

UNIVERSITY OF CAPE COAST

COMPARATIVE ANALYSIS OF TECHNICAL EFFICIENCY OF LISTED
AND UNLISTED BANKS IN GHANA

BY

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the award of Master of Philosophy degree in Economics

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DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this University or elsewhere.

Candidate's Signature Date.....

SANDRA BEMA AMOAKO-BOATENG

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

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ABSTRACT

Financial institutions are the main intermediation channels between saving and investment in a country. Bank efficiency allows for mobilizing of savings from diverse sources and allocate it to more productive activities for economic growth. This study carries out a comparative analysis of technical efficiency for listed and unlisted banks in Ghana. Using panel annual financial data from eleven (11) banks starting from 2009 to 2013, the study employed the Stochastic Frontier Approach to estimate technical efficiency of the listed banks and the technical efficiency of the banks not listed.

The study found that on the average, banks not listed on GSE are more efficient than listed banks. Foreign banks were more efficient than domestic banks. Bank-specific factors like the liquidity ratio, assets tangibility and profitability had a direct effect on both listed and unlisted banks. Increase in money supply will lead to increase in the efficiency level of both categories of banks.

The study proposed that Bank of Ghana should consider reducing the banks required reserves with the Bank of Ghana to increase money supply and improve efficiency of banks. Bank managers are advised to maintain high level of liquidity in their operations to improve the efficiency of banks.

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DEDICATION

To my Dad, Mr. Kwasi Amoako-Boateng

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LIST OF ACRONYMS

BoG - Bank of Ghana

DEA - Data Envelopment Analysis

GAB - Ghana Association of Bankers

GDP - Gross Domestic Product

GSE - Ghana Stock Exchange

IA - Share of industry advances

ID - Share of industry deposits

LDR - Loan Deposit ratio of bank

NII - Net interest income of bank

PROF - Profitability level of bank

PwC - PricewaterhouseCoopers

SFA - Stochastic Frontier Approach

TA - Total assets of bank

TANG - Asset Tangibility of banks

CHAPTER ONE

INTRODUCTION

Background to the Study

The opportunity of actualising a new business plan or expanding an existing business venture is accompanied by financial obligations. The difficulty in securing funds in setting-up or growing a business is what makes financial institutions a vital component in every growing economy.

Individuals in need of capital mostly rely on loans from financial institutions or help from family and friends. Likewise, people who intend to put away excess funds for future needs often save with financial institutions till such time when the money is needed. Financial institutions therefore play the dual role of financial intermediation: collecting and mobilizing funds and using the accumulated funds to finance individual businesses and developmental projects that are essential for economic development (Kutsienyo, 2011).

The Ghanaian banking sector is based on the concept of universal banks, where banks can offer all banking services such as accepting customer cash deposits and providing various kinds of banking and financial business like insurance, mutual funds, investment banking, housing finance, factoring, bank accounts, loans, share trading account, mutual funds, among others (www.bog.gov.gh).

Over the years, the Ghanaian economy has experienced the establishment of new banks, the setting-up of already existing international banks, the merging of

different banks, various structural developments and financial reforms in its banking sector. These reforms include the adoption of International Financial Reporting Standards (IFRS), setting up of the Financial Intelligence Centre (FIC) and establishment of Collateral Registry and Credit Reference Bureaus (Kutsienyo, 2011). The reforms were geared toward mitigating risk, stabilising the banking system and liberalizing the financial sector from excessive government regulation. Post-reform period witnessed changes in the institutional structure of the sector as it became more competitive, deepened and diversified. Growth and development of the banking sector is the foundation for sustainable economic growth, if only the sector is efficient in its operations.

Banks use accumulated savings in the form of customer cash deposits from diverse sources to finance efficient and profitable productive activities. These activities benefit not only investors and beneficiaries of the investment but the whole economy (Pattillo, Gulde, Carey, Wagh, & Christensen, 2006).

In order for the banking sector to contribute to the growth and development of the economy, the sector must improve on its efficiency as well as its performance level (Levine, 1997). An efficient banking institution is capable of effectively connecting suppliers and borrowers of funds to transact business at low or no transaction cost.

It is a proven fact that an institution that is efficient in all its operations must have a high performance level. Studies done by Raphael (2013b); Kumar and Gulati (2009) prove that performance has a strong and positive correlation with efficiency.

Findings from the research conducted by Raphael; Kumar and Gulati indicate that improvement in the efficiency level of production would improve the performance level of the institution by a significant margin. Likewise, an efficient financial system is a prerequisite for proper financial intermediation leading to sustainable private sector investment and promotion of entrepreneurship (Kutsienyo, 2011).

The Ghana Stock Exchange like any other Stock Exchange market was principally established to connect stock buyers with stock sellers with the aim of providing the platform for trading and as such raising of capital for operations. The recent performance of Ghana Stock Exchange suggests that the GSE is becoming robust in offering the cheapest means of raising capital for investment projects in the country (Lartey, 2015). Hence, contributing to the efficiency of operations for the companies trading their shares on the stock market.

In addition to capital generation, these listed companies on the Ghana Stock Exchange enjoy other inherent benefits. That is, as a company opens itself to public scrutiny by making its financial books available to the general public, the management becomes more conscious of business decisions and more efficient to maintain a level of profitability to attract new investors. Also, the stock market acting as a regulatory body is expected to monitor the activities of the listed companies', hence, influences the business operations of these corporations. In the nutshell, it can be assumed that all these checks make the listed companies more efficient. Although this assumption is permissible in theory, the question is, will it hold in practice? Does listing on the stock market improve the company's performance and profit level but not the technical efficiency of the company?

Problem Statement

There is a concern that the state dominated, inefficient and fragile banking systems in many low-income countries, especially Sub-Saharan Africa, are a major hindrance to economic growth (Hauner & Peiris, 2008). The efficiency of banks is germane to the productivity of an economy. Study conducted by Ikhide, (2000) on the efficiency of commercial banks across some sub-Saharan African countries indicate that efficiency in the banking system ensures reduction in the spreads between lending and deposit rates. Hence, increasing the proportion of loan demands for industrial investment, which will contribute to the growth of the domestic economy.

Banks are responsible for ensuring a smooth functioning payment system, which allows financial and real resources to flow freely to their highest-returns uses (Ikhide, 2000). In order for banks to perform this fundamental role, they must be efficient in their operations. The concept of efficiency in banking institutions has been a topic for many research papers in various countries across the globe (Dietsch & Lozano-Vivas, 2000; Favero & Papi, 1995; Huang & Song, 2004; Noor & Ahmad, 2012). Studies done in this area differ due to the multi-facet nature of efficiency which can be technical efficiency, cost efficiency, profit efficiency, allocative efficiency, operational efficiency or scale efficiency.

Furthermore, most of these studies like Raphael, (2013a), Maudos, Pastor, Perez, and Quesada (2002), and Hauner and Peiris, (2008) indicate that the efficiency of banking institutions is reliant on numerous factors. These

determinants can be grouped into bank specific, industry specific characteristics and macroeconomic conditions. (Raphael, 2013a).

Hauner and Peiris, (2008) discovered that in the case of Banks in Uganda, domestic banks are less efficient as compared to foreign-owned banks. Meaning, the ownership status and size of a bank influence the efficiency of Ugandan banks. In Ghana, Frimpong (2010b) established that ownership status of commercial banks affects the efficiency of Ghanaian banks. However, investigation into the technical efficiencies of banks listed on the GSE and banks that are not listed on the GSE is non-existing to the best of my knowledge. That is, no earlier study has been done to determine if listing on the stock market influence the efficiency level of banks in Ghana.

Over the years, the stocks of banking institutions in the country have become more and more attractive to investors both local and foreign due to the recorded profit levels. The attractiveness of the listed stocks on the Stock Exchange would definitely draw investors into the market which will eventually lead to improvement in Ghana's development. It's based on this reasoning that the Central Bank has relentlessly continued to encourage and get banks to get listed on the Ghana Stock Exchange (Graphic.com.gh, 2013).

This leads to the question, what benefits do companies and specifically banks that have listed their shares on GSE have over their unlisted counterparts? Are the listed banks more efficient and more profitable than unlisted banks? And

what are those factors that determine the efficiency level of these banks? Answers to these questions are the main concern of this study.

Research Objectives

The general objective of the study is to examine technical efficiency of listed and unlisted commercial banks in Ghana. The specific objectives are to:

- Estimate the level of technical efficiency of selected listed and unlisted commercial banks;
- Compare the average technical efficiencies of the listed and unlisted banks;
- Determine the factors that influence the technical efficiency of listed and unlisted banks.

Research Hypotheses

1. H_0 : Commercial banks are operating on the technical efficient frontier with a zero inefficient error term.

H_1 : Commercial banks are not operating on the technical efficient frontier with a non-zero inefficient error term.

2. H_0 : The average technical efficiency of listed banks is not different from that of unlisted banks.

H_1 : The average technical efficiency of listed banks is different from that of unlisted banks.

Motivation of the Study

According to Levine, (1997) (as cited in Saka, Wittbom, & Tavassoli, 2010) “a banking system that is able to efficiently channel its financial resources to optimum production level is a powerful mechanism for economic growth”. The International Monetary Fund (IMF) and the World Bank (WB) have over the years prescribed policies accompanying either their financial bail-out or other technical support programmes to improve the efficiency and performance of the financial sector and spread over to other sectors of the economy. These international bodies appreciate the significant importance of the effectiveness and growth of the financial sector, especially the banking industry.

Likewise, the former Governor of Bank of Ghana acknowledged that listing on the GSE is beneficial to both the individual corporations and the economy. He mentioned that the governance structures imposed by the stock market, such as broadening ownership, providing regular and periodic reporting to the market and independent directors, enhances confidence in the institutions and compliments the oversight role of the regulator (Graphic.com.gh, 2013).

The study estimated the efficiency of banks categorised on whether the bank is listed on the stock exchange or not. Specifically, the study estimated the technical efficiency of listed banks and compared it to that of unlisted banks to either buttress or contradict the necessity of banks listing on the Ghana Stock Exchange to simply improve efficiency.

Significance of the Study

Findings from this research would provide evidence of the importance of listing on the stock market to management of the unlisted banks- it would guide the institutions decision to list on the stock market. This study would help managers of already listed banks to analyse their bank's efficiency performance scores over the years under study and the underlying reasons causing the rise or fall of said efficiency scores.

The study would inform the formulation of financial policies aimed at improving the overall efficiency of the banking industry and identify the gaps and need for reforms in the banking sector. Lastly, the results of the study would help academicians in their continuous search for knowledge and theories. The research could serve as a reference point for further future research.

Scope of study

This research looked into the technical efficiency scores of banks that are listed on the Ghana Stock Exchange from 2009 to 2013 and compared the figures to that of some selected banks that are not listed in Ghana. The inferences made on the findings have been delimited only to banks in Ghana and report their annual financial report in the local currency, Ghana Cedis.

In determining the technical efficiency of the banks selected and the effect of the institutional specific and socio-economic factors, the study delimits itself to the use of Stochastic Production Function only.

Organisation of the Study

The study is organised into six main chapters with each chapter further divided into sections and sub-sections. The first chapter which is the introductory chapter presents a background to the study, problem statement, objectives of the study, hypotheses, motivation and the significance of the study. Chapter Two highlights on the overview of the Ghana Banking sector, the performance of the Ghana Stock Exchange (GSE) and the link between the performance of the banking sector and the GSE. Chapter Three reviews existing literature on various forms of efficiency, the connection between efficiency, effectiveness and performance, findings of previous studies on the efficiency levels of banks when different methods of measuring efficiency were used. It also discusses the developments in the parametric and non-parametric measures. Chapter Four discusses the research design, data type and sources, choice of input and output, theoretical and empirical models specification, the estimation technique and definition of variables used in this study. Chapter Five presents the technical efficiency scores of the selected banks and all other findings from this research. Chapter Six presents the summary of the findings, conclusions of the study, and recommendations for policy formulation and suggestions for further research.

CHAPTER TWO

OVERVIEW OF GHANA'S ECONOMY

Introduction

This chapter presents an overview of the Ghanaian economy. The first section focuses on the overview of Ghana's financial sector and the banking sector. The following sections look at the development and performance of the Ghana Stock Exchange and the relationship between the stock exchange and the banking sector.

Overview of Ghana's Financial Sector

Ghana's financial sector is one of the fastest growing sectors in the economy as reflected by the speed of growth in both the branch and non-branch network of existing banks as well as the entrance of new banks into the industry. Similar to other economies, Ghana's financial system consist of banking institutions; rural and community banks, insurance companies, discount houses, finance houses, leasing companies, savings and loans companies, credit unions, a stock exchange, stockbrokerage houses and foreign exchange bureau (Bank Of Ghana, 2016).

Currently, the Register of licensed financial institutions in Ghana are Banks, Rural and Community Banks, Non-Bank Financial Institutions, Forex Bureaux, Licensed Microfinance Institutions and Licensed Inward Money Transfer companies. The Non-Bank Financial Institutions (NBIFs) are made of finance house, remittance companies, credit reference bureau, savings and loans, leasing,

finance and leasing and mortgage finance. There is a total of 29 licensed Banks, 140 Rural and Community Banks, 66 Non-Bank Financial institutions including finance houses, savings and loans, leasing and mortgage firms, 392 active Forex Bureaux allocated in all the regions with the exception of Upper East and Upper West regions of Ghana, 10 operational Financial Non-Governmental Organisations, 385 Licensed Microfinance Companies and 60 Licensed Money Lending Companies (www.bog.gov.gh).

The structure of Ghana's financial system evolve around the banking system. The banks make up the largest component of the financial system using total assets or customer base as a measure. Ghana's banking sector occupied close to 70 percent of the entire financial sector as at 2008 (Bawumia, Owusu-Danso, & McIntyre, 2008).

Out of the 29 banks, 15 are foreign banks (banks with foreign majority ownership) and 14 are domestically controlled banks (banks with local majority ownership). Currently, all these 29 banks are operating as Universal banks that provide a wide range of universal banking retail services to customers.

As at 2008, the licensed banking institutions included the traditional Commercial banks, Merchant banks, Development banks. The commercial banks were licensed by the Bank of Ghana (BoG), to engage in traditional banking business, with a focus on universal retail services. Merchant banks were fee-based banking institutions and mostly engaged in corporate banking services. Development banks specialized in the provision of medium- and long-term finance

(Saka et al. 2010). As reported by Buchs and Mathisen (2005), this three-pillar banking model exhibited insufficient competition in the banking industry. The uncompetitive structure of the banking sector was attributed to the majority of the market share held by few major commercial banks in the form of total assets. The liberalisation of the industry through reforms levelled the playing field and encouraged competition, product innovation and new entry into the banking industry.

Over the years, in order to move beyond the marginal and volatile economic growth and experience a more sustainable growth in performance and productivity of the banking sector, campaign to liberalize the economy has been embarked upon. This campaign was what prompted a couple of financial sector forms in the economy. These reforms resulted in Universal banking replacing the three-pillar banking model- development, merchant and commercial banking.

The launching of the Economic Recovery Programme (ERP) in 1983 forms part of the campaign. Also, the Financial Sector Adjustment Programme (FINSAP) in 1988 was to address the weaknesses in the industry: low competition, weak financials, and low profitability as a result of high non-performing loan assets, less liquidity, low capital base, and low level of technology (Anim, 2000).

Most recently, the adoption of International Financial Reporting Standards (IFRS), the establishments of the Collateral Registry and Credit Reference Bureaus are to improve the productivity, efficiency and profitability of the of the sector, contributing to an overall economic development. These economic reforms plus

policy prescriptions from the International Monetary Fund (IMF) and the World Bank in the form of IMF bail-out conditions for stabilizing the economy reinforces the importance of the financial sector in promoting growth and development of the economy.

Performance of the Ghanaian Banking Industry

Over two decades now, the Ghanaian banking industry has experienced some major regulatory developments that affected the industry's regulatory landscape. As reported by PricewaterhouseCoopers (PwC) and Ghana Association of Bankers (2009), the table below captures the major developments that have occurred within the industry from 2003 to 2008.

Table 1

Key regulatory developments in the Banking Industry from 2003 to 2008

Year	Key Development
2003	<ul style="list-style-type: none"> • Universal Banking License was introduced; banks with ₵70 billion (GH₵ 7million) in capital permitted to carry out any form of banking. • Maintenance, transaction, and transfer fees charges by commercial banks were abolished
2004	<ul style="list-style-type: none"> • The Banking Act 2004 (Act 673) replaced the Banking Law 1989 (PNDCL 225)
2006	<ul style="list-style-type: none"> • Secondary deposits reserves requirement (15%) was abolished Foreign Exchange Act 2006 (Act 723) and Whistle Blowers Act 2006 (Act 720) came into effect

Table 1 continued

2007	<ul style="list-style-type: none"> • Credit Reporting Act 2007 (Act 726) and Banking (Amendment) Act 2007 (Act 738) were passed • National Reconstruction Levy was abolished • Re-denomination of the cedi (¢10,000 = GH¢1)
2008	<ul style="list-style-type: none"> • Borrowers and Lenders Act, 2008 (Act 773), • Non-Banking Financial Institutions Act, 2008 (Act 774), • Home Mortgage Finance Act, 2008 (Act 770) and • Anti-Money Laundering Act, 2008 (Act 749) were passed • Banks to comply with International Financial Reporting Standards (IFRS)

Source: As reported by PwC in association with GAB (2009)

In 2008, the Parliament of Ghana passed four bills into laws to generally aid in the development of the financial sector and specifically the banking industry.

The rationale of each of the bills are explained below;

The Borrowers and Lenders Act- to ensure high level disclosure in creditor and borrower relations and clarity in lending conditions and rights and obligations of lenders and borrowers. Non-Bank Financial Institution Act- it provides a framework to provide effective prudential regulation and supervision of the wide range of non-bank financial institutions. Home Mortgage Finance Act- to regulate home mortgage financing and applies to transactions between financial institutions and their customers (mortgagor) to finance the construction, purchase, completion, extension or renovation of residential property either for ownership, sale or rental. Anti-money Laundering Act- It seeks to prohibit money laundering and establish a Financial Intelligence Centre. Under the Act, a person commits the offence of

money laundering if they knowingly convert, conceal, disguise, transfer, take possession of, or use property forming part of the proceeds of unlawful activity.

The objective of these regulatory developments was to improve the way banks and the industry conduct business and improve the ability of the banks to withstand the shocks and protect the soundness of the financial system. Although, the global financial crisis did not severely impact Ghana's banking industry in 2008, it was predicted by analyst that the effect will manifest itself more significantly in developing countries in 2009, hence, the strengthening of the regulatory and supervisory framework in 2008.

The objective of the banking industry to encourage customers to use the banking system for their transactions may not be achieved due to the additional cost created by the amended Value Added Tax (VAT) 2013 (Act 870) that is borne by customers. The amendment of the aggregate VAT and NHIL rates to include banking and insurance providers increased the rates to 17.5% from 15%, effective from December 31st, 2013. The industry has to restructure the banking system to capture these low value but extremely high volume of transaction the new VAT law introduced.

The Bank of Ghana policy rate was increased from 15% to 16% in May 2013 and was maintained at that rate to the end of the year. The Government of Ghana in an unprecedented action, issued two separate 7-year fixed bonds in August and November 2013 at 17.5% and 18.0% respectively. The base rate formula was revised in 2013 to calculate the minimum rate for all new loans and advances obtained from July 2013. The formula is to ensure transparency and

uniformity in loan pricing in the industry and to help customers make accurate comparison of cost of borrowing rate that exists in other banks and make informed decisions.

First Capital Plus Bank Limited secured a universal banking license in August 2013. Prior to that it operated as a savings and loans company. ICB Financial Group Holdings AG sold its holdings in the African subsidiaries to First Bank of Nigeria (FBN). Consequently, the ownership of International Commercial Bank, Ghana was transferred to FBN. This brings to six the number of West African regional banks operating in Ghana. Under the of BOG's approval, FBN is required to offload at least 40% of the shares to Ghanaians through private placement and /or the Ghana Stock Exchange. The time frame set for at least 25% should be offloaded by 31 December 2014 and the remainder not later than 31 December 2016. The Bank of Ghana announced on 1 November 2013 that Fortiz Private Equity Fund Ltd, a wholly owned Ghanaian equity fund reached an agreement with the Social Security and National Insurance Trust (SSNIT) and SIC Life to take over the majority stake in Merchant Bank.

The industry has embraced the use of technological innovation to improve delivery systems in Ghana. Such advancement in its technology is the development of the gh-link mobile by Ghana Interbank Payment and Settlement System (GhIPSS) in collaboration with Nigerian payment company eTranzact. This technological innovation was part of GhIPSS's mandate to transform Ghana into an electronic payment society. Also, the launching of the collateral registry by the Bank of Ghana in 2013 was aimed at streamlining the credit delivery system in the

country. This eases the challenges in perfection of securities and its realisation in the event of default.

The minimum capital regulatory requirement as at the end of 2009 was stated as GH¢60 million and GH¢25 million for foreign banks (banks with foreign majority ownership) and local banks (banks with local majority ownership) respectively. As at November 2011, the Central Bank recorded that 16 banks have been able to meet the minimum requirement of GH¢60 million. With the exception of Sahel Sahara Bank and Bank of Baroda, all the other 13 foreign banks and 3 of the indigenous banks have met the minimum capital requirement. The regulatory body urged the local banks to expand their shareholders' base by listing enough of their shares on the GSE to raise funds that will provide the additional capital needed to meet the capital requirement. Failure to shore up its capital to GH¢60 million will have their license revoked and converted to a non-bank financial institution. In the course of five years, the Bank of Ghana doubled the minimum capital required for new commercial banks to operate in the country to GH¢120 million. Already existing banks were allowed to operate at the previously stated minimum capital requirement of GH¢60 million but with the agreement that these existing banks will grow their business capital to the new capital requirement. This increase in the minimum capital requirement reinforced the urgency of banks listing on their shares on the GSE, especially with the inflation and depreciation of the Ghana cedi.

The Ghana Stock Exchange (GSE)

The Ghana Stock Exchange (GSE) was established in July 1989 as a private company limited by guarantee under the Ghana's Companies' Code of 1963 (Act 179). However, the objective of establishing the Stock Exchange was built on the findings from a study conducted by the Government in the 1960s on the necessity of establishing a stock market to fast-track the economic development of the Ghana. This resulted in the decree of the Stock Market Act of 1971 (Act 384), which laid the foundation for the establishment of the Accra Stock Market Ltd. (ASML) in the same year.

The unfavourable economic environment caused by the political tension in the country and lack of support from the government during this period largely influenced the failure of actualising the objective of establishing a stock market (Yartey, 2006). Regardless of these unfavourable conditions, National Trust Holding Company Ltd. (NTHCL) and National Stockbrokers Ltd. (NSBL), now Merban Stockbrokers Ltd. (MSBL), were able to do Over-the-Counter (OTC) trading in shares of some foreign-owned firms prior to the establishment of the Ghana Stock Exchange (Ambrose & Buttimer, 2005).

