, cost of operation, foreign ownership, market concentration and the security market as key determinants of bank efficiency. Moreover, other literature added macroeconomic variables such as inflation, GDP per capita and interest rate spread (Adjei-Frimpong, et al. (2014), Casu and Molyneux (2003), Pasiouras, et al. (2007), Ayadi (2013), Eriki and Osifo (2015) and Alrafadi, et al. (2014)). Whereas profitability ratio, average capital ratio, bank size, credit risk, cost of operation are accounting ratios and are easily computed from financial statements, other variables like inflation, GDP per capita and interest rate spread, market concentration, market share are more inclined towards Economics. This study uses a combination of both variables.

Empirical Literature

A study of 130 works on the efficiency of financial institutions across twenty one countries, conducted by Berger and Humphrey (1997), found that deregulation of financial institutions as well as mergers and acquisitions can either ameliorate or aggravate efficiency depending upon the prevailing conditions in the industry before to deregulation. The case of numerous states showed that deregulation resulted in fast expansion of branches, massive asset increases, bank failures, and reduced efficiency. Similarly, mergers and acquisitions aggravated the performance of the merged firms compared with the individual institutions existing on their own. Vegesna and Dash (2014) employed the DEA approach to examine the efficiency of banks in India between 2005 and 2011 comparing public sector banks to their counterpart in the private sector. They found that public sector banks in India were more efficient than private banks. In a study of Canadian Banks from 1983 to 2003, Allen and Liu (2005) found that larger banks appeared to be more cost-efficient than smaller banks. They could enjoy cost savings of 6% to 20% by increasing their scale of production. Using SFA and multiple linear regression to arrive at their conclusion on a research examining the determinants of bank efficiency among conventional banks and Islamic banks in Malaysia, Rozzani and

Abdul Rahman (2013) stated that, there was no much difference between the level of profit efficiency between conventional banks and Islamic banks. Banks in the country had an overall efficiency falling below 50%. There was also a mammoth positive association between bank size and conventional bank efficiency but no such association existed between bank size and Islamic bank efficiency.

Contrarily, we found an essential negative correlation between operational cost and efficiency for both conventional and Islamic banks. Finally, there was no significant negative relationship between credit risk and Islamic bank efficiency. Nonetheless, conventional banks had an important negative relationship between credit risk and efficiency. Casu and Molyneux (2003) employed DEA and Tobit regression to examine the determinants of European bank efficiency. The results proved that average efficiency was low although it improved over time. They also mentioned that the key factors distinguishing among bank efficiency levels across the continent were country-specific factors of banking technologies. There was however, little to show that average capital ratio and return on average equity explained variations in bank efficiency levels. Similarly, Pasiouras, et al. (2007) employed DEA and Tobit regression to analyses the determinants of bank efficiency in Greek. Their result showed the possibility of improving average cost efficiency by 17.7%. They equally found size had a positive impact while GDP per capita had negatively and materially affected all measures of efficiency. Unemployment rate had a substantial negative impact on both technical and cost efficiencies but not on allocative efficiency.

Ayadi (2014) used DEA to analyses the technical efficiency of banks in Tunisia and their determinants from 2000 to 2011. He estimated technical efficiency of banks in Tunisia to be 57.1%; pure technical efficiency and scale efficiency were 64.7% and 86.9% respectively. He concluded that high bank capitalization had a positive impact on technical efficiency of the banks while market share in terms of deposit of the banks adversely affected their technical efficiency. He added that private banks were more efficient that their public counterparts but size had no bearing on technical efficiency considering the sample studied. Alrafadi, et al. (2014) made use of DEA and Tobit regression to ascertain the level of efficiencies of Libyan banks from 2004 to 2010 and their determinants. They held that, on one hand Libyan banks had a mean TE of 59.3% and could therefore minimize input by 40.7% at the same output level. On the other hand, factors like return on assets, size, government ownership and capital adequacy influenced the efficiency of bank positively. Making use of DEA and multiple regression, Kamau and Were, (2013) looked at the forces that drove the high performance in the Kenyan banking sector between 1997 and 2011 by analyzing the relationship structure, performance and bank efficiency. They concluded that structure and/or the collusion power of industry players were the major factor propelling high performance rather than efficiency. In a study of the impact of the 2008 - 2009, global financial crisis on large South African banks, Erasmus and Makina (2014), used DEA to arrive at the conclusion that most of the big banks were efficient and therefore the crisis had no adverse influence on them.

