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COLLEGE OF HUMANITIES

IMPACT OF RISKS ON THE PRODUCTIVITY OF BANKS IN GHANA

BY

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THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF MPHIL IN OPERATIONS MANAGEMENT DEGREE.

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DECLARATION

I do hereby declare that this thesis is the result of my own research and has not been presented by anyone for any academic award in this or any other university. All references used in the work have been fully acknowledged.

I bear sole responsibility for any shortcomings.

…………………………… **30TH JULY, 2021**

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CERTIFICATION

I hereby certify that this thesis was supervised in accordance with procedures laid down by the University of Ghana.

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DEDICATION

This work is dedicated to the Holy Spirit, who has been my help, to my lovely parents, Mr. Jonathan Mensah Doku and Ms. Patience Ayornu for their support and encouragement, and to my academic mentor, Dr. Kwaku Ohene-Asare, for believing in me and guiding me throughout the period of this studies.

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TABLE OF CONTENTS

University of Ghana http://ugspace.ug.edu.gh

University of Ghana http://ugspace.ug.edu.gh

University of Ghana http://ugspace.ug.edu.gh

LIST OF TABLES

University of Ghana http://ugspace.ug.edu.gh

LIST OF FIGURES

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LIST OF ACRONYMS

AE	Allocative Efficiency
AQR	Asset Quality Review
BCC	Banker Charnes & Cooper Model
BMPI	Biennial Malmquist Productivity Index
BMPSCORE	Biennial Malmquist Productivity Score
BOG	Bank of Ghana
BPEC	Biennial Pure Efficiency Change
BPTC	Biennial Pure Technical Change
BSEC	Biennial Scale Change
BTC	Biennial Technical Change
CCR	Charnes Cooper & Rhodes Model
CRS	Constant Returns to Scale
DEA	Data Envelopment Analysis
DFA	Distribution Free Approach
DMU	Decision Making Unit
EC	Efficiency Change
FA	Fixed Assets
FE	Fixed Effects
GDP	Gross Domestic Product
GHS	Ghana Cedis
GMM	Generalized Method of Moments
GSE	Ghana Stock Exchange

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LP	Linear Programming
MPC	Monetary Policy Committee
MPI	Malmquist Productivity Index
MPR	Monetary Policy Rate
OWN	Ownership
PPE	Plant, Property & Equipment
PTE	Pure Technical Efficiency
PWC	Price water house Coopers
RE	Random Effects
RE	Revenue Efficiency
RTS	Returns to Scale
SE	Scale Efficiency
SFA	Stochastic Frontier Analysis
TC	Technical Change
TE	Technical Efficiency
VRS	Variable Returns to Scale

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ABSTRACT

This study assessed the impact of risk on dynamic productivity of banks in Ghana over a 16-year period-2004 to 2019. The study considered six distinct risk parameters: credit risk, market risk, capital risk, operational risk, insolvency risk and liquidity risk. The study employed Biennial Malmquist Productivity Index: A framework within DEA to assess the productivity of banks. Using fixed effects, truncated and systems GMM regression models, this study analysed the effect of all risk measures on productivity in order to explore a more detailed causality between risk and productivity. The findings revealed that the efficiency change component of productivity was the key driver of productivity increase in the Ghanaian banking industry. Findings suggest that, size, capital risk and liquidity risk are statistically significant and positively affects productivity. However, insolvency risk had a positive relationship with productivity yet insignificant. Finally, credit risk, market risk and operational risk were found to have a negative relationship with productivity though not significant. The findings of the study have possible implications for bank prudential supervision to monitor the risk taking behaviours of managers of banks.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the study

The financial sector of the Ghanaian economy is made up of Banking and Non-Bank Financial Institutions, forex bureaus, Insurance and capital markets (BOG, 2019), of which banks perform key roles towards economic growth and development (Asteriou & Spanos, 2019; Beck & Levine, 2018; Tongurai & Vithessonthi, 2018; Fethi & Pasiouras, 2010; Levine & Beck, 2004; Miwa & Ramseyer, 2002; Beck, Demirgüç-Kunt & Levine, 2000; Demetriades & Luintel, 1996). Fethi & Pasiouras (2010) stated that, banks keep the savings of the public which they later use to finance the development of businesses. According to a mid-year report by the BOG in 2019, the total domestic deposits of the banking sector sumed up to GH¢75.2 billion, of which GH¢38.7 billion were given out as loans to enterprises and institutions to finance their business operations. Thus, the banking sector plays a pivotal function in the financial industry (Tan & Anchor, 2017; Hou, Wang & Zhang, 2014, Zhang, Jiang, Qu & Wang, 2013).

Proper resource distribution and risk diversification leads to an efficient banking sector which boosts economic growth (Maredza and Ikhide, 2013; Suzuki & Sastrosuwito, 2011; Saka, Aboagye & Gemegah, 2012). Given the important role of banks in mobilising savings for productive investment opportunities and sound corporate governance, the efficient production and sustainability of the banking sector is crucial to economic growth (Tongurai & Vithessonthi, 2018; Moradi-Motlagh, Saleh, Abdekhodaee & Ektesabi, 2011; Halling and Hayden, 2006; Hondroyiannis, Lolos & Papapetrou, 2005). Efficient production means doing things right and it involves eliminating waste by maximising outputs given the available inputs needed to produce desired results (Fried, Lovell & Schmidt, 2008; Mester, 1987).

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Therefore, efficient production of banks looks at how banks, which act as financial intermediaries, employ various inputs such as deposits, operating labour expenses among others to generate optimal output such as total assets, loans and advances which translates into higher profit margin. The most popular measures of evaluating a bank's efficient production are efficiency and productivity.

Many of such studies evaluating banking efficiency and productivity exist (Daraio, Kerstens, Nepomuceno & Sickles, 2019; Paradi, Sherman & Tam, 2018; Paradi & Zhu, 2013; Fethi & Pasiouras, 2010; Berger, 2007; Berger & Humphery, 1997). Studies on efficiency assess the performance of banks over one-time period, whilst studies on bank productivity provide in-depth understanding by estimating improvement in efficiency between diverse time periods (Fethi & Pasiouras, 2010; Emrouznejad, Parker & Tavares 2008; Berger, 2007). Efficiency and productivity studies on banks are needful because, they separate poor performing banks from well-performing banks and further provide more recommendations for improvement in performance of financial institutions (Fujii, Managi, Matousek & Rughoo, 2018; Chansarn, 2014; Lozano-Vivas & Pasiouras, 2014; Lin & Chiu, 2013). Hence the need to constantly evaluate their performance (Mokhtar, AlHabshi and Abdullah, 2006).

Consequently, as banks pursue their intermediation roles such as loan expansion and deposit mobilization, banks incur risks (Zhang et al., 2013; Diler, 2011; Chang & Chiu, 2006; Allen & Santomero, 1997; Pyle, 1971). Banks intermediation involves a variety of risks (Asmild & Zhu, 2016; Zhang et al., 2013; Chen, 2012; Odonkor, Osei, Abor & Adjasi, 2011; Sun & Chang, 2011). Studies have shown that, banks are exposed to these financial risks; credit risk, market risk, liquidity risk, operational risk, insolvency risk, and capital risk (Mare & Gramlich, 2020; Chen, Wu, Jeon & Wang, 2017; Tanda, 2015; Ariffin, Archer & Karim, 2009; Chavez-Demoulin et al.,

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2006). Credit risk is the risk that, a customer of a bank will default in a loan facility offered by a bank (Christophe, 2004). Liquidity risk stems from the inability to meet short-term obligations promptly due to insufficient liquidity (Drehmann & Nikolaou, 2013). When the value of an investment decreases due to volatility in exchange rate or interest rate it is termed as market risk (Sun & Chang, 2011). Operational risk is defined “as the risk of loss resulting from inadequate or failed internal processes, people, and systems, or from external events” (Basel, 2004). Insolvency risk arises out of lack of adequate funds to pay bank depositors in the event of failure (Iyer et al., 2016). Capital risk is the risk of banks losing part or all of an amount in an investment (Brooks et al., 2000). These aforementioned risks are crucial to examine because risks can influence such performance indicators as profitability, efficiency, and productivity (Daraio et al., 2019; Tan, Floros & Anchor, 2017, Tan & Floros, 2013; Lampe & Higlers, 2015; Das, 2002). Hence, it has become imperative to assess banks' performance and the amount of risks they can take. Against this background, this study examined dynamic productivity of Ghanaian banks and comprehensive risk (credit risk, liquidity risk, market risk, operational risk, insolvency risk, and capital risk) factors affecting dynamic productivity.

1.2 Problem Statement

One of the key issues in the banking industry is risk and how to manage it (Maredza and Ikhide, 2013; Hoseininassb, Yavari, Mehregan & Khoshsima, 2013). Bank risks are crucial to examine because, regulators monitor such risk-taking behaviours for policy implications (Pathan, 2009; Tan & Floros, 2018), and this is same for efficiency and productivity (Berger & Humphrey, 1997; Daraio et al., 2019). Yet, few banking efficiency and productivity studies examine the link between bank risk and performance, and existing ones are mainly in developed countries (Assaf, Berger,

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Roman, & Tsionas, 2019; Tan & Floros, 2018; Fu, Juo, Chiang & Huang, 2016; Fiordelisi, Marques-Ibanez & Molyneux, 2011; Altunbas, Liu, Molyneux & Seth, 2000; Altunbas, Carbo, Gardener & Molyneux, 2007; Berger & Mester, 1997).

For instance, Assaf et al. (2019), regressed measures of bank failure, risk, and profitability on cost and profit efficiency. They found that, cost efficiency helps banks decrease risk (non-performing loan ratio). Altunbas et al. (2007), also examined the link between capital, risk, and efficiency. They found that, efficient European banks take on more risk, whereas inefficient banks take on less risk. Tan & Floros (2018), assessed the efficiency of commercial banks in China and also tested the interconnections between risk, competition, and efficiency in the Chinese banking industry. They discovered that, bank efficiency is significantly affected by these four aspects of risks: credit risk, insolvency risk, liquidity risk and capital risk. Cost efficiency of banks in eight emerging Asian countries was assessed by Sun & Chang (2011). They considered three distinct risks; market, operational, and credit; and analyzed the effects of these risk measures on cost efficiency of the banks. They found risk to be significant in affecting efficiency.

Although these studies examine the relationship between some aspect of risk and efficiency, they ignore different types of risks (Tan & Floros, 2018) and their impact on productivity. There is therefore the need to examine the risk taking behaviours of banks on productivity because increase in risk precedes a decline in performance (Tan & Floros, 2018), and uncontrolled risk-taking can lead to failures of banks, resulting in bank runs and even devastating financial crises (Zhang et al, 2013).

Additionally, most Data Envelopment Analysis on efficiency and productivity studies are carried out based on the premise that, Decision Making Units are operating either under CRS or VRS without any proper evidence (Battese, Rao, & O'Donnell, 2004; Bonin, Hasan, & Wachtel, 2005;

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Chen, 2009; Chen, 2009; Chen & Yang, 2011; Juo, Lin, & Chen, 2015; Parteka & Wolszczak-Derlacz, 2013; Scotti & Volta, 2015). Practically, the DEA model generates different estimates when the assumptions of either CRS or VRS is applied. Thus there will be inconsistencies with estimates if the true technology underlying the industry is CRS and the researcher assumes VRS without proper evidence.

According to Simar & Wilson (2002) in order to come up with authentic results void of biases using DEA, it is essential to test for the Returns to Scale technology that the DMUs are operating under. Yang, Rousseau, Yang & Liu (2014) asserts that, the test for the Returns To Scale method is expedient for the analysis of organizational success as it will allow decision makers to decide the size of their company in order to help them in decisions about expansion or downsizing.

Yet, few studies have applied the Simar and Wilson (2002) nonparametric test of RTS in non-banking industries (de Borger, Kerstens, & Staat, 2008; Mahlberg & Url, 2010; Badunenko, 2010; Sueyoshi & Goto, 2012; Gómez-Calvet, Conesa, Gómez-Calvet, & Tortosa-Ausina, 2014; Simar & Wilson, 2015; Ippoliti, Melcarne, & Ramello, 2015). Hence, before DEA is used in this study to examine the productivity of Ghanaian banks, the Returns To Scale property underlying the industry will be tested to ensure that, the appropriate assumption is applied.

In addition, the second-stage DEA analysis is an approved method used to make statistical inference into efficiency and productivity scores by examining how independent variables affect dependent variables. The regression models often employed in this stage on bank risks and productivity nexus ignore potential endogeneity. According to Roberts & Whited (2013), endogeneity exist when there is an association between predictor variables and the stochastic term. The problem of endogeneity originates from omitted variable bias, simultaneity and measurement error in data. The problem if not addressed will cause bias in estimates generated.

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This study employs systems dynamic generalized method of moment regression model in the second-stage DEA analysis to assess the impact of risks on productivity progress. The regression model employed in this stage addressed the problem of endogeneity by introducing more instruments to dramatically improve efficiency and transform instruments to make them uncorrelated with the fixed effects (Blundell & Bond, 1998; Arellano & Bover, 1995). De Souza & Gomes (2015) asserts that, Generalised Methods of Momments (GMM) estimations correct for endogeneity, heteroscedasticity, cross-sectional correlation and serial correlation. Hence the regression model employed in this study presents statistically significant estimates that are associated with the actual performance of Ghanaian banks (Messai, Gallali & Jouini, 2015; De Souza & Gomes, 2015).

1.3 Contributions of the study

The study would contribute to policy, practice, and academic research in the banking industry. On the policy side, the findings will serve as relevant policy recommendations for the bank regulator and bank managers regarding apt risk-taking and management behaviours, mergers and acquisitions, and competition.

Furthermore, the research contribution to academic literature is in three fold:

This study is one of the few studies in Africa, to examine the rate of productivity convergence. A first time study to examine productivity and the various risk factors that are affecting it. One of the few DEA second-stage regression studies to uniquely consider endogeneity, heteroscedasticity and serial correlation.

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1.4 Research Purpose and Objectives

The main purpose of this study is to assess dynamic productivity of banks in Ghana and investigate the various risks affecting dynamic productivity.

Specifically, to:

1. To assess dynamic productivity of banks in Ghana and to decompose dynamic productivity into efficiency change and technical change.
2. To evaluate the changes in the productivity of domestic and foreign banks in Ghana.
3. To investigate the rate of productivity convergence.
4. To examine the impact of risks (operational risk, credit risk, liquidity risk, market risk, solvency risk, capital risk) on dynamic productivity of banks in Ghana.

1.5 Research Questions

This study attempts to address these questions;

1. What is the dynamic productivity of banks in Ghana?
2. What is are the sources of productivity change of banks in Ghana: efficiency or technical?
3. Are there significant differences in the productivities of domestic and foreign banks in Ghana?
4. Are Ghanaian banks moving towards productivity convergence?
5. Is there a significant impact of various risks measures on productivity?

1.6 Limitations of the study

This study has few drawbacks despite it contributions. First of all, the study sought to examine the impact of stock market risk (operational risk) on productivity. However, not all banks are licensed on the Ghana Stock Exchange which implies that, not all banks will have estimates for operational

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risk. Hence a common proxy for operational risk will be used. Secondly, unlike the traditional Malmquist Index which allows the application of statistical properties to its estimates, the methodology employed in this study, Biennial Malmquist Index, does not make use of these statistical properties that measure the accuracy of its estimates. However, the regression model used will ensure that, productivity estimates are statistically significant and associated with actual performance.

1.7 Thesis Structure

The study is compressed into six chapters. The first chapter focuses on the research background, problem statement, research contributions, objectives, and questions which the study seek to resolve. Chapter Two elaborates on the context of the study. Chapter Three will explore the relevant conceptual and empirical arguments that drive the topic of interest: risk and productivity studies in banking Chapter Four elaborates on the methodology of the study whiles Chapter Five presents an overview of the outcome and findings of the study. The final chapter concludes on the study and highlights on its implications for policy, and research whilst proposing directions for further study.

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CHAPTER TWO

CONTEXCT OF STUDY

2.0 Introduction

The context of the study gives an overview of certain transformations within the Ghanaian Banking Industry. This chapter is divided into two main sections. The first session provides insights into certain transformations and regulatory reforms that have shaped and enhanced performance within the industry. The second session throws light on the conditions of risk that have plagued the industry. This background is expedient to understand the arguments of the study.

2.1 Financial Transformations and Regulations.

The banking system in Ghana has undergone many economic growth and development reforms (Alhassan & Ohene-Asare, 2016). The enactment of the new Banking Act of 2004, Act 673, introduced a universal banking license which replaced the three-tier model system of banking operation (Commercial, Merchant, Development) by enabling banks to provide various banking services. The enhancement of the banking industry has led to intense competition, leading to new product creation in various fields, including consumer-hire purchase loans for foreign funds transfer, traveler's cheques, negotiable certificates of deposit, school fees and car loans, among many others. (Hinson, Mohammed & Mensah, 2006).

Currently, the banking sector consists of 23 universal banks with eight of them licensed on the Ghana Stock Exchange (GSE, 2019) as shown in Appendix A and C below. In the economy, the banking industry is the most highly regulated sector (Bopkin, 2013). They are intensely regulated to avoid negative effects from any “systematic risk” and to protect the interest of customers (Flannery, 1998).

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Bank boards do play critical role in the sound governance of banks (Pathon, 2009). The Ghanaian banking sector has at its apogee the BOG, which is responsible for monetary policy and overall supervision of banks and Non-Financial Institutions. The key objective of the BOG is to formulate sound monetary policies with a view to stabilise price and to create an enabling environment for sustainable growth and development (BOG, 2019). It accomplishes so through its monetary policy framework, which is based on the Inflation Targeting (IT) framework, which includes the use of the Monetary Policy Rate (MPR) as a fundamental policy tool that gives guidance on the monetary policy stance and helps to keep inflation expectations in check. To achieve these functions effectively, Bank of Ghana Act 2016 (Act 918, as amended) instituted a Monetary Policy Committee (MPC) to formulate monetary policy.