Under the Financial Sector Adjustment Programme (FINSAP), the stock market was recognized as an authorized Stock Exchange under the Stock Exchange Act 384 in October 1990. On-the-Floor trading of shares commenced on the 12th of November 1990 with 11 listed firms and one government bond after the Council of

the Exchange was inaugurated. However, GSE became a public company limited by guarantee in April 1994.

Currently the Ghana stock market can boast of a total of 39 listed companies from varying industries in the economy, out of which 8 are commercial banks. The commercial banks are HFC Bank Ltd., Societè Generale Ghana Ltd., Ghana Commercial Bank Ltd., Standard Chartered Bank, Trust Bank, CAL Bank Ltd., Ecobank Ghana Ltd., and Unique Trust Bank Ltd.

Performance of the GSE

The performance of the Ghana Stock Exchange is measured by the stock market Index. With the exception of the negative returns of stocks recorded in the years 1999, 2005 and 2011, the stock market has been performing remarkably well looking at the returns to investors. In 1994, the Birinyi Associates, a Research Group based in the USA, ranked the GSE as the 6th best performing stock market index among all the emerging stock markets in Africa with a growth rate of 124.3. Based on the capital appreciation by the Standard Chartered Bank London Limited, the stock market also adjudged the best performer among all stock markets in Africa and the third best in emerging markets in 1998. The GSE was again pronounced the world's best-performing market at the end of 2003 with a yearly return of about 154.7% (or 144 % in US Dollar terms) compared with 30% return by Morgan Stanley Capital International Global Index (Yartey & Adjasi, 2007).

The less favourable years for the growth of the GSE were reported to coincide with international crisis that spilled over to the growth in the local

economy. For instance, in 2005, the stock market index estimated a negative return of approximately -30% that was as a result of the rising oil prices on the global market, high inflation scores and interest rates. Similarly, in 2011, the index recorded a growth rate of -47 that financial analysts attributed to the spill over effects of the global financial crisis of 2007 and 2008. The growth rate recorded in 2011 marked the lowest rate for the stock market since its establishment.

The good performance of the stock market in 1994, 1998, 2003 and 2008 was attributed partly to favourable macroeconomic indicators (inflation, interest rate) and mainly to the listing of the Ashanti Goldfields Company Limited in 1994. In 1998 in particular, there was high demand for equity shares on the market that led to a remarkable increase in share prices on the market. The trend of the index shows a steady rise from 1991 through the years to 2002, before rising sharply in 2003 to peak initially at 2004. It then fluctuated in 2005 and 2006 before increasing again in 2007 to reach an all-time high in 2008. It again fluctuated in 2009, 2010 and 2011 before increasing marginally in 2012

Included in the goals for setting up the Exchange is the responsibility of regulating the dealings between members and their clients as well as with other members, and cooperating with stockbrokers and other stock markets in various countries. These responsibilities are to obtain and make available to members information and facilities that are likely to be of importance to them or their clients are inclusive. The above named objectives and others are to promote transparency

and open-up members to new and more efficient opportunities. Thereby, improving the performance of members in their respective listed industries.

Also, the existence of listing rules that spells-out the criteria for original listing as well as the continuing obligations attached to listing serves as a regulatory check on listed companies. The listing rules document, that is continuously being revised, prescribes both the requirements for obtaining and maintaining a listing of securities on the Exchange. Abuse of these rules can result in the delisting of said company.

Since its establishment, the Ghana Stock Exchange, have delisted five firms. These are; UTC Estates Ghana, Metalloplastica Ghana, British American Tobacco, Accra Brewery and CFAO Ghana. Also, five mergers and acquisitions involving the following GSE-listed firms also took place. They are; Kumasi Breweries merging with Ghana Breweries to become Ghana Breweries, Ghana Breweries merging with Guinness Ghana to become Guinness Ghana Breweries, Ashanti Goldfields with AngloGold to become AngloGold Ashanti, Mobil Oil Ghana and Total Ghana to become Total Petroleum Ghana and Unique Trust Financial Services with UT Bank to become UT Bank (Lartey, 2015).

The Ghana Banking Survey, 2014 (PricewaterhouseCoopers (PwC) & Ghana Association of Bankers, n.d.-b) indicates that legislation and regulation is the second most important route that would ensure that banking businesses are pushed to greater heights in the next five years. Second to competition, 72.7% of the sampled bank executives ranked legislation and regulation as a major factor that

would have the biggest impact on the banking industry in the years to come (Ghana Banking Survey, 2014).

The clearly spelt out rules and regulations set the Ghana Stock Exchange on the path of ensuring that all listed companies are transparent in their dealings with their respective clients and companies are efficient in their production processes as well.

Summary

The Chapter two presented a general overview of Ghana's financial sector and zoomed in on the overview and performance of the Banking industry, outlining the key developments to the banking environment. It went further to give an overview and the performance trend of the Ghana Stock Exchange from 1991 to 2012.

CHAPTER THREE

LITERATURE REVIEW

Introduction

This chapter gives a detailed review of existing literature on the investigations of the various forms of efficiency, the connection between efficiency, effectiveness and performance, stochastic frontier production function approach to measurement of technical efficiency and finally findings of previous studies on the efficiency levels of banks when various forms of measuring efficiency were used.

Relationship between Efficiency, Effectiveness and Performance

Efficient minimization of resource inputs to obtain an optimum level of output in production is regarded as attaining an efficiency level but this does not measure the success of the firm in the market place; hence, the firm is said to be ineffective in its operations (Raphael, 2013b).

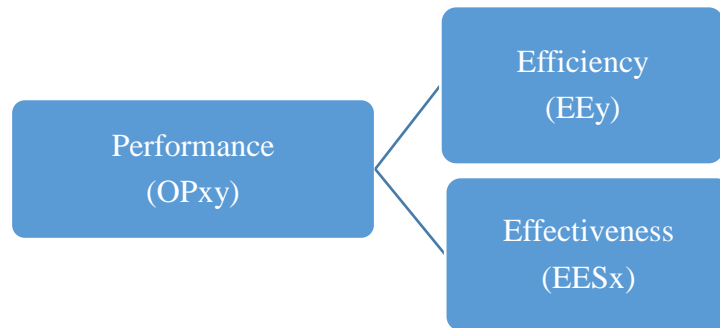


Figure 1: Efficiency, Effectiveness and Performance Framework

Source: Adopted from, Ozcan (2008)

As seen in Figure 1, performance is a function of both efficiency and effectiveness. Performance is the product of efficiency and effectiveness, i.e. $OP_{xy} = EES_x \times EE_y$. Where OP_{xy} represents overall performance, EES_x represents efficiency estimates and EE_y represents effectiveness estimates. Using financial ratios, Raphael (2013b) measured efficiency as a ratio of Operating income and Total asset and effectiveness as the ratio of Earning Before Interest and Taxes. He adopted the concept of efficiency and effectiveness to obtain performance estimates since both efficiency and effectiveness are mutually exclusive and influence each other.

The use of efficiency and effectiveness in measuring performance of revenue generated has attracted lots of scholarly attention over the past years. As seen in the work of Mouzas (2006) and others, the measure of performance is highly correlated to the efficiency and effectiveness of the unit. Some researchers believe that efficiency can be distinguished from effectiveness in simple but clear terms. That is, whereas efficiency is doing things right, effectiveness is doing the right things. This means that an efficient organization is not necessarily effective and vice versa. This follows the findings of a study done in Taiwan by Ho and Zhu, (2004) that some companies are efficient but ineffective at the same time, indicating a poor correlation between efficiency and effectiveness. This is in contrast to findings from Karlaftis (2004) that there is strong positive correlation between efficiency and effectiveness. The fulfilment of the overall goal and objective of an organization measures the effectiveness of the organization. Efficiency and

effectiveness are related and interact with each other, thus there is some form of interdependence between these two concepts (Kumar & Gulati, 2009).

Theoretical Review of Efficiency

The theoretical beginnings of the concept of efficiency used in this study were proposed scholars like Debreu, (1951); Färe and Grosskopf, (1985); Farrell, (1957); Koopmans, (1951). Berger and Humphrey, (1997) and Hauner (2004) later provided extensive literature on the concept of efficiency and productivity. Efficiency could mean a lot of things similar to maximizing value through economies of scale, scope, output mix synergy and managerial efficiency. The yardstick of an efficient firm would be to generate more output from a given mix of inputs. The measurement of efficiency was therefore initially performed in relation to the various industrial sectors of the real economy but in the past 15 to 20 years the focus has shifted to the financial sector with an emphasis on researching the efficiency of banks (Holló & Nagy, 2006).

The positive underlying belief of efficiency analysis in economics emanates from the urge to create and enhance tangible value, while the normative *raison d'être* for efficiency analysis is founded on the challenge to obtain useful policy information (Aikaeli, 2008). The understanding of value is subjective. The scholar, Vilfredo Pareto, defined efficiency as a condition where any change which makes at least one individual better off without making any one worse off, that change is efficient (Debreu, 1959; Schenk, 2004; Varian, 1992). The relationship between cost function and production function, which underlies efficiency assessment, was

first established by Shepherd (2015) with the assumption of theoretically known efficiency. Quantitative methods for measuring total economic efficiency (with assumption of unknown theoretical efficiency) were pioneered by Farrell (1957).

The fundamental economic problem is scarcity of resources. Efficiency is concerned with the optimal production and distribution of these scarce resources. Fried, Lovell and Schmidt (2008) defined efficiency as a comparison between observed and optimal value of output and input. Efficiency is realised if more outputs are generated without changing inputs. In other scenarios, efficiency could be seen if the same outputs are generated with fewer inputs. Efficiency measurements begin with a production technology in the form of frontiers. The frontier measures how close a firm is to attaining the optimum output level that a best practised firm will earn facing similar exogenous conditions. Production technology can be depicted by production functions, cost functions or profit functions. Efficiency consists of two main components: technical efficiency and allocative efficiency (Coelli, Rao, & Battese, 1998). Nonetheless, technical efficiency, allocative efficiency, profit and overall economic efficiency are some of the forms of efficiency usually found in existing literature.

In the estimation of efficiency scores, one can use either parametric or non-parametric estimation technique. The popular non-parametric techniques are the Data Envelopment Analysis (DEA) and the free Disposable Hull Analysis (DHA). The parametric approach techniques consist of the Stochastic Econometric Frontier

Approach (SFA), the Thick Frontier Approach (TFA) and the distribution-free approach (DFA).

Both parametric and non-parametric estimation techniques are equally good when measuring various forms of the efficiency of firms. Aikaeli (2008) used both techniques in his study into the efficiency of Tanzanian banks. He used the DEA model to estimate technical and scale efficiency and SFA to estimate X-inefficiency.

However, the parametric techniques are often preferred as they generally correspond well with cost and profit efficiency concepts studies. Non-parametric techniques generally ignore prices and therefore can only account for technical inefficiency and not allocative inefficiency (Berger & Mester, 1997 as cited in Ncube, 2009).

The most paramount difference being that the DEA reports both the inefficiency scores and the random error term as one, which consequently provides inaccurate efficiency measures whereas the SFA reports the random disturbance term separately from the one-sided inefficiency scores of the individual firm. The SFA approach gives a more robust estimate of the bank's efficiency scores at its intermediation stage.

The estimation procedure for an efficiency analysis can either be a one-stage estimation or a two-stage estimation. The more popular of these two estimation techniques is the two-stage as many empirical analyses have proceeded with the two-stage estimation. In the first step, one estimates the Stochastic Frontier Model

and the firms' efficiency levels, without controlling for bank specific and macroeconomic factors. In the second step, analysis is made on how efficiency levels vary with these factors by regressing the estimates of efficiency on these external determinants (Wang & Schmidt, 2002). Some studies like Caudill and Ford, (1993); Wang and Schmidt, (2002) are of the view that the two-stage approach gives biased results, because the model estimated at the first step is wrongly specified. However, Dasmani (2010) and Alhassan and Tetteh (2017) adopted the two-stage estimation technique and identified that the difference between the efficiency scores using either the one-stage or two-stage estimation technique is insignificant.

The study used the two-stage estimation technique and controlled for macroeconomic variables. At the second stage, the bank-specific factors, industry specific factors and macroeconomic indicators that affect the efficiency of banks were determined. The question of whether being listed on the Ghana Stock Exchange influence the efficiency of a bank is answered at the second stage of the estimation. The first stage is known as the stochastic production model and the second stage is the technical efficiency effects model.

Either the Translog production function or Cobb-Douglas production function specification can be used in this type of efficiency estimation. As indicated by Kopp and Smith (1980), the functional form has a distinct but rather very small impact on estimated efficiency. Other studies however highlighted the limitations of using the Cobb-Douglas approach, opting for the translog approach since it is

not difficult to estimate and manipulate mathematically (Bravo-Ureta, Pinheiro, & others, 1993; Battase & Hassan, 1999; Hassan, 2004) as cited in Owusu Ansah (2015). Similarly, Ikhide (2000) used the Translog functional form in estimating the bank efficiencies of banks in Namibia. The reason being that it allows for more generalised results and fewer restrictions than is commonly found in the Cobb-Douglas functional forms.

The study uses the Translog functional form in the specification of both the stochastic frontier modelling and the technical efficiency modelling. Then using the LR test, we conclude whether the Translog specification reduces to Cobb-Douglas function.

In accordance with the literature on the intermediation function of banks in collecting and accumulating deposits and transferring the funds back to customers as loans and advances at a price (cost), the study adopted the intermediary approach in the choice of inputs and output. Banks in this study are viewed as entities that employ inputs to produce outputs that are sold to consumers of these output at a cost. Hence, the use of a production frontier model in the estimation of the efficiency scores.

Forms of Efficiency

Technical Efficiency

Technical efficiency of a given firm at a given time period is defined as the ratio of its mean production (conditional on its levels of factor inputs and firm

effects) to the corresponding mean production function if the firm utilized its levels of inputs most efficiently (Battese & Coelli, 1988). Ogunniyi (2008) defines technical efficiency as the ability to achieve a higher level of output given similar levels of inputs.

In measuring technical efficiency the question of how much input could be proportionally reduced without changing output produced; or how much output could be enhanced without changing the combination of input; is unravelled. These dual options give birth to the two forms of technical efficiency. Technical efficiency can either be output or input-oriented. An input-oriented technical efficiency is when a firm is able to employ less of at least one input and still able to maintain the level of output while an output-oriented technical efficiency occurs when maximum output is produced using the same level of inputs. According to Koopmans (as cited in Murillo-Zamorano, 2004), when either of the above stated instances occur, then the firm is said to be technical efficient.

Technical efficiencies are derived from production function or production possibility frontier. Firms that produce outputs on the production frontier are operating at maximum possible productivity and are recognized as technically efficient. Firms producing below the frontier line are considered to be technically inefficient, indicating that such firms are failing to optimize the use of all its available resources. According to Coelli, Rao, and Battese (1998), movements outward of a production frontier imply productivity growth which may be as a result of advances in technology. Discovery and utilization of new and improved

resources are also likely to result in a firm producing outside of its production frontier. In the short run, a firm may achieve technical efficiency by operating on the production frontier and in the long run, improve in its productivity from exploiting the expanding scale of operations. This supposes that productivity growth may be linked to improvements in technical efficiency, to technological improvements and also to exploitation of scale of operation, or a combination of all three causes (Coelli et al., 1998).

At the optimal scale or the frontier, any increase or reduction in the size of operation either through the inputs or output results in fall of efficiency level. Hence the only efficient level of operations is on the frontier. For instance, a 25% inefficiency score indicates that the firm can both minimize cost by 25% and maintain their current output level by altering their production technique, or the firm can increase production by 25% and maintain the cost of production.

A production frontier can be specified by production functions and distance functions. A single output specification of the production frontier function is valid for cases when many inputs are used to produce single output. Distance functions are useful for cases when many inputs are used to produce many outputs. The parametric estimation of the Stochastic Distance Function has proven to be very useful in estimating technical efficiency with multiple-output technologies and avoiding the major drawbacks of parametric methods associated with the single-output approach (Färe & Primont, 2012).

It is argued that technical efficiency – efficient frontier is computed using the production function at an intermediary stage – is a more appropriate measure when estimating the efficiency levels of firms in their production process. This is because technical efficiency allows the use of inputs and outputs involved in the production process to indicate whether the firm is efficient or not. Given the difficulty of procuring information from the banking industry concerning their profit margin, cost of production and other sensitive information, the choice of technical efficiency is the best. Also, in assessing the efficiency of banks in performing their intermediation function; estimating the technical efficiency scores of the banks is superior to other forms of efficiency measure.

Allocative Efficiency

Allocative efficiency (AE) has to do with the selection of an input mix that distributes factors to their highest value uses and introduces the opportunity cost of factor inputs to the measurement of productive efficiency. Allocative efficiency is realized when a firm chooses the optimal combination of inputs, while taking the level of prices and the production technology as given (Coelli, Rao & Battese 1998). Failure of a firm to choose the optimal combination of inputs at the set prices in producing its output makes the firm inefficient in inputs allocation. Badunenko, Henderson, and Kumbhakar (2012), in an empirical study on allocative efficiency, proposed that allocative efficiency can be estimated using information on input and output quantities and profit. This composition shows the ability of a financial co-operative institution to optimally combine available inputs given factor prices and

available technology. It tries to come up with the choice that best compare to the budget constraint among different possible combinations of input that yield the same amount of the desired output. That is, the ability of economic agents to equate marginal cost with marginal benefit measures the allocative efficiency of firms (Guerrero & Negrín, 2005; Manjunatha, Speelman, Van Huylenbroeck, & Chandrakanth, 2009). Allocative efficiency, therefore, is concerned with and measures how well firms combine inputs to minimize the cost of producing a given output level (Radam, Yacob, & Muslim, 2010).

Profit Efficiency

Profit efficiency evaluates how close a firm is to earning the profit that a best-practice firm earns facing the same exogenous conditions. The performance of a best-practice firm under the same exogenous conditions is a reasonable benchmark for how the firm would be expected to perform. The profit efficiency is a good measure when looking at agency cost of firms in relation to capital structure. Profit efficiency is superior to cost efficiency for evaluating the performance of managers, since it accounts for how well managers raise revenues as well as control costs and is closer to the concept of value maximization. Although maximizing accounting profits and maximizing shareholders' worth are not identical, it seems reasonable to assume that shareholder losses from agency costs are close to proportional to the losses of accounting profits that are measured by profit efficiency (Berger & Di Patti, 2006).

Overall Economic Efficiency

Another measure of efficiency, called economic or overall efficiency, is the product of technical and allocative efficiencies. From the discussion it is clear that production and cost functions subsume the concepts of technical and allocative efficiency. Cost functions assume that firms are both technically and allocative efficient and then hint out the relationship between maximum levels of output and minimum prices. However, if the minimization of costs is to be considered in efficiency and it is to be achieved, costs of inputs must be taken into account. Technical efficiency and allocative efficiency combine to provide overall efficiency (Coelli, Rao & Battese 1998). When a firm achieves maximum output from a particular input level, with utilization of inputs at the least cost, it is considered to be an overall efficient firm. The assumption is that an organization is already technically efficient; however, it may not choose the optimal mix of inputs to produce output at the least cost.

Efficiency in Banking

If a bank is efficient, it does not necessarily mean it produces the maximum level of output given the set of inputs. Rather, an efficient bank is the bank which has the best practice (Reddy, 2003). As a matter of fact, bank productivity and efficiency have raised much interest in these recent years. A popular and notable scholarly work by Berger and Humphery (1997) researched into the efficiency levels of over 130 banks across the world. In essence, by knowing how banks

provide an optimal combination of financial services with a given set of inputs, efficiency measurement in banking could be determined.

Measurement of efficiency in banking is used as a meter to determine the ability of banks to attain the optimum combination of financial services with a given level of inputs and existing technology. In this sense, efficiency and productivity can be viewed as related concepts and the mention of one signifies the presence of the other. An efficient bank is a productive bank, hence for this thesis, the researcher would use efficiency and productivity interchangeably.

Efficiency in banking has been defined and studied in different dimensions including: (i) scale efficiency, which refers to the relationship between the level of output and the average cost; (ii) Scope efficiency, which refers to the relationship between average cost and production of diversified output varieties; and (iii) Operational efficiency, which is a wide concept sometimes referred to as x-efficiency, which measures deviation from the cost efficient frontier that represents the maximum attainable output for the given level of inputs (Aikaeli, 2008).

Measurement of Efficiency

In measuring various forms of efficiency, either parametric or non-parametric approach is adopted. However, the most adopted methods in measuring technical efficiencies include the Malmquist index, the Data Envelopment Analysis and the Stochastic Frontiers (Rwaheru, 2015). The frontier function approach measures productive inefficiency of individual producers. Inefficiency is measured by the deviation from the frontier, which represents a best-practice technology

among all firms under consideration. In economic theory, production efficiency/inefficiency is characterized into technical and allocative efficiency (or price efficiency). Simply, technical efficiency reflects the ability of a firm (bank) to maximize output using a given set of inputs while allocative also known as factor price efficiency focuses on the ability of the bank to use inputs in optimal proportions, given their respective prices and production technology as already discussed in previous sections. Farrell (1957) presents computational measures for productive inefficiency based on Debreu (1951) and Koopmans (1951).

Various researchers favour the use of Data Envelopment Analysis, thus the non-parametric over the Stochastic Frontier Analysis, the parametric. Researchers like Ally, (2013); Deng, Liu, and Wu, (2007); Frimpong, (2010a) and Yeh, (1996) have adopted the financial ratio and Data Envelopment Analysis (DEA) as a measure for estimating efficiency. Whereas others like Berger, Hasan, and Klapper (2004); Bonin, Hasan, and Wachtel (2005) and Beccalli, Casu, and Girardone (2006) have adopted the Stochastic Frontier Analysis (SFA) in measuring efficiency. Few papers such as Fiorentino, Karmann, & Koetter, (2006), have employed the use of both the DEA and SFA in measuring other forms of efficiency.

Coelli (1995) explains two reasons why it is necessary to estimate frontier functions rather than average functions which are conventionally estimated by OLS method. First, the frontier function is in line with theoretical representation of production activities, which is derived from an optimization process. For instance, the production function contains a series of outputs attainable, given different

combinations of inputs; whereas cost and profit functions are represented by frontiers derived from optimization. Second, the estimation of a frontier function provides a total for measuring the efficiency level of each firm within a given sample.

