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ESTIMATING THE COST PRODUCTIVITY INDEX OF BANKS IN GHANA

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JULY, 2015

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DECLARATION

I do hereby declare that this work 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 of this study.

…….. ……..…..

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CERTIFICATION

We hereby certify that this thesis was supervised in accordance with procedures laid down by the university.

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DEDICATION

I dedicate this work to my daughter Maureen and sons Kekeli and Nalikem Anagba. This is to thank God for you as gifts to me and for being understanding for my long hours of absence when you needed my presence during this project.

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LIST OF ABREVIATIONS

AEC	-	Allocative Efficiency Change
AfDB	-	African Development Bank
AMAL	-	Amalgamated Bank Ghana Limited
ADB	-	Agricultural Development Banks
BBG	-	Barclays Bank Limited
BI	-	Boone Indicator
BSCI	-	Banque Sahélo-Saharienne pour l'Investissement et le Commerce
BOA	-	Bank of Africa Ghana Limited
BOG	-	Bank of Ghana
CAL	-	Cal Bank Limited
CAP	-	Capitalization
CMPI	-	Cost Malmquist Productivity Index
COMP	-	Competition
CTC	-	Cost Technical Change
DEA	-	Data Envelopment Analysis
DMU	-	Decision Making Unit
ECOBANK	-	ECOBANK Ghana Limited
FAMB	-	First Atlantic Merchant Bank Limited
FBL	-	Fidelity Bank Limited
FINSAP	-	Financial Sector Adjustment Programme
GCB	-	Ghana Commercial Bank
GDP	-	Gross Domestic Product (Growth Rate)
GSE	-	Ghana Stock Exchange
GSS	-	Ghana Statistical Service
HFC	-	Housing Finance Company Bank
HHI	-	Herfindahl-Hirschman Index
ICB	-	International Commercial Bank Limited
INF	-	Inflation Rate

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ISSER	-	Institute of Statistical Social, and Economic Research
LLP	-	Linear Programming Problem
MPI	-	Malmquist Productivity Index
MPR	-	Monetary Policy Rate
MCPI	-	Malmquist Cost Productivity Index
NPART	-	Non-Performing Assets Recovery Trust
NIB	-	National Investment Bank limited
OWN	-	Ownership Type of a Bank
OEC	-	Overall Efficiency Change
PBL	-	Prudential Bank Limited
PCE	-	Price Change Effect
PNDCL	-	Provisional National Defence Council Law
POSB	-	Post Office Savings Banking
PR	-	Policy Rate
PwC	-	PricewaterHouseCoopers
SAP	-	Structural Adjustment Programme
SFA	-	Stochastic Frontier Analysis
STANBIC	-	Stanbic Bank Limited
SCB	-	Standard Chartered Bank Limited
SGG	-	Societe General Ghana
TBILL	-	Treasury Bill Rate
TEC	-	Technical Efficiency Change
UBBL	-	Universal Banking Business License
UMB	-	Universal Merchant Bank Ghana Limited
UNIBANK	-	UniBank Ghana Limited
WACB	-	West African Currency Board

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ABSTRACT

The role of the banking sector in promoting economic growth cannot be underestimated. In view of this, the assessment of the performance of the banking industry is very important. Increasingly, a number of methods have been used to effectively account for the total factor productivity of banks. This study employed the Data Envelopment Analysis (DEA) cost Malmquist productivity analysis to assess the productivity of banks in Ghana. This is a technique that has strong roots in optimization techniques in operations management. The main aim of this study was to assess the cost productivity of banks in Ghana. An unbalanced panel data of Ghanaian banks for a fourteen year period from 2000 to 2013 was used for the study. According to the results the banking industry is cost productive and this is attributable to the ability of banks to take advantage of changes in price effect followed by technological changes (increasing introduction of technology) and finally technical efficiency change.

The results show that the cost productivity index is largely complementary to the traditional productivity index, since it presents a fuller picture of Ghanaian banks' performance. The cost productivity growth experienced by the industry is 3.2% and the technical productivity is 1.7%. Finally, environmental factors like competition, size, inflation rate, growth rate, treasury bill rate, capitalization, and foreign-ownership type significantly influence the cost productivity of banks in Ghana. However, regulatory standards like policy rate and universal banking business license do not significantly affect the cost productivity of banks in Ghana. In view of these findings the study recommends increased efforts from operations managers to periodically assess the cost productivities and to take advantage of the price changes, technological progress and technical efficiency change for the optimal operations in relation to cost productivity.

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CHAPTER ONE

INTRODUCTION

1.1 Background of Study

The role of financial institutions, particularly banks, in stimulating economic growth and development of countries cannot be underestimated (Fethi & Pasiouras, 2010; Fries & Taci, 2005; Kwakye, 2012; Levine, Loayza, & Beck, 2000; Paradi, Yang, & Zhu, 2011). The banking sector's contribution to gross domestic product (GDP) was 7.9 % in 2012 in the USA and 9.4 percent in 2011 in the United Kingdom (UK) Maer and Broughton (2012). In Ireland, it was 10.55 % in 2012 and in Australia, 11 % in 2012 (Ince, 2012). South Africa's financial subsector contributed 21.2 % to GDP in 2012, Kumo, Rielander, and Omilola (2014) and that of Ghana was 6.5 % to GDP in 2013 (GSS, 2015). Given the contribution of banks to economic growth, operations managers, operations researchers, bank managers, regulators and academic researchers have become interested in the assessment of banks' efficiency and productivity dynamics (Isik & Hassan, 2002). Operations analysts and managers have observed that, the inefficiency of the banking sector can have a ripple effect on other sectors of the economy as was evident during the recent 2008 global financial crisis (Dell'Ariccia, Detragiache, & Rajan, 2008). Therefore, the assessment of its performance is important for policy recommendations which can promote growth and stability could be prescribed for the banking industry.

In delivering their services as depository financial intermediaries, banks employ inputs such as labour, deposits, fixed assets etc., which must be paid for (LaPlante & Paradi, 2015). For instance, savings deposits incur an interest expense and employment of labour incurs salary costs. These cost elements must be accounted for during performance evaluation of banks. Traditionally, this assessment have been undertaken using financial and accounting ratios. Still there could be issues with ratio analysis. First, even though ratios are easily computed and understandable, different ratios can be fashioned out of banks financial statements which tend

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to be contradictory and undistinguishable (Paradi et al., 2011). Second, ratios examine only a particular aspect of an organisation, although these organisations are complex and use multiple inputs to produce multiple outputs (Paradi & Zhu, 2013; Smith, 1990). Third, ratios implicitly assume constant returns to scale which may not be practical in real life settings where firms may differ in size (Smith, 1990). Recent efficiency and productivity analysis in the banking industry have employed frontier methodologies such as Data Envelopment Analysis (DEA) (Banker, Charnes, & Cooper, 1984; Charnes, Cooper, & Rhodes, 1978) and Stochastic Frontier Analysis (SFA) (Aigner, Lovell, & Schmidt, 1977). These approaches have been widely applied to the banking industry to assess static cost efficiency[1] of banks and bank branches (Barros & Wanke, 2014; Camanho & Dyson, 2008; Camanho & Dyson, 2005; Fries & Taci, 2005; Fu & Heffernan, 2007; Kauko, 2009; Kirkwood & Nahm, 2006; Kwan, 2006; Liadaki & Gaganis, 2010; Lozano-Vivas & Pasiouras, 2010; Pasiouras, Tanna, & Zopounidis, 2009; Shen & Chen, 2010; Tortosa-Ausina, 2002; Weill, 2004; Yildirim & Philippatos, 2007). However, static cost efficiency is unable to capture the trends and patterns within dynamic efficiency and productivity.

The aim of this study is to use the innovative Cost Malmquist Productivity Index (CMPI) of Maniadakis and Thanassoulis (2004) to effectively capture dynamic cost productivity of the Ghanaian banking sector from 2000 to 2013. This is important because literature suggest that one way of identifying key approaches to cost saving and strategic planning by management in competitive industry, is using the Cost Malmquist Productivity Index to determine performance (Tzu-Chun, Kai-Ping, & Yung-Lieh, 2012). The study further investigates the sources of cost productivity via the two-factor and the four-factor decomposition of the index in the context of the Ghanaian banking market. To explore if the banks are able to improve

[1] Static efficiency is used here to refer to the assessment the performance of firms at a point in time whereas dynamic efficiency evaluates performance over time.

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their cost productivities a second stage analysis was used. Factors like ownership, competition, size, capitalization, the use of universal banking license, treasury bill rate, policy rate, economic growth rate and inflation rate was regressed on the Cost Malmquist Productivity Index. The study utilizes the truncated bootstrapped regression (Simar & Wilson, 2011; 2007).

1.2 Problem Statement

Regardless of copious research on dynamic productivity of banks, we identify gaps in recent academic study. First, previous studies have either used the standard technical Malmquist index (Färe, Grosskopf, Lindgren, & Roos, 1992; Färe, Grosskopf, Norris, & Zhang, 1994) and Luenberger Productivity Indicator (Arjomandi, Valadkhani, & Harvie, 2011; Assaf, Barros, & Matousek, 2011; Casu, Girardone, & Molyneux, 2004; Chambers, Chung, & Färe, 1998; Chang, Hu, Chou, & Sun, 2012; Chen, Liu, & Kweh, 2014; Fujii, Managi, & Matousek, 2014; Galdeano-Gómez, 2008; Kenjegalieva & Simper, 2011; Mahlberg & Url, 2010; Matthews & Zhang, 2010b; Matthews, Zhang, & Guo, 2009; Murillo-Melchor, Pastor, & Tortosa-Ausina, 2009; Simar & Wilson, 1999; Tortosa-Ausina, Grifell-Tatjé, Armero, & Conesa, 2008). However, the standard technical Malmquist productivity change index ignores allocative efficiency changes which captures the minimum cost of inputs and their appropriate mix for a given output. In particular, there is lack of recent empirical studies that analyse dynamic cost productivity which accounts for the combined effect of technical and allocative efficiency change. To the best of the our knowledge, only four applications of the Cost Malmquist Productivity Index exit in the health sector, Maniadakis and Thanassoulis (2004); agricultural sector, (Baležentis, 2012; Balezentis, Krisciukaitiene, & Balezentis, 2013); and pharmaceutical sector, (Tzu-Chun et al., 2012). The current study firsthand, makes a novel empirical application of the Cost Malmquist Productivity Index in the banking industry globally.

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Second, previous empirical applications of the CMPI did not empirically estimate the two-factor decomposition before exploring the four-factor one. Balezentis et al. (2013) appeared to have wrongly estimated the standard Malmquist index under the variable returns to scale (VRS) assumption and then combined that with the CMPI which was rather estimated under constant returns to scale. The decomposition must be made in terms of cost rather than only quantities. Similar decomposition is observed in Balezentis (2013). This study fills this gap by empirically decomposing the CMPI into overall (cost) efficiency change and cost technical change components before pursuing the four-factor decomposition.

Third, like all the banking efficiency analyses in Ghana, none considered a productivity analysis, whether technical or cost. Therefore, the current study uses data of banks in Ghana to determine the cost productivity, in view of the numerous reforms. Furthermore, none of the studies determine the effect of environmental factors on the cost productivity of banks in Ghana. Even the 4 CMPI studies, none of them considered the effect of environmental factors on cost productivity, especially using the two-stage bootstrap approach of Simar and Wilson (2007). The current study fills this literature gap by investigating the impact of firm and industry-specific variables. Besides, only few studies adopted the new measure of competition, the Boone indicator, BI (Boone, 2008; Boone, Griffith, & Harrison, 2005) in addition to the Herfindahl–Hirschman Index (HHI) at the second stage. The BI measures the extent to which banks suffer lost earnings or market share by being inefficient.

1.3 Contributions

First, this study uses the innovative CMPI of Maniadakis & Thanassoulis (2004) to assess dynamic cost productivity of banks globally using a sample of Ghanaian banks. This is important because, as the number of banks in Ghana increase, there is the need to minimize the cost of operations due to banks desire to have competitive advantage (Kwakye, 2012).

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Consequently, determining how to minimize cost of banks in Ghana over time is very important to assist industry players to appreciate the need to operate at minimum cost.

Second, this study tests the significant differences between dynamic technical productivity of Fare et al., (1992, 1994) and dynamic cost productivity of Maniadakis and Thanassoulis (2004). The test is to determine the potential underestimation or overestimation of productivity change by the former. This enables operations managers to select the appropriate measure of assessing the productivity of banks and this is the first time such a comparison is being made.

Third, this study contributes to the banking efficiency and productivity change literature by empirically testing the effect of such contextual variables. These factors have been discussed in the banking efficiency literature as some of the key performance drivers (Athanasoglou, Brissimis, & Delis, 2008; Koutsomanoli-Filippaki, Margaritis, & Staikouras, 2009; Sanyal & Shankar, 2011).

Finally, the study also makes a firsthand empirical contribution via a novel application of the truncated-bootstrapped regression of Simar and Wilson (2007, 2011) to investigate the nexus between dynamic cost productivity and its components, and the exogenous variables. To the best of our knowledge, none of the 4 cost productivity studies used a second-stage bootstrapped-truncated regression. Also, the uniqueness of the analysis lies in the fact that time-dependence structure of the dynamic cost productivity indices must be taken into account during the second-stage regression.

1.4 Research Objectives

This study examines the cost productivity dynamics of banks in Ghana over a fourteen year period, 2000-2013. The aim is to empirically estimate the cost Malmquist productivity change

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index and to decompose it into cost efficiency change and cost technical change as well as its four-factor decompositions. Basically, to determine the sources of cost productivity of banks in Ghana. This enables an appropriate strategy based on the source of inefficiency. Specific objectives are:

1. To assess the cost productivity dynamics of banks using the CMPI.
2. To decompose and identify the sources of dynamic cost productivity of banks into overall efficiency change and cost technical change, and technical efficiency change, allocative efficiency change, technical change and price effect.
3. To compare the traditional Malmquist index and the cost Malmquist index of banks in Ghana and explore the potential bias, had the former only been used.
4. To determine the significant effect of competition, size, capitalisation, ownership, universal banking license, economic growth rate, policy rate, treasury bill rate and inflation on dynamic cost productivity of banks in Ghana.

1.5 Research Questions

1. What is the overall cost productivity change of banks in Ghana over the study period?
2. What drives cost productivity change in the Ghanaian banking industry?
3. Is there a statistical difference between the average cost productivity change and the average productivity change of banks in Ghana?
4. Which environmental factors - competition, size, capitalisation, universal banking license, ownership, economic growth rate, policy rate, treasury bill rate and inflation - significantly affect dynamic cost productivity in the Ghanaian banking industry?

1.6 Significance of the Study

The findings from this study have outcomes related to regulatory policy, business practice and academic research. The policy implications relate to the fact that the study empirically

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determines whether cost productivity change is a comparative or complementary way of assessing performance dynamics than technical productivity change. It should guide bank management both in Ghana and globaly to inexpensively operate the business of a bank. For business practice, the study evaluates cost productivity change in the banking sector and provides insights into the trends and patterns in industry cost productivity over a 14 year period. The research also decomposes cost productivity change index that undoubtedly shows the drivers of cost productivity change within the industry by using recent, innovative dynamic productivity methodologies. Managerial policies could then be formulated to focus on the key drivers of performance.

Principally, the study makes 4 contributions. First, it contributes to the existing body of knowledge on productivity dynamics through a primary novel application of the CMPI in the banking industry Second, it enhances our understanding of the drivers of dynamic cost productivity through its constituents. Third, it compares dynamic technical productivity of Fare et al., (1992, 1994) with the dynamic cost productivity of Maniadakis and Thanassoulis (2004) in order to determine the potential underestimation or overestimation of productivity change by the former. Lastly, it uniquely applies the recently developed bootstrapped truncated regression of Simar and Wilson (2007, 2011) to investigate the impact of key environment variables on the cost productivity of banks in Ghana. Policy prescriptions and directions for further research are provided.

1.7 Limitations of Study

Despite the expected positive outcomes of this study, there are some constraints. To start with, this analysis uses DEA which is a nonparametric mathematical programming method. As it is distribution-free, it may be statistically constrained because of outliers and sampling variations that bias the results. This issue can be dealt with via bootstrapping. But, the algorithm for bootstrapping cost productivity may be difficult to model within the timeframe. In any case,

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bootstrapping approximates the true frontier and is not a panacea to the sampling variation problem in DEA. However, a bootstrapped truncated regression is used to handle the serial correlation of productivity indices and second-stage regression regressor. The other challenge, is the difficulty in undertaking the second-stage bootstrapped truncated regression since there is a further issue of dealing with the time periods used in estimating the productivity.

1.8 Structure and Organization of the Study

The study is organized into six chapters. Chapter one includes the background of the study, the research problem, the gaps in existing studies, the objectives of the study and the research questions. Additionally, the chapter states the justification of the study, and the structure and organization of the study. The second chapter of the study reviewed the theoretical framework, and empirical review of relevant literature. This is followed by chapter three, with the context of the study in relation to the trends in the macroeconomic environment and the banking industry in Ghana. In chapter four the research methodology employed in the study is outlined, with the explanations of variables used as inputs and outputs in the first stage analysis and the variables for the second stage analysis. Chapter five deals with the empirical findings and data analysis, while chapter six is the concluding chapter consisting of a summary, discussion, recommendations and suggestions for further research.

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CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter reviews relevant theoretical and empirical literature on total factor productivity, production economics, dynamic cost productivity and theories that explain the environmental factors that may influence cost productivity change. The chapter begins with the productivity theories used to elucidate the performance of firms, in general, and competition and ownership-cost productivity change nexus. Furthermore, the chapter reviews the empirical literature on dynamic technical and cost productivities via the Malmquist index, and particularly, as they relate to the banking industry.

2.1 Theoretical Review

This study uses theories to lay the foundation for the theoretical basis for the productivity in general. The first productivity theories are Cobb-Douglas production function and Solow Growth Model which are discussed under both static and dynamic settings. The second is the Financial intermediation theory (transaction cost theory) which involves the cost of securing inputs or the factors of production. The third examines the theoretical underpinnings of the second-stage environmental variables namely competition, ownership, inflation, policy rate etc.

2.1.1 Production Theory

Generally, efforts to improve firm value and ensure productivity growth is always desired irrespective of the type of firm (Thanassoulis, Shiraz, & Maniadakis, 2015). Additionally, the identification of factors responsible for the productivity growth is crucial for efficient planning and resource allocation. Production is a process of transforming various material input(s) into output(s). The neoclassical economists holds the view that, the production theory has been generally used as a key tool for economic analysis (Stiroh , 2001). Basically the theory explains

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the principle of firms' decision to choose the factors of production (capital, labour, raw material etc.) which are converted into output(s). Wicksteed (1938) is the first economist to be accredited with the establishment of the algebraic formula for the interdependency between inputs and output. Primarily, the production function developed to establish the relationship between output and inputs was:

$$Q = f(x_1, x_2, x_3 ....., x_m) \quad \text{(i)}$$

Where Q denotes the total output produced and x_m denotes varied inputs used for production. Ideally, as the objective of every firm, the function is expected to have maximum output given the firms deployment of minimum inputs. This establishes a relationship between quantity of input used in production and the volume of output produced. Other useful production models include the Cobb-Douglas productivity model (Cobb & Douglas, 1928) and the Solow growth model (Solow, 1957).

i) Cobb-Douglas Productivity Model

In extending Wicksteed (1894) model for assessment of input-output relationship, Cobb and Douglas (1928) following the new neoclassical economics concept of the production theory developed a functional form of production as:

$$Q = AK^{\alpha} L^{1-\alpha} \quad \text{(ii)}$$

Where Q is the output, A is the level of technology, K is capital, L is labour, α is a constant that lies between zero and one. Year-to-year assessment of possible changes in output (goods and services) given, the input (labour, capital, etc.) is essential (Cobb & Douglas, 1928). The initial ideas of this productivity model was based on the production of tangible goods. The idea behind the theory was to understand the changes in output and identify the possible underlining factors influencing the change. The theory has become the basis for the established production

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function named after the authors, the Cobb-Douglas production function, which has become the most common basis for theoretical and empirical analyses of growth and productivity (Felipe & Adams, 2005).

The production theory has been applied in a the manufacturing, banking, agriculture, etc. (Armagan & Ozden, 2007; Bhattacharyya, Lovell, & Sahay, 1997; Black & Lynch, 2001; Kuan, Hongchang, Yuxin, Jefferson, & Rawski, 1988). The production theory involves some of the most fundamental principles of economics, which hinges on firm's maximizing output given their inputs. However, the traditional production theory does not account for time variability of firms, which could impact the input-output relationship. Productivity is comparatively considered an improved performance measure as compared to a production that does not include time (Coelli, Prasada Rao, O'Donnell, & Battese, 2005). The reason for the cost productivity include variability in time, since the growth of entities follows the natural course over time and not an event. Since growth is a time influence activity, it is relevant to consider growth between time as a crucial element. Furthermore, once a method employed in assessing an entity is flawed, decisions or ploicies emanating from those assessment are bound to be ineffective (Stiglitz, Sen, & Fitoussi, 2009). This makes the choice of prodivitity essential since it reveals more about a bank for more potent policy measure to improve growth (Gruen, 2012). In view of this as an extention of the production theory to include time, the Solow Growth Model was developed. The limitation notwithstanding, this study considers the input-output relationship assumption underlining the production theory as very critical since the prime goal for firms (banks) to be concerns about how to minimize the cost of mobilizing loans and invest given inputs like deposits, labour and fixed assets.

ii) Solow Model

The Cobb-Douglas production function is a static model which ignores the changes of economic variables due to time variability (Solow, 1957). To account for the time variability

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the Solow model has been used for productivity change for some time now. The Solow growth model, is a framework which helps to understand growth of firms, given the combinations of inputs (capital, labour, etc.) to produce outputs (Y) over time (Costello, 1993; Durlauf, Kourtellos, & Minkin, 2001; Jorgenson, 1988; Solow, 2001). The model assumes input-output interdependency and time variability for periods $(1,2,....,N)$, given the evolving nature of inputs and a given technology relative to time. From Cobb and Douglas (1928), production function, if $Q\ or\ Y$ represents output and K and L represent capital and labour inputs, given the influence of time variation, then the aggregate production function can be re-written as:

$$Y = f(K, L : t)\ or\ Y_t = f(K_t, L_t) = A_t K_t^{\alpha} L_t^{(1-\alpha)} \qquad \text{(iii)}$$

The additional variable (t) for time, appears in the function to allow for the technical change, which represents a shift of the production function as a result of a manager's ability to manage the inputs and for a maximum outputs given the change between two time periods. The Solow model reflects the changing trends in firms, therefore an appropriate dynamic productivity estimator that captures both the efficiency and time variations in productivity index is required. The Solow model does not also capture the cost or value elements of an entity under consideration. However, the model's has an advantage to capture time is relevant to this study, hoever its inability to capture the cost element is addressed by the cost productivity indices.

iii) Growth Accounting Model

The theoretical framework for understanding the sources of growth is explained by the Solow growth model. However, in conducting a less theory-bound analysis, an alternative framework called growth accounting was developed to obtain a different perspective on the sources of economic growth. Solow's (1957) paper is considered the foundation for the development of growth accounting. According to Barro (1999), the breakdown of productivity into components given the changes in factor inputs can be attributed to Growth Accounting Model. This theory

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serves as the basis for the decompositions of the cost productivity index to identify the sources of efficiency change in many industry. This identification of efficiency change is surely the basis for appropriate policy measures for operations managers and regulators of banks. Therefore this study decomposes the Cost Malmquist Productivity Index (CMPI) into two broad components. The first stage includes the Overall Efficiency Change (OEC) and Cost Technical Change (CTC). The second stage further decomposes the OEC into Technical Efficiency Change (TEC) and Allocative Efficiency Change (AEC) and the CTC into Technical Change (TC) and Price Change Effect (PE). This decompositions encourage a targeted policies measure by operations managers and industry regulators.

iv) Endogenous Growth Model

It has been argued that the basis for total factor productivity is biased, given that the neoclassical growth theory of Solow (1957) assumes that, economic growth is independent of economic forces. There are some controversy in the endogenous growth which is based on weak assumption of the Solow growth, that there is limitation in scale factor (Ickes , 1996). For example, the Solow model shows that, countries with lower per capita growth experience higher growth. Consequently, this poses a problem for standard model of growth. The neoclassical growth model function is $Y = A(t)K^{1-\alpha}L^{\alpha}$. From the expression $A(t)$ denotes the level of technology, dependent on time (t) in relation to exogenous rate of technical change. This model failed to account for all possible factors both internally and externally. Another observation is that the above productivity growth studies failed to acknowledge potential exogenous factors that can affect growth. Therefore, this study borrows the concept of endogenous growth in the second stage analysis. This is to establish the fact that, the cost productivity index of banks may be influenced by other factors which were not captured as part of the inputs and outputs, so as not to limit the sources of influencing factors of the performance of banks. To adequately account for these influence on the cost productivity of firms variables

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such as competition, size, ownership etc., were included in the second stage analysis. This gives a clearer picture of the influence of other factors on the cost productivity.

2.1.2 Theory of Financial Intermediation

Generally, the existence of financial intermediaries (FIs) is deeply rooted in the theory of the firm (Bhattacharya & Thakor, 1993). The multiplicity of financial intemediareis has been questioned and the simple answer is, the need for numerous firms as compared to one big firm to make the market efficient in resource organisation as posited by the theory of the firm (Williamson, 1973). Traditional theories of financial intermediation are based on transaction cost and asymmetric information (Allen & Santomero, 1997a). The role of financial intermediaries in reducing the cost of transaction since, as institutions they are better organised to have significant informational asymmetries regarding borrowers and facilitate a better risk transfer through the use of financial instruments and markets (Bhattacharya & Thakor, 1993). This makes the market better and signal quality that engender confidence as compared to other forms of credit. Most important to this study is the Transaction cost theory. Transaction cost theory dates back to Coase (1937) and Williamson (1973); Williamson (1981) and is based on the concept of firms minimizing cost. Furthermore, the theory examines the economic efficiency of resources in the presence of internal and external controls, which impact firms cost of operations Gatignon and Anderson (1988). Proponents of this theory questioned why firms organise internally those exchanges that might otherwise be conducted in the markets. The cost efficiency and productivity of firms largely depends upon the ability of managers to minimized transaction costs of production (Hirschey & Richardson, 2003). The concept of cost efficiency has been applied in a wide range of industries, mamely Fries and Taci (2005) and Camanho & Dyson, (2008); insurance Tone and Sahoo (2005) and soccer Barros, Peypoch, and Tainsky (2014). This study considers how banks are able to cheapy run their business

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operations over time in order to generate technological economies (saving on the cost of physical inputs) and transaction economics (cost saving on exchange of inputs).

2.1.3 Competition Theory

Two main schools of thought for explaining market power and competition are Hicks (1935) Quiet Life Hypothesis (QLH) and Demsetz (1973) Efficiency Structure Hypothesis (ESH). Hicks (1935) suggests that producers or agents with more market power might prefer to use their market power to behave inefficiently. This is possible since other firms in the industry do not pressurise agents or managers to reduce costs. An alternative market structure-performance paradigm is the Efficiency Structure Hypothesis pioneered by Demsetz (1973). In case of banks it is stipulates that, a bank which operates more efficiently than its competitors gain higher profits resulting from lower operational costs. It is believed that the QLH applies particularly to banks, since the industry generally avoids showing large returns (Rhoades & Rutz, 1982).

The level of competition is very important in the process of banking activities and product innovation, relative to bank efficiency and productivity (Claessens, 2009). Therefore, to improve efficiency and productivity, which create room for cost reduction and increased profitability, the level of competition in the industry is a necessary condition (Casu & Girardone, 2009). However, competition in any industry is influenced by the market power or the concentration ratio in the industry. In some industries, market participants have the power to influence outputs or prices and they do that at the expense of other players. Based on the QLH and the ESH, this study empirically determines the causal relationship between bank competition and bank cost productivity among banks in Ghana.

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2.1.4 Ownership Theory

Two major theories in literature for banks ownership and efficiency are internationalization and eclectic theories (Sufian , 2011). The most relevant to this study is the eclectic theory. The theory posits that firms consider factors such as ownership type (O) and location (L) before investing abroad. The eclectic paradigm was first introduced by Dunning (1973, 1979, and 1980) based on earlier studies by Rostas (1948) and Frankel (1955) regarding higher productivity of the US manufacturing firm as compared to UK firms. Dunning questioned the transferability of those competitive advantages across boundaries to see if they will remain same. Therefore, he developed a hypothesis (ownership specific effect) to test if the superiority in productivity was entirely due to managerial factors, then subsidiaries of those firms in another country should perform like their mother companies. However, he further hypothesized that if the US firm in the UK have lower productivity than the indigenous firms, then the competitive advantage is partly due to location. This he referred to as the location specific component of differences in productivity. Innovative products, better technologies, more efficient production function, better distribution facility and superior managerial abilities are some of the most important competitive advantages that foreign firm possess over indigenous firm (Hymer , 1976 & Sufian, 2011). Therefore, this study employs the ownership theory to examine the effect of ownership type on the cost productivity of banks in Ghana.

2.2 Empirical Review

2.2.1 Productivity Assessment in the Banking Industry

Evidence of the application of productivity indices using different techniques abound in the banking industry. The use of DEA to assess a bank's productivity has received some attention (Fare, Grosskopf, & Roos, 1998; Fethi & Pasiouras, 2010; Liu, Lu, Lu & Lin, 2013). Malmquist Productivity Index (MPI) has become a popular approach for evaluating

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productivity change. Existing applications of MPI in the banking industry include Alam (2001), Drake, (2001), Mukherjee, Ray, and Miller (2001), Sathye, (2002), Kumbhakar and Sarkar, (2003), Isik and Hasan, (2003), Krishnasamy, Hanuum Ridzwa, and Perumal (2004), Rezitis, (2006), Zhao, Casu and Ferrari, (2008), Sailesh (2009), Murillo-Melchor et al., (2010), Matthews and Zhang (2010), Fiordelisi and Molyneux (2010), Delis, Molyneux and Pasiouras (2011), Halkos and Tzeremes (2013), Kamau, (2011), and Wheelock and Wilson (2013).

A number of these frontier productivity dynamics studies in the banking industry focus on Europe. Drake (2001), for example, assessed productivity change in the United Kingdom (UK) for nine (9) banks between the period 1984-1995 and found that, UK banks exhibited a modest positive productivity growth. Similarly, Fiordelisi and Molyneux, (2010) and Murillo-Melchor et al., (2010) in the assessment of productivity change for European banks from1995-2002 and 1995-2001 respectively, found out that productivity growth in the European banking system was due to improved production possibility frontier. These results possess some biases since these studies failed to consider prices of the inputs or allocative efficiency, an important determinant of total factor productivity change. In view of this, the conclusion of productivity does not reflect the full picture of the European industry.

Focusing on a sample of 6 and 45 Grecian banks over the period, 1982-1997 and 2007-2011, Rezitis (2006) and Halkos and Tzeremes (2013) respectively estimated the operational efficiency gain or loss and concluded that the Greek banking industry experienced productivity gains due to regulatory reforms including mergers and acquisitions. However, Halkos and Tzeremes (2013) also found that the current financial crisis in the Greek banking industry poses a huge threat to banks losing out on their productivity gain. The question these findings still leaves unanswered, has to do with the completeness of the productivity change assessment carried out. Could it be that using only the standard Fare et al.'s (1992, 1994) productivity

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change measure which does not consider price influenced the result? This issue is addressed in the current study.

Mukherjee et al. (2001) also investigated the productivity growth of 201 large US commercial banks over the period 1984-1990, the initial post-deregulation period. The result demonstrated that on average the industry experienced a 3% productivity progress. However, the initial implementation of the deregulation between the period of 1984-1985, saw a productivity decline of 7%. Given Maniadakis and Thanassoulis' (2004) aguement that allocative efficiency assessment could further improve the productivity growth, the conclusion of this study may be biased since it failed to account for the input prices. In the Asia, Krishnasamy et al. (2004) estimated the productivity of 10 Malaysian banks between the period 2000-2001, as post-merger period. The study found that 8 out of the 10 banks experienced productivity growth. This was attributable to the benefit of technological change as a result of the strategic alliances of most of the banks. As compared to the post deregulation and productivity impact in the USA banking industry experienced the higher productivity (Mukherjee et al., 2001). The period after deregulation, productivity assessment was more encouraging in the Malaysian banking industry as compared to the initial post-deregulation in the US, with a regressed productivity just a year after the implementation of the reforms.

In China, a study by Matthew and Zhang, (2010) showed a complete deviation from the other studies. The authors found out that, on average productivity was constant in the Chinese banking industry for the period 1997-2007. The findings showed that the policy of opening up the banking industry was yet to accrue any benefit at the time of the study. However, in relation to bank ownership, comparing State-owned commercial banks (SOBCs), Joint-stock Bank (JSCBs) and City Commercial Banks (CCBs), CCBs experience a productivity progress, indicating possible benefits of the liberalization of the banking industry.

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In Africa, Moffat et al. (2009) posit that considering the pivotal role of the financial sector in attaining economic growth it is important to estimate the productivity index. For appropriate policy direction. They studied 10 banks, for the period, 2001-2006, the post-reform era in Botswana. The empirical results of the study indicate a productivity regress, which was attributed to technological regress due to the failure of the banks in Botswana to adopt new technology such as telephone and internet banking. Furthermore, the sector was not employing cost effective technologies due to the lack of competition. Similarly, Kamau (2011) studied the intermediation efficiency and productivity in the Kenyan banking industry in the post-Liberation era. The motivation for the study was based on the pivotal role played by the financial sector in the economic growth of countries. The study employed the DEA and MPI to study the performance of 40 banks from 1997 to 2009 and found that banks were not fully efficient as a result of lack of technological improvement and lack of economies of scale. However, Moffat et al. (2009), found out that, there was little or productivity regress in the Botswana banking industry, which could be attributed to technological regress. It seems that in Africa, productivity in the banking industry is attributable to technological dynamics since the continent has not fully taken advantage of the global technological advances in the industry.

2.2.2 Cost Malmquist Productivity Index

The popular MPI as proposed by Fare et al., (1992, 1994) is more related to quantity index or consumption of input quantities without considering input prices and hence allocative efficiency and cost values. Maniadakis and Thanassoulis (2004) argued that firms who are cost minimizers in the presence of input prices, should consider the use of (CMPI) in assessing productivity. Banks are no exception to this. The motivation for the CMPI is that the traditional MPI does not capture allocative efficiency, which is important in reflecting the distance between actual and minimum costs. As stated earlier, to the best of the author's knowledge, there are only four studies that have used the CMPI in the health sector, manufacturing

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(pharmaceutical sector) and the agricultural sector. Despite the numerous studies on cost efficiencies and technical productivity change in the banking industry, no study has considered the cost productivity change index for the banking industry.