The MPC consists of seven members, of which the Governor acts as the Chairman of the Committee. In order to evaluate economic conditions and threats to inflation and growth outlooks, the MPC meets twice a month over the course of the year and forecasts a path for the Monetary Policy Rate (MPR). This is important for financial intermediation and to ensure that the risk associated with financial markets are considered during the Monetary Policy formulation process (BOG, 2019). Thus, policy makers often try to amend regulations to aid better monitoring of bank activities including risk-taking (Pathan, 2009).

2.2 Overview of risk disclosures in the Banking Industry.

The BOG’s role as a policy maker is to promote financial system soundness and protect the interest of bank depositors. Over the years, steps and mechanisms to strengthen the resilience of the financial system have been carried out.

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BOG issued the Capital Requirement Directive for existing banks and new entrants to increase the minimum capital requirement from GH¢ 120 million to GH¢ 400 million as part of initiatives to boost risk management across the industry. The new requirement for capital was to further grow, improve and modernize the financial sector in order to support the economic vision and development agenda of the government.

Despite the tight regulatory frameworks working within to improve the industry, the banking sector is plagued with some challenges which have made some banks vulnerable. The BOG's Asset Quality Review (AQR) operation in 2015, which was updated in 2016, revealed that a few domestic banks were vulnerable due to insufficient capital and large non-performing loans. These banks include Capital Bank, Unique Trust Bank, UniBank Ghana Limited, Construction Bank Limited, The Royal Bank Limited, Sovereign Bank Limited and Beige Bank Limited.

In August 2017, BOG closed down UT Bank Ghana Limited and Capital Bank Limited, and publicly stated that the two banks were "heavily deficient in capital and liquidity and their continuous operation exposed the financial system to instability and depositors' funds to risks" (PWC, 2018). Both UT Bank and Capital Bank were later acquired by GCB under a purchase and assumption agreement which allowed GCB Bank Limited to take over some of the assets and liabilities of the insolvent banks.

Unibank during the Asset Quality Review in 2016 was identified as undercapitalized. BOG appointed an official administrator, KPMG, for UniBank Ghana Limited to help ascertain the true financial state of the bank, protect depositor's funds, and explore how the bank could be made successful.

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KPMG's reports revealed that, the bank's balance sheet was insolvent with non-performing loans which forms the largest component of the bank's assets. In the case of the Royal Bank, its non-performing loans represented 78.9% of the total loans issued due to poor risk management framework. The loan portfolio of Beige Bank also declined, resulting in a non-performing loan ratio (NPL) of 72.80 percent.

On 1st August, 2018, BOG revoked the licenses of UniBank Ghana Limited, The Royal Bank Limited, Beige Bank Limited, Sovereign Bank Limited, and Construction Bank Limited, and granted a universal banking license to a newly established bank named Consolidated Bank Ghana Limited to take over all assets and liabilities of these banks in a Purchase and Assumption transaction.

The aftermath of this financial crisis saw the closure of some banks while others merged up, and others had their license revoked. Broadly, the following vulnerabilities were identified as the cause of the problems of the institutions that had their licences revoked:

a. Poor corporate governance;

b. Poor risk management practices;

c. Weak credit administration;

d. Unsafe and unsound banking practices;

e. Diversion of customer deposits into unproductive ventures; and

f. General non-compliance with prudential norms.

Presently, there are 23 universal banks operating in Ghana after 9 banks lost their licenses due to the financial sector clean-up. The list of banks in 2020 is shown in Appendix A below.

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Additionally, in the year 2018, PWC surveyed bank executives – to draw out their views on which risk they are likely to prioritise in their attempt to mitigate overall risk.

Credit risk proved to be the most significant exposure that banks must minimize in order to preserve capital adequacy in the future. As shown in Appendix B, 29% of bank executives view credit risk as the major risk to prioritise, whereas 21%, 20%, 19%, 10% of bank executives seek to prioritise operational risk, liquidity risk, market risk, and settlement risk respectively, in their quest to mitigate overall risk. The increase deterioration of asset quality in the banking industry has created alertness among bank regulators and managers.

The results of the survey, especially with regard to liquidity and credit risks, largely reflect the lessons learned from the recent capital erosion of non-performing loans, which have also affected the liquidity of some banks and led to some bank failures in the sector (PWC, 2018).

2.3 Conclusion

The purpose of the chapter is to provide insights into how the industry operates and the major risk factors that have plagued the sector overtime.

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CHAPTER THREE

LITERATURE REVIEW

3.0 Introduction

Theoretical and empirical analysis of literature explaining the interconnection between risk and performance are analysed in this chapter. The theoretical review presents the theoretical grounding for the study, whiles the empirical review elaborates on the current state of research relating to risk, efficiency, and productivity.

3.1 Theoretical Review

3.1.1 Risk and firm performance

In incorporating risk elements for assessing organizational efficiency and decision-making processes, March (1988) criticised the School of Management for later adaptation of risk elements in assessing performance. However, these studies – Jemison (1987), Singh (1986), Baird & Thomas (1985), Bettis (1981), Rumelt (1974) – had given attention to risk in determining the performance of firms. Scholars who have shown much interest in the study of risk argue that, firms with lower performance have riskier source to their income stream (Bowman 1980, 1982, 1984); and that, increased risk leads to an extensive reduction in performance (Bromiley, 1991). Theoretical underpinnings of risk and performance have been grounded on some behavioural economic theories including the prospect theory and behavioural theory of a firm (Fiegenbaum and Thomas, 1988; Bowman 1982). These theories in behavioural finance and economics explain bank risk taking from a behavioural perspective and expatiate on how these risk taking behaviours affect the performance of firms.

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Prospect theory explains decision making under uncertainties. It was widely assumed that people make choices based on a rationally preconceived "expected utility" of the risk and return of different choices. However, Kahneman and Tversky (1979); Tversky & Kahneman (1981, 1992) provided a concrete proof that people do not make rational calculations before taking a decision.

A component of the prospect theory states that, when entities are to choose between prospects, they weigh their gains and losses and make decisions based on perceived gains instead of perceived loss. For instance, if two options are given to a bank to invest into mutual funds and the first option promises a 20% annual return, whereas the second option promises 15% with possible losses, the bank (investor) will choose first option. This explains how banks make choices between diverse alternatives when risk is involved and others where the outcome is unknown. Banks are financial intermediaries who perform diverse functions by providing liquidity, transfer funds from depositors to investors in order to maximize output and shareholder value (Gorton and Winton, 2003). These functions involve credit administration and monitoring borrowers, facilitating payments, managing and investing funds, among others. They use labour, and capital to perform these activities to earn revenue from interest-rates differentials and fees (Martín-Oliver, Ruano & Salas-Fumás, 2013). Decision making forms an integral part of all functions and activities performed by banks. Banks are often referred to as Decision Making Units. They make decisions on how much to invest in bonds, stock markets, commodity; how much to disburse as credit facility, among others. These decisions have prospects for gains and losses and the theory proposes that, losses (risks) cause greater negative impact on entities. Additionally, the theory's curve is S shaped and it varies in areas of gains and losses (Plott & Zeiler 2007).

The S curve means individuals prefer to avoid risk in domain where there are gains and seek risk in the domains where there are losses (Kahneman & Tversky, 1979).

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In practical sense, the theory states that individuals and firms frame their losses and gains differently from a reference point where anything higher than the reference point is seen as a gain and anything below the reference point is seen as a loss. The theory does not state how the reference point is determined but it is determined by the subjective acumen of the firm or person (Shiller, 1999). For instance, if a firm aims at a level of performance it seeks to achieve, then that level of performance is said to be the reference point of that firm. This firm can either meet that performance target or fall below that target. The theory explains that, a fall below that target level is seen as a loss to that firm and a rise above that performance target is seen as a gain. It further states that, firms who meet their performance targets tend to avoid risk whilst firms who fall below the performance target seek risk in order to meet their set performance target; the reference point. According to the prospect theory as propounded by Kahneman and Tversky (1979), when the operating and aspirations levels of firms are low, they turn to take up more risk. This can cause them to take a riskier alternative that may provide a possibility of achieving the desired outcome and such risks reduces subsequent performance (Bromiley, 1991). March (1978) stated that, an attempt to increase performance often requires changes to organizational routine and innovations with increased uncertainty. Lant and Montgomery (1987) found that, performance below expectation levels creates riskier decisions than when performance meets or exceeds aspirations. Thus, managers of firms declining in performance take riskier choices than managers of high performing firms because of frictional problems, agency problems and desire to compensate for loss returns (Jeitschko & Jeung, 2005; Hughes & Moon, 1995; Bowman 1982). The findings of Kahneman and Tversky (1979) were confirmed by Laughhunn, Payne & Crum (1980). Thus, according to prospect theory, a person can exhibit varying tendency of avoiding risk over time,

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based on his or her position relative to the expected outcome (Johnson, 1994). These views seem to suggest a negative relationship between a firm's performance and their risk-taking behaviours.

3.1.2 Ownership and Performance

Both theoretical and empirical literature **(**Helhel, 2015; Bayyurt, 2013; Claessens & Van Horen, 2011; Lensink & Naaborg, 2007; Kosmidou et al., 2004; Berger et al., 2000) have proven that, ownership has a significant influence on performance. A variety of studies have explored ownership and performance relationships using agency theory, home field advantage theory, and resource based theory as the theoretical lens (Douma et al., 2006; Berger et al., 2000). It has been argued that, domestic banks outperform foreign banks (Bonin et al., 2005). Theoretical and empirical evidence on the effect of ownership on bank performance is conflicting. As some theories are used to argue that domestic banks perform better than foreign banks, other theories and studies argue that, foreign banks outperform domestic banks. When a bank establishes other subsidiaries and branches outside of its home country, or takes over a bank already operating in a host market, it is said to be foreign (Kosmidou et al., 2004) – whereas, a bank is said to be domestic where a branch or subsidiaries established within a country is not owned by a national of a designated foreign country.

In this study we predict that domestic banks will outperform foreign banks. This prediction is grounded on the home field advantage hypothesis which was developed and tested by Berger et al. (2000) in their study to address the implication, causes of cross-border bank efficiency in five home countries (France, German, Spain, UK, US) and banks from foreign nations such as Canada, Italy, Japan, Netherland, South-Korea and Switzerland. Foreign owned institutions were expected to be as efficient as domestic institutions.

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However, the test found the opposite result which is that, on average foreign institutions are generally less efficient than domestic firms. The home field advantage hypothesis (Berger et al., 2000) states that, on average, domestic banks have higher efficiency than foreign banks. This advantage could occur due to home and host country characteristics. They argued that, it may be difficult for foreign banks to monitor their subsidiaries abroad and evaluate the behaviour and effort of managers due to monitoring problems. Foreign banks may find it difficult to foster and keep customer relationships with indigenes as well as lending relationships with small and medium local firms within its host country.

Claessens and Van Horen (2011) also argued that foreign banks have a number of advantages over domestic ones although they seemed to be disadvantaged in their host country. Foreign banks may receive financial support from their parent banks, which can reduce their cost of funding. Also, by being large, they can achieve other scale advantages which can grant them a competitive advantage over their counterparts. These scale advantages can translate into higher productivity. Therefore, if the advantages of being foreign outweighs the disadvantages of being foreign, then foreign banks should perform better than domestic banks.

Despite the merits and demerits that affect both foreign and domestic banks, it behooves on these banks to capitalize on their strength to achieve a better performance.

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3.2 Empirical Review

A significant attention has been given to risk in economic and banking sectors after crises occur across the globe (Crowe, 2009). This is because, crisis reveal poor risk management and mismanagement at institutional and organizational levels (Ahmed, 2009). Internationally, there has been a considerable amount of research examining the efficiency and risk of banks in the banking industry for several countries and continents (Sillah, Khokhar, & Khan, 2015; Hoseininassab et al. 2013, Fethi & Pasiouras, 2010; Laeven, 1999), not much evidence in this regard has been forthcoming on productivity and diverse risk faced by banks – although there are comprehensive literatures on changes in bank productivity and how productivity has been affected by policy, deregulation, innovation, competition, technological processes, ownership and sound governance (Fethi and Pasiouras, 2010; Liu, 2010; Berger 2007; Isik 2007; Asmild et al., 2004; Casu et al., 2004; Berger & Mester, 2003; Mukherjee et al., 2001; Rebelo & Mendes 2000; Grifell-Tatje & Lovell, 1996). Empirical studies on the nexus between risk-taking and bank performance is in its inception (Zhang et al., 2013).

Das (2002) assessed the interconnectedness among capital, non-performing loans ratio (credit risk) and productivity using Two-stage least squares regression and Malmquist productivity index. Capital, risk, and productivity change were found to be linked with higher productivity leading to lower credit risk. In a related study, Alhassan and Biekpe (2016) examined productivity changes among Ghanaian banks. They employed MPI to measure productivity and found that productivity growth has a negative relationship with credit risk. Contrary to this findings, Nartey et al. (2019), investigated the determinants affecting bank productivity in Africa using BMPI and various regression models (ordinary least squares, Tobit and truncated bootstrapped regression). The three regression models used revealed similar results stating that, bank credit risk has a significant

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positive relationship with productivity. These studies used regression models which do not control for endogeneity. Diler (2011) employed DEA and MPI to measure efficiency and productivity. A two-stage regression was used to analyse the determinants of DEA efficiency scores. They found that, credit risk is significantly related to productivity. Also, they used credit risk as indicators to explain differences in productivity scores, but did not consider other kinds of risks and bank performance.

There are extensive pieces of research examining efficiency using SFA and DEA in banking literature; most studies use credit risk indicators, such as NPLs, allowance for loan losses, and risky assets, to explain bank efficiency score, but do not address other risks associated with bank efficiency. Most of these studies often use non-performing loans, loan loss provision rendered as bad output to test banks' appetite for risk (Salim et al., 2017; Fu et al., 2015; Tsolas & Charles, 2015; Chen, 2012; Kenjegalieva & Simper, 2010; Altunbas et al.,2000; Scheel, 2001; Chang, 1999; Berger & DeYoung, 1997; Elyasiani et al.,1994; Cebenoyan et al., 1993). Whilst others test for risk as a possible determinant of bank efficiency in their second stage analysis by using loan loss provision or non-performing loans to account for credit risk (Ghafoorian et al., 2013; Mokhtar et al., 2006; Pastor, 2002). However, few studies investigate the impacts of other risk factors on efficiency. Zhang et al. (2012) employed SFA to estimate efficiency and a fixed effects regression model to investigate bank risk taking, efficiency and their relation to law enforcement. They found that, law enforcement tends to promote greater bank risk taking. However, there is a possible problem of endogeneity of institutions in the form of omitted variables bias or reverse causality, which can lead to inconsistent coefficient efficiency estimates which further translates into wrong conclusion due to the regression model used. Altunbas et al. (2007) analysed the relationship

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between capital, risk and efficiency for a large sample of banks in Europe between 1992 and 2000. They found a positive relationship between inefficiency and bank risk-taking.

Fiordelisi et al. (2011) studied efficiency and risk in European banking using Granger-causality techniques to assess the bi-directional causality between bank efficiency, capital, and risk for the European commercial banking industry. Their results suggested that lower bank efficiency scores lead to greater bank risk. The risk of banks was assessed using the Expected Default Frequency (EDF) for each bank calculated by Moody's KMV which accounted for all banks' risks This method of measuring overall risks makes it difficult to identify the specific risk that affects performance. Miah & Sharmeen (2015) investigated the relationship between capital, risk and efficiency of Islamic and conventional banks. SFA was used to estimate efficiency whilst Seemingly Unrelated Regression (SUR) was used in assessing the relationship between capital, risk, and efficiency. Their results showed a bidirectional and negative relationship between capital and efficiency Also, banks with higher risks are less efficient**.** Ariff and Can (2008) used DEA approach to investigate the cost and profit efficiencies and risk of 28 commercial banks in China. Their findings suggested that improving risk management is helpful in increasing the efficiency of Chinese banks. Sillah et al. (2015) analysed the technical efficiency scores for the 52 banks in Gulf Cooperation Council Countries. They found that Kuwaiti and Emirati banks are regionally best performers. They investigated possible determinants of bank technical efficiency, and they found bank technical efficiency is influenced by unsystematic risks and monetary policy. Moradi-Motlagh et al. (2011) studied the efficiency, effectiveness, and risk in Australian Banking Industry. They analysed three aspects of profitability of the Australian banking industry using a three-stage DEA technique. In their study, small banks were found to be ineffective as compared to large banks who were effective. In addition, some banks were profitable due to higher risk taking.

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Howbeit, these aforementioned studies focus on overall risk or credit risk and insolvency risk without considering different types of risk-taking behaviours in the banking industry. Similarly, Chang and Chiu (2006) assessed bank efficiency index using DEA and Tobit regression, to determine the impact of credit and market risk on efficiency. Their findings suggest that, risk factors impact bank efficiency. By incorporating market or credit risk to account for risk, banks with higher levels of non-performing loans or value at risk will see a reduction in their efficiency. Chiu and Chen in 2009 assessed the bank efficiency of Taiwanese bank efficiency coupled with internal and external risk factors affecting these banks. The study revealed that, there is an association between credit, market, and operational performance risk and bank efficiency. Zhang et al. (2013) also investigated the relationship between risk-taking, market concentration and bank performance using SFA with a sample of domestic commercial banks from China, India, Russia, and Brazil. They found banks with higher efficiency scores take less risk. Hoseininassab et al. (2013) used SFA and MEA methods to assess the efficiency of 15 Iranian banks and also examined the impact of credit risk, operational risk, and liquidity risks on banking efficiency. Their results suggested differences in the two methods with regard to performance evaluation, and of the two, SFA method showed a relative superiority compared to MEA method. In addition, each of the risks examined significantly affects efficiency.