Nonparametric and Parametric Approaches to Frontier Analysis

Nonparametric and parametric frontier analyses are the two classified techniques of measuring efficiency. A parametric or a nonparametric approach is chosen depending on how the frontier is specified and estimated. The nonparametric technique, using linear programming techniques, constructs frontiers and measures efficiency relative to the constructed frontiers. The nonparametric approach frequently goes by the descriptive title of Data Envelopment Analysis (Ali & Seiford, 1993; Charnes, Cooper, Golany, Seiford, & Stutz, 1985 as cited in Dasmani, 2010). The nonparametric approach can be categorized based on the type of data available (that is, whether it is a cross-sectional data or a panel data), and the type of variables available (quantities only, or quantities and prices). With both quantities and prices, technical efficiency can be calculated, while allocative efficiency requires both quantities and prices.

On the other hand, the parametric technique estimates frontiers and provides efficiency using econometric techniques. The parametric approach can also be categorized according to the type of data as well as the type of variables available. In particular, the use of panel data enables one to overcome two important problems

associated with estimation using cross-sectional data, which are also common to the parametric approach in the non-frontier analysis. First, panel data provides observations of each producer more than once, which makes it possible to earn more accurate estimates of efficiency for each producer than can be obtained from cross-sectional data. Second, panel data makes it possible to control individual heterogeneity, which can cause inconsistent estimation due to the problem of endogeneity.

The two approaches differ in many ways but the essential differences reduce to two characteristics. One is that the nonparametric approach typically does not take statistical noise into account, which consequently provides inaccurate efficiency measures, while the parametric approach with stochastic frontier specification can accommodate stochastic noise. The other is that the nonparametric approach does not require specific functional forms to be imposed on the data while the parametric approach is subject to potential specification error since estimated frontiers and efficiency measures are conditional on the functional form chosen. Hence, the selection of appropriate functional form is a vital factor in the parametric approach.

The Concept of Stochastic Frontier Approach

Aigner, Lovell, and Schmidt (1977) and Meeusen and Van den Broeck (1977) are credited as the proponents or the pioneers of the Stochastic Composed Error Frontier Methodology. In the formulation of this methodology, Aigner, Lovell, and Schmidt specified the functional error term into two parts. That is, the

error term was split into a normal random error term and a one-sided normal error term.

In order to generate the ratio of actual to expected maximum output, given inputs and the existing technology, the Stochastic Production Frontier Model allows for a non-negative one-sided random component in the functional error term. Apart from acknowledging the fact that random shocks outside the control of producers can affect the output level, stochastic frontier models allow for the measure or assessment of technical inefficiency. This owes to the fact that stochastic effects such as weather conditions among others could result in variations in maximum output. The differences in output may well also be as a result of firms (in an industry) operating at various levels of inefficiency owing to poor incentives, mismanagement, inappropriate input levels or less than perfectly competitive behavior (Kumbhakar & Lovell, 2000). In a nutshell, the Stochastic model assesses the impact of shocks resulting from random effects among others on output, which could be separated from the contribution of variation in technical efficiency. The basic stochastic frontier model is specified as follows:

$$Y_{it} = \alpha + X_{it}\beta + V_{it} - U_i, U_i \geq 0; i = 1, \dots, N; t = 1, \dots, T \quad (1)$$

Where Y_{it} is the natural logarithm of the observed output for the i^{th} firm, t indexes time periods, α is a non-random scalar intercept term, X_{it} is a vector of logarithms of inputs and β is the corresponding vector of parameters to be estimated. V_{it} is a disturbance term or measurement error and other random factors such as the effects of weather, strikes, luck, etc. (Coelli et al, 1998). This error term is assumed to be

independently and identically distributed $N(0, \sigma^2)$ and $U_i \geq 0$ is the one-sided error term that represents technical inefficiency.

The model is such that, the efficient frontier distinguishes between the observed output (Y_{it}) and the unobserved or frontier output (Y_{it}^*). The observed output model is given as:

$$Y_i = \alpha + X_i\beta + V_i - U_i, \text{ bound by stochastic frontier} \quad (2)$$

The frontier output is given as:

$$Y_i^* = \alpha + X_i\beta + V_i \text{ given that } U_i = 0 \quad (3)$$

The usual case is $Y_i^* = f(Y_i)$, this is due to inefficiency and other reasons. For the i^{th} firm, given its inputs, technical efficiency of an individual firm is defined in terms of ratio of the observed output to the corresponding unobserved output, given the available technology. This can be specified as:

$$TE_i = \frac{\alpha + X_i\beta + V_i - U_i}{\alpha + X_i\beta + V_i} = e^{-u_i} \quad (4)$$

The technical efficiency of the i^{th} firm is defined from equation (4) as:

$TE_i = \exp(-U_i)$. Therefore, the technical inefficiency of the i^{th} firm is measured by $1 - TE_i = \exp(-U_i)$ which is the inefficiency, can be approximated by U_i . This implies that the equation can be reformulated as:

$$Y_{it} = \alpha_i + X_{it}\beta + V_{it} \quad (5)$$

Where $\alpha_i = \alpha - u_i$.

Where α_i is time invariant and accounts for any unobservable individual specific effect that is not included in the regression model. The term u_i represents the remaining disturbance, and varies with the individual firms and time. The term u_i can be likened to the usual disturbance or stochastic term in regression. The nature of relationship between the unobserved specific effects informs the choice of estimation technique. If the unobserved effects are fixed and systematic, fixed effect estimation is used and if the unobserved effects are varying and differing across observations, then random effects estimation is adopted. Other estimation techniques include pooled regression model, between effect estimation and within effect estimation.

Development of the Stochastic Frontier Production Function Analyses

As already stated in the previous section, Aigner et al. (1997), Battese and Corra (1977), and Meeusen and Van den Broeck (1997) can be considered as the pioneering scholars of the Stochastic Frontier Analysis. Following the pioneering works of the afore-mentioned scholars, the effort to bridge the gap between theory and empirical work on the possibility of estimating the frontier function has attracted much attention.

Kumbhakar, Ghosh and McGuckin (1991) specified a stochastic frontier production function in which the technical effects were assumed to be a function of values of other observable explanatory variables. In addition, their model considered allocative and scale efficiencies. Battese and Coelli (1995) also proposed a stochastic frontier production function for panel data, in which the

technical inefficiency effects were specified in terms of various explanatory variables, including time. Huang and Liu (1994) specified a non-neutral stochastic frontier production function in which the technical inefficiency effects were specified in terms of various firm-specific variables and interaction among these variables and the input variables in frontier. Reifschneider and Stevenson (1991) also proposed a stochastic frontier model in which the technical inefficiency effects were dependent on other variables.

Several empirical works have identified the sources of technical inefficiency as they try to predict technical inefficiencies for the firms. Pitt and Lee (1982) analysed the sources of technical inefficiency in the Indonesian weaving industry. They used the method of maximum likelihood in estimating a stochastic frontier production function. The predicted technical efficiencies were then regressed upon some variables, including size, age, and ownership structure of each firm, and were shown to have significant effect on the degree of technical inefficiency of the firms. Many subsequent empirical works have investigated the sources of technical inefficiency in different industries using the two-stage analytical method. Kumbhakar, Ghosh and McGuckin (1991), Reifschneider and Stevenson (1991), and Huang and Liu (1994), however, questioned the theoretical consistency of this two-stage analytical technique. They suggested the use of stochastic frontier specifications that incorporate models for the technical inefficiency effects and simultaneously estimate all the parameters involved.

An improvement was made by Desli, Ray, and Kumbhakar (2003), who extended the stochastic frontier model to allow for efficiency change through firm specific intercept which evolves over time as first order auto-regressive process in a panel data framework. Their model follows the idea that people learn from their mistakes in a gradual process. Therefore, an efficient firm is allowed to correct its efficiency from the past in order to improve its production. They specified their model as

$$Y_{it} = \alpha_i + \delta Y_{i,t-1} + X_{it}\beta - X_{i,t-1}\delta + W_{it}\gamma + \varepsilon_{it}, \quad (6)$$

Where $\varepsilon_{it} = (V_{it} - \delta Y_{i,t-1}) - U_{it}; U_{it} \geq 0$.

W_{it} represents systematic factors that might persistently influence the firms production frontier over time. The composed error term (ε_{it}) follows an MA (1) process that is two sided $(-\infty, +\infty)$, whilst the other component (U_{it}) is one sided $(0, +\infty)$.

Technical efficiency of a firm i at time t is measured by $U_{it} = Y_{it}^f - Y_{it}$. This is the deviation of the observed output, Y_{it} , from the maximal producible output Y_{it}^f given by:

$$Y_{it} = \alpha_i + \delta Y_{i,t-1} + X_{it}\beta - X_{i,t-1}\delta\beta + W_{it}\gamma \quad (7)$$

The technical efficiency (TE) is measured by:

$$TE = e^{y_{it} - y_{it}^f} = e^{-u_{it}} \quad (8)$$

The model is dynamic since lagged value of “Y” appears as a regressor, implying that past history of inefficiency affects present output. Moreover, technical inefficiency is separated from time-invariant firm effect (α_i). Finally, Desli et al. explained that if time is introduced as a regressor, the model via W_{it} , technical change can be estimated exogenously from $\frac{\partial y}{\partial t}$ and technical change can be separated from technical efficiency as $TE_{it} - TE_{i,t-1}$.

Huang (2004) also proposed a flexible stochastic frontier model with random coefficients to distinguish technical efficiency from technological differences across firms. Huang specified the model as:

$$Y_i = \alpha + X_i' \beta + Z_i' \gamma + V_i - U_i \quad (9)$$

Where Z_i is a $k_i \times 1$ ($k' \geq k$) vector of variables that are a subset of X_i . The corresponding $k' \times 1$ vector of coefficients $\gamma = (\gamma_{i1} + \gamma_{i2}, \dots, +\gamma_{ik})'$ for the i^{th} firm is assumed to be independently, identically and normally distributed with mean vector zero and variance-covariance matrix Ω , which is $\gamma_i \sim WN_{k'}(0, \Omega)$. The model distinguishes technical efficiency from technological differences across firms.

The Concept of Stochastic Metaproduction Frontier Approach

Further developments of the Stochastic Frontier Model led to the Stochastic Frontier Metaproduction Model. Hayami (1969) and Hayami and Ruttan (1970) are credited as the proponents or the pioneers of the concept of metaproduction function for the assessment of efficiency. They defined the metaproduction

function as “the envelope of commonly conceived neoclassical production functions”. According to Lau and Yotopoulos (1989), the metaproduction function is a common underlying production function that is used to represent the input-output relationship of a given industry. The metaproduction function concept is founded on the hypothesis that all producers in different groups have potential access to the same technology. However, it is the sole prerogative of each producer to decide to operate on a different part of it depending on circumstances such as the natural endowments, relative prices of inputs, and the economic environment (Lau & Yotopoulos, 1989). Battese and Rao (2001) have made extensions and modification of the Stochastic Frontier Metaproduction Function approach. This is reviewed below.

The Stochastic Metaproduction Model

Battese and Rao (2001) showed how technical efficiency scores for firms across regions can be estimated using a stochastic frontier metaproduction function model, and used a decomposition result to present an analysis of regional productivity potential and efficiency levels. If stochastic frontier models are defined for different regions within an industry, and for the j^{th} region, there exist simple data on firms that produce one output from the various inputs. The stochastic frontier model for this region is specified as:

$$Y_{ij} = f(X_{ij}, \beta_j) e^{V_{ij} - U_{ij}}, i = 1, 2, \dots, N_i \quad (10)$$

Where Y_{ij} denotes the output for the i^{th} firm in the j^{th} group; X_{ij} denotes a vector of functions of the inputs used by the i^{th} group. It is also assumed that the V_{ij} s are identically and independently distributed as $N(0, \sigma_v^2)$ random variables, independent of the U_{ij} s, which are defined by the truncation (at zero) of the $N(0, \sigma_v^2)$ distributions. Simplify the model for the j^{th} group gives:

$$Y_i = f(X_i, \beta) e^{V_i - U_i} \equiv e^{X_i \beta + V_i - U_i} \quad (11)$$

The stochastic frontier metaproduction function model for all firms in all regions for the industry is defined as:

$$Y_i = f(X_i, \beta^*) e^{V_i^* - U_i^*} \equiv e^{X_i \beta^* + V_i^* - U_i^*}, i = 1, 2, \dots, N \quad (12)$$

Where $N = \sum_{i=1}^R N$ is the total number of sample firms in all (R) groups. Where Y_i denotes the output for the i^{th} firm, X_i denotes a vector of functions of the inputs used by the i^{th} firm.

The maximum-likelihood estimates of the parameters of the above Stochastic Frontier Metaproduction function do not necessarily result in the estimated function being an envelope of the individual regional production functions. This is because if the assumptions for the regional frontiers are satisfied, those associated with the stochastic frontier metaproduction function may not be satisfied. However, Battese and Rao (2001) discussed that it is possible to constraint the estimation of the metaproduction function such that it is an envelope of observations for efficient firms in all regions. Battese and Rao (2001) showed that

the model for the j^{th} group and the stochastic frontier metaproduction function yields the following identity relationship:

$$1 = \frac{e^{X_i \beta}}{e^{X_i \beta^*}} \cdot \frac{e^{V_i}}{e^{V_i^*}} + \frac{e^{-U_i}}{e^{-U_i^*}}, \quad (13)$$

Where the three ratios on the right-hand side of the above equation are called productivity potential ratio (PPR), the random error (RER) and the technical efficiency ratio (TER) respectively

$$PPR_i \equiv \frac{e^{X_i \beta}}{e^{X_i \beta^*}} \equiv e^{X_i (\beta^* - \beta)}, RER_i \equiv \frac{e^{V_i}}{e^{V_i^*}} \equiv e^{V_i - V_i^*}, \text{ and } TER_i \equiv \frac{TE_i}{TE_i^*} \quad (14)$$

Battese and Rao (2001) defined the productivity potential ratio as potential ratio for the given region, according to the currently available technology for firms in the region, relative to the technology available in the whole industry. The technical efficiency of firm i , relative to its regional frontier, $TE_i \equiv e^{-U_i}$ is estimated by:

$$\widehat{TE} \equiv E(e^{-U_i}/E_i \equiv V_i - U_i)$$

and the technical efficiency of firm i , relative to the metaproduction frontier is estimated as:

$$\widehat{TE}_i^* \equiv E\left(\frac{e^{-U_i^*}}{E_i^*} \equiv V_i^* - U_i^*\right) \cdot E_i^* \equiv E_i - X_i(\beta^* - \beta) \quad (15)$$

Empirical Literature

Many studies are still relying on financial ratios to measure the performance of commercial banks. Only a handful of studies have extended the idea of integrating financial ratio with a non-parametric method to evaluate the performance of banks. Moreover, many studies have concentrated on measuring efficiency of commercial banks and less weight is put on effectiveness which is also very important in evaluating the achievement of the organization's objectives. Performance evaluation has been muddled in the literature with some indicating efficiency as performance and vice versa. However, efficiency and effectiveness should be treated as separate concepts although they are closely related, and performance is the product of the two (Ho & Zhu, 2004; Mouzas, 2006). Earlier studies on technical efficiency of banks employed diverse approaches in measuring efficiency of banks. Whereas some of the banks employed the use of panel data collected of different groups of banks, other studies focused on the efficiency scores of banks in a single year period.

The main purpose for the key regulatory developments in Ghana's banking industry from 2003 to 2008 discussed in this study (refer to page 14), is to build a competitive and stable banking industry to improve banks' efficiency and ultimately result in economic growth and development (Adjei-Frimpong, 2013). The aim of these regulatory developments was the foundation for Adjei-Frimpong's study into the link between bank efficiency and competition in the banking industry. Using annual data spanning from 2001 to 2010, he captured the possible impact on

efficiency from the competition among banks resulting from the steady implementation of financial service reforms since 1988.

Bank efficiency study for developing countries, in the case of West African Economic Monetary Union (WAEMU) by Kablan, (2007) measured banks efficiencies and the determining factors for 1993-1996. The study used Data Envelopment Analysis method (DEA) for assessing technical efficiency and Stochastic Frontier Analysis (SFA) for cost efficiency. The findings from the study suggest that with the exception of Côte d'Ivoire and Burkina Faso, all the other WAEMU countries have similar evolution of the two types of efficiency under study. Also, it was discovered that WAEMU banks efficiency is sensitive to variables like ownership status, financial soundness, the ratio of bad loans per country, the banking concentration and the GDP per capita.

Ncube (2008) investigated into the the cost and profit efficiency of banks in South Africa. This paper uses a stochastic frontier model to determine both cost and profit efficiency of four large and four small, South African-based banks. The results of the study show that South African banks have significantly improved their cost efficiencies between 2000 and 2005. However, a weak positive correlation was found to exist between the cost and profit efficiencies. Increase in bank size was found to reduce cost efficiency. Banks were operating on the upward sloping section of their cost curve.

There are few studies such as Adjei-Frimpong (2013); Akoena, Aboagye and Antwi-Asare (2013); and Alhassan and Tetteh (2017) have ventured into investigating the technical efficiency scores of banks in Ghana.

Owusu-Ansah (2015) used an unbalanced panel data from 2009 to 2012 for sixty-six financial cooperatives to examine technical and cost efficiency of cooperative financial institutions in Ghana. The study used the Cobb-Douglas Stochastic frontier model. To capture the dual roles of financial cooperatives, Owusu Ansah used production and intermediation approaches in the selection of inputs and outputs. The distribution of technical efficiency scores showed an average of 53.40% and 57.96% across the sampled units for production and intermediation approaches respectively. On the other hand, the distribution of cost efficiency scores showed an average of 92.44% and 70.67% across the sampled units for production and intermediation approaches respectively.

Saka, Wittbom and Tavassoli (2010) employed a sample size of twenty-three banks and a two stage approach for the data analysis to investigate into the effects of foreign bank entry on technical efficiency of the bank sector in Ghana. The purpose of the research was to analyze the effects of the entry of foreign banks on the technical efficiency performance of the domestic banking sector over the period 2000 -2008. The study used a sample of 23 banks (3 state banks, 9 private domestic banks and 11 foreign banks) and a two-stage approach for the data analysis. The researcher first used the Data Envelopment Analysis (DEA) approach to estimate technical efficiency scores of all 23 banks. The paper used a Tobit

estimation technique for the regression. The regression focused on the determinants of technical efficiency of the domestic banks, using variables like return on assets, liquidity ratio, inflation and others. In this same regression, a proxy labelled as foreign share was added as one of the independent variables in order to help test how the entry of the foreign banks has affected the domestic banks. The results indicate that technical efficiency performance of the banking industry has been fluctuating over the study period.

Kumar and Gulati (2009) applied DEA, for a cross-sectional data for the financial year 2006/2007, to appraise the efficiency, effectiveness, and performance of 27 public sector banks (PSBs) operating in India by using a two-stage performance evaluation model. They used DEA to compute the efficiency and effectiveness scores for individual PSBs. The empirical results revealed that high efficiency does not mean high effectiveness in the Indian PSB industry. A positive and strong correlation between effectiveness and performance measures was noted.

Raphael (2013b), adopted the use of a two stage analysis from the theory of performance to measure efficiency, effectiveness and performance of Tanzania commercial banks. That is, integrating financial ratio with a non-parametric method to evaluate the performance of the banks. The study adopted the DuPont model to obtain the efficiency and effectiveness estimates and used Innovative DEA to obtain the performance estimates. Raphael (2013a), investigated into the effect of bank specific, industry specific and macroeconomic variables on commercial banks' efficiency. Data Envelopment Analysis was applied to obtain efficiency

estimates such as, Technical Efficiency (TE), Pure Technical Efficiency (PTE) and Scale Efficiency (SE) for the period of 2005-2008. Afterwards the efficiency estimates were obtained through Tobit regression model.

The reviewed existing literature on efficiency of banks hint at external factors that influence the efficiency level of the banks. The most paramount of these factors being the ownership status and size of the bank. Regardless of the estimation technique used in measuring the efficiency level of the banks, the type of efficiency being investigated into or the functional form used in the analysis, all these studies agree on the importance of an efficient banking system.

Determinants of Technical Efficiency

In identifying the external determinants that are not related to decisions of management but influence the efficiency of a firm, two estimation techniques can be used. These external factors affect the economic environment in which the firm is present. After the use of stochastic production frontier in estimating the technical efficiency scores, the two approaches used to analyze the exogenous factors are: the two-stage estimation procedure and the one-stage simultaneous estimation approach.

The most adopted approach is the two-stage approach. As pointed out by Greene (2008), most researchers often incorporate the exogenous factors using this approach. Wang and Schmidt (2002) indicate that this approach results in severely

biased estimates, thus researchers including these exogenous effects should adopt the one-stage simultaneous estimation approach.

The major drawback with the two-stage approach is that it defies the assumption of inefficiency estimates being independent and identically distributed (iid) that allows the use of Jondrow, Lovell, Materov, and Schmidt's (1982) approach to predict the values of technical efficiency indicators. However, at the second step of this approach, the predicted technical efficiency indicators are dependent on some firm specific and industry specific factors, implying that the inefficiency estimates are not iid, unless all the coefficients of the exogenous factors happen simultaneously.

Various researchers have undertaken studies that estimate the technical efficiency indicators in the banking sector using the two-stage technique. Studies by scholars like Saka et al. (2010); Owusu-Ansah (2014); Raphael (2013a); Ally (2013); Frimpong (2010); Aikaeli (2008); Drake (2001) and Resti (1997) have investigated into the relative efficiency of commercial banks in various countries using varying methods of analysis. These studies investigate into the determinants of the efficiency levels of the banks.

As provided by Chen (2009) and Raphael (2013a), the determinants of efficiency is categorized into:

1. Bank specific factors
2. Industry specific factors
3. Macroeconomic conditions

Bank Specific Factors

Bank specific factors that affect the efficiency level of individual banks are not controlled by the managers of the banks. The factors discussed in this study have been identified as effects that have the potential of affecting efficiency of the banks. They are:

1. **Ownership:** Literature on efficiency estimations indicate that the ownership status of a bank influences the efficiency scores of the bank. That is, whether a bank has majority of its shares foreign owned or domestic/local owned will influence the efficiency level of the bank.
2. **Bank Size:** The size of a bank influences the efficiency of the bank's operations. The size of a bank is measured in various ways; the total assets of the bank, the size of employers or the customer base of the bank.
3. **Profitability:** The profit level of banks is likely to influence their efficiency level. Banks with high profit margin are often more efficient than banks with low profit levels.
4. **Liquidity ratio:** The liquidity ratio of a bank determines the bank's ability in fulfilling customers demand for money at any given time. Banks with high liquidity ratio are less likely to go bankrupt as they are capable of fulfilling all its monetary liabilities.
5. **Performance:** The performance of any company is linked to the efficiency of the company's operations. In the performance of their intermediation function, banks that are efficient have a high performance rate.