The CMPI was initially applied to estimate the cost productivity of 30 Greek hospitals over the period, 1992-1993 by the authours who introduced the index (Maniadakis & Thanassoulis, 2004). Cost productivity growth ([100-96.5]$_{\times}$100% = 3.5%) was mainly attributable to the detrimental impact of price effect (1.029), efficiency growth (0.976) and allocative efficiency growth.. Hence, the allocative efficiency change and price effect helped to ascertain the decomposable sources of cost productivity dynamics. Furthermore, a comparson between MPI and CMPI shows that the CMPI posted a growth of 3.5% as compared to the former's which grew by 2.5%. This enforces the argument of using the CMPI as a complementary productivity measure in estimamting the productivity growth, since it less conservative. Another application of CMPI was by Tzu-Chun et al. (2012), who estimated the three-stage cost Malmquist Productivity index in the biotech and biopharmaceutical industry in Taiwan from 2004 to 2007. The results showed improvement in CMPI by 7.17% and a regress in MPI by 8.79%. Assuming the MPI was the only measure of productitvity, the conclusion would have been a regress on productivity. This further strengthen the proposal to consider the CMPI as a relatively comprehensive productivity measure for firms since it include both cost and input minimization over time .

Using the combined approaches of Maniadakis and Thanassoulis (2004) and Fare et al., (1994), Baležentis (2012) also computed the cost productivity change of 200 Lithuanian family farms for the period of 2004-2009. The index estimated the dynamic total factor productivity and extended the decomposition of the index to tackle variable returns to scale technology and hence, scale efficiency. The results showed that the cost productivity increased by some 7.7% and the technical productivity grew by 22.4%. The improvement in cost productivity was

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mainly attributable to technical efficiency dynamics. Similarly, Balezentis et al. (2013) estimated the trends of technical and allocative efficiency in Lithuanian family farms.. The result showed a cost productivity decrease of 8% whereas average technical productivity was sby 20%. These findings further increase the suggestion for the dual producitivty estimate to comprehensively inform operations managers of the firm's performance. From the findings of Baležentis (2012) and Balezentis et al. (2013) the higher technical productivity growth only could have been a bit misleading to conlude the firm's overall performance. Therefore, the addition of cost productivity expands the outlook of the firm productivity. Despite the CMPI's ability to account for all factors of production, there still are other contextual variables or exogenous factors beyond management control that can affect dynamic cost productivity. Therefore, a second-stage analysis is relevant in exploring their influences. Having said that, none of the previous CMPI studies, to the best of our knowledge, considered the potential second-stage correlates of cost productivity change. These issues are handled in the present study.

2.2.3 Competition and Productivity

One potential contextual factor that can affect cost productivity change is the competitiveness of the industy. Generally, competition among industry players should enhance efficiency or production, which consequently should discourage deviation from cost minimization and optimal production (Allen & Rai 1996). One reason for this is the dynamic nature of the banking landscape which is expected to create a competitive environment which will affect performance (Fiordelisi & Molyneux, 2010). A number of studies on efficiency of banks tested the significant impact of environmental variables, including competition on the efficiency of banks (Alhassan & Ohene-Asare, 2013; Casu & Girardone, 2009; Claessens & Laeven, 2004; Hauner & Peiris, 2008; Sanyal & Shankar, 2011).

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In the EU and other places, there have been deregulation and liberalisation of the financial services sector with the aim of removing entry barriers and foster competition and efficiency in the banking industry. Casu and Girardone (2009) investigated the impact of competition on efficiency and found little evidence that more efficient or productive banking systems are competitive. This implies that the relationship between competition and banking industry efficiency is not straightforward, that is, increased competition has forced banks to be more efficient, but increased efficiency does not necessarily lead to more competition in the EU banking industry.

In an European cross-country productivity analysis and the influence of size as an ernvironmental variable, showed the same result as the specific country analysis. Further exploration of the influence of environmental factors by Murillo-Melchor et al., (2010), showed that exogenous factors impact on dynamic productivity is very little. This implies that it is important not to belittle the impact of size as an exogenous variable on dynamic productivity. Drake (2001), on the impact of size on the UK banking industry productivity found out that smaller banks benefited more from increasing returns to scale than large banks.

Sanyal and Shankar (2011) investigated the effect of ownership and competition on Indian bank productivity after the financial sector reforms. The authors found that competition had a positive impact on productivity growth of old Indian private banks as compared to the new private banks with worsening productivity growth as competition intensifies.

Casu and Giradone (2009) also they tested the relationship between competition and efficiency in the banking industry using DEA, SFA and Granger causality. The study concluded that the reverse causality between efficiency and competition does not suggest that increase in efficiency foster market power. This finding differs from other studies that observed a positive relationship between efficiency and competition.

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Closer to Africa, Hauner and Pieris (2008) investigated banking efficiency and competition in Uganda and concluded that improved efficiency in the banking sector has led to an increased level of competition. The findings showed that the Ugandan banking industry had become more competitive and efficient due to the financial sector reforms. Similarly, Mlambo and Ncube (2011) analysed the evolution of competition and efficiency of the banking sector in South Africa using firm-level data for the period 1999 to 2008. The study found an upward trend of efficiency on average. But, the number of efficient banks were falling suggesting that the sector was characterized by a monopolistic competition. Closer to our study, Alhassan and Ohene-Asare (2013) examined the impact of competition on technical and cost efficiency of banks in Ghana. Using an unbalanced panel data of 26 banks for the period 2003-2011, a second stage analysis indicated that the nexus between efficiency and competition was dependent not only on general efficiency but the type of efficiency under consideration was critical. The study found that cost efficiency for the period had improved in a competitive environment supporting the "Quite Life Hypothesis" that say that increased competition forces managers to have only one objective, which is cost efficiency.

2.2.4 Ownership and Efficiency and Productivity

Bank ownership and efficiency in recent years have received increased attention in the banking efficiency and productivity analysis literature. Banks with owners' share of more than 50% of the shares by domestic residence are considered as domestic banks, whereas those banks with more than 50% in foreign ownership are classified as foreign banks.

Generally, there are mixed results regarding ownership-structure and bank efficiency or productivity change. Some banking efficiency and dynamics productivity literature have endorsed that foreign-owned banks are more efficient or experience productivity growth than

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domestic-owned banks (Adjei & Chakravarty, 2012; Berger, Hasan, & Zhou, 2009; Bonin, Hasan, & Wachtel, 2005; Das, Nag, & Ray, 2005; Fries & Taci, 2005; Havrylchyk, 2006; Jemric & Vujcic, 2002; Koutsomanoli-Filippaki et al., 2009; Saka, Aboagye, & Gemegah, 2012; Sturm & Williams, 2004). Other studies posit that foreign ownership has little or no influence on the efficiencies of banks (Altunbas , Evans & Molyneux, 2001; Lensink , Meesters & Naaborg, 2008; Sanyal & Shankar, 2011). These studies did not apply Simar and Wilson's (2007, 2011) truncated bootstrapped regression in the second-stage analysis. Therefore, the current study introduced the approach to reduce the basis in the second stage analysis.

Other studies in Asia compared privately-owned, publicly-owned and foreign-owned banks. For instance, Bhattacharyya et al. (1997) observed that publicly-owned Indian banks experienced productivity growth, followed by foreign-owned banks and privately-owned banks. Few years later, in the same industry, Sanyal and Shankar (2011) investigated the impact of ownership and competition on productivity growth since the 1991 reforms and found Indian private banks dominated public and foreign banks in terms of productivity growth. . Similarly, Das, Nag and Ray (2005) in the Indian banking industy, found that, bank size and ownership jointly have significant influence on the efficiency of the banks. This effect was largely attributed to the liberalization of the financial sector, which increased the level of competition and efficiency. In the Taiwanese banking industry, Chen and Yeh (2000) using DEA investigated bank efficiency, ownership and productivity change. The findings indicated a lower level of technical efficiency in public-owned banks than privately owned-banks due to pure technical efficiency rather than scale factor. They attributed productivity growth in private or foreign banks to the nature of the labour movement in the banking industry in Taiwan. They stated that, the ability of the foreign banks to attract experienced labour inputs with already existing knowledge of the industry was responsible for the productivity growth. This, coupled

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with the advantage of technology spillover of the foreign banks made them outperform the local banks.

In contrast, other studies have reported mixed and negative impact of foreign ownership on efficiency or productivity change. Altunbas et al., (2001) considered types of firm ownership and efficiency in Germany and found little evidence to suggest that privately-owned banks were more efficient than publicly-owned ones. However, public and foreign banks had some cost and profit advantage over the private ones. This finding has been corroborated by Fries and Taci, (2005), Carvallo and Kasman (2005), Yildirim and Philippatos (2007) and Fu and Heffernan (2007). Conclusions are that foreign-owned banks that existed prior to the introduction of the banking reforms have on average been more cost efficient as compared to those who joined after the introduction of the reforms.

The mixed empirical results regarding ownership-performance nexus could emanate from the frontier method used and the type of performance estimated. Some of these studies estimated static efficiency (Das, Nag and Ray, 2005; Altunbas et al., 2001; Fries and Taci, 2005; Saka, Aboagye and Gemegah, 2012) and regressed it on some environmental variables. As stated earlier, static efficiency is biased as it does take into consideration the time variability relative to all inputs and outputs within the banking industry.

Turning to African banking efficiency and productivity dynamics studies, Hauner and Pieris (2008) found foreign-owned banks in Uganda to be more efficient with the increased competition than other banks in the industry. The study further found larger foreign banks to be more efficient than small local banks. This confirms the importance of economies of scale for the foreign banks once they are operating at an optimal scale as compared to their local counterparts. In another study in Nigeria, to assess the effect of privately owned banks on

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performance from the period 1990 to 2001, a study was conducted to determine the effect of ownership on performance (Beck, Cull, & Jerome, 2005). The study found evidence of impoved performance by all the nine banks that were privatized. Furthermore, the authors stress the perculiarirty of the hostile environment during that period for efficienct financial intermediation. Similarly, Figueira, Nellis, and Parker (2006), investigated the essence of ownership in bank performance in Africa. The study considered ownership in three ways, namely privately-owned banks, satate-owned banks and foreign-owned banks. The results show that in Africa, foreign-owned banks performs better state-owned banks and privately-owned local banks. These studies confirm the superiority of foreign owned banks in Africa despite the advantage of the familiarity the local environment for the host banks. However, Ongore and Kusa (2013), used a linear multiple regression model on panel data to estimate the effect of environmental factors on bank performance in Kenya. The study sampled 37 banks out of which 13 were foreign and 24 local or domestic banks. The study found banks specific variables (capital adequacy, asset quality, management efficiency and liquidity management) significantly influence performance of the banks. However, in relation to ownership, foreign banks have no significant impact on performance of banks in Kenya. These studies have a number of biases which the current study will address . Hauner and Peiris (2008), Figueira, Nellis, and Parker (2009) and Beck et al. (2005), used a first stage analysis which is a static measure, ignoring time variance, which can have effect on the firms' performance. Additionally, all the studies on the African continent in the second stage analysis used the multiple regression which may bias the result. This study uses the cost dynamic index as the dependent variable and regressed on other environmental factors in the second stage. These approaches estimate the effect of ownerhip better as compared to the other studies in Africa.

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In Ghana, few studies have considered the effect of ownership on banks efficiency, these include (Adjei & Chakravarty, 2012; Saka et al., 2012). Saka et al. (2012) investigated the effect of foreign banks, and change in bank concentration on the technical efficiency of Ghanaian banks using DEA and Tobit regression. The findings suggested that foreign banks' entry into the market and the resultant competition positively affected the efficiency of domestic banks. Adjei and Chakravarty (2012) used an unbalanced panel data of 25 banks for the period 1997-2008 to assess the influence of reforms and ownership type on the cost efficiency of banks in Ghana. The study found that liberalization of the banking sector helped diversify ownership and governance structure of banks which impacted on bank efficiency. They thus reported that foreign banks outperformed local ones. This follows the suggestion by Classens et al., (2001) that, foreign banks generally possess superior management practices and technological advantage and are likely to exhibit higher efficiency levels than their local peers. However, they added that time may erode any competitive advantage of foreign banks. The deficiencies with these results come from the methods used. Saka et al. (2012) used the static DEA approach which suffers from the failure of time variability on bank efficiencies. Furthremore, the second stage analysis used Tobit regression which is flawed for nonparametric efficiency analysis (Simar &Wilson, 2007; 2011). Adjei and Chakravarty (2012) also used the stochastic frontier approach (SFA) to estimate the dependent variable which is limited by restrictive assumtions about specification of the error term and the inefficiency term and also deals with a single regressand.Therefore this study uses first of all, the dynamic cost productivity, which is sensitive to time variability and further use the double bootstrap truncated regression which is more analytically robust than the the Tobit regression used by the othe studies for the ownership effect on cost productivity.

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CHAPTER THREE

CONTEXT OF THE STUDY

3.0 Introduction

The study context provides an overview of the special features of the banking industry in Ghana. The chapter examines the background or financial landscape in which banks operate in order to clearly understand the empirical arguments presented in this study. It first presents an overview of the Ghanaian economy with particular emphasis on key macroeconomic factors that can impact on the performance of the banking industry. Second, it provides background of the Ghanaian banking system. Principal issues under discussion include, evolution of the banking industry, competition, reforms in the banking industry and their expected impacts. These factors help understand the factors explaining the dynamic cost productivity trends in the industry during the study period, and provide an overview of the players in the industry.

3.1 Overview of the Ghanaian Economy

Relatively, the potentially sound management of the Ghanaian economy has resulted in a competitive business climate, leading to the economy being regarded as middle income (ISSER, 2013). The Ghanaian economy is largely endowed with natural resources and employs majority of its work force in the agriculture sector. Other sectors such as service and industrial have also been performing well and contributing largely to the Gross Domestic Product (GDP). The economy since the year 2000 has experienced growth rate averaging 5.5 percent per annum and peaking in 2011 with an all-time growth as high as 15%. Note that the production of oil in Ghana which started in 2011 is largely responsible for the record growth. Since that impressive growth, the Ghanaian economy has been experiencing a decreasing growth. Despite the decline in Ghana's economic growth after the year 2011, the economy remains fairly resilient in the face of the global recession over the decade (ISSER, 2013). Largely, the Ghanaian economy

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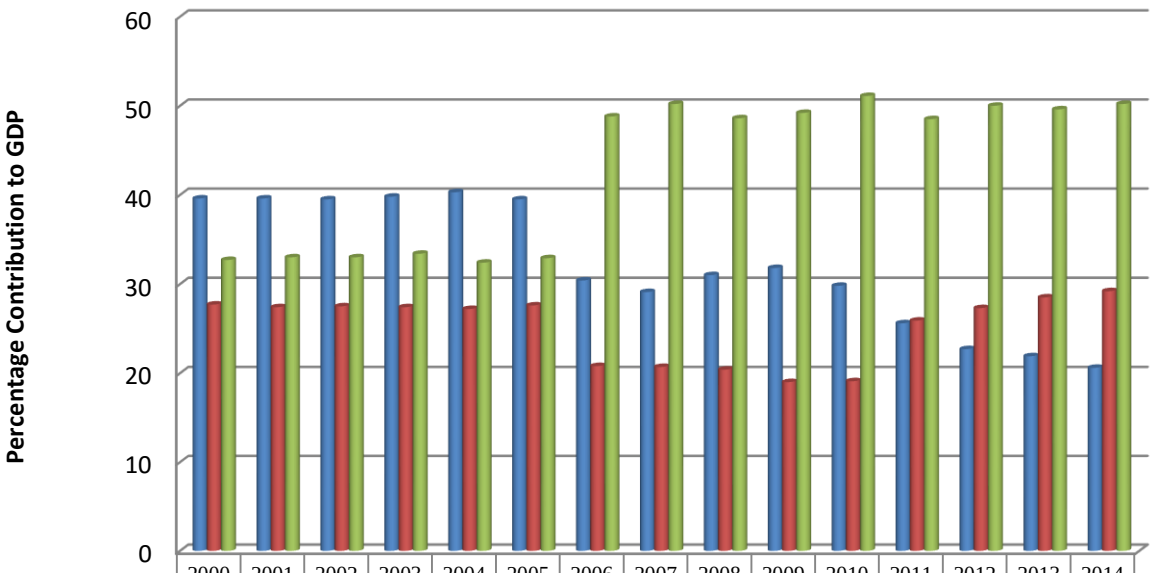
inability to sustain its growth momentum reflect the global economic trends. Disaggregating the performance of the various sectors of the Ghanaian economy presented an interesting trend over the period of the study, 2000 to 2014. The increasing performance of the service sector, with the financial sub-sector is worth noting. Given that the banking sub-sector drives the financial sector, it is crucial to estimate the cost productivity of the banking sector in the economic development and growth.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Agriculture (%)	39.6	39.6	39.5	39.8	40.3	39.5	30.4	29.1	31	31.8	29.8	25.6	22.7	21.9	20.6
Industry (%)	27.7	27.4	27.5	27.4	27.2	27.6	20.8	20.7	20.4	19	19.1	25.9	27.3	28.5	29.2
Services (%)	32.7	33	33	33.4	32.4	32.9	48.8	50.2	48.6	49.2	51.1	48.5	50	49.6	50.2

Figure 1: Sectorial Performance of the Ghanaian Economy

Source: (GSS, 2014)

Until the year 2006, the largest contributor to the economy was the agriculture sector, followed by the service sector. The industrial sector contributed the least to the economy. However, from 2006 the service sector has been the largest contributor to the economy, shifting the agriculture sector to the second position. Still, with the discovery of oil, the industrial sector since 2011 has also overtaken the agriculture sector to become the second largest contributor to the Ghanaian economy's GDP. Thus, despite the major improvement in the performance of the agriculture sector it continues to perform abysmally, and is beginning to assume less

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prominence within the Ghanaian economy. The performance of the service sector and its importance to sustainable economic growth, brings into sharp focus the financial subsector's efficiency. The services sector includes the banking industry which plays a principal role both in the financial system and the socio-economic development. In view of the banking industry's important role, various governments including the Ghanaian government have made it an objective to build an efficient, effective and stable industry to support the growth of the economy (Hinson, Mohammed, & Mensah, 2006). The Ghanaian banking industry experienced a fierce competition for deposit mobilization from government and non-traditional sources (savings and loans companies and finance houses). This resulted in a five low of 27% deposit mobilization given the average between the year 2008-2012 to 28% (PwC, 2014). Generally, it is expected that, the macroeconomic variables would impact the performance of the financial sector which includes the banking sectors.

3.1.1 Macroeconomic Factors

Considering the role of banks in supporting and financing business operations in an economy, their internal efficiency is critical. The internal efficiency which affects the cost of operations does impact on the whole economy since it is transferred to the cost of financing business. Additionally, there are other factors beyond the control of the banks which can affect efficiency or productivity dynamics. Thus banking efficiency and dynamic cost productivity can be influenced by factors controlled by the banks and factors that are beyond the control of banks. Controllable factors are those related to management of inputs (labour, deposits etc.) and outputs (loans, investments etc.) and how they are transformed for productivity progress of banks. The uncontrollable factors affecting banking performance are natural and man-made factors such as macroeconomic indicators. Historically, the Ghanaian banking industry has been vulnerable to macroeconomic influences. For example, the crisis in the industry during

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the period of the late 1970's to the 1980's was mainly due to the economy, as a result of high depreciation and increasing inflation (Antwi-Asare & Addison, 2000).

Practically, the concept of a stable macroeconomic framework mean a situation where there is low and predictable inflation, real interest rates are appropriate, fiscal policy is stable and sustainable, the real exchange rate is competitive and predictable, and the balance of payment situation is perceived as viable (Fischer, 1993). This effectively influence the performance of the financial sector in contributing to economic growth. Therefore, investigating the effect of macroeconomic factors on dynamic cost productivity of banks in Ghana would provide better insight into causes of underperformance so that appropriate policy measures can be orientated towards affected areas.

i) Inflation Trends in Ghanaian Economy

Policymakers, economists and operations managers are always confronted with the decision of sustaining business and economic growth and ensuring price stability. There is a general consensus that very high inflation rates are detrimental to the economy and affect the efficiency and productivity of firms (banks) (Athanasoglou et al., 2008; Lindgren, Garcia, & Saal, 1996). Most of the theory and empirics hold that high inflation impedes efficient resource allocation (Fischer , 1993). Inflation influences purchasing power of money and real values of variables such as interest rates, wages etc. Generally, prevailing interest rates in an economy at any point in time are nominal interest rates, i.e. real interest rates plus a premium for expected inflation. Due to the rate of inflation, there is a decrease in the purchasing power of money earned due to interest in the future. Therefore, in the long run, other things being equal, interest rate rise in direct correlation to the rise in inflation. In view of this, inflation has an inverse relation to economic growth. Ceteris paribus, economic growth is equal to the difference between money supply growth and inflation (Jones & Manuelli, 1995). Ghana's inflation rate has been volatile

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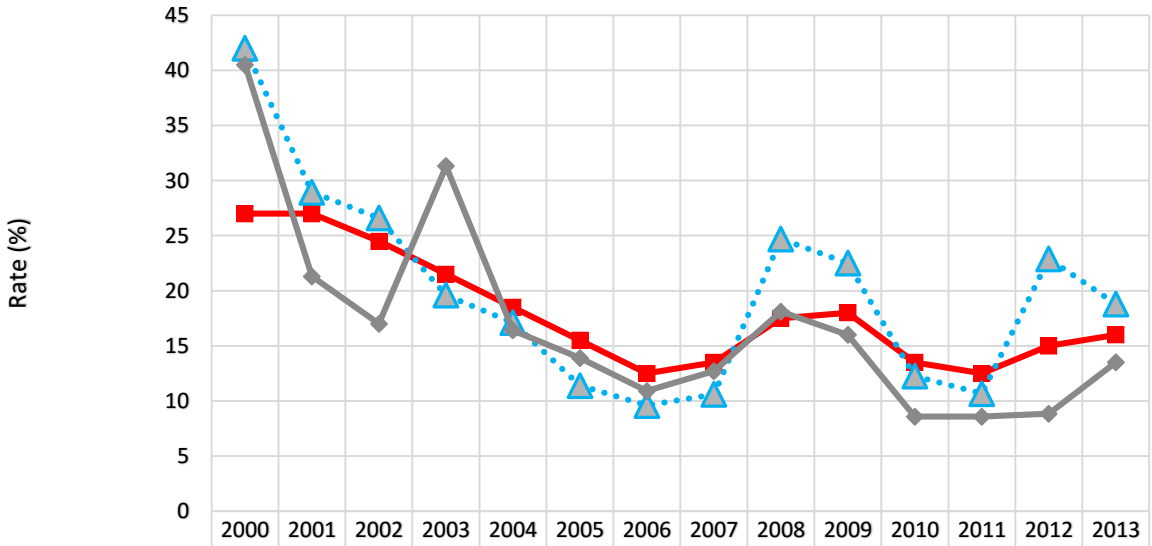
and this is attributable to several factors such as high public expenditure, excessive money supply growth, rapid depreciation of the cedi against other major trading currency etc.

ii) Policy Rate Trends

The Monetary Policy Rate (MPR) is the rate set by the monetary authorities, as a short-term credit to banks to replenish their liquidity short falls. Furthermore, policy rate primarily influence how much banks have to spend as interest on deposits. The policy rate which is fixed by the Central Bank (Bank of Ghana, BoG) as the borrowing rate, goes a long way to influence how much it cost the industry players to mobilize deposits. Evidently, depositors will demand more on their deposits which may push banks to increase interest on loans. Therefore, the policy rate possesses the potential for banks to be cost productive or otherwise. For the period of the study, BoG announcement of the policy rate has seen a relative decline which is expected to have an impact on the productivity of banks. The MPR largely played the role in the cost effectiveness of mobilizing deposits.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Policy Rate	27	27	24.5	21.5	18.5	15.5	12.5	13.5	17.5	18	13.5	12.5	15	16
T-Bill	41.99	28.94	26.6	19.6	17.1	11.4	9.6	10.6	24.7	22.5	12.25	10.67	22.9	18.8
Inflation	40.5	21.3	17	31.3	16.4	13.9	10.9	12.7	18.1	16	8.58	8.58	8.84	13.5

Figure 2: Inflation, Treasury bill and Policy Rates Trend in Ghana (2000-2013)

Source: BoG, (2013)

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iii) Treasury bill Rate Trends

Generally, the users of loanable funds in every economy are government, firms and individual households. Comparatively, government as the biggest spender competes with other users of funds, namely companies and households who borrow for investment and consumption purposes. In view of this, the price of funds is affected due to government high demand for funds through Treasury Bills and Notes/Bonds markets. The trend in Ghana for the period of the study shows an unstable trend but generally a declining. Therefore it is expected that if government is using the treasury bills rate to attract funds, this will lead to higher cost for the banking industry to compete with government in mobilizing deposits. This could have cost implication for the banks over time. Treasury Bills rate is generally regarded as an indicator of the interest rate policy being pursued by the government, and a benchmark for the rates charged by commercial banks. This variable is therefore also expected to be positively correlated with cost productivity.

iv) Gross Domestic Products (GDP) Trends in the Ghanaian Economy

Ghana' economy has maintained a commendable growth trajectory with an average annual growth of about 6.3% over the last fourteen years, reaching a record high of 15% in 2011 (ISSER, 2013). This was made possible as a result of Ghana joining the league of oil-producing countries. Generally, higher economic growth encourages banks to lend more and permits them to charge higher margin, as well as improving the quality of their assets.

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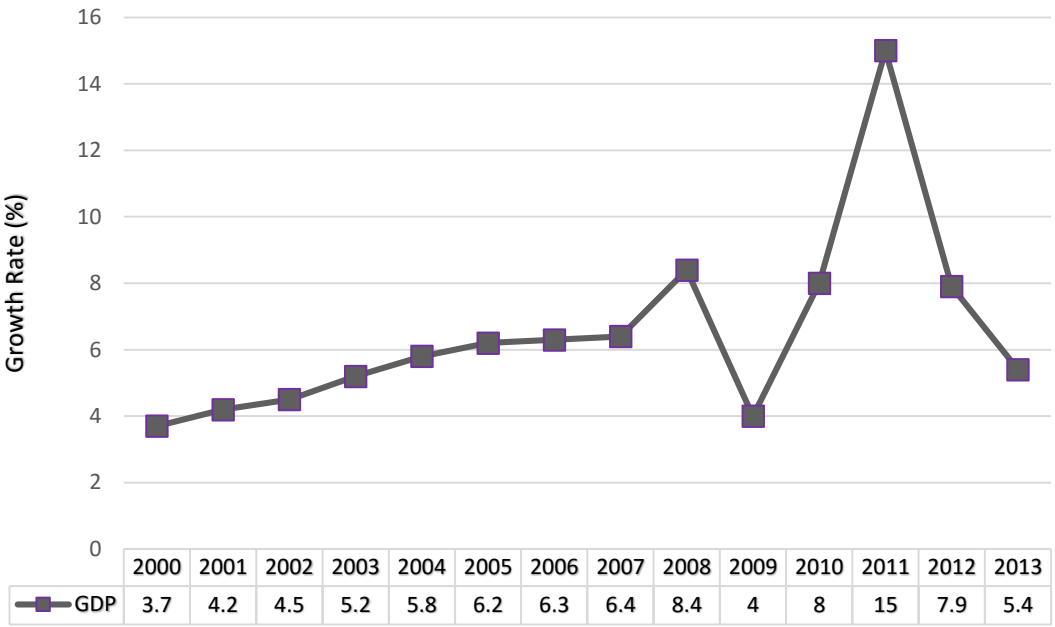

Figure 3: Gross Domestic Product (GDP) Trend in Ghana 2000-2013

Source: ISSER (2013)

Conversely, as the growth rate of the country slows down, credit quality tends to deteriorate and the default rate rises. Therefore, a bank's performance is sensitive to macroeconomic conditions. This makes the understanding of the relationship between GDP and efficiency and dynamic cost productivity of banks very important for policy direction for industry players.

v) Per Capita Income Trends in the Ghanaian economy

This represents the spread of income (total value of products) produced in a particular year as ratio of the total population in the Ghanaian economy. Graphically, the trend demonstrates an upward phenomena, since it shows an increase in output of the economy. The increasing trends indicates an increase in income of the population, which should influence the demand for more money. Banks' ability to mobilize more deposits due to an increased demand for money and loan out same and/or invest will increase their income.

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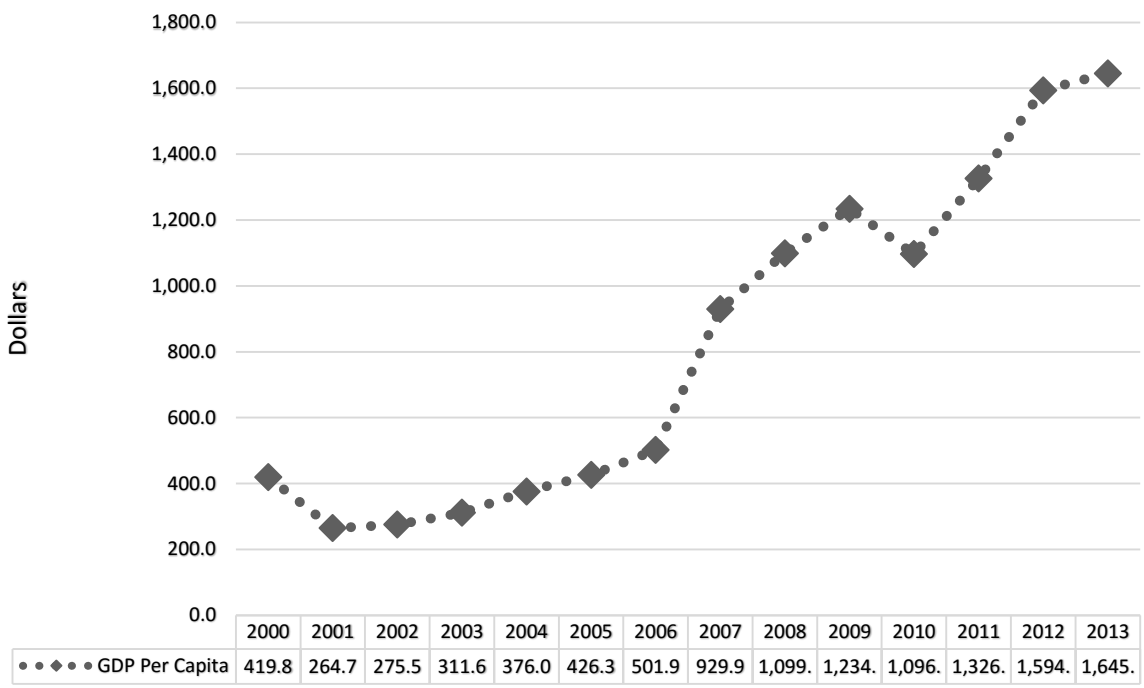

Figure 4: Per Capita GDP Trend in Ghana 2000-2013

Source: BoG, 2014

Generally, an increasing per capita income is expected to increase demand for money. This should afford he banks the opportunity to manage their cost and take advantage of the high demand to make profit.

3.2 Ghanaian Banking Industry

The financial sector is of central importance for a country's growth and development, but its usefulness cannot be exploited unless there exist an efficient structure of intermediaries which will channel idle balance into more productive investment at the highest available rates of return, and with minimum transaction costs. The stability of an economy's financial system is based on the reliability and continuous functioning of the banking industry (Fernando & Nimal, 2014). The financial system in Ghana is made up of, intermediaries such as universal banks, rural and community banks, insurance companies, discount houses, finance houses, leasing companies, savings and loans companies, credit unions, a stock exchange, stock brokerage

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houses and foreign exchange bureaux. The banking sub-sector is the largest component of the financial sector, whether measured by assets or customer base (Akoena et al., 2008).

From the beginning of the twentieth century, many African countries' financial systems were virtually underdeveloped (Sowa , 2003). However, Ghana had begun a banking system by the 1888 with the Post Office Savings Banking (POSB) operations. There were only 2 banks as overseas subsidiaries with their operations dominated by financing trade between the Gold Coast and the UK at the time of Ghana's independence. The banks were British Bank of West Africa, now the Standard Chartered Bank (SCB), established in the then Gold Coast in 1896, and Barclays Bank, now Barclays Bank Ghana Ltd (BBG) in 1917. Several factors resulted in the recommendation to form a bank which was partly owned by locals with the main aim to support indigenous private sector. This culminated in the formation of the Bank of the Gold Coast in 1953.

During the colonial period, regulations on the provision of banking services were carried out through the various enactments of Company Ordinances and Directives of the West African Currency Board (WACB) and the Bank of the Gold Coast. The Ghanaian banking industry has undergone various legislative changes since independence in 1957. Key among them are; The Bank of Ghana Ordinance (No. 34) of 1957, which was repealed by the Bank of Ghana Act (1963), Act 182. The Act was subsequently amended by the Bank of Ghana (Amendment Act) 1965, (Act 282). The Bank of Ghana Law, 1992 PNDCL 291 repealed Acts 182 and 282. The act was replaced by Ghana Act, 2002 (Act 612) the and further Banking Act, 2004 (Act 673). The current law under which the Bank operates is the Bank of Ghana Act, 2007 (Act 738). These Acts contained provisions giving the central bank regulatory control over the financial system and extensive powers over; the composition of banks' liquid assets; the right to demand information from banks; changes in the structure of banks; restrictions on credit and

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investments; and the amount of paid-up capital and liquidity ratios. The first explicit Banking Law for Ghana was Act 339 promulgated in 1970, brought together the many references to banking institutions in various laws into one document, which specifically spelt out the assurance of bank solvency, bank liquidity and the Bank of Ghana's supervisory powers. The legal framework provided by the 1970 Banking Act was not effectively enforced by the Bank of Ghana (Quartey & Afful-Mensah, 2014). As a result of non-performing loans which were rolled over from year to year from the 1970s, the banking sector was seriously affected by the economic decline prior to 1983. The Bank of Ghana failed to live up to its responsibilities in the area of on-site inspection. A key feature for maintaining bank solvency was introduced in the form of a minimum capital adequacy ratio of 6 percent of risk- rated assets, which was made adjustable for a particular bank or all banks by the Bank of Ghana (Antwi-Asare & Addison, 2000).

The Ghanaian economy in the period 1976 to 1983 experienced severe crises, (high inflation, high current account deficit, high fiscal deficits, slow pace of economic growth and some level of financial depression) which negatively affected the financial sector, which consequently led to poor economic growth and development (Osei, 2013). In view of this, in 1983 an economic recovery programme was initiated, which included the restructuring of the then distressed financial sector. This reform was introduced largely as a result of the successes of similar reforms in some developed countries like the US (Kumbhakar & Sarkar, 2003). In association with the World Bank, the Government of Ghana introduced a Financial Sector Adjustment Programme in 1987 (Antwi-Asare & Addison, 2000). Generally, the reforms were to strengthen and enhance the capacity of the Central Bank to effectively play its regulatory and supervisory roles. Additionally, it was to improve managerial oversight of banks and the quality of assets

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being held by banks, which will improve performance (efficiency or productivity change) and increased profitability of the banks.

Traditionally, the Ghanaian banking sector has been partitioned into merchant, commercial (retail) and development banks. The merchant banks have been restricted to corporate clients, the commercial and development banks have had customers across the entire financial market segments. This division created some disparities in the banking industry. To create a level playing field for all banks in Ghana, the idea of Universal Banking was adopted (BOG, 2004).The Universal Banking Law gives banks the right to conduct all types of banking under a single corporate banking entity and this greatly reorganizes the competitive scopes of several banking products. The law was made possible for banks to meet prescribed capital requirements and to engage in permissible banking business without restrictions. Some of the reforms include the Financial Sector Adjustment Programme (FINSAP I and II), Non-Performing Assets Recovery Trust (NPART) and the Foreign Exchange Bureau legislation. A new Banking Law was also promulgated. The Bank of Ghana was strengthened to enhance its capacity to play its regulatory role and influence the productivity of the banks in Ghana. These reforms have:

a) Strengthened the banks in terms of their capital base and managerial competence;

b) Enhanced supervisory capabilities of Bank of Ghana;

c) Improved the quality of assets being held by banks;

d) Increased profitability of the banks.