Tan and Anchor (2017) examined the impacts of risk-taking behaviour and competition on technical efficiency of the Chinese banking industry using DEA approach to measure efficiency. Comprehensive risk-taking behaviours (credit risk, liquidity risk, capital risk, and insolvency risk) were considered as determinants of bank efficiency. They reported that, PTE and TE of Chinese commercial banks are significantly and negatively affected by liquidity risk. Tan and Floros (2018) used DEA to assess the efficiency of commercial banks in China and also tested the

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interconnectedness among risk, competition, and efficiency of the Chinese banking industry. They found that, banks with higher efficiency have higher credit risk and insolvency risk. Also, credit risk and insolvency risk, increases as efficiency is high but liquidity risk and capital risk reduces as efficiency is high. Tan and Floros (2013) assessed risk, capital, and efficiency in Chinese banking. They investigated the link between bank efficiency, risk, and capitalization. Their empirical results suggested that, there is a positive and significant relationship between risk and efficiency. Sun and Chang (2011) estimated bank cost efficiency of banks in eight emerging Asian countries. They considered three distinct risks; market, operational, and credit; and analyzed the marginal effects of these risk measures on cost efficiency of the banks. Said (2013) measured the efficiency of banks by employing DEA to measure efficiency and investigate the correlation between risks (credit, operational, and liquidity risks) and efficiency. The study results revealed that, credit risk has negative relationship with efficiency, while operational risk was found to be negatively correlated to efficiency and liquidity risk showed an insignificant correlation with efficiency in these banks. Fernandes, Stasinakis & Bardarova (2018) also examined the effect of bank risk on performance using DEA-Truncated Regression approach. The study considered four aspects of risk: liquidity, credit, capital and profit risk. Their results showed that, liquidity risk and credit risk negatively affects bank productivity whereas capital risk and profit risk positively affect productivity. They concluded that, financial risk variables affect bank performance when the financial industry is not well developed.

By contrasting the parametric and nonparametric programming approaches to measuring efficiency and productivity in light of the preceding findings, most studies do not conduct a comprehensive study on all possible risk factors that affect banks. Also, most of these studies are conducted based on the assumption that, banks operated under constant or varied scale without

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actually testing for this assumption. In addition, most regression models employed in second stage DEA analysis do not control for endogeneity. Banks are exposed to diverse risks, and this study seeks to incorporate all distinct risks mentioned above. It follows the study conducted by Fernandes, Stasinakis & Bardarova (2018) and Tan & Floros (2018) by examining productivity of banks and the impact of six distinct risk factors on performance. This study differs from Fernandes et al. (2018) and Tan & Floros (2018) in that, it acknowledges that banks operate under varied size Hence, the Return To Scale properties of banks will be tested to ascertain this claim or prove otherwise. Also, other risk factors such as operational, liquidity and market risks will be included in this study. The study will further assess the rate of productivity convergence in the banking industry.

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CHAPTER FOUR

METHODOLOGY

4.0 Introduction

The chapter elaborates on the processes and techniques adopted to achieve the objectives of the study. The study presents the research design, the data sources, and sampling procedures as well as the analytical techniques for the analysis of variables in the study.

4.1 Research Design

In this study, non-experimental quantitative research approach was used in which statistical and mathematical techniques are used to examine and compare the relationship and degree of association between two or more variables or sets of scores (Creswell, 2012). This research is guided by a Post-positivism paradigm which holds a deterministic philosophy in which causes determine outcomes (Creswell, 2014). Thus, possible risk factors are identified and assessed to ascertain their effects on an outcome such as productivity. The study begins with a theory, collects data to support or object the theory, in order to make necessary revisions (Creswell, 2008). This approach has an advantage of limiting researcher bias (Creswell, 2012). A panel data methodology is used, making it possible to collect multiple observations on the same units, enabling the control for certain unobserved characteristics of firms which can facilitate causal inference (Wooldridge, 2015).

4.2 Sampling and Data Sources

The population of this study consist of an average of 21 universals banks of which 10 are domestic banks and 11 foreign banks. An unbalanced panel of data of averagely 21 banks operating each

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year in Ghana over the period 2004-2019 was used for this empirical study due to unavailability of data. Data was sourced from published audited annual reports of banks on banks website and cross-validated with that of BOG to ensure cogency of reports. The knowledge that the published annual reports were audited by external auditors and approved by the Central Bank of Ghana (BOG) provides assurance to a large extent as to the credibility and the reliability of the data. Secondly, published audited annual reports have been the source of data for many studies on bank performance in Ghana (Duho, Onumah, Owodo, Asare, & Onumah, 2020; Antwi, 2019; Nyarko-Baasi, 2018); Adusei, 2016).

4.3 Dynamic productivity model

4.3.1 The Malmquist index

Efficiency and productivity studies have been examined using DEA method. DEA was developed by Charnes *et al.* (1978) as a model with an input-orientation assumed under the axiom of CRS. This CRS axiom was appropriate when all firms are operating at an optimal scale. However, imperfect competition, financial constraints and government regulations may violate that CRS assumption (Coelli et al., 2005). Hence, a need for an extension of the model by Banker *et al.* (1984), to account for VRS situations. DEA is a non-parametric benchmarking technique that employs linear programming to evaluate the relative efficiency of DMUs that use multiple inputs to generate multiple outputs, relative to an efficient, or a "best-practice," but unknown frontier (Wheelock & Wilson, 1995; Avkiran, 2006).

The technique constructs a boundary using the best-practice DMUs based on the minimum extrapolation principle (Thanassoulis, 2001) by determining the smallest convex cone that

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envelopes that observed data set (Kumar & Russell, 2002). Then, the relative technical efficiency or inefficiency of an observed DMU is evaluated by its distance in relation to the constructed frontier. Firms on the constructed frontier are seen as efficient whilst firms within the frontier are seen as inefficient. It then specifies the sources of inefficiency for the inefficient firms, rank these firms, sets target, and can be used to assess management performance, evaluate the effectiveness of programs or policies, generate quantitative analysis for resource reallocations etc. (Golany & Roll, 1989). DEA is an effective performance evaluation and benchmarking tool that has received many extensions and applications (Liu *et al*., 2016; Liu *et al*., 2013).

Another extension of DEA is the Malmquist Productivity Change Index (MPI) of Färe *et al*. (1992), based on the findings of Malmquist (1953), Caves *et al*. (1982) and Charnes *et al* (1978). The MPI is used to assess efficiency studies over different periods. Thus, it compares changes in productivity of DMUs in the base period (t) within other periods (t+1), (t+2), etc. It estimates the changes in output arising out of input changes over different time periods. The index decomposes productivity change into technical change (TECHCH) and efficiency change (EFFCH) so to offer insight into the sources of productivity growth. The technical change measures frontier shifts and indicates whether the "best-practice firm" relative to which the evaluated firm is compared is improving, stagnating or regressing (Tortosa-Ausina et al, 2008). The efficiency change (catch-up effect) shows how much a firm move (farther away or closer to) the frontier made up of best practice firms.

Suppose for each time period $t: 1,\ldots,T$ and given that, K banks at a time produces m non-negative outputs (denoted by $y \in \Re_t^m$) using n non-negative inputs (denoted by $x \in \Re_t^n$) the production possibility set (input-output combination set) can be defined as:

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$$.\psi^{t} = \{(x^{t}, y^{t}) \in \Re_{t}^{m+n} \left| x^{t} can \text{ produce } y^{t} \right. \} \quad \textbf{(1)}$$

The radial output-oriented Farrell (1957) technical efficiency score, $\phi_0^t(x^{t+1}, y^{t+1})$, of a given firm (x_o, y_o) at time *t* relative to frontier *t*, under constant returns to scale can be obtained by solving the linear programming problem below:

$$Max\phi_0^t(x^t, y^t)$$

$$s.t$$

$$\sum_{j=1}^{n} \lambda^{t}{}_{j} x^{t}{}_{ij} \leq x^{t}{}_{io} \qquad \forall_{i} = 1,2,...,n,$$

$$\sum_{j=1}^{n} \lambda_{j}{}^{t} y_{rj}{}^{t} \geq \varphi y^{t}{}_{r0} \qquad \forall_{r} = 1,2,...,m,$$

$$\lambda_{j}^{t} \geq 0 \qquad \forall_{j} = 1,2,...,K, \quad \textbf{(2)}$$

Where $\phi_0^t(x^t, y^t)$ is the output-oriented efficiency score that measures the proportional increase in the output of a DMU necessary to be efficient given the level of input. Note that, if $\phi_0^t(x^t, y^t) \geq 1$ and only if $\phi_0^t(x^t, y^t) \in \psi$, also, if $\phi_0^t(x^t, y^t) = 1$ and only if (x^t, y^t) is on the frontier of the technology set (Fare et al., 1994). The LP model in Equation 2, shows the various quantities of n inputs each DMU utilises to produce various quantities of m outputs, where a particular DMU j uses x_{ij} quantities of input i to produce y_{ij} quantities of output r. Note that, λ is the weights assigned to output r and input i respectively (for the DMUs under evaluation) and these weights are yet to be determined. Also, the above model is formulated as CRS and it is applicable when all banks are operating at an optimal scale (Charnes *et al.*, 1978a). Hence, this third constraint $\sum_{j-1}^{K} \lambda = 1$ is usually added to transform it into a VRS model when all banks are not operating at an

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optimal scale. In defining the Malmquist index, there is the need to define efficiency scores with respect to two different time periods which would measure the maximum proportional change in outputs necessary to make (x^{t+1}, y^{t+1}) efficient in reference to technology in *t*. The result, $\phi_0^t(x^{t+1}, y^{t+1})$, may be less than 1 since (x^{t+1}, y^{t+1}) may not belong to Ψ^t. The proportional change in output necessary to make (x^{t+1}, y^{t+1}) efficient in relation to the technology in time *t*+1 can also be denoted as $\phi_0^{t+1}(x^{t+1}, y^{t+1})$. The Malmquist index according to Caves *et al*. (1982) with reference to the technology in time period *t* can, therefore, be defined as:

$$MPI^t = \frac{\phi^t(x^t, y^t)}{\phi^t(x^{t+1}, y^{t+1})} \quad \textbf{(3)}$$

Alternatively, Malmquist index for the adjacent period can be defined in relation to the technology at time period *t* +1 as:

$$MPI^{t+1} = \frac{\phi^{t+1}(x^t, y^t)}{\phi^{t+1}(x^{t+1}, y^{t+1})} \quad \textbf{(4)}$$

In order to avoid arbitrary values of the productivity change index, Fare *et al*. (1992) proposed a geometric mean of the two indices. This can be expressed as:

$$MPI^{t,t+1} = \left[\frac{\phi_0^t(x^t, y^t)}{\phi_0^t(x^{t+1}, y^{t+1})} \times \frac{\phi_0^{t+1}(x^t, y^t)}{\phi_0^{t+1}(x^{t+1}, y^{t+1})}\right]^{1/2} \quad \textbf{(5)}$$

Following Fare *et al*. (1994), the Malmquist index in equation **(5)** can be further decomposed into efficiency change and technical change thus:

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$$MPI^{t,t+1} = \frac{\phi^t(x^t, y^t)}{\phi^{t+1}(x^{t+1}, y^{t+1})} \times \left[\frac{\phi^{t+1}(x^{t+1}, y^{t+1})}{\phi^t(x^{t+1}, y^{t+1})} \times \frac{\phi^{t+1}(x^t, y^t)}{\phi^t(x^t, y^t)} \right]^{1/2} \qquad \textbf{(6)}$$

Efficiency Change **Technical Change**

Whereas the efficiency change component (EC) measures productivity change attributable to managerial acumen, the technical change (TC) component is as a result of changes in the total industry technology (Tortosa-Ausina, Grifell-Tatjé, Armero, & Conesa, 2008) depicting the impact of process or product innovation. The EC of Equation (6) can be further decomposed into a pure efficiency change (PEC) and scale change (SEC) components with reference to the VRS (v) and CRS (c) frontiers as:

$$EC_O(x^t, y^t, x^{t+1}, y^{t+1}) = \frac{\emptyset^t_{ov}(x^t,y^t)}{\emptyset^{t+1}_{ov}(x^{t+1},y^{t+1})} \times \left| \frac{\emptyset^t_{ov}(x^t,y^t)/\emptyset^t_{oc}(x^t,y^t)}{\emptyset^{t+1}_{ov}(x^{t+1},y^{t+1})/\emptyset^{t+1}_{oc}(x^{t+1},y^{t+1})} \right| \qquad \textbf{(7)}$$

Pure Efficiency Change **Scale Efficiency Change**

The PEC component is the part of the efficiency (or inefficiency) truly attributable to management production decisions. The SEC however measures the effect of changes in the size of the firm on dynamic productivity of the firm.

To demonstrate the proposed method to estimate dynamic productivity of banks, a two-year hypothetical data of 10 banks is used as shown in Table 4.1 below. The outputs and inputs are in thousands of Ghana Cedis.

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Table 4. 1: Hypothetical Data of Ten Banks

BANK	YEAR	DMU	DEPOSITS (INPUT)	LOANS AND ADVANCES (OUTPUT)
A		A1	22	32
B		B1	14	8
C		C1	18	20
D		D1	6	15
E		E1	25	50
F		F1	13	8
G		G1	3	13
H		H1	16	12
I		I1	15	30
J	ONE	J1	13	8
A		A2	10	8
B		B2	9	24
C		C2	18	5
D		D2	14	28
E		E2	2	9
F		F2	14	28
G		G2	5	40
H		H2	15	10
I		I2	4	24
J	TWO	J2	10	8

The data above is graphed using one input and one output and it is shown in Figure 4.1 below. The VRS boundaries are for both year 1 and 2 as shown in the Figure below.

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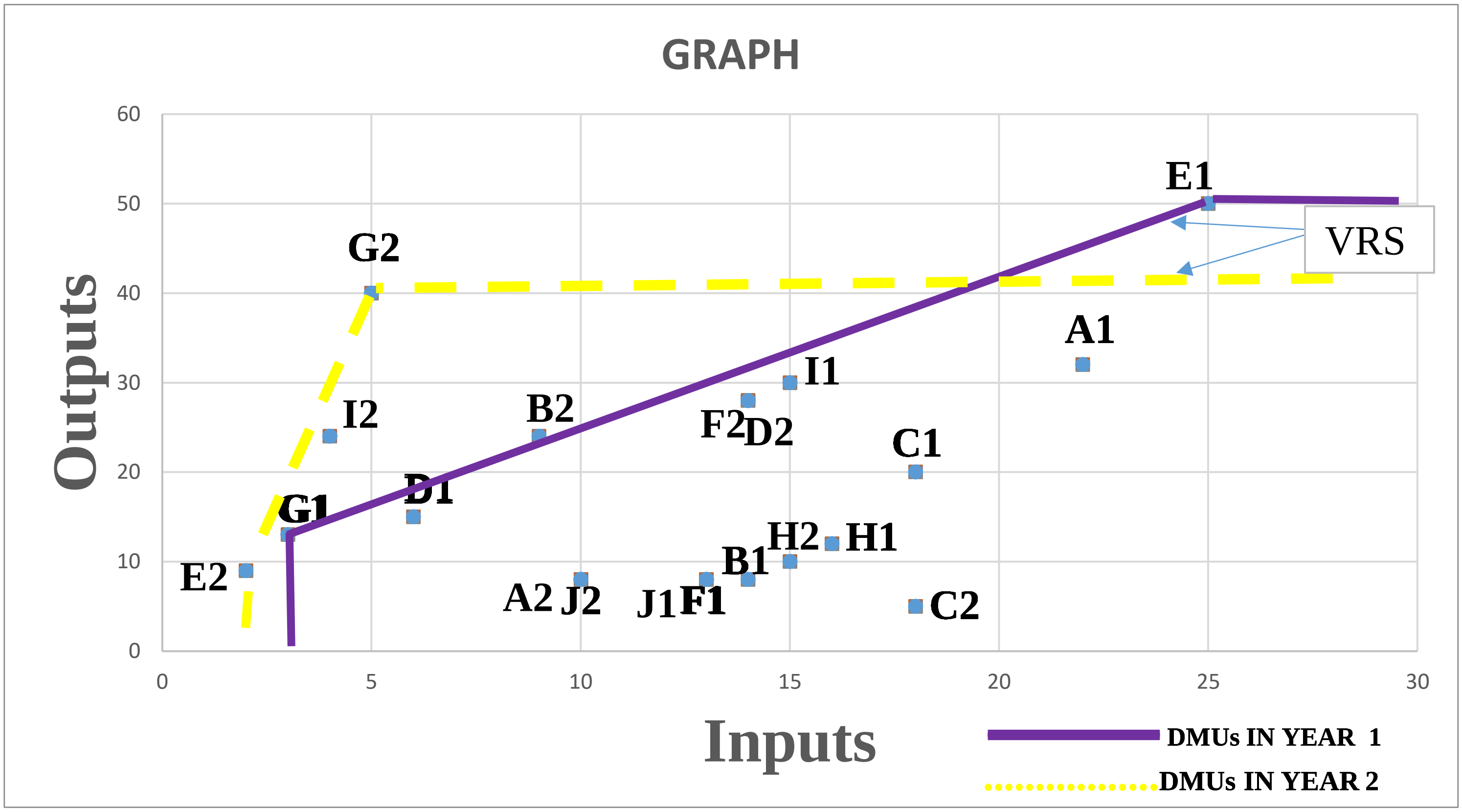

Figure 4. 1: VRS Production Frontiers

Source: Author (2020)

Note that, DMU (Banks) in year 1 are denoted by the DMU name and year. Thus, A1 to J1 represents banks in year 1 and A2 to J2 represents DMU (Banks) in year 2. Also, in calculating the MPI score for each DMU, the efficiency score for each DMU has to be computed since productivity measures efficiency over time. Each of these scores can be estimated using the frontiers in Figure 4.1. Because all efficiencies are measured using an output orientation, the efficiency of a DMU would be measured by the proportion by which the output of the firm can be

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increased without changing the current input level. This is measured by the distance between a firm and the nearest vertical distance to the frontier. Therefore, the linear programming (LP) model to find the output efficiency score of DMU G in year 1 relative to frontier 1 is formulated based on the general model in Equation 2 above.