Industry Specific Effects

The performance of the industry or the market directly influences the efficiency of individual firms in the industry. These industry specific characteristics, such as market share and market concentration, have a strong and direct influence on a bank's efficiency (Raphael, 2013a). The contribution of each bank towards the industry total production accounts for the market concentration. The degree of concentration in the market can be measured using either the Lerner index or Herfindahl-Hirschmann Index (HHI). This study measured the market share using the share of industry advances and industry deposit as quoted in the PwC Ghana Banking Survey for the years under-study.

Macroeconomic Conditions

Macroeconomic factors such as gross domestic product (GDP), real exchange rate, consumer price index (CPI), interest rate, inflation rate and money supply affect income levels of people and as such the ability of firms to perform optimally and efficiently. Studies like Raphael (2013a) prove that whereas GDP highly influence banks efficiency, CPI was found not to influence efficiency. The study would therefore control for these macroeconomic variables: exchange rate, money supply and inflation.

Production and Intermediary Approach

Studies on assessing technical efficiency of banks generally adopts two approaches in the choice of variables used. They are the production approach and the intermediary approach (Cappizzi, 1999; Chaffai, 1997).

The production approach was first developed by Benston (1965) and Bell and Murphy (1968) and further advanced by Berger and Humphrey (1991). It focuses on the commercial activities of the bank in producing different forms of deposits, loans, overdrafts and other services to account holders using physical inputs such as labour physical capital, building properties, plant, equipment materials and others. This approach is also termed as service provision approach because of the commercial behaviour of banks in providing services for customers (Bergendahl, 1998). Although various studies have used the production approach to analyze bank branches' efficiency, rarely has it been used for efficiency analysis at bank level due to the difficulty in obtaining the needed and accurate data.

The intermediary approach, on the other hand, views the bank as a financial intermediary that transfers financial assets between borrowers and savers. These agents, under this approach, use inputs such as labour and physical capital to convert financial capital such as deposits and other funds/liabilities into loans, securities, investment and other earning assets, hence, performing intermediation services between demand sources (investors) and supply sources (savers). Berger and Humphrey (1997) and Taylor, Thompson, Thrall, and Dharmapala (1997) and

other researchers concur that the intermediary approach is better suited in studying efficiency as it captures the economic role of the bank as a financial intermediary.

Recently, there have been the development of other approaches like the user cost approach, the asset approach, the operating approach and the modern approach (Das & Ghosh, 2006).

Production Function Specification

The production function is used to specify the relationship between a single output and inputs used in the production. The general functional relationship is of the form:

$$q = f(x_1, x_2, \dots, x_N) + v$$

In model specification of production functions, different functional forms can be used. They include Cobb-Douglas (linear logs of outputs and inputs), Quadratic (in inputs), Normalised quadratic and Translog function. The most popular of these functional forms according to literature is the Cobb-Douglas and the Translog function as they are both linear in parameters and can be estimated using least squares methods.

Translog Function Specification

The Translog function also known as Transcendental Logarithmic is a generalisation of the Cobb-Douglas function that includes second order approximation of the exogenous input variables. This functional form is quadratic

in logarithms. The main advantage of this form is that it poses less restrictions on production elasticities and substitution elasticities. However, this form requires estimation of many parameters that are difficult to interpret. There is also the problem of curvature violations.

$$\ln q_i = \beta_0 + \beta_1 \ln x_{1i} + \beta_2 \ln x_{2i} + 0.5\beta_{11}(\ln x_{1i})^2 + 0.5\beta_{22}(\ln x_{2i})^2 + \beta_{12} \ln x_{1i} \ln x_{2i} + v_i - u_i$$

Cobb-Douglas Function Specification

This functional form is linear in logarithm. The Cobb-Douglas functional form is easy to interpret and estimates fewer parameters. The theoretical assumption of this form is that all firms have similar production elasticities and that substitution elasticities equal 1 is disadvantageous to the functional form.

$$\ln q_i = \beta_0 + \beta_1 \ln x_{1i} + \beta_2 \ln x_{2i} + v_i - u_i$$

Summary

Chapter Three of this study focused on reviewing literature on efficiency as a whole and technical efficiency in banks and other firms in particular. The chapter began by looking at the relationship that exists between efficiency, effectiveness and performance of a firm. A theoretical review of literature on efficiency followed. The various forms of efficiency, efficiency in banking and forms of measuring efficiency were discussed. Particular attention was devoted to the discussion of the Stochastic Production Frontier Analysis as a form of estimating efficiency. The concept of external factors, aside the selected inputs affecting the efficiency level of banks, was introduced. The three groupings of these external factors namely; bank specific, industry specific and macroeconomic variables were looked at and examples were given. The chapter ended with a discussion on production and intermediary approach, Translog Production Function and Cobb-Douglas Production Function.

CHAPTER FOUR

METHODOLOGY

Introduction

This chapter presents the methodological framework most suitable for this study. Specifically, the chapter first discusses the research design, data type and sources and selection of inputs and output used in the study. A description of the theoretical and empirical specification of the model used in the study is then presented. Lastly, definitions, prior expectation and justification of variables; the estimation techniques used in achieving the objectives are presented.

Research Design

The study adopts the positivist philosophy which is built on the principles of scientific research. Positivism is developed on the grounds of science being deterministic and mechanistic. The philosophy adopts methods in operationalizing theory or hypothesis and deals only with what can be seen and measured. Like all scientific studies, the positivist tradition is to be free of individual beliefs and judgement and that knowledge is externally objective. Provided the assumptions of the positivist approach are all met, the findings of the phenomenon being investigated can accurately be replicated following strictly the methodological approach used and the same population. The assumptions of this approach are discussed below.

The positivist philosophy assumes prediction and control. The paradigm assumes that the general pattern of cause and effect relationship between X and Y, under certain circumstances, can be used for predicting and controlling natural phenomena. The role of a researcher in this approach is to discover the specific nature of the cause and effect relationships.

The philosophy operates on the assumption of empirical verification. The approach also assumes that data used is accurate since we rely on what can be seen and measured. Observations and measurements of world phenomenon are used in the scientific analysis.

Lastly, the assumption that research is value-free guides the positivist philosophy. This approach ensures that the findings will be free of human interests ensuring a high degree of objectivity in the research.

The approach gives objective and unbiased estimates as researchers take a strictly neutral and detached positions as the school of thought assumes that knowledge is externally objective. Results that are presented in this study are strictly based on the facts and data gathered on the ground and are independent of the researcher's own subjective reasoning.

This study adopts the quantitative approach in the analysis because of the quantitative nature of the technical efficiency scores estimated plus the continuous nature of the variables used in the estimation.

The use of quantitative instruments such as panel data analysis adopted for this study supersedes the use of either a cross sectional or time series analysis as it takes into consideration effects of certain factors that would have otherwise been lost in the analysis. These factors when not taken into account in the analysis result in an unobserved heterogeneity that can be overcome by using panel data. The advantage being that all factors that influence the main variable of concern will be accounted for when combining both the time series and cross-sectional form of data, as done by panel analysis.

The objective of examining the relationship between listing on the stock market and the efficiency of banks is explanatory in nature and as such, the use of quantitative design is very suitable. The revolution in econometrics has facilitated researchers in quantifying qualitative variables used in quantitative analysis, which simplifies the task of incorporating categorical variables in the analysis, as it is for this study (Wooldridge, 2010).

Data Type and Sources

The study employed the use of micro-panel data of selected banks in Ghana. In order to attain the objective of examining if banks listed on the stock exchange are more efficient than unlisted banks, both listed banks and unlisted banks were sampled.

Out of the 29 licensed banks in Ghana, as reported by Bank of Ghana by the end of 2015, the study used a sample of 11 banks- seven (7) listed and four (4) unlisted banks. With the exception of the Trust Bank, the study used all the listed

banks on the Ghana Stock Exchange in the analysis. This is because the annual financial statements of Trust Bank is quoted in US Dollars, making comparative analysis difficult. The listed banks were HFC Bank Ltd., Societe Generale Ghana Ltd., Ghana Commercial Bank Ltd., Standard Chartered Bank Ltd., CAL Bank Ltd., Ecobank Ghana Ltd. and Unique Trust Bank Ltd. The unlisted banks were Barclays Bank of Ghana, Stanbic Bank Ltd., Prudential Bank Ltd. and Fidelity Bank Ltd.

The sampling of banks for this study was done in two groups, sampling from banks listed on the stock market and banks not listed on the stock market. Under the listed banks, the study adopted all the banks listed with the exception of Trust Bank, as justified in the paragraph above. With the unlisted banks category, the four (4) banks were sampled based on ownership status (foreign or domestic majority ownership), number of branches nationwide and year of incorporation.

The four unlisted banks are two domestic banks and two foreign banks. That is, Barclays Bank of Ghana and Standard Chartered Bank Ltd are foreign banks and Fidelity Bank Ghana Ltd and Prudential Bank Ltd. are domestic or local banks. The branch network of these four unlisted banks were similar to the listed banks as at 2009. Appendix B of this study tabulate the 25 banks that were in existence during the period of the study.

Barclays Bank of Ghana Ltd and Ghana Commercial Bank are similar in size with 154 and 148 branches respectively in 2009. However, they differ with ownership status. Meaning, differences in the efficiency of these two banks can be attributed to the different ownership structure and not on the size of the branch network. Comparing the year of corporation for Prudential Bank and CAL Bank

Ltd., 1993 and 1990 respectively, these two banks are similar in age and number of branches. However, the difference in ownership will allow the difference in efficiency to be attributed to one being foreign and other being domestic. Fidelity Bank Ltd. and GCB Bank Ltd. are both domestic banks, allowing for comparative analysis on their efficiency level.

The study analysed the efficiency of the selected banks for the years 2009-2013. With the exception of Access Bank and Agricultural Development Bank that were just recently listed on the stock market, Unique Trust (UT) Bank was last bank to get its shares listed on the GSE. UT Bank got listed on November, 2008. In order to obtain a balanced micro-panel data for this study, the researcher settled on the year 2009 as the beginning year for the study. This allowed for the inclusion of UT Bank.

Also, the key regulatory developments in the banking industry occurred before and during the year 2008. Some of which are Borrowers and Lenders Act (Act 773), introduction of Universal Banking License, the abolishing of secondary deposits reserve requirement and the abolishing of maintenance, transaction and transfer fees charged by commercial banks. The choice of five (5) years duration for this study was done to ensure that individual heterogeneity, which can cause inconsistent estimation due to the problem of endogeneity, are controlled for.

The firm-specific data used in this study was obtained from the annual reports of the selected banks for the years 2009 to 2013. The required variables were obtained from the published financial statements including balance sheet statements, cash flow statements and income statements. The macroeconomic

variables; GDP, inflation and money supply were obtained from the World Development Indicators (WDI) for the same years. The data from these variables were obtained annually.

Choice of Input and Output Variables

The specification of outputs and inputs in frontier modelling has not been clearly defined in the existing literature. The choice of variables in efficiency studies significantly affect the findings. As aforementioned, assessment of technical efficiency in this study adopts the intermediation-based approach. Inputs used in this study are deposits, physical capital and interest expenses.

Deposits include all customer demand deposits, savings deposits and all deposits and current accounts from individuals and corporate institutions. The choice of deposit as an input in this study follows Hughes and Mester (1993), regardless of the controversy of deposit being input or output (Berger & Humphrey, 1997).

Physical capital is included in this study as an input and is represented by the fixed assets of the bank. Fixed assets include the property, plant, and equipment, machinery, fixtures and premises obtained by the bank either on lease or fully purchased less accumulated depreciation and impairment losses. Studies done by researchers such as Assaf, Barros and Matousek, (2011b); Chiu, Walseth, and Suh (2009); Kenjegalieva, et al. (2009) and Harylchyk (2006) as cited in Owusu-Ansah (2015) have similarly used fixed assets as a proxy measure of physical capital.

Interest expense is the last input used in the efficiency frontier model. The choice of interest expenses as input was also used by Raphael (2013a) in his study into the external determinants of bank efficiency in Tanzania. Interest expenses comprise interest paid on time and other deposits, current account, current account and borrowed funds by the bank. The interest income and expenses are recognised in the income statement for all interest bearing financial instruments including loans and advances and investment securities using the effective interest rate method.

The output variable used is Net loans and advances. Net loans and advances is gross loans and advances to staff and customers minus impairment allowance and interest in suspense. The gross loans and advances comprises residential-mortgage loans, overdraft, term loans and other loans. Loans and advances are earning assets that reflect the lending activity of banks to both business institutions and individual customers.

The principal function of banks as financial intermediaries between demand sources (investors) and supply sources (savers) uses inputs, such as mentioned above, to convert financial capital into outputs such as loans, investment and other earning asset. Hence, the bank is producing intermediation services to its customers in accordance with the intermediation model of Sealey and Lindley (1977).

Theoretical Model Specification

In accordance with the literature on the function of banks as financial intermediaries that perform the role of collecting and accumulating deposits and transferring the funds back to customers as loans and advances at a price (cost), the

study adopted the intermediary approach in the choice of inputs and output. The study analyse the efficiency of banks in the performance of their role as financial intermediary institutions.

In the course of this study, the intermediary inputs used were deposits from customers and other banks, physical capital and interest expenses and the output used was net loans and advances.

The study used the Translog functional form for both the stochastic frontier modelling and the technical efficiency modelling. The Log-likelihood Ratio test was used to prove that the Translog specification does not reduce to Cobb-Douglas function.

A production function is a model used to develop the relationship between the inputs and output of the production process. The production function using a panel data is specified below:

$$y_{it} = f(x_{it}, \beta) \quad (1)$$

In equation 1, y_{it} is the output level of firm i at time t and x_{it} is the vector of intermediation inputs used in production.

In a perfect scenario where there is absolute efficiency in the production process and maximum quantities of output are produced given the inputs available and existing technology, then equation 1 holds. However, practically, a firm usually produces less than it can, which is below its production frontier, due to the degree of inefficiency in production. Hence equation 2,

$$y_{it}^* = f(x_{it}, \beta) \varepsilon_{it} \quad (2)$$

The component ε_{it} is the level of efficiency for firm i at time t . The efficiency component must be between 1 and 0, thus $0 \leq \varepsilon_{it} \leq 1$. If $\varepsilon_{it} = 1$, then the firm is producing at an optimal level on its production frontier with the available technology and inputs. If $\varepsilon_{it} < 1$, the firm is not producing at its optimum capacity using the given inputs z_{it} . The technical efficiency score is assumed to be positive since $q_{it} > 0$.

By acknowledging the fact that random shocks are beyond the control of producers but affect output level of firms, equation 2 develops into equation 3. Where $\exp(v_{it})$ is the standard error term present in a functional equation and also signifies the random shocks beyond the control of producers.

$$y_{it} = f(x_{it}, \beta) \varepsilon_{it} \exp(v_{it}) \quad (3)$$

Taking the natural logarithm of the variables, thus, both the output and the input variables.

$$\ln(y_{it}) = \ln \{ f(x_{it}, \beta) \} + \ln(\varepsilon_{it}) + v_{it} \quad (4)$$

Assuming that the production function is linear in logs and there are multiple inputs for the production process, let $\ln(\varepsilon_{it})$ be equal to u_{it} .

$$\ln(y_{it}) = \ln \{ f(x_{it}, \beta) \} + u_{it} + v_{it} \quad (5)$$

Where u_{it} is the efficiency scores of each decision making unit i at time t . The inefficiency component lowers output which is why its sign is negative. Note that, whereas v_{it} is a two-sided error term that is identically and independently distributed (iid) with a zero (0) mean and constant variance, $-u_{it}$ is a non-negative inefficiency component that is one-sided error that is identically and independently distributed.

Empirical Model Specification

The use of micro-panel data in this study pools a cross-section of the annual financial reports of the selected banks over the course of five years. This approach ensures the identification of mostly unobserved influences with either time series or cross section data. Panel data corrects for unobserved heterogeneity caused by hidden factors that influence the dependent variable but are omitted in the other forms of data and can result in reliable estimates (Baltagi, 2008).

Following the theoretical model specification in Equation 5 that estimates the efficiency levels of the banks in various years, the empirical model is discussed below.

Estimation of the Stochastic Frontier and Technical Efficiency Model

The intermediation model process is specified in equation 6. The level of intermediation determines the efficiency of the banks.

$$\ln(Loans)_{it} = \beta_{0it} + \beta_{1it} \ln(Dep_{it}) + \beta_{2it} \ln(FAss_{it}) + \beta_{3it} \ln(IEx_{it}) + v_{it} - u_{it} \quad (6)$$

Dependent variable (output):

$Loans_{i,t}$ = Net Loans and advances to customers for the i th bank at time t

Independent variables (intermediation inputs):

Dep_{it} = Deposits from banks + Deposits due to customers of bank i at time t

IEx_{it} = Interest expenses by the bank i at time t .

$FAss_{it}$ = Fixed assets (Property, plant and equipment)

v_{it} = Random error term

u_{it} = Technical inefficiency scores for each bank at time t

Specification of the stochastic frontier intermediation model in the two-stage estimation using the Translog production function is given as:

$$\begin{aligned} \ln(LOANS)_{it} = & \beta_{0it} + \beta_{1it} \ln(Dep_{it}) + \beta_{2it} \ln(FAss_{it}) + \beta_{3it} \ln(IEx_{it}) + \\ & \beta_{11it} \ln(Dep_{it})^2 + \beta_{2it} \ln(FAss_{it})^2 + \beta_{3it} \ln(IEx_{it})^2 + \\ & \beta_{12it} \ln(Dep_{it}) * \ln(FAss_{it}) + \beta_{23it} \ln(FAss_{it}) * \ln(IEx_{it}) + \\ & \beta_{13it} \ln(Dep_{it}) * \ln(IEx_{it}) + v_{it} - u_{it} \end{aligned} \quad (7)$$

Estimation of the technical efficiency model is specified as:

$$TE_{it} = \delta_0 + \sum_{i=1}^k \delta_i FS_{it} + \sum_{i=1}^k \delta_i IS_{it} + \sum_{t=1}^5 \delta_t MA_t + \varepsilon_{it} \quad (8)$$

Where TE_{it} is the technical efficiency scores predicted from the first step of the estimation, FS_{it} captures the bank specific variables (liquidity ratio, ownership status, degree of profitability and performance, bank size, age); IS_{it} is industry concentration variables (industry advances and industry deposits); MA_{it} is a vector

of macroeconomic variables (inflation and money supply), ε_{it} is the bank specific error term.

Empirically, Equation 6c is specified as:

$$\begin{aligned}
 TE_{it} = & \delta_0 + \delta_1 LR_{it} + \delta_2 OWN_i + \delta_3 PER_{it} + \delta_4 PROF_{it} + \delta_5 SIZE_{it} + \\
 & \delta_6 AGE_i + \delta_7 TANG_{it} + \delta_8 LDR + \delta_9 LI_{it} + \delta_{10} ID_{it} + \delta_{11} IA_{it} + \delta_{12} Infl_t + \\
 & \delta_{13} GDP_t + \delta_{14} MS_t + \varepsilon_{it}
 \end{aligned} \tag{9}$$

Where,

TE_{it} = Technical efficiency scores of bank i at time t

LR_{it} = Liquidity ratio of bank i at time t

OWN_i = Ownership status of bank i

PER_{it} = Performance of bank i at time t

$PROF_{it}$ = Profitability of bank i at time t

$SIZE_{it}$ = Firm size of bank i at time t

AGE_{it} = Number of years of operation in Ghana for bank i at time t

$TANG_{it}$ = Asset tangibility of firm i at time t

LDR_{it} = Loan deposit ratio of bank i at time t

LI_{it} = Loan intensity of bank i at ime t

IA_{it} = Percentage of Industry advances by bank i at time t

ID_{it} = Percentage of Industry deposits by bank i at time t

INF_t = Inflation rate at time t

GDP_t = Gross Domestic Product at time t

MS_t = Money Supply at time t

Coefficient estimates from equation 9 indicate the bank specific, industry specific and macroeconomic variables that have significant relationship with the efficiency of banks and the direction of the relationship.

Testing of Hypotheses

It should be noted that technical inefficiency model in the equation above can only be estimated if the technical inefficiency effects, U_i 's are stochastic and have particular distributional properties (Coelli & Battese, 1996). The inefficiency estimates are to be independent and identically distributed. It is therefore of interest to test the following hypotheses:

1. $H_0: \gamma = \delta_0 = \delta_1 = \dots = \delta_{14} = 0$, the null hypothesis specifies that inefficiencies are absent from the model at every level;
2. $H_0: \gamma = 0$, the null hypothesis specifies that the inefficiencies are not stochastic;
3. $H_0: \delta_1 = \delta_2 = \dots = \delta_{14} = 0$, the null hypothesis specifies that the inefficiency effects are not a linear function of each of the inefficiency factors and

4. $H_0: \mu=0$, the null hypothesis specifies that each farm is operating on the technical efficient frontier and that the asymmetric and random technical efficiency in the inefficiency effects are zero.

Under the null hypothesis, $H_0: \gamma = 0$; the Stochastic Frontier Model reduces to a traditional average response function, without the technical inefficiency effect U_{it} . These and related null hypotheses can be tested using the generalized likelihood – ratio statistic, λ , given by:

$$\lambda = -2[\ln\{L(H_0)\} - \ln\{L(H_1)\}]$$

Where $L(H_0)$ and $L(H_1)$ denote the values of the likelihood function under the null (H_0) and alternative (H_1) hypotheses respectively. If the given null hypothesis is true, λ has approximately χ^2 – distribution or mixed χ^2 – distribution when the null hypothesis involves $\gamma = 0$ (Coelli, 1995).

Methods of identifying the determinants of Technical Efficiencies

From equation 5, log of the output variable, net loans and advances, of the bank is denoted by ‘ y_{it} ’ and the intermediary input variables; deposits, fixed assets and interest expenses, are given as ‘ x_{it} ’. These inputs are used in producing any level of output and to establish the production frontier for the banks. The determinant variables; bank specific, industry specific and macroeconomic factors, are responsible for the variation of the observed output from the optimal (frontier) output, that is, technical inefficiency. The existence of these external factors indicates that the position of the frontier does not rely on only the selected inputs;

likewise, the inputs could be among the factors determining the technical efficiency (Wang & Schmidt, 2002)

Definition and Justification of variables

The variables to be examined are the external factors which constitute the bank-specific variables, industry specific variables and macroeconomic variables. These variables are the determinants of efficiency. They defer from the intermediary inputs and output variables explained in the previous section. Whereas the inputs and output variables were used to estimate the Stochastic frontier model to obtain the efficiency scores of the banks, the determinant variables are used to estimate the Technical efficiency model for the variables that significantly affect the efficiency level of a bank.