The major objectives of FINSAP-1 were:

(1) To review legal and regulatory environment and amend existing Acts and Laws;

(2) Restructuring the banking sector to make the banks viable and efficient; and

(3) Revitalize the financial sector by creating new institutions.

FINSAP-2 and 3 were to continue with the restructuring of the financial sector.

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(i) Regulatory and Legal Reforms

The Banking Law (PNDCL 225) was revised in 1989, with the aim of;

(i) tightening of risk exposure limits,

(ii) establishment of tighter capital adequacy ratios,

(iii) strengthening of accounting standards and making them uniform for all banks,

(iv) broadening the scope for audits of the banks,

(v) imposition of stringent reporting requirements, and

(vi) improvement of on-site and off-site supervision of banks by the Bank of Ghana.

The revised Bank of Ghana Law (PNDCL 291) was also enacted in 1992 to give more supervisory powers to the central bank of Ghana for effective monitoring of industry players. These two laws together provide the legal and regulatory framework for banking business in Ghana.

(ii) Financial Restructuring

The reforms also involved management and financial restructuring of the banks. New boards were created for most of the banks and there were changes in the top management positions as well. Furthermore, the reform involved recapitalization of the banks with equity injection where liquidity was low, and the cleaning up of their balance sheet of non-performing assets.

(iii) Institutional Restructuring

There was also institutional restructuring of the financial system involving the establishment of new institutions, mergers and liquidation of banks and divestiture of public sector shareholding in some of the banks.

(iv) The Capital Market

Under the FINSAP, Ghana's capital market was established in 1989. The Ghana Stock Exchange (GSE) began full operations in November 1990 with 12 listed companies and one Government bond. The GSE over the years had established itself as a profitable investment

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venture for the Ghanaian economy. There is no doubt that the Ghana Stock Exchange has the potential to attract long- term financing of investment in Ghana.

(v) Interest Rate Liberalization

Under the financial reform interest rates have been deregulated. This move was in part to encourage competition among the banks. But, the deregulation of the interest rate was also to conform to the new form of financial programming Ghana was following under the Structural Adjustment Programme (SAP).

3.2.1 Structure of the Ghana's Financial Sector

The Ghanaian financial system presently includes intermediaries such as deposit money banks, rural and community banks, insurance companies, discount houses, finance houses, leasing companies, savings and loans companies, credit unions, a stock exchange, stock brokerage houses and foreign exchange bureaux. The structure depicting hierarchically the Ghanaian financial industry is shown in Figure 5.

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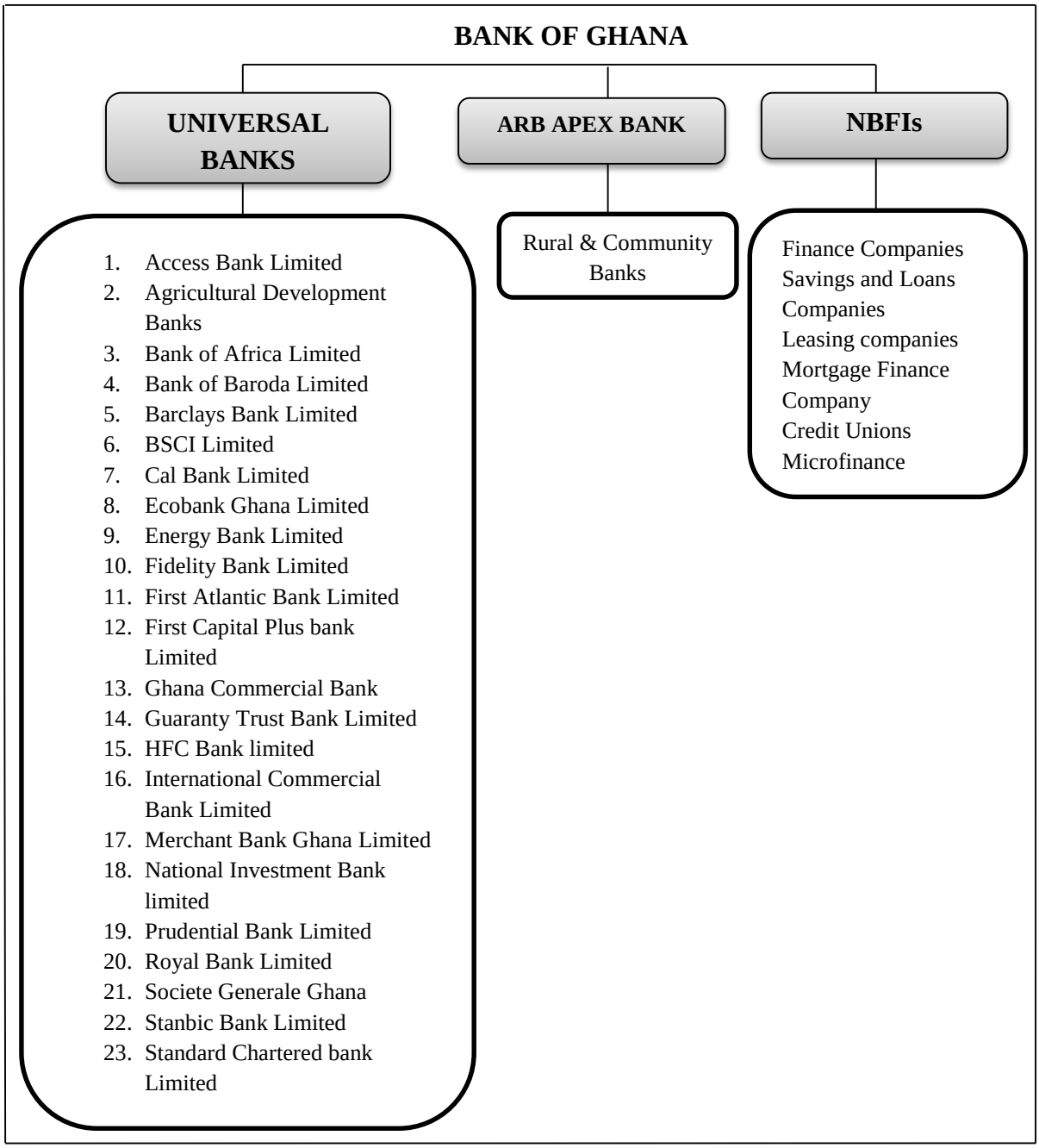

Figure 5: Structure of the Ghanaian Financial Institutions

Source: BoG , (2013)

Largely, the banking sector of developing economies exhibited poor performance which was a result of excessive central government regulation in place and to make them productive and efficient, deregulation of the sector was introduced (Kumbhakar & Sarkar, 2003). The Ghanaian financial sector has undergone many substantial changes such as liberalization and

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technological advances which have resulted in extensive restructuring (Kumi , Amoamah & Winful, 2013). This caused the industry to move from the severe distress and malfunctioning banking system, illiquidity and insolvency, interest rate controls and credit rationing to a market-based regime. Consequentially, the banking sector over the last decade has seen appreciable growth and improvements in performance as a result of reforms instituted by governments before this period. The reforms were aimed at improving the regulatory framework to gain increased efficiency or productivity and profitability.

Prior to the financial sector reforms 11 banks operated in the Ghanaian economy, this was made up of seven (7) local banks and four (4) foreign ones (Adjei & Chakravarty, 2012). The number of banks in the industry has dramatically increased with majority of them been foreign banks. Currently, as of December 2014, the total number of banks in Ghana is 27, of which 15 were foreign-owned and 9 were domestic privately-owned (PwC, 2014). Three of the banks remained as majority government ownership. Therefore, the liberalisation of the financial sector aimed at enhancing the soundness of the system through improved regulatory framework, increased efficiency funds mobilization, and strengthening competition and efficiency in the banking sector, had largely been improving the sector. According to the central bank, the reforms instituted have achieved significant success based on factors like more foreign banks entry into the industry. The financial sector reforms dating back to 1987, influenced the stable and robust nature of the Ghanaian financial system (AfDB , 2014). This is also evident in the global ranking of 62nd out of 144 countries in financial market development in the Global Index Report for 2014-2015 (Schawb, 2014). Despite, this improvement issues still remains, concerning the efficiency and productivity of the industry. Therefore, it is very important to assess the cost productivity of banks in Ghana to ascertain the impact of the various reforms on the productivity of the banking sector.

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Table 1: List of banks and Year of Incorporation

	Name of Bank	Year of Incorporation	Majority Ownership	Number of Branches (December, 2013)
1.	Access Bank Limited	2008	Foreign	39
2.	Agricultural Development Banks	1965	Local	78
3.	Bank of Africa Limited	1997	Foreign	19
4.	Bank of Baroda Limited	2007	Foreign	2
5.	Barclays Bank Limited	1917	Foreign	59
6.	BSCI Limited	2008	Foreign	15
7.	Cal Bank Limited	1990	Local	19
8.	Ecobank Ghana Limited	1990	Foreign	78
9.	Energy Bank Limited	2010	Foreign	7
10.	Fidelity Bank Limited	2006	Local	43
11.	First Atlantic Bank Limited	1994	Local	8
12.	First Capital Plus bank Limited	2013	Local	15
13.	Ghana Commercial Bank	1957	Local	158
14.	Guaranty Trust Bank Limited	2004	Foreign	28
15.	HFC Bank limited	1990	Local	28
16.	International Commercial Bank Limited	1996	Foreign	12
17.	Universal Merchant Bank Ghana Limited	1971	Local	22
18.	National Investment Bank limited	1963	Local	29
19.	Prudential Bank Limited	1993	Local	31
20.	Royal Bank Limited	2011	Foreign	11
21.	SGG Bank Limited	1975	Foreign	45
22.	Stanbic Bank Limited	1999	Foreign	26
23.	Standard Chartered Bank Limited	1896	Foreign	25
24.	The Trust Bank Limited	1996	Local	17
25.	UniBank Ghana Limited	1997	Local	22
26.	United Bank for Africa Ghana Limited	2004	Foreign	27
27.	UT Bank Limited	1995	Local	30
28.	Zenith Bank Limited	2005	Foreign	28

Source: PwC, (2014)

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CHAPTER FOUR

METHODOLOGY

4.0 Introduction

This chapter details the data collection approach and specific techniques adopted in the analysis. The chapter presents the research design, the data sources, sampling procedures as well as the techniques that helped address the objectives of the study. The chapter expatiates the technical details on the estimation of the Cost Malmquist Productivity Index (CMPI) using the assumptions of both the cost efficiency and the traditional Malmquist productivity change index of Fare et al. (1992; 1994). Basically, these methods are in line with a range of literature in management science, operations management and economics for evaluating the performance of homogenous organizations.

4.1 Research Design

This study employed quantitative approach which helps in explaining phenomena based on numerical data that are analysed using mathematically based methods (Aliaga & Gunderson, 2000). Similarly, quantitative research is referred to as an empirical investigation of phenomena by means of mathematical and statistical techniques (Creswell, 2009). This approach is selected for the study since the data is essentially numerical. Furthermore, the approach helped to assess the cost productivity of banks, and answer particular questions pertaining to the influences of exogenous factors on dynamic cost productivity. The quantitative model is relevant to this study since it has been a default tool for Operations Management Research for many years (Bertrand & Fransoo, 2002).

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4.2 Sampling and Sources of Data

The population of the study constitutes all universal banks in Ghana from the period 2000 to 2013. An unbalanced panel data was used for the study to reflect firms' specific heterogeneity. Additionally, the basic motivation for the unbalanced panel data hinges on the fact that there would be loss of information had the sample been restricted to a balanced panel. Despite the argument of entry and exit of banks which create a lot of missing data for periods, the banks were not in existence (Stiroh, 2000). It must be noted that, in the productivity analysis literature, the computation of the Malmquist index requires the comparison efficiency estimates between two time periods. Hence, some researchers have wrongly interpreted this to mean that the dataset must be a balanced panel at all cost, posited by Hollingsworth and Wildman (2003). This assumption result in the exclusion of some data points during the calculation of the Malmquist index and its components index in order to balance the dataset (Alam, 2001; Baležentis, 2012; Casu & Girardone, 2004a, 2004b, 2005; Casu et al., 2004; Maniadakis & Thanassoulis, 2004; Parteka & Wolszczak-Derlacz, 2013; Sathye, 2002; Simon, Simon, & Arias, 2011).

This study deviates from those studies that used balanced panel data by rather using unbalanced one. Consequently, all banks are included in the sample. But, the cost productivity indices and its components are just computed for those banks that have Data Envelopment Analysis (DEA) scores for two adjacent periods. Using an unbalanced panel data to estimate cost productivity indices is novel addition of the current study as many researchers, with the exception of Kerstens and Van de Woestyne (2014) and possibly, Mahlberg and Url (2010) and Matthews and Zhang (2010), tend to incorrectly only use balanced panel thereby sidestepping potentially valuable information that could help the analysis. Data on universal banks in Ghana was extracted from annual reports of banks and cross-validated by similar data from the bank of Ghana's research unit.

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4.3 Efficiency and Dynamic Productivity Analysis

4.3.1 Basics of Nonparametric Efficiency Measurement

Evaluating firms' performance is essential for the improvement of the performance of the industries in which the firms operate (Jahanshahloo, Mirdehghan & Vakili, 2011). The frontier methodological approach for the estimation of efficiency, dynamic technical productivity and dynamic cost productivity begun with the studies of Koopmans (1951), Debreu (1951), and Farrell (1957). Such efficiency and dynamic productivity techniques, irrespective of which type, proceeds by first identifying an efficient production or cost boundary from observed data set and then evaluating the efficiency or inefficiency of an observed decision making unit (DMU) relative to the boundary of the technical or cost technology set. The researcher can either use a parametric frontier method or a nonparametric frontier methodology (Berger & Humphrey, 1997; Cooper, Seiford, & Zhu, 2011; Daraio & Simar, 2007; Fried, Lovell, & Schmidt, 2008). Data Envelopment Analysis (DEA), developed as a mathematical programming-based approach by Charnes et al. (1978), and expanded by Banker, Charnes and Cooper (BCC) (1984) based on Farrell's (1957) work, assesses the relative efficiency of homogeneous DMUs employing multiple resources to produce multiple outcomes, relative to an efficient, or a "best practice" frontier which envelopes the observed units (Cooper et al., 2011).

4.3.2 Classical DEA-based Malmquist Index

Since the works of Koopmans (1951), Debreu (1951), Shephard (1953), Farrell (1957), Charnes et al. (1978) and Banker, Charnes and Cooper (1984) many extensions and applications of DEA have been pursued in the operations management via the productivity analysis literature. This includes the Malmquist Total Factor Productivity Index by Fare et al. (1992; 1994). As the basic DEA measures efficiency at a point in time (static), the Malmquist

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index was developed for a two-time period comparison of technical efficiency in terms of input-output levels. The productivity measurement is an index first proposed by Malmquist (1953) in the context of consumer theory and was adapted by Caves et al. (1982). The DEA Malmquist index has the merit of handling several inputs and outputs, with few assumptions and can be decomposed into efficiency change (catch-up) and technical change (frontier shift) components based on a constant returns to scale assumption.

To formalise the index, let us assume that for each time period $t:1,...,T$ and that N banks (*j=1, ...N*) at time t produce s non-negative outputs denoted by $(y=\in \Re_{+}^{s})$, using m non-negative inputs denoted by $(x \in \Re_{+}^{m})$, the technology set (input-output combination set) can be defined as:

$$L^{t} = \{(x^{t}, y^{t}) \in \Re_{+}^{m+s} \mid x^{t} \text{ can produce } y^{t}\} \tag{1}$$

The production technology set can be captured in terms of input distance function (Shepard , 1953) as:

$$D_{i}^{t}\left(x^{t}, y^{t}\right) = \sup_{\theta}\left\{\theta : \left(\frac{x^{t}}{\theta}\right) \in L^{t}\left(y^{t}\right), \theta > 0\right\} \tag{2}$$

Where D represent the technology set of the industry and the subscript i denotes input orientation and $L^{t}(y^{t})$ is the set of input vectors x^{t} which can secure the output vector y^{t}. Note that as the distance function implies the ratio of actual input to the input level on the frontier, according to Farrell (1957), input-oriented technical efficiency can be measured as: $0 \leq TE^{t}(x^{t}, y^{t}) = D^{t}(x^{t}, y^{t}) \leq 1.$

The input-distance based Malmquist index can be defined as the geometric mean of two input oriented Malmquist indices, one with period *t* as the reference period and another with period *t+1* as the reference period (Caves et al, 1982, Fare et al, 1992):

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$$MPI = \left[\frac{D_i^t\left(y^{t+1}, x^{t+1}\right)}{D_i^t\left(y^t, x^t\right)} \times \frac{D_i^{t+1}\left(y^{t+1}, x^{t+1}\right)}{D_i^{t+1}\left(y^t, x^t\right)} \right]^{1/2} \tag{3}$$

From the definition $0 \le TE^t(x^t, y^t) = D^t(x^t, y^t) \le 1$, and given the simpler interpretation of the reciprocal property, an $MPI < 1$, implies regress, $MPI > 1$ means the firm or the industry has experience productivity growth between *t* and *t+1* and an $MPI = 1$, means constant (or no) progress over the period.

4.3.2 Cost Efficiency

Despite the ability of the classical Malmquist index to account for time variability, it is biased towards cost. Since it does not consider the cost of the number of inputs for the level of output. The standard cost efficiency (CE) was pioneered by Farrell (1957) and Debreu (1951) was operationalized into nonparametric DEA by Färe et al. (1985) using linear programming problems to evaluate the ability of DMUs to produce the present outputs at minimal cost, given its input prices. For more information Sahoo, Mehdiloozad, and Tone (2014) is a good reference. From the standard technical efficiency equation which is;

$$TE_i^t(x^t, y^t) = \min_{\theta}\{\theta : (\theta\, x^t) \in L^t(y^t), \theta > 0\} \tag{4}$$

When input prices, $w^t \in \Re_+^m$, are obtainable, the cost efficiency technology may be defined in terms of the cost function:

$$C^t\left(x^t, y^t, w^t\right) = \min_{x^t}\{w^t, x^t : x^t \in L^t(y^t), w^t > 0\} \tag{5}$$

Where $w^t x^t \equiv \sum_{k=1}^{m} w_k^t x_k^t$ the subscript *k* denoting the kth input. The minimum cost is $C^t\left(y^t, x^t\right)$ for producing a fixed output vector y^t given the input w^t and period t technology. The set of input x^t corresponding to the scalar $C^t\left(y^t, x^t\right)$, lie on the isocost line which defines a cost boundary which is the locus of the input vectors that, given the technology and inputs prices, are capable of securing y^t C^tat the cost of (y^t, w^t) (Maniadakis & Thanassoulis, 2004). The

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cost boundary or isocost line, in Equation 3 encompasses the input vectors that can secure outputs, y^t at the cost of $C^t(y^t, x^t)$:

$$Iso\overline{C^t}(y^t, w^t) = \{x^t : w^t x^t = C^t(y^t, w^t)\} \tag{6}$$

Cost efficiency (CE) score or overall efficiency (OE) score is the combination or product of technical efficiency (TE) and allocative Efficiency (AE). It is the ability to produce current outputs at the minimal cost. The TE or managerial efficiency implies DMU's ability to generate maximum output from a fixed set of inputs (Fried et al., 2008). The Price or allocative efficiency (AE) deals with the DMU's ability to use inputs in optimal proportions given their respective prices (Farrell, 1957). For example, an AE value of 0.70 means that we could have saved 30% if funds were properly allocated towards a cheaper but sufficient input mix (Farrell, 1957). Note that crucial to the success of the use of CE is the assumption that prices of inputs are known and are fixed, even though it is an impossibility to have fixed price for inputs between DMUs. The least price of producing the current output can be obtained by solving the linear problem as formulated by Färe et al. (1985).

Following from our earlier definitions, equation 6 can be transformed using the transformation of Charnes and Cooper (1962) of fractional programming into cost efficiency under CRS for DMU_o and expressed as a linear programming problem:

$$\begin{aligned}
&C(y,w) = \min_{\lambda_j, x_k} \sum_{k=1}^{m} w_{ko} x_{ko} \\
&s.t \\
&\sum_{j=1}^{N} \lambda_j x_{kj} \le x_{ko} \qquad \forall k = 1,2,\ldots\ldots\ldots\ldots, m \\
&\sum_{j=1}^{N} \lambda_j y_{rj} \ge y_{ro} \qquad \forall k = 1,2,\ldots\ldots\ldots\ldots, s \\
&\lambda_j \ge 0; \quad j = 1,2\ldots\ldots\ldots\ldots, N
\end{aligned} \tag{7}$$

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In equation 7, w_{ko} is the price of input k for DMU_o under assessment, λ_j is a vector of constants or weights and is the intensity factor. x_{ko} is the input for any DMUs and y_{rj} is the output for any DMUs. x_{k0} is a value of input k to be used by DMU_0, so as to produce the current outputs at minimal cost denoted by the variable $w_k x_{ko}$. If C_0 is the total cost of the current input levels of DMU_0, then, CE or overall efficiency can be defined to be the ratio of minimum cost to observed cost (Farrell, 1957; Färe et al., 1985; Camanho & Dyson, 2008):

$$CE\left(y^t, x^t, w^t\right) = \frac{C^t\left(y^t, w^t\right)}{w^t x^t} = \frac{\sum_{k=1}^{m} w_{ko} x_{ko}^*}{\sum_{k=1}^{m} w_{ko} x_{ko}} \tag{8}$$

If CE<1, then production of output was due to excessive input usage (technical inefficiency) or this production occurred at the wrong input mix given input prices (allocative inefficiency), or both (Maniadakis & Thanassoulis, 2004). Consequently, the allocative efficiency (AE) is given by:

$$AE\left(y^t, x^t, w^t\right) = \frac{C\left(y^t, w^t\right) \times D_i^t\left(y^t, x^t\right)}{w^t x^t} \tag{9}$$

If $AE_i^t(y^t, x^t, w^t) = 1$

$$\Leftrightarrow OE_i^t(y^t, x^t, w^t) = TE_i^t(y^t, x^t) = 1/D_i^t(y^t, x^t).$$

4.3.3 Cost Malmquist Productivity Index

Early estimations of dynamic technical productivity ignored input prices and hence, allocative efficiency. The allocative efficiency has to do with how a technically efficient firm can further reduce aggregate cost of securing its outputs by selecting an optimal mix of inputs given their associated costs. Since allocative efficiency and its change can significantly affect dynamic productivity it should be factored into cost efficiency dynamics (Thanassoulis et al., 2015). Before, Bauer (1990) had followed Nishimizu and Page (1982) parametric stochastic frontier analysis (SFA) and decomposed total factor productivity change (TFP) into technical efficiency

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change, allocative efficiency change, technical change, price effect and scale economies effect. But Bauer's technique has been criticised by Balk (1998) and Maniadakis and Thanassoulis (2004) as demanding and practically unrealistic. As noted, the classical technical Malmquist productivity index of Fare et al., (1992, 1994) was proposed when inputs and output quantities, but not their prices, are available. Maniadakis and Thanassoulis (2000, 2004) extended the technical Malmquist index to cost Malmquist productivity index (CMPI) using nonparametric DEA models and decomposed it into cost (overall) efficiency change and cost technical change. The cost (overall) efficiency change can further be decomposed into technical efficiency change (TEC) and allocative efficiency change (AEC), both capturing cost whilst the cost technical change can be broken down into the standard technical change (TC) and price effect (TC). The CMPI is better defined in terms of cost rather than inputs distance functions or input efficiency scores and is useful when managers minimise costs give input price data.

To formalise the CMPI, following our definition of the cost function, when input prices, $w^t \in R_+^m$, are available in equation 8, the dual cost Malmquist productivity index in period *t* and period *t+1* and the geometric means are (Maniadakis & Thanassoulis, 2004):

$$CMPI^t = \left[\frac{w^t x^{t+1} / C^t(y^{t+1}, w^t)}{w^t x^t / C^t(y^t, w^t)} \right] \tag{10}$$

$$CMPI^{t+1} = \left[\frac{w^{t+1} x^{t+1} / C^{t+1}(y^{t+1}, w^{t+1})}{w^{t+1} x^t / C^{t+1}(y^t, w^{t+1})} \right] \tag{11}$$

$$CMPI = \left[\frac{w^t x^{t+1} / C^t(y^{t+1}, w^t)}{w^t x^t / C^t(y^t, w^t)} \times \frac{w^{t+1} x^{t+1} / C^{t+1}(y^{t+1}, w^{t+1})}{w^{t+1} x^t / C^{t+1}(y^t, w^{t+1})} \right]^{1/2} \tag{12}$$

where, $w^t y^t \equiv \sum_{k=1}^{m} w_k^t x_k^t$, *k* denotes the *k*-th input and $C^t(y^t, w^t)$ defined to be the minimum cost of producing a given output vector y^t given the prices w^t and the technology of period *t* with reference to constant returns to scale (CRS) technology. The cost $w^t x^t / C^t(y^t, w^t)$

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measures the extent to which the aggregate production cost in period t can be reduced while still securing the output y^t under the input price w^t. This ratio measures the distance between the observed/actual cost $w^t x^t$ and the cost boundary $C^t(y^t, w^t)$ (Maniadakis & Thanassoulis, 2004). The cost distance will have a minimum value of 1, (when the minimum cost is the same as the actual cost). This (cost) distance is the reciprocal of the input oriented measure of overall efficiency (Maniadakis & Thanassoulis, 2004). A CMPI index value less than 1 (CMPI< 1) implies productivity progress, a value greater than 1 (CPMI >1) implies a regress and a value of 1 (CPMI=1) indicates constant productivity. However, from the definition $0 \le TE_i^t(x^t, y^t) = D_i^t(x^t, y^t) = OE_i^t(x^t, y^t) \le 1$ where OE is overall (cost) efficiency, and given the simpler interpretation of the reciprocal property and duality, in this study, a CMPI<1 is interpreted as cost productivity regress, CMPI>1 cost productivity regress and CMPI=1 denotes constant cost productivity.

4.3.4 Decomposing the CMPI

The CMPI in equation 14 can be decomposed into other components in order to identify the sources or drivers of dynamic cost productivity for effective managerial policy prescriptions. Following Thanassoulis and Maniadakis (2004), the CMPI can first be decomposed into overall (cost) efficiency change (OEC) and cost-technical change (CTC):

$$CMPI = \underbrace{\left[\frac{w^{t+1}x^{t+1}/C^{t+1}(y^{t+1}, w^{t+1})}{w^t x^t / C^t(y^t, w^t)}\right]}_{OEC} \times \underbrace{\left[\frac{w^t x^{t+1}/C^t(y^{t+1}, w^t)}{w^t x^t / C^t(y^t, w^t)} \times \frac{w^{t+1}x^{t+1}/C^{t+1}(y^{t+1}, w^{t+1})}{w^{t+1}x^t / C^{t+1}(y^t, w^{t+1})}\right]}_{CTC}^{1/2} \quad (13)$$

The numerator and denominator of the OEC are the reciprocals of Farrell's overall (cost) efficiency in equation 8. It captures input OEC (or the catch-up effect in cost terms) between periods t and $t+1$. It can be seen as the own-period cost efficiency in period $t+1$ divided by the own-period cost efficiency in period t.

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The OEC indicates whether the production unit is "catching-up" the cost boundary by moving from period t to $t+1$. CTC estimates the cost frontier shift evaluated at the input mixes x^t and x^{t+1} and indicates process or product innovation. It captures the net effect of input price and technological dynamics and it does this by comparing the lowest cost of generating an output in period, say t, in relation to say period $t+1$ (Maniadakis & Thanassoulis, 2004). Ideally, a value of CTC <1 indicates a positive shift or technical progress, CTC >1 indicates negative shift or technological regress and CTC=1 indicates no shift in the cost frontier. But, given our reciprocal property and for easier and realistic explanation, in this study, a value of OEC or CTC<=>1 implies regress, stagnation and progress respectively. The two-factor decomposition of the CMPI (OEC and CTC) is will later be illustrated in terms of the distances.

The first stage decomposition of the CMPI in equation 13 can further be decomposed. The Overall Efficiency Change (OEC) can be decomposed into Technical Efficiency Change (TEC) and Allocative Efficiency Change (AEC) as:

$$OEC = \underbrace{\frac{D_i^{t+1}(y^{t+1}, x^{t+1}}{D_i^t(y^t, w^t)}}_{TEC} \times \underbrace{\frac{w^{t+1}x^{t+1}/(C^{t+1}(y^{t+1}, w^{t+1})D_i^{t+1}(y^{t+1}, x^{t+1}))}{w^t x^t/(C^t(y^t, w^t)D_i^t(y^t, x^t)}}_{AEC} \tag{14}$$

According to Fare et al. (1992, 1994) Malmquist index, the first component of equation 14 is termed "catch-up". It measures the input technical efficiency change between periods t and $t+1$. Similarly, the second component captures the input allocative efficiency or the optimum input-mix given the input prices in each period. Furthermore, similar to the shift in the production boundary in the decomposed MPI, the CTC in equation 13 captures the shift in the cost boundary. This shift may be caused either by shifts of the production boundary and/or by relative input price shifts. The CTC can be further decomposed as in equation 15:

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$$CTC = \underbrace{\left[\frac{D_i^t(y^{t+1},x^{t+1})}{D_i^{t+1}(y^{t+1},x^{t+1})}\frac{D_i^t(y^t,x^t)}{D_i^{t+1}(y^t,x^t)}\right]^{1/2}}_{TC} \times$$

$$\underbrace{\left[\frac{w^t x^t/(C^t(y^{t+1},w^t)D_i^t(y^{t+1},x^{t+1}))}{w^{t+1}x^{t+1}/(C^{t+1}(y^{t+1},w^{t+1})D_i^{t+1}(y^{t+1},x^{t+1}))} \times \frac{w^t x^t/(C^t(y^t,w^t)D_i^t(y^t,x^t))}{w^{t+1}x^t/(C^{t+1}(y^t,w^{t+1})D_i^{t+1}(y^t,x^t))}\right]}_{PE} \quad (15)$$

4.3.5 Computation of the Index and its Components

The input distance function and the cost distance function can be computed using either parametric approach like SFA or nonparametric, mathematical programming-based method like DEA. DEA simply estimates the production possibility set (PPS) by laying a convex hull around the empirically available input-output combinations of the different observed DMUs. The decisive components of the various indices are the input distance function $D_i^t(x^t,y^t)$ and the cost function $C^t(y^t,w^t)$ which depend on the isoquant and the isocost respectively. To formalise the CMPI using DEA linear programming problems, suppose that each time period $t:1,...,T$ has production units $j=1,.....,N$. In period t, DMU_o^t employs inputs amount, $x_{ko}^t(k=1,.....,m)$ available at prices w_{ko}^t and produces $y_{ro}^t(r=1,.....,s)$. For unit O, the cost of securing its output is denoted by $w^t y^t \equiv \sum_{k=1}^{m} w_{ko}^t x_{ko}^t$. Similarly, the actual costs denoted by $w^{t+1}x^{t+1}, w^{t+1}x^t$ and $w^t x^{t+1}$ are respectively $\sum_{k=1}^{m} w_{ko}^{t+1}x_{ko}^{t+1}$, $\sum_{k=1}^{m} w_{ko}^{t+1}x_{ko}^t$ and $\sum_{k=1}^{m} w_{ko}^t x_{ko}^{t+1}$. For DMU_o^t the minimum cost $C^t(y^t,w^t)$ can be computed using the models such as:

$$C^t(y^t,w^t) = \min_{\lambda_j x_k} w_{ko}^t x_k,$$

s.t

$$\sum_{j=1}^{N} \lambda_j x_{kj}^t \le x_k, \qquad \forall k=1,.....,m, \quad (16)$$

$$\sum_{j=1}^{N} \lambda_j y_{rj}^t \ge y_{ro}^t \qquad \forall r=1,.....,s,$$

$$\lambda_j \ge 0, \qquad x_k \ge 0, \qquad j=1,.....,N$$

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In the equation 16 w_{ko}^{t} is the price of input k for DMU_0 at time t. From equation 13, the cross-period cost relative to output in the next period $C^t(y^{t+1}, w^t)$ is computed when the time period is $t+1$ in y_{rj}^{t}, (this means using period $t+1$ output levels for DMU_0^{t+1}. The constraints and prices remain as they are, using period t data. The model uses CRS technology-based index measure, implying that banks are able to scale their inputs and outputs linearly, since the variable return to scale (VRS) provides a bias measure of productivity change in the presence of decreasing return to scale or increasing return to scale when there is productivity growth or decline respectively (Grifell-Tatjé & Lovell, 1995). The motivation for the CRS measure is the reliability or accuracy of the productivity regardless of the true form of the technology (CRS) (Färe, Grosskopf & Norris, 1997; Färe & Grosskopf, 1994; Ray & Delsi, 1997). The term $C^t(y^{t+1}, w^t)$ can be computed as:

$$
\begin{aligned}
& C^t(y^{t+1}, w^t) = \min_{\lambda_j x_k} w_{ko}^{t} x_k, \\
& \text{s.t} \\
& \sum_{j=1}^{N} \lambda_j x_{kj}^{t} \le x_k, \qquad \forall k = 1,.....,m, \\
& \sum_{j=1}^{N} \lambda_j y_{rj}^{t} \ge y_{ro}^{t+1} \qquad \forall r = 1,.....,s, \\
& \lambda_j \ge 0, \qquad x_k \ge 0, \qquad j = 1,.....,N
\end{aligned}
\tag{17}
$$

The own-period cost efficiency, $C^{t+1}(y^{t+1}, w^{t+1})$ and mixed-period cost efficiency, $C^{t+1}(y^t, w^{t+1})$ can be computed using the two previous equations 15 and 16, after the changes in time periods from t to $t+1$. To decompose the CMPI, we compute the distance functions as shown by Färe et al (1989, 1992, 1994). The input-oriented (*i*) distance functions of a particular *DMU O* are estimated relative to the CRS technology frontiers, which can be formulated as a Linear programming problem (LPP).

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The own-period input efficiency score or input distance function is:

$$\begin{aligned}
&\left[D_i^t(y^t, x^t)\right]^{-1} = \min_{\lambda,\theta} \theta \\
&s.t \\
&\sum_{j=1}^{N} \lambda_j x_{kj}^t \le \theta x_{ko}^t, \qquad \forall k = 1,.....,m, \\
&\sum_{j=1}^{N} \lambda_j y_{rj}^t \ge y_r^t \qquad \forall r = 1,.....,s, \\
&\lambda_j \ge 0, \quad \theta \text{ is free}, \quad j = 1,.....,N
\end{aligned} \tag{18}$$

The input distance function for own-period $t+1$, is also as follow:

$$\begin{aligned}
&\left[D_i^t(y^{t+1}, x^{t+1})\right]^{-1} = \min_{\lambda,\theta} \theta \\
&s.t \\
&\sum_{j=1}^{N} \lambda_j x_{kj}^t \le \theta x_k^{t+1}, \qquad \forall k = 1,.....,m, \\
&\sum_{j=1}^{N} \lambda_j y_{rj}^t \ge y_{ro}^{t+1} \qquad \forall r = 1,.....,s, \\
&\lambda_j \ge 0, \quad \theta \text{ is free}, \quad j = 1,.....,N
\end{aligned} \tag{19}$$

$D_i^{t+1}(y^{t+1}, x^{t+1})$ and $D_i^{t+1}(y^t, x^t)$ can be computed using equations 18 and 19 respectively, after changing round the time periods from t to $t+1$.