$$Max\emptyset_{G,}^{1} DMU\ G_1(x^1, y^1)$$

Subject to;

$$22\lambda_{A1} + 14\lambda_{B1} + 18\lambda_{C1} + 6\lambda_{D1} + 25\lambda_{E1} + 13\lambda_{F1} + 3\lambda_{G1} + 16\lambda_{H1} + 15\lambda_{I1} + 13\lambda_{J1} \leq 3$$

$$32\lambda_{A1} + 8\lambda_{B1} + 20\lambda_{C1} + 15\lambda_{D1} + 50\lambda_{E1} + 8\lambda_{F1} + 13\lambda_{G1} + 12\lambda_{H1} + 30\lambda_{I1} + 8\lambda_{J1} \geq 13\emptyset_G^1$$

$$\lambda_{A1} + \lambda_{B1} + \lambda_{C1} + \lambda_{D1} + \lambda_{E1} + \lambda_{F1} + \lambda_{G1} + \lambda_{H1} + \lambda_{I1} + \lambda_{J1} = 1$$

$$\lambda_j \geq 0$$

$$= \emptyset_G^1 (x^1, y^1) = 1$$

DMU G efficiency score in year 1 relative to frontier 2

$$Max\emptyset_{G,}^{2} DMU\ G_2(x^1, y^1)$$

Subject to;

$$22\lambda_{A1} + 14\lambda_{B1} + 18\lambda_{C1} + 6\lambda_{D1} + 25\lambda_{E1} + 13\lambda_{F1} + 3\lambda_{G1} + 16\lambda_{H1} + 15\lambda_{I1} + 13\lambda_{J1} \leq 3$$

$$32\lambda_{A1} + 8\lambda_{B1} + 20\lambda_{C1} + 15\lambda_{D1} + 50\lambda_{E1} + 8\lambda_{F1} + 13\lambda_{G1} + 12\lambda_{H1} + 30\lambda_{I1} + 8\lambda_{J1} \geq 13\emptyset_G^2$$

$$\lambda_{A1} + \lambda_{B1} + \lambda_{C1} + \lambda_{D1} + \lambda_{E1} + \lambda_{F1} + \lambda_{G1} + \lambda_{H1} + \lambda_{I1} + \lambda_{J1} = 1$$

$$\lambda_j \geq 0$$

$$= \emptyset_G^2 (x^1, y^1) = 1.54$$

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DMU G efficiency score in year 2 relative to frontier 2

$$Max\emptyset^2_{G,} DMU\ G_2(x^2, y^2)$$

Subject to;

$$10\lambda_{A2} + 9\lambda_{B2} + 18\lambda_{C2} + 14\lambda_{D2} + 2\lambda_{E2} + 14\lambda_{F2} + 5\lambda_{G2} + 15\lambda_{H2} + 4\lambda_{I2} + 10\lambda_{J2} \leq 5$$

$$8\lambda_{A2} + 24\lambda_{B2} + 5\lambda_{C2} + 28\lambda_{D2} + 9\lambda_{E2} + 28\lambda_{F2} + 40\lambda_{G2} + 10\lambda_{H2} + 24\lambda_{I2} + 8\lambda_{J2} \geq 40\emptyset^2_G$$

$$\lambda_{A2} + \lambda_{B2} + \lambda_{C2} + \lambda_{D2} + \lambda_{E2} + \lambda_{F2} + \lambda_{G2} + \lambda_{H2} + \lambda_{I2} + \lambda_{J2} = 1$$

$$\lambda_j \geq 0$$

$$= \emptyset^2_G\ (x^2, y^2) = 1$$

DMU G efficiency score in year 2 with respect to frontier 1.

$$Max\emptyset^1_{G,} DMU\ G_2(x^2, y^2)$$

Subject to;

$$10\lambda_{A2} + 9\lambda_{B2} + 18\lambda_{C2} + 14\lambda_{D2} + 2\lambda_{E2} + 14\lambda_{F2} + 5\lambda_{G2} + 15\lambda_{H2} + 4\lambda_{I2} + 10\lambda_{J2} \leq 5$$

$$8\lambda_{A2} + 24\lambda_{B2} + 5\lambda_{C2} + 28\lambda_{D2} + 9\lambda_{E2} + 28\lambda_{F2} + 40\lambda_{G2} + 10\lambda_{H2} + 24\lambda_{I2} + 8\lambda_{J2} \geq 40\emptyset^1_G$$

$$\lambda_{A2} + \lambda_{B2} + \lambda_{C2} + \lambda_{D2} + \lambda_{E2} + \lambda_{F2} + \lambda_{G2} + \lambda_{H2} + \lambda_{I2} + \lambda_{J2} = 1$$

$$\lambda_j \geq 0$$

$$= \emptyset^1_G\ (x^2, y^2) = 1$$

The MPI of DMU G can therefore be computed with reference to equation 6 as

$$MPI\ DMU_G = \left[\frac{1}{1} \times \frac{1.54}{1}\right]^{1/2}$$

=1.24

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The productivity score of DMU G improved by 24% from period 1 to period 2. This improvement is technological change which could be as a result of product innovation or digitalization of services within the industry. Furthermore, any attempt to calculate the MPI of the DMU E will be impossible. This is because, of the infeasibilities in calculating the efficiency score of DMU E in year 1 with respect to frontier 2. A vertical projection of DMU E in year 1 is not bounded by frontier 2. This is the infeasibility problem Biennial Malmquist Index was developed to address.

4.3.2 The Biennial Malmquist Index

The measurement of productivity change using the Malmquist index was first introduced by Caves *et al*. (1982) based on the earlier work of Malmquist (1953). Fare *et al*. (1992), however, situated the Malmquist productivity index in DEA. The work of Fare *et al*. (1994) also provided insights into how to decompose the index into two factors – "efficiency change" or catch-up effect and "technical change" or frontier shift effect. Efficiency Change is divided into Pure Efficiency Change and Scale Efficiency Change, where also, the sources of efficiency change: pure technical efficiency change is attributable to improvements in management practices, whereas scale efficiency change is due to improvement towards optimal size (Isik & Hassan, 2003). Also, in determining the scale efficiency change, the assumptions of CRS and VRS technologies are considered (Essid, Ouellette & Vigeant, 2014; Sufian, 2011, Fujii, Managi, Matousek & Rughoo, 2018). However, when cross-period efficiency is computed under the variable returns to scale assumption, may result in linear programming infeasibilities since the observed input-output combination lies outside the frontier for the previous period (Ray & Desli, 1997; Wheelock & Wilson, 1999; Pastor, Asmild & Lovell, 2011). Also, much information is lost as a result of these infeasibilities. In view of this, three VRS based Malmquist indices have been proposed to handle these infeasibilities (Pastor et al., 2011). These are the sequential Malmquist (Shestalova, 2003),

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global Malmquist (Pastor & Lovell, 2007) and the biennial Malmquist (Pastor et al., 2011). However, biennial Malmquist (Pastor et al., 2011) has some advantages over the former because it can account for technical regress unlike the sequential Malmquist index, and does not require recalculating productivity estimates each time an additional time period is added to the sample as in the case of the global Malmquist (Asmild & Tam, 2007; Pastor et al., 2011). The biennial Malmquist generates a separate frontier that will envelope all observations from two time periods, thereby solving the linear programming infeasibilities.

Consider the output-oriented distance functions and Malmquist indices and a balanced panel of j=1, n banks in each of t=1, u time periods. Denote by $(x, y) \in \Re_{+}^{m} \times \Re_{+}^{s}$ the input-output vector of a generic bank and by $(x^{t}, y^{t}) \in \Re_{+}^{m} \times \Re_{+}^{s}$ s the corresponding vector for a specific bank in time period t. For each time period t, considering two benchmark technologies, the period t technology is given as:

$$T_c^t = \{Max\, \emptyset_v(x, y) \in \Re_{+}^{m+s} \,\big|\, x \leq \sum_{j=1}^{n} \lambda_j^t x_j^t,\ y \geq \sum_{j=1}^{n} \lambda_j^t, \lambda_j^t \geq 0, j = 1, \dots, n\} \quad \textbf{(8)}$$

And the technology associated with the subsequent period, T_c^{t+1} defined similarly. Based on these two technologies the base t biennial technology T_c^B can be defined as the convex hull of the period t and period t + 1 technologies. $T_c^B = Conv\{T_c^t, T_c^{t+1}\}$. The subscript c in T_c^k,k=t, t+1 indicates that T_c^k exhibits constant returns to scale (CRS), $\lambda T_c^k = T_c^k$ for all $\lambda > 0$. Hence T_c^B also satisfies CRS.

The biennial CRS Malmquist index (with subscript c) can be computed with reference to a biennial technology can be expressed as:

$$BMPI_C(x^t, y^t, x^{t+1}, y^{t+1}) = \frac{\emptyset_c^B(x^t, y^t)}{\emptyset_c^B(x^{t+1}, y^{t+1})} \quad \textbf{(9)}$$

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The general formulation of efficiency scores considering a period t technology under VRS is given as:

$$T_v^t = \{Max\ \emptyset_v(x,y) \in \Re_+^{m+s} \,\big|\, x \leq \sum_{j=1}^{n} \lambda_j^t x_j^t,\ y \geq \sum_{j=1}^{n} \lambda_j^t,\ \ \sum_{j=1}^{n} \lambda_j^t = 1\,, \lambda_j^t \geq 0, j = 1, \dots, n\} \qquad \textbf{(10)}$$

The biennial VRS Malmquist index (with subscript v) can be computed with reference to a biennial technology can be expressed as:

$$BMPI_V(x^t, y^t, x^{t+1}, y^{t+1}) = \frac{\emptyset_V^B(x^t,y^t)}{\emptyset_V^B(\,x^{t+1},y^{t+1})} \qquad \textbf{(11)}$$

The only difference between T_c^t and T_v^t is that the latter includes the convexity constraint on the lambdas, and the VRS technologies are denoted by subscript v instead of c.

The BMPI has three factor decomposition into the biennial pure efficiency change (BPEC), the biennial technical change (BPTC) components, and the biennial scale change (BSEC) components. As with the traditional adjacent period Malmquist index, the biennial efficiency change component is defined as:

$$BPEC_V(x^t, y^t, x^{t+1}, y^{t+1}) = \frac{\emptyset_v^t(x^t,y^t)}{\emptyset_v^{t+1}(\,x^{t+1},y^{t+1})} \qquad \textbf{(12)}$$

The technical change component can be seen as the ratio of the BMPI in (11) and EC in (12). It is defined as:

$$BTC_V(x^t, y^t, x^{t+1}, y^{t+1}) = \frac{BMPI_V\,(x^t,y^t,x^{t+1},y^{t+1})}{EC_V\,(x^t,y^t,x^{t+1},y^{t+1})} = \frac{\emptyset_v^B(x^t,y^t)/\emptyset_v^B(x^{t+1},y^{t+1})}{\emptyset_v^t(x^t,y^t)/\emptyset_v^{t+1}(\,x^{t+1},y^{t+1})}$$

$$= \frac{\emptyset_v^{t+1}(x^{t+1},y^{t+1})}{\emptyset_v^B(\,x^{t+1},y^{t+1})} \times \frac{\emptyset_v^B(x^t,y^t)}{\emptyset_v^t(x^t,y^t)} \qquad \textbf{(13)}$$

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It can be observed that, by comparing the last part of (13) to the technical change component of (6), there are little differences in how they are computed. The own-period efficiency scores of BTC in (13) does not change just as (6); however, the cross-period efficiency scores are rather computed in relation to the constructed biennial frontier. BSEC index can also be defined as:

$$BSEC = \frac{BMPI_c}{BMPIC_V} = \frac{\emptyset_C^B(x^t,y^t)/\emptyset_v^B(x^t,y^t)}{\emptyset_C^B(x^{t+1},y^{t+1})/\emptyset_v^B(x^{t+1},y^{t+1})}$$

$$= \frac{\emptyset_C^B(x^t,y^t)}{\emptyset_v^B(x^t,y^t)} \times \frac{\emptyset_v^B(x^{t+1},y^{t+1})}{\emptyset_C^B(x^{t+1},y^{t+1})} \qquad \textbf{(14)}$$

In order to illustrate the main proposed technique; Biennial Malmquist Productivity Index (BMPI) for this study, the hypothetical data of 10 Banks over two-year period in Table 4.1 is used to illustrate the biennial frontier in Figure 4.2 below. The Biennial frontier as shown in Figure 4.2 provides solution to the problem of VRS infeasibilities in MPI. The Biennial frontier solves the VRS infeasibilities by constructing a biennial (global) VRS frontier that envelopes both period 1 and period 2 frontiers, as illustrated in Figure 4.2. The biennial VRS frontier is the bold dashed-blue convex frontier that creates a boundary for both frontiers of periods one and two.

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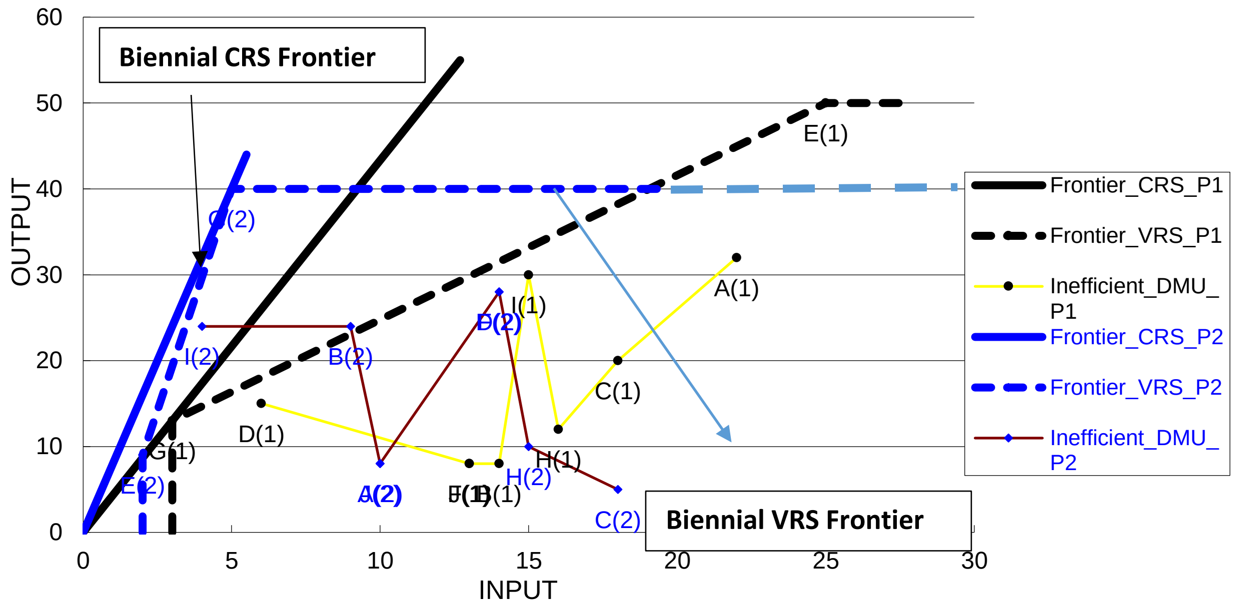

Figure 4. 2: Biennial VRS and CRS Production Frontiers of Firms Biennial CRS Frontier Biennial VRS Frontier

Source: Author (2020)

By this, the mixed-period frontier for DMU E in period one can be calculated relative to the biennial frontier which envelopes its own-period frontier too (unlike the traditional Malmquist VRS frontier). Using linear programming, the mixed-period efficiency of DMU E in year 1 is computed as:

$$Max\emptyset_{V,}^{B} DMU\ E_1(x^1, y^1)$$

Subject to;

$$22\lambda_{A1} + 10\lambda_{A2} + 14\lambda_{B1} + 9\lambda_{B2} + 18\lambda_{C1} + 18\lambda_{C2} + 6\lambda_{D1} + 14\lambda_{D2} + 25\lambda_{E1} + 2\lambda_{E2} + 13\lambda_{F1} + 14\lambda_{F2} + 3\lambda_{G1} + 5\lambda_{G2} + 16\lambda_{H1} + 15\lambda_{H2} + 15\lambda_{I1} + 4\lambda_{I2} + 13\lambda_{J1} + 10\lambda_{J2} \leq 25$$

$$32\lambda_{A1} + 8\lambda_{A2} + 8\lambda_{B1} + 24\lambda_{B2} + 20\lambda_{C1} + 5\lambda_{C2} + 15\lambda_{D1} + 28\lambda_{D2} + 50\lambda_{E1} + 9\lambda_{E2} + 8\lambda_{F1} + 28\lambda_{F2} + 13\lambda_{G1} + 40\lambda_{G2} + 12\lambda_{H1} + 10\lambda_{H2} + 30\lambda_{I1} + 24\lambda_{I2} + 8\lambda_{J1} + 8\lambda_{J2} \geq 50\emptyset_E^1$$

$$\lambda_{A1} + \lambda_{A2} + \lambda_{B1} + \lambda_{B2} + \lambda_{C1} + \lambda_{C2} + \lambda_{D1} + \lambda_{D2} + \lambda_{E1} + \lambda_{E2} + \lambda_{F1} + \lambda_{F2} + \lambda_{G1} + \lambda_{G2} + \lambda_{H1} + \lambda_{H2} + \lambda_{I1} + \lambda_{I2} + \lambda_{J1} + \lambda_{J2} = 1$$

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$$\lambda_j \geq 0$$

The results attained from solving the above problem with MaxDEA pro 7.0 ultra is shown in the Table 4.2 below.

Table 4. 2: The hypothetical results of banks

DMU	BMPI	EC	TC
A	0.285294	0.280966	1.015405
B	3.178571	2.3625	1.345427
C	0.25	0.23892	1.046373
D	1.698876	0.842121	2.017378
E	1	1	1
F	3.460674	2.609091	1.326391
G	1.487179	1	1.487179
H	0.842593	0.726326	1.160075
I	1.213483	0.894791	1.356164
J	1.035294	0.745455	1.388809

BMPI scores above 1 represent advancements in productivity. BMPI scores less than 1 represent retrogression in productivity. BMPI scores of 1 represent productivity stagnation. The sources of productivity growth are either due to Efficiency Change (EC) or Technical Change (TC). In order to know the source of productivity growth for each DMU, the scores of EC are compared with that of TC. The highest score depicts the source of productivity growth of each DMU. For instance, the source of productivity growth for DMU G is attributed to technological change. The TC score for DMU G indicates that DMU G productivity growth increased by 48% and the improvement is due to technological progress within the banking industry.