Eriki and Osifo (2015) found out the determinant of performance efficiency of a sample of 19 Nigerian banks using DEA. They reached the conclusion that small and medium banks were better than huge banks in terms of performance efficiency. They equally found that board independence and bank ownership had negative association with Nigerian bank efficiency but bank size and age had a positive influence on efficiency. These findings appear inconsistent because if small and medium banks outperformed huge banks one would expect size to have a negative relation with efficiency. Mawutor and Fred (2015) also employed Return on Assets (ROA) ratio and panel regression model to assess the efficiency and profitability of listed banks in Ghana from 2006 to 2011 and stated that productivity, loan and credit risk had a significant negative effect on profitability but liquidly had a significant positive effect on it. Bank size, according to them had no influence on productivity. Adjei-Frimpong, et al. (2014) employed DEA, fixed effect model and the Generalized Method of Moment (GMM) to study the cost efficiency of the Ghanaian banking industry. The results suggest that banks in Ghana were inefficient. Moreover, the fact that bank size had no relation with cost efficiency led the authors to state that larger banks in Ghana had no cost advantages over

smaller ones. Other results are that, the ratio for provision for loan loss had no effect on bank efficiency but GDP growth rate negatively affected bank cost efficiency.

Tetteh (2014) used ROA ratio as well as panel regression model to measure the performance of local and foreign banks in Ghana between 2003 and 2012. He observed that generally, foreign banks outperformed their local competitors. Furthermore, market experience, size and ownership had substantial negative impact on bank performance whilst success in the market, and interest income were positively significant in influencing performance. The implication is that lengthy years of experience and large sizes reduced bank performance. Saka, et al. (2012), used DEA and Tobit regression to study the determinants of Technical Efficiency (TE) of Ghanaian banking industry and the impacts of the entry of foreign banks. They found that the entry of foreign banks had a positive impact on the technical efficiencies of domestic banks although the TE of new foreign entrants was lower than the TE of new local entrants. They attributed the lower TE experienced by foreign entrants to high start-up costs. They also stated that foreign ownership, return on assets and inflation had a significant positive influence on TE while market concentration, loan ratio and capitalization ratio had a negative relation with TE.

Oteng-Abayie, et al. (2011) relied on the maximum likelihood estimation to study the determinant of efficiency of microfinance institutions. They concluded that variations in technical expertise (in both training and portfolio quality) and management practices accounted for inefficiencies in the sector. Buchs and Mathisen, (2005), using Panzar and Rosse Model, studied the competition and the level of efficiency in the Ghanaian banking industry and concluded that scale matters significantly in the Ghanaian banking system. They stated that bank size could constitute a hindrance to market entry. They added that excessive domestic borrowing by government has not only contributed to inefficiency in the banking system but also limited competition between banks because it was profitable and safer for banks to hold government securities. Other impacts of government domestic borrowing are the crowding out of the private sector in accessing bank loans and high interest rates. Finally, they recommended that government should strive to achieve effective fiscal adjustment in order to widen and increase the efficiency in the banking sector. This, they argued would reduce the overreliance of banks upon Treasury bill investment with high return but low-risk. Consequently, this would generate stiffer competition that would in turn propelled the banks to look for ways and means to widen their clientele in order to augment revenue.

DATA AND METHODOLOGY

We obtained the annual financial statements and macro-economic variables from the Bank of Ghana and the website of the Ghana Statistical Service. Efficiency Measurement System version 1.3.0 facilitated DEA analysis whilst Stata/MP 13.0 enabled the computation of the regressions. We use the following input and output variables as shown in Table 1 for the intermediation and production approaches.

Table 1: Variables Used for DEA Computations

Production Approach Variables		**Intermediation Approach Variables**	
Inputs	Outputs	Inputs	Outputs
Fixed Assets	Investments	Fixed Assets	Interest Income
Non-Interest Expenses	Loans	Non-Interest Expenses	Deposit with other banks
Staff Cost	Deposit with Central Bank	Staff Cost	Non-Interest Income
Interest Expenses	Deposit with other banks		
	Non-Interest Income		

This table shows the composition of input and output variables that enable the computation of DEA for both the intermediation approach and the production approach. In the production approach, the inputs considered are only physical inputs such as labor and capital as well as the costs thereof. On the other hand, the measurement of output encompasses factors such as the numerical size and category of documents or transactions processed over a time interval. However, due to the challenges in obtaining vivid details of this data, alternatives such as the number of deposit or loan accounts serviced are used. Contrarily physical inputs are not necessarily the inputs of the intermediation approach.

The population of banks in the country in 2013 was 27 but we sampled 21 for this work. We equally used a balanced panel on cross-sectional annual data spanning from 2009 to 2013. The adoption of International Financial Reporting Standard (IFRS) by banks in Ghana in 2007 influenced the choice of this time interval. Therefore commencing with 2009 enabled this work to study financial statements prepared according to IFRS after two years of experience with IFRS. Table 2 contains the list of banks in the sample.