Ownership

Several studies have examined the relationship between efficiency and bank ownership status (Claessens, Demirgüç-Kunt and Huizinga, 2001; Di Patti and Hardy 2005). The general finding of these studies indicates that foreign banks are more efficient than private domestic banks, especially in developing economies. The intuition is that foreign banks in developing countries earn higher profits as compared to the domestic banks. The difference between foreign banks and domestic banks due to the differing taxes paid, overhead, management and net interest margins give the foreign banks an advantage over the domestic bank. A transnational study of banks in developing countries by Berger, Hasan, and Klapper

(2004) found out that foreign banks had the highest efficiency scores, followed by private domestic banks, and then state-owned banks.

However, the study by Frimpong (2010) on the efficiency of banks in Ghana for the year 2007, indicates that the domestic private banks were the most efficient group of banks in Ghana, followed by foreign banks with state-owned banks being the least efficient group.

All these studies prove that the ownership status of a bank influences the efficiency score, although the direction of the relationship are in opposition.

For the purpose of this study, the selected banks are grouped into two categories. They are, foreign owned banks and local owned banks. That is, domestic-private owned and state-owned are grouped together to form local owned banks. This categorisation follows the Ghana Banking Survey classification based on the party with the majority ownership. This indicates that four (4) of the listed banks are foreign and three (3) are local. Also for the unlisted banks, there are two (2) foreign and two (2) local banks.

Bank Size

The size of any firm is commonly presented as the natural logarithm of total assets (ln Total Asset) (Pasiouras, Delis, & Papanikolaou, 2009; Assaf, Barros, & Matousek, 2011; Miller, & Noulas, 1996; Favero, & Papi, 1995). According to Aikaeli, (2008) small banks have higher technical efficiency scores as compared to large domestic banks but lower than that of international banks. The reason being

that supervision and monitoring is greatest when the branch network is small and domestically owned as compared to large domestic banks and international banks.

A study by David and Alhadeff, (1964) also discovered the largest 200 banks in the US grew more slowly than the other smaller banks did. Rhoades and Yeats (1974) replicated this study for the period 1960-71 and drew similar conclusions as David and Alhadeff. The size of a bank is expected to negatively affect the technical efficiency of a bank. However, according to Gibrat's law, size does not matter when looking at the performance as well as the profitability of a firm (Gibrat, 1931).

Performance

The study measured performance using Net interest income as a proxy. This variable was obtained from the financial reports of the selected banks over the years. Net interest income (NII) is Interest income less interest expenses. The gap between the interest paid and interest received by the bank indicates the bank's performance level in the industry. A direct relationship is expected to exist between the performance and the efficiency of a bank.

Profitability

Profitability is a key determinant of technical efficiency, as established by the various literature. It is expected that profitability will be positively related to efficiency, regardless of the measure used to proxy profitability. The field of finance uses profit after tax to assets, also known as Returns on Asset (ROA) as a

proxy to measure profitability (Saka, et al, 2010). This study used asset turn over as proxy for measuring the profitability of the banks studied. The study employed the ratio of Earning before interest and taxes (EBIT) over Total assets as a proxy for profitability as Huang and Song (2004) and Deesomsak, Paudyal, and Pescetto (2004) used in their studies.

Liquidity ratio

The ratio of the liquid assets over short-term liabilities of a bank or other institution is classified as the liquidity ratio. This ratio is a financial metric used to determine the company's ability to pay off its short-term debts obligations. The ratio defines the stance of the company to turn short-term assets into cash to cover debts. The larger the ratio, the larger the margin of safety that the firm possesses to fulfil its short-term debt obligations, hence, there is little to no chance of bankruptcy making the company credit worthy. In the case of unfavourable conditions in the financial market, the bank need not resort to raising funds through external bodies such as the stock market. The definition of liquidity ratio adopted in this study is the ratio of the bank's liquid assets to the short-term liabilities, thus total deposits to both customers and other financial institutions. In this essence, this study expects to discover a direct relationship between liquidity and efficiency of the banks.

Asset Tangibility

The use of the ratio of fixed assets over total asset as a proxy for asset tangibility is very common in the literature. Pandey (2002) represented tangibility of asset as the ratio of fixed assets to total assets in his study in Malaysia, a similar

study was done by Drobetz and Fix (2003) and Hosono (2003). The study suspects a negative relationship between tangibility of assets and bank loans. The purchasing or hiring of fixed assets like plant and equipment, land and building reduce the financial assets available to the bank to give out as loans, hence, making the bank less efficient.

Loans Deposit Ratio

The ratio of the total volume of loans to the total deposit is the loans deposit ratio. The directional relationship between this ratio and the efficiency of the bank is not quite clear as it can be either positive or negative. Thus, a higher loans deposit ratio could either signify that the volume of deposits (input) has decreased but loans (output) have relatively remained unchanged. Indicating that the bank is now more efficient. On the hand, the high ratio could also mean that the volume of loans, given the relatively fixed deposit, has reduced, hence, the bank has become less efficient or more inefficient in its intermediary functions.

Loan Intensity

Loan intensity is measured as the ratio of the book value of total loans over total assets in the bank. This ratio estimates the percentage change in volume of loan relative to a percentage change in the total assets of the bank. The higher the loan intensity, the higher the efficiency of the bank would be. There is a positive directional relationship between loan intensity and efficiency of banks (Noor & Ahmad, 2012).

Age of Bank

This measures the number of years the bank has been in operation in the country. The inclusion of this variable is to test if banks become more efficient over time or the effect of an increase in years does not significantly affect the performance and efficiency of banks in Ghana. The effect of age on efficiency is, therefore, indeterminate. Pitt and Lee (1982) conceded that the years of operation (age) of a firm has a significant effect on the efficiency of the firm.

Inflation

Inflation is measured using the consumer price index which reflects the annual percentage change in the cost of acquiring a fixed basket of goods and services to the average consumer. This factor is measured as a yearly average inflation variable published by the Bank of Ghana. It is expected that a negative relationship exists between inflation and technical efficiency of banks. It is expected that a strong sustainable economic growth improves the intermediation efficiency as it boost the level of deposits to banks and the demand for loans by individuals and business entities. This is only experienced when noninterest expenses is relatively stable. However, if noninterest expenses are increasing faster than the rate of inflation, then literature acknowledges that the effect of inflation on efficiency of banks is not easily determined. Many efficiency studies like Dietsch and Lozano-Vivas (2000); Favero and Papi (1995); Hassan and Bashir (2003); Papanikolaou and Delis (2009) and Sufian (2009) used inflation as a macroeconomic indicator in determining technical efficiency.

Gross Domestic Product

The study used the growth in GDP with oil as a macroeconomic indicator in the technical efficiency estimation. This is to control for the macroeconomic effects that influence the efficiency of banks in their intermediary function in the economy. An economy exhibiting a low economic growth will send negative signals to the people, which discourages banking activities such as investments, savings and demand for loans. On the other hand, a strong economic growth results in high intermediation efficiency in the banking sector. Studies that used inflation as a macroeconomic effect also included growth in GDP as a controlling variable, such as cited above. As such, the study expects a direct relationship between GDP and the efficiency estimates of the banks.

Money Supply

M2 money supply also known as the broad money comprises currency in circulation, private demand deposits in local currency with banks and quasi-monetary deposits (Badarudin, Khalid, & Ariff, 2009). Intuitively, it is expected that as money supply in circulation increases, total deposit to financial institutions will increase significantly in the economy. However, this simple scenario will be realised if certain factors operate. These factors include banking industry concentration and expected inflation in the economy. As such, the relationship between money supply and bank efficiency is indeterminate.

Industry/ Market Concentration

The study used industry advances and deposits for the market share analysis. The PwC banking survey measured market shares using share of industry operating assets, share of industry deposits and share of industry advances in their analysis. However, the literature measured industry concentration by calculating the Herfindahl –Hirschman Index, as the sum of market share of all banks in the banking industry (Raphael, 2013; Saka et al, 2010). As cited by Raphael, some studies calculate market share in terms of deposits, others in terms of Asset, as adopted in studies like Darrat, Topuz, and Yousef (2002); Favero, and Papi (1995); Miller, and Noulas (1996) and Papanikolaou, and Delis (2009). All these studies assent to the significant relationship between a bank's share in the industry's asset and liabilities on the bank's efficiency.

The operating capabilities of banks for this study were measured by the resources available to earn returns for their shareholders, lenders and depositors (PWC Banking Survey, 2014). These resources that are termed operating assets of the bank are indicators of the performance of the bank as well as the basis for valuing shareholders wealth in the bank. This study defines operating assets as all assets that generate interest income to the bank, excluding assets like property, plant and equipment.

Estimation Technique

This study used the Stochastic Production Function model that allowed for the simultaneous estimation of individual technical efficiency of the banks as well as the determinants of technical efficiency (Battese & Coelli, 1995). Following Battese and Coelli (1983), technical efficiencies and their determinants were estimated using the two-step Maximum Likelihood Estimates (MLE) procedure. This study specifies the Stochastic Frontier Production function using the Translog specification and later, carries out a log likelihood ratio test to confirm that Translog specification does not reduce to the Cobb-Douglas production function specification.

Post Estimation Tests

Ensuring that estimates from the regression are robust and consistent, the following post estimation tests were conducted. These tests were conducted to test the fitness of the models estimated in this study. In choosing the production functional form, Likelihood ratio test is used to choose between the Cobb-Douglas production function and the Translog production function specification. The unrestricted model was estimated and the value of its log likelihood was stored as LLF_1 . Then, the restricted model is estimated and the value of the log likelihood saved as LLF_0 . The Likelihood Ratio is then calculated as

$$LR = -2(LLF_0 - LLF_1) = -2\{\ln[L(H_0)] - \ln[L(H_1)]\}$$

LLF₀ is the value of the log likelihood function for the Stochastic Frontier estimated using Cobb-Douglas production function on the data.

LLF₁ is the value of log likelihood function for the Stochastic Frontier estimated using Translog production function.

The null hypothesis (H₀) of this test is to reject H₀ if $LR > \chi^2_{R}$ table value, where R=number of restrictions.

With the use of F-test and simple t-test, the study tested some hypotheses to confirm if the technical inefficiency effects are stochastic and that the inefficiency estimates are independent and identically distributed. The test statistic conducted on the means of efficiency levels of listed and unlisted banks guides the conclusion of whether being listed on the stock exchange influence the performance of banks in the financial industry.

Summary

The Chapter Four presented the methodology of the study. The research design adopted provides scientific and positive findings. The quantitative approach used is also in-line with fulfilling the objectives of this study. The data used was obtained from financial reports of the sampled banks over the course of five (5) years, the data collected was a micro panel data. The choice of inputs and output for the intermediary analysis was also discussed in this chapter. The theoretical and empirical specification of the model was further discussed. The chapter then looked at the measuring and justification of the selected external variables that are likely to influence the efficiency of the banks. Finally, the estimation technique and the post estimation tests were discussed.

CHAPTER FIVE

RESULTS AND DISSCUSIONS

Introduction

This chapter presents the empirical findings and discussions of the results of the study obtained using the models specified in the previous chapter. The technical efficiency scores computed for the 11 out of 27 licensed commercial banks in Ghana for the period 2009 to 2013, given a total of 55 observations, are presented in this section. The banks are ranked in accordance with their relative average technical efficiency scores. We investigate into the possible relationship that exists between the efficiency scores and the listed status of banks, and also the directional relationship and marginal effects of selected determinants of efficiency that were discussed in Chapter 2 on listed banks and unlisted banks .

Descriptive Statistics

The descriptive statistics of the variables used in this study are presented in the Table 2. The descriptive statistics cover the mean, median, maximum, minimum, standard deviation, skewness, kurtosis and number of observations.

The measure symmetry of distributions, Skewness and Kurtosis were used to test the normality of data. For data to be normally distributed it will be symmetrically distributed and mesokurtic. Skewness looks at the spread or the off-centre of a distribution. The data can either be positively, negatively or symmetrically distributed. Symmetrically distributed data have all its measure of

central tendencies at midline point and are equal, with a skewness coefficient of 0. This is the ideal situation. The less perfect scenarios are either positively or negatively skewed. Kurtosis focuses on the thickness of a distribution. The kurtosis of a distribution can be Mesokurtic, Leptokurtic or Platykurtic.

Table 2 indicates that variables employed in this study are all skewed, either positively or negatively. Apart from bank size and liquidity ratio, all the other variables are skewed to the right. However, employing the joint Skewness/Kurtosis test for Normality, bank size, fixed assets (property, buildings and machinery), profitability and liquidity ratio are normally distributed at a calculated probability of 0.05. Notably, the negative minimum value of profitability is as a result of the negative earnings before interest and taxes recorded by Barclays Bank in 2009, making the minimum value of profitability an outlier. The use of the natural logarithm of the intermediary inputs and output variables even out and minimize the degree of outliers in the distribution of the variables.

Table 2

Summary Statistics Testing for Normality in Variables

Statistics	Mean	Standard Deviation	Skewness Pr(Sk)	Kurtosis Pr(K _r)	Observations
Loans	6.76e+08	5.09e+08	2.410185 0.0000	11.23002 0.0000	55
Dep	1.04e+09	7.44e+08	1.304344 0.0003	1.304344 0.0003	55
LN(TA)	20.82124	.7088264	-.210476 0.4841	2.370382 0.3067	55
FAss	3.23e+07	2.00e+07	.8566931 0.0095	2.876602 0.8535	55
NII	1.14e+08	9.76e+07	1.586355 0.0000	5.263933 0.0091	55
TANG	.0275816	.0149501	1.180958 0.0008	4.32046 0.0503	55
PROF	.0395597	.0234133	.2443563 0.4177	2.81861 0.9420	55
LR	.6458182	.1675719	-.105014 0.7255	2.896706 0.8241	55

Source: Computed from financial reports of sampled banks

The natural logarithm of the intermediary inputs and output for the stochastic production frontier model is presented. Following the methodology of the study, the natural logarithm of the variables are used in the estimation of the

Stochastic production frontier. This conversion also aids in normalising the values of the variables.

Table 3 presents the definition and summary statistics of the variables involved in the Stochastic Production Function modelling. The results indicate that the time trend of both inputs and output follow approximately the same wavelength, as such the choice of inputs for the study is systematic. This is further depicted in Appendix A.

Table 3

Descriptive Statistics of the Variables in Stochastic Production Frontier Models

Variable	Description	Minimum	Mean	Maximum	St. Deviation
ln(Loans)	Natural log of Net loans and advances	18.7448	20.10822	21.84516	.6749368
ln(Dep)	Natural log of Total deposits received	18.74803	20.50395	22.03137	.7573061
ln(FAss)	Natural log of fixed assets (plant, property and equipment)	15.75007	17.09403	18.23105	.6482306
ln(IEx)	Natural log of Interest expenses	16.137	17.5172	18.72771	.6109224

Source: Computed using the financial data from the selected banks, 2016

The definition of variables and descriptive statistics of the technical efficiency model is presented in Table 4. Variables such as loans deposit ratio, loans intensity, bank size, profitability, asset tangibility and growth in deposits were

estimated from the financial data of the various banks. Liquidity ratio, on the other hand, was obtained from the annual banking survey conducted by PwC. The negative minimum value of profitability is due to the negative earnings before interest and taxes that Barclays reported in 2009.

Table 4

Descriptive Statistics of Variables in the Technical Efficiency Models

Variables	Description	Minimum	Mean	Maximum	St. Deviation
LDR	Loans Deposit Ratio	.3363701	.7028492	1.227647	.2055561
LI	Loan intensity	.280087	.5045832	.6889701	.1164804
SIZE	Bank Size	19.17172	20.82124	22.25461	.7088264
Age	Years in operation	10	36.18182	99	24.65622
LR	Liquidity ratio	.27	.6458182	1.06	.1675719
Prof	Profitability of bank	- .0178725	.0395597	.0917764	.0234133
TANG	Asset tangibility	.0092798	.0275816	.0753076	.0149501

Table 4 continued

Infl	Yearly average inflation	8.73	13.432	19.3	3.923159
MS	Money supply (M2 = Broad Money)	7566.9	14187.17	20691.39	4683.864
ID	Share of Industry deposits	.008	.0602727	.14	.037272
IA	Share of industry advances	.008	.0591455	.207	.0328196

Source: Financial Data, 2016

The ownership status of a bank has been proven in existing literature and in the Chapter 4 of this study to influence the technical efficiency of a bank. The party with majority ownership of the bank determines the efficiency level of the bank. In this study, we sampled eleven (11) banks out of which there are domestic-private owned, foreign owned and state-owned banks.

Table 5 indicates that banks that list their shares on the GSE are mostly foreign owned banks, followed by the state-owned banks and lastly domestic-private banks. The Pearson Chi-square Test was conducted on these categorical variables to test for the independence of ownership and enlisting on the stock exchange. The probability value indicates that ownership of a bank and being listed on the market are not independent of each other.

Table 5

Ownership Status of Selected Banks

Ownership	Listed Banks	Unlisted Banks	Total
Domestic-Private	1	2	3
Foreign	4	2	6
State-owned	2	0	2
Total	7	4	11

Pearson $\chi^2(2) = 11.7857$ Pr=0.003

Source: Field Work, 2016

As discussed in the methodology of this study (Page 76 paragraph 3), the categorisation of banks follows the Ghana Banking Survey classification. Hence the study used six (6) foreign banks and five (5) local or domestic banks.

Banking Industry Operating Assets

Industry operating assets have doubled since 2009 having increased from GH¢12.9b in 2009 to GH¢25.8b in 2012 and risen to GH¢34.2b in 2013. The increase over that period was mainly due to growth in deposits and the rallying by banks to meet the minimum capital requirement of the Bank of Ghana. However, the composition of the operating assets has not changed significantly in the past few years.

INDUSTRY OPERATING ASSETS (GH¢bn)

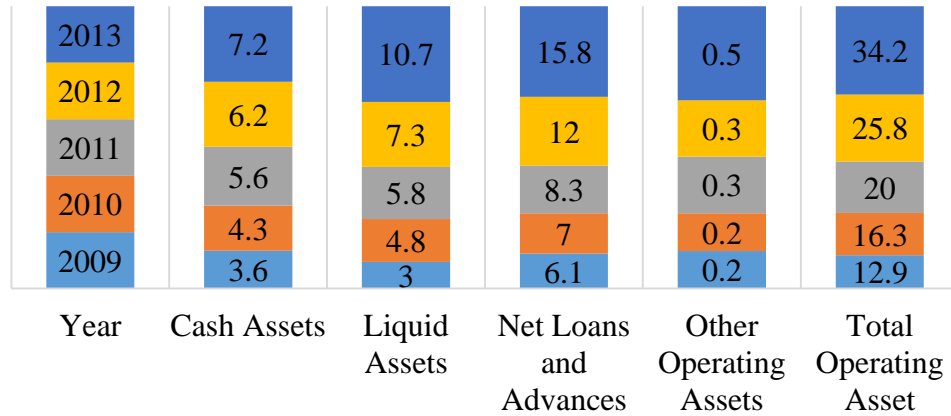


Figure 2: Industry Operating Assets recorded in billions of Ghana Cedis

Source: Computed using data from PWC Banking Survey, Microsoft Excel

Figure 3 indicates that Net loans and advances is the highest and most significant component of the industry operating assets throughout the five years understudy. Followed by liquid assets and cash assets. This means that, the presence of Net loans and advances in the banking industry is paramount in the efficient performance and operations of this industry. From Figure 3, the proportion of Net loans and advances to total earning assets only began to incline in 2012 after reporting a decline in the past three years from 47% in 2009 to 41% in 2011.

Composition Of Industry Operating Asset

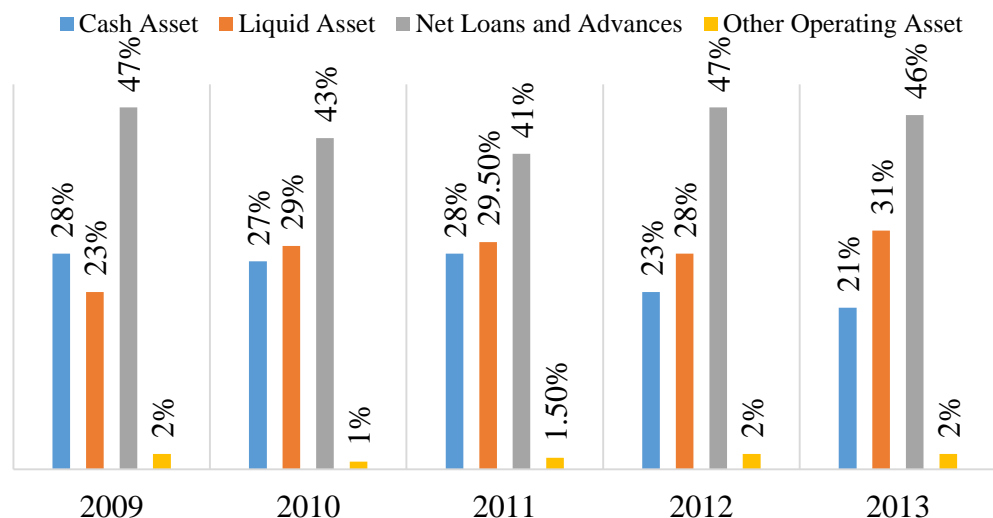


Figure 3: A clustered column showing the percentage composition of Industry Operating Assets for the years 2009-2013

Source: Computed using data from PWC Banking Survey, Microsoft Excel

Market Share Analysis

The market concentration of the banking industry is analysed using the share of industry deposits and share of industry advances as adopted by the Ghana Banking Survey conducted yearly on licensed banks in Ghana.

As at the end of 2013, the total deposits in the banking industry was GH¢26,336m as compared to the end of 2012 total deposits which was GH¢20,700m. The market share of the industry's deposits has not changed significantly as products offered by banks are not entirely different to provide any individual bank an advantage over the other banks. Banks have moved away from

the use of extensive branch network to providing quality customer services to boost their margin of deposits to the sector.

Ecobank Ghana Limited is recorded to have the largest share of industry deposits, although they come forth in ranking of the largest network of branches and agencies. The takeover of The Trust Bank by Ecobank Transnational and the merger of the acquired institution with Ecobank Ghana at the end of 2011 pushed the bank to rise to the first position of share of industry deposits as against GCB, BBGL and SCB by 2012.

Total industry loans and advances increased from GH¢9.1b in 2011 to GH¢13.0b, a growth of 43% in 2012. In 2010, the growth in industry loans and advances was 15% compared to a growth of 6% in 2009. Banks are gradually softening their credit stance after a downward trend in loans and advances from 2009-2011.

Most of the banks maintained their relative market shares of industry loans and advances by increasing or decreasing their market share by less than +/-0.5%. EBG reinforced its position as the largest lender in the industry in 2012 by increasing its market share by 1.2% and overtaking GCB in 2011. This follows the merger with TTB which had a market share in 2011 of 4.1%. The industry's loan to deposit ratio increased from 57% in 2011 to 63% in 2012 confirming the renewed appetite for lending. This follows a drop in the prior period.