4.3.5.1 Simple Numerical Example

The proposed CMPI approach of Maniadakis and Thanassoulis (2004) is illustrated using simple numerical example. Suppose 4 DMUs A_0, B_0, C_0, and D_0, and A_1, B_1, C_1, and D_1, are the same banks in two different time periods. In both periods, each bank uses two inputs (deposits = $x1$ and labour = $x2$) to produce one output (Loans $y1$), given the price of the inputs ($w1$ as average interest expense and $w2$ as average personnel expense). For an easy illustration it is assumed that input prices in each period are the same. The data is graphed in Figure 3 to show the dynamic of time A_o, B_o, C_o, D_o in period 0 or time t and A_1, B_1, C_1, D_1 in period 1 or time $t+1$.

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Table 2: Hypothetical Data of Banks in Ghana

NO	DMU	x1	x2	y	w1	w2
1	A_0	4	4	1	4	4
2	B_0	6	3	1	4	4
3	C_0	3	6	1	4	4
4	D_0	6	5	1	4	4
1	A_1	5	1	1	4	4
2	B_1	1	6	1	4	4
3	C_1	2	3	1	4	4
4	D_1	3	2	1	4	4

In Figure 7, A_o, B_o, C_o *and* D_o is the production technology set in period 0 or time t and A_1, B_1, C_1 *and* D_1 is the production technology set in period 1or time $t+1$. The cost boundary is represented by $isoC^t(y^t, w^t)$ in period t and by $isoC^{t+1}(y^{t+1}, w^{t+1})$ in period $t+1$.

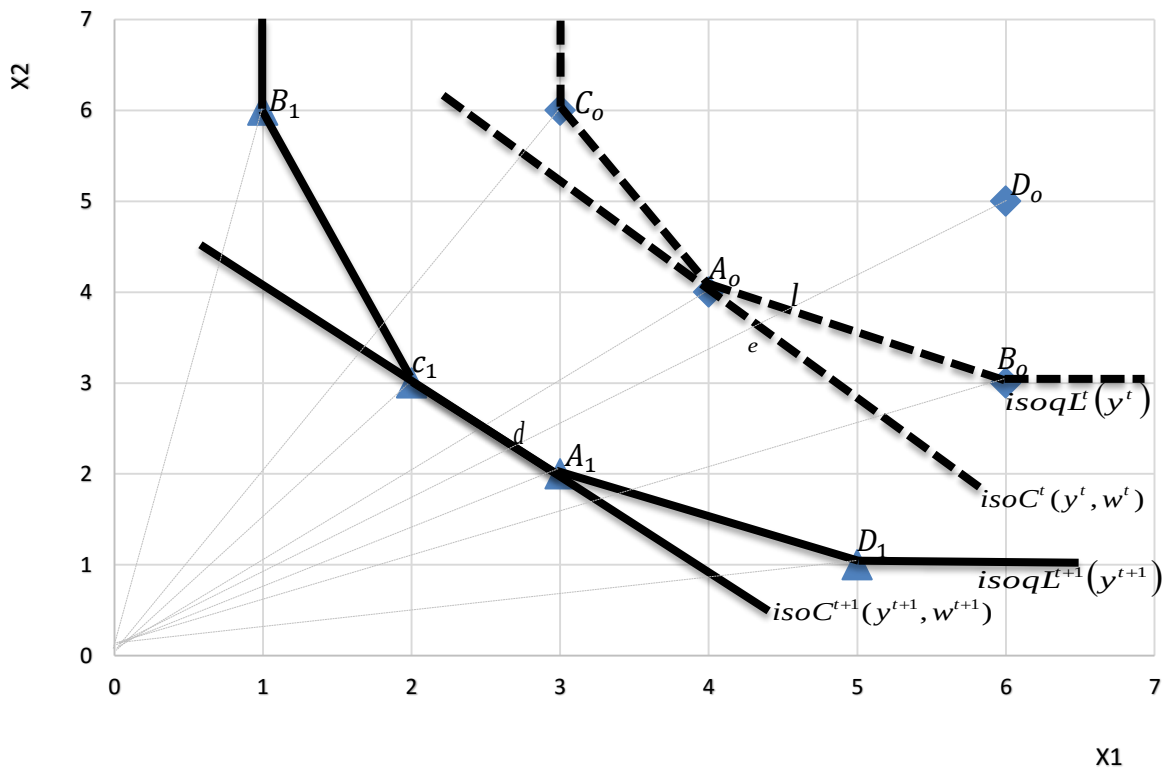

Figure 6: Illustration of Cost Malmquist Productivity Index

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Notice that, firms in period t are A_o, B_o, C_o *and* D_o , are the same firms in period $t+1$, are represented by A_1, B_1, C_1 *and* D_1. We now proceed to show the computational process of the CMPI for banks A and D with respect to some units as follows:

$$CMPI = \left[\frac{w^t x^{t+1} / C^t(y^{t+1}, w^t)}{w^t x^t / C^t(y^t, w^t)} \times \frac{w^{t+1} x^{t+1} / C^{t+1}(y^{t+1}, w^{t+1})}{w^{t+1} x^t / C^{t+1}(y^t, w^{t+1})} \right]^{1/2}$$

Estimating CMPI for the firms $(A_o \text{ and } A_1)$, noting that the denominator is the minimum/lowest cost among the list of costs in that year:

Own Period Cost Efficiency

$$A_0 = \frac{w^0 x^0}{C^0(y^0, w^0)} = \frac{(4\times 4)+(4\times 4)}{32} = \frac{32}{32} = 1.00$$

$$A_1 = \frac{w^1 x^1}{C^1(y^1, w^1)} = \frac{(5\times 4)+(1\times 4)}{20} = \frac{24}{20} = 1.20$$

Cross-Period Cost Efficiency

$$A_0 = \frac{w^0 x^1}{C^0(y^1, w^0)} = \frac{(4\times 5)+(4\times 1)}{32} = \frac{24}{32} = 0.75$$

$$A_1 = \frac{w^1 x^0}{C^1(y^0, w^1)} = \frac{(4\times 4)+(4\times 4)}{20} = \frac{32}{20} = 1.60$$

$$CM^t = \left[\frac{w^t x^{t+1} / C^t(y^{t+1}, w^t)}{w^t x^t / C^t(y^t, w^t)} \right] = \left[\frac{w^0 x^1 / C^0(y^1, w^0)}{w^0 x^0 / C^0(y^0, w^0)} \right] = \left[\frac{0.75}{1} \right] = 0.75$$

$$CM^{t+1} = \left[\frac{w^{t+1} x^{t+1} / C^{t+1}(y^{t+1}, w^{t+1})}{w^{t+1} x^t / C^{t+1}(y^t, w^{t+1})} \right] = \left[\frac{w^1 x^1 / C^1(y^1, w^1)}{w^1 x^0 / C^1(y^0, w^1)} \right] = \left[\frac{1.20}{1.60} \right] = 0.75$$

$$CMPI = \left[\frac{w^t x^{t+1} / C^t(y^{t+1}, w^t)}{w^t x^t / C^t(y^t, w^t)} \times \frac{w^{t+1} x^{t+1} / C^{t+1}(y^{t+1}, w^{t+1})}{w^{t+1} x^t / C^{t+1}(y^t, w^{t+1})} \right]^{1/2} = [0.75 \times 0.75]^{1/2} = 0.75$$

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First stage decomposition of CMPI as proposed by Maniadakis and Thanassoulis (2004), into OEC and CTC:

$$CMPI = \underbrace{\left[\frac{w^{t+1}x^{t+1}/C^{t+1}(y^{t+1},w^{t+1})}{w^{t}x^{t}/C^{t}(y^{t},w^{t})}\right]}_{OEC} \times \underbrace{\left[\frac{w^{t}\,x^{t+1}/C^{t}(y^{t+1},w^{t})}{w^{t}x^{t}/C^{t}(y^{t},w^{t})} \times \frac{w^{t+1}x^{t+1}/C^{t+1}(y^{t+1},w^{t+1})}{w^{t+1}x^{t}/C^{t+1}(y^{t},w^{t+1})}\right]^{1/2}}_{CTC}$$

$$CMPI = \underbrace{\left[\frac{1.2}{1}\right]}_{OEC} \times \underbrace{\left[\frac{0.75}{1.2} \times \frac{1}{1.6}\right]^{1/2}}_{CTC} = \underbrace{1.2}_{0EC} \times \underbrace{[0.625 \times 0.625]^{1/2}}_{CTC}$$

$$= \underbrace{1.2}_{OEC} \times \underbrace{[0.391]^{1/2}}_{CTC} = \underbrace{1.2}_{0EC} \times \underbrace{0.625}_{CTC} = 0.75$$

$OEC_A = 1.2,\quad CTC_A = 0.625$ and $CMPI_A = 0.75$

Estimating CMPI for the firms $(D_o \text{ and } D_1)$

Own-Period Cost Efficiency

$$D_0 = \frac{w^0x^0}{C^0(y^0,w^0)} = \frac{(4\times6)+(4\times5)}{32} = \frac{44}{32} = 1.378$$

$$D_1 = \frac{w^1x^1}{C^1(y^1,w^1)} = \frac{(4\times3)+(4\times2)}{20} = \frac{20}{20} = 1.00$$

Cross-Period Cost Efficiency

$$D_0 = \frac{w^0x^1}{C^0(y^1,w^0)} = \frac{(4\times3)+(4\times2)}{32} = \frac{20}{32} = 0.625$$

$$D_1 = \frac{w^1x^0}{C^1(y^0,w^1)} = \frac{(4\times6)+(4\times5)}{20} = \frac{44}{20} = 2.20$$

$$CM^{t} = \left[\frac{w^{t}\,x^{t+1}/C^{t}(y^{t+1},w^{t})}{w^{t}x^{t}/C^{t}(y^{t},w^{t})}\right] = \left[\frac{w^0x^1/C^0(y^1,w^0)}{w^0x^0/C^0(y^0,w^0)}\right] = \left[\frac{0.625}{1.375}\right] = 0.455$$

$$CM^{t+1} = \left[\frac{w^{t+1}\,x^{t+1}/C^{t+1}(y^{t+1},w^{t+1})}{w^{t+1}x^{t}/C^{t+1}(y^{t},w^{t+1})}\right] = \left[\frac{w^1x^1/C^1(y^1,w^1)}{w^1x^0/C^1(y^0,w^1)}\right] = \left[\frac{1.00}{2.20}\right] = 0.455$$

$$CMPI = \left[\frac{w^{t}\,x^{t+1}/C^{t}(y^{t+1},w^{t})}{w^{t}x^{t}/C^{t}(y^{t},w^{t})} \times \frac{w^{t+1}x^{t+1}/C^{t+1}(y^{t+1},w^{t+1})}{w^{t+1}x^{t}/C^{t+1}(y^{t},w^{t+1})}\right]^{1/2} = [0.455\times0.455]^{1/2} = 0.455$$

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First decomposition of DMUD Cost Malmquist Productivity Index (CMPI)

$$CMPI = \underbrace{\left[\frac{w^{t+1}x^{t+1}/C^{t+1}(y^{t+1},w^{t+1})}{w^{t}x^{t}/C^{t}(y^{t},w^{t})}\right]}_{OEC} \times \underbrace{\left[\frac{w^{t}\,x^{t+1}/C^{t}(y^{t+1},w^{t})}{w^{t}x^{t}/C^{t}(y^{t},w^{t})} \times \frac{w^{t+1}x^{t+1}/C^{t+1}(y^{t+1},w^{t+1})}{w^{t+1}x^{t}/C^{t+1}(y^{t},w^{t+1})}\right]^{1/2}}_{CTC}$$

$$CMPI_D = \underbrace{\left[\frac{1.00}{1.375}\right]}_{OEC} \times \underbrace{\left[\frac{0.625}{1.00} \times \frac{1.375}{1.6}\right]^{1/2}}_{CTC} = \underbrace{1.2}_{0EC} \times [0.625 \times 0.625]^{1/2}$$

$$= \underbrace{0.727}_{OEC} \times \underbrace{[0.391]^{1/2}}_{CTC} = \underbrace{1.2}_{0EC} \times \underbrace{0.625}_{CTC} = 0.454$$

$OEC_D = 0.727,\quad CTC_D = 0.625$ and $CMPI_D = 0.454$

Table 3: Manual Computation of CMPI for Hypothetical DMUs A and D

DMU	OEC	CTC	CMPI=(OEC*CTC)	Reciprocal of CMPI
A	1.2	0.625	**0.750**	**1/0.750=1.333**
D	0.727	0.625	**0.454**	**1/0.454=2.203**

From Table 3, DMU_A progressed on cost productivity by $[(1.333-1)\times 100\% = 33.33\%]$, which is attributable to cost technological change/progress of $[(1-0.625)\times 100\% = 37.5\%]$. It is worth noting that DMU_A regressed on overall efficiency change (OEC) by 20%; $[(1-1.2)\times 100\% = -20\%]$. The DMU_D progressed more within the period with a growth of 120.3%; $[(2.203-1.000)\times 100\% = 120.3\%]$. The growth is attributable to growth in OEC and CTC are $OEC = [(1-0.727)\times 100\% = 27.3\%]$ and $CTC = [(1-0.625)\times 100\% = 37.5\%]$.

Using the R version 2.14.0 and the MaxDEA Pro 6.4b for the data sample, the cost Malmquist have been computed for the four (4) DMUs for the two time period. For the manual calculation the cost Malmquist was estimated for DMUs A and B.

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Table 4: Cost Malmquist Second Stage Decompositions of Sample data

DMU	CMPI	MPI	ΔAE	ΔPE	ΔTE	ΔT
A	**0.750**	**0.456**	**1.200**	**1.369**	**1.000**	**0.456**
B	0.778	0.441	1.244	1.417	1.000	0.441
C	0.556	0.592	0.889	1.056	1.000	0.592
D	**0.455**	**0.446**	**0.970**	**1.051**	**0.750**	**0.595**

Table 5: Reciprocal of Cost Malmquist Second Stage Decompositions

DMU	CMPI	MPI	ΔAE	ΔPE	ΔTE	ΔT
A	**1.333**	**2.193**	**0.833**	**0.730**	**1.000**	**2.193**
B	1.285	2.268	0.804	0.706	1.000	2.268
C	1.799	1.689	1.125	0.947	1.000	1.689
D	**2.198**	**2.242**	**1.031**	**0.951**	**1.333**	**1.681**

Table 4 depicts the computation of the second stage decomposition of the CMPI from the overall efficiency change (OEC) and cost technical change (CTC). The OEC is further decomposed into technical efficiency change (TEC) and allocative efficiency change (AEC). Furthermore, the CTC is decomposed into technical change (TC) and price effect (PE). From the four-factor decomposition, the growth (33.33%) in the CMPI of DMU A, is attributable to technical change only within the two period. In the case of DMU D, the CMPI growth of 119.8% is based on the contributions of AEC (3.1%), TEC (33.33%) and TC (68.1%). The contribution of the allocative efficiency change make the computation of the cost Malmquist index very important in assessing the productivity of firms.

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4.6 Inputs and outputs

Generally, two approaches (production approach and intermediation approach) are employed to determine the efficiencies of banks (Berger & Humphrey, 1997; Colwell & Davis, 1992). The production approach considers deposits and loans as outputs using purchased funds with a number of accounts and transactions on them critical to the selection of inputs (Mester, 1987, 1997). The major difficulty with this approach is the inability of banks to give adequate transactions information of the banks which is important in determining some inputs (Berger & Humphrey, 1997). Furthermore, this approach is limited in productivity analysis (Colwell & Davis, 1992). However, a number of studies exist when it comes to static cost efficiency (Athanassopoulos, 1997; Camanho & Dyson, 1999; Giokas, 2008; Vassiloglou & Giokas, 1990). The intermediation approach as the name suggests, considers banks as offering financial intermediation in mobilizing funds from surplus units and transforming them into loans for the deficit units for investments (Berger & Humphrey, 1997). This approach measures outputs and inputs in monetary terms to help access the economic viability of banks. The approach has been widely used in many efficiency studies (Carvallo & Kasman, 2005; Rezitis, 2006, 2008; Tortosa-Ausina et al. 2008).

This study follows the argument of Berger and Humphrey (1997) and selects the intermediation approach of Sealey and Lindley (1977) well suited for bank level efficiency or productivity analysis as compared to the production approach for bank branch analysis (Chen, Skully, & Brown, 2005). Furthermore, the intermediation approach recognizes the intermediary role of banks as accepting deposits (input) to produce outputs (loans and advances) (Mukherjee et al., 2001; Sealey & Lindley, 1977).The intermediation approach considers the role of a bank as financial intermediary that take deposits and transforms them with the factors of production (labour and fixed assets) into loans and other earnings assets (Sealey & Lindley, 1977). These inform the use of loans, investment in securities, and other earnings by the banks over the

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period as outputs, whereas number of employees, interest expenses and fixed assets as inputs variables. Three prices are used: the price of labour, the price of purchased funds, and the price of physical capital. The price of labour is calculated as the ratio between personnel expenses and total assets (TA). The price of capital is given by operating costs net of personnel expenses over fixed assets. The price of funds is calculated by dividing total interest expenses by total deposits.

Table 6: Summary Description of Inputs and Outputs

Variables	Definition	Description	Empirical Application
Outputs			Bokpin (2013); Delis, Koutsomanoli-Fillipaki, Staikouras, and Katerina (2009); Fu and Heffernan (2007); Ray and Das (2010); (Rezitis, 2006); Tortosa-Ausina (2004); Tortosa-Ausina et al. (2008);
Y_1	Loans	Total loans and Advances	
Y_2	Investments	Securities and Money Market Investments	
Input Levels			Bokpin (2013); Carvallo and Kasman (2005); Fu and Heffernan (2007); Grifell-Tatjé and Lovell (1997); Isik and Hassan (2003); Ray and Das (2010); Rezitis (2006); Tortosa-Ausina (2004); Tortosa-Ausina et al. (2008)
X_1	Deposits	Total deposits for banks	
X_2	Labour	Staff Cost	
X_3	Fixed-Assets	Balance sheet Fixed Assets	
Input Price			
W_1	Price of Labour	Personnel Expenses/Total Assets	Chang et al. (2012); Fu and Heffernan (2007); Murillo-Melchor et al. (2009); Ray and Das (2010)
W_2	Price of Purchased Funds	Total Interest/Total Deposits	
W_3	Price of Physical Capital	Other Operating Cost/Fixed Assets	

4.6.1 Outputs, Inputs and Inputs Prices

The objective of operations managers to minimizing operating expenses as a result of competitive advantage strategy is deeply rooted in the intermediation approach to determining efficiencies or productivity (Sathye, 2003).

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i) Inputs

This criterion considers activities that yield flow of banking services associated with substantial inputs such as deposits $(x1)$ labour $(x2)$ and physical capital expenditure $(x3)$ .These are very essential in the intermediates activities of the banks.

a) ***Deposits*** is mobilized by the banks are other key inputs. Critical to the banks survival are deposits, which are transformed into outputs which generate revenue for the banks. Therefore the bank's objective is to mobilize more deposits at cheaper cost and transform same as loans and investments.

b) ***Labour*** is commonly considered as a resource to the production of an output. Labour is represented by the cost of labour. This adequately captures the values of the labour as input.

c) ***Physical Inputs*** are used by the banks and these funds are mobilized with the labour and physical capital. Therefore, physical capital expenditure in another input used by banks.

ii) Outputs

The study used two outputs namely loans and advances $(y1)$ and investment in securities $(y2)$. The selection of these variables follows similar approach by Rezitis (2006); Fu and Heffernam (2007); Tortosa-Ausina et al, (2008); Delis & Tsionas (2009) and Ray and Das (2010); Bokpin (2013). These variables were selected in line with the intermediaries approach to efficiencies and productivity of banks.

a) Loans and advances: as a measure of the monetary value of the aggregate of corporate, commercial loans and individual loans.

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b) Investment: All deposits mobilized are not given out as loans. Some are invested in securities to yield extra income for the banks. Therefore, this study used investment as output which banks have the objective of maximizing.

iii) Inputs Prices

This study used three inputs, namely staff expenses, bank deposits, and fixed assets. They attracted prices such as finance input (deposits) $(w1)$, labour expenses or staff costs $(w2)$ and physical input $(w3)$ (Fu & Heffernan, 2007; Ray & Das, 2010). These prices are the shadow prices of securing the various inputs for banks operations. Therefore, average price of interest on deposit for a bank is obtained as the ratio of interest expense to total deposits for a bank within a year.

4.7 Empirical Model

4.7.1 Second-Stage Analysis

After estimating the dynamic cost productivity indices, it is important to assess the effect of key exogenous factors (uncontrollable covariates) believed to be outside management control, but can affect the dynamic cost productivity estimates (Fried, Lovell, Schmidt, & Yaisawarng, 2002). This analysis is usually termed, the two-stage, semi-parametric process, in which the stage-one dynamic cost productivity indices are regressed on some environmental variables (Athanasoglou et al., 2008; Avkiran, 2009; Drake, Hall, & Simper, 2006; Mukherjee et al., 2001; Nakane & Weintraub, 2005; Rezitis, 2006; Simar & Wilson, 2011; Simar & Wilson, 2007).These stage-two independent variables are assumed to have *a priori* theoretical link with the productivity estimates obtained in the first stage. Simar and Wilson (2007) argued that the stage-one DEA estimates are dependent on the inputs and outputs used for the stage-one analysis in a convoluted and strange way (in a statistical sense). Simar and Wilson (2007)

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indicated that this serial correlation first-stage meant that the random noise term of the Tobit regression is also dependent on the contextual variables which makes the use of Tobit model inappropriate. In effect, inferences based on the second-stage regression estimates are inconsistent and biased. To cope with the inconsistencies, Hirschberg and Lloyd (2002); Xue and Harker (1999) proposed a single bootstrap approach to handle the dependency issue, an approach that was empirically applied by Casu and Molyneux (2003). However, Simar and Wilson (2007) critiqued the "naive" bootstrap method because it resamples without accounting for the peculiar distributions of efficiency scores and the fact that they are bounded between zero and one. Consequently, Simar and Wilson (2007) suggested the use of a bias-corrected efficiency estimate in the second-stage regression in order to increase the statistical accuracy of the regression estimates and improve the coverage of their estimated confidence intervals. Simar and Wilson (2007, 2011) provided a coherent, well-defined statistical model where truncated regression yields consistent estimates instead of OLS or Tobit models. Their double-bootstrap approach to construct left-truncated bias-corrected DEA estimates is to allow valid inferences and improve statistical efficiency of the second-stage estimates. Detailed information on the algorithm of the second stage can be found in Simar and Wilson (2011); Simar and Wilson (2007).

The study thus used the innovative bootstrapped truncated regression proposed by Simar and Wilson (2007). As mentioned earlier, and explained in Table 7, the second-stage variables include competition, size, total assets, GDP, inflation, policy rate, treasury bill rate, capitalization, universal banking license and ownership types.

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Table 7: Description of Variables in the Regression Model

Variable	Description	Measure
CMPI	Cost Productivity Indices for banks	Results from 1st stage CMPI used as the regressand
COMP	Herfindhal-Hirshman Index (HHI) for Loans and Advances	Competition in the Ghanaian Banking industry in Relation to total loans given
Size	Log of banks total assets	The Log of total assets of individual banks
GDP	Annual Growth Rate of the Ghanaian economy	The second year GDP for two time periods
INF	Annual Inflation Rate between the periods of the study.	The second year annual inflation rate.
PR	Policy Rate	The second year Bank of Ghana policy rate between two time period
TBILL	Treasury Bill Rate	The second year rate of treasure bill.
CAP	Banks Listed on the Stock Exchange	Capitalization Dummy (Listed banks =1 and non-listed banks = 0)
OWN	Foreign ownership	Ownership Dummy (Foreign banks =1 and Local banks = 0)
UBBL	Period of the introduction of Universal Banking Business License	License Dummy (Period before the introduction of the license=0 and period after=1)

The specified truncated regression model is given by;

$$CMPI_{i,t} = \beta_o + \beta_1 COMP_t + \beta_2 SIZE_{i,t} + \beta_3 GDP_t + \beta_4 INF_t + \beta_5 PR_t + \beta_6 TBILL_t + \beta_7 CAP_i + \beta_8 OWN_i + \beta_9 UBBL_t + \varepsilon_{i,t} \quad (20)$$

4.7.2 Bank Characteristics

4.7.2.1 Measuring Bank Competition

The establishment of the influence of competition is important for the determination of the level of industry competition (Casu & Girardone, 2009). Herfindhal-Hirshman Index (HHI) is commonly used to determine the level of competition (Campello, 2003). However, besides the HHI, this study used the innovative Boone Indicator (BI) that measures competition from the behaviour of the market (Boone et al., 2005).These two measures of competition are used for the purposes of "methodological cross-checking" (Charnes, Cooper, & Sueyoshi, 1988), that may have some policy implications for the Ghanaian banking industry.

Following Beiner, Schmid, and Wanzenried (2011), the HHI was computed as the sum of the squared market shares of each bank. HHI accounts for the number of firms present in a market,

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by taken into account the relative size (market share relative to loans, deposits and total assets) and this is given by (Rhoades, 1993):

$$HHI_{j,t} = \sum_{i=1}^{N,J} \left(\frac{Sales_{i,j,t}}{\sum_{i=1}^{N,J} Sales_{i,j,t}} \right)^2 \tag{21}$$

Where S_i is the market share of the i-th firm in the market and N is the number of firms in the market. This study considered share of deposits, total loans and total assets of the industry to determine the most promising variable to infer adequate competition. For the interpretation of HHI, an index below 0.01 or 100 indicates a highly competitive environment, an index below 0.15 or 1,500 indicates an industry that is not concentrated, an index between 0.15 to 0.25 or 1,500 to 2,500 indicates moderate concentration and above 0.25 or 2,500 indicates high concentration.

The Boone Indicator (BI) is premised on the idea that, given two firms in an industry, where one firm is efficient (has a lower marginal cost) and the other is inefficient, with an increase in competition in this industry, the profits of the more efficient firm will increase relative to that of the inefficient firm (Boone, 2000). The Boone indicator is estimated using the regression, following svan Leuvensteijn, Bikker, van Rixtel, and Sørensen (2010) as:

$$\ln s_i = \alpha + \beta_t \ln Mc_{ij} \tag{22}$$

From equation 22, lns_i is the natural logarithm of the market share of bank i, $lnMc_{ij}$ is natural logarithm of the marginal cost of bank i in industry j and β_t is a time varying parameter with its absolute value determining the degree of competition.

4.7.2.2 Bank-and-industry-specific variables

The variable $COMP_t$ is used to proxy competition. It reflects market concentration for the year t and is defined as the sum of the squares of the share of deposits, loans and advances and total

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assets of each bank in the market. A highly concentrated banking sector promotes less competition and creates the incentive for inefficiency. Therefore, a negative coefficient for this variable is expected. The variable $SIZE_{it}$ is measured by the natural log of total assets of bank i in the year t. This variable is seen as key determining factor which accounts for differences in the cost Malmquist productivity change index attributable to the size effect (economies and diseconomies of scale). A positive coefficient implies economy of scale and a negative, diseconomies of scale. The next variable is capitalization represented by CAP_i. This is a dummy variable denoted by 1 if a bank is listed in the Ghana Stock Exchange or 0 if it is not listed. Listed banks are expected to benefit from public funds which are expected to come at a cheaper cost thereby making them experience a higher dynamic cost productivity. Another variable is ownership structure of bank i represented by OWN_i which is a dummy variable which equals 1 if the bank is a foreign bank or 0 if it is a domestic bank. Some studies argue that foreign banks are more efficient than local domestic banks due to some managerial and technological advantage (Bonin et al., 2005; Jemric & Vujcic, 2002; Koutsomanoli-Filippaki et al., 2009; Lin & Zhang, 2009; Sturm & Williams, 2004; Yudaeva, Kozlov, Melentieva, & Ponomareva, 2003). The outcome of this variable should be a positive sign. The Universal Banking Business License was represented by $UBBL_t$. The introduction of the license is supposed to make banks efficient to enable them compete favourably (PwC, 2015). This variable is a dummy. Periods prior to the introduction of the license takes the value of 0 and post introduction take a value of 1.

4.7.2.3 Economic and Market Condition

GDP_t is used to proxy growth rate**.** The rate of growth is measured at a time period say, *t*. A higher economic growth encourages banks to lend more and charge higher interest and potentially improve their assets quality since the demand for money is likely to increase. Conversely, as GDP declines, credit quality tends to deteriorate and loan default rates increase.

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The higher growth rate is expected to have a positive influence on bank dynamic cost productivity. Studies that employ this GDP growth rate include (Bikker & Hu, 2012; di Patti & Hardy, 2005; Vong & Chan, 2009). Inflation rate, denoted by (INF_t) is another important macroeconomic variable, which accounts for macroeconomic risk of correctly predicting the trend of inflation (Perry, 1992; Revell, 1979). Inflation rate that is fully anticipated reduce cost of operations but, an unanticipated change could raise cost due to imperfect interest rate adjustment (Perry, 1992). Generally, the failure of banks to anticipate inflation accurately disrupt banks' cost efficiency and worsen loans policy. If banks are able to adequately anticipate future inflation and adjust interest rate to reflect it they are less likely to regress on cost or they may benefit from cost reduction (Athanasoglou et al., 2008; Vong & Chan, 2009). A negative inflation coefficient is expected. The policy rate, denoted by PR_t is the rate fixed by the Bank of Ghana, stating the minimum cost of borrowing from the central banks. This policy rate is likely to influence dynamic cost productivity of banks since a higher rate may not be favourable as it may raise the cost of borrowing and hence overall total cost over time. Furthermore, the policy rate influences interest on loans and cost of deposits mobilization. Therefore, a negative sign is expected, to show a negative relationship between dynamic cost productivity and policy rate. Another macroeconomic variable is the treasury bill rate, denoted by $TBILL_t$. This represent the rate at which central government offers to prospective depositors to mobilise funds. This however, may create an incentive or disincentive for depositors as to where they earn higher returns. If the treasury bill rate are high, banks will have incurred more cost to attract depositors thereby making them likely to regress on cost productivity. Therefore, either a positive or negative coefficient sign is expected. Finally, the composed error term $\varepsilon_{i,t} = \mu_i + \nu_{i,t}$, where μ_i is the unobserved firm specific effects and $\nu_{i,t}$ is the time-varying error term.

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4.8 DEA estimation considerations

This study employed input orientation DEA for all estimations. The input orientation is on the ideal orientation under cost minimisation when using inputs given their prices and the current levels of outputs over time. A firm is seen to be experiencing productivity growth if it produces the same level of possible output using the minimum levels of inputs acquired at the lowest price. The study adopted the constant returns to scale (CRS) approach, due to the variable returns to scale (VRS) biases in estimating the productivity index (Grifell-Tatjé & Lovell, 1995; Maniadakis & Thanassoulis, 2004; Ray & Desli, 1997). The VRS approach presents an inherent bias of overstating or understating the productivity change relative to input growth in the presence of input variability (Grifell-Tatjé & Lovell, 1995). Furthermore, regardless of the frontier exhibiting VRS, there is an argument of the Malmquist index being correctly measured by the CRS distance function (Casu et al., 2004). Therefore, CRS approach presents a comparatively better productivity change and it has been applied in the banking industry by many studies (Alam, 2001; Casu & Girardone, 2005; Casu et al., 2004; Chang et al., 2012; Matthews & Zhang, 2010a; Murillo-Melchor et al., 2009). Furthermore, the few studies that estimated dynamic cost productivity used the CRS approach (Baležentis, 2012; Balezentis et al., 2013; Maniadakis & Thanassoulis, 2004). Ideally, it would be robust to test whether CRS or VRS using the test suggested by Simar and Wilson (2002), but, this is pursued later as a further research.

In the cost productivity assessment, an unbalanced panel was used for the estimation. Generally Malmquist indices require that efficiency results in adjacent periods are compared. This adequately captures the consistency of firms' performance over time and to enable the software to easily compute the adjacent time comparison. Based on this assumption, some hold the view that it is only balanced panel that reflects that assessment of continuous performance of firm (Stiroh, 2000). However, the use of balanced data panel creates the situation of ignoring

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valuable information which defines the entire technology set of the industry (Asmild & Tam, 2007). Therefore, this study use an unbalanced data panel for cost productivity analysis.

4.9 Instruments for data analysis

All statistical results are generated using R versions 2.14.0 and 3.1.3 in conjunction with the Benchmarking package version 0.24 of Bogetoft and Otto (2011) and Frontier Efficiency Analysis with R (FEAR) version 2.0.1 package by Wilson (2008) . Also, MaxDEA Pro 6.4b software is used for mainly confirmatory purposes.

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CHAPTER FIVE

DATA ANALYSIS AND DISCUSSIONS

5.0 Introduction

This chapter begins with the descriptive statistics of the input and output variables of Ghanaian banks used in this study and the explanatory variables employed in the second-stage analysis. Furthermore the results of the data analysis are presented in a logical manner to based on the objectives of the study. In addition, discussions are made, to support both empirical and theoretical arguments.

5.1 Description of Variables

Table 8 presents the means, medians, minimum, maximum and standard deviations of the inputs, input prices and outputs used in this study. The data of 28 banks was sourced from the published annual reports of the individual banks over the study period and cross-validated with similar data from the research unit of the Bank of Ghana. Three inputs and two outputs were used. The inputs are total deposits $(x1)$, personnel expenses $(x2)$ and fixed assets $(x3)$. Personnel expenses are used as proxy for labour input while fixed assets are used to proxy capital input. The output variables are represented by total loans and advances $(y1)$ and investments $(y2)$. To estimate the CMPI, the respective prices of the three inputs are also presented. The price of deposits $(w1)$ is the ratio of interest expense to banks deposits. The labour price $(w2)$ is the ratio of staff cost to total assets of banks and the price of capital $(w3)$ is represented by other operating cost divided by the fixed assets of individual banks.

To better appreciate the dynamics in the data, Table 8 shows the descriptive statistics of the unbalanced panel data for banks in Ghana pooled together for the period 2000-2013. The industry as at 2014 was made up of 28 banks (16 foreign banks and 12 local banks). However,

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the study period saw the entry and exit of a number of banks resulting in different samples for each period over the 2000-2013 study period.