Table 2: List of Banks in the Sample

Abbreviation	Official Name
ACCESS	Access Bank
ADB	Agriculture Development Bank
BARODA	Bank of Baroda
BOA	Bank of Africa
BSIC	Sahel Sahara Bank
CAL	Cal Bank
ECO	Eco Bank
FABL	First Atlantic Bank
FBL	Fidelity Bank
GCB	Ghana Commercial Bank
GTB	Guaranty Trust Bank
HFC	HFC Bank
ICB	International Commercial Bank (now FBN Bank)
PBL	Prudential Bank Ltd
SCB	Standard Chartered Bank
SG-SSB	SG-SSB (now Society General Ghana Ltd)
STANBIC	Stanbic Bank
UBA	United Bank for Africa
UNIBANK	Unibank Ghana Ltd
UTB	UT Bank
ZENITH	Zenith Bank Ghana Ltd

This table indicates the official name of banks (and their respective abbreviation) used in the sample. It contains 21 banks derived from a population of 27 banks as of December 2013. All the 21 banks had their Financial Statements prepared according to IFRS. This enhances comparability and could have a positive impact on the results of the analysis.

DEA Technique

The "two-step" procedure was applied in this work using DEA (both production and intermediation approaches) at the first stage and Tobit regression and OLS at the second stage. DEA is a stochastic non-parametric model, which is flexible and susceptible to several alternative formulations. This is because there is virtually no assumption of a specific functional form of relationship between input and output. Moreover, the efficiency frontier was determined using the whole sample. Another strength of DEA is that, it enables a distinction between TE and statistical noise. This feature is relevant to the achievement of objectives of this work. DEA also allows the division of TE into scale efficiency and pure technical efficiency. One can categorize DEA model into Constant Return to Scale (CRS) and Variable Return to Scale (VRS). Charnes, et al. (1978) developed the first DEA model and named it CCR (Charnes, Cooper and Rhodes) model. Among the assumptions, underlying CCR is constant return to scale. Others are strong disposability of inputs and outputs and convexity of the set of feasible input-output combinations. CRS means producers are linearly able to scale the inputs and outputs without increasing or decreasing efficiency (DEA Home Page, 1996). For further clarification, strong disposability signifies the likelihood of varying the quantity of an input or output factor without varying the output produced. CRS relies on the assumption that all DMUs under consideration operate at an optimal scale. In reality however, this assumption rarely materializes due to factors like externalities, financial challenges, imperfect competition, to mention but few. Consequently, the use of CCR model brings about a misleading measure of technical efficiency because technical efficiency scores reported in the midst of these constraints suffer from distortions due to

the negligence of scale efficiencies. In an attempt to rectify this shortcoming, Banker, et al. (1984) developed VRS by introducing one additional constraint to those of CRS. This constraint only ensures that the comparison of each DMU is solely against others of similar size. Another name for VRS is BCC (Banker, Charnes and Cooper) model. Mathematically, for any *d* DMUs, producing each *p* products after using *m* input factors, the following Linear Programming (LP) expresses the input-oriented DEA model: in

Minimize θ_i subject to (1)

$Y\lambda_i - y_i \geq 0$ (2)

$\theta_i x_i - X^i\lambda_i \geq 0$ (3)

$\Sigma\lambda_i \geq 0$ (DEA – CCR) (4)

$\Sigma\lambda_i = 1$ (DEA – BCC) (5)

Where: θ_i is a scalar, which stands for the efficiency of the i^{th} firm. λ_i is a percentage of other producers used to generate the virtual producer. *X* is the d×m input matrix represented by the vector x_i for the i^{th} firm. *Y* is the d×p output matrix represented by the vector y_i for the i^{th} firm.

The efficiency score for each firm is determined by solving the LP for each of the d firms. Equations 1 to 4 represent CCR whilst equations 1 to 5 represent BCC. With the first constraint, the virtual DMU is compelled to produce at least as many output as the real DMUs under study. The second constraint also forces the virtual DMU to equal or less input that the real DMUs. In this work, we shall follow the above approach although there are other formulations such as the ratio approach or the dual approach. To compare the efficiencies according to bank size, we grouped banks in the sample into four quartiles based of their average total assets and we named them as "largest banks", "large bank", "medium banks" and "small banks". Given that there were twenty-one (21) banks in the sample, we placed Six (6) banks into the large banks quartile. The other three (3) quartiles have five (5) banks each but on a year-by-year average, the banks that made up each quartile varied. Based on the overall average efficiency of each quartile over the period, we compare the level of efficiencies by size.