Before the merging of TTB and EBG, GCB had the highest share of industry advances and industry deposits in 2009 and 2010. Figure 4 presents the average of

industry advances and deposits for the years 2009-2013. Aggressive lending by CAL and SG-GH can be attributed to the focus of breaking into the 1st tier of Ghana's banks.

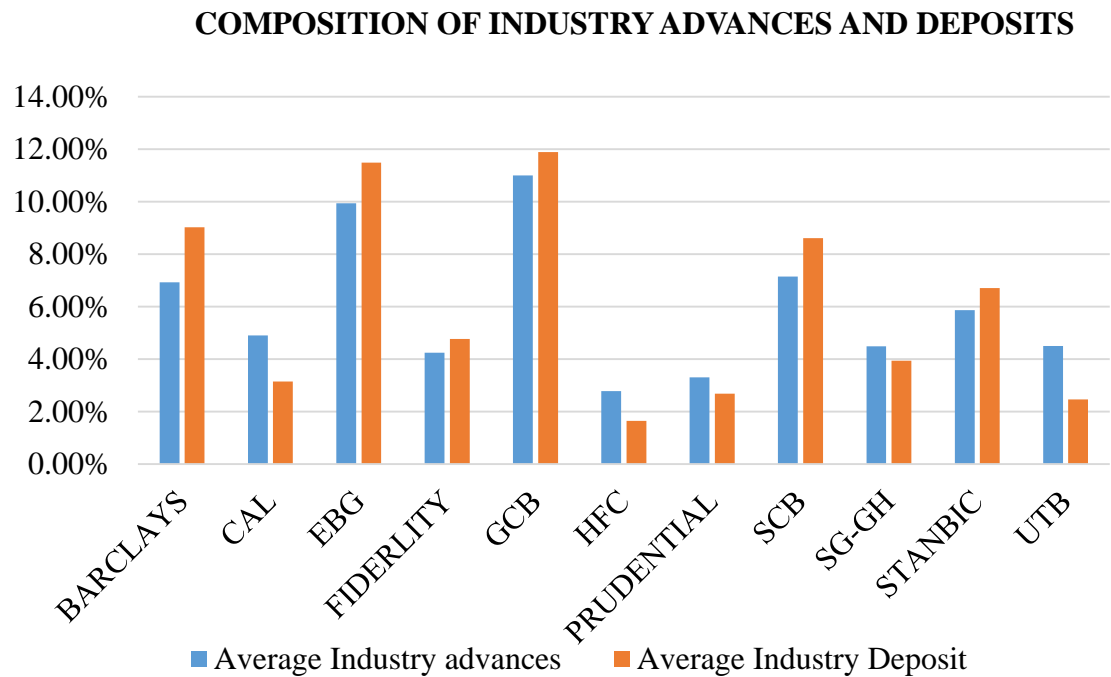


Figure 4: Composition of Industry Advances and Deposits

Source: Computed using Microsoft Excel from PWC Banking Survey Data

As indicated in the Figure 4, the four top banks: Barclays, EBG, GCB and SCB ranked highest in industry deposits and net loans and advances. As at 2013, these banks controlled 38.90% of the market deposits, a fall from 43.30% in 2009. Likewise, by 2013, 33.50% of industry deposits were held by these 1st tier banks, as compared to 43.10% in 2009. The decline in both deposits and advances holdings

of these banks resulted from the tightening of credit stance by banks from 2009-2011.

Stochastic Production Frontier

The data were analysed using the different functional forms discussed in the literature review, Cobb-Douglas and Translog Production Functions. Table 6 presents the estimates using both functional forms. The LR test confirms the choice of the unrestricted Translog functional specification as being the more accurate one.

Table 6

Maximum Likelihood estimation of the Stochastic Production frontier Models

Variables	Parameters	Cobb-Douglas	Translog
Constant	β_0	342.749	509.741
$\ln(\text{Dep})$	β_1	0.659***	4.823***
$\ln(\text{FAss})$	β_2	-.00857	-1.984
$\ln(\text{IEx})$	β_3	0.276***	-4.132**
$\ln(\text{Dep})^2$	β_{11}		0.197**
$\ln(\text{FAss})^2$	β_{22}		0.0923
$\ln(\text{IEx})^2$	β_{33}		0.146**
$\ln(\text{Dep}) * \ln(\text{IEx})$	β_{13}		-0.341***
$\ln(\text{FAss}) * \ln(\text{IEx})$	β_{23}		0.365***
$\ln(\text{Dep}) * \ln(\text{FAss})$	β_{12}		-0.368**

Table 6 continued

Variance parameters			
MU	/mu	340.7268***	494.9637***
ETA	/eta	.0001908*	.0001116*
Sigma-squared (u)	σ_u^2	.0372969	.0438864
Sigma-squared (v)	σ_v^2	.0252669	.0143199
Gamma ($\sigma_u^2/\sigma_u^2+\sigma_v^2$)	γ	.5961417	.7539804
Log likelihood	LLF	11.4142	23.3648

Note: *, **, *** denote significance at 10%, 5% and 1% respectively.

MU signifies the presence of inefficiency effects in the model and ETA refers to time-varying inefficiency effects. The statistical significance of these two terms indicates that inefficiency effects exist in the model, using either functional forms. This study focuses on the result of the Translog Functional form due to its flexibility and fewer restrictions as compared to the Cobb-Douglas Production Functional form.

Table 6 presents the estimate and log likelihood figures of the Stochastic Production frontier Model using the entire dataset that is, both listed and unlisted sampled banks for the study. Thus, Table 6 gives the estimates derived from regressing both listed and unlisted sampled banks. The estimates obtained here are not relevant for the study. Rather, the log-likelihood figures are needed to conduct the Likelihood Ratio Test. This test would guide the choice of either the Translog or Cobb-Douglas function specification.

Likelihood Ratio Test

The maximum likelihood estimates of the stochastic frontier model were obtained from using both the Cobb-Douglas and Translog production function in Table 6. The study then used the likelihood ratio to test if the Translog reduces to Cobb-Douglas Production Function. In reference to the methodology, the log likelihood ratio statistics were computed below:

$$LR = -2(LLF_0 - LLF_1) = -2\{\ln[L(H_0)] - \ln[L(H_1)]\}$$

$$LLF_0 = \ln[L(H_0)] = 11.4142$$

$$LLF_1 = \ln[L(H_1)] = 23.3648$$

$$LR = 23.9012$$

$$\chi_6^2 = 12.592$$

At 6 degrees of freedom, the Chi-squared distribution table value at 95% confidence level is 12.592. Since $LR > \chi_R^2$, where R is the number of restrictions, we reject the null hypothesis (H_0) of restricted form, Cobb-Douglas function, and accept the unrestricted functional form, Translog. Henceforth, the study uses the Translog Production Function estimation technique in estimating the technical efficiency levels of banks in Ghana, whether listed or unlisted.

Two-Step approach in estimating the efficiency scores

The two-step approach was used to estimate the Stochastic Production Frontier and the technical efficiency model using the maximum likelihood translog

estimation. In other to do a detailed comparison of efficiency on listed and unlisted banks, this section analysed the efficiency estimates of these two groups of banks separately. The first is to look at listed banks and the second, at unlisted banks.

The parameter estimates of the stochastic production function and the technical efficiency model for listed banks are presented in Appendix C. The Stochastic Production Frontier and technical efficiency estimates were realised using the truncated-normal distribution option. λ is the vector of unknown parameters to be estimated, thus, the inefficiency effects.

Parameter estimates of stochastic production frontier and technical efficiency models for unlisted banks using the maximum likelihood estimation introduced by Battese and Coelli (1995) with a truncated normal distribution is presented in the Appendix D. A simply t-test was then conducted on the means of the efficiency estimates for any statistical difference between the means.

Table 7

Summary Descriptive of Technical Efficiencies for Listed and Unlisted Banks

Banks	Average Efficiency	Standard deviation	Lowest Efficiency	Highest Efficiency
Listed	0.4774971	0.1139153	0.2229601	0.8668827
Unlisted	0.5884151	0.3426691	0.0864871	0.9883319

Source: Computed using STATA 13.1, 2016

Table 7 simply indicates the summary statistics of the efficiency scores of listed banks and unlisted banks, when estimated separately, as done in Appendix C

and Appendix D. The average efficiency level for listed and unlisted banks are 0.477 and 0.588 respectively, as presented in Table 7. According to the production data collected, the average efficiency level of banks listed on the stock exchange is approximately 48% while that of unlisted banks is 59%. An unlisted bank recorded the highest efficiency at 98.8%. The highest efficiency for banks listed on the GSE is recorded at 86.7% and lowest being 22.3%. These summary statistics, however, do not indicate whether the differences in the average efficiencies between the listed and unlisted banks are statistically significant. In order to test for the statistical significance of the difference in the two averages presented in Table 7, ANOVA test is adopted and the result is presented in Table 8.

Test for Differences in Technical efficiency for Listed and Unlisted Banks

In accordance with the objectives of the study, the following tests were conducted to determine the statistical significance of the difference in the average technical efficiency of listed and unlisted banks. Analysis of Variance is first used to test the significance of the difference in means of efficiency scores between groups and the t test was used to determine the group which had the higher efficiency on the average.

Table 8

ANOVA Test for Difference in Mean Efficiency of Listed Banks and Unlisted Banks

Source	SS	df	MS	F	Prob > F
Between groups	.156581385	1	.156581385	3.11	0.0838
Within groups	2.67222846	53	.050419405		
Total	2.82880984	54	.052385367		

Source: Computed using STATA 13.1

The ANOVA test functions on the assumption of homogeneity in variance of different samples. The results from the analysis of variance presented in Table 8 shows that between listed and unlisted banks, there is a statistically significant difference in the means of the efficiency scores at a probability value of 10%. This implies that there is a significant difference in the average efficiency of banks listed on GSE and banks that are not listed.

Table 9

Difference in Mean efficiency of Listed and Unlisted Banks Using Simple T-Test

Listed	Obs	Mean	Std. Error	Std. Dev	95% Conf. Interval	
Yes	35	.4774971	.0192552	.1139153	.4383658	.5166283
No	20	.5884151	.0766231	.3426691	.4280411	.7487892
Combined	55	.5178309	.030862	.2288785	.4559564	.5797054
Diff		-.1109181	.0629406		-.237161	.0153249

Diff = mean(YES) - mean(No) t = -1.7623
 Ho: diff = 0 Degrees of freedom = 53
 H₁: diff < 0 H₁: diff ≠ 0 H₁: diff > 0
 Pr(T < t) = 0.0419 Pr(|T| > |t|) = 0.0838 Pr(T > t) = 0.9581

Source: Computed using STATA 13.1

The simple two-sample t--test conducted in Table 9 assumes equal variances in the efficiency of listed and unlisted banks. The p-values from Table 9 indicate that the null hypothesis that the means are not different would be rejected in favour of the alternative of H₁: diff < 0. Thus, the test statistic indicate that there is a difference in means of efficiency between listed and unlisted banks. Furthermore, the average efficiency of banks unlisted is statistically higher than the average efficiency of listed banks. This indicates that the theoretical assumption that companies listed on a stock market are more efficient than unlisted companies is not valid at practical level.

Table 10

Ranking Banks by Their Overall Average Efficiency

BANK	Listed on GSE 1=Listed	Years in Operation	Average Bank Efficiency	Overall Ranking
Stanbic	0	17	.8443083	1
Fidelity	0	10	.6040305	2
SG-GH	1	41	.6010147	3
Prudential	0	23	.5709563	4
Ecobank	1	26	.5097347	5
HFC	1	26	.5066415	6
Standard Chartered Bank	1	120	.4819664	7
UT Bank	1	21	.4674002	8
CAL	1	26	.4649379	9
GCB	1	63	.310784	11

Source: Computed with STATA 13.1

Table 10 depicts the average technical efficiency of the sampled banks over the five years under study. It also gives an overall ranking of the banks according to their

average efficiency scores. According to Table 10, Stanbic Bank ranks first with an average efficiency level of 84% and 60% for the second ranking bank, Fidelity. These two banks, Stanbic and Fidelity Bank, are the youngest banks in the sample and both do not have shares listed on the GSE. Barclays Bank and GCB Bank have the lowest technical efficiency scores in this study. Note that, these two banks have the largest banking operations network and have been operational in the country for a long time, plus GCB is listed on GSE. This implies that being listed on the stock market reduces the technical efficiency of the bank.

As indicated in Appendix B, Fidelity Bank and GCB Bank are both domestic banks but over five decade difference in their ages. The significant difference in the efficiency of these two banks can be attributed to either the 50 years difference in the years of establishment or the fact that one is listed and the other is not listed.

Table 11 gives the estimated efficiency scores of all 11 banks used in this study over the five years under-study. From the banks used in this study, HFC Bank maintained the efficiency in its operations throughout the study period. Banks like Fidelity and Barclays however showed a rather radical efficiency estimates. Thus, the efficiency scores of these banks kept increasing and decreasing at irregular trend. GCB Bank presented a continuous decrease in their technical efficiency level. The relatively newly established banks like Stanbic Bank and Fidelity Bank recorded high bank efficiency scores.

Table 11

Year By Year, Bank By Bank Efficiency Scores for 2009 – 2013

BANK	2009	2010	2011	2012	2013
Barclays	.9236137	.4286256	.0864871	.0942659	.138835
CAL	.3846387	.5083023	.3985938	.5264349	.5067199
Ecobank	.5067143	.5065145	.50403	.5067148	.5246996
Fidelity	.9555315	.6029059	.8598546	.4185939	.1832668
GCB	.5067143	.3166628	.2229601	.258666	.2489168
HFC	.5067143	.5067143	.5063422	.5067222	.5067143
Prudential	.1723801	.3501279	.7797682	.760184	.7923211
SCB	.5066604	.3435282	.5263258	.5800176	.4533002
SG-GH	.5097925	.4320755	.6007421	.5955805	.8668827
Stanbic	.9883319	.955065	.332458	.9621085	.983578
UT Bank	.5067141	.4256919	.4797579	.4804584	.4443785

Source: Using the financial reports of the banks, computed with STATA 13.1

Determinants of Technical Efficiency

The analysis done so far has focused on the Stochastic Frontier part of the model and the presumably different efficiency estimates for listed banks and unlisted banks. Thus, determining if being listed on the GSE influences the efficiency level of banks. This section reports on the determinants of efficiency estimated in the model with all the sampled banks. The negative or positive sign on a parameter efficiencies indicate the directional relationship between the efficiency effect variable and the technical efficiency level of the bank. A positive sign means that increase in the exogenous variable will cause efficiency to increase and if the sign is negative, efficiency will decrease.

The analysis have two dummy variables, ownership and listed. The dummy variable for ownership categorizes banks into private or state owned and foreign banks. The variable, age (measured in years), accounts for total number of years a licensed bank has been operating in Ghana. The coefficients of the macroeconomic variables; inflation, money supply and GDP, depict the directional impact of Ghana's economic growth on banks technical efficiency.

It should be noted that these results only provide a directional and statistical significance of determinants of technical efficiency of banks. The marginal effects of these parameters cannot be interpreted directly using the coefficients obtained in Table 12 and Table 13. Rather using the coefficients and the mean values of the efficiency variables, the marginal effects are estimated and discussed.

The three groups of determinants of technical efficiency on banks discussed in the methodology of this study are estimated in Table 12 and Table 13 to identify the factors that determine technical efficiency for listed banks and unlisted banks respectively.

Table 12 indicates that the bank specific factors that determine the technical efficiency of banks listed on the GSE are ownership status of the bank, profitability level, net interest income and volume of tangible assets. A bank's share in industry advances is statistically significant in determining the technical efficiency level of listed banks. The volume of money supply in the economy is the only statistically significant macroeconomic variable that influences the technical efficiency level of listed banks.

Table 12

Determinants of Technical Efficiency for Listed Banks

Efficiency Model	Coefficients	Standard Error
Ownership (1=Domestic)	.0803193***	.0255546
Bank Size	.3000009	.4420902
Profitability	2.212957**	.8665843
Liquidity ratio	.0249552	.1377858
Net Interest Income	-9.98e-10***	2.84e-10
Loan deposit ratio	-.6086081	.4559481
Loan intensity	.9708346	.8427469
Age	.0006351	.0023526
Asset Tangibility	2.800413***	.7418464
Industry deposit	1.314724	1.581725
Industry advances	1.564028*	.9507959
Inflation	.0081461	.0058458
GDP	.0006344	.0049343
Money Supply	.0000236**	9.67e-06
Variance Parameters		
Sigma-squared	.0023889	.0006721
Gamma	.0095934	.1557755
Sigma_u2	.0000229	.0003756
Sigma_v2	.002366	.0005653

Note: *, **, *** denote significance at 10%, 5% and 1% respectively

Source: Computed using STATA 13.1

The positive coefficient of the categorical variable Ownership, indicates that banks with majority of its shares owned by foreign parties are more technically efficient than majority locally owned banks. This finding is follows that of Di Patti

and Hardy (2005), Hauner and Peiris, (2008) and Berger, Hasan, and Klapper (2004). Hauner and Peiris discovered in their research into bank efficiency for Ugandan banks that domestic banks are less efficient as compared to foreign-owned bank. However, this contradicts Frimpong (2010b). Frimpong summarized that banks with majority domestic or local ownership are more efficient than banks with majority foreign ownership.

The statistically significant direct relationship between profitability level of the bank and its technical efficiency level in Table 12 is in line with the findings from Huang and Song (2004). This indicates that listed banks that are profitable in their operations are efficient in their intermediary functions in the financial market. This follows the intuitive prior expectations of the study. As mentioned by Buchs and Mathisen (2005), the non-competitive banking system in Ghana enables banks to reap supernormal profits. Banks that list on the GSE are able to absorb this abnormal profit in the market.

The net interest income variable is used as a proxy for measuring the performance of the banks. The estimate of this variable shows that the performance level of banks negatively influence the technical efficiency level of banks listed on the GSE. This estimate contradicts the prior expectation of this study.

The size of the bank measured by the growth in total assets of the bank, is positively related to the efficiency level of banks listed on the domestic stock exchange. Thus, as the firm grows in its total assets, its technical efficiency improves. This is in line

with Aikaeli, (2008), that small banks have higher technical efficiency scores as compared to large domestic banks.

However, this relationship is not statistically significant, given credence to the Gibrat Law (1931) that the size of the bank does not significantly influence the efficiency of their operations.

The number of years that a bank operates has a weak positive impact on the efficiency level of the bank. The impact of growing years of operation of a listed bank in Ghana on its technical efficiency is statistically insignificant. As the number of years a bank operates in the country increases, the efficiency level of their production also increase year after year. However marginally, as a listed bank ages, it becomes more efficient in performing its intermediary functions.

The asset tangibility of a bank determines the technical efficiency of banks listed. Banks with high level of tangible assets have higher technical efficiency scores as compared to low tangible assets. Liquidity ratio has a direct but statistically insignificant relationship with the efficiency level of listed banks as expected. A banking institution with more liquid asset to accommodate short term liabilities would be more efficient in its operations. The positive but statistically insignificant relationship between loan intensity and efficiency level indicated in Table 12 follows the findings of Noor and Ahmad (2012). Thus, banks with a high ratio of volume of loans to total asset are more efficient.

The market share of an individual bank highly influences the technical efficiency level of the bank. Using the share of industry advances as a measure of

market concentration, there is a significant direct relationship between market concentration and technical efficiency level of listed banks. Increase in a bank's share in industry advances results in improvement of its efficiency level or fall in its inefficiency level. Using a bank's share of industry deposit as a measure, there is a positive relationship between the market share and the efficiency level. Thus, a bank with high percentage of industry total deposit would be highly efficient. This indicates that banks in this category that have high market concentration are more efficient than other listed banks.

The inflation, money supply and real GDP have a direct relationship with efficiency levels of listed banks. The estimates of the parameter on GDP follows the prior expectation. Thus, banks are more efficient in a fast growing economy. On the other hand, the inflation estimate goes contrary to the initial expectation since it indicates that high inflation levels would result in higher efficiency level of banks. However, money supply is the only macroeconomic variable that shows a statistically significant effect on the efficiency level of listed banks. At a probability level of 5%, increase in the volume of money pumped into the domestic economy will cause the technical efficiency level of banks, whether listed or unlisted banks to increase significantly.

Table 13

Determinants of Technical Efficiency for Unlisted Banks

Efficiency Model	Coefficients	Standard Error
Ownership (1=Domestic)	.042111	.489531
Bank Size	51.19614**	24.01234
Profitability	.1997838**	6.182837
Liquidity ratio	6.479667***	1.261416
Net Interest Income	1.16e-08*	6.81e-09
Loan deposit ratio	-93.07517**	42.44452
Loan intensity	107.6996**	51.47697
Age	-.0029773	.0056004
Inflation	.0878845**	.0434962
GDP	.1069746***	.0404751
Money Supply	.0003105**	.0001493
Industry deposit	76.20488**	36.70676
Industry advances	-1.972822	11.53351
Asset Tangibility	-86.88004**	35.13326

Table 13 continued

Variance Parameters		
Sigma-squared	.0108701	.0064575
Gamma	.0086335	.4993043
Sigma_u2	.0000938	.0054748
Sigma_v2	.0107762	.0034067

Note: *, **, *** denote significance at 10%, 5% and 1% respectively Source: Computed using STATA 13.1

Size of the bank, its profitability level, liquidity ratio, net interest income, loan intensity, loan deposit ratio, industry deposits, inflation level, real GDP and the level of money supply in the domestic economy are all statistically significant in determining the technical efficiency level of banks not listed on the GSE. Table 13 shows the directional and statistical significance of the determinants of technical efficiency in regards to unlisted banks in Ghana.

Bank size, profitability, loan intensity, loan deposit ratio, growth in total deposits, industry deposits, real GDP, inflation and money supply have similar directional relationship with technical efficiency of both listed and unlisted banks in Ghana. Although real GDP and inflation are determinants of efficiency of listed banks, their effect on listed bank efficiency is not statistically significant. Determinants of efficiency for unlisted banks with opposing directional

relationship compared to listed banks include years of operation, industry advances, net interest income and asset tangibility. That is, increase in the volume of net interest income will increase the efficiency of banks that are not listed but decrease the efficiency of banks that are listed on the GSE.

The directional effect of ownership status on efficiency of banks shown in Table 13 confirms the prior expectation that foreign banks are more efficient than domestic-owned banks. This outcome indicates that regardless of whether a bank is listed on the GSE or not, banks with majority of its shares owned by foreign parties are more efficient than those having majority domestic ownership.