Table 8: Descriptive Statistics of Banks in Ghana for 2000-2013

First Stage Variable	Mean	Median	SD	Min	Max
DEP ($x1$) ('000)	349,134.72	170,905.45	463,900.79	532.19	3,220,777.00
LBEXP ($x2$) ('000)	17,530.60	7,933.95	25,937.96	49.09	169,996.00
FA ($x3$) ('000)	13,299.87	7,636.38	15,807.72	59.11	94,756.64
LADV ($y1$) ('000)	218,258.23	113,939.97	281,952.30	154.71	2,124,530.00
INV ($y2$) ('000)	133,099.18	58,588.56	228,913.07	61.00	1,747,087.00
IEXP/DEP ($w1$)	0.081	0.067	0.051	0.014	0.402
LEXP/TA ($w2$)	0.120	0.031	0.399	0.003	3.047
OEXP/FA ($w3$)	2.269	1.280	3.366	0.012	22.840
Second Stage					
CMPI (CRS)	1.142	1.053	0.628	0.145	6.488
SIZE	19.401	19.631	1.378	15.248	22.255
HHI-DEPOSITS	0.154	0.088	0.245	0.062	0.999
HHI-LOANS	0.102	0.100	0.039	0.059	0.183
HHI-ASSETS	0.094	0.085	0.032	0.061	0.148
GDP	6.500	6.000	2.869	3.700	15.000
Inflation	16.971	14.950	9.046	8.580	40.500
Policy Rate	18.036	16.750	5.033	12.500	27.00
TBILL	19.832	19.200	9.077	9.600	41.99

DEP = Total Deposits of Banks; **LBEXP** = Labour Cost; **FA** = Fixed Assets of Banks; **LADV**= Loans and Advances of Banks; **INV** = Investments of Banks; **IEXP/DEP** = Average Price of Deposits; **LEXP/TA**= Average Price of Labour and **OEXP/FA** = Price of Fixed Assets

On average, Ghanaian banks employed workers at the value of GH¢ 17,530,601.95, used physical capital valuing GH¢ 13,299,871.81 and used deposits valuing GH¢349,134,719.58 to generate an average of GH¢ 218,258.23 loans and advances, and investment is GH¢ 133,099.18. The variability in total assets is enough grounds for the choice of variable return to scale (VRS) technology approach. However, as stated by Grifell-Tatjé and Lovell (1995), regardless of the true frontier, the constant return to scale (CRS) is a better technology to use in estimating the efficiency or productivity. The inputs and input prices and the outputs were

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test for significance differences across time. The result shows that at a 1% significance level there are difference across time. In view of this the data could not be pooled together due to the variation in the variables across years.

The mean of the CMPI as an independent variable is 1.142, and minimum is 0.145 and maximum is 6.488. This the variation in the minimum and maximum showed a vast difference between the most cost productive bank and the worst performer. Additionally, the HHIs represent deposits, loans and advances and total assets as a proxy for competition. The results shows that the Ghanaian banking industry is competitive, since the HHIs for loans and deposits are greater than 0.01 and less than 0.15. The Ghanaian banking industry for the study period can be said not to be concentrated, implying the industry is quite competitive. However, in relation to HHI for deposits the industry has moderate concentration. This is evidence of a huge variation between the maximum and the minimum average deposits. This imply few banks have the largest share of the industry deposits. During the study period, GDP averaged 6.5%, an appreciable level of growth for an efficient bank performance. However, an inflation rate averaging 16.97% which is relatively high and could affect the cost of mobilizing deposits as input for the banks operations.

Since the study used a non-parametric analysis, there is the need to undertake an isotonicity test. In a nonparametric frontier analysis such as DEA, one can test for the inter-correlations between input variables and output variables. There is not an issue if a high correlation between inputs or between outputs exist, albeit a low correlation is fine (Dyson et al., 2001) . The test requires that all inputs show a positive relationship with all outputs (Cooper et al., 2011; Thanassoulis, 2001). Table 9 presents a correlation matrix for all inputs and outputs.

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Table 9: Correlation Matrix of Inputs and Outputs

	Loans & Advances	Investments	Total Deposits	Labour Expenses	Fixed Assets
Loans & Advances	1				
Investments	0.67***	1			
Total Deposits	0.92***	0.85***	1		
Labour Expenses	0.86***	0.83***	0.93***	1	
Fixed Assets	0.8***	0.61***	0.8***	0.76***	1

Inputs: Total deposits ($\boldsymbol{X1}$), Personnel expenses ($\boldsymbol{X2}$) and Fixed Assets ($\boldsymbol{X3}$) Capital Input. **Output**: Total loans and advances ($\boldsymbol{Y1}$) and Investments ($\boldsymbol{Y2}$).
$***p < 0.01$

All three inputs (labour, deposits and fixed assets) show a significantly positive and strong association with both outputs (loans and investments). This confirms that the isotonicity property of DEA is not violated. It states that an output should not decrease with an increase in an input (Dyson et al., 2001; Wanke, Barros, & Faria, 2015). This confirms the selected inputs and outputs are relevant for the appropriate determination of the cost productivity of banks in Ghana.

5.2 Dynamic Cost Productivity of Banks in Ghana

The first objective of this study is to determine the dynamic cost productivity of banks in Ghana. The aim is to ascertain whether productivity in the banking industry is progressing, stagnating or retrogressing. Table 10 shows the yearly averages of the estimated cost productivity indices for individual banks, which are the geometric means since original individual DEA efficiency scores and productivity change indices can be skewed. Note that, cost productivity index is between two adjacent time periods. Unlike the original definition of cost Malmquist indices by Maniadakis and Thanassoulis (2004), this study used a reciprocal index which maintains the same productivity changes but provides an easier interpretation of productivity indices. Therefore, CMPI<1 implies cost productivity regress, a CMPI>1 indicates

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a cost productivity progress and CMPI=1 indicates constant productivity or productivity stagnation.

Table 10: Dynamic Cost Productivity for the Period 2000-2013

DMU	00/ 01	01/ 02	02/ 03	03/ 04	04/ 05	05/ 06	06/ 07	07/ 08	08/ 09	09/ 10	10/ 11	11/ 12	12/ 13	Geomean
ACCESS	-	-	-	-	-	-	-	-	-	0.81	1.04	0.92	1.33	**1.00**
ADB	0.83	0.79	1.24	1.02	1.02	0.91	0.54	1.24	0.89	2.12	0.71	1.08	0.84	**0.96**
BARODA	-	-	-	-	-	-	-	-	-	2.91	1.81	0.58	1.48	**1.12**
BBG	0.58	1.08	1.10	0.78	1.07	1.04	0.79	0.85	1.11	0.99	1.41	1.21	1.25	**1.00**
BOA	4.22	1.16	1.69	1.24	0.35	0.72	1.30	0.99	1.24	0.97	1.39	1.34	0.95	**1.16**
BSIC	-	-	-	-	-	-	-	-	0.20	2.47	1.50	1.18	0.86	**0.98**
CAL	1.16	1.10	1.09	0.58	0.89	1.28	0.86	1.14	0.83	1.02	0.97	1.46	1.12	**1.02**
ECOBANK	0.81	1.56	0.83	0.90	1.24	1.05	0.80	0.90	0.94	1.09	1.34	1.20	1.19	**1.04**
ENERGY	-	-	-	-	-	-	-	-	-	-	-	0.65	1.44	**0.99**
FAMB	0.36	0.96	1.62	1.21	1.01	0.90	0.84	1.15	0.64	1.29	1.17	0.92	0.83	**0.94**
FBL	-	-	-	-	-	-	0.64	0.85	1.06	0.69	1.14	1.23	0.88	**0.95**
GCB	1.39	1.17	0.71	0.93	0.83	0.94	1.05	1.05	0.95	0.69	0.54	1.16	0.98	**0.93**
GTB	-	-	-	-	-	-	1.20	4.21	0.77	1.04	0.88	1.57	0.99	**1.14**
HFC	-	-	-	0.80	0.93	0.89	0.94	1.19	0.80	0.85	0.97	1.32	1.13	**0.98**
IBG	-	-	-	-	-	-	2.62	1.68	0.96	1.04	-	-	-	**1.12**
ICB	0.83	1.20	0.88	3.86	0.47	0.91	0.76	1.10	2.27	0.87	1.22	0.96	1.15	**1.09**
NIB	1.05	1.01	1.54	1.06	0.76	0.71	1.16	1.18	0.94	0.94	1.17	1.00	1.06	**1.03**
PBL	1.16	0.93	1.10	2.61	0.40	0.93	0.86	0.92	0.94	0.87	1.00	1.29	0.98	**1.00**
ROYAL B.	-	-	-	-	-	-	-	-	-	-	-	-	-	**1.00**
SCB	0.70	0.84	1.24	1.28	1.46	1.23	1.28	0.65	1.25	0.90	1.10	1.34	1.06	**1.07**
SG	0.86	1.03	1.09	0.86	1.24	0.71	0.96	1.02	0.74	1.07	0.58	1.31	1.22	**0.95**
STANBIC	1.49	0.99	1.93	1.52	0.95	0.78	1.10	0.85	1.26	1.17	1.06	0.86	0.80	**1.09**
TRUST	0.54	0.97	1.26	4.90	0.27	1.22	0.68	1.11	0.84	1.16	-	-	-	**0.98**
UBA	-	-	-	-	-	1.52	1.96	1.10	1.54	1.55	1.58	1.65	1.61	**1.31**
UMB	1.09	0.87	1.12	1.41	0.89	1.38	0.99	1.09	0.77	0.61	1.01	1.34	1.14	**1.03**
UNIBANK	-	1.43	1.23	0.43	1.06	1.01	0.91	0.80	1.05	1.25	1.11	1.07	1.06	**1.00**
UT BANK	1.00	0.49	1.07	6.49	0.15	-	-	1.00	0.84	1.09	1.13	1.10	1.08	**0.96**
ZENITH	-	-	-	-	-	-	2.68	0.74	1.13	1.34	0.75	1.31	1.88	**1.14**
Geomean	**0.98**	**1.00**	**1.11**	**1.20**	**0.81**	**0.99**	**1.03**	**1.06**	**0.94**	**1.09**	**1.06**	**1.12**	**1.10**	**1.03**

UBA progressed most, by an average of 30.82% (i.e. [1.3082-1]$_{\times}$100). The growth can be attributed to the annual cost progress for the entire period of the banks existence. The second bank that progressed most, is BOA with a 16.20% growth. The banks performance can be attributed to annual growth ranging from 321.94 % in 2000-2001 to 23.58% in 2003-2004. The bank experienced regress in only three periods. The third and fourth best performing banks in terms of productivity were ZENITH and GTB with 14% growth. However, some other banks including FBL, FAMB, and GCB were among the worst performers for the period. Considering the productivity regress of FBL, for seven adjacent periods it progressed on 3 and deteriorated

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on 4 periods. With its worst performance in 2006-2007, with a regress of 36.24%. Similarly FAMB in 13 adjacent periods progressed on only 6 periods with a highest regress of 64.31% in 2000-2001. Finally, GCB progressed only 5 adjacent periods and regressed on 8 adjacent periods with the highest regress of 45.79% in 2010-2011. Interestingly, the banks that experienced the worst productivity levels are local banks.

Table 11: Cost Productivity Rankings of Banks in Ghana

DMU	CMPI (CRS)	Productivity Growth (%)	Rank	OWNERSHIP
UBA	1.3082	30.82	1	Foreign
BOA	1.1620	16.2	2	Foreign
ZENITH	1.1412	14.12	3	Foreign
GTB	1.1406	14.06	4	Foreign
BARODA	1.1240	12.4	5	Foreign
IBG	1.1210	12.1	6	Foreign
ICB	1.0946	9.46	7	Foreign
STANBIC	1.0940	9.4	8	Foreign
SCB	1.0699	6.99	9	Foreign
ECOBANK	1.0434	4.34	10	Foreign
UMB	1.0285	2.85	11	Local
NIB	1.0268	2.68	12	Local
CAL	1.0158	1.58	13	Local
ACCESS	1.0019	0.19	14	Foreign
ROYAL BANK	1.0000	0	15	Local
UNIBANK	0.9992	-0.08	16	Local
BBG	0.9962	-0.38	17	Foreign
PBL	0.9951	-0.49	18	Local
ENERGY	0.9944	-0.56	19	Foreign
TRUST	0.9838	-1.62	20	Foreign
BSIC	0.9776	-2.24	21	Foreign
HFC	0.9751	-2.49	22	Local
ADB	0.9647	-3.53	23	Local
UT BANK	0.9637	-3.63	24	Local
SGG	0.9501	-4.99	25	Foreign
FBL	0.9464	-5.36	26	Local
FAMB	0.9368	-6.32	27	Local
GCB	0.9277	-7.23	28	Local

In comparing the cost productivity changes of individual banks by ranking them, 14 banks, representing 50% of banks in the industry, experienced productivity growth during the study period. The rate of growth is from 30.82% for the highest growing bank, to the bank with the minimum growth of 0.19%. The study also categorises the top performing banks into their

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ownership structure in order to determine the influence of ownership structure on dynamic cost productivity. Using the CMPI, the top ranking banks, have 11 out of the 14 being foreign banks. This is followed by only three local banks. On the other hand, 13 banks retrogressed their cost productivity, with a regress rate raging as low as 0.8% to as high as 7.23%. Out of the 13 banks that regressed on cost productivity, 7 are local banks and 6 are foreign banks. It could be noticed that almost an equal number of foreign and local banks regressed within the study period. Interestingly, only one bank experienced a constant cost productivity growth. The dynamic cost productivity of the foreign banks could be attributed to their advantages in technological advantages which differs from domestic banks. This outcome is similar to the finding which posits that foreign banks performance in developing countries are better than domestic or local banks (Bonin et al., 2005; Claessens, Demirgüç-Kunt, & Huizinga, 2001; Detragiache, Tressel, & Gupta, 2008; Hasan & Marton, 2003; Sathye, 2003). The majority of the worst cost-productive banks are local banks. This raises the issue of how best the local banks are taken advantage of the technological spill overs to improve their cost productivity levels (Kontolaimou, Kounetas, Mourtos, & Tsekouras, 2012) . Generally, the advent of financial liberalization, overall economic and financial integration, has internationalised the banking industry (Claessens et al., 2001). This means that local domestic banks need to take advantage of the competition posed by the foreign banks to improve their products and process innovations. There are enough grounds for domestic local banks, especially in developing economies to take advantage of foreign firms technological transfer or spill over (Dosi, 1982, 1993). Especially, banks from countries that have a more developed financial systems, or have a better banking infrastructure relative to Ghana should be a sor of benchmark for banking industry in the developing economies.

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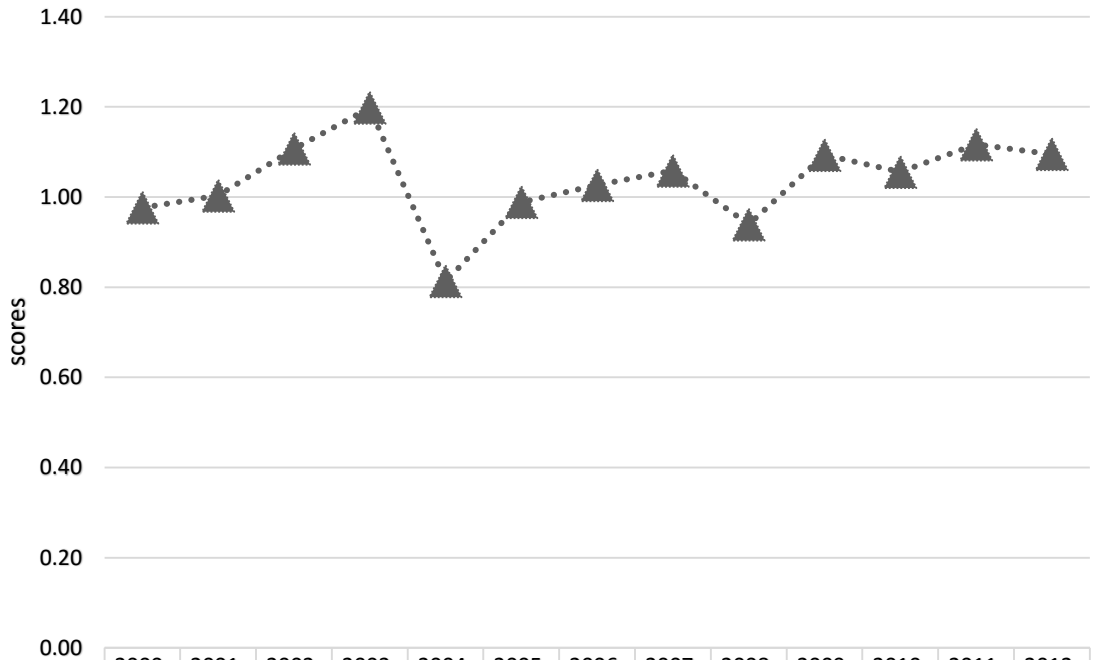

	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013
CMPI	0.98	1.00	1.11	1.20	0.81	0.99	1.03	1.06	0.94	1.09	1.06	1.12	1.10

Figure 7: Trends in Cost Productivity of the Banking Industry (2000-2013)

In reference to Figure 7, which was extracted from Appendix A, the industry's average cost productivity trend seems to be fluctuating over the period of the study. The study observed an average highest cost productivity progress of 20% in the year 2003-2004 and the worst performance of 19% cost productivity regress in 2004-2005. The cost productivity progress between 2001-2002, 2002-2003 and 2003-2004 can be attributed to a number of factors. These include stable political environment, attainment of some micro and macroeconomics stability and the central bank successful promotion and enforcement of some statutory requirements (BOG, 2005). Specifically, the 2003-2004 period saw the introduction of the Universal Banking Business License (UBBL), which is to improve competitiveness and performance of the industry (PwC, 2015). Furthermore, the fiscal development which significantly reduced the level of domestic financing by central government minimised domestic borrowing by government thereby reducing the crowding out of the private sector (BOG, 2004). These factors

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made funds available for the private sector. All these factors possibly contributed to cost productivity of the industry.

The worst performing periods may be due to some macroeconomic downturns that the Ghanaian economy suffered. During the 2004-2005 period, the agricultural sector, which is the largest contributor to the economy, declined from the previous year's growth rate of 7.5% to 6.5%, largely as a result of a decline in the cocoa production, a critical contributor to the government revenue (BoG, 2005). Additionally, some global dynamics including increasing oil prices increased expenditure. Consequently, this may have cost the banks more to mobilize deposits during this periods. This is likely to be the reason for the worsening cost productivity during this period. Interestingly, the worst performing periods were election years. This raises some concern about the influence of general election and government spending on the cost productivity of banks in Ghana. The finding is consistent with other studies, (Baum, Caglayan, & Talavera, 2010; Chen & Liu, 2013; Dinç, 2005; Micco, Panizza, & Yañez, 2007). Since the mobilization of deposits during this period is not encouraging due to the speculations of election related issues mostly in developing countries, the industry is likely to have a regressed cost productivity.

5.3 Decomposition of the Cost Malmquist Productivity Index

The cost productivity indices are further decomposed to explore their sources or drivers. The decomposition helps to achieve the second objective of the study. Other studies decomposed the MPI, (Chang et al., 2012; Färe, Grifell-Tatjé, Grosskopf, & Lovell, 1997; Färe et al., 1994; Fiordelisi & Molyneux, 2010; Fuentes, Grifell-Tatje, & Perelman, 2001; Grifell-Tatjé & Lovell, 1997; Lovell, 2003; Orea, 2002; Ray & Desli, 1997). Given the failure of these studies to capture allocative efficiency, the decomposition does not help paint the full picture of the sources on inefficiencies or dynamic performances.

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Table 12 extracted from Appendices C & D displays the results of the first-stage decomposition of the cost Malmquist productivity indices (CMPI) which are overall efficiency change (OEC) and cost technical change (CTC). The CTC generally compares cost between two periods, relative input prices. The CTC index reflects the combined impact of input price and technology change over time.

Table 12: First-stage Decomposition of CMPI

NO	DMU	OEC	CTC	CMPI
1	**ACCESS**	0.9370	1.0693	1.0019
2	**ADB**	0.9690	0.9955	0.9647
3	**BARODA**	1.0000	1.1240	1.1240
4	**BBG**	0.9664	1.0308	0.9962
5	**BOA**	1.0583	1.0980	1.1620
6	**BSIC**	0.9822	0.9954	0.9776
7	**CAL**	0.9894	1.0267	1.0158
8	**ECOBANK**	0.9941	1.0496	1.0434
9	**ENERGY**	0.9230	1.0774	0.9944
10	**FAMB**	0.9546	0.9814	0.9368
11	**FBL**	0.9059	1.0447	0.9464
12	**GCB**	0.9299	0.9977	0.9277
13	**GTB**	1.0164	1.1222	1.1406
14	**HFC**	0.9940	0.9810	0.9751
15	**IBG**	0.9882	1.1344	1.1210
16	**ICB**	0.9367	1.1686	1.0946
17	**NIB**	0.9693	1.0594	1.0268
18	**PBL**	1.0154	0.9800	0.9951
19	**ROYAL BANK**	1.0000	1.0000	1.0000
20	**SCB**	0.9330	1.1467	1.0699
21	**SGG**	1.0071	0.9434	0.9501
22	**STANBIC**	1.0737	1.0189	1.0940
23	**TRUST**	0.9920	0.9918	0.9838
24	**UBA**	1.0542	1.2409	1.3082
25	**UMB**	0.9610	1.0702	1.0285
26	**UNIBANK**	1.0007	0.9985	0.9992
27	**UT BANK**	0.9482	1.0164	0.9637
28	**ZENITH**	1.0175	1.1216	1.1412
	Geometric Mean	**0.9819**	**1.0508**	**1.0318**
	SD	**0.0415**	**0.0700**	**0.0864**
	Min	**0.9059**	**0.9434**	**0.9277**
	Median	**0.9888**	**1.0378**	**1.0010**
	Max	**1.0737**	**1.2409**	**1.3082**
	Coefficient of Variation	**0.0423**	**0.0667**	**0.0837**

The industry CMPI progressed marginally by an average of 3.18% for the period of the study. The progress can be attributed to CTC growth of 5.08%, since the OEC regressed by 1.81%,

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implying that, progress in cost productivity in the Ghanaian banking industry is as a result of the general performance of 19 banks. The top contributors to the cost technical change include UBA (24.09%), ICB (16.86%), SCB (14.67%), BARODA (12.40%) and GTB (12.22%).

The performance of these banks reflect the ability of the operations managers of these banks to keep their cost lower within the study period driven by the increases in technological change for the study period. This means that it is possible to have increasing technological advancement in the banking industry and still manage the cost, especially if the managers are particular about the cost as they introduced more of these technologies to enhance productivity.

Figure 8 gives further details about the annual dynamic cost productivity and the components of it. This is to ascertain the particular year the industry performed well and which of the decomposed factors could be the key underlining driver.

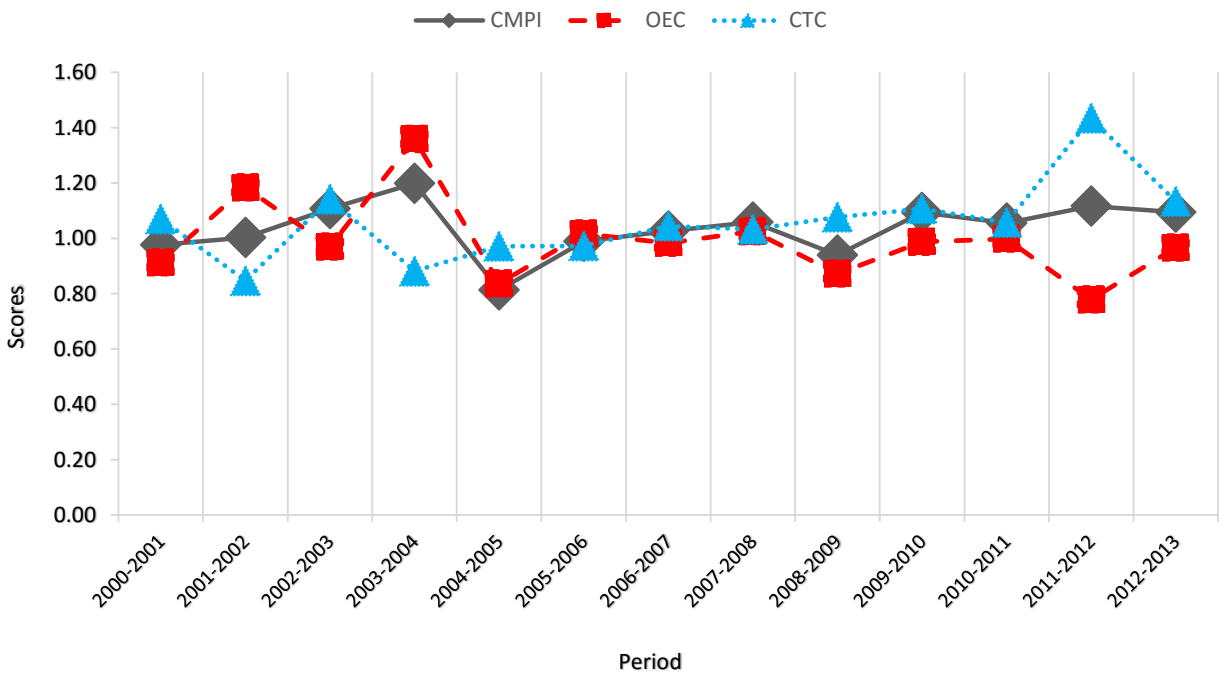

Figure 8: CMPI and its first-stage decomposition

The general trend observed from Figure 8 is that, annually, a progress in CMPI means a progress in OEC, but a regress in CTC. For example the annual decomposition show that the 36% cost progress in 2003-2004, saw the OCE also progress by 54% and CTC fall by 27%.

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Clearly, this indicates that the best performing periods of the industry can be attributed to effective operations managers' ability to manage both inputs quantity and cost. Whilst individual banks are concerned about the quantity of inputs, at the same time, the usage and the cost of those inputs are crucial to the operations managers and collectively these help the industry to perform better and remain competitive in the offering of their services.

The performance of the industry during the 2003-2004 periods demonstrates that the entire banking industry's is able to adequately utilize the input resources acquired. The CMPI and the OEC progress and the CTC decrease show an improvement in the industry performance, in relation to operations managers' ability to allocate resources effectively. This may be due the increased stringent industry regulatory framework by the supervisory body to improve on the existing frameworks to keep the industry performance as best as possible.

According to Fare et al. (1992), the classical Malmquist indices could be decomposed into efficiency change and technical change components. Consequently, we decompose the MPI, which is a component of the CMPI, to ascertain the source of progress or regress in the banking industry. Table 13 shows the geometric mean of the MPI, TEC and TC for each bank, estimated from appendices B, E and F.

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Table 13: Decomposition of the Malmquist Index

NO	DMU	MPI	TEC	TC
1	ACCESS	0.9263	0.9548	0.9702
2	ADB	0.9765	0.9844	0.9920
3	BARODA	1.1014	1.0000	1.1014
4	BBG	0.9831	0.9585	1.0256
5	BOA	1.0961	1.0664	1.0279
6	BSIC	0.9797	0.9605	1.0200
7	CAL	1.0287	1.0317	0.9971
8	ECOBANK	1.0097	0.9996	1.0100
9	ENERGY	1.0318	1.0676	0.9665
10	FAMB	0.9581	0.9893	0.9685
11	FBL	0.9616	0.9573	1.0045
12	GCB	0.9558	0.9745	0.9808
13	GTB	1.0263	1.0189	1.0073
14	HFC	0.9370	1.0000	0.9370
15	IBG	1.0258	1.0689	0.9597
16	ICB	1.1047	0.9772	1.1305
17	NIB	1.0093	0.9730	1.0373
18	PBL	1.0527	0.9984	1.0544
19	ROYAL BANK	1.0000	1.0000	1.0000
20	SCB	1.0315	0.9705	1.0628
21	SGG	0.9681	0.9831	0.9847
22	STANBIC	1.1123	1.0274	1.0827
23	TRUST	1.0040	1.0000	1.0040
24	UBA	1.1703	1.0798	1.0838
25	UMB	1.0128	0.9997	1.0131
26	UNIBANK	1.0283	1.0471	0.9821
27	UT BANK	0.9748	0.9518	1.0242
28	ZENITH	1.0627	1.0372	1.0246
	Geometric Mean	**1.0173**	**1.0021**	**1.0152**
	SD	**0.0583**	**0.0377**	**0.0452**
	Min	**0.9263**	**0.9518**	**0.9370**
	Median	**1.0112**	**0.9997**	**1.0087**
	Max	**1.1703**	**1.0798**	**1.1305**
	Coefficient of Variation	**0.0573**	**0.0377**	**0.0445**

The MPI results show that the industry grew marginally by 1.73%, per annum on an average. TEC and TC grew by 0.21% (1.0021) and 1.25% (1.0125) respectively. This demonstrates that growth in MPI can be largely attributed to TC of the industry. The increasing improvement in the technological inputs in the banking industry should be improved. The industry has moved away from almost all manual transactions has seen normal activities like cash deposits, cash withdrawals, checking of account balance, making enquiries among others, done electronically. However, the impact of the operations managers cannot be overlooked. The technical efficiency change (TEC) also contributed to the improvement. This means that the performance

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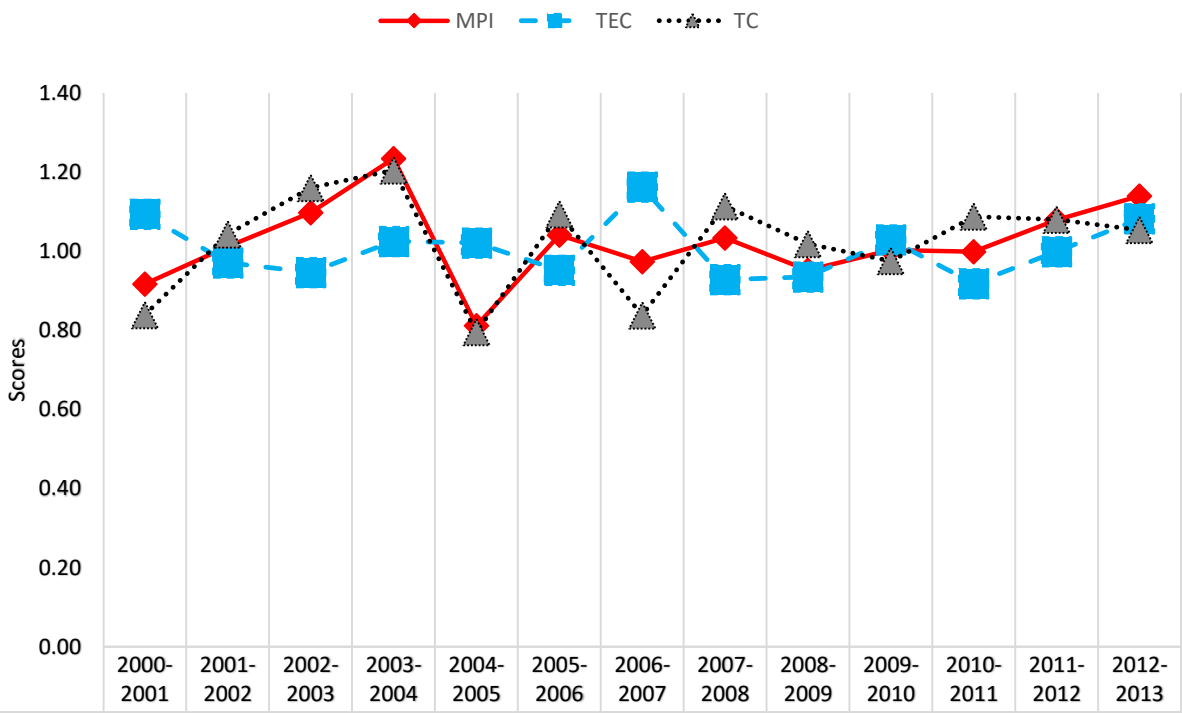
of operations managers in the allocation of the input over time did improve overall productivity in the industry.

Similarly, in assessing the decomposed MPI on annual basis, the industry experienced the highest growth in productivity in 2003-2004 just as the cost productivity. The other components TC grew, by 16% in 2002-2003; 20% in 2003-2004; and 11% in 2007-2008. On the other hand TEC, experienced a growth of 9% in 2001-2002; 2% in 2003-2004 and 2004-2005; 16% in 2006-2007; and 8% in 2012-2013. The industry experienced the worst regress in MPI and TC of 19% and 20% respectively in 2004-2005. Evidently, in periods in which the industry deteriorated more on TC, the impact on MPI was comparatively higher. This points to the fact that, banks in Ghana improved their MPI over the period. This could be as a result of operations managers' ability to allocate the minimum resources efficienctly over the period.



	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013
MPI	0.92	1.01	1.10	1.23	0.81	1.04	0.97	1.03	0.95	1.00	1.00	1.08	1.14
TEC	1.09	0.97	0.95	1.02	1.02	0.95	1.16	0.93	0.93	1.03	0.92	1.00	1.08
TC	0.84	1.04	1.16	1.20	0.80	1.09	0.84	1.11	1.02	0.97	1.09	1.08	1.05

Figure 9: Decomposition of MPI into TEC and TC

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Table 14 shows individual banks and summary result for the industry. Table 14 displays results for the second-stage decomposition based on Färe et al. (1992, 1994) and Maniadakis and Thanassoulis (2004). In this decomposition, MPI can be attributed to technical efficiency change (TEC), which measures the change in the overall technical efficiency (pure technical efficiency and scale efficiency) and technical change (TC) measures the frontier shift representing process and product innovation during the two periods. In addition, CMPI is decomposed into allocative efficiency change (AEC) and price effect (PE). The AEC measures the change in the ability to use inputs in an optimal proportion given their respective prices and the price effect (PE) captures changes in the inputs needed to produce certain output attributed to changes in relative input prices (Maniadakis & Thanassoulis, 2004). The cost Malmquist indices were aggregated across banks using a geometric averages to maintain the integrity of the indices (Baležentis, 2012).

