Nonparametric Efficiency and Productivity Change Measurement of Banks with Corporate Social Responsibilities: The Case for Ghana

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All remaining errors are mine.

Declarations

I certify that this thesis does not incorporate without acknowledgement any material previously submitted within a degree programme at this or any other institution and to the best of my knowledge, it does not contain any information previously published where due reference is not made in the text.

During the PhD studies, the following research papers were written and conference presentations made.

Paper(s)

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Abstract

This thesis has twofold objectives. The first is to develop a framework based on the existing theory and method of Data Envelopment Analysis (DEA) for measuring performance of financial firms that have the dual goals of profit maximisation and Corporate Social Responsibilities (CSRs). The second is to examine the impact of banking regulatory reforms including bank ownership, specialisation, and capitalisation types on the average efficiency and frontier differences of banking subgroups. The objectives are achieved using the standard DEA, the metafrontier analysis and the global frontier differences (GFD). DEA can handle multidimensional inputs and outputs without specifying specific functional forms. CSR is conceptually justified and modelled as an additional output into the banking intermediation approach. Two DEA models, one with CSR and another without CSR are measured and compared. Parametric and nonparametric tests and regressions are utilised to support, empirically, the relevance of CSR in bank performance evaluation.

Do foreign banks outperform private-domestic and state banks? Should banks diversify their products or focus in narrow range of products and services? Are listed banks more efficient than non-listed banks? The second part of the thesis contributes to the extant literature by answering these questions using the metafrontier analysis and the GFD to provide new evidence on the effect that the entry of foreign and private-domestic banks, universal banking and listing of banks on the stock market, have on bank performance. Banks are segmented into groups based on their bank-specific attributes and their average efficiencies and best-practice differences compared. Relevant policy recommendations are drawn from the analysis for both the banking regulator and bank management.

The final methodological contribution extends the GFD by defining a further decomposition of the global frontier shift, into components that indicate whether an observation is situated in a more or less favourable location in the production possibility set. Consequently, a four-factor "Newly-decomposed Malmquist productivity change index" is proposed. The index and its decompositions have potentially interesting policy implications, which are illustrated using the empirical data on Ghanaian banks. The index is in the spirit of the standard Malmquist index but the intuition is that some components can be used to draw conclusions about productivity changes for a whole population of firms whilst others determine whether individual firms are in favourable locations and/or moving towards locations that are more favourable over time. More importantly, arguably, a listed, universal or foreign bank can be located in a favourable position and move towards location that is more favourable by virtue of its bank-specific attributes or by contributing more towards CSR. These factors are explored and policy measures prescribed in the final contribution of the thesis.

Abbreviations

ADB: Agricultural Development Bank
AMAL: Amalgamated Bank Limited
BBG: Barclays Bank of Ghana Limited
BCC: Banker, Charnes and Cooper (1984)
BOG: Bank of Ghana
CAL: CAL Bank Limited
CCR: Charnes, Cooper and Rhodes (1978)
CFP: Corporate Financial Performance
CIG: Corporate Initiative Ghana
COLS: Corrected Ordinary Least Squares
CRS: Constant Returns to Scale
CSR: Corporate Social Responsibility
CSP: Corporate Social Performance
DGP: Data Generating Process
DEA: Data Envelopment Analysis
DFA: Distribution Free Analysis
DMU: Decision Making Unit
DDF: Directional Distance Function
EBG: Ecobank Ghana Limited
EC: Efficiency Change
EU: European Union
FAMB: First Atlantic Merchant Bank Ghana Limited
FB: Fidelity Bank Limited
FI: Favourability Index
FCI: Favourability Change Index
FDH: Free Disposal Hull
GCB: Ghana Commercial Bank Limited
GFD: Global Frontier Difference
GFS: Global Frontier Shift
GH¢: Ghanaian cedis
GOG: Government of Ghana
GSE: Ghana Stock Exchange
GTB: Guaranty Trust Bank (Ghana) Limited
HFC: HFC Bank (Ghana) Limited
IBG: Intercontinental Bank (Ghana) Limited
ICB: International Commercial Bank Limited
IRS: Increasing Returns to Scale