The volume of tangible assets for unlisted banks has a strong inverse relationship with the technical efficiency level of these banks. Implying that, unlisted banks that have high quantities of tangible assets are most likely to have low efficiency level. As discussed in earlier in this study, Shah and Khan (2007) and Hosono (2003) reported similar findings on the relationship between asset tangibility and technical efficiency.

The number of years that a bank operates has a weak negative influence on the efficiency level of the bank. As a bank operates, the efficiency level of their production falls year after year. This implies that the relationship between age of a bank and its efficiency is inverse.

The market share of a bank measured using the bank's share of industry deposit shows a significant negative relationship between the market share and the

efficiency level. Thus, a bank with high percentage of industry total deposit would be highly inefficient.

The results shown in Table 13 indicate that growth performance in the Ghanaian economy significantly affect the efficiency of banks not listed on the Ghana Stock Exchange. The macroeconomic indicators; inflation, real GDP and money supply, are all statistically significant in determining the technical efficiency of banks not listed on GSE. Indicating that the economic conditions of Ghana influence the efficiency of banks not listed on the GSE more than it does for banks listed.

Marginal Effects

As proposed by Battese and Coelli (1993), the quantification of the marginal effects of these determinants of efficiency or inefficiency is possible by partial differentiation of the technical efficiency predictor with respect to each variable in the efficiency function. Table 14 presents results of partial differentiation of the technical efficiency model, with respect to each of the efficiency variables, evaluated at their mean values or with a value of one for dummy variables (Wilson et al 2001, as cited by Dasmani 2007).

Table 14

Marginal effects of the Determinants of Technical Efficiency for Listed Banks

Variables	Change in TE
Ownership (1=Domestic owned)	0.0438
Bank Size	6.2463
Profitability	0.08754
Liquidity ratio	0.01612
Net Interest income	-0.11377
Loan deposit ratio	-0.42776
Loan intensity	0.489867
Age	0.02298
Inflation	0.096743
GDP	0.00544
Money Supply	0.334817
Industry Deposit	0.079242
Industry Advances	0.09251
Asset tangibility	0.07724

Source: Computed using STATA 13.1

Table 14 shows that the technical efficiency of listed banks that are foreign owned is approximately 4.4% higher than listed banks that are domestic owned. Any marginal increase in the profit margin of listed banks would improve technical

efficiency by 8.6%. The volume of tangible assets available to the bank is very important to improving the efficiency level of listed banks.

According to Table 14, an additional unit of tangible asset procured by the bank would increase its technical efficiency by 7.7%. A bank increasing its share of industry advances marginally would improve its efficiency by 9.3%. The marginal increase in technical efficiency for an extra Ghana Cedi released into the economy is approximately 33.5%. This logic follows for the remaining variables.

Bank Size and Technical Efficiency

In order to ascertain the directional relationship between bank size and technical efficiency, Figure 5 is constructed.

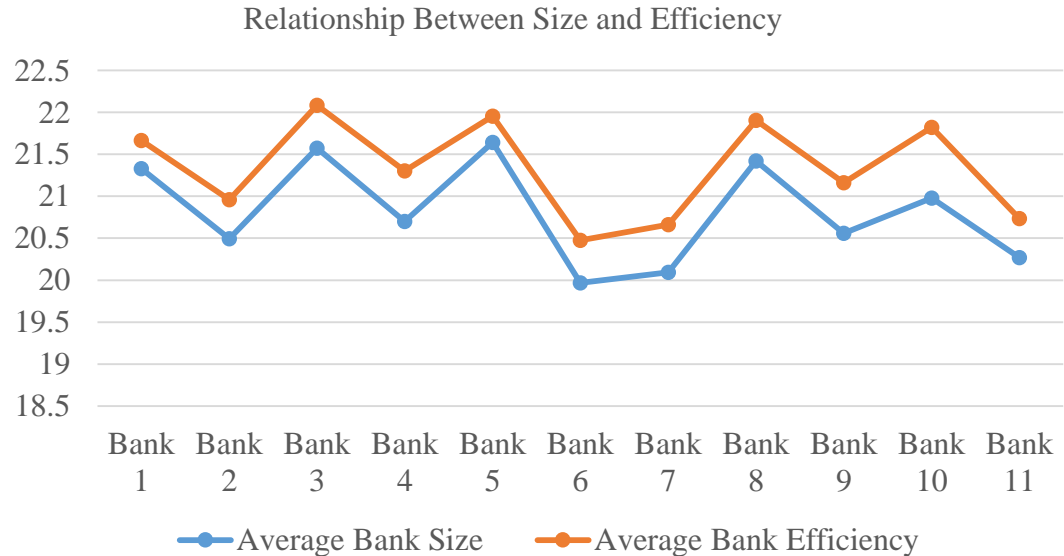


Figure 5: The Pattern of Average bank size and Technical Efficiency

Source: Computed Using Financial Data from 2009-2013

Figure 5 depicts the pattern of correlation between average bank size and average technical efficiency of banks. The line plot indicates that there is a positive directional relationship between efficiency and size of firm.

Profitability and Ownership

To analyse the difference in profits between locally owned banks and foreign banks, a t-test was conducted as seen in Table 15. The findings from Table 15 indicates that there is a highly significant difference in the profit levels of domestic and foreign owned banks.

Table 15

Measuring Differences in Profit Based on Ownership status of a Bank

Ownership	Obs	Mean	Std. Error	Std. Dev.	95% Confidence Inter	
1. Domestic	25	.0302882	.0044126	.0220632	.021181	.0393955
2. Foreign	30	.0472858	.0040085	.0219555	.0390875	.0554841
combined	55	.0395597	.0031571	.0234133	.0332301	.0458892
diff		-.016998	.0059588		-.0289494	.0050457

diff = mean(1. Domestic) – mean (2. Foreign) t = -2.8525

H₀: diff = 0 Degrees of freedom = 53

H₁: diff < 0 H₁: diff ≠ 0 H₁: diff > 0

Pr(T < t) = 0.0031 Pr(|T| > |t|) = 0.0062 Pr(T > t) = 0.9969

Table 15 indicates that the profit margin of banks with majority ownership belonging to foreign organisations are higher as compared to banks with majority domestic ownership. This interpretation uses the probability value of 1%. This means that at a significance level of 1% the average efficiency for foreign banks is significantly higher than the average efficiency for domestic banks. Making foreign banks more efficient than domestic banks.

Profitability and Listing

Banks listed on the GSE are noted to be more profitable than unlisted banks, as measured by the earnings before interest and tax. Table 16 shows the results of

a t- test on the average difference between the profit levels of banks listed on the GSE and unlisted banks.

Table 16

Testing the Difference profit level for listed and unlisted Banks

Listed	Obs	Mean	Std. Error	Std. Dev.	95% Confidence Inter	
Yes	35	.0443743	.0035445	.0209694	.037171	.0515775
No	20	.0311341	.0057171	.0255677	.019168	.0431001
Combined	55	.0395597	.0031571	.0234133	.0332301	.0458892
Diff		.0132402	.00637		.0004636	.0260168

Diff = mean(Yes) - mean(No) t = 2.0785

H₀: diff = 0 Degrees of freedom = 53

H₁: diff < 0 H₁: diff ≠ 0 H₁: diff > 0

Pr(T < t) = 0.9787 Pr(|T| > |t|) = 0.0425 Pr(T > t) = 0.0213

The results from Table 16 indicate that listed banks are more profitable than unlisted banks on the average. The profit level of listed banks exceed that of unlisted banks on average. From Table 16, we fail to reject the hypothesis, H₁: diff > 0 at a 5% significant level. Meaning, on the average listed banks are more profitable than unlisted banks. This highlights the literature that listed banks are more profitable than unlisted banks, even though they are less efficient than unlisted banks. Indicating that efficiency does not necessarily mean profitability.

Hypotheses Testing

Previously, a Likelihood Ratio Test was used to test the null hypothesis that the Translog Stochastic Frontier Functional form reduces to Cobb-Douglas form. The test statistic, $H_0: \beta_{ij}=0$ and $H_1: \beta_{ij} \neq 0$, gives a likelihood ratio that makes the Translog Model a much preferred and robust model. The Translog Model does not reduce to a Cobb-Douglas Model.

Table 17

Hypotheses Tests for Model Specification and Statistical Assumptions

Null Hypothesis	Likelihood Ratio test (LR)	df	P-value	Decision
Testing the null hypothesis that translog model can be reduced to Cobb-Douglas model				
$H_0: \beta_{ij}=0$	47.3329	6	0.000	Reject H_0
Testing the specification of technical inefficiency model				
$H_0: \gamma=\delta_0=\delta_1=\dots=\delta_{13}=0$	80.3716	11	0.000	Reject H_0
$H_0: \gamma = 0$	32.4354	1	0.000	Reject H_0
$H_0: \delta_0=\delta_2=\dots=\delta_{13}=0$	47.9362	8	0.000	Reject H_0
$H_0: \mu=0$	7.1471	1	0.000	Reject H_0

Sources: Computed Using STATA 13.1

Testing the model specification for technical inefficiency in Table 17, the results show that both null hypotheses that the technical inefficiency effects are absent and that inefficiency effects are not stochastic, as stated in the first two null hypotheses, are rejected. In this case, it can be said that inefficiencies are present and they are stochastic. The third null hypothesis determines whether the variables included in the inefficiency effects model have no effect on the level of technical inefficiency. $H_0: \delta_0 = \delta_1 = \dots = \delta_{13} = 0$, the null hypothesis is rejected confirming that the joint effect of these variables on technical inefficiency is statistically significant. The final null hypothesis explores the test that specifies that each bank is operating on the technically efficient frontier and that the systematic and random technical efficiency in the inefficiency effects are zero. This is rejected in favour of the presence of inefficiency effects.

Summary

This chapter indicates that banks listed on the GSE are no more efficient than banks not listed on the stock market. However, the listed banks are more profitable than unlisted banks. Also, the study discovered that foreign owned banks are more efficient than domestic owned banks. The profit level, net interest income and tangible assets are bank specific factors that affect both listed and unlisted banks. The size of a bank positively influences bank efficiency, although it affects unlisted banks more strongly than it does for listed banks. Increasing the share of industry advances will improve the bank's efficiency level. Ghana's economic performance was found to influence unlisted banks strongly.

CHAPTER SIX

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

This chapter summarizes the report and presents findings from the tables of frontier estimates and marginal effects in chapter four. It makes policy recommendations based on the findings and suggestions for further studies.

Summary

Banks provide liquidity, payments and safekeeping for depositors` and channel these funds into investment and working capital requirements. The efficiency of Banks contribute to the rapid economic growth of a country.

The study adopted the intermediary approach and used net loans and advances as output and as inputs; deposits, physical capital and interest expenses, to estimate the technical efficiency levels of the banks for five (5) years. The estimation technique used was the Maximum Likelihood Estimation with the two-step Stochastic Production Frontier Model and the Translog functional form specification. The efficiency estimates from the stochastic frontier modelling were controlled for exogenous variables that determines bank technical efficiency.

The objective of the study to determine listing on GSE influence bank efficiency was accomplished. The findings indicated that unlisted banks were more technically efficient than listed banks. Thus, a policy recommendation of listing firms on GSE solely for increasing its efficiency is unnecessary. However, it was

proven that foreign owned banks have higher efficiency scores than state-owned and domestic private owned banks. Also, the findings indicated that listed banks are more profitable.

Findings from the study regarding determinants of technical efficiency of banks proved that different factors determine the efficiency of listed banks and unlisted banks. Ownership status, profit level, performance, asset tangibility, bank share of industry advances and money supply were factors that significantly determines the technical efficiency of banks listed on the GSE. Determinants of technical efficiency for unlisted banks were bank size, profit level, liquidity ratio, loan deposit ratio, loan intensity, bank share in industry deposit, asset tangibility, inflation, GDP, money supply and net interest income.

Conclusions

The general objective of estimating the technical efficiency level of sampled licensed banks, both listed and unlisted banks, in Ghana has been achieved. The average efficiency score of listed banks is 47.74% and that of unlisted banks is 58.84%. The overall average technical efficiency of the industry efficiency is approximately 51.78%. This means that the banking industry in Ghana can increase the amount of loans and advances given to the public by 48% without increasing the amount of inputs usage.

In comparing of the means of efficiency for the two groups, it was concluded that listing on GSE does not improve the technical efficiency of a bank.

Rather, it increases the profit margin of the bank. Thus, the need to increase profit level of banks should guide banks into listing on the stock market.

The results from the study indicate that factors like, profit level, performance of the bank, asset tangibility and money supply are determinants of banks regardless of the bank being listed or not. The bank size, liquidity ratio, loan deposit ratio and loan intensity were found to only determine the technical efficiency estimates of banks that are not listed on the GSE. Inflation and share of industry advances positively influence efficiency estimates, whereas bank's share in industry deposit negatively affect efficiency. Foreign banks were found to be better-off with a higher efficiency level as compared to domestic-owned banks, either state-owned or private-owned.

The results from the study indicated that foreign banks that are listed on GSE would have the highest profit level when ranked with foreign unlisted banks, domestic listed and domestic unlisted banks. This is because on the average, listed banks are more profitable than unlisted banks. Also, foreign banks are more profitable than their domestic owned counterpart. Thus, a bank with majority of foreign ownership and listed on the GSE would be most profitable.

The size of a bank is only relevant to the technical efficiency of unlisted banks. The technical efficiency of banks that are listed on the GSE is not influenced by the size of the bank.

The study indicated that the technical efficiency of unlisted banks largely depends on the performance of the economy, measured by the macroeconomic

indicators used in the study. Whereas the technical efficiency of listed banks is determined by the level of money supply in the economy, efficiency of unlisted banks is dependent on inflation, real GDP and money supply. This indicates that listed banks are more independently efficient from Ghana's economic performance as compared to unlisted banks.

Recommendation

Given the empirical findings of the study, the following recommendations are made for the attention of policy makers and managers of banks in Ghana.

Findings from this study provides evidence that banks that list shares on the stock market are more profitable. Therefore, the study recommends the formulation and implementation of policy for banks in Ghana to list their shares on the GSE to increase the profit margin and provide the avenue for banks in capital generation. Bank of Ghana is advised to take active role in encouraging firms in general to list on the stock market.

Partnership with foreign organisations in owning state-owned banks is recommended for the government. In order to improve the domestic bank's efficiency, the Government is advised to consider partnership with foreign management. This is because the study confirmed that foreign owned banks are more efficient than domestic owned banks.

The study proposes that Bank of Ghana formulates expansionary monetary policy through reduction in the required reserves with the Central Bank for instance

to increase the quantity of money in the economy. This will increase the technical efficiency of all banks, both listed and unlisted banks.

Bank size was found to have a positive influence over bank efficiency outcome. This means that banks that are not listed increases their technical efficiency as they increase their total assets. Managers are advised to maintain large quantities of liquid assets on the bank's premises to satisfy customer's demands for either loans or personal account withdrawal. As it was discovered that banks with high liquidity ratio are more efficient than banks with low liquidity.

Limitations of the study

The sample selection for this study was done on the availability of recorded data and cooperation of bank authorities. Limiting the researcher from doing a strictly random sampling of the unlisted banks. The annual financial reports of the banks extracted from the websites of the banks did not have the full report, leading to the omission of some suggested variables from the study.

Easily accessible and complete financial reports of financial institutions will allow for a more comprehensive future study. We encountered financial constraints in the course of this research considering the high cost of frequent trips to headquarters of banks, use of internet and visit to libraries for information gathering, printing and photocopying documents. The money allocated for Thesis from the Ghana government is not sufficient to cover all the expenses that was incurred by the researcher.

Despite the above limitations, we believe this research has been a valuable study because it has offered an original contribution to the knowledge on the technical efficiency of banks in the Ghana and the factors that will cause it to improve.

Suggestions for Further Study

Further research must focus on developing an appropriate frontier model analysing efficiency of banks and embodying all components of the banking industry including bank risk, portfolio at risk (PaR) and human capital variables such as educational background, gender and age of the head manager of the bank. Including these variables in the estimation of the stochastic frontier model would result in improvements of the estimated efficiency scores.

Similarly, further research can extend this study by estimating not only technical efficiency but cost efficiency and X-efficiency of licensed banks in Ghana. Researchers can also incorporate analysis of efficiency levels and profitability of foreign listed banks and domestic unlisted banks. Such study would broaden the scope of analysis and include all 27 licensed banks in Ghana.

REFERENCES

- Adjei-Frimpong, K. (2013). *Bank efficiency and bank competition: empirical evidence from Ghana's banking industry*. (Doctoral dissertation). Lincoln University.
- Aigner, D., Lovell, C. K., & Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, 6(1), 21–37.
- Aikaeli, J. (2008). Commercial Banks Efficiency in Tanzania. Presented at the Economic Development in Africa, St. Catherine's College, Oxford.
- Akoena, S. K., Aboagye, A. Q. Q., & Antwi-Asare, T. O. (2013). A study of Bank Efficiencies in Ghana. *African Journal of Management Research*, 21(1), 2–17.
- Alhassan, A. L., & Tetteh, M. L. (2017). Non-Interest Income and Bank Efficiency in Ghana: A Two-Stage DEA Bootstrapping Approach. *Journal of African Business*, 18(1), 124–142.
- Ali, A. I., & Seiford, L. M. (1993). Computational accuracy and infinitesimals in data envelopment analysis. *INFOR: Information Systems and Operational Research*, 31(4), 290–297.
- Ally, Z. (2013). Efficiency Analysis of Commercial Banks in Tanzania: An Application of Data Envelopment Analysis (DEA) Approach: The Case

study of Regional & Small Banks. *European Journal of Business and Management*, 5, 12.

Ambrose, B. W., & Buttimer, R. J. (2005). GSE impact on rural mortgage markets. *Regional Science and Urban Economics*, 35(4), 417–443.

Anim, T. E. (2000). *Banking in Ghana*. Accra, Ghana: Woeli Publishing Services, Accra, Ghana.

Assaf, A. G., Barros, C. P., & Matousek, R. (2011a). Productivity and efficiency analysis of Shinkin banks: Evidence from bootstrap and Bayesian approaches. *Journal of Banking & Finance*, 35(2), 331–342.

Assaf, A. G., Barros, C. P., & Matousek, R. (2011b). Technical efficiency in Saudi banks. *Expert Systems with Applications*, 38(5), 5781–5786.

Badarudin, Z. E., Khalid, A. M., & Ariff, M. (2009). Money supply behaviour in emerging economies: a comparative analysis. *Journal of the Asia Pacific Economy*, 14(4), 331–350.

Badunenko, O., Henderson, D. J., & Kumbhakar, S. C. (2012). When, where and how to perform efficiency estimation. *Journal of the Royal Statistical Society: Series A (Statistics in Society)*, 175(4), 863–892.

Baltagi, B. (2008). *Econometric analysis of panel data*. John Wiley & Sons.

Bank of Ghana. (2016, May). *Financial Stability Report Vol. 1.1*.

Bank of Ghana, 2016< <http://www.bog.gov.gh>: Register of Licensed Institutions>, accessed: 2016-05-13

Battese, G. E., & Rao, D. P. (2001). Productivity potential and technical efficiency levels of firms in different regions using a stochastic frontier metaproduction function model. *Productivity Potential and Technical Efficiency Levels of Firms in Different Regions Using a Stochastic Frontier Metaproduction Function Model*.

Battese, George E., & Coelli, T. J. (1988). Prediction of firm-level technical efficiencies with a generalized frontier production function and panel data. *Journal of Econometrics*, 38(3), 387–399.

Battese, George E., & Corra, G. S. (1977). Estimation of a production frontier model: with application to the pastoral zone of Eastern Australia. *Australian Journal of Agricultural Economics*, 21(3), 169–179.

Battese, George Edward, & Coelli, T. J. (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics*, 20(2), 325–332.

Bawumia, M., Owusu-Danso, T., & McIntyre, A. (2008). Ghana's reforms transform its financial sector. *IMF Survey Magazine: Countries & Region*, 1–4.

- Beccalli, E., Casu, B., & Girardone, C. (2006). Efficiency and stock performance in European banking. *Journal of Business Finance & Accounting*, 33(1–2), 245–262.
- Bell, F. W., & Murphy, N. B. (1968). *Costs in commercial banking: A quantitative analysis of bank behavior and its relation to bank regulation* (Vol. 41). Federal Reserve Bank of Boston.
- Benston, G. J. (1965). Branch banking and economies of scale. *The Journal of Finance*, 20(2), 312–331.
- Bergendahl, G. (1998). DEA and benchmarks—an application to Nordic banks. *Annals of Operations Research*, 82, 233–250.
- Berger, A. N., & Di Patti, E. B. (2006). Capital structure and firm performance: A new approach to testing agency theory and an application to the banking industry. *Journal of Banking & Finance*, 30(4), 1065–1102.
- Berger, A. N., Hasan, I., & Klapper, L. F. (2004). Further evidence on the link between finance and growth: An international analysis of community banking and economic performance. *Journal of Financial Services Research*, 25(2–3), 169–202.
- Berger, A. N., & Humphrey, D. B. (1991). The dominance of inefficiencies over scale and product mix economies in banking. *Journal of Monetary Economics*, 28(1), 117–148.

- Berger, A. N., & Humphrey, D. B. (1997). Efficiency of financial institutions: International survey and directions for future research. *European Journal of Operational Research*, 98(2), 175–212.
- Bonin, J. P., Hasan, I., & Wachtel, P. (2005). Bank performance, efficiency and ownership in transition countries. *Journal of Banking & Finance*, 29(1), 31–53.
- Bravo-Ureta, B. E., Pinheiro, A. E., & others. (1993). Efficiency analysis of developing country agriculture: a review of the frontier function literature. *Agricultural and Resource Economics Review*, 22(1), 88–101.
- Buchs, T. D., & Mathisen, J. (2005). Competition and efficiency in banking: Behavioral evidence from Ghana.
- Business News, < <http://www.graphic.com.gh>: The Capital Market: A key to the Economic Growth and Development>, accessed: 2013-05-14
- Cappizzi, V. (1999). *Banking efficiency study: A qualitative and quantitative approach*. Working paper. Universita Bocconi, Milan, Italy.
- Caudill, S. B., & Ford, J. M. (1993). Biases in frontier estimation due to heteroscedasticity. *Economics Letters*, 41(1), 17–20.
- Chaffai, M. E. (1997). Estimating input-specific technical inefficiency: The case of the Tunisian banking industry. *European Journal of Operational Research*, 98(2), 314–331.