Regression Models

Katchova (2013) mentioned that Tobit regression is an example of limited dependent variable models. Gregorian and Monole, (2002) supports the use of Tobit model in the second stage of the two-stage procedure because according to them, efficiency estimate of DEA is censored and limited to variation between the range of 0 and 1. They added that Tobit models generate consistent estimates of regression coefficient. In Tobit regression, there is a restriction on the dependent variable either at lower level (lower limit) or the upper level (upper limit) or both. If the parameter of the dependent variable falls below the lower limit, then it is restricted to the lower limit. Similarly, if its parameter exceeds the upper limit, then we confine it to the upper limit. Below is the mathematical representation of these statements:

$$y = \begin{cases} y^* if\ y^* > L \\ L\ if\ y^* \leq L \end{cases} \quad (6)$$

$$y = \begin{cases} y^* if\ y^* < U \\ U\ if\ y^* \geq L \end{cases} \quad (7)$$

Where: U is the upper limit, L the lower limit, y the actual value of the dependent variable, and y^*latent variable. Equations 4 to 6 represent the empirical regression models.

$$VRS\ TE = \beta_0 + \beta_1 SIZE + \beta_2 OPRC + \beta_3 CRED + \beta_4 OWNR + \beta_5 INFL + \beta_6 MKTC + \beta_7 GDPPC + \varepsilon \quad (8)$$

$$CRS\ TE = \beta_0 + \beta_1 SIZE + \beta_2 OPRC + \beta_3 CRED + \beta_4 OWNR + \beta_5 INFL + \beta_6 MKTC + \beta_7 GDPPC + \varepsilon \quad (9)$$
$$SE = \beta_0 + \beta_1 SIZE + \beta_2 OPRC + \beta_3 CRED + \beta_4 OWNR + \beta_5 INFL + \beta_6 MKTC + \beta_7 GDPPC + \varepsilon \quad (10)$$

Another name for Tobit regression is Censored Normal Regression. In the absence of censoring of observations, then Tobit regression is the same as the Ordinary Least Square (OLS) regression. The equation for the OLS regression is similar to equations 4 to 6.

Where: VRS TE = Variable Return to Scale Technical Efficiency, *CRS TE* = Constant Return to Scale Technical Efficiency, *SE* = Scale Efficiency, *SIZE* = Bank Size, *OPRC* = Operation Cost, *CRED* = Credit Risk, *OWNR* = Ownership, *INFL* = Inflation, *MKTC* = Market Concentration, *GDPPC* = Per Capita Gross Domestic Product, β_0 = Constant coefficient for the regression model, β_1 to β_7 are Coefficients for the dependent variables. The following shows the estimation of the variables:

VRS TE = Output of DEA – BCC CRS TE = Output of DEA – CCR

$SE = \frac{DEA-CCR}{DEA-BBC}$ *SIZE* = ln (Total assets) $OPRC = \frac{Operating\ Cost}{Operating\ Income}$

$CRED = \frac{Total\ loan}{Total\ assets}$ $GDPPC = \frac{GDP}{Midyear\ Population}$ $\mathrm{MS}_i = \frac{Bank\ Total\ Asset}{Industry\ Total\ assets}$

OWNR = Dummy variable (foreign = 1, local = 0) *INFL* = Annual average inflation

MKTC = $\sum_{i=1}^{n}(\mathrm{MS}_i)^2$ where MS_i is Market Share

RESULTS AND DISCUSSION

Results of DEA Production Approach

The production approach averagely showed that three banks were technically efficient within the period based on DEA – CCR model (Table 3) as against eight technically efficient banks based on DEA – BCC model (Table 4). The overall mean efficiency stood at 63.89% for DEA – CCR and 80.48% for DEA – BCC. In conclusion, the production approach estimated that, averagely 61.90% to 85.71% of banks were technically inefficient between 2009 and 2013. Furthermore, the average bank in the country was 63.89% to 80.48% as efficient as the best banks.

Table 3: Summary of Results of DEA Production Approach (CCR –Model)

	2013	**2012**	**2011**	**2010**	**2009**	**OVERALL AVERAGE**
Number of DMUs	21	21	21	21	21	21
Number of Efficient DMUs	2	5	5	2	2	3
Number of Inefficient DMUs	19	16	16	19	19	18
Average Efficiency (M)	59.86%	67.92%	68.75%	62.70%	60.24%	63.89%
Average Inefficiency (1-M)	40.14%	32.08%	31.25%	37.30%	39.76%	36.11%
	2013	**2012**	**2011**	**2010**	**2009**	**OVERALL AVERAGE**
Standard Deviation (Θ)	0.2514	0.2480	0.2365	0.2283	0.2286	0.238
Interval I (M-Θ ; M+Θ)	34.72% - 85.01%	43.12% - 92.72%	45.10% - 92.39%	39.87% - 85.53%	37.38% - 83.1%	40.04% - 87.75%
% of DMUs in I	61.90%	57.14%	52.38%	61.90%	61.90%	59.05%

Source: Author's Computation. This table shows the results of the DEA Production Approach (CCR – Model). It also points out the number of technically efficient banks, the average efficiency and standard deviation. The overall mean efficiency stood at 63.89% for DEA – CCR. The production approach estimated that, averagely 85.71% of banks were technically inefficient between 2009 and 2013. Moreover, the average bank in the country was 63.89% as efficient as the best banks.