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Table 14: Second Stage Decomposition of Cost Malmquist Index Decomposition

NO	DMU	MPI	TEC	TC	CMPI	TEC	AEC	TC	PE
1	ACCESS	0.926	0.955	0.970	1.002	0.955	0.876	0.970	1.102
2	ADB	0.976	0.984	0.992	0.965	0.984	0.973	0.992	1.004
3	BARODA	1.101	1.000	1.101	1.124	1.000	0.890	1.101	1.021
4	BBG	0.983	0.959	1.026	0.996	0.959	0.938	1.026	1.005
5	BOA	1.096	1.066	1.028	1.162	1.066	0.964	1.028	1.068
6	BSIC	0.980	0.960	1.020	0.978	0.960	0.987	1.020	0.976
7	CAL	1.029	1.032	0.997	1.016	1.032	0.964	0.997	1.030
8	ECOBANK	1.010	1.000	1.010	1.043	1.000	0.947	1.010	1.039
9	ENERGY	1.032	1.068	0.967	0.994	1.068	0.857	0.967	1.115
10	FAMB	0.958	0.989	0.968	0.937	0.989	0.973	0.968	1.013
11	FBL	0.962	0.957	1.004	0.946	0.957	0.867	1.004	1.040
12	GCB	0.956	0.974	0.981	0.928	0.974	0.932	0.981	1.017
13	GTB	1.026	1.019	1.007	1.141	1.019	0.906	1.007	1.114
14	HFC	0.937	1.000	0.937	0.975	1.000	1.013	0.937	1.047
15	IBG	1.026	1.069	0.960	1.121	1.069	0.871	0.960	1.182
16	ICB	1.105	0.977	1.131	1.095	0.977	0.801	1.131	1.034
17	NIB	1.009	0.973	1.037	1.027	0.973	0.915	1.037	1.021
18	PBL	1.053	0.998	1.054	0.995	0.998	1.036	1.054	0.929
19	ROYAL BANK	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
20	SCB	1.032	0.971	1.063	1.070	0.971	0.814	1.063	1.079
21	SGG	0.968	0.983	0.985	0.950	0.983	1.068	0.985	0.958
22	STANBIC	1.112	1.027	1.083	1.094	1.027	1.054	1.083	0.941
23	TRUST	1.004	1.000	1.004	0.984	1.000	1.000	1.004	0.988
24	UBA	1.170	1.080	1.084	1.308	1.080	0.850	1.084	1.145
25	UMB	1.013	1.000	1.013	1.028	1.000	0.898	1.013	1.056
26	UNIBANK	1.028	1.047	0.982	0.999	1.047	1.002	0.982	1.017
27	UT BANK	0.975	0.952	1.024	0.964	0.952	0.933	1.024	0.992
28	ZENITH	1.063	1.037	1.025	1.141	1.037	0.907	1.025	1.095
	Geometric Mean	**1.017**	**1.002**	**1.015**	**1.032**	**1.002**	**0.934**	**1.015**	**1.035**
	SD	**0.058**	**0.038**	**0.045**	**0.086**	**0.038**	**0.070**	**0.045**	**0.060**
	Min	**0.926**	**0.952**	**0.937**	**0.928**	**0.952**	**0.801**	**0.937**	**0.929**
	Median	**1.011**	**1.000**	**1.009**	**1.001**	**1.000**	**0.935**	**1.009**	**1.025**
	Max	**1.170**	**1.080**	**1.131**	**1.308**	**1.080**	**1.068**	**1.131**	**1.182**
	Coefficient of Variation	**0.057**	**0.038**	**0.045**	**0.084**	**0.038**	**0.075**	**0.045**	**0.058**

It is evident from Table 14 that CMPI and MPI indices indicate similar trends at the individual and industry level. Both productivity indices grew between the periods 2000-2013 as gathered from the geometric mean values of 1.017 and 1.032 for MPI and CMPI respectively in Table 14. The decomposition of the MPI shows that productivity change is attributed to both technical change and efficiency change. But more to technical change with geometric mean of 1.015 than efficiency change. This implies for the period, 2000-2013, the improvement of 1.73% in MPI can be attributed largely to TC (1.52% growth) than TEC (0.21%). The CMPI brings

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additional information given the second stage decompositions. The geometric mean of AEC (0.930 or 7% regress) suggests the banks on average were not able to improve their input mix to match input price changes for subsequent periods of their operations. Price effect component, with geometric mean of 1.035 or 3.5% growth, suggests that the effect of relative input price changes for the period 2000-2013 for the banking industry marginally improved cost productivity. Since there was a growth in the price effect change, which contributed to the industry CMPI. Comparatively, the cost productivity growth is higher than technical productivity growth. This strengthens the argument of Maniadakis and Thanassoulis (2004) concerning the importance of allocative efficiency change and price change in total factor productivity analysis.

Comparing the decomposed CMPI on annual basis, the period that the industry experienced the highest growth on cost productivity was 2003-2004. During this period, the industry experienced a 54% growth in AEC, 20% TC, 2% TEC, but regressed by 2% on PE. However, a year after 2005-2006, the industry experienced its worst cost productivity retrogression of 19%. This is largely due to a regress in AEC of 14% and TC of 20%. The period, 2004-2005 the industry experienced its highest growth on PE (9%) and TEC (9%) in 2001-2002. Therefore all the price effect and technical efficiency change do not influence the productivity gain in the period that the industry performs well on cost productivity.

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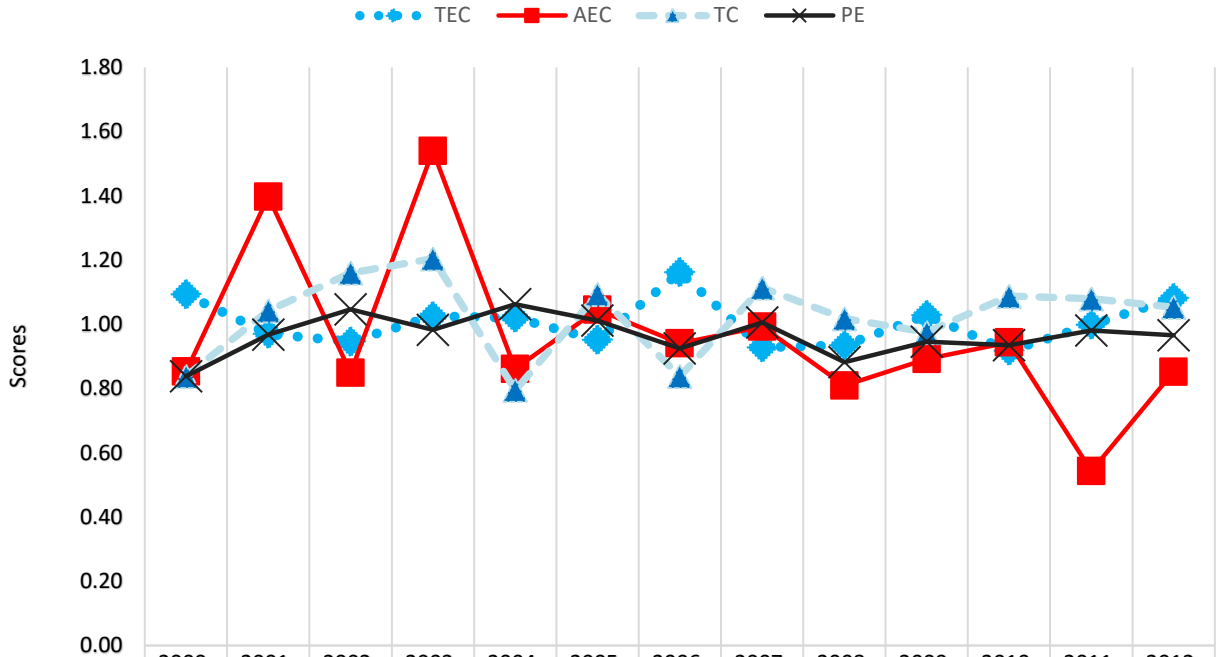

	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013
TEC	1.09	0.97	0.95	1.02	1.02	0.95	1.16	0.93	0.93	1.03	0.92	1.00	1.08
AEC	0.85	1.40	0.85	1.54	0.86	1.05	0.94	0.99	0.81	0.89	0.94	0.54	0.85
TC	0.84	1.04	1.16	1.20	0.80	1.09	0.84	1.11	1.02	0.97	1.09	1.08	1.05
PE	0.84	0.97	1.05	0.98	1.06	1.01	0.92	1.01	0.88	0.95	0.94	0.98	0.97

Figure 10: Annual trends of second-stage CMPI Decomposition

Table 15 depicts the associations between the various components of dynamic cost productivity using the nonparametric Spearman's rank correlation. The rank correlation results show that dynamic cost productivity is more associated with MPI (technical efficiency change and technical change) and price effect change. This is shown in the positive correlation between Malmquist productivity index and cost productivity index of (0.84, p-value < 0.01). Furthermore, the price effect has a positive and significant relationship with dynamic cost productivity of (0.56, p-value < 0.01). However, the relationship between allocative efficiency change and CMPI is negative and significant (-0.41, p-value < 0.05), implying an inverse relationship. Finally, the positive relationship between MPI and CMPI are largely influenced by technical efficiency change (TEC) to a greater extent as compared to technical change (TC).

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Table 15: Spearman's Correlation of CMPI and its Components during 2000-2013

	CMPI	MPI	TEC	AEC	TC	PE
CMPI	1					
MPI	0.84***	1				
TEC	0.63***	0.62***	1			
AEC	-0.41**	-0.24	-0.02	1		
TC	0.54***	0.75***	-0.04	-0.3	1	
PE	0.56***	0.19	0.5***	-0.71***	-0.18	1

****p < 0.01and **p < 0.05*

This shows that, if the banks can take advantage of the increasing technologies in the banking industry to innovatively improve on their dynamic productivity, they will benefit. Furthermore, there is a higher likelihood of further improving on dynamic productivity if the operations managers of the banks take advantage of the catching up or improvement in efficiency. This will lead to more managerial efficiency and hence more overall cost productivity.

The analysis of distribution dynamics of cost productivity and its components is likely to be more informative than the mean or variance (Kumar & Russell, 2002; Quah, 1997; Ray & Das, 2010). The distribution of the CMPI and MPI and the first-stage decompositions for the banks are presented in Figure 11. Considering the Kernel densities for CMPI and MPI, there is multimodal distributions between both productivities. Whereas the CMPI, CTC and MPI all have some distributions at higher levels of productivity, for the OEC component, a major part of the density of the distribution is at lower levels of productivity change. All productivity change indicators, however, have higher densities at unity signifying that most banks stagnated on most of the indices.

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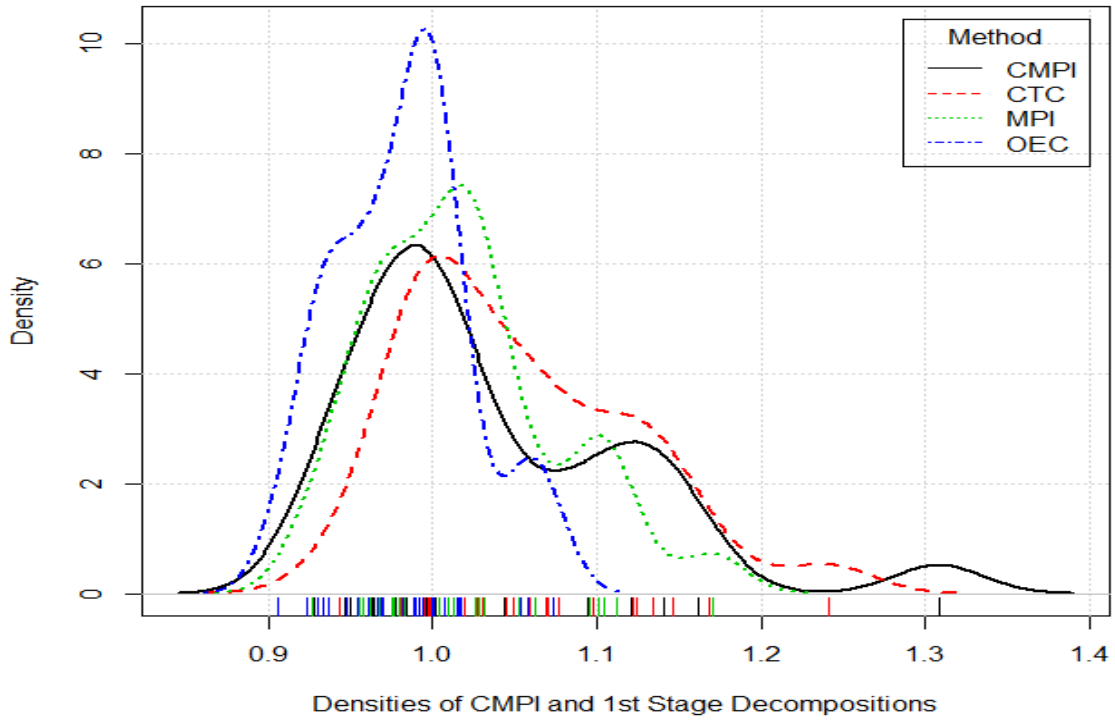

Figure 11: Kernel Density plots of CMPI and its Components

Considering the distribution of the CMPI and the first-stage decompositions depicts evidence of multimodality. On average, a large number of banks experienced constant overall efficiency change (OEC). Quite a number of the banks experienced growth in their CMPI, MPI, and CTC. The cost productivity growth can generally be attributed to the cost technical growth in the banking industry. This is the case, since the kernel density distribution of the CTC and the CMPI appear to be very similar.

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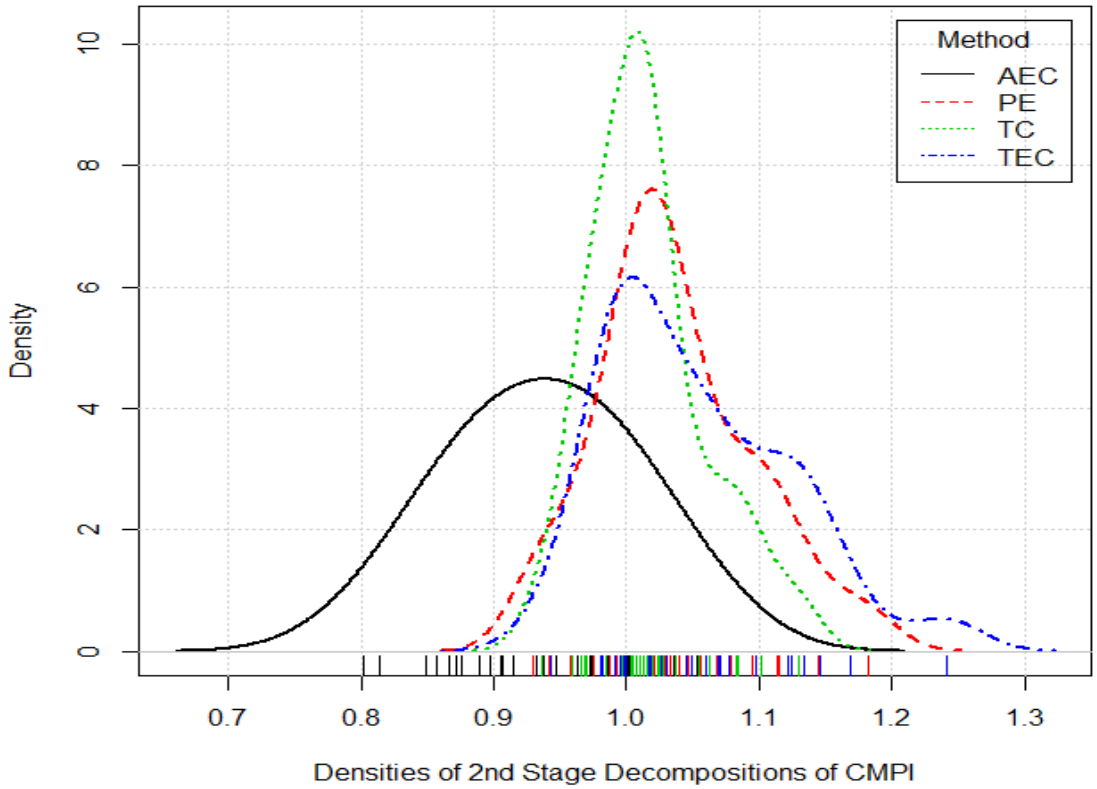

Figure 12: Kernel Density of Second-stage Components of CMPI

To further appreciate the distribution of the components of the CMPI, Figure 12 shows the distribution of the second stage decomposition of the CMPI. The allocative efficiency change of the industry appears normally distributed. However, the price effect (PE), technical efficiency change and Technical Change (TC) appear multi-modal. The technical change has higher density at unity than all other components of the CMPI implying that, majority of the firms stagnated on TC than any other component of CMPI. This is followed by the price effect, then technical efficiency change. This corroborates the result of the correlation which also reflects a higher correlation between the TC and CMPI, followed by PE. The TEC was the least contributor to the growth in the CMPI. These outcomes establish the superiority of the cost Malmquist assessment over the traditional Malmquist since the contribution of the price effect would have been ignored if the price of the inputs were to be omitted in the analysis.

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5.4 Comparison of the MPI and the CMPI

To account for biases in ignoring the allocative efficiency and price effect overtime, objective three compares the CMPI with MPI. This answers the dilemma of banks operations managers' and researchers' regarding the appropriate total factor productivity change approach to adopt. Table 16 reports the dynamic cost productivity index and the classical technical productivity change index of individual banks and for the industry values represented by the geometric means. These values are also presented in Figure13 for easy understanding.

Table 16: Comparison of CMPI and MPI for 2000-2013

DMU	MPI	CMPI
ACCESS	0.926	1.002
ADB	0.976	0.965
BARODA	1.101	1.124
BBG	0.983	0.996
BOA	1.096	1.162
BSIC	0.980	0.978
CAL	1.029	1.016
ECOBANK	1.010	1.043
ENERGY	1.032	0.994
FAMB	0.958	0.937
FBL	0.962	0.946
GCB	0.956	0.928
GTB	1.026	1.141
HFC	0.937	0.975
IBG	1.026	1.121
ICB	1.105	1.095
NIB	1.009	1.027
PBL	1.053	0.995
ROYAL BANK	1.000	1.000
SCB	1.032	1.070
SGG	0.968	0.950
STANBIC	1.112	1.094
TRUST	1.004	0.984
UBA	1.170	1.308
UMB	1.013	1.028
UNIBANK	1.028	0.999
UT BANK	0.975	0.964
ZENITH	1.063	1.141
Geometric Mean	**1.017**	**1.032**
SD	**0.058**	**0.086**
Min	**0.926**	**0.928**
Median	**1.011**	**1.001**
Max	**1.170**	**1.308**
Coefficient of Variation	**0.057**	**0.084**

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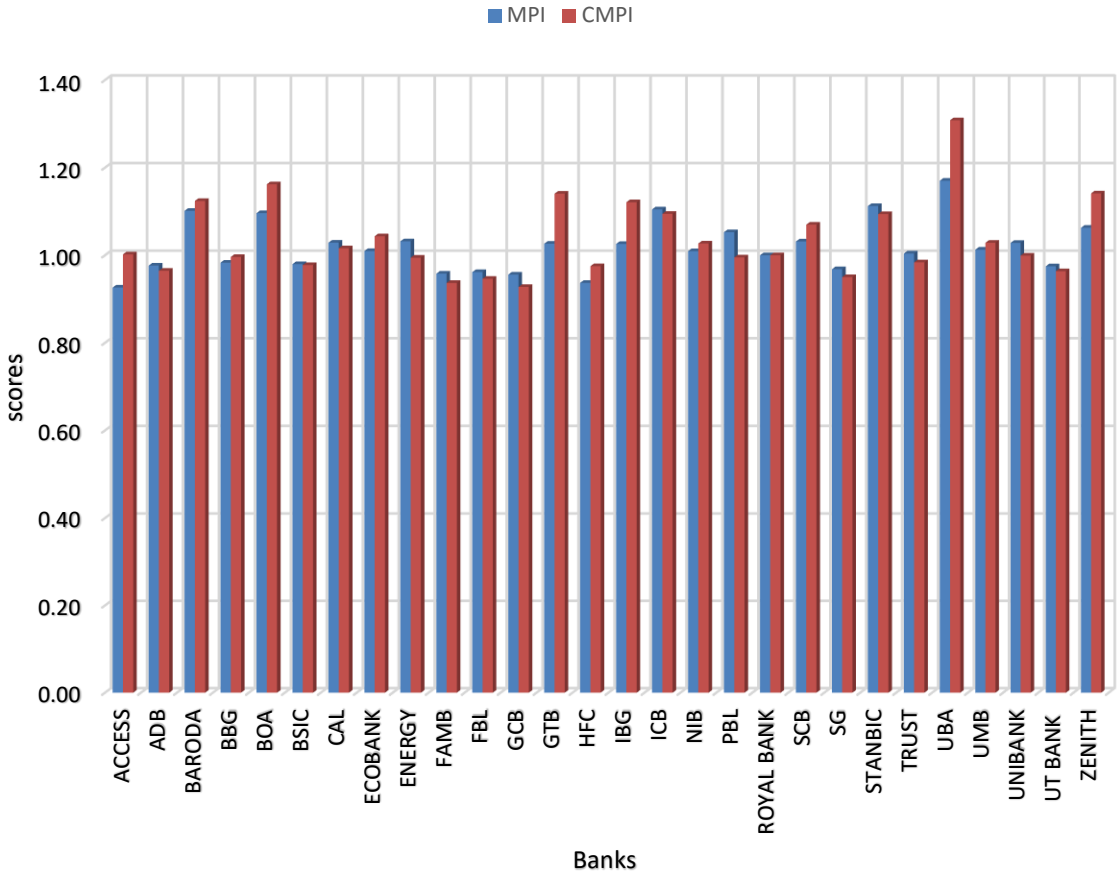

Figure 13: Comparison of CMPI and MPI

Generally, at the industry level, a growth of 1.7% was experienced in relation to MPI, while 3.2% was recorded for the CMPI. Considering the technical Malmquist index only, the result is similar to other studies like Drake (2001) for United Kingdom banks, Casu and Girardone (2006) and Murillo-Melchor et al. (2009) for other European banks. Clearly, the industry in these studies just like the current study had experienced growth. However, the key issue is whether the estimated growth represent the true picture of growth in the industry. It can be observed that the cost productivity growth is higher than technical productivity growth. This confirms the inability of the MPI to fully capture total factor productivity change on which operation managers can make managerial policies or industry regulators could formulate policies. As argued by Maniadakis and Thanassoulis (2004), the bias within the MPI concerns its inability to fully capture all the factors responsible for productivity growth.

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At the individual bank level, it was found that 15 out of 27 banks experienced cost productivity progress (deduced from CMPI) compared to 18 banks that saw technical productivity progress (deduced from MPI). These results show that there are inconsistencies in the two indices for the individual banks. If these banks were to rely only on the MPI, some would be overestimating or underestimating their total factor productivity growths. Example, from Table 16, Energy bank progressed by 3.2% using MPI and regressed by 0.6% based on CMPI. The Trust Bank and Unibank, also experienced a similar trend of a progress in MPI of 0.4% and 2.8% respectively and regressed on CMPI by 1.6% and 0.1% respectively. If these banks based their assessment only on the MPI, they would have been misled, into believing the firms were experiencing growth, when in actual fact, they would have experienced regress using the CMPI. Such inconsistencies emphasises the need to use the CMPI which better reflects both cost and input efficiency over time and hence, more encompassing than the MPI.

To confirm the superiority of the CMPI over the MPI, it can be observed that not a single bank that progressed on cost productivity and did not do same on input technical productivity. These findings establish the effectiveness of CMPI as a superior estimator of productivity change than MPI that can help bank managers and operations managers. Since the DEA approach is used to estimate the technical and cost Malmquist index, a Wilcoxon signed rank test was conducted to identify differences between the CMPI and the MPI. The test showed a significant difference in the indices. From Appendix P, at 0.05 significance level, given that the p-value 0.008713< 0.05, there is a significant difference between the Technical Malmquist and the Cost Malmquist Indices.

A graphical comparison of CMPI and MPI, annual trends is presented in Figure 14, reveals interesting trends. For the period 2000-2001, 2001-2002, 2002-2003 and 2003-2004, cost productivity growth experienced an upward trend until it was higher than technical productivity growth. For the period, 2004-2005, MPI and CMPI were at their worst for the entire period of

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the study. However, for the period, 2005-2006 the industry experienced a higher CMPI as compared to MPI. For the other periods on annual comparison of the study, the MPI performed better than CMPI.

During the period 2004-2005, the industry experienced the highest deterioration of cost productivity and technical productivity. This situation may be as a result of some industry dynamics, for example mandatory holdings as secondary reserves and other external environmental factors like inflation rate have negatively affected the productivity change as explained earlier.

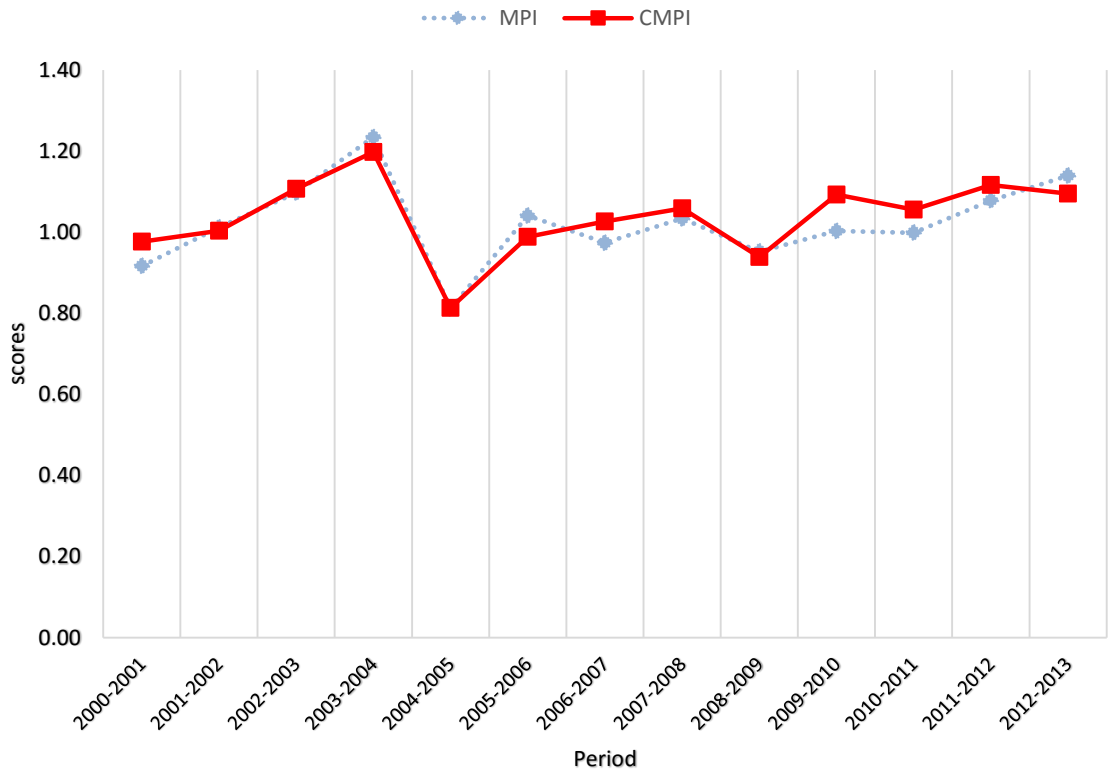

Figure 14: Dynamic Cost Malmquist and Malmquist Productivity Indices, 2000-2013

The progressive trends of CMPI between the periods 2000-2004, could be as a result of the influence of regulatory frameworks as a guideline on accounting standard, which will enhance regulatory activity and efficiency of the banking industry. To a large extent, since the industry

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has never had any productivity assessment namely technical or cost, this study presents banks' operations managers and researchers the avenue for effective policies prescription for the industry.

5.5 Competition and Ownership-structure and the CMPI of Ghanaian banks

This study did not only estimate the CMPI of banks in Ghana, but also investigated potential exogenous factors or environmental determinants that could affect dynamic cost productivity of banks. These uncontrollable covariates include bank-specific characteristics,(competition, size, universal banking license, and ownership-type) market-specific features (policy rate, treasury bill rate, and capitalization) and macroeconomic conditions (growth rate, and inflation rate) apart from bank (Drake et al., 2006; Kiymaz, 2004; Lozano-Vivas, Pastor, & Pastor, 2002; Pasiouras & Kosmidou, 2007).

Therefore a second-stage analysis was conducted by regressing the cost productivity scores on the exogenous variables (competition, size, universal banking license, ownership-type, policy rate, Treasury bill rate, capitalization, growth rate, and inflation rate). However, to ensure the statistical accuracy of the estimates, we employ the double-bootstrap truncated regression method suggested by Simar and Wilson (2011); Simar and Wilson (2007). From Table 17, the second stage variables were tested for multicollinearity using the Pearson correlation matrix.

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Table 17: Correlation Matrix for Explanatory Variables

Variable	CMPI	HHID	SIZE	INF	GDP	CAP	OWN	PR	TBILL	UBBL
CMPI	1.00									
HHID	0.00	1.00								
SIZE	-0.16***	-0.4***	1.00							
INF	0.04	0.36***	-0.45***	1.00						
GDP	0.00	-0.27***	0.33***	-0.51***	1.00					
CAP	-0.09	0.05	0.19***	0.07	-0.04	1.00				
OWN	0.13**	-0.07	0.06	-0.07	0.05	-0.08	1.00			
PR	0.03	0.67***	-0.51***	0.74***	-0.57***	0.07	-0.10	1.00		
TBILL	0.02	0.45***	-0.17***	0.49***	-0.45***	0.01	-0.06	0.8***	1.00	
UBBL	0.04	-0.71***	0.46***	-0.29***	0.33***	-0.05	0.10	-0.8***	-0.58***	1.00

***P < 0.01and **P < 0.05

Note that the independent variables do not exhibit any multi-collinearity since the correlation between the variables are very weak. To further confirm the Pearson correlation results, a variance of inflator factor (VIF) was estimated for the explanatory variables as well. The VIF is a widely used measure of the degree of multi-collinearity between independent variables as a confirmatory measure (O'brien, 2007). The rule of thumb using the VIF states that a value less than 10 should be included in the regression analysis. Following the VIF analysis, none of the explanatory variables were more than 10. Therefore, there is no evidence of multi-collinearity between the variables.

The study applied the two-stage bootstrapped truncated regression with 2000 replications as proposed by Simar and Wilson (2007), with the R-Software 2.14.0 package. Note that the second-stage analysis investigates the effect of exogenous factors on dynamic cost productivity of banks in Ghana for the period 2000-2013. The estimated coefficients and significance levels are shown in Tables 18 and 19. Two measures of competition are used for comparative purposes. Table 18 uses the HHI whilst Table 19 uses the BI to proxy competition.

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Table 18: Bootstrapped Truncated Regression with HHI (2000-2013)

Variable	Original	Bias	SE	Bias Corrected	pLL (95%)	pUL (95%)	Sig
(Intercept)	0.7158	0.0187	1.4671	0.6971	0.7158	-2.4913	
HHID	-0.0265	-0.0081	0.3306	-0.0184	-0.0265	-0.6516	**
SIZE	-0.1461	-0.0054	0.0480	-0.1408	-0.1461	-0.3911	**
INF	-0.0518	-0.0017	0.0228	-0.0501	-0.0518	-0.1545	**
GDP	0.0324	0.0007	0.0212	0.0317	0.0324	0.0028	**
PR	0.1486	0.0035	0.0691	0.1450	0.1486	-0.0552	
TBILL	-0.0072	-0.0001	0.0170	-0.0071	-0.0072	-0.0505	**
CAP	-0.0447	0.0086	0.1062	-0.0533	-0.0447	-0.2463	**
OWN	0.2131	-0.0029	0.0966	0.2160	0.2131	0.0414	**
UBBL	1.3782	0.0348	0.4546	1.3434	1.3782	-0.1570	
Sigma	0.6807	-0.0170	0.0410	0.6977	0.6807	0.4132	**

HHID is Herfindahl Index for Deposits, *SIZE*= Log of total assets, *GDP*= Annual rate of growth, *INF*= Annual Inflation, PR= Policy Rate, TBILL= Treasury Bill Rate (For GDP, INF, PR and TBILL the *2nd period values were used to represent the year of focus. CAP= Dummy* Listed Banks, *OWN= Dummy* Ownership Type and UBBL= Dummy for Universal Banking Business License.

**P < 0.05

Table 19: Bootstrapped Truncated Regression with Boone Indicator (2000-2013)

Variable	Original	Bias	SE	Bias Corrected	pLL (95%)	pUL (95%)	Sig
(Intercept)	1.3457	0.0577	1.3590	1.2880	-1.1937	4.3064	
BI	0.0349	0.0032	0.0342	0.0317	-0.0179	0.1190	
SIZE	-0.1457	-0.0055	0.0992	-0.1402	-0.3881	-0.0012	**
INF	-0.0398	-0.0009	0.0373	-0.0389	-0.1237	0.0241	
GDP	0.0257	0.0004	0.0159	0.0253	0.0007	0.0623	**
PR	0.1167	0.0015	0.1055	0.1152	-0.0639	0.3482	
TBILL	-0.0052	0.0001	0.0193	-0.0053	-0.0452	0.0310	
CAP	-0.0461	0.0089	0.1242	-0.0550	-0.2467	0.2494	
OWN	0.2119	-0.0023	0.0921	0.2143	0.0392	0.4104	**
UBBL	1.1719	0.0225	0.8717	1.1494	-0.2321	3.1094	
sigma	0.6787	-0.0169	0.1471	0.6956	0.4131	0.9839	**

**P < 0.05

Results from Table 18 show that many of the second-stage regressors are significant. HHID is used to proxy for competition in the Ghanaian banking industry. HHID significantly and negatively affects CMPI. This means an increase in HHI means less competition in the banking industry. This finding does not supports Hick's (1935) quiet life hypothesis, which states that an increase in banks monopoly does not translate into decrease in efficiency or productivity.

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However, it agrees with the efficient hypothesis structure by Demsetz (1973), which posits that a firm (bank), which operates more efficiently than its competitors experiences a lower operational costs. The result is similar to findings in other emerging economies like Uganda, studied by Hauner and Peiris (2008), India studied by Sanyal and Shankar (2011), and Ghana studied by Alhassan and Ohene-Asare (2013). These studies found positive and significant impact of competition on banks performance (efficiency and productivity). However, these studies neither used the two-stage bootstrapping truncated second stage analysis nor assessed the dynamic cost productivity of banks.

Similar to studies by Drake, (2001) and Murillo-Melchor et al., (2010), this study found size of banks in Ghana to negatively influence their dynamic cost productivity. The estimated effect of size in the Ghanaian banking industry does not provide evidence of economies of scale. This means that in the banking industry large size does not necessarily make banks cost productive over time. Arguably, an optimal size in relation to input quantity and price and the output produce to make banks cost productive rather than the desire to increase in size.

Next, considering the macroeconomic factors inflation and GDP, inflation negatively impacts on the dynamic cost productivity of banks in Ghana. This finding is similar to other studies such as by Athanasoglou et al. (2008) and Vong and Chan (2009), who found a negative relationship between the rate of inflation and performance of banks. The findings mean that, if inflation rates are high, it will cost banks more to mobilize deposits thereby making them regress on cost productivity. Also, there is a significantly positive link between economic growth rate (GDP) and dynamic cost productivity. Generally, higher economic growth encourages banks to lend more, which permits them to charge higher margin and improve the quality of their assets. Therefore, a higher economic growth improves the demand for money leading to a growth on cost productivity of banking industry.

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Next was capitalization, whether or not banks listed on the Ghana Stock Exchange (GSE) are more cost productive than tose not listed. The result showed that listed banks are likely to regress on their cost productivity as compared to banks not-listed. This implies, listed banks in Ghana have not fully taken advantage of listing on the stock to be cost productive. This is so because the inefficiencies of listed banks can reflect in their stock prices and this can affect their cost productivity (Beccalli, Casu, & Girardone, 2006). This finding is different from a study in India which found capitalised or listed banks to be more productive than non-listed banks (Das, 2002). However, Das (2002), did not use a two-state double bootstrapping in the second-stage analysis which could bias the result.

Regulatory variables like policy rate (PR) and Universal Banking License have no significant impact on dynamic cost productivity during the study period. This implies Bank of Ghana's introduction of the Universal Banking License does not significantly influence the cost productivity of banks. Furthermore, the policy rate set by the Bank of Ghana does not influence dynamic cost productivity. This is surprising since the rate influence the interest on loans which could positively or negatively affect non-performing loans which affect the cost productivity.