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4.4 Returns to Scale (RTS) or scale elasticity in DEA

One of the assumptions underlying the use of DEA is an assumption on returns to scale of the underlying technology.

Empirical literature suggests that, the assumption of either CRS or VRS is a crucial question for any efficiency analysis since adopting a wrong technology assumption may result in wrong conclusions or lead to statistical inconsistencies (Simar & Wilson, 2002). Simar & Wilson (2002) established a reliable bootstrap approach that allows a set of data to reveal which global returns to scale can be attributable to the technology. The authors provided a technique that may be used to examine not only the returns to scale of the global technology, but also test hypotheses regarding the scale efficiency of individual firms. The hypothesis to test for the RTS underlying technology is given as follows:

H_0 *= underlying technology globally CRS*

H_a *= underlying technology is VRS*

To test the above hypothesis, the mean of ratios test by Simar and Wilson (2002) is adopted. The test statistic is defined as:

$$\hat{S} = n^{-1}\sum_{i=1}^{n}\left(\frac{D_n^{CRS}(x,y)}{D_n^{VRS}(x,y)}\right) \quad \textbf{(15)}$$

When $\hat{S}$ is significantly less than unity, H_0 is rejected. To statistically test the hypothesis, bootstrapping procedures are used to generate p-values and critical values. Hence H_0 *is* rejected if the p-value is less or equal to the chosen significant level or alternatively, reject H_0 if the level of the test statistic is less than the critical value (Simar & Wilson, 2002).

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4.5 Input and Output Specification.

In selecting the input and output variables for a DEA efficiency and productivity study, the choice of inputs and outputs is a relevant issue. DEA efficiency scores are sensitive to the nature of inputs and outputs utilized in the model (Coelli et al., 2005; Dyson, Allen, Camanho, Podinovski, Sarrico, & Shale, 2001). Generally, researchers use the production approach, value-added approach and intermediation approach. The choice of an approach is dependent on the availability of data and the purpose of the study (Assaf, Barros & Matousek, 2011). The production approach was introduced by Benston (1965), whereby banks turn out loans and deposits account services using labour and capital as inputs. The value-added approach considers deposits and other borrowed funds as output as they are associated with a substantial amount of value-added activities, viz., liquidity, safekeeping, and payments services provided to depositors or investors (Koutsomanoli-Filippaki, Margaritis & Staikouras, 2009). On the other hand, the intermediation approach by Sealey and Lindley (1977), unlike the production approach and value-added approach (Berger & Humphrey, 1992; Benston, 1965; Koutsomanoli-Filippaki et al., 2009), was employed. The approach considers banks as financial intermediaries who mobilize funds from surplus units in the form of deposits and transform them into loans for the deficit units. Hence, total loans and securities are outputs, whereas deposits along with labour and physical capital are inputs. In this regard, labour, physical capital (Property, Plants and Equipment), and deposits are considered as inputs; whereas loans and advances, other earning assets and fees and commission income are considered as outputs. Thus, three inputs and three outputs are chosen in the measurement model. These are presented in Table 4.3 below.

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Table 4. 3: Inputs and Outputs for Dynamic Productivity Estimation**.**

Intermediation Approach		
Variables	**Description**	**Empirical Application**
Inputs		
Deposits	Customer Deposits	Alhassan and Ohene-Asare, 2016
Labour	Personnel Expense	Tortosa-Ausina et al., 2008; Kenjegalieva & Simper, 2010; Kamarudin et al., 2018
Physical Capital	Property, Plants, and Equipment (PPE)	Chronopoulos et al., 2011
Outputs		
Other Earning Assets	Investment Securities (Government Securities and investment securities available for Sale), Investment in Subsidiary, Investment in Associate Companies	Chang et al., 2012,
Loans and Advances	Total Loans and Advances given to Customers excluding Banks	Lyroudi & Angelidis,2006; Chronopoulos et al., 2011
Fees and Commission Income	Non-Interest Income	Tortosa-Ausina et al., 2008; Sufian & Habibullah, 2014; Wang et al., 2014

4.5.1 Inputs

4.5.1.1 Deposits

An enormous portion of bank assets are funded by customer deposits. Banks mobilise deposits from surplus units and lend them as loans to businesses and individuals in need of loan facilities.

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Deposits are found in the liability column of a bank's Statement of Financial position. Lending is normally funded by liability.

4.5.1.2 Labour

Labour is commonly considered as a factor of production. Labour is represented by the cost of labour, which is personnel expense. Personnel expense consists of expenses incurred by banks on their employees. This include salaries, social security fund contributions, provident fund contributions, other allowances, among others. The composition of personnel expenses varies across banks over time.

4.5.1.3 Physical Capital

Often known as fixed assets, physical capital refers to the book value of all land, plant and equipment, machinery, fixtures and premises purchased by the bank either by a direct acquisition or through a contract. Empirical application of this input is seen in studies conducted by Tortosa-Ausina et al. (2012), Assaf et al. (2011), and Kenjegalieva et al. (2009).

4.5.2 Output

4.5.2.1 Other Earning Assets

Other Earning Assets refer to the bank's investments. It is the summation of investment securities (made up of government securities and investment securities available for sale), investments in subsidiaries and investment in associate companies.

4.5.2.2 Loans and Advances

Loans and Advances refer to debt given by banks to households and businesses. To ensure the quality of loan portfolio, net loans and advances is used instead of gross loans and advances given to customers.

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4.5.2.3 Fees and Commission Income

Fees and commission income, also known as non-interest income and are essential to the effective interest rate of a financial asset or liability. They included fees charged by banks on certain services they render to customers, investment management fees, sales commission, placement fees and syndication fees. It is found in a Bank's income statement.

4.6 Productivity Convergence

Beginning with the popularized empirical work of Barro & Sala-i-Martin (1991), Sala-i-Martin & Barro (1995) and Sala-i-Martin (1996) on the concept of convergence, a considerable amount of work has examined the efficiency and productivity convergence of banks worldwide (Fung, 2006; Fung & Leung, 2008; Weill, 2009; Casu & Girardone, 2010; Matthews & Zhang, 2010; Alhassan & Ohene-Asare, 2016; Wild, 2016; Degl'Innocenti, Kourtzidis, Sevic & Tzeremes, 2017). Barro and Sala-i-Martin (1991) constructed two tests for convergence, β-convergence and σ-convergence. The β-convergence test aims to regress the growth rate on the initial level for any variable, whilst σ-convergence aims to investigate the evolution of the dispersion of a cross-section (Weill, 2009). In the context of productivity convergence of banks – β-convergence and σ-convergence, β-convergence considers whether a firm's productivity exhibits a negative association with its performance over time (Fung, 2006). In order words, β-convergence measures the tendency of unproductive banks to achieve the same productivity levels as the productive banks over time.

Also, σ-convergence describes the speed at which the dispersion of productivity narrows over time (Matthews & Zhang, 2010). In order words, σ-convergence measures how quickly all the productivity levels of banks converge towards the average productivity level of the industry. These

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two measures of convergence are complementary. Sala-i Martin (1996) proved in his study that, β-convergence is needful but not an absolute condition for σ-convergence. This is because, β-convergence test does not give information on the evolution of the dispersion of the cross-section as given when σ-convergence is used. Hence, these two measures cannot be excluded in an attempt to test for convergence.

Therefore, following the convergence models used by Barro and Sala-i-Martin (1991), Fung (2006), Weill (2009), Casu & Girardone (2010), Andrieş and Căpraru (2014), Wild (2016), Degl'Innocenti, Kourtzidis, Sevic & Tzeremes (2017) and Duho, Onumah & Asare (2020), the function for beta-convergence is stated in equation 16 as:

$$\Delta y_{i,t} = \beta_1 In(y_{i,t-1}) + \beta_2 Trend_t + \mu_i + \varepsilon_{i,t} \quad \textbf{(16)}$$

From the above, $y_{i,t}$ is the productivity score of bank i at time t; $y_{i,t-1}$ is the productivity score of bank i at time $t-1$; $\Delta y_{i,t} = In(y_{i,t}) - In(y_{i,t-1}), \beta_1$ the unknown parameter of interest indicating the rate of β-convergence; $Trend_t$ captures technological changes; $\mu_i, \varepsilon_{i,t}$ are the firm specific effects and the error term respectively. $\beta_1 < 0$, meaning a negative coefficient of beta-convergence indicates that, unproductive banks are catching up with the productive ones. Also, a higher absolute value implies a faster rate of convergence. There is a proof of beta-convergence if $\beta < 0$ with higher values indicating faster rates while there is a proof of beta-divergence if $\beta > 0$ with a higher value indicating faster rates.

To estimate σ-convergence, this study employs the methodology of Parikh and Shibata (2004) and Daley et al. (2013), as shown in equation 17 below.

$$\Delta E_{i,t} = \sigma_1 E_{i,t-1} + \sigma_2 Trend_t + \varphi_i + \varepsilon_{i,t} \quad \textbf{(17)}$$

$$E_{i,t} = In(y_{i,t}) - In(\bar{y}_t);\ E_{i,t-1} = In(y_{i,t-1}) - In(\bar{y}_{t-1})$$

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And $\Delta E_{i,t} = E_{i,t} - E_{i,t-1}$; $\bar{y}_t$ is the average productivity score for the industry at time t; $\bar{y}_{t-1}$ is the average productivity score of the industry at time $t-1$; σ_1 is the unknown parameter of interest that indicates the rate of convergence from $y_{i,t}$ to $\bar{y}_t$. $y_{i,t}$ and $y_{i,t-1}$ are the productivity scores of bank i at time t and $t-1$ respectively. $\sigma_1 < 0$ indicates that there is a reduction in the disparities among the productivity levels in the industry. Also, the higher the absolute value of $\sigma_{1,}$ the faster the rate of convergence.

4.7 The Second Stag-DEA Estimation Procedure

DEA analysis begins with the estimation of technical, cost, revenue, profit efficiencies with inputs and outputs. This is often known as the first stage DEA Analysis.

After the first stage analysis is done to get the efficiency estimates, the resulting efficiency estimates are regressed on environmental variables in the second stage known as second-stage regression (Simar & Wilson, 2011). Second-stage regression is used to regress efficiency scores on factors perceived to influence efficiency (McDonald, 2009). Productivity and efficiency analysis are concerned with performances of firms to identify firms that are productive or efficient. From a managerial perspective, it is important to analyse the influential factors that can determine changes in productivity patterns (Badin, Daraio & Simar, 2012) which is possible via Second-Stage DEA analysis.

Despite the popularity of the Second stage DEA analysis, there has been some controversies on the appropriate regression approach to use. Hoff (2007) advocates using Tobit and ordinary least squares in Second stage DEA analysis. McDonald (2009) argued that, Tobit is appropriate when the predictor variable data are generated by a censoring DGP (Data Generating Process) but not

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suitable when data is fractional data. Tobit estimation for second stage efficiency analysis has been criticized because Tobit estimation technique is not able to address the heteroscedasticity errors in the second stage analysis using the efficiency scores (Arabmazar & Schmidt, 1982). Simar and Wilson (2007) in their study criticized preceding studies that used Tobit, because of their failure to expound the underlying Data Generating Process (DGP) that allow uncontrollable explanatory variables to affect firm's efficiencies. They also contended that the first stage dependency issue suggests that, the idiosyncratic term of the Tobit regression is correlated with the environmental variables, making Tobit estimation unsuitable. Also, using ordinary least squares (OLS) estimation techniques for panel model can be inefficient and biased due to the form of error terms in a panel model (Wooldridge, 2015).

The study employs panel data methodology to attain the set objective. Panel data methodology is used instead of cross-sectional data or time series, because it exploits the merits of both time series and cross-section, and also addresses the weakness of the latter techniques. It also helps to better identify a model more than time series and cross section technique (Gujarati, 2009). Another advantage of panel data estimation is that, it helps control for omitted variable error, bank specific effect and time specific effect (Wooldridge, 2010, 2015). According to Brooks (2019), the panel model is given by:

$$Y_{it} = \alpha + \beta X_{it} + \mu_{it} \qquad \textbf{(18)}$$

i represents cross-sectional dimension (bank); t represents time series dimension (time); Y_{it} is the dependent variable; α is a constant term; β is $k \times 1$ vector of parameter of the independent variables; X_{it} is a $1 \times k$ is a vector of observations on the predictor variables and μ_{it} is the Stochastic term.

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In estimating the panel model, the study used the panel model for random effects (RE) or fixed effects (FE) based on the Hausman test. The model also has the ability to capture the within-entity error and the between-entity error separately in its model. The individual specific effect in the random effect model is a random variable, which is uncorrelated to the predictor variables (Greene, 2008).

Also, the authors argued that efficiency scores are not between the limits of 0 and 1 but truncated; hence, proposed the truncated regression for second stage efficiency analyses (Barros et al., 2010; Du et al., 2018; Kenjegalieva et al., 2009; Lu et al., 2014; , 2009).

Therefore, truncated regression is adopted in this study. It has been criticized that the restrictive assumptions under truncated regression is not realistic under empirical setting (Banker et al., 2019). Also, due to potential endogeneity resulting from reverse causality between productivity scores and covariates which can result in bias estimations (Williams, 2012), systems GMM is used in the regression analysis to correct for endogeneity.

4.7.1 Bank Specific, Industry Specific and Macroeconomic factors and BMPSCORE

To examine the various factors that affect productivity of Ghanaian banks, the following specific model is adopted:

$$BMPSCORE_{i,t} = \beta_0 + \beta_1 BS_{i,t} + \beta_2 FOR_{i,t} + \beta_3 LIS_{i,t} + \beta_4 CR_{I,t} + \beta_5 LR_{i,t} + \beta_6 OR_{i,t} + \beta_7 SR_{i,t} + \beta_8 CAPR_{i,t} + \beta_9 MR_{i,t} + \beta_{10} GDP_{i,t} + \beta_{11} IR_{i,t} + \beta_{12} ER_{i,t} + \beta_{13} UR_{i,t} + \beta_{14} MPR_{i,t}\, \alpha_i + \lambda_t + \varepsilon_{i,t} \qquad \textbf{(19)}$$

Where *BMPSCORE* happens to be the productivity score obtained from the first stage DEA analysis; and αi represents bank-specific fixed effects, λt captures time effects, $\mathcal{E}_{i,t}$ is the stochastic

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term; and the subscripts *i*, *t* represent a particular bank *i*, at time *t*. However, the regressors are explained in Table 4.4 below.

The second stage variables are described in Table 4.4 below:

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Table 4. 4: Second-Stage Variable Definition and Description

Variables	Description	Proxies	Empirical Application
BS	Size	Natural Logarithm of total Assets	Andrieș, Căpraru & Nistor (2018)
FOR	Ownership	Dummy (1 if foreign-owned 0 otherwise)	**Adeabah,Gyeke-Dako & Andoh, 2019**
LIS	Capitalization	Dummy (1 if Listed 0 otherwise)	Adusei, 2011
CR	Credit Risk	Non-performing loans/ Gross loans and advances	Fiordelisi et al. , 2011
LR	Liquidity risk	Liquid assets/Total assets	Zhang et.al, 2013
OR	Operational risk	Volatility of Net Interest Margin	Danisman & Demirel, 2019
SR	Insolvency risk	Z-score	Tan & Floros, 2018
CAPR	Capital risk	Stated capital /Total assets	Tan & Floros, 2018
MR	Market risk	Exchange rate volatility	Sun & Chang, 2011
GDP	Real GDP rate	Yearly real GDP growth rate per capita	Petria, Capraru & Ihnatov, 2015
IR	Inflation Rate	Yearly Inflation rate	Petria, Capraru & Ihnatov, 2015
ER	Exchange Rate	Exchange rate (against US$) in the host country at time t	Taiwo & Adesola, 2013
UR	Unemployment Rate	Yearly unemployment rate in the Ghanaian economy	Mokhova & Zinecker, 2014
MPR	Monetary Policy Rate	Yearly MPR rate by BOG	Kelilume, 2014

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4.8 Instruments for Data Analysis

Data for running Biennial Malmquist Index scores was analysed using MaxDEA Pro 7.0. R software version 3.13 was used in analysing both descriptive statistics and hypothesis testing. In the second stage, Stata Edition 14 was used for all regression analysis.

4.9 Chapter Summary

This chapter described the approach used to assess the productivity of selected banks within the Ghanaian banking sector. It began by justifying the research design adopted in the study, then presented the data sources and how the sample was selected for the study. Further examples are given for complex productivity estimation techniques. Both the standard Malmquist and the Biennial Malmquist indices and their components are described. Finally, all tests and techniques used in achieving the research objectives were thoroughly clarified and justified.

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CHAPTER FIVE

DATA ANALYSIS AND DISCUSSION OF FINDINGS

5.0 Introduction

This chapter is set to analyse the results of the data and also to discuss the findings of the study in a logical manner. Discussion of both empirical and theoretical arguments are often provided to draw inferences from research findings.

5.1 Data Description

The aim of this study is to examine the effect of some risk factors on the productivity of banks in Ghana. To achieve this purpose, data for this study was sourced from audited annual reports of averagely, 21 banks from 2004 to 2019. In modelling inputs and outputs for the study, inputs and output variables were selected based on the intermediation approach. The input variables consist of total customer deposit, labour and physical capital whilst output variables consist of total loans and advances to customers, other earning assets and fees and commission income. Table 5.1 also shows the descriptive statistics of inputs and outputs variables used. The mean, maximum, minimum and standard deviation of the pooled data for each component from 2004 to 2019 are presented below.

To examine the impact of covariates on productivity, productivity scores were regressed on some predictor variables. Table 5.3 also provides the descriptive statistics of the variables used in the regression. The mean, maximum, minimum and standard deviation of the pooled data from 2004 to 2019 for each variable are presented.