Table 4: Summary of Results of Production Approach (BCC – Model)

	2013	2012	2011	2010	2009	Overall Average
Number of DMUs	21	21	21	21	21	21
Number of Efficient DMUs	9	11	10	7	5	8
Number of Inefficient DMUs	12	10	11	14	16	13
Average Efficiency (M)	71.56%	86.81%	86.54%	80.47%	77.03%	80.48%
Average Inefficiency (1-M)	28.44%	13.19%	13.46%	19.53%	22.97%	19.52%
Standard Deviation (Θ)	0.2805	0.1798	0.1668	0.2104	0.2176	0.2110
Interval (I) (M-Θ ; M+Θ)	43.51% - 99.60%	68.83% - 104.79%	69.86% - 103.22%	59.43% - 101.51%	55.27% - 98.80%	59.38% - 101.58%
% of DMUs in I	33.33%	76.19%	80.95%	85.71%	80.95%	71%

Source: Author's Computation. This table shows the results of the DEA Production Approach (BCC – Model). It also points out the number of technically efficient banks, the average efficiency and standard deviation. The overall mean efficiency stood at 80.48% for DEA – BCC. The intermediation approach estimated that, averagely 61.90% of banks were technically inefficient between 2009 and 2013. Moreover, the average bank in the country was 80.48% as efficient as the best banks.

The interpretation of the results of intermediation approach is analogous to that of the production approach. Therefore, for the avoidance of repetition, the focus will be on comparing the number of efficient banks and the overall average efficiencies given by the production approach to those of the intermediation approach.

Comparison of Results of Intermediation and Production Approach

From Panel A of Table 5, it is clear that the intermediation approach produced a greater number of efficient banks and a higher overall efficiency score than the results estimated by the production approach. However, a common feature of the results of both CCR and BC is that the number of efficient banks is less than 50% of the number of banks in the sample. The models estimated average efficiency of banks to be between 63.89% and 80.48% whilst the percentage of efficient banks, given the sample size of 21, varied between 14.29% and 42.86%.

Table 5: Comparison of Efficiency Results

	DEA			
Measure	**Production Approach**		**Intermediation Approach**	
	CCR	**BCC**	**CCR**	**BCC**
Panel A: Efficiency of Banks				
Number of efficient banks	3	8	8	9
Average efficiency	63.8%	80.48%	67.38%	77.99%
Panel B: Technical Efficiency by Bank Size				
Largest banks	71.98%	89.71%	84.4%	90.50%
Large banks	67.18%	83.27%	65.18%	77.24%
Medium banks	66.44%	79.65%	51.88%	70.06%
Small banks	48.36%	65.39%	64.63%	70.91%
Panel C: Number of Technically Efficient Banks by Size				
Largest banks	1	4	4	5
Large banks	1	2	2	2
Medium banks	1	1	1	1
Measure	**DEA**			
	Production Approach		**Intermediation Approach**	
	CCR	**BCC**	**CCR**	**BCC**
Panel C: Number of Technically Efficient Banks by Size				
Small banks	0	1	1	1
Panel D: Scale Efficiency by bank Size				
Largest banks	78.18%		91.68%	
Large banks	83.23%		63.99%	
Medium banks	80.43%		79.45%	
Small banks	78.05%		81.91%	

This table compares the results of production approach to those of the intermediation approach of the DEA –CCR model and DEA-BCC model. It contains five panels. Panel A estimates the average efficiency of banks and the number of efficiency banks regardless of bank size. Panel B estimates the TE by bank sizes at classifying them into largest bank, large bank, medium banks and small banks. Panel C then examines the number of technically efficient banks per each of the four categories. Finally, Panel D displays the scale efficiency according to bank size. Throughout the panels, the BCC models recorded the highest results compared to the CCR models. Panel D shows that average efficiency varied in proportion to bank sizes only in the upper quartiles.

Technical Efficiency by Bank Size

Panel B of Table 5 shows a decrease in average TE as one moves from largest banks to small banks. The results for both DEA – CCR and DEA – BCC of the production approach follow the same pattern. This implies that the larger the bank the better its technical efficiency. However, observing the intermediation of the same panel, one experiences a slight change in the above-mentioned trend. The results of both DEA – CCR and DEA - BCC of the intermediation approach indicate that largest banks were technically more efficient than all the banks in the other three groupings. Similarly, large banks were technically more efficient than medium banks and small banks. Nevertheless, unlike the production approach, the intermediation approach reveals that small banks were technically more efficient than medium banks. The margin by which small banks outperformed medium banks was very immaterial from the DEA – BCC point of view but significant from the DEA – CCR point of view.