Ownership is found to be significant and positively related to dynamic cost productivity. This implies that foreign banks on average increased their cost productivity by 0.2160 as compared to local banks. The result is similar to other studies in Ghana - Adjei and Chakravarty (2012); Saka et al. (2012), Nigeria- Beck et al. (2005), Hauner and Peiris (2008), entire Africa, Figueira et al. (2006). These studies found ownership type to significantly influence dynamic efficiency and productivity of banks. This is possible because foreign-owned banks have superior transferable technological advantage due to their country of origin. Furthermore, even in some emerging and developed countries, studies have shown that some foreign banks outperform their local counterparts (Das et al., 2005; Havrylchyk, 2006; Berger et al., 2009). These findings are similar to Claessens et al. (2001) who documented significantly positive impact of

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foreign banks efficiency in developing economies banking industry. However, Ongore and Kusa (2013), in a study on the influence of foreign ownership in Kenyan banking industry, found that foreign ownership in the Kenyan banking industry is less likely to influence the efficiency of the banking industry.

The result shows that, when a bank is foreign–owned, there is a higher possibility of cost productivity progress, given the potential advantage that foreign management brings to the industry. This is in line with Dunning's (1973) hypothesis (ownership specific effect). Therefore, the superiority in cost productivity is likely to be entirely due to managerial factors which help take advantage of the falling price between two periods and technological advancement in the Ghanaian banking industry. This implies local banks need to benchmark their performance in relation to foreign banks to help benefit from the technological spill over. However, since information to benchmark is seen as strategic to every firm (banks), there is the need for operation managers of local banks to put in much effort to be cost productive over time.

Comparing the significance of the variables in Table 18 to 19, only three variables (size, GDP and OWN) are significant. Using HHI and BI as proxies for competition, shows that HHI significantly influence dynamic cost productivity in the Ghanaian banking industry. Furthermore, the type of ownership, size and GDP all significantly influence CMPI. This study considered the use both HHI and BI in the banking industry as a measure of competition in relation to dynamic cost productivity. This helps to identify the variation if any in the two methods.

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CHAPTER SIX

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.0 Introduction

The previous chapter presented the findings of CMPI and its components and compared the dynamic cost productivity index with the dynamic technical productivity index. Finally, the cost productivity indices were regressed on possible environmental factors of banks in Ghana. Chapter six is divided into three sections. Section one summarises key findings from the empirical analysis. Section two presents the conclusions based on the findings previously presented. The final section provides implications and policy prescriptions for operations managers and directions for further research.

6.1 Summary of the Study

This study uniquely contributes to the productivity analysis literature by adopting the cost Malmquist productivity index of Maniadakis and Thanassoulis (2004), to assess dynamic cost productivity in the banking industry. This is based on the linear programming technique called Data Envelopment Analysis. The aim is to assess the sources of cost productivity and how bank to choosin the optimal mix of inputs given the input prices over time. The study makes another contribution by nonparametrically testing for the significant differences between dynamic technical productivity and dynamic cost productivity in order to document the bias encountered for ignoring allocative efficiency change and price effect. Finally, the study is the first to investigate the impact of environmental variables on dynamic cost productivity using the innovative truncated-bootstrapped regression of Simar and Wilson (2007). An unbalanced panel data of all banks in Ghana for the period 2000-2013 was used. The annual average data set of 28 banks was sourced from the annual reports of the individual banks over the study

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period and cross-validated with similar data from the research unit of the Bank of Ghana. The key findings of the study are as follows:

a. The Ghanaian banking industry experienced cost productivity growth for the period under study. Yet, majority of the individual banks that progressed on cost productivity are foreign banks. The best performing local banks are clearly limited, creating the impression that they did not fully benefit from the technological spill overs and managerial innovations of the foreign banks.

b. For the period of the study, the industry performed best in the year 2003-2004 an indication of several internal such as improved regulatory activities and external variables including increasing economiuc growth and reduce inflation, working to the advantage of the industry which could be harnessed for the sustainability of the industry.

c. The average cost productivity growth of the Ghanaian banking for the period is mostly attributable to price changes. These changes reflect the minimum cost at which banks' outputs are produced in one period compared to another. This could be as a result of shift in the production boundaries (TC) or the shifts of relative input price changes or both. For a better understanding of the sources of cost productivity growth, the second stage decomposition confirms that improvement in prices paid for the inputs by the banks are largely responsible (shift in input price) for general improvement in cost productivity. Additionally, the ability of the industry to use the available inputs (deposits, labour and fixed assets) to produce outputs (loans and advances) based on innovation such as technological innovations (electronic banking, debit and credit cards, automated teller machines (ATM) etc.) has played a significant role as well. Furthermore the role of operations managers of the banks to obtain maximum output given the set of inputs usage

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(TEC) to some extent played a role as well. The contributions of the components to cost productivity growth, makes the price effect change (PEC) as the highest, followed by technical change (TC), then technical efficiency change (TEC) as the least contributor.

At the individual bank level, 14 banks, representing 50% of the total banks, experienced growth in their cost productivity. Majority of them are foreign-owned. This indicates that foreign banks employ better management practices in their operations over time relative to other banks in terms of cost reduction. Annually, the cost productivity growth in the industry for the study period, 2000 to 2013, was at its highest growth of 20% in 2003-2004. This situation is as a result of allocative efficiency change (AEC) and technical change (TC) being at their highest of 54% and 20% respectively justifying the importance of allocative efficiency in productivity analysis. The CMPI is influenced by the technological innovations, ability to manage price and operations managers' ability to minimise inputs to obtain the highest outputs. This is influenced largely by innovations such as new technologies and new products and services in the industry and improvement in the efficiencies of the banks.

d. Comparing the CMPI and MPI, if banks were to use the traditional Malmquist, they may not get a full understanding of productivity change over time. This is because more banks experienced technical productivity growth than cost productivity growth. This indicates that reliance on traditional Malmquist may overestimate productivity change if cost of production is not controlled for in the productivity estimation. This shows the deficiency of the traditional index to guide operations managers of the banks in effective planning over time. This increases the need for the use of CMPI as an improved total factor productivity measure. This is further confirmed by the geometric mean of both CMPI and

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MPI since significance differences were recorded in the two averages. Interestingly, the annual trends showed that it is only in one period that CMPI showed a higher productivity trend as compared to the MPI. This implies that firms should monitor their annual cost productivity to keep the management of expenditure, while maximizing outputs.

e. The effect of environmental factors on cost productivity revealed that cost productivity change in the Ghanaian banking industry is significantly influenced by competition, size, inflation, growth rates, Treasury bill rates and ownership type. An increased competition causes the bank to be cost efficient over time. Banks with comparatively larger total assets (bigger banks), mainly foreign banks tend to experience cost productivity regress. Foreign-owned banks have significantly higher cost productivity indices that domestic banks. This shows that foreign-owned banks are more likely to take advantage of industry technological innovations coupled with managerial abilities and price effect than locally-owned banks. Macroeconomic conditions do significantly influence dynamic cost productivity in the Ghanaian banking industry implying higher growth rate is good for banks to increase their outputs and be cost productive. However, an increased inflation causes banks to regress on cost productivity since it cost them more in mobilizing deposits when inflation is high. On the other hand, a lower inflation rate makes banks more cost productive since the effect of margin/spread is positive. Industry-specific variables, Treasury bill rate and capitalization significantly influence the cost productivity of banks. Specifically, higher Treasury bill rate meant the banks have to compete with government in mobilizing deposits, which may negatively affect them. If banks compete with government in mobilizing deposits, they cannot afford the higher rate if they want to be cost productive. This showed the negative relationship between cost productivity and Treasure Bill Rate. Therefore, an increase in Treasury bill rate negatively affect the cost productivity of banks. It is also worth noting

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that, the average listed bank does not necessarily benefit from the public funds, which is likely to dampen their dynamic cost productivity. Policy rate and universal banking license do not significantly influence the dynamic cost productivity of bank in Ghana. This, coupled with the earlier findings, indicates bank-specific dynamics, industry and economic conditions all influence dynamic cost productivity of banks in Ghana. Management therefore needs to master banks' specific dynamics including banking regulatory guidelines and input variables and their effect on cost productivity trends of banks in Ghana.

6.2 Conclusions of the Study

The results of this empirical work have indicated some important factors to consider when assessing the productivity changes of banks. First, it has shown that cost efficiency is more encompassing than technical efficiency. It has shown that, the Ghanaian banking industry experienced cost productivity growth for the period under the study. Majority of the individual banks that progressed on cost are foreign banks implying that majority of the local banks regressed on cost productivity. The results show that most of the local firms fail to take advantage of the innovations in the industry. Some of which include reducing the number of fully-fledged bank branches to sales points. Since, the sales points are cheaper to maintain and require less of some inputs and furthermore reduces physical contact of customers with the bank by increasing online banking and automated teller machines (ATM) and similar technological innovations. Local banks therefore need to introduce cost saving technological innovations in their operations and take advantage of progressive cheaper cost of inputs.

To appropriately account for the sources of efficiency change, the decomposed CMPI evidently showed that, the growth in the cost productivity in the Ghanaian banking industry is related largely to price effect, technical change and technical efficiency change for the period. This

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means improvement of banks innovations is relevant and changes in prices of inputs over time is critical to the success of the banks. Therefore, if banks' operations managers desire to be cost productive, a cost productivity analysis will be effective, since technical productivity does not fully capture the issues that relate to cost.

The findings of this study demonstrate that for a more appropriate complementary productivity analysis in the banking industry there is the need to consider dynamic cost productivity since it shows dual indices, which capture both the cost and the input (quantity) productivity. This demonstrates if firm concentrate on only the technical productivity change when in actual fact with some additional information on the prices of the inputs, the firm can have a more holistic total factor cost productivity change.

Also, based on the performance of the foreign banks, it is not surprising that the cost productivity progress in the Ghanaian banking industry is significantly influenced by the entry of foreign-owned banks in the industry. This study also suggests that increased competition (0.0265), size of the bank (0.1461), inflation (0.0518) and Treasury bill rates (0.0072) negatively and significantly influence the cost productivity of banks in Ghana. However, increasing growth rate of the Ghanaian economy positively influence the cost productivity of banks in Ghana.

6.3 Recommendations

The findings and conclusions of this study provides some recommendations on policy, practice and further research. Among them are the following:

For policy:

a. This assessment of dynamic cost productivity better informs regulatory authorities to formulate policies which should effectively improve cost productivity of the industry in the

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future. The effect of some industry-specific variables gives a clear understanding for the regulatory authority to develop policies which are guided by the impact of those variables.

b. Considering the negative influence of inflation rate and Treasury bill rate on dynamic cost productivity of banks in Ghana, it is important for the Bank of Ghana, the regulatory authority to implement policies that reduce the impact of an increasing inflation and Treasury bill rate on the banks. For example, a reduction in company taxes to encourage greater investment and increase risk-taking, to increase demand for money.

c. Foreign ownership and dynamic cost productivity in the Ghanaian banking industry is positively related. However, it does not necessarily mean that local banks are disadvantaged. Therefore it is important, as a policy measure to encourage the benchmarking of the best performing foreign banks so as to increase the cost productivity of local bank.

For practice:

a. The limited number of local banks who progressed on cost indicates their inability to compete favourably. Therefore, the operations managers of the local banks should manage their cost of inputs by assessing their cost productivity periodically to ascertain their performance.

b. Given the importance of the banking industry, this study raises the pertinent issue for operations managers to consider the cost productivity to be a relatively better productivity assessment of their firms. The effect of price and innovations is relevant for critical management decision and holistic productivity progress.

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c. Although some local banks have progressed on cost productivity for the period, majority of them performed poorly implying that these local banks need to reorganise and take advantage of some industry gains, example, technological progress.

d. The entire industry is allocatively inefficient for the period under the study. The banks' operations managers' ability to effectively mix the inputs (labour cost, deposits and fixed assets) given their changing price to produce outputs (loans and advances and investments) is not the best. Therefore, the operations managers need to understand the best way to blend their minimum cost inputs to produce outputs and avoid wastage which translate into cost.

e. The increase in foreign ownership in banking industry is responsible for the growth being experienced. Furthermore, operations managers of all bank should understand their optimal level in relation to their operations. This is important for them to effectively know the amount of labour needed, the number and type of bank branches to operate in into to experience economies of scale

For further research:

a. The current study did not consider undesirable output (non-performing loans, NPLs) which remains a significant burden for bank productivity (Barros, Managi, & Matousek, 2012). In view of this, future research can consider undesirable or bad output to adequately account for their impact on the cost productivity change of banks in Ghana. Furthermore, there is the need for a test for CRS and VRS, using Simar and Wilson (2002) to conclusively decide which one is better for the assessment of cost productivity in the banking industry.

b. This study had only one group for all banks, whether foreign-owned and local ones, state-owned etc., for the cost productivity, ignoring the unique differences which could relatively

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influence the cost productivity of the different groups. However, as stated by Camanho and Dyson (2006), DMUs can be categorised into operating units making it possible to adequately assess their dynamic cost productivity relative to their group frontier. Therefore, as proposed by Thanassoulis et al. (2015), as an extension on Maniadakis and Thanassoulis (2004) CPMI, further research can be done to determine the relative productivity in terms of the different groups. This should be coupled with their decomposition, which may provide useful information for improving further management performance relative to their groups. It may enable regulatory authorities to identify the best practices across groups.

c. The CMPI could be biased by outliers, noises and sampling variations. The CPMI could thus be bootstrapped in order to purge these indices off their potential sensitivity to sampling variations (Simar & Wilson, 2000).

d. Finally, the concept of "innovators" may be considered so as to identify banks that can possible become cost innovators in the Ghanaian banking industry. This will explain whether the technological change is attributable to industry dynamics or the cost productive banks are driving the cost productivity growth. The analysis could also be extended to metafrontier CMPI.

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APPENDICES

APPENDIX A: COST PRODUCTIVITY MALMQUIST INDEX (CMPI) OF THE GHANAIAN BANKING INDUSTRY FOR THE PERIOD 2000-2013

NO	DMU	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	Geomean
1	ACCESS										0.8089	1.0355	0.9226	1.3265	**1.0019**
2	ADB	0.8314	0.7854	1.2387	1.0192	1.0164	0.9117	0.5382	1.2432	0.8926	2.1196	0.7100	1.0806	0.8446	**0.9647**
3	BARODA										2.9117	1.8133	0.5832	1.4838	**1.1240**
4	BBG	0.5835	1.0822	1.0977	0.7819	1.0736	1.0362	0.7913	0.8492	1.1085	0.9934	1.4089	1.2072	1.2539	**0.9962**
5	BOA	4.2194	1.1635	1.6941	1.2358	0.3463	0.7215	1.2964	0.9865	1.2393	0.9745	1.3866	1.3412	0.9548	**1.1620**
6	BSIC									0.1996	2.4673	1.4953	1.1790	0.8582	**0.9776**
7	CAL	1.1602	1.1025	1.0863	0.5849	0.8872	1.2776	0.8592	1.1427	0.8345	1.0197	0.9723	1.4615	1.1215	**1.0158**
8	ECOBANK	0.8107	1.5649	0.8327	0.9043	1.2409	1.0521	0.8005	0.8959	0.9415	1.0870	1.3383	1.1965	1.1855	**1.0434**
9	ENERGY												0.6470	1.4366	**0.9944**
10	FAMB	0.3569	0.9550	1.6208	1.2089	1.0080	0.8969	0.8359	1.1542	0.6393	1.2911	1.1675	0.9212	0.8282	**0.9368**
11	FBL							0.6376	0.8472	1.0569	0.6930	1.1410	1.2291	0.8803	**0.9464**
12	GCB	1.3910	1.1721	0.7102	0.9316	0.8293	0.9416	1.0544	1.0479	0.9500	0.6875	0.5421	1.1630	0.9835	**0.9277**
13	GTB							1.2024	4.2074	0.7726	1.0387	0.8798	1.5704	0.9859	**1.1406**
14	HFC				0.7978	0.9302	0.8883	0.9361	1.1888	0.8009	0.8481	0.9737	1.3166	1.1276	**0.9751**
15	IBG							2.6244	1.6846	0.9631	1.0373				**1.1210**
16	ICB	0.8319	1.2048	0.8755	3.8602	0.4704	0.9062	0.7636	1.0980	2.2665	0.8742	1.2199	0.9646	1.1478	**1.0946**
17	NIB	1.0537	1.0057	1.5377	1.0607	0.7641	0.7143	1.1554	1.1782	0.9379	0.9421	1.1725	0.9966	1.0641	**1.0268**
18	PBL	1.1579	0.9308	1.0988	2.6071	0.4021	0.9286	0.8603	0.9158	0.9429	0.8712	0.9996	1.2900	0.9750	**0.9951**
19	ROYAL BANK														**1.0000**
20	SCB	0.6955	0.8417	1.2367	1.2750	1.4629	1.2306	1.2773	0.6511	1.2469	0.8999	1.0973	1.3362	1.0586	**1.0699**
21	SG	0.8582	1.0263	1.0881	0.8556	1.2355	0.7056	0.9631	1.0246	0.7437	1.0720	0.5757	1.3065	1.2157	**0.9501**
22	STANBIC	1.4898	0.9930	1.9304	1.5160	0.9478	0.7845	1.0959	0.8456	1.2601	1.1728	1.0597	0.8599	0.8005	**1.0940**
23	TRUST	0.5434	0.9744	1.2644	4.9009	0.2747	1.2183	0.6781	1.1125	0.8385	1.1648				**0.9838**
24	UBA						1.5196	1.9635	1.0967	1.5425	1.5514	1.5798	1.6514	1.6088	**1.3082**
25	UMB	1.0875	0.8703	1.1209	1.4050	0.8916	1.3829	0.9885	1.0930	0.7684	0.6081	1.0115	1.3435	1.1424	**1.0285**
26	UNIBANK		1.4317	1.2287	0.4264	1.0631	1.0072	0.9145	0.8048	1.0526	1.2508	1.1127	1.0739	1.0642	**0.9992**
27	UT BANK	1.0032	0.4867	1.0747	6.4878	0.1454			1.0033	0.8444	1.0861	1.1340	1.1033	1.0845	**0.9637**
28	ZENITH							2.6777	0.7405	1.1305	1.3436	0.7501	1.3125	1.8768	**1.1412**
	Geometric Mean	**0.9763**	**1.0031**	**1.1071**	**1.1980**	**0.8129**	**0.9886**	**1.0265**	**1.0584**	**0.9391**	**1.0931**	**1.0555**	**1.1166**	**1.0950**	**1.0318**

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APPENDIX B: MALMQUIST PRODUCTIVITY INDEX OF BANKS IN GHANA FOR THE PERIOD 2000-2013

NO	DMU	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	Geomean
1	ACCESS										0.461	0.842	0.920	1.037	**0.926**
2	ADB	0.929	0.781	1.202	0.987	1.067	0.905	0.733	1.162	0.874	1.514	0.792	1.002	0.987	**0.976**
3	BARODA										2.407	1.473	0.702	1.410	**1.101**
4	BBG	0.618	1.198	1.134	0.860	1.115	1.044	0.943	0.839	1.045	0.917	1.040	1.098	1.101	**0.983**
5	BOA	1.962	1.323	1.384	2.704	0.229	0.570	1.443	0.976	1.340	0.795	1.382	1.282	0.978	**1.096**
6	BSIC									0.410	1.473	1.110	0.957	1.192	**0.980**
7	CAL	1.080	1.097	1.111	0.737	0.859	1.420	0.903	1.034	0.882	1.163	0.861	1.372	1.080	**1.029**
8	ECOBANK	0.738	1.354	0.820	0.885	1.272	1.097	0.951	0.896	0.982	0.926	1.165	1.078	1.151	**1.010**
9	ENERGY												0.823	1.827	**1.032**
10	FAMB	0.433	1.135	1.457	0.940	1.103	0.900	0.794	1.301	0.556	1.272	1.018	1.005	1.149	**0.958**
11	FBL							0.604	0.804	1.206	0.715	1.221	1.240	0.948	**0.962**
12	GCB	1.275	0.964	0.935	0.914	0.957	0.998	1.205	1.067	0.932	0.659	0.547	1.309	0.980	**0.956**
13	GTB							0.757	2.730	0.684	0.961	0.984	1.076	0.975	**1.026**
14	HFC				0.698	0.747	1.135	0.888	1.135	0.779	0.848	0.844	1.181	1.094	**0.937**
15	IBG							0.996	1.359	0.967	1.064				**1.026**
16	ICB	0.772	1.488	0.878	3.778	0.475	0.856	0.843	1.007	2.406	0.873	1.075	1.056	1.165	**1.105**
17	NIB	0.966	0.948	1.357	1.190	0.614	1.029	1.015	1.112	1.076	0.917	1.090	0.914	1.088	**1.009**
18	PBL	1.114	1.082	1.023	2.316	0.582	1.075	1.120	0.990	1.026	0.954	0.878	1.180	0.971	**1.053**
19	ROYAL BANK														**1.000**
20	SCB	0.620	0.773	1.250	1.167	1.270	1.319	0.941	0.840	1.157	0.900	1.015	1.383	1.108	**1.032**
21	SG	0.871	1.072	1.078	0.806	1.294	0.834	0.919	0.904	0.789	0.879	0.920	1.074	1.318	**0.968**
22	STANBIC	1.043	0.877	1.829	1.334	0.997	1.359	1.147	0.833	1.137	1.114	1.013	0.871	1.236	**1.112**
23	TRUST	0.499	1.113	1.354	4.320	0.310	1.484	0.745	0.989	0.834	1.144				**1.004**
24	UBA						1.267	1.369	1.089	1.216	1.088	1.413	1.530	1.430	**1.170**
25	UMB	0.883	0.919	1.153	1.461	0.860	1.354	1.000	1.056	0.782	0.578	1.014	1.285	1.191	**1.013**
26	UNIBANK		1.350	1.159	0.675	1.072	0.993	0.894	0.919	0.822	1.350	1.132	1.026	1.208	**1.028**
27	UT BANK	0.855	0.450	1.063	7.253	0.156			0.938	1.212	1.201	0.986	1.032	1.118	**0.975**
28	ZENITH							1.642	0.888	0.827	1.365	0.691	1.226	1.581	**1.063**
	Geometric Mean	**0.917**	**1.012**	**1.097**	**1.234**	**0.812**	**1.041**	**0.974**	**1.034**	**0.952**	**1.003**	**0.998**	**1.078**	**1.139**	**1.017**

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APPENDIX C: OVERALL EFFICIENCY CHANGE (OEC) OF GHANAIAN BANKING INDUSTRY FOR THE PERIOD 2000-2013

NO	DMU	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	Geomean
1	ACCESS										0.6790	0.7117	0.5697	1.5583	**0.9370**
2	ADB	0.8778	1.0263	1.1641	1.0336	1.0808	0.9640	0.8978	1.0143	0.8316	1.1065	0.8385	0.6060	1.3815	**0.9690**
3	BARODA										1.0000	1.0000	1.0000	1.0000	**1.0000**
4	BBG	0.6863	1.2016	1.2127	1.0000	1.0000	1.0000	1.0000	0.6579	0.8344	0.8857	2.0568	0.6167	1.0398	**0.9664**
5	BOA	2.6204	1.2344	0.7034	2.0853	0.7117	0.8583	1.1562	1.1559	0.7073	0.9645	0.9567	1.0665	0.7745	**1.0583**
6	BSIC									0.6163	1.6809	1.2355	0.6447	0.9591	**0.9822**
7	CAL	0.8726	1.3231	0.8576	1.8213	0.5882	1.4295	0.6562	1.1558	0.9389	1.2944	1.1667	0.7582	0.7045	**0.9894**
8	ECOBANK	0.5030	2.5645	0.8256	1.1411	0.8249	1.2149	0.8220	0.8755	1.0438	1.3305	0.9392	0.5928	1.3663	**0.9941**
9	ENERGY												0.3936	0.8959	**0.9230**
10	FAMB	0.4970	2.0644	0.7894	1.9779	0.6234	0.9586	0.9683	1.9782	0.3728	0.9034	1.4805	0.5695	1.0491	**0.9546**
11	FBL							0.9306	0.6941	0.8145	0.8779	1.0124	0.6750	0.8762	**0.9059**
12	GCB	1.0000	1.0000	0.9455	1.0116	0.8027	1.1863	1.0420	1.0537	0.8504	0.8094	0.4865	1.4531	0.7985	**0.9299**
13	GTB							1.4475	2.5333	0.5623	0.9604	0.6318	1.0572	0.9338	**1.0164**
14	HFC				1.4060	0.7943	1.0421	0.7077	1.0336	1.0307	1.2970	0.8224	0.9347	1.0568	**0.9940**
15	IBG							1.0670	1.1786	0.6603	1.0327				**0.9882**
16	ICB	1.1085	0.6087	1.4252	1.1859	1.1346	1.0000	0.8981	1.0364	0.7900	0.4843	1.3334	0.7297	0.9527	**0.9367**
17	NIB	0.4275	2.8833	1.1947	0.9661	0.5648	0.9858	0.9236	1.0230	1.1141	0.8710	1.4595	0.6368	0.9874	**0.9693**
18	PBL	1.2659	0.9191	0.8341	2.5436	0.7073	0.8752	0.8384	1.0278	1.0496	1.1031	1.0548	0.7566	1.0020	**1.0154**
19	ROYAL BANK														**1.0000**
20	SCB	0.6236	1.8956	0.6548	1.4724	0.9083	1.1196	1.0199	0.6770	1.2115	0.7664	1.1548	1.0966	0.4314	**0.9330**
21	SG	0.7543	1.8586	0.6147	1.7248	0.8650	1.0269	1.0779	1.0271	1.0739	1.0000	0.6895	0.9340	1.0849	**1.0071**
22	STANBIC	1.9408	0.8516	1.7657	1.4881	1.0520	0.7140	1.4005	0.8436	1.0467	0.7602	1.4896	0.5248	1.0510	**1.0737**
23	TRUST	0.6376	0.8093	1.5135	1.8563	0.7827	0.9675	0.9031	0.9510	1.0048	0.9507				**0.9920**
24	UBA						1.0682	1.6331	1.1819	0.7621	0.6993	1.6865	0.8753	1.2245	**1.0542**
25	UMB	0.9585	2.1788	0.7680	1.6094	0.9378	1.0990	0.5477	1.2025	0.9464	0.5427	1.0538	0.8061	0.7795	**0.9610**
26	UNIBANK		1.6558	0.6263	3.0978	0.4998	1.1559	0.8394	0.9448	1.1050	1.4971	0.9160	0.5812	0.7790	**1.0007**
27	UT BANK	0.6688	0.7488	1.0954	4.1229	0.3361			0.8487	0.7811	1.8403	0.8959	0.6788	0.8879	**0.9482**
28	ZENITH							1.4759	0.8280	0.9384	1.6919	0.4464	1.2051	1.1999	**1.0175**
	Geomean	**0.9125**	**1.1839**	**0.9697**	**1.3583**	**0.8370**	**1.0165**	**0.9828**	**1.0250**	**0.8720**	**0.9873**	**0.9984**	**0.7786**	**0.9662**	**0.9819**

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APPENDIX D: COST TECHNICAL CHANGE (CTC) OF GHANAIAN BANKING INDUSTRY FOR THE PERIOD 2000-2013

NO	DMU	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	Geomean
1	ACCESS										1.191	1.455	1.619	0.851	**1.069**
2	ADB	0.947	0.765	1.064	0.986	0.940	0.946	0.600	1.226	1.073	1.916	0.847	1.783	0.611	**0.996**
3	BARODA										2.912	1.813	0.583	1.484	**1.124**
4	BBG	0.850	0.901	0.905	0.782	1.074	1.036	0.791	1.291	1.329	1.122	0.685	1.957	1.206	**1.031**
5	BOA	1.610	0.943	2.408	0.593	0.487	0.841	1.121	0.853	1.752	1.010	1.449	1.258	1.233	**1.098**
6	BSIC									0.324	1.468	1.210	1.829	0.895	**0.995**
7	CAL	1.330	0.833	1.267	0.321	1.508	0.894	1.309	0.989	0.889	0.788	0.833	1.927	1.592	**1.027**
8	ECOBANK	1.612	0.610	1.009	0.792	1.504	0.866	0.974	1.023	0.902	0.817	1.425	2.018	0.868	**1.050**
9	ENERGY												1.644	1.603	**1.077**
10	FAMB	0.718	0.463	2.053	0.611	1.617	0.936	0.863	0.583	1.715	1.429	0.789	1.617	0.789	**0.981**
11	FBL							0.685	1.221	1.298	0.789	1.127	1.821	1.005	**1.045**
12	GCB	1.391	1.172	0.751	0.921	1.033	0.794	1.012	0.995	1.117	0.849	1.114	0.800	1.232	**0.998**
13	GTB							0.831	1.661	1.374	1.082	1.392	1.485	1.056	**1.122**
14	HFC				0.567	1.171	0.852	1.323	1.150	0.777	0.654	1.184	1.409	1.067	**0.981**
15	IBG							2.460	1.429	1.459	1.004				**1.134**
16	ICB	0.750	1.979	0.614	3.255	0.415	0.906	0.850	1.059	2.869	1.805	0.915	1.322	1.205	**1.169**
17	NIB	2.464	0.349	1.287	1.098	1.353	0.725	1.251	1.152	0.842	1.082	0.803	1.565	1.078	**1.059**
18	PBL	0.915	1.013	1.317	1.025	0.569	1.061	1.026	0.891	0.898	0.790	0.948	1.705	0.973	**0.980**
19	ROYAL BANK														**1.000**
20	SCB	1.115	0.444	1.889	0.866	1.611	1.099	1.252	0.962	1.029	1.174	0.950	1.219	2.454	**1.147**
21	SG	1.138	0.552	1.770	0.496	1.428	0.687	0.893	0.998	0.693	1.072	0.835	1.399	1.121	**0.943**
22	STANBIC	0.768	1.166	1.093	1.019	0.901	1.099	0.782	1.002	1.204	1.543	0.711	1.638	0.762	**1.019**
23	TRUST	0.852	1.204	0.835	2.640	0.351	1.259	0.751	1.170	0.834	1.225				**0.992**
24	UBA						1.423	1.202	0.928	2.024	2.219	0.937	1.887	1.314	**1.241**
25	UMB	1.135	0.399	1.460	0.873	0.951	1.258	1.805	0.909	0.812	1.121	0.960	1.667	1.466	**1.070**
26	UNIBANK		0.865	1.962	0.138	2.127	0.871	1.090	0.852	0.953	0.835	1.215	1.848	1.366	**0.998**
27	UT BANK	1.500	0.650	0.981	1.574	0.433			1.182	1.081	0.590	1.266	1.626	1.222	**1.016**
28	ZENITH							1.814	0.894	1.205	0.794	1.680	1.089	1.564	**1.122**
	Geometric Mean	**1.070**	**0.847**	**1.142**	**0.882**	**0.971**	**0.973**	**1.044**	**1.033**	**1.077**	**1.107**	**1.057**	**1.434**	**1.133**	**1.051**

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APPENDIX E: TECHNICAL EFFICIENCY CHANGE (TEC) OF INDIVIDUAL BANKS FOR THE PERIOD 2000-2013

NO	DMU	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	Geomean
1	**ACCESS**										1.1913	1.4549	1.6194	0.8512	**1.0693**
2	**ADB**	0.9471	0.7653	1.0641	0.9860	0.9404	0.9457	0.5995	1.2257	1.0733	1.9156	0.8467	1.7832	0.6114	**0.9955**
3	**BARODA**										2.9117	1.8133	0.5832	1.4838	**1.1240**
4	**BBG**	0.8502	0.9007	0.9052	0.7819	1.0736	1.0362	0.7913	1.2907	1.3285	1.1216	0.6850	1.9574	1.2059	**1.0308**
5	**BOA**	1.6102	0.9426	2.4084	0.5926	0.4865	0.8406	1.1213	0.8535	1.7521	1.0104	1.4493	1.2576	1.2328	**1.0980**
6	**BSIC**									0.3238	1.4679	1.2103	1.8288	0.8948	**0.9954**
7	**CAL**	1.3296	0.8333	1.2667	0.3212	1.5082	0.8937	1.3095	0.9887	0.8888	0.7878	0.8334	1.9275	1.5920	**1.0267**
8	**ECOBANK**	1.6119	0.6102	1.0087	0.7925	1.5042	0.8660	0.9738	1.0233	0.9020	0.8170	1.4249	2.0185	0.8677	**1.0496**
9	**ENERGY**												1.6436	1.6035	**1.0774**
10	**FAMB**	0.7181	0.4626	2.0533	0.6112	1.6168	0.9356	0.8632	0.5834	1.7147	1.4291	0.7886	1.6175	0.7894	**0.9814**
11	**FBL**							0.6852	1.2205	1.2976	0.7893	1.1270	1.8208	1.0046	**1.0447**
12	**GCB**	1.3910	1.1721	0.7512	0.9210	1.0331	0.7937	1.0119	0.9945	1.1171	0.8493	1.1143	0.8003	1.2318	**0.9977**
13	**GTB**							0.8307	1.6608	1.3740	1.0815	1.3925	1.4854	1.0558	**1.1222**
14	**HFC**				0.5674	1.1711	0.8524	1.3228	1.1502	0.7771	0.6539	1.1839	1.4086	1.0670	**0.9810**
15	**IBG**							2.4596	1.4293	1.4586	1.0044				**1.1344**
16	**ICB**	0.7504	1.9793	0.6143	3.2552	0.4146	0.9062	0.8502	1.0594	2.8692	1.8050	0.9149	1.3219	1.2049	**1.1686**
17	**NIB**	2.4645	0.3488	1.2872	1.0979	1.3529	0.7245	1.2510	1.1518	0.8419	1.0817	0.8033	1.5651	1.0776	**1.0594**
18	**PBL**	0.9147	1.0128	1.3174	1.0250	0.5685	1.0610	1.0261	0.8910	0.8984	0.7897	0.9477	1.7049	0.9730	**0.9800**
19	**ROYAL BANK**														**1.0000**
20	**SCB**	1.1152	0.4440	1.8886	0.8659	1.6106	1.0992	1.2524	0.9617	1.0292	1.1741	0.9501	1.2185	2.4537	**1.1467**
21	**SG**	1.1378	0.5522	1.7703	0.4960	1.4284	0.6871	0.8935	0.9975	0.6925	1.0720	0.8350	1.3989	1.1206	**0.9434**
22	**STANBIC**	0.7676	1.1661	1.0933	1.0188	0.9009	1.0987	0.7825	1.0024	1.2039	1.5427	0.7114	1.6384	0.7617	**1.0189**
23	**TRUST**	0.8522	1.2039	0.8354	2.6402	0.3510	1.2592	0.7508	1.1697	0.8344	1.2252				**0.9918**
24	**UBA**						1.4226	1.2023	0.9279	2.0240	2.2186	0.9367	1.8866	1.3138	**1.2409**
25	**UMB**	1.1346	0.3994	1.4596	0.8730	0.9507	1.2583	1.8048	0.9089	0.8119	1.1205	0.9599	1.6668	1.4655	**1.0702**
26	**UNIBANK**		0.8647	1.9617	0.1377	2.1271	0.8713	1.0895	0.8519	0.9526	0.8355	1.2148	1.8479	1.3662	**0.9985**
27	**UT BANK**	1.5001	0.6500	0.9812	1.5736	0.4327			1.1822	1.0809	0.5902	1.2657	1.6255	1.2215	**1.0164**
28	**ZENITH**							1.8143	0.8942	1.2047	0.7941	1.6804	1.0891	1.5641	**1.1216**
	Geometric Mean	**1.0699**	**0.8474**	**1.1417**	**0.8820**	**0.9713**	**0.9725**	**1.0444**	**1.0326**	**1.0769**	**1.1072**	**1.0572**	**1.4341**	**1.1334**	**1.0508**