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Table 5. 1: Summary Statistics for Inputs and Outputs-Pooled Data (Amount in Ghana Cedis Only)

	Variables	Count	Mean	SD	Min	Max
Inputs	Deposits	334	1381313993	1586295129	92360	9730000000
	Labour	334	188807018	88794594	100000000	494000000
	Physical Capital	334	205882353	102686834	104000000	504000000
Outputs	Loans and Advances	334	846226923	826796515	1030000000	5320000000
	Other Earning Assets	334	826073529	1090246874	102000000	6230000000
	Fees and Commission Income	334	179407407	69419715	103000000	395000000

Count =Number of observation, SD = Standard Deviation, Min= Minimum Value, Max = Maximum Value

From Table 5.1 above, the difference, between the maximum and the minimum values for each variable gives the range size. The range varies for both input and output. It shows that Ghanaian banks vary in size. The higher standard deviations values as compared with the mean values of both input and output confirms the claim. Secondly, the mean values of the inputs show that, on average the input used most by banks in Ghana is deposits as it has the highest mean value of GH₵1,381,313,993. Also, the mean values of the outputs show that, on average the output used most by banks in Ghana is loans and advances given to customers as it has the highest mean value of GH₵846,226,923.

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Table 5. 2: The Isotonicity Test (Correlation Analysis between Inputs and Outputs)

	Deposits	Physical Capital	Labour	Loans and Advances	Other Earning Assets	Fees and Commission Income
Deposits	1					
Physical Capital	0.77***	1				
Labour	0.93***	0.7***	1			
Loans and Advances	0.87***	0.76***	0.84***	1		
Other Earning Assets	0.78***	0.52***	0.7***	0.49***	1	
Fees and Commission Income	0.86***	0.63***	0.88***	0.81***	0.57***	1

*****P< 0.005 (Correlation significant at 5% level of significance).**

Before estimating productivity under DEA, it is expedient that, the property of isotonicity is satisfied. The property demands that, all inputs show a positive relationship with outputs (Cooper, Seiford & Zhu, 2011; Thanassoulis, 2001). This can be achieved by the test of correlation between inputs and outputs.

From the above results, the relationship between the inputs and output variables show that, there is a significant positive relationship between the input and output variables meaning that, an increase in inputs will result in an increase in outputs, thus fulfilling the assumption for DEA on the characteristics of isotonicity relations.

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Table 5. 3: Shows a Summary Statistics of the Variables used in Regression Analysis

Variables	Mean	Max	Min	SD
BMPSCORE	0.99	2.58	0.01	0.22
BS	20.68	23.3	14.81	1.4
FOR	0.56	1	0	0.5
LIS	0.35	1	0	0.48
CR	0.12	0.72	0	0.11
LR	0.18	2.29	0.01	0.17
OR	18.1	20.88	13.79	1.42
SR	14.17	145.62	-0.48	18.14
CAPR	0.39	49.65	0	3.69
MR	1.43	1.83	0.07	0.35
GDP	6.4	14	2.2	2.95
IR	12.54	19.25	7.13	3.94
ER	2.65	5.7	0.91	1.54
UR	5.32	6.81	4.16	0.85
MPR	17.88	26	12.5	4.48

SD= Standard Deviation, Min= Minimum Value, Max= Maximum Value

From Table 5.3, Biennial Productivity Score (BMPSCORE) which ranges between a maximum of 2.58 and a minimum of 0.01 is averagely 0.99. This implies that Ghanaian banks are moderately productive. From the standard deviation value of 0.22 which shows the degree of dispersion of productivity around its mean, it is observed that productivity is moderately distributed around its mean. In relation to insolvency risk which measures the risk of not being able to handle losses caused by all forms of risks, it is observed that banks are on the average 14.17 points away from financial distress. Also, GDP averaged 6.4%, an appreciable level of growth for a bank performance. However, inflation rate averaging 12.54% which is relatively high and can increase the cost of mobilizing deposits as input to aid banking operations.

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5.2 Test for Returns to scale

One of the assumptions underlying the use of DEA is that, the technology underlying the industry under estimation can either be VRS or CRS. Choosing either CRS or VRS has implication on efficiency and productivity results. To this effect, the appropriate scale elasticity property in the banking sector of the Ghanaian economy was tested. The study used the test procedure of Simar and Wilson (2002). The null hypothesis which is CRS is tested against the alternate hypothesis which is VRS. The null hypothesis is rejected when the p-value is less than the level of significance which is 1%. The results in Table 5.4 below provides support for the null hypothesis to be rejected at 1% level of significance, and conclude that, the technology underlying the Ghanaian banking industry is VRS.

Table 5.4: Test of RTS

TEST STAT	**0.6146414**
CRITICAL VALUE	**0.8117221**
P-VALUE	**0.001**

5.3 Dynamic productivity in the Ghanaian Banking Industry

The first objective of this study is to determine the dynamic productivities of banks in Ghana and to determine the sources of the change in productivity using Biennial Malmquist Productivity indices. The objective is to assess if the productivity of banks in Ghana is rising, stagnating or decreasing. The yearly averages of the estimated productivity indices are shown in Table 5.5 as

“BMPSCORE”. Geometric means are used since DEA efficiency estimates are ratios and there is a tendency that, they can be skewed.

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Table 5. 5: Biennial Malmquist Productivity Index and Decompositions

YEAR	BMPSCORE	EC	TC
2004-2005	0.9281	0.9619	0.9649
2005-2006	0.8156	1.047	0.779
2006-2007	0.9128	0.9718	0.9393
2007-2008	1.0007	0.9942	1.0066
2008-2009	0.9121	0.9499	0.9603
2009-2010	0.9716	1.04	0.9342
2010-2011	1.0247	1.0055	1.0191
2011-2012	1.0091	0.9801	1.0296
2012-2013	1.0203	0.993	1.0275
2013-2014	0.9707	0.9479	1.0241
2014-2015	1.0045	1.0071	0.9974
2015-2016	0.9701	1.0591	0.9159
2016-2017	0.9595	0.9042	1.0612
2017-2018	1.0827	1.0301	1.051
2018-2019	1.08	0.9724	1.1106
GEOMEAN	**0.9752**	**0.9901**	**0.9849**

BMPSCORE= Biennial Malmquist Productivity Score, **EC=**Efficiency Change, **TC=** Technical Change

Findings from Table 5.5 shows that, the productivity of banks in Ghana have retrogressed by an average of -2.48% (.i.e. [0.9752–1]×100) annually during 2004 to 2019. This is mainly driven by cycles of a retrogression in productivity in 2004-2005 (-7.19% decline), 2005-2006 (-18.44% decline), 2006-2007 (-8.72% decline), 2008-2009 (-8.79% decline), 2009-2010 (-2.84% decline), 2013-2014 (-2.93% decline), 2015-2016 (-2.99% decline) and 2016-2017 (-4.05 decline%). However, the biannual estimates of productivity mostly showed progress for the following periods: 2007-2008, 2010-2011, 2011-2012, 2012-2013, 2014-2015, 2017-2018 and 2018-2019. The growth in 2010-2011 of 24.7% is the most significant growth in the industry during the period; this is followed by an 8.27% growth in 2017-2018 and 8% in 2018-2019.

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This is significant because, it shows that, while the average productivity for the whole period (2004 to 2019) retrogressed, productivity change in each year varies. The retrogression in the overall productivity of banks in the Ghanaian banking industry can be partly, explained in reference to trends in the industry during 2016 to 2017 when there were risk disclosures by BOG as explained in the context of study.

As knowledge of the extent of productivity shift in the industry for the sample period has been understood, what remains unknown is the cause of the productivity situation in the industry. Suitable reasons to this can be gained by decomposing the BMPI into EC and TC. Table 5.5 shows the two factor decomposition of the Malmquist index by Fare et al (1992). Productivity changes are attributable to managerial decisions- efficiency change (EC) and attributable to technological innovation in the industry - technical change (TC). Careful inspection of TC and EC in Table 5.5 shows that, the source of the overall productivity gain in the Ghanaian banking industry was neither due to EC which is attributed to prudent managerial decisions which can led to the efficient allocation of resources nor technical change which is attributable to technological innovation. Although, there exist a decline in both efficiency change (EC) and technical change (TC), the decline in technical change (TC) outweighed that of efficiency change (EC). Hence, productivity growth was seen due to efficiency change than technical change within the industry. The above decompositions show that, there is a retrogression in both Efficiency growth and Technical growth of which 0.99% (.i.e. $[0.9901-1]\times100$) is due to efficiency change and 1.51% (.i.e. $[0.9849-1]\times100$) is due to technical change.

Although, there is a retrogression in the source of productivity change for the overall period; 2004 to 2019, the biannual estimates of the sources of productivity growth mostly showed progress for the following periods: 2010-2011 and 2017-2018.

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A growth of 0.55% and 3.01% in both 2010-2011 and 2017-2018 respectively is attributed to efficiency change whereas a growth of 1.91% and 5.01% in both 2010-2011and 2017-2018 respectively is due to technical change.

Furthermore, the biannual estimates of the sources of productivity growth mostly showed progress which is associated with efficiency than technical change and vice-versa. A growth of 4.7%, 4%, 0.71%, 5.91% in the period- 2005-2006, 2009-2010, 2014-2015 and 2015-2016 is attributed to efficiency change respectively whereas a growth of 0.66%, 1.91%, 2.75%, 2.41%, 6.12%, 11.06% in the period- 2007-2008, 2011-2012, 2012-2013, 2013-2014, 2016-2017 and 2018-2019 is attributed to technical change respectively. The results show that, both prudent managerial decisions and technological innovation are the sources for the overall productivity growth and declines in all scenarios.

This is contrary to results by Fernandes et al. (2018) which indicate that between 2007-2014 Portuguese banks had the highest productivity growth of 2.5%, Spain, Greece, Italy and Ireland on the other hand obtained productivity growth rates of 2.2%, 2.1%, 1.9% and 1.2% respectively. In terms of MPI decomposition, they observed that the productivity growth rates of these countries were as a result of technological component (TECHCH) instead of efficiency change.

In measuring the technical efficiency and productivity change, Liu (2010) evaluated 25 commercial Taiwanese banks. The focus for this study was the post Asian crisis period of 1997–2001. Results of this study indicated that 15 out of the 25 banks were improving in terms of their technical efficiency meanwhile, the 10 others saw a decline in their technical efficiencies over the period. Also while the Taiwanese banking industry had been experiencing an upward shift in technology since 1998, it had been characterized by a decreased technical efficiency.

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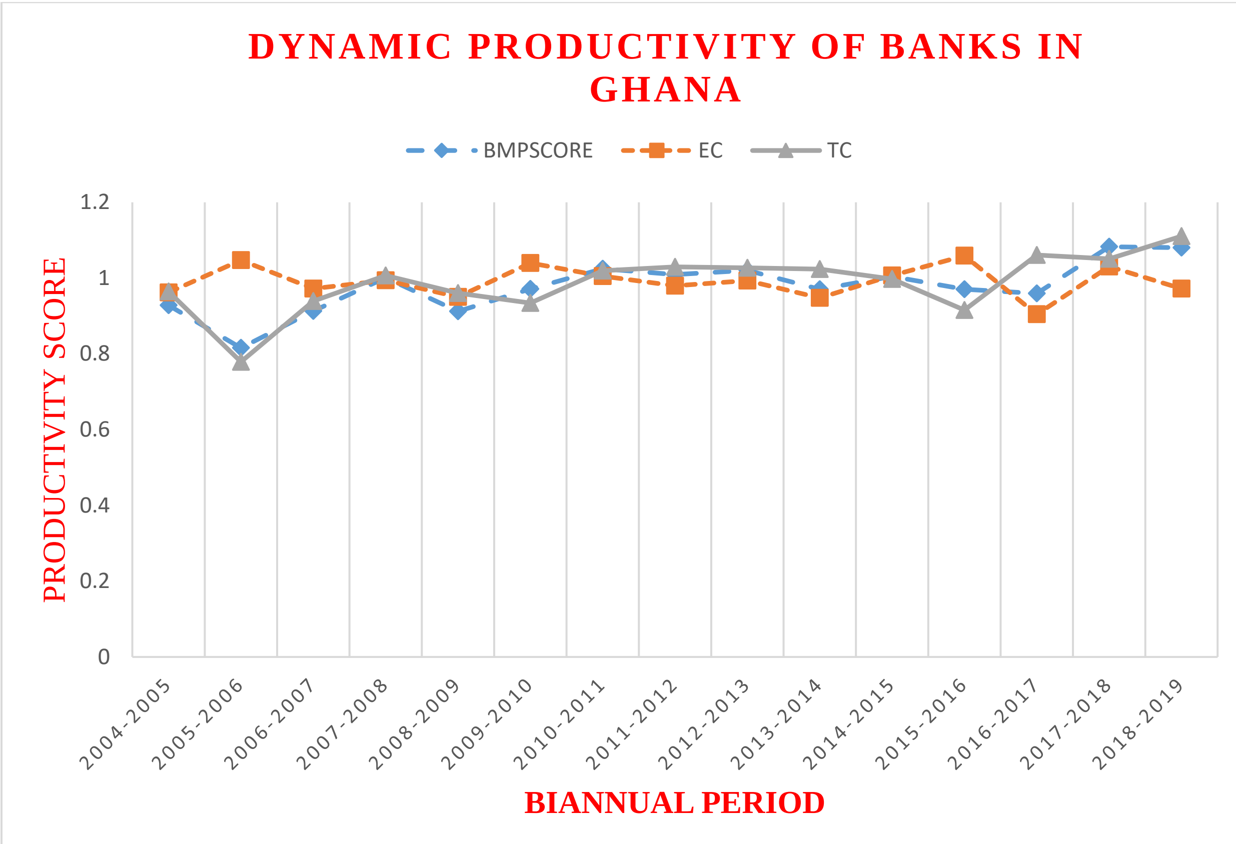

Figure 5. 1: Biannual dynamic productivity of Ghanaian banks

Source: Author's Construct (2020)

Productivity measures efficiency over two-time period. Figure 5.1 showed the biannual change in productivity from 2004 to 2019. It can be observed from the above graph that, there was a retrogression in overall productivity growth between years 2004-2005. The source of the retrogression was mainly due to a decline in technical change than efficiency change.

However, between 2005 -2006, there was an improvement in efficiency change by 4.7% whereas there was a technological regress by 22.1%. The effect of this changes caused a reduction in overall productivity growth by 18.44%

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Furthermore, between the periods; 2010-2011 and 2017-2018, banks in Ghana experienced overall growth in productivity. Banks saw process in both efficiency change and technological change. However, the change in technological outweighed that of efficiency change. This progress could be due to an innovation that took place within the industry.

5.4 Dynamic Productivity Comparisons

The second objective of the study is to determine whether there is a significant difference in the productivities of domestic and foreign banks in Ghana. To achieve this objective, the non-parametric Wilcoxon Rank-sum Test and the parametric Independent T-test are employed. The means, variance and test-statistics together with the p-values in parentheses are reported in Table 5.6 below.

Table 5.6: Dynamic Productivity Differences

	BMPSCORE		**EC**		**TC**	
	Domestic	**Foreign**	**Domestic**	**Foreign**	**Domestic**	**Foreign**
Mean	1.0039	1.0015	1.0070	0.9954	0.9995	1.0114
Variance	0.2365	0.2022	0.1834	0.1188	0.1468	0.2027
Observations	139	156	139	156	139	156
Wilcoxon Rank-sum Test	10925(0.9091)		11271(0.5129)		10912(0.9228)	
T-test	0.09458(0.9247)		0.64042(0.5225)		0.5846(0.5593)	

p-values are shown in parentheses

The results from Table 5.6 evidently shows that, domestic banks experienced an average productivity gain of 0.39% (.i.e. [1.0039–1]×100) whereas foreign banks experienced an average productivity gain of 0.15% (.i.e. [1.0015–1]×100). Numerically, the marginal productivity gains of domestic banks exceed that of foreign banks by 0.24% only. However, the marginal difference

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is not statistically significant. Similarly, whereas the average efficiency growth of domestic banks increased by 0.70% (.i.e. [1.0070–1]×100), that of foreign banks declined by 0.46% (.i.e. [0.9954–1]×100). Also, the average technical growth of domestic banks declined by 0.05% (.i.e. [0.9995–1]×100) whilst that of foreign banks increased by 1.14% (.i.e. [1.0114–1]×100). Differences for both efficiency and technical growth of domestic and foreign banks were found to be statistically insignificant. This seems to suggest that, domestic banks do not perform better or worse off over time as compared to foreign banks. Therefore, no support was found for the home field advantage hypothesis since the marginal differences for productivity and efficiency growth were statistically insignificant.

Empirically, the observations here seem to support the claims of earlier studies that no significant differences exist between the performance of domestic and foreign banks. Sanyal & Shankar (2011) and Sufian & Kamarudin (2014) compared the performance of foreign and domestic banks but found no significant difference in productivity growth between the two types of banks. However, this finding contrasts previous studies of Sufian (2011) who found support for the home field advantage hypothesis by (Berger et al., 2000) confirming that foreign banks are the least productive banking group compared to their domestic counterparts.

5.5 Productivity convergence.

The third objective of the study is to estimate the rate of productivity convergence within the Ghanaian banking industry and to uncover the ways in which convergence occurs for both domestic and foreign banks. Findings of productivity (BMPSCORE) convergence is based on the fixed effects (FE) estimations which are presented in Table 5.7 below.

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Table 5.7: Regression Results on Productivity Convergence

	All Banks		Domestic	Foreign	Domestic	Foreign
	Beta-Convergence	**Sigma-Convergence**	**Beta-Convergence**		**Sigma-Convergence**	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	FE	**FE**	**FE**	**FE**	**FE**	**FE**
Constant	-0.119***	-0.0474	-0.127***	-0.130*	-0.0474	-0.0573
	(0.0343)	(0.0349)	(0.0389)	(0.0645)	(0.0405)	(0.0635)
Trends	0.0108**	0.00232	0.0127**	0.0111	0.00362	0.00257
	(0.00396)	(0.00403)	(0.00493)	(0.00689)	(0.00514)	(0.00677)
$\boldsymbol{\beta_1}$	-1.258***		-1.347***	-1.157***		
	(0.0811)		(0.128)	(0.0675)		
$\boldsymbol{\delta_1}$		-0.283***			-0.384***	-0.131**
		(0.0735)			(0.115)	(0.0586)
F test	121.14	7.47	61.20	163.91	6.31	2.66
Prob > F	0.0000	0.0022	0.0000	0.0000	0.0084	0.0990
R-squared	0.637	0.081	0.67	0.58	0.149	0.018
Hausman	141.69	185.34	25.66	49.76	34.33	43.10
Prob > x^2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Observations	295	295	139	156	139	156

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

From Table 5.7, the adoption of FE is justified by the Hausman test results. The significant p-values ($p < 0.05$) under all the models in the above table is a proof. Generally, the Models; 1, 3 and 4 indicate a reasonable goodness of fit because their R-sqaured is greater than 50%. Secondly, the F-statistics of these models are statistically significant at 1%, which indicates the joint significance of the explanatory variables in explaining the variations in productivity growth for

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reliability of the regression results. Although the goodness of fit (R-squared) for Models; 2 and 5 are low, the probability of F test for these models are less than 0.05, indicating that the models are reliable and valid.