To find out how many banks were technically efficient in each of the four groupings, we carried out the analysis in Panel C of Table 5. The results of the production approach of DEA – CCR model indicate that only one bank was efficient in each of the following categories: largest banks category, large bank category and medium bank category. No bank was efficient in the small bank category. Compared to the DEA – BCC model of the production approach, four banks were efficient in the largest bank category and two in the large banks category. Medium banks and small banks had one efficient banks each. In addition, Panel C of Table 5 shows the results of the intermediation approach of DEA. Both the CCR and the BCC approaches indicate that largest banks had the highest number of efficient banks (four for CCR and five for BCC). Then, large banks followed with two efficient banks each for both CCR and BCC. Medium and small banks followed large banks and had the same number of efficient banks (one efficient bank for both CCR and BCC). The conclusion one could draw is that, generally, largest banks had the highest number of efficient banks and large banks followed. Even where the number of efficient banks was the same among largest banks and the other category of banks (the case of intermediation approach, DEA – CCR model), largest banks had the highest relative efficiency score (Panel B of Table 5).

Scale Efficiency by Bank Size

Panel D of Table 5 shows the result of scale efficiency by bank size. One does not see any clear pattern that may lead to any meaningful conclusion. The results of the production approach indicate that, on the average, large banks had the highest scale efficiency. In order of significance, medium banks, largest banks, and small banks succeeded. On the other hand, the results of the intermediation approach show that, averagely, largest banks were the most efficient. Then small banks and medium banks followed sequentially. One could therefore infer that large banks did not enjoy economy of scales as an edge over small banks.

Random-Effects Tobit Regression

Table 6 summarizes the result of the Tobit regression using CRS, VRS and SE as response variables. Two different models are regressed on each response variables in order to deal with multicollinearity. The symbol ** represents statistical significance at 5% level. The meaning of this symbol applies to all other tables on regression. We discuss the result as follows. From Model 1 to Model 4, OPRC has a significant negative relation with CRS TE, and VRS TE. Inflation and GPDPC have a significant negative influence on CRS TE in Model 1 and VRS TE in Model 3 and Model 4. GDPPC is also significantly associated with VRS TE in Model 3 and Model 4. CRED has a substantially negative association with CRS TE in model 1 while MKTC influences VRS TE negatively in Model 3. OWNR and SIZE have no association with TE and no explanatory variable influences SE. In brief, CRED, OPR, INFL, GDPPC and MKTC have a significant negative influence on VRS TE and CRS TE but OWNR and SIZE have no influence on them. No independent variables affects SE.

OLS Regression

For each model of OLS, we conducted Hausman specification test to determine which model between the fixed-effect model and random effect would be appropriate. Table 7 contains the results of the test. With the exception of Model 3 and Model 4, the Hausman test favored the application of random effect. Therefore, in addition to analyzing the result of random-effect models in Table 7, we also analyze Model 3 and Model 4 using the fixed-effect. The following are the result of the Random-Effect OLS Regression. OPRC has a significant negative relation with CRS TE and VRS TE in models 1 to 4, but has no association with SE (Table 7). SIZE is the only variable that significantly relates to SE (Model 6). This relation is positive but SIZE has no important influence on any other response variable. In Model 3 and Model 4, INFL and GDPPC have negative influence on VRS TE. MKTC also influences VRS TE positively.

In summary, OPRC negatively affects CRS TE while OPRC, INFL and GDPPC negatively influence VRS TE. MKTC also influences VRS TE but in a positive direction. Of all the explanatory variables, only SIZE relates to SE and that relation is positive. As mentioned earlier, we recomputed Model 3 and Model 4 (in Table 8) using the fixed-effect model because the Hausman test favored it. The results indicate that INFL, GDPPC and MKTC influence VRS TE. However, whereas the relations of INFL and GDPPC with VRS TE are negative, that of MKTC with VRS is positive. In summary, Tobit regression, random-effect OLS regression and fixed-effect OLS regression show that INFL, GDPPC and MKTC influence TE. Whereas the influence of INFL and GDPPC are negative, that of MKTC is positive. This implies that increases in INFL and GDPPC lead to a decrease in efficiency whilst an increase in MKTC leads to improvement in efficiency. With regards to company-specific variables, both Tobit regression and random-effect OLS regression points at OPRC as having a negative impact on TE; implying that increases in OPRC would hinder TE. According to random-effect OLS, SIZE negatively influences SE whilst Tobit indicates that CRED has a negative impact on TE. By inference, SE tends to suffer as banks get bigger and increases in CRED cause TE to decline. None of the regression models establishes a substantial association between OWNR and efficiency.