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APPENDIX F: TECHNICAL CHANGE (TC) OF INDIVIDUAL BANKS FOR THE PERIOD 2000-2013

NO	DMU	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	Geomean
1	ACCESS										0.461	1.400	1.010	1.036	**0.970**
2	ADB	0.929	0.844	1.134	1.096	1.089	0.928	0.658	1.333	0.966	1.123	0.792	1.141	1.063	**0.992**
3	BARODA										2.407	1.473	0.702	1.410	**1.101**
4	BBG	0.618	1.198	1.134	0.860	1.115	1.216	0.834	1.237	1.313	0.755	1.230	1.108	1.017	**1.026**
5	BOA	0.742	1.323	1.384	2.704	0.250	1.257	0.840	1.133	0.890	0.997	1.215	1.155	1.044	**1.028**
6	BSIC									1.525	0.780	0.808	1.176	1.144	**1.020**
7	CAL	0.834	0.946	1.174	0.847	0.970	1.255	0.746	1.279	0.860	0.963	0.973	1.214	1.080	**0.997**
8	ECOBANK	0.566	1.174	1.305	0.927	1.011	1.117	0.899	1.130	1.010	0.872	1.139	1.165	1.057	**1.010**
9	ENERGY												0.635	1.011	**0.967**
10	FAMB	0.512	1.154	1.432	0.909	0.965	1.004	0.719	1.288	0.872	0.957	0.931	1.178	1.044	**0.968**
11	FBL							0.604	0.853	1.137	1.007	1.457	1.169	1.054	**1.004**
12	GCB	0.926	0.964	0.990	1.012	1.238	1.077	0.790	1.078	0.859	0.977	1.204	0.825	0.919	**0.981**
13	GTB							0.613	1.295	1.135	0.925	1.171	1.089	1.034	**1.007**
14	HFC				0.698	0.747	1.135	0.888	1.135	0.779	0.848	0.844	1.181	1.094	**0.937**
15	IBG							0.646	1.144	0.843	0.941				**0.960**
16	ICB	0.772	1.488	1.034	4.982	0.306	0.856	0.843	1.007	2.406	0.962	1.335	1.152	1.054	**1.131**
17	NIB	0.937	0.919	1.357	1.190	0.785	1.368	0.920	1.173	0.789	0.988	1.028	1.185	1.052	**1.037**
18	PBL	0.758	1.132	1.238	1.830	0.582	1.162	1.036	1.095	0.928	1.157	0.971	1.199	1.069	**1.054**
19	ROYAL BANK														**1.000**
20	SCB	0.620	0.986	1.687	0.875	1.053	1.230	0.941	0.997	1.283	1.075	1.229	1.146	1.037	**1.063**
21	SG	0.809	0.979	1.537	1.088	0.849	1.096	0.615	1.302	0.774	0.875	0.909	1.172	1.151	**0.985**
22	STANBIC	0.807	1.286	1.263	1.150	0.912	1.111	1.147	1.077	1.010	1.089	1.176	1.144	1.005	**1.083**
23	TRUST	0.636	1.092	1.157	4.045	0.310	1.484	0.745	0.989	0.834	1.144				**1.004**
24	UBA						1.085	0.680	1.224	2.468	0.825	1.330	1.137	1.025	**1.084**
25	UMB	0.626	1.043	1.400	1.019	0.793	1.360	1.020	1.047	0.891	0.949	1.035	1.169	1.079	**1.013**
26	UNIBANK		0.980	1.403	0.836	0.816	1.123	0.814	1.023	0.795	0.972	0.958	1.207	1.010	**0.982**
27	UT BANK	0.855	0.905	1.276	3.459	0.270			1.317	0.833	1.120	0.986	1.153	1.058	**1.024**
28	ZENITH							0.846	1.230	0.813	1.052	1.305	1.151	1.026	**1.025**
	Geometric Mean	**0.838**	**1.042**	**1.160**	**1.204**	**0.795**	**1.094**	**0.838**	**1.114**	**1.018**	**0.975**	**1.088**	**1.080**	**1.053**	**1.015**

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APPENDIX G: ALLOCATIVE EFFICIENCY CHANGE (AEC) OF INDIVIDUAL BANKS FOR THE PERIOD 2000-2013

NO	DMU	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	Geomean
1	ACCESS										0.5699	0.4892	0.3518	1.8306	**0.8763**
2	ADB	0.9268	1.3411	1.0939	1.0483	1.1493	1.0193	1.4976	0.8275	0.7748	0.5776	0.9902	0.3399	2.2597	**0.9734**
3	BARODA										0.3434	0.5515	1.7148	0.6739	**0.8897**
4	BBG	0.8072	1.3340	1.3397	1.2790	0.9315	0.9650	1.2637	0.5097	0.6281	0.7897	3.0027	0.3151	0.8622	**0.9375**
5	BOA	1.6274	1.3096	0.2921	3.5188	1.4628	1.0211	1.0311	1.3543	0.4037	0.9546	0.6601	0.8480	0.6283	**0.9638**
6	BSIC									1.9034	1.1451	1.0209	0.3525	1.0719	**0.9867**
7	CAL	0.6562	1.5879	0.6770	5.6709	0.3900	1.5995	0.5011	1.1690	1.0563	1.6430	1.3999	0.3934	0.4425	**0.9637**
8	ECOBANK	0.3120	4.2028	0.8185	1.4399	0.5484	1.4028	0.8442	0.8556	1.1572	1.6285	0.6591	0.2937	1.5747	**0.9471**
9	ENERGY												0.2395	0.5587	**0.8567**
10	FAMB	0.6921	4.4624	0.3844	3.2362	0.3856	1.0245	1.1217	3.3907	0.2174	0.6322	1.8772	0.3521	1.3289	**0.9726**
11	FBL							1.3581	0.5687	0.6277	1.1122	0.8984	0.3707	0.8722	**0.8671**
12	GCB	0.7189	0.8532	1.2587	1.0984	0.7770	1.4947	1.0297	1.0595	0.7612	0.9530	0.4366	1.8157	0.6482	**0.9320**
13	GTB							1.7426	1.5253	0.4092	0.8880	0.4537	0.7118	0.8844	**0.9057**
14	HFC				2.4778	0.6783	1.2226	0.5350	0.8986	1.3263	1.9834	0.6947	0.6636	0.9904	**1.0132**
15	IBG							0.4338	0.8246	0.4527	1.0281				**0.8712**
16	ICB	1.4772	0.3075	2.3201	0.3643	2.7370	1.1035	1.0563	0.9782	0.2753	0.2683	1.4574	0.5520	0.7907	**0.8015**
17	NIB	0.1735	8.2665	0.9281	0.8800	0.4175	1.3606	0.7383	0.8882	1.3234	0.8052	1.8168	0.4069	0.9163	**0.9149**
18	PBL	1.3839	0.9075	0.6331	2.4817	1.2441	0.8249	0.8171	1.1535	1.1683	1.3969	1.1131	0.4438	1.0298	**1.0360**
19	ROYAL BANK														**1.0000**
20	SCB	0.5592	4.2690	0.3467	1.7004	0.5639	1.0185	0.8144	0.7040	1.1771	0.6528	1.2155	0.8999	0.1758	**0.8136**
21	SG	0.6629	3.3660	0.3472	3.4771	0.6056	1.4945	1.2064	1.0297	1.5507	0.9328	0.8257	0.6676	0.9682	**1.0675**
22	STANBIC	2.5282	0.7303	1.6151	1.4606	1.1677	0.6499	1.7898	0.8416	0.8694	0.4928	2.0941	0.3203	1.3797	**1.0537**
23	TRUST	0.7482	0.6722	1.8118	0.7031	2.2298	0.7684	1.2029	0.8130	1.2043	0.7759				**1.0002**
24	UBA						0.7509	1.3583	1.2737	0.3765	0.3152	1.8003	0.4640	0.9320	**0.8495**
25	UMB	0.8447	5.4548	0.5262	1.8435	0.9864	0.8734	0.3035	1.3230	1.1658	0.4843	1.0978	0.4836	0.5319	**0.8979**
26	UNIBANK		1.9149	0.3193	22.5038	0.2350	1.3266	0.7704	1.1091	1.1600	1.7919	0.7540	0.3145	0.5702	**1.0023**
27	UT BANK	0.4458	1.1519	1.1164	2.6201	0.7767			0.7179	0.7227	3.1181	0.7078	0.4176	0.7269	**0.9329**
28	ZENITH							0.8134	0.9260	0.7789	2.1305	0.2657	1.1065	0.7672	**0.9072**
	Geomean	**0.8529**	**1.3971**	**0.8493**	**1.5400**	**0.8617**	**1.0453**	**0.9410**	**0.9927**	**0.8098**	**0.8918**	**0.9443**	**0.5429**	**0.8525**	**0.9344**

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APPENDIX H: PRICE EFFECTS OF INDIVIDUAL BANKS FOR THE PERIOD 2000-2013

NO	DMU	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	Geomean
1	ACCESS										2.5864	1.0389	1.6040	0.8217	**1.1022**
2	ADB	1.0193	0.9069	0.9384	0.8996	0.8638	1.0192	0.9109	0.9198	1.1107	1.7053	1.0693	1.5624	0.5751	**1.0036**
3	BARODA										1.2099	1.2308	0.8307	1.0525	**1.0205**
4	BBG	1.3750	0.7520	0.7982	0.9089	0.9630	0.8520	0.9491	1.0434	1.0116	1.4854	0.5569	1.7668	1.1858	**1.0051**
5	BOA	2.1700	0.7123	1.7403	0.2192	1.9430	0.6685	1.3355	0.7535	1.9689	1.0138	1.1929	1.0884	1.1809	**1.0682**
6	BSIC									0.2123	1.8820	1.4970	1.5556	0.7821	**0.9758**
7	CAL	1.5943	0.8806	1.0788	0.3792	1.5553	0.7123	1.7561	0.7729	1.0329	0.8178	0.8563	1.5880	1.4747	**1.0297**
8	ECOBANK	2.8486	0.5199	0.7729	0.8546	1.4877	0.7756	1.0836	0.9054	0.8928	0.9368	1.2514	1.7324	0.8211	**1.0392**
9	ENERGY												2.5871	1.5854	**1.1147**
10	FAMB	1.4036	0.4008	1.4340	0.6723	1.6760	0.9315	1.2009	0.4529	1.9664	1.4936	0.8469	1.3726	0.7561	**1.0134**
11	FBL							1.1335	1.4309	1.1412	0.7838	0.7733	1.5582	0.9534	**1.0401**
12	GCB	1.5017	1.2156	0.7588	0.9101	0.8344	0.7372	1.2809	0.9224	1.3012	0.8694	0.9253	0.9705	1.3406	**1.0172**
13	GTB							1.3552	1.2829	1.2105	1.1688	1.1887	1.3640	1.0212	**1.1141**
14	HFC				0.8135	1.5668	0.7509	1.4889	1.0137	0.9978	0.7715	1.4029	1.1929	0.9757	**1.0470**
15	IBG							3.8079	1.2499	1.7303	1.0676				**1.1820**
16	ICB	0.9722	1.3303	0.5942	0.6534	1.3565	1.0587	1.0091	1.0517	1.1927	1.8766	0.6854	1.1474	1.1429	**1.0337**
17	NIB	2.6309	0.3795	0.9487	0.9230	1.7233	0.5296	1.3596	0.9818	1.0664	1.0950	0.7813	1.3203	1.0246	**1.0212**
18	PBL	1.2065	0.8947	1.0641	0.5600	0.9776	0.9132	0.9903	0.8137	0.9678	0.6824	0.9762	1.4217	0.9105	**0.9294**
19	ROYAL BANK														**1.0000**
20	SCB	1.7994	0.4503	1.1194	0.9892	1.5292	0.8937	1.3314	0.9649	0.8023	1.0927	0.7728	1.0632	2.3651	**1.0789**
21	SG	1.4060	0.5639	1.1516	0.4560	1.6825	0.6266	1.4537	0.7663	0.8951	1.2257	0.9189	1.1941	0.9734	**0.9581**
22	STANBIC	0.9508	0.9068	0.8655	0.8862	0.9875	0.9891	0.6821	0.9304	1.1921	1.4164	0.6051	1.4318	0.7576	**0.9411**
23	TRUST	1.3395	1.1028	0.7218	0.6526	1.1311	0.8488	1.0073	1.1829	1.0003	1.0709				**0.9878**
24	UBA						1.3113	1.7689	0.7579	0.8201	2.6904	0.7042	1.6598	1.2818	**1.1450**
25	UMB	1.8135	0.3831	1.0424	0.8563	1.1985	0.9254	1.7688	0.8684	0.9110	1.1811	0.9274	1.4260	1.3581	**1.0564**
26	UNIBANK		0.8826	1.3980	0.1647	2.6064	0.7758	1.3390	0.8326	1.1980	0.8600	1.2683	1.5316	1.3526	**1.0167**
27	UT BANK	1.7549	0.7185	0.7690	0.4549	1.6008			0.8979	1.2972	0.5268	1.2839	1.4094	1.1545	**0.9924**
28	ZENITH							2.1452	0.7271	1.4817	0.7548	1.2871	0.9459	1.5248	**1.0946**
	Geomean	**1.2761**	**0.8128**	**0.9842**	**0.7324**	**1.2212**	**0.8893**	**1.2465**	**0.9271**	**1.0576**	**1.1356**	**0.9721**	**1.3283**	**1.0759**	**1.0351**

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APPENDIX I: EFFICIENCY STUDY IN THE GHANAIAN BANKING INDUSTRY

Author (Year)	Method & RTS	Efficiency Measure & Estimate	Inputs	Outputs	Banking Modelling Process	Orientation	Sample; Country; Study Period	Findings
Adjei-Frimpong et. al (2014)	DEA & SFA	CE = 0.505	Deposits Labour Physical Capital	Loans Other Earnings Asset	Intermediation	Input	25 Banks; (2001-2010)	Cost Inefficient
Adjei-Frimpong et. al (2013)	DEA		Deposits Labour Physical Capital	Loans Other Earnings Asset	Intermediation	Input	25 Banks;(2001-2010)	Increase cost efficiency leads to increase in bank's market power.
Adjei & Chakravarty (2012)	SFA	CE= 0.7646	Labour Deposits	Loans Deposits (with other banks)	Intermediation		25 Banks; (2001-2010)	Cost Inefficient
Akoena et. al (2008)	DEA, Window Analysis	TE = 97.7 SE = 93.4 Big Banks TE = 98.3 SE = 98.7 Small Banks	Deposits Labour Interest expense Operational expense	Loans Interest Income Investments Non-interest Income	Intermediation	Input	16 banks; (2000-2006)	Average cost of small banks lower than big ones
Alhassan & Ohene-Asare (2013)	DEA		Staff Expenses Fixed Assets Deposits	Investment Loans Fees	Intermediation	Input	26 Banks; (2003-2011)	Competition influence Cost Efficiency
Biekpe (2011)	SFA						17 Banks; (2000-2007)	Banks in Ghana are non-competitive

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Author (Year)	Method & RTS	Efficiency Measure & Estimate	Inputs	Outputs	Banking Modelling Process	Orientation	Sample; Country; Study Period	Findings
Bokpin (2013).	SFA		Labour input Finance input Physical input	Loans Investments			25Banks; (1999-2007)	Foreign banks are more cost efficient.
Isshap & Bopkin (2012)	SFA		Labour Finance Input Physical Input	Loans Investments	Intermediation	Output	148 Bank branches, (2000-2011)	Improving Cost Efficient and worsening profit efficiency
Korash et al., (2001)	DEA	CE = 0.61	Labour Cost Other Operating Cost Capital(Premise & Fixed Assets)	Deposits Loans Commissions & Fees	Intermediation	Input	16 banks (1988-1999)	Increased Competition had made banks efficient.
Kumi et. al (2013)	Financial Ratio				Intermediation		3 Banks, (2007-2009)	Cost efficient
Osei (2013)	DEA	CE = 0.78, (2009) CE = 0.98, (2010) CE = 0.99, (2011)	Deposits Interest expense Operational expense	Loans Interest Income Profits	Intermediation	Input and Output	9 Banks; (2000-2011)	Improved Efficient
Sarpong et. al (2014)	Financial Ratio				Intermediation		5 Banks, (2005-2011)	Declining cost & Profit efficiencies
Saka, Aboagye & Gemegah (2012)	DEA	TE (2000-2004) Foreign = 0.84 Local = 0.84 (2005-2008) Foreign = 0.71 Local = 0.78	Deposits Fixed- Assets Total Expense Share Holders Equity	Loans Investment in Securities Deposits with other Banks Total Revenue	Intermediation	Output	26 Banks;(2000-2008)	Domestic banks have been positively affected by the entry of foreign banks

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APPENDIX J: EFFICIENCIES IN OTHER COUNTRIES

Author (Year)	Method	Efficiency Measure & Estimate	Inputs	Outputs	Banking Modelling Process	Orientation	Sample; Country; Study Period	Findings
Arrif & Can (2008)	DEA 2nd Stage	CE = 0.798 PE = 0.505	Deposits Labour Physical Capital	Loans Investments	Intermediation	Inputs and Outputs	28 banks, China, (1995-2004)	Inefficient
Akhtar (2013)	DEA 2nd stage	CE = 0.55 PE = 0.88	Deposits Labour Physical Capital	Interest Income Loans and Advances Investments	Intermediation	Inputs and Outputs	9 Commercial Banks, Saudi Arabia, (2000-2009)	Inefficient
Carvallo & kasman (2005)	**SFA**	CE, Average inefficiency 0.178	Purchase Funds Labour Physical Assets	Loans Deposits Other Earnings	Intermediation	Inputs and Outputs	481 Banks, 16 Latin American Countries (1995-1999)	Inefficient
Ferrier & Lovell (1990)	DEA SFA	20-30% Above the minimum cost	Labour Rent and Expenditure on furniture and equipment	Demand Deposit Time Deposit Real Estate loans Instalments Loans Commercial Loans	Production	Input	575 banks in 1984	Inefficient
Fu and Heffernan (2007)	SFA	40-60% below the X-Efficiency	Labour Fixed Assets Interest on Deposits	Deposits Loans Investment	Intermediation	Input	14 Commercial Banks; China; (1985-2002)	Cost Inefficient
Kassem, El-Mousawi & Awdeh (2014)	SFA	CE = 0.81	Physical Assets Deposits Labour	Loans Bad Loans Off-balance Sheet Activities	Intermediation	Input and Output	11 countries in the MENA, Region, (2005-2011)	Inefficient
Kraft et al.,(2006)	SFA	CE = 1.37	Capital Labour Funding Cost	Loans Deposits	Intermediation	Input	363 Commercial banks, Croatia; (1994-2000)	Cost inefficient
Kumbhakar & Tsionas (2008)	SFA LML	CE = 0.9	Purchased Funds Deposits	Loans Securities Others Assets	Intermediation	Input	3691 Commercial Banks; U. S. A; (2000)	Cost inefficient
Ncube (2009)	SFA, 2nd Stage	CE = 1.121 PE = 0.55	Labour Physical Capital Funds	Loans Deposits	Intermediation	Input	8 Commercial Banks; South Africa; (2000-2005)	Improved Cost and Profit Efficiency

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APPENDIX K: MALMQUIST PRODUCTIVITY INDEX

Author (Year)	Method	Efficiency Measure & Estimate	Inputs	Outputs	Banking Modelling Process	Orientation	Sample; Country; Study Period	Findings
Berg, Forsund & Jasen (1992)	DEA	MPI	Labour Hrs Operating Expense	Loans Non-bank Deposits	Intermediation Approach	Input Orientation	152 Banks, Norway (1980-1989)	Productive growth after deregulation
Casu, Girandone & Molyneux (2004)	DEA	TFP	Cost of Labour Interest Expense Cost of Capital	Loans Securities	Intermediation Approach	Input Orientation	2000 European Banks, (1994-2000)	Productivity growth as a result of technological change
Chang, Hu, Chou & Sun (2012)	DEA	MI / TFP	Labour Physical Capital Total Deposits	Total Loans Other Earning Assets	Intermediation Approach	Input Orientation	19 Banks, China (2002-2009)	Increased Productivity
Drake (2001)	DEA	MI	Number of Employees Fixed Assets	Loans Investments Deposits	Hybrid Approach	Input Orientation	9 Banks, United Kingdom (1984-1995)	Modest Productivity Growth
Fiordelisi & Molyneux (2010)	DEA	TFP	Personnel Expense Physical Capital Financial Capital	Demand Deposit Total Loans Other Earnings	Value Added Approach	Input Orientation	4 Countries in Europe, (1995-2002)	Increased Productivity as a result of technological change
Fukuyama & Weber (2002)	DEA	MI	Physical capital Labour Deposits	Securities Investments Interest Bearing Assets	Intermediation Approach	Input Orientation	Banks in Japan, (1992-1996)	Productivity decline
Matthews & Zhang (2010)	DEA	MI	Deposits Overheads	Loans	Hybrid Approach	Input Orientation	10 Banks , China (1997-2007)	Neutral Average Growth but positive growth for City Banks
Chortereas et al., (2011)	DEA	MI	Personnel Expenses Interest Expense Non-interest	Total Loans Securities	Intermediation Approach	Input Orientation	9 Countries in Latin America, (2000-2006)	Decline Productivity, except Chile and
Murillo-Melchor et al., (2010)	DEA	MI	Labour Expenses Capital Short-term Funds	Loans Deposits Securities	Intermediation Approach	Input Orientation	3997 Banks, 14 European Countries, (1995-2001)	Productivity Growth due to improvement in production possibilities
Rezitis (2006)	DEA	MI	Labour Capital Expense		Intermediation Approach	Input Orientation		

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APPENDIX L: THEORITICAL PAPERS ON COST AND PROFIT MALMQUIST PRODUCTIVITY INDICES

Author (Year)	Method	Efficiency Measure & Estimate	Findings
Maniadakis & Thanassoulis (2004)	DEA	CMI	Theoretical paper
Razarvyan & Tohidi (2012)	DEA	CMI with negative data	Theoretical paper
Tohidi & Tohidnia (2014)	DEA	Biennial Cost Malmquist	Theoretical paper
Tohidi, Razavyan & Tohihnia (2010)	DEA	Profit Malmquist Productivity Index	Theoretical paper
Tohidi, Razavyan & Tohihnia (2012)	DEA	Global cost Malmquist	Theoretical paper
Tohidi &, Razavyan (2013)	DEA	Circular Global Profit Malmquist	Theoretical paper
Thanassoulis et al., (2015)	DEA	CMI Capturing Group performance	Theoretical paper

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APPENDIX M: COST MALMQUIST PRODUCTIVITY INDEX

Author (Year)	Method	Efficiency Measure & Estimate	Inputs	Outputs	Input Prices	Orientation	Sample; Country; Study Period	Findings
Maniadakis & Thanassoulis (2004)	DEA	CMI	Total number of doctors Total number of nurses Total number of administrative and other personnel	Total number of inpatient days. Total number of Laboratory test. Total number of clinical examination	Average Annual earnings of each staff category	Input	30 Hospitals, Greece, 1992 and 1993.	The traditional Malmquist overstated the growth, relative to the coat Malmquist.
Balezentis (2012)	DEA	CMI	Utilized Agricultural land area- Land Input Annual work Units- Labour Inputs Total Assets in Litas – Capital Factor	Crop Number of Livestock Output Litas	Average land price Average salary in the agricultural sector The price of capital	Input	200 Farms, Lithuanian, 2004-2009	Classical Malmquist (TFP) shows a higher decline as compared to cost productivity.
Balezentis et al., (2013)	DEA	CMI	Utilized Agricultural land area- Land Input Annual work Units- Labour Inputs Total Assets in Litas – Capital Factor	Crop Number of Livestock Output Litas	Average land price Average salary in the agricultural sector The price of capital	Input	200 Farms, Lithuanian, 2004-2009	Technical Malmquist Index showed 22.4% growth and cost Malmquist by 7%.
Tzu-Chun et al., (2012)	DEA	CMI	Labour Capital Material and Purchases	Net Revenue Market value	Labour input price- Number of employees Input capital- Value of Fixed Assets Price of Material and other purchases	Input	28 Drug Manufacturing Firms, Taiwan, 2004-2007	Malmquist index regressed by 8.79%, while cost Malmquist progressed by 7.17%

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APPENDIX N: SAMPLE INPUT-OUTPUT DATA FOR FEW PERIODS (2000 – 20004)

Company	Year	Dep	lexp	FA	ladv	Inv	Iexp.Dep	lexp.ta	ooexp.fa
ADB	2000	53333117.1	3943435.2	1871703.1	54029356.6	31469214.9	0.1036	0.0307	2.8896
BBG	2000	134434100	3549800	2604900	47955100	100405200	0.0595	0.0205	2.2797
BOA	2000	532192.1	49094	142846.3	154708	149307.8	0.0648	0.0555	1.1112
CAL	2000	13263400	844200	1293900	6961400	6026100	0.1314	0.0359	0.6769
ECBK	2000	66714683.4	1658128	2937827	28098701.7	8532742.7	0.0594	0.0197	0.7958
FAMB	2000	12725429.2	284481.2	340725.4	3456347.8	10163314.6	0.1442	0.0165	2.2310
GCB	2000	169328300	9881200	5454000	102016900	69281700	0.0761	0.0438	0.8259
ICB	2000	2927891.9	189747.7	156736	364467.9	2983897.7	0.1093	0.0356	1.3520
NIB	2000	12878800	1211800	930700	12263900	6758300	0.1588	0.0431	1.1354
PBL	2000	8011199.8	345122.4	385242.1	3434532.8	3626895.2	0.1552	0.0307	1.8140
SCB	2000	149938900	4297000	9732800	128695800	54913700	0.1271	0.0136	0.7658
SG	2000	70248200	3399700	3927000	48436300	30059900	0.1053	0.0279	1.4731
STANBIC	2000	2682508	271267.6	533671.5	822702.7	1139599.6	0.0947	0.0482	1.1422
TRUST	2000	18530195.6	722317.6	436279.6	6146292.9	15290970	0.1206	0.0273	1.9223
UMB	2000	39915800	1216100	4623000	19521500	8089200	0.1449	0.0226	0.7050
UT BANK	2000	4942500	355900	289100	3033200	4140300	0.1984	0.0423	2.1328
ADB	2001	64351161.5	5436853.5	3158092.9	54220868.6	40488718.7	0.1191	0.0373	1.2363
BBG	2001	172056900	5186000	4040000	68688300	68086800	0.0621	0.0226	2.6773
BOA	2001	2806604.6	71530	124941.4	953303.2	1038483.3	0.1005	0.0171	2.1432
CAL	2001	20814100	1025500	1146600	10993400	9069200	0.1568	0.0333	1.0751
ECBK	2001	77960500	2187100	3753700	26792700	15983900	0.0619	0.0224	1.0804
FAMB	2001	14536349.4	433583.6	1340498.8	4974877.5	4953578.8	0.2076	0.0231	0.7112
GCB	2001	192441900	13744100	6728800	182619800	102411000	0.0752	0.0362	1.0914
ICB	2001	5097663.3	327660.8	198503.8	982647.1	3809882.1	0.1121	0.0418	1.9335
NIB	2001	15219700	1933000	897800	13998300	7390200	0.1565	0.0650	3.7679
PBL	2001	14242230.3	556681.5	553578.8	6562070	6949090.7	0.1567	0.0262	1.9045
SCB	2001	163614300	6060300	15981700	89444500	73957900	0.1101	0.0265	0.7735
SG	2001	76545300	4995300	6544000	40420100	40942300	0.1149	0.0366	1.4640

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STANBIC	2001	6258886.5	552046.4	658452.3	1324975.7	2957133.2	0.1151	0.0568	1.1612
TRUST	2001	21607300	1119581.2	701688	7301478.2	9535569.5	0.1522	0.0353	1.9871
UMB	2001	44226700	1780200	4455300	20636200	13910500	0.1470	0.0308	0.4160
UNIBANK	2001	2172653.1	153358.8	309439.7	646601.5	729233.7	0.0598	0.0565	1.4288
UT BANK	2001	6405100	537300	169300	3899000	3553700	0.2570	0.0468	5.8216
ADB	2002	96871298.3	7859893.3	4925927.7	63515497	47721413.7	0.0637	1.1014	0.0425
BBG	2002	195662600	5734700	4038500	102606200	66842900	0.0360	2.6491	0.0212
BOA	2002	8251793.3	122659.4	181583.5	2476568.6	2738820.3	0.0722	3.0467	0.0118
CAL	2002	22925500	1232200	1051700	15513500	9619800	0.1275	1.4996	0.0301
ECBK	2002	71103200	3057700	4627200	46248500	14761300	0.0728	0.8543	0.0231
FAMB	2002	22983600	575800	1312900	8760700	5891100	0.1002	0.8483	0.0201
GCB	2002	240860900	17773200	10362500	95531000	247857600	0.0493	1.0902	0.0384
ICB	2002	9199823.9	469906.8	191701.4	1754394	6970534.5	0.0810	2.0293	0.0391
NIB	2002	23344600	2718200	1759100	21372800	13267300	0.0686	1.0556	0.0505
PBL	2002	23406200	694000	608900	11019600	8321800	0.1328	2.3639	0.0197
SCB	2002	217476900	10387900	18417800	92177500	90927600	0.0448	0.6697	0.0345
SG	2002	102158400	4919200	8115100	57784300	45956900	0.0592	1.1316	0.0287
STANBIC	2002	13954520.5	770348.2	855164.9	2545902.1	4812275.7	0.0534	1.4501	0.0334
TRUST	2002	30012935.6	1489183.1	725188.3	11701226	11311458.8	0.0820	2.4741	0.0317
UMB	2002	62521100	2506700	4428200	27303500	10968800	0.0699	0.5954	0.0334
UNIBANK	2002	3584258.9	190312.8	300869.7	1721614.6	1010145.2	0.0959	1.6830	0.0387
UT BANK	2002	11658600	649900	496700	3549500	3018000	0.1246	2.3469	0.0508
ADB	2003	151819520.2	9054849.4	4502322.1	86534781.8	90974725.3	0.0632	0.0302	1.5692
BBG	2003	277141500	8938100	5280200	159382500	118959300	0.0257	0.0236	2.8939
BOA	2003	13944051.3	306230	232341.3	4385457.3	9596126.3	0.2118	0.0102	5.4883
CAL	2003	33594500	1454100	1163300	21790300	17444500	0.1282	0.0247	1.8608
ECBK	2003	135272000	5294000	5585500	62396900	32845900	0.0383	0.0315	0.9613
FAMB	2003	25310998.1	771418.2	1443909	16063923.4	8948680.8	0.1502	0.0187	0.9289
GCB	2003	318383000	29715800	10120100	175429700	194454600	0.0570	0.0586	1.3599
HFC	2003	10783187.7	615775.1	2329457.7	21375292.5	20639543.2	0.4022	0.0120	0.6192

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ICB	2003	16644198.3	781161.7	517875.7	3461252.2	11291581.7	0.1043	0.0358	1.2046
NIB	2003	34510800	3050600	3587600	37333000	46888000	0.1123	0.0293	0.9493
PBL	2003	30591400	1203900	1071900	13855100	17328500	0.1616	0.0196	2.6032
SCB	2003	281794500	10867300	16696200	141075900	98363600	0.0489	0.0278	0.9859
SG	2003	126321000	7291100	7809800	74627700	61060500	0.0683	0.0349	1.4676
STANBIC	2003	30869041.8	1170831.6	816875	10243277.2	12570405.3	0.0404	0.0280	2.2481
TRUST	2003	39174607.7	2285800	829210.8	17842122.7	20894675	0.1028	0.0366	2.5561
UMB	2003	79754900	3215300	3966200	36718300	14352500	0.0749	0.0324	0.6448
UNIBANK	2003	7355846.2	287497.5	264843.9	3005457.4	2374278.6	0.1000	0.0299	3.0543
UT BANK	2003	11895753.3	549197.3	541306.7	3685279	3329462.3	0.1143	0.0446	1.9711
ADB	2004	160370400	13674800	4806600	84536500	116786944.6	0.0642	0.0442	17.5876
BBG	2004	392995000	11100100	9041400	206505600	116786944.6	0.0205	0.0200	22.8400
BOA	2004	25307548	574005	2122150	8129514	116786944.6	0.1597	0.0157	3.8308
CAL	2004	47943500	1871600	3839200	30131700	25257800	0.0971	0.0227	7.8484
ECBK	2004	193867500	6243300	6972900	70131800	60690000	0.0374	0.0259	10.0578
FAMB	2004	25573565.6	1631543.1	1747331.1	21721913.5	10678018	0.1599	0.0323	12.4315
GCB	2004	426573300	32348200	11875800	209506100	199992600	0.0396	0.0580	17.6414
HFC	2004	17289129.6	1162833.5	2794280	23053897.8	23372845.4	0.2800	0.0196	8.2504
ICB	2004	25751662	1015164	485032	6601138	116786944.6	0.0715	0.0303	13.6097
NIB	2004	44670300	5165700	6599700	77929700	23061700	0.1296	0.0350	11.8081
PBL	2004	50395000	1709500	1445200	29462000	116786944.6	0.1066	0.0196	20.3861
SCB	2004	307664500	11601400	14160300	163674400	111303200	0.0413	0.0264	11.5587
SG	2004	157992300	10430800	10422600	74461700	88149800	0.0452	0.0428	7.1443
STANBIC	2004	57594662	2568506	1170943	19954922	35235288	0.0334	0.0346	17.0418
TRUST	2004	65276005.2	3118603	1044438.1	22265921.4	711250000	0.0690	0.0347	21.3186
UMB	2004	107859300	4099200	7773100	65002700	106780180	0.0458	0.0294	8.3625
UNIBANK	2004	11220601.8	485331.7	1661891	4530506.7	5671903.5	0.0746	0.0283	2.7261
UT BANK	2004	13068200	625900	511200	4361800	116786944.6	0.0640	0.0389	8.5325

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APPENDIX O: Listed Companies Currently on the Ghana Stock Exchange (GSE)

Companies	Number
CAL Bank	1
Ecobank Ghana	2
Ghana Commercial Bank	3
HFC Bank (Ghana)	4
Standard Chartered Bank Ghana	5
Societe Generale Ghana	6
UT Bank	7

Source: http://www.annualreportsghana.com/ **(12:32pm; 26/06/2015)**

APPENDIX P: Wilcoxon Signed-Rank Test for MPI and CMPI

Data: MPI and CMPI	
V =15275,	p-value =0.008713
alternative hypothesis:	TRUE Location shift is not equal to 0
99 percent confidence interval: -0.05223-0.00043	
sample estimates: (pseudo)median-0.0255	
Data: MPI and CPMI	
V = 15275,	p-value = 0.008713
Alternative hypothesis:	TRUE location shift is = 0
95 percent confidence interval: -0.04546 -0.00646	
Sample estimates: (pseudo)median -0.0255	