Again, the results in all models provide evidence about beta-convergence and sigma-convergence within the Ghanaian banking industry. Indeed, the coefficients β_1 and δ_1 are statistically significant for all banks and both types of ownership.

The regression results for beta-convergence in Model 1 shows that, β_1 , the coefficient of $In(y_{i,t} - 1)$ is negative and statistically significant at 1% significance level. This shows that over the study period, banks with initially lower productivity have improved their performance faster and are able to achieve the same productivity levels with productive banks.

In terms of sigma-convergence in Model 2, its coefficient is negative and statistically significant at 1% significance level. This demonstrates that, the dispersion of productivity growth has also narrowed during the study period.

Similarly, in Model 3 and 4, results for beta-convergence for domestic and foreign banks shows that, β_1 , the coefficient of $In(y_{i,t} - 1)$ is negative and statistically significant at 1% significance level. However, the rate of beta-convergence for domestic banks is faster than that of foreign banks indicated by the higher absolute value of β_1 .

In terms of sigma-convergence, results in Model 5 and 6, suggests that, the productivities of domestic and foreign banks are converging towards the industry's average productivity levels. Specifically, δ_1 is negative and significant at 1% significance level with a rate of 0.38% and 0.13% for domestic and foreign banks respectively. Hence, the productivities of domestic banks are converging faster towards the industry's average productivity levels than that of foreign banks.

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This is also confirmed by the average productivity score of domestic banks which is 1.0039 compared to the average productivity score of foreign banks which is 1.0015.

The evidence for convergence is consistent with the results of Matthews & Zhang (2010) who found the existence of convergence of productivity among state-owned commercial banks (SOCBs) joint-stock banks (JSCBs) and city commercial banks (CCBs) in China. Banyen & Biekpe (2020) also found evidence for both beta-convergence and sigma-convergence in the efficiency of 405 banks across 47 African countries over 2007–2014

5.5 Returns to Scale Property at the firm Level.

One of the assumptions underlying DEA formulations- whether envelopment or multiplier models, is that, firms are operating under CRS in CCR models (Charnes et al., 1978). In instances when there are financial constraints, imperfect of competition and regulatory changes, this CRS assumption may not hold (Coelli et al., 2005). Thus the underlying technological set can show different Returns to Scale (RTS) characteristics if DMUs are not operating at an optimal size. Banker et al. (1984) modified the CCR (CRS) model into VRS model which allows for DMUs to be compared to other similar size DMUs. The VRS assumption enables the technology to exhibit CRS, DRS and IRS.

The study examined the returns to scale property at the firm level in order to determine the size of a bank. The scale elasticity property shows the relationship between inputs and outputs quantities (Ohene-Asare, Asare & Turkson, 2019). It shows whether a firm is exhibiting either increasing, decreasing and constant returns to scale as they combine various inputs and outputs. The decreasing returns to scale (DRS) shows how outputs increase less than proportionately with inputs and increasing returns to scale (IRS) shows how outputs rise more than proportionally with inputs

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and CRS shows how an increase in output does not change with an increase in input (Yang et al., 2014).

This study uses the criterion proposed by Aly, Grabowski, Pasurka & Rangan (1990), Cummis & Xie (2013) and Ohene-Asare, Asare & Turkson (2019).

The frequencies and percentages of the returns to scale property for the bank sub-groups over the period 2004-2019 are shown in Table 5.8.

Table 5. 8: Annual Returns to scale Statistics (Ownership)

Year	**Domestic**			**Foreign**			**All**		
	CRS	DRS	IRS	CRS	DRS	IRS	CRS	DRS	IRS
2004	3 (30%)	2 (20%)	5 (50%)	1 (17%)	2 (33%)	3 (50%)	4 (25%)	4 (25%)	8 (50%)
2005	2 (20%)	1 (10%)	7 (70%)	0 (0%)	0 (0%)	6 (100%)	2 (13%)	1 (6%)	13 (81%)
2006	2 (18%)	5 (45%)	4 (36%)	2 (25%)	2 (25%)	4 (50%)	4 (21%)	7 (37%)	8 (42%)
2007	3 (27%)	4 (36%)	4 (36%)	3 (33%)	2 (22%)	4 (44%)	6 (30%)	6 (30%)	8 (40%)
2008	1 (13%)	3 (38%)	4 (50%)	0 (0%)	6 (67%)	3 (33%)	1 (6%)	9 (53%)	7 (41%)
2009	2 (29%)	1 (14%)	4 (57%)	3 (38%)	1 (13%)	4 (50%)	5 (33%)	2 (13%)	8 (53%)
2010	0 (0%)	2 (25%)	6 (75%)	2 (20%)	4 (40%)	4 (40%)	2 (11%)	6 (33%)	10 (56%)
2011	1 (10%)	3 (30%)	6 (60%)	2 (20%)	4 (40%)	4 (40%)	3 (15%)	7 (35%)	10 (50%)
2012	1 (10%)	3 (30%)	6 (60%)	1 (10%)	3 (30%)	6 (60%)	2 (10%)	6 (30%)	12 (60%)
2013	7 (50%)	2 (14%)	5 (36%)	1 (9%)	5 (45%)	5 (45%)	8 (32%)	7 (28%)	10 (40%)
2014	5 (36%)	5 (36%)	4 (29%)	3 (23%)	4 (31%)	6 (46%)	8 (30%)	9 (33%)	10 (37%)
2015	3 (21%)	9 (64%)	2 (14%)	2 (13%)	6 (40%)	7 (47%)	5 (17%)	15 (52%)	9 (31%)
2016	5 (42%)	2 (17%)	5 (42%)	3 (20%)	5 (33%)	7 (47%)	8 (30%)	7 (26%)	12 (44%)
2017	1 (13%)	6 (75%)	1 (13%)	2 (13%)	8 (53%)	5 (33%)	3 (13%)	14 (61%)	6 (26%)
2018	0 (0%)	7 (88%)	1 (13%)	0 (0%)	10 (71%)	4 (29%)	0 (0%)	17 (77%)	5 (23%)
2019	0 (0%)	5 (71%)	2 (29%)	2 (15%)	7 (54%)	4 (31%)	2 (10%)	12 (60%)	6 (30%)

Table 5.8 shows the returns to scale property of both domestic and foreign banks at the firm level during the period 2004 to 2019. It can be observed from the scores that, both most domestic and foreign banks experienced IRS and DRS than CRS.

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In the year 2008, 50% of domestic banks were experiencing increasing returns to scale (IRS) while in 2014, 36% of domestic banks experienced decreasing returns to scale (DRS) and 21% of domestic banks in 2015 experienced constant returns to scale (CRS).

Unlike domestic banks, 41% of foreign banks in the year 2008 were experiencing increasing returns to scale (IRS) while in 2014, 33% of foreign banks experienced decreasing returns to scale (DRS) and 17% of foreign banks in 2015 experienced constant returns to scale (CRS).

From the overall statistics for both domestic and foreign banks, in the year 2005,2006 and 2007, 81%, 42% and 40% of banks in Ghana experienced IRS respectively while in 2014, 2015, 2016; 33%,52% and 26% of banks experienced DRS respectively. However, in 2017, 2018 and 2019; 13%, 0% and 2% of banks in Ghana experienced CRS.

The findings show that, the claim that all banks operate at constant returns to scale will not always hold in certain context or scenarios.

5.6 Effect of risk on the productivity of Banks in Ghana.

The fourth objective of this study is to examine the impact of risk on the productivity of banks. To achieve this objective, the study employed truncated regression, fixed effects and systems GMM models for a comparative analysis. The choice of FE was based on the Hausman test. A Hausman test was carried out to find out which estimation technique (fixed effects or random effects) is best suited for the data. Due to potential endogeneity which arises as a result of reverse causality between productivity scores and covariates which can result in bias estimation (Roberts & Whited, 2013; Williams, 2012), systems GMM is used. Finally, the three requirements are met for the validity of the system GMM as shown in Model 3 below. First, there is no second order autocorrelation as indicated by the p-value (0.433). Second, the Hansen J statistics is statistically

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insignificant indicating that the instrumental variables are not related with the disturbance term, thus they are valid. Finally, the number of instruments is smaller than the number of observations in the study. All conclusions are based on Truncated regression model.

Table 5. 9: Correlation matrix for the second stage variables.

	BMPSCORE	*FOR*	*LIS*	*SIZE*	*SR*	*CR*	*OR*	*CAPR*	*LR*	*MR*	*GDP*	*IR*	*UR*	*ER*	*MPR*
BMPSCORE	1.00														
FOR	-0.01	1.00													
LIS	0.06	-0.02	1.00												
SIZE	0.21	0.11	0.18	1.00											
SR	0.03	-0.19	-0.23	-0.05	1.00										
CR	0.03	0.04	0.01	0.25	0.10	1.00									
OR	0.22	0.15	0.31	0.68	-0.10	0.24	1.00								
CAPR	0.00	0.01	0.11	-0.34	-0.03	-0.07	0.09	1.00							
LR	0.09	0.21	0.09	-0.01	0.09	0.08	0.15	0.05	1.00						
MR	0.09	-0.02	0.25	0.33	-0.01	0.06	0.36	0.03	-0.01	1.00					
GDP	0.06	0.00	0.05	-0.06	-0.06	-0.07	-0.13	-0.10	0.03	0.04	1.00				
IR	-0.11	-0.05	-0.03	-0.15	-0.04	-0.05	-0.08	0.06	0.00	-0.08	-0.59	1.00			
UR	-0.01	-0.02	-0.06	-0.05	-0.02	-0.09	0.04	0.12	-0.23	-0.03	-0.26	0.38	1.00		
ER	0.11	0.19	0.00	0.65	0.12	0.30	0.66	0.02	0.24	0.07	-0.27	-0.12	-0.21	1.00	
MPR	0.00	0.09	-0.05	0.40	0.07	0.21	0.46	0.06	0.15	-0.01	-0.66	0.69	0.38	0.62	1.00

For any regression analysis, first the degree of multicollinearity between the independent variables must be tested. According to Kennedy (2008), there is multicollinearity if the correlation coefficients are greater than 0.70. This is done by way of a correlation matrix as presented in Table 5.9. There is no evidence of multicollinearity in the correlation matrix in Table 5.9 since all of the correlation coefficients are less than 0.70. The above correlation matrix shows that, there is a positive association between risk variables and productivity.

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Table 5. 10: Regression results for Second Stage

VARIABLES	1 FE	2 TRUNCATED	-3 SYS GMM
CONSTANT	-0.392	-0.42	-0.277
	(0.635)	(0.357)	(2.989)
FOR	-0.0736	-0.0172	-0.283
	(0.107)	(0.0288)	(2.004)
LIS	0.0118	0.0018	-0.629
	(0.103)	(0.0321)	(1.417)
SIZE	0.116**	0.0924**	0.371
	(0.0499)	(0.0391)	(0.382)
SR	0.00158	0.00108	0.00254
	(0.00233)	(0.000862)	(0.013)
CR	0.0492	-0.0327	-0.0739
	(0.181)	(0.14)	(1.115)
OR	-0.0515	-0.0201	-0.288
	(0.0456)	(0.0354)	(0.272)
CAPR	0.0165*	0.0131*	0.0657
	(0.00838)	(0.00684)	(0.0636)
LR	0.210*	0.196**	0.202
	(0.11)	(0.0973)	(0.796)
MR	-0.0389	-0.0287	-0.583
	(0.0823)	(0.0513)	(2.624)
GDP	-0.00267	-0.00161	0.00333
	(0.00713)	(0.00658)	(0.00795)
IR	-0.00735	-0.00451	0.00444
	(0.0103)	(0.00991)	(0.0128)
UR	0.00983	0.00605	0.005
	(0.0315)	(0.027)	(0.0706)
ER	-0.0666	-0.0515	-0.0232
	(0.0467)	(0.0366)	(0.205)
MPR	0.00525	0.000901	2.64E-05
	(0.015)	(0.0144)	(0.0254)
R^2	0.059		
Wald Chi2		24.18	
Prob >Chi2		0.0436	
Hausman Test	12.09**		
F test			61.25

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Prob >F			0.0000
Hettest: Prob > x^2			0.0000
AR (1): Prob > F			0.043
AR (2): Prob > F			0.433
Hansen J x^2 Prob > x^2			0.844
Instruments			20
Observations	229	229	195

Note: hettest = heteroscedasticity; AR(1) = first order autocorrelation; AR(2)= second order autocorrelation; R^2= R-squared

Standard errors in parentheses
***** p<0.01, ** p<0.05, * p<0.1**

Results from Table 5.10 show that, few of the risk variables are significant. Thus two (capital risk, liquidity risk) out of six risk variables were significant at 10% and 5% respectively. In addition, three of these risk variables (insolvency risk, capital risk, liquidity risk) suggest a positive relationship between risk and productivity whereas three risk variables (operational risk, credit risk, market risk) suggest a negative relationship between risk and productivity. Thus, these findings confirm the prospect theory by Kahneman and Tversky (1979) which suggests that, there is a negative relationship between risk and firm performance. The discussions of results are based on truncated regression model estimation. The nexus between explanatory variables of interest and productivity are presented below.

5.6.1 Credit Risk and Productivity

The ratio of non-performing loans to total loans was used to assess credit risk; a higher ratio indicates higher credit risk. The results showed that, Credit risk negatively affects banks productivity although not statistically significant. The coefficient of credit risk suggests that, on average, holding all other factors constant, a unit increase in credit risk will lead to a decline in the

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productivity of a bank by 0.03 percent, all things being equal. Previous studies suggest that, the difficulty in monitoring and controlling borrowers after loans are provided to them coupled with economic events induces credit risk which leads to a decline in bank's productivity levels as a result of expense incurred to recover problems loans (Munangi & Bongani, 2020; Haneef et al., 2012; Berger & DeYoung, 1997). The findings that, credit risk negatively affects productivity is in tandem with the findings of (Fernandes et al., 2018; Alhassan & Biekpe, 2016; Fiordelisi et al., 2011; Sufian & Haron, 2008, Das, 2002). However, Fernandes, Stasinakis & Bardarova (2018) found credit risk to be statistically significant whereas Sufian & Haron (2008) found credit risk not to be statistically significant. Zhang et al (2013) also found that credit risk is negatively linked to performance with a higher credit risk ratio, suggesting that a bank is more likely to incur losses from loan repayment defaults.

5.6.2 Insolvency Risk and Productivity

Insolvency risk was measured by the Z-Score ratio, a measure of the distance of a bank from bankruptcy; a higher ratio indicates a lower insolvency risk. Here, a higher ratio indicates a healthier and a more stable bank (Hersugondo, Anjani & Pamungkas, 2021). The results showed that, insolvency risk positively affects banks productivity although not statistically significant. The coefficient of insolvency risk suggests that, on average, holding all other factors constant, a unit increase in insolvency risk will lead to an increase in the productivity of a bank by 0.001 percent, all things being equal. The effect of insolvency risk on productivity can be interpreted as indicating that Ghanaian banks use all available resources to engage in a wide range of business (including non-interest income-generating business), making it difficult for them to satisfy their commitments when they become due. However, the diverse businesses also generate economies of scale and

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scope which boost performance. This finding is similar to that of Tan & Floros (2018). However, they found insolvency risk to be statistically significant.

5.6.3 Liquidity Risk and Productivity

Liquidity risk was measured by the ratio of liquid assets to total assets; here, a higher ratio indicates a lower liquidity risk. The results showed that, liquidity risk positively affects banks productivity and it is statistically significant at 5 percent. The coefficient of liquidity risk suggests that, on average, holding all other factors constant, a unit increase in liquidity risk will lead to an increase in the productivity of a bank by 0.20 percent, all things being equal. The positive and significant coefficients for liquidity risk suggests that banks have higher liquidity and are able to deal with sudden withdrawals by depositors, indicating effective management to some extent. Higher managerial ability enhances the allocation of inputs and outputs, resulting in increased productivity (Tan & Floros, 2018). The findings that, liquidity risk positively affects productivity is in tandem with the findings of (Duho, Onumah, Owodo, Asare & Onumah, 2020; Tan & Floros, 2018).

Nevertheless, the findings contradict the findings of (Fernandes, Stasinakis & Bardarova, 2018; Chen, Shen, Kao, & Yeh, 2018). Their findings suggest that, liquidity risk negatively affects bank productivity.

5.6.4 Operational Risk and Productivity

Operational risk was measured by the volatility of net interest margin which indicates the level of risk in a bank's operations (Houston et al. 2010; Kanagaretnam et al., 2013). A more volatile NIM results in a riskier lending strategy (Danisman & Demirel, 2019). The results showed that, operational risk negatively affects banks productivity although not statistically significant. The coefficient of operational risk suggests that, on average, holding all other factors constant, a unit increase in the operational risk of a bank will lead to a decline in the productivity of that bank by

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0.02 percent, all things being equal. This confirms the predictions of the bad management hypothesis which suggests that, poor management practices coupled with improper monitoring of operational expenses creates operational problems leading to an increase in bank's risks and consequently, a decline in productivity (Berger & De Young, 1997; Tan & Floros, 2013). This finding is consistent with that of Said (2013).