Table 6: Random-Effects Tobit Regression Analysis – Determinants of Bank Efficiency

Dependent Variables	**(1) CRS TE**		**(2) CRS TE**		**(3) VRS TE**		**(4) VRS TE**		**(5) SE**		**(6) SE**	
Independent Variables	***Coef.***	***P***	***Coef.***	***P***	***Coef.***	***P***	***Coef.***	***P***	***Coef.***	***P***	***Coef.***	***P***
CRED	-0.4997	0.042**	-0.3463	0.077	0.0268	0.882	-0.0204	0.911	0.0943	0.587	0.1744	0.391
OWNR	0.1044	0.187	0.0960	0.166	0.0153	0.813	0.0112	0.864	0.0911	0.094	0.1139	0.074
SIZE	0.0201	0.292	0.0209	0.218	0.0022	0.889	0.0051	0.754	0.0256	0.095	0.0252	0.15
OPRC	-0.1570	0.038**	-0.1534	0.022**	-0.1883	0.003**	-0.1818	0.006**	-0.0414	0.486	-0.0531	0.435
INFL	-3.3076	0.022**	-0.1090	0.154	-3.9239	0.001**	-1.4883	0.002**	0.6153	0.218		
GDPPC	-0.1435	0.103			-0.2043	0.004**	-0.2140	0.004**	0.0972	0.188	0.0539	0.434
MKTC	29.762	0.099	-7.4539	0.253	33.578	0.022**						
cons	0.3155	0.797	1.8559	0.036	0.7723	0.437	2.6650	0	-0.6634	0.27	-0.2988	0.561
Prob > chi2	0.0021		0.0095		0.0092		0.0051		0.0488		0.0499	
Observation	105		105		105		105		105		105	

*This table summarizes the result of the Random-Effect Tobit Regression using CRS, VRS and SE as response variables. Two different models are regressed on each response variable in order to deal with multicollinearity. The symbol ** represents statistical significance at 5% level. CRED, OPR, INFL, GDPPC and MKTC have a significant negative influence on VRS TE and CRS TE but OWNR and SIZE have no influence on them. No independent variables affects SE.*

Table 7: Random-Effects OLS Regression Analysis – Determinants of Bank Efficiency

Dependent Variables	**(1) CRS TE**		**(2) CRS TE**		**(3) VRS TE**		**(4) VRS TE**		**(5) SE**		**(6) SE**	
Independent Variables	***Coef.***	***P***	***Coef.***	***P***	***Coef.***	***P***	***Coef.***	***P***	***Coef.***	***P***	***Coef.***	***P***
CRED	-0.3095	0.123	-0.3397	0.089	0.0256	0.889	-0.0184	0.921	0.0864	0.641	0.0798	0.663
OWNR	0.0992	0.165	0.0965	0.176	0.0146	0.81	0.0108	0.86	0.0906	0.136	0.0902	0.138
SIZE	0.0185	0.28	0.0200	0.245	0.0057	0.722	0.0084	0.604	0.0266	0.099	0.0311	0.027**
OPRC	-0.1599	0.015**	-0.1535	0.019*	-0.2087	0.001**	-0.2019	0.001**	-0.0381	0.538	-0.0476	0.426
INFL	-2.5092	0.052	-0.9599	0.07	-3.9280	0.001**	-1.4795	0.004**	1.0895	0.383		
GDPPC	-0.1386	0.079	-0.1435	0.07	-0.2161	0.004**	-0.2254	0.003**	0.0951	0.21		
MKTC	21.373	0.188			33.756	0.03**			-6.5370	0.677		
CONS	0.5773	0.604	1.7787	0.006	0.7974	0.454	2.6978	0	-0.3034	0.778	0.0735	0.803
Prob > chi2	0.0041		0.0473		0.0005		0.0021		0.1118		0.0473	
Dependent Variables	*(1) CRS TE*		*(2) CRS TE*		*(3) VRS TE*		*(4) VRS TE*		*(5) SE*		*(6) SE*	
Hausman Test	0.4065		0.2791		0.024		0.0011		0.9998		0.8410	

*This table summarizes the result of the Random-Effect OLS Regression using CRS, VRS and SE as response variables. Two different models are regressed on each response variable in order to deal with multicollinearity. The symbol "**" represents statistical significance at 5% level. Model 5 is insignificant at 5% level so we ignore it in the analysis. OPRC negatively affects CRS TE while OPRC, INFL and GDPPC negatively influence VRS TE. MKTC also influences VRS TE but in a positive direction. Of all the explanatory variables, only SIZE relates to SE and that relation is positive*

Table 8: Fixed-Effects OLS Regression Analysis – Determinants of Bank Efficiency

	(3) VRS TE		**(4) VRS TE**	
	Coef.	*P*	*Coef.*	*P*
CRED	-0.0094	0.967	-0.0764	0.741
OWNR	-	-	-	-
SIZE	-0.0142	0.432	-0.0123	0.505
OPRC	-0.1079	0.105	-0.095	0.16
INFL	-3.8961	0.001**	-1.5332	0.003**
GDPPC	-0.1528	0.044**	-0.1588	0.041**
MKTC	32.635	0.031**	-	-
_cons	0.7472	0.469	2.5904	0
Prob > F	0.0096		0.0324	