- Charnes, A., Cooper, W., Golany, B., Seiford, L., & Stutz, J. (1985). Foundations of data envelopment analysis for Pareto-Koopmans efficient empirical production functions. *Journal of Econometrics*, 30(1–2), 91–107.
- Chen, C. (2009). Bank efficiency in Sub-Saharan African middle income countries. *IMF Working Papers*, 1–32.
- Chiu, Y.-W., Walseth, B., & Suh, S. (2009). Water embodied in bioethanol in the United States. *Environmental Science & Technology*, 43(8), 2688–2692.
- Claessens, S., Demirgüç-Kunt, A., & Huizinga, H. (2001). How does foreign entry affect domestic banking markets? *Journal of Banking & Finance*, 25(5), 891–911.
- Coelli, T., Rao, D. P., & Battese, G. E. (1998). An Introduction to Efficiency and Productivity Analysis Kluwer Academic Publishers. *Boston/Dordrecht*.
- Coelli, Tim. (1995). Estimators and hypothesis tests for a stochastic frontier function: A Monte Carlo analysis. *Journal of Productivity Analysis*, 6(3), 247–268.
- Darrat, A. F., Topuz, C., & Yousef, T. (2002). Assessing cost and technical efficiency of banks in Kuwait. In *Unpublished paper. The ERF 8th Annual Conference, January, Cairo*.
- Das, A., & Ghosh, S. (2006). Financial deregulation and efficiency: An empirical analysis of Indian banks during the post reform period. *Review of Financial Economics*, 15(3), 193–221.

- Dasmani, I. (2010). Determinants of Technical Efficiency of Small Scale Batik Producers In The Central Region Of Ghana.
- David, & Alhadeff, C. (1964). Growth of large banks, 1930-1960. *The Review of Economics and Statistics*, 356–363.
- Debreu, G. (1951). The coefficient of resource utilization. *Econometrica: Journal of the Econometric Society*, 273–292.
- Debreu, G. (1959). *Theory of value: An axiomatic analysis of economic equilibrium*. Yale University Press.
- Deesomsak, R., Paudyal, K., & Pescetto, G. (2004). The determinants of capital structure: evidence from the Asia Pacific region. *Journal of Multinational Financial Management*, 14(4), 387–405.
- Deng, C.-G., Liu, T., & Wu, J. (2007). Efficiency analysis of China's commercial banks based on DEA: Negative output investigation. *China-USA Bus. Rev.*, 6(2), 50–56.
- Desli, E., Ray, S. C., & Kumbhakar, S. C. (2003). A dynamic stochastic frontier production model with time-varying efficiency. *Applied Economics Letters*, 10(10), 623–626.
- di Patti, E. B., & Hardy, D. C. (2005). Financial sector liberalization, bank privatization, and efficiency: Evidence from Pakistan. *Journal of Banking & Finance*, 29(8), 2381–2406.

- Dietsch, M., & Lozano-Vivas, A. (2000). How the environment determines banking efficiency: A comparison between French and Spanish industries. *Journal of Banking & Finance*, 24(6), 985–1004.
- Drake, L. (2001). Efficiency and productivity change in UK banking. *Applied Financial Economics*, 11(5), 557–571.
- Drobetz, W., & Fix, R. (2003). What are the determinants of the capital structure? Some evidence for Switzerland. *WWZ/Department of Finance, Working Paper*, (4/03), 1–37.
- Färe, R., & Grosskopf, S. (1985). A nonparametric cost approach to scale efficiency. *The Scandinavian Journal of Economics*, 594–604.
- Färe, R., & Primont, D. (2012). *Multi-output production and duality: theory and applications*. Springer Science & Business Media.
- Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society. Series A (General)*, 120(3), 253–290.
- Favero, C. A., & Papi, L. (1995). Technical efficiency and scale efficiency in the Italian banking sector: a non-parametric approach. *Applied Economics*, 27(4), 385–395.
- Fiorentino, E., Karmann, A., & Koetter, M. (2006). The cost efficiency of German banks: a comparison of SFA and DEA. *Available at SSRN 947340*.

- Fried, H. O., Lovell, C. K., & Schmidt, S. S. (2008). Efficiency and productivity. *The Measurement of Productive Efficiency and Productivity Growth*, 3, 3–91.
- Frimpong, J. M. (2010a). Investigating efficiency of Ghana banks: A non-parametric approach. *American Journal of Scientific Research*, 7(4), 64–76.
- Frimpong, J. M. (2010b). The financial performance of commercial banks in Ghana: a post-FINSSP analysis. *Banking and Finance Letters*, 2(3), 349.
- Graphic.com.gh. (2013, May 15). BoG pushes banks to list on the GSE. *Business News*.
- Greene, W. H. (2008). The econometric approach to efficiency analysis. *The Measurement of Productive Efficiency and Productivity Growth*, 92–250.
- Guerrero, R., & Negrín, J. L. (2005). Efficiency of the Mexican banking system 1997-2004: A dynamic estimation. *Bank of Mexico*.
- Hassan, M. K., & Bashir, A.-H. M. (2003). Determinants of Islamic banking profitability. In *10th ERF annual conference, Morocco* (pp. 16–18).
- Hauer, D. (2004). Explaining efficiency differences among large German and Austrian Banks.
- Hauer, D., & Peiris, S. J. (2008). Banking efficiency and competition in low income countries: the case of Uganda. *Applied Economics*, 40(21), 2703–2720.

- Havrylchyk, O. (2006). Efficiency of the Polish banking industry: Foreign versus domestic banks. *Journal of Banking & Finance*, 30(7), 1975–1996.
- Hayami, Y. (1969). Sources of agricultural productivity gap among selected countries. *American Journal of Agricultural Economics*, 51(3), 564–575.
- Hayami, Y., & Ruttan, V. W. (1970). Agricultural productivity differences among countries. *The American Economic Review*, 895–911.
- Ho, C.-T., & Zhu, D.-S. (2004). Performance measurement of Taiwan's commercial banks. *International Journal of Productivity and Performance Management*, 53(5), 425–434.
- Holló, D., & Nagy, M. (2006). Bank efficiency in the enlarged European Union. *BIS Papers*, (28), 217–235.
- Hosono, K. (2003). Growth opportunities, collateral and debt structure: the case of the Japanese machine manufacturing firms. *Japan and the World Economy*, 15(3), 275–297.
- Huang, C. J., & Liu, J.-T. (1994). Estimation of a non-neutral stochastic frontier production function. *Journal of Productivity Analysis*, 5(2), 171–180.
- Huang, H.-C. (2004). Estimation of technical inefficiencies with heterogeneous technologies. *Journal of Productivity Analysis*, 21, 277–296.

- Huang, S. G., & Song, F. M. (2004). The determinants of capital structure: Evidence from China. *CHINA ECONOMIC QUARTERLY-BEIJING-*, 3, 395–414.
- Hughes, J. P., & Mester, L. J. (1993). A quality and risk-adjusted cost function for banks: Evidence on the “too-big-to-fail” doctrine. *Journal of Productivity Analysis*, 4(3), 293–315.
- Ikhide, S. (2000). Efficiency of Commercial Banks in Namibia. BANK OF NAMIBIA, RESEARCH DEPARTMENT.
- Jondrow, J., Lovell, C. K., Materov, I. S., & Schmidt, P. (1982). On the estimation of technical inefficiency in the stochastic frontier production function model. *Journal of Econometrics*, 19(2–3), 233–238.
- Kablan, S. (2007). Measuring Bank Efficiency in Developing Countries: The Case of WAEMU (West African Economic Monetary Union). *African Economic Research Consortium*, 1–30.
- Karlaftis, M. G. (2004). A DEA approach for evaluating the efficiency and effectiveness of urban transit systems. *European Journal of Operational Research*, 152(2), 354–364.
- Kenjegalieva, K., Simper, R., Weyman-Jones, T., & Zelenyuk, V. (2009). Comparative analysis of banking production frameworks in Eastern European financial markets. *European Journal of Operational Research*, 198(1), 326–340.

- Koopmans, T. C. (1951). Efficient allocation of resources. *Econometrica: Journal of the Econometric Society*, 455–465.
- Kopp, R. J., & Smith, V. K. (1980). Frontier production function estimates for steam electric generation: A comparative analysis. *Southern Economic Journal*, 1049–1059.
- Kumar, S., & Gulati, R. (2009). Measuring efficiency, effectiveness and Performance of Indian Public Sector banks. *International Journal of Productivity and Performance Management*, 59(1), 51–74.
- Kumbhakar, S. C., & Lovell, C. A. K. (2000). Stochastic Frontier Analysis, Cambridge University Press. *Cambridge Cambridge*.
- Kumbhakar, Subal C., Ghosh, S., & McGuckin, J. T. (1991). A generalized production frontier approach for estimating determinants of inefficiency in US dairy farms. *Journal of Business & Economic Statistics*, 9(3), 279–286.
- Kutsienyo, L. (2011). *The Determinant Of Profitability Of Banks In Ghana* (Doctoral dissertation). Institute of Distance Learning, Kwame Nkrumah University of Science and Technology.
- Lartey, E. (2015). *The Effect of Interest Rate on Capital Structure Of Listed Ghanaian Firms On The Ghana Stock Exchange*. University of Cape Coast, Ghana.

- Lau, L. J., & Yotopoulos, P. A. (1989). The meta-production function approach to technological change in world agriculture. *Journal of Development Economics*, 31(2), 241–269.
- Levine, R. (1997). Financial development and economic growth: views and agenda. *Journal of Economic Literature*, 35(2), 688–726.
- Manjunatha, A. V., Speelman, S., Van Huylenbroeck, G., & Chandrakanth, M. G. (2009). Impact of groundwater markets in peninsular India on water use efficiency: A Data Envelopment Analysis approach. In *Contributed Paper prepared for presentation at the International Association of Agricultural Economists Conference, Beijing, China, August* (pp. 16–22).
- Maudos, J., Pastor, J. M., Perez, F., & Quesada, J. (2002). Cost and profit efficiency in European banks. *Journal of International Financial Markets, Institutions and Money*, 12(1), 33–58.
- Meeusen, W., & J Van den Broeck. (1977). Efficiency Estimation from Cobb-Douglas production functions with Composed Error. *International Economic Review*, (18), 435–444.
- Miller, S. M., & Noulas, A. G. (1996). The technical efficiency of large bank production. *Journal of Banking & Finance*, 20(3), 495–509.
- Mouzas, S. (2006). Efficiency versus effectiveness in business networks. *Journal of Business Research*, 59(10), 1124–1132.

- Murillo-Zamorano, L. R. (2004). Economic efficiency and frontier techniques. *Journal of Economic Surveys*, 18(1), 33–77.
- Noor, M. A. N. M., & Ahmad, N. H. B. (2012). The determinants of Islamic banks' efficiency changes: empirical evidence from the world banking sectors. *Global Business Review*, 13(2), 179–200.
- Ogunniyi, L. T. (2008). Profit efficiency among cocoyam producers in Osun State, Nigeria. *International Journal of Agricultural Economics and Rural Development*, 1(1), 38–46.
- Owusu-Ansah, B. (2015). *Analysis of Technical and Cost Efficiency of Co-Operative Financial Institutions in Ghana: An Application of Stochastic Frontier Approach*.
- Ozcan, Y. A. (2008). Health care benchmarking and performance evaluation. *An Assessment Using Data Envelopment Analysis (DEA)*. Retrieved from <http://link.springer.com/content/pdf/10.1007/978-1-4899-7472-3.pdf>
- Papanikolaou, N., & Delis, M. (2009). Determinants of bank efficiency: Evidence from a semi-parametric methodology. *Managerial Finance*, 35(3), 260–275.
- Pasiouras, F., Delis, M. D., & Papanikolaou, N. I. (2009). Determinants of bank efficiency: evidence from a semi-parametric methodology. *Managerial Finance*, 35(3), 260–275.

- Pattillo, M. C. A., Gulde, M. A. M., Carey, K. J., Wagh, M. S., & Christensen, M. J. (2006). *Sub-Saharan Africa: financial sector challenges*. International Monetary Fund.
- Pitt, M. M., & Lee, L. F. (1982). The measurement and sources of technical inefficiency in the Indonesian Weaving Industry. *Journal of Development Economics*.
- PricewaterhouseCoopers (PwC), & Ghana Association of Bankers. (2009). Ghana Banking Survey 2009.
- PricewaterhouseCoopers (PwC), & Ghana Association of Bankers. (2014). Ghana Banking Survey 2014.
- Radam, A., Yacob, M. R., & Muslim, H. F. M. (2010). Technical efficiency of the Malaysian wooden furniture industry: A stochastic frontier production approach. *International Business Research*, 3(3), 10.
- Raphael, G. (2013a). Bank-specific, industry-specific and macroeconomic determinants of bank efficiency in Tanzania: A two stage analysis. *European Journal of Business and Management*, 5(2).
- Raphael, G. (2013b). Measuring efficiency, effectiveness and performance of Tanzanian commercial banks: A two stage analysis. *European Journal of Business and Management*, 5(7), 55–67.
- Reddy, B. S. (2003). Overcoming the energy efficiency gap in India's household sector. *Energy Policy*, 31(11), 1117–1127.

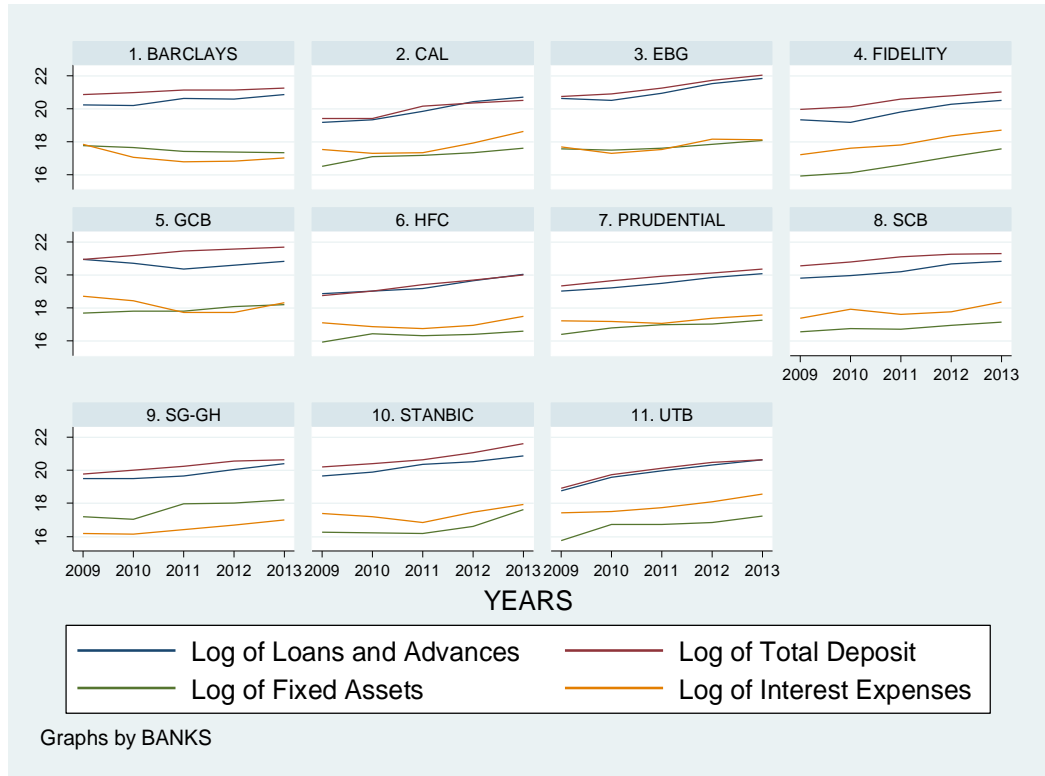
- Reifschneider, D., & Stevenson, R. (1991). Systematic departures from the frontier: a framework for the analysis of firm inefficiency. *International Economic Review*, 715–723.
- Resti, A. (1997). Evaluating the cost-efficiency of the Italian banking system: What can be learned from the joint application of parametric and non-parametric techniques. *Journal of Banking & Finance*, 21(2), 221–250.
- Rhoades, S. A., & Yeats, A. J. (1974). Growth, consolidation and mergers in banking. *The Journal of Finance*, 29(5), 1397–1405.
- Rwaheru, A. A. (2015, August). *Technical Efficiency And Its Determinants In Seed Potato Value Chain In Uganda*. PHD Proposal presented at the AERC-CPP-JFE, Tanzania.
- Saka, A. N. A., Wittbom, E., & Tavassoli, M. (2010). Effects of Foreign Bank Entry on Technical Efficiency of a Bank Sector—The Case of Ghana.
- Schenk, R. (2004). What is economic efficiency? *Journal of Economic Education, Cyber Economics*, 34(2), 191.
- Sealey, C. W., & Lindley, J. T. (1977). Inputs, outputs, and a theory of production and cost at depository financial institutions. *The Journal of Finance*, 32(4), 1251–1266.
- Shepherd, R. W. (2015). *Theory of cost and production functions*. Princeton University Press.

- Sufian, F. (2009). Determinants of bank efficiency during unstable macroeconomic environment: Empirical evidence from Malaysia. *Research in International Business and Finance*, 23(1), 54–77.
- Taylor, W. M., Thompson, R. G., Thrall, R. M., & Dharmapala, P. S. (1997). DEA/AR efficiency and profitability of Mexican banks a total income model. *European Journal of Operational Research*, 98(2), 346–363.
- Varian, H. R. (1992). *Microeconomic Analysis* (3rd ed.). W.W. Norton & Inc., New York.
- Wang, H.-J., & Schmidt, P. (2002). One-step and two-step estimation of the effects of exogenous variables on technical efficiency levels. *Journal of Productivity Analysis*, 18(2), 129–144.
- Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data*. MIT press.
- Yartey, C. A. (2006). The stock market and the financing of corporate growth in Africa: the case of Ghana. *IMF Working Papers*, 1–44.
- Yartey, C. A., & Adjasi, C. K. (2007). *Stock market development in Sub-Saharan Africa: Critical issues and challenges*. International Monetary Fund.
- Yeh, Q.-J. (1996). The application of data envelopment analysis in conjunction with financial ratios for bank performance evaluation. *Journal of the Operational Research Society*, 47(8), 980–988.

APPENDICES

Appendix A

A line chart showing the trend of the intermediary inputs and output of banks for 2009-2013



Source: Computed using STATA 13.1

Appendix B

Banks in existence during the 2009 Ghana Banking Survey.

Name of Bank	Year of Incorporation	Ownership	Branches
Agricultural Development Bank Ltd	1965	Local	51
Amalgamated Bank Limited	1997	Foreign	12
Barclays Bank Ghana Limited *	1917	Foreign	154
Bank of Baroda Ltd	2007	Foreign	1
BSIC Ghana Limited	2008	Foreign	1
CAL Bank Limited**	1990	Local	13
Ecobank Ghana Limited **	1990	Foreign	44
Fidelity Bank Ghana Limited *	2006	Local	9
First Atlantic Merchant Bank Ltd	1994	Local	5
GCB Bank Limited **	1953	Local	148
GT Bank (Ghana) Limited	2004	Foreign	9
HFC Bank Ghana Limited **	1990	Local	17
Intercontinental Bank Limited	2006	Foreign	12
International Commercial Bank (Ghana) Ltd	1996	Foreign	12
Merchant Bank (Ghana) Limited	1971	Local	15
National Investment Bank Ltd	1963	Local	27
Prudential Bank Limited *	1993	Local	9
Societe Generale Ghana Limited **	1975	Foreign	29
Stanbic Bank Ghana Limited *	1999	Foreign	13
Standard Chartered Bank Ghana Ltd**	1896	Foreign	19
The Trust Bank Limited	1996	Local	17
UniBank Ghana Limited	1997	Local	12
United Bank of Africa (Ghana) Limited	2004	Foreign	16

Zenith Bank (Ghana) Limited	2005	Foreign	12
UT Bank Limited **	1995	Local	9

*Sampled banks that are not listed on the Ghana Stock Exchange

**Sampled banks that have their shares listed on the Ghana Stock Exchange

Source: Ghana Banking Survey, 2009

Appendix C

*Parameter Estimates of Stochastic Production Frontier and Technical Inefficiency
Models for Listed Banks*

Variables	Parameters	Coefficient	Standard error
<i>Stochastic Production Frontier</i>			
Constant	β_0	-6.733091	.
ln(Dep)	β_1	-4.556869**	2.200156
ln(FAss)	β_2	8.07363**	3.210002
ln(IE _x)	β_3	-.6639022	1.40078
ln(DEP) ²	β_{11}	-.306472**	.1242615
ln(FAss) ²	β_{22}	-.761028***	.1759394
ln(IE _x) ²	β_{33}	-.010481	.0873632
ln(Dep)ln(FAss)	β_{12}	.9310127***	.2007669
ln(Dep)ln(IE _x)	β_{13}	.1010032	.2013627
ln(FAss)ln(IE _x)	β_{23}	-.0445272	.1566384

Table continued

Technical Inefficiency Model			
Constant	δ_0	-29.59542	.
Liquidity ratio	δ_1	-118.5093*	69.87659
Own (1=Domestic-owned)	δ_2	-12.27456**	5.840771
Profitability	δ_4	8.432427	.
Firm Size	δ_5	31.21873***	5.788831
Age	δ_6	-.88776*	.5177855
Asset tangibility	δ_7	-1.584759	.
Industry deposits	δ_{10}	-41.751	.
Variance parameters			
E(sigma_u)	σ_u	836943.4	
sigma_v	σ_v	.0704408***	.0104433
Ln (likelihood)		49.8800***	

Note: *, **, *** denote significance at 10%, 5% and 1% respectively

Source: Computed using STATA 13.1

Appendix D

Parameter estimates of stochastic production frontier and technical inefficiency models for unlisted banks.

Variables	Parameters	Coefficient	Standard error
Stochastic Production Frontier			
Constant	β_0	-82.88886	371.1167
ln(Dep)	β_1	11.60217	76.44009
ln(FAss)	β_2	-1.45517	51.51312
ln(IEx)	β_3	-1.095896	.
ln(DEP) ²	β_{11}	1.750384	1.263742
ln(FAss) ²	β_{22}	-.80161	1.824065
ln(IEx) ²	β_{33}	2.038683	4.344966
ln(Dep)ln(FAss)	β_{12}	.008178	2.857255
ln(Dep)ln(IEx)	β_{13}	-4.768626	9.632192
ln(FAss)ln(IEx)	β_{23}	1.642798	3.098798

Table continued

Technical Inefficiency Model			
Constant	δ_0	-63.4024	
Liquidity ratio	δ_1	40.74621*	21.24837
Own (1=Domestic-owned)	δ_2	-11.07663***	.9324306
Profitability	δ_4	120.8689	.
Firm Size	δ_5	-54.21064***	.7644926
Age	δ_6	.1240787***	.0306161
Asset tangibility	δ_7	8.323517	136.3352
Industry deposits	δ_{10}	-7.97931	.
Variance parameters			
E(sigma_u)		557.837	
sigma_v		0.096897	
Ln (likelihood)		5.1085	

Note: *, **, *** denote significance at 10%, 5% and 1% respectively

Source: Computed using STATA 13.1