5.6.5 Capital Risk and Productivity

Capital risk was measured by the ratio of a bank's capital to its total assets; a higher ratio indicates lower capital risk. The results showed that, capital risk positively affects bank productivity and it is statistically significant at 10 percent. The coefficient of capital risk suggests that, on average, holding all other factors constant, a unit increase in the capital risk will lead to an increase in the productivity of a bank by 0.01 percent, all things being equal. The positive and significant coefficients for capital risk suggests that banks are well capitalised and have enough funds to support their businesses, using less leverage with lower cost of going bankrupt (Fernandes et al., 2018). This finding is in tandem with the findings of (Fernandes et al., 2018; Sufian & Habibullah, 2014).

5.6.6 Market Risk and Productivity

Market risk was measured by exchange rate volatility; a higher ratio indicates higher market risk. The results showed that, market risk negatively affects bank productivity although not statistically significant. The coefficient of market risk suggests that, on average, holding all other factors constant, a unit increase in market risk will lead to a decline in the productivity of a bank by 0.03 percent, all things being equal. This is related to findings by Sun & Chang (2011) and Zhang et al (2013).

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Previous studies suggest that, lower exchange rate reduces the value of company's exchange cash assets, business assets and cash flows (Hoseininassb et al., 2013; Parlak & Ilhan, 2016). Exchange rate volatility was used in measuring the market risks banks are exposed to. Annual exchange rate (against US$) in Ghana cedis was used. According to Alagidede & Ibrahim (2017), excessive volatility is dangerous to economic growth and the Ghana cedis has been volatile and its value keep depreciating. The depreciation and volatility of the Ghanaian cedi relative to the US dollar is a contributing factor to the negative relationship between market risk and productivity. This is because, as the Ghanaian cedis depreciates, the value of a bank's investment into company shares or a subsidiary will decline.

5.6.7 Size and Productivity

The natural logarithm of total asset was used to determine the size of a bank. The results showed that, size positively affects bank productivity and it is statistically significant at 5 percent. The coefficient of size suggests that, on average, holding all other factors constant, a unit increase in the size of a bank will lead to an increase in the productivity of that bank by 0.09 percent, all things being equal. Previous studies suggest that, there is a positive relationship between bank size and performance because, as a banking organization grows in size, costs decrease due to economies of scale and scope, and performance improves. (Tan & Anchor, 2017; Dietrich and Wanzenried, 2011; Berger, Hanweck, & Humphrey, 1987).

The positive relationship indicates that, as size (total assets) increases productivity increases and this is consistent with the findings of (Andries, 2011; Sufian & Haron, 2008; Isik & Hassan 2003; Fukuyama, 1995; Berg, Forsund & Jansen, 1992).

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5.7 Chapter Summary

This chapter reported an in-depth discussion on results from the various models and methods used in the study to answer the research objectives.

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CHAPTER SIX

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter is categorized into three sections. In section one, a synopsis of the objectives of the study as well as peculiar findings are presented. On the bases of these, conclusions are drawn from each study objective. Lastly, guidelines for practice and suggestions for further study are given.

6.2 Synopsis of Research Objectives and Peculiar Findings

The purpose of the study was to examine dynamic productivity and the various risk factors affecting the productivity of banks in Ghana. Although there are a number of studies that have examined productivity changes and covariates such as deregulation, ownership, technology, competition, recapitalization, and corporate governance that affect productivity of banks worldwide, this study differs from these other studies in this domain: it is the first study to examine comprehensive risk factors (credit risk, capital risk, liquidity risk, insolvency risk, operational risk, market risk) and their impact on bank productivity.

Coupled with this, the study assessed productivity changes as well as the sources of productivity changes of banks within the Ghanaian Banking Industry. The study determined the rate of productivity convergence within the industry. It also determined the Returns to Scale (RTS) property of banks at the firm level. At the methodological level, Biennial Malmquist Productivity Index (BMPI) scores was, for the first time, used with other risk factor estimates in a second-stage DEA analysis.

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This study used data from audited annual reports of averagely 21 banks in Ghana for a 16-year period, from 2004 to 2019. The data for the study was run and analysed using the various software and techniques explained in Chapter Four of the study; after which data was discussed to deduce the findings stated below:

The study tested for the Returns to Scale (RTS) technology underlying the Ghanaian Banking Industry. The method used in assessing productivity; BMPI, is a framework within the DEA model. One of the assumptions of DEA is the Returns to Scale (RTS) property underlying the industry under evaluation. This RTS property is either CRS or VRS. This property must be specified before the model will work. However, stating the wrong assumption can lead to inconsistencies in efficiency scores, which can lead to some form of bias in productivity estimates (Samar & Wilson, 2000). Hence, this assumption was tested to ascertain whether banks in Ghana were operating under CRS or VRS. Findings of the study showed that banks in Ghana were operating under Variable Returns to Scale. Therefore, size matters in productivity estimation.

The first objective of study examined the dynamic productivity of Ghanaian banks and decomposed productivity into efficiency and technical change components. The findings of this study showed that, the overall productivity of banks in Ghana have retrogressed by an average of -2.48% (.i.e. $[0.9752-1]\times100$) annually during 2004 to 2019. The source of the overall productivity gain in the Ghanaian banking industry was neither due to efficiency change (EC), which is neither attributed to prudent managerial decisions (efficiency change) nor technical change (TC). Although, there exist a decline in both efficiency change (EC) and technical change (TC), the decline in technical change (TC) outweighed that of efficiency change (EC). Hence, productivity growth was seen due to efficiency change than technical change within the industry.

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The decompositions showed that, there is a retrogression in both Efficiency growth and Technical growth, of which 0.99% is due to efficiency change and 1.51% is due to technical change.

The second objective of the study sought to examine differences in the productivity change of domestic and foreign banks in the Ghanaian banking industry. The findings of the study revealed that, though domestic banks' marginal productivity gains were numerically higher than foreign banks', the differences in productivity gains were not statistically significant enough to establish that domestic banks were more productive. Similarly, whereas the average efficiency growth of domestic banks increased by 0.70%, that of foreign banks declined by 0.46%. Also, the average technical growth of domestic banks declined by 0.05% whilst that of foreign banks increased by 1.14%. Again, the differences for both efficiency and technical growth of domestic and foreign banks were not statistically significant. Therefore, the study found no support for the home field advantage hypothesis.

The third objective was to test for the rate of productivity convergence within the Ghanaian banking industry. The findings of the study suggest that, unproductive banks were able to achieve the same productivity levels with productive banks; and also, productive banks are converging towards the industry's average productivity levels. The overall findings for this test suggest the presence of convergence within the Ghanaian banking industry. For all banks and both types of ownership, the coefficients β_1 and δ_1 are statistically significant. However, the productivities of domestic banks are converging faster than that of foreign banks.

The fourth objective examined the impact of risk factors on dynamic productivity. The findings showed that, three of these risk (insolvency risk, capital risk, liquidity risk) variables suggest a positive relationship between risk and productivity, whereas three risk (credit risk, market risk,

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operational risk) variables suggest a negative relationship between risk and productivity. Also, size is highly significant in determining the productivity growth of a bank.

6.3 Conclusions

The study explores the role of risk in determining the productivity of banks in Ghana. The study considered six different aspects of risk, which are credit, liquidity, capital, insolvency, operational and market risks. Using Biennial Malmquist Productivity Index, the study measured the productivity score of banks in Ghana. Productivity scores was used as a regressand in a second stage DEA analysis where truncated, fixed effects and systems GMM regression models were used to examine the impact of risk factors on Biennial Malmquist Productivity scores. The findings from the result were based on the truncated regression model. Some critical issues have been illustrated by the findings of this research.

The test of returns to scale conducted revealed that, the banking sector operates on variable returns to scale (VRS). This is an indication that not all banks examined are operating at optimal production scales. Hence it important that, policy makers know whether banks operate under increasing, constant or decreasing returns to aid in prudent decisions on mergers and acquisitions because studies have shown that mergers and acquisitions affect productivity growth of banks (Berger & Humphrey, 1997; Alias, Baharom, Dayang-Afizzah & Ismail, 2009; Abd-Kadir, Selamat & Idros, 2010).

Secondly, evaluation of bank performance is expedient in order for stakeholders of these banks to know how well they are performing over a time period so to enable them improve where the need be. The findings revealed the fact that banks do not have to only maximize their total assets, but

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to also improve the quality of these assets as they maximize them, because the quality of their assets significantly affects their productivity.

Furthermore, the findings revealed that, technical change (TC), which is attributed to technological advancement or product innovation within the industry, is a major source of the retrogression in the productivity of banks in Ghana. Therefore, the industry has to innovate to keep up with emerging products and technology.

Another finding worth noticing is that, there were differences in the marginal productivity gains, efficiency growth and technological growth of domestic banks and foreign banks - however, the differences were not statistically significant to justify the claims of the home field advantage hypothesis by Berger et al. (2000). This may seem to suggest that, domestic banks do not enjoy enough home advantages to enable them perform better than their counterparts and this could be justified by the fact that, only domestic banks had their licenses revoked by the bank regulator during the recent financial clean-up exercise.

The results of this study also suggests that both beta-convergence and sigma-convergence exist among Ghanaian banks. However, the productivities of domestic banks are converging faster than that of foreign banks.

Finally, risk factors are key influencers of the variability in the productivity of a bank. Although all the risks used in the study are influencers, the findings indicated that, capital and liquidity risks are significant in affecting the productivity of a bank. The findings of the study confirmed the prospect theory, which suggests that risk negatively affects performance.

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6.4 Recommendations

Recommendations are made on policy, practice, and further research that were deduced based on the findings and conclusion discussed. Recommendations are clearly presented to aid in better conceptualization of concepts of the study.

For policy:

First and foremost, based on the assessment of dynamic productivity and risk, the bank regulator (BOG) should implement policies that will regulate the risk-taking behaviours and decisions of bank managers, to ensure that managers make prudent decisions on how they allocate resources for certain risky investments portfolios. This is because, the findings of the study suggest that, some aspects of risks have a negative relationship with performance (productivity). The prospect theory, was used in the study to confirm this fact. Thus managers of banks can become both risk seeking and risk averse depending on the level of performance they want to attain and since productivity is not static but dynamic, there is a tendency for mangers to exhibit certain inherent risk taking behaviours. Therefore, it is prudent that policy guidelines are implemented to regulate the risk taking behaviours of managers.

Second, most studies and findings of this study suggest that, credit risk has a negative impact on productivity growth. Credit risk arises as a result of high non-performing loans within banks. The annual reports of banks in Ghana revealed the fact that, all banks are faced with issues of non-performing loans. The major reason attributed to high non-performing loans is poor credit administration. The reason for loan default focuses more on banks than customers of these banks. However, a customer has a crucial part to play when a loan defaults. Most researches focus on banks without focusing on customers of these banks. Therefore, Bank of Ghana should have a

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customer-focused research on why customers default in loan repayments. Findings from this research can help serve as policy guidelines for a robust bank supervision.

Also, regulatory authorities should focus on strengthening capital requirements regularly in order to boost the amount of capital held by Ghanaian banks. The capital injections that have already been made have shown to be quite beneficial in terms of lowering capital risk and enhancing performance.

Fourth, the bank regulators should formulate policies that will enable banks to implement sustainable banking practices within their risk management framework.

Fifth, the bank regulator (BOG) should implement policies that will aid banks to invest quickly in emerging technologies and products. Bank of Ghana should explore the various possibilities of the blockchain technology in order to aid technological advancement within the sector. Studies have proven that, the technology has the potentials of improving transparency, reducing operational cost of banks, enhancing business processes of banks and improving performance of banks (Rekha & Resmi, 2021; Garg et al., 2021; Cocco, Pinna & Marchesi, 2017). The findings of the study revealed that, the banking sector is retrogressing in technological advancement. Technological change component of the BMPI is attributed to product innovation and technological advancement and since the major source of retrogression in overall productivity within the industry is due to technological change, BOG should explore other emerging technology and innovative products which will boast performance within the industry.

Finally, the bank regulator should revisit regulations on domestic ownership and improve upon them to ensure that domestic banks have an upper hand in the industry. Policy reforms can focus on enhancing the presence of domestic ownership, development of domestic financial markets,

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supporting the consolidation of domestic banks and intensifying competition among banks in the industry in order to boast the performance of domestic banks.

For practice:

Firstly, bank managers should focus on improving their managerial efficiency by making prudent risk decisions on risky assets and investment portfolios.

Secondly, bank managers should consider all aspects of risk in their attempt to manage risk, since risk is an influencer of their performance and risk can affect their profitability. Focusing on just one or two aspects of risk can be a detriment to their survival within the industry. Therefore, in their quest to manage credit risk, bank managers should inculcate sustainable practices within their credit administration process. Thus, managers should not only give out loans to customers, but also offer prudent advice to its customers to enable them maximize their returns. Also, banks should continually monitor the creditworthiness of clients to reduce borrowers who will default.

In managing market risk, Ghanaian banks especially domestic ones should consider using financial derivatives and asset securitization to mitigate market risk. This will aid in the reduction of their interest rate and foreign currency risk exposure to ensure that market risks are kept within reasonable limits.

In managing liquidity risk, the treasury department of banks must maintain a portfolio of short-term liquid assets to ensure that bank's overall liquidity is sufficient. Also, banks must ensure that, their balance sheet is not concentrated with more illiquid assets.

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Regarding capital risk, equity capital should be greatly enhanced, so that if the value of the banks' assets falls, it does not immediately result in distress, and the ensuing losses would be borne by the bank's owners. Also, banks should have a target capital which they choose to hold in order to cushion them in times of distress as well as sudden regulatory capital demands.

Furthermore, bank managers can minimize operational risk by constantly improving their lending strategy. A comprehensive credit evaluation should be used by banks in their lending process to aid in the development of an effective plan that will minimize banks' exposure to risk and also increase their profitability. Also, a complete automation of all lending process reduces errors by both the borrower and the bank, enabling banks to reduce inaccurate analysis. This will also create more visibility in the lending process and aid managers to monitor and control all aspects of their lending process.

Finally, to limit the risk of insolvency and bank failure, banks should hold capital to offset losses in both long term investment and loans and advances. Also, banks should depend less on external funding which may result in higher cost of funds and more liabilities.

For further research:

The study sought to examine the impact of risk on productivity of banks in Ghana. However, due to the unavailability of data on non-financial risk, the study focused on financial risk. Hence, future studies can consider non-financial risk and their impact on productivity.

Secondly, future studies can employ SFA, MPI, and BMPI to access productivity of banks; and also conduct a comparative analysis of each of these scores, and investigate the impact of comprehensive risk factors on productivity.

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To evaluate the impact of risk on productivity, future research can use different regression methods such as OLS-PCSE, POLS, and RE in their second stage regression analysis.

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APPENDIX A

LIST OF BANKS IN GHANA IN YEAR 2020

BANK	OWNERSHIP (FOREIGN/DOMESTIC)	ORIGIN	YEAR OF INCORPORATION /LICENSE AS A BANK IN GHANA
Absa Bank Ghana Limited	Foreign	South Africa	1917
Access Bank (Ghana) Plc	Foreign	Nigeria	2009
Agricultural Development Bank Limited	Domestic	Ghana	1965
Bank of Africa Ghana Limited	Foreign	Bamako, Mali	2011
CAL Bank Limited	Domestic	Ghana	1990
Consolidated Bank Ghana Limited	Domestic	Ghana	2018
Ecobank Ghana Limited	Foreign	West Africa (Headquarters in Togo)	1990
FBN Bank (Ghana) Limited	Foreign	Nigeria	1996
Fidelity Bank Ghana Limited	Domestic	Ghana	2006
First Atlantic Bank Limited	Domestic	Ghana	1994
First National Bank (Ghana) Limited	Foreign	South Africa	2015
Ghana Commercial Bank Limited	Domestic	Ghana	1953
Guaranty Trust Bank (Ghana) Limited	Foreign	Nigeria	2004
National Investment Bank Limited	Domestic	Ghana	1963
OmniBSIC Bank Ghana Limited	Domestic	Ghana	2019

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Prudential Bank Limited	Domestic	Ghana	1993
Republic Bank (Ghana) Limited	Foreign	Trinidad & Tobago	1990
Societe General (Ghana) Limited	Foreign	France	1975
Stanbic Bank Ghana Limited	Foreign	South Africa	1999
Standard Chartered Bank (Ghana) Limited	Foreign	UK	1896
United Bank for Africa (Ghana) Limited	Foreign	Nigeria	2004
Universal Merchant Bank Limited	Domestic	Ghana	1971
Zenith Bank (Ghana) Limited	Foreign	Nigeria	2005

Source: Author's compilation from BOG and Banks website (2020)

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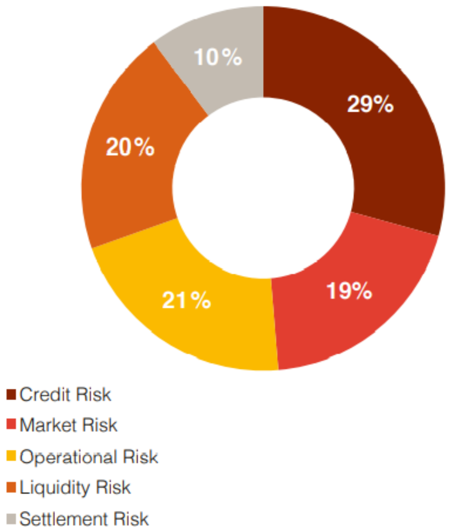
APPENDIX B

KEY BANK RISKS TO BE PRIORITISED BY BANK EXECUTIVES.



PWC (2018)

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APPENDIX C

BANKS LISTED ON THE GHANA STOCK EXCHANGE

NUMBER	LISTED BANKS	YEAR LISTED ON GSE
1	Agricultural Development Bank Ltd.	12th December, 2016
2	Access Bank Ghana Ltd.	21st December, 2016
3	Cal Bank Ltd.	5th November, 2004
4	Ecobank Ghana Ltd.	July,2006
5	Ghana Commercial Bank Ltd.	17th May,1996
6	Standard Chartered Bank Ltd.	Proisoinal-12th November, 1990;Formal 23rd August,1991
7	Societe General Ghana Ltd.	13th October, 1995
8	HFC/Republic Bank Ghana Ltd.	17th March,1995
9	UT Bank Limited	They were listed as UT Bank in 2010. However, they delisted on (14/09/2017)

Source: GSE Website (2020)