*This table shows the result of the Fixed-Effect OLS Regression using on one hand VRS as response variable and on the other hand CRED, OWNR, SIZE, OPRC, INFL, DPPC and MKTC as explanatory variables. The symbol "**" represents statistical significance at 5% level. It shows that INFL, GDPPC and MKTC influence VRS TE. However, whereas the relations of INFL and GDPPC with VRS TE are negative, that of MKTC with VRS is positive.*

CONCLUDING COMMENT

This thesis mainly examined, the TE of banks in Ghana and its determinants. More precisely, it looked at the variation of TE by bank size and whether big banks enjoyed economy of scale as an advantage over small banks. Using balanced panel data of a sample of twenty-one (21) banks from 2009 to 2013, the various analyses prove that at most eight (8) banks were technically efficiency according to the production approach

of DEA – BCC model. By implication, a minimum of 61.9% of banks in the country were inefficient. The analyses further indicate that the average bank in the country was 63.89% to 80.48% as efficient as the "best" banks. This means that, given the same level of output, the average bank utilized 19.52% to 36.11% more input than the technically efficient bank. Largest banks had the highest number of technically efficient banks, followed by large banks. Even where the number of technically efficient banks was the same among largest banks and the other category of banks (the case of intermediation approach, DEA – CCR model), largest banks had the highest relative TE score. There is therefore ample evidence to support the assertion that on the average, TE varied directly in proportion to bank size within the two upper quartiles. It was also evident that big banks did not benefit from economy of scales as an edge over small banks.

All the regression models show that INFL, GDPPC and MKTC influence TE substantially. Whereas the influence of INFL and GDPPC are negative, that of MKTC is positive. This signifies that increases in INFL and GDPPC lead to a decrease in efficiency whilst an increase in MKTC leads to improvement in efficiency. With regards to company-specific variables, both Tobit regression and random-effect OLS regression points at OPRC as having a negative impact on TE; implying that increases in OPRC hinder TE. According to random-effect OLS, SIZE negatively influences SE whilst Tobit regression indicates that CRED has a negative impact on TE. By inference, SE tends to suffer as banks get bigger and increases in CRED cause TE to decline. None of the regression models establishes any substantial association between OWNR and efficiency.

RECOMMENDATIONS

Bank managers should institute measures that will improve efficiency of operating cost. This involves for instance, the maintenance of an optimum number and structure of staff and the minimization of loan impairment. We can achieve the latter through prudent and efficient credit risk management, which includes rigorous analyses of potential borrowers, regular review of interest and capital repayment schedule for existing borrowers, collateralization of lending and the use of credit limits. On the other hand, government should create a conducive economic environment to enable banks to thrive. For example, because inflation relates negatively to efficiency, there is the need to keep it at a barest minimum. Our finding supports the assertion of Khan, et al. (2001) who stated that above the threshold of 3% to 6% range, inflation significantly impedes growth of the financial sector. Finally, a negative association between GDPPC and efficiency suggest that and increase in GDPPC adversely affects efficiency. Hassan and Sanchez (2007) admit the difficulty in predicting the direction of efficiency when an economy experience growth. They added that efficiency could respond to growth tardily. We therefore recommend that government pursue policies that ensure economic growth due to its immense benefit.

The direct variation of efficient in proportion to bank size in the two upper quartiles is of relevance to existing and prospective investors in the banking sector. To existing investors, it is recommended that they all yearn to augment the size of their bank to enable them correspond to that of those in the two upper quartiles (if this is not currently the case) since banks in these categories were more efficient. We also caution prospective investors to target big banks if they are risk averse. Bank customers must equally be mindful of the predominance of inefficiency in the sector and contribute towards its reduction by being trustworthy and credit worthy. Their credit worthiness may lower non-performing assets and bad debts. It may further lead to lower lending risk and possibly lower lending rate. Trustworthy customers would contribute to efficiency by providing accurate and reliable information about themselves and their businesses. This would reduce the intensity and cost of due diligence conducted by banks before granting loans. Ultimately, both credit worthiness and trustworthiness of customers may result in a reduction in operating cost and an increase in TE.

LIMITATIONS

The limitation of this work is the reliance on only one estimation techniques (i.e. DEA) to compute the efficiencies since this may produce misleading results. Combination of models like SFA, FDH may produce a more realistic result. Secondly, the use of balance panel for the analysis resulted in the elimination of banks whose operation did not span entirely over the period under consideration. Their involvement in the sample could have yielded different results. Finally, the number of variables that influences TE exceeds those considered in this paper and therefore our findings and recommendations cannot be exhaustive.

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