KDE: Kernel Density Estimation
KLD: Kinder, Lydenber and Domini
LAD: Least Absolute Deviation
LP: Linear Programming
LPP: Linear Programming Problem
MBG: Merchant Bank (Ghana) Limited
MOLS: Modified Ordinary Least Squares
NIB: National Investment Bank Limited
OLS: Ordinary Least Squares
PBL: Prudential Bank Limited
NDRS: Non-Decreasing Returns to Scale
NIRS: Non-Increasing Returns to Scale
PPS: Production Possibility Set
RTS: Returns To Scale
SAP: Structural Adjustment Programme
SCB: Standard Chartered Bank Ghana Limited
SFA: Stochastic Frontier Analysis
SGSSB: SG-SSB Limited
STANB: Stanbic Bank Ghana Limited
T: Technology set
TC: Technological Change
TFA: Thick Frontier Analysis
TTB: The Trust Bank Limited
VRS: Variable Returns to Scale
UBA: United bank for Africa (Ghana) Limited
UBBL: Universal Banking Business Licence
UGL: Unibank Ghana Limited

Chapter 1

Introduction

1.1 Introduction

The financial sectors of many countries play key roles in the process of economic growth and development through the provision of intermediation services and funds between lenders and borrowers in our society (Levine et al., 2000; Hassan et al., 2011). The banking industry is usually the leading player of the financial sector. Banks price and value financial securities, and manage financial risks. Some banking studies show that the efficient performance of financial institutions impinge on economic growth while other studies report that bank insolvencies can lead to systematic risks which can cripple a whole economy (Fethi and Pasiouras, 2010). Other studies indicate that the role of banks may affect sustainable development (Scholtens, 2006) – defined to be development that addresses present needs without preventing the future generations to achieve their goals (WCED, 1987). The functions of banks are vitally important to government regulators who must create conducive atmosphere for increasing volume of financial intermediation and design policies for the best performing banks and avoid bank failures that can be caused by the worst performing banks. Banking efficiency is also important to bank managers who must devise enhanced management strategies, and customers and the public who use the products and services provided by banks. Given the role of financial institutions in the economic development of a society, it is crucial to evaluate their efficiency and productivity change and the determinants of their performance.

The efficiency assessment of financial institutions is useful for identifying the best and worst performers (Berger and Humphrey, 1997). Such analysis, often employing frontier techniques, requires the development of banking models that appropriately capture the banks' objectives and their activities (Avkiran, 2006). Nonetheless, the literature on the theory of the banking firm and the specification of banking inputs and outputs has implicitly assumed banks as aiming to maximise only profits (Brown, 2006) without considering other multiple objectives of banks (cf. García-Cestona and Surroca, 2008) including the potential importance of Corporate Social Responsibilities (CSRs). But, business performance evaluation depends on how well the organisation performs and achieves its underlying goals (Piesse and Townsend, 1995). CSR is explained in this study as *voluntary* actions pursued by business organisations, beyond the minimum legal requirements and beyond direct interest of shareholders to further some social good (McWilliams and Siegel, 2001). This means that beyond their normative economic and legal obligations established by statutes and laws, corporate organisations have some responsibilities to their society that stretches beyond these obligations.

The central aim of this thesis is to contribute to the banking efficiency literature by developing suitable banking intermediation models that incorporate both the traditional profit-maximisation goal and the goal of CSR resulting in a banking system termed in this thesis as "dual-objective". The models will be applied to empirically evaluate and compare the efficiency and productivity change of banks and banking groups in Ghana, one of the fastest growing economies in Africa. By considering the CSR activities of banks besides their profit-maximising goal, their efficiency ratings obtained using Data Envelopment Analysis (DEA) might be comprehensive. To undertake the analysis, a number of parametric and nonparametric statistics are employed to a) asses the relevance of including CSR in a DEA banking intermediation model and to b) contribute to the debate on the nexus between CSR and economic performance. By doing so, this thesis increases the awareness of the importance of the CSR concept in banking efficiency studies, especially for a developing country like Ghana. The study also aims to investigate the impact that the entry of foreign and private-domestic banks, the introduction of universal banking and the listing of banks on the Ghana Stock Exchange (GSE), can have on bank static and dynamic performance. Finally, the study aims to establish the linkage between banks CSR, and favourability and favourability change. It should be noted that accounting for CSR is not easy due to the multidimensional nature of the concept and the difficulty in measuring it (Clarkson, 1995; Carroll, 2000). This task of defining the dimensions of CSR is pursued in this study. The discussion will suggest probable measures of CSR before proceeding to incorporate CSR in the performance analysis of banks.

1.2 Justification for CSR and socially responsible banking

CSR has received a great deal of attention from both the corporate world and academic researchers within the management and business ethics literature (Carroll, 1979; Freeman, 1994; Paul and Siegel, 2006; Beurden and Gössling, 2008). A number of development organisations are also of the opinion that CSR can have a positive effect on the socio-economic developments of nations (Jenkins, 2005). For example, the Department for International Development (DFID) remarks that "By following socially responsible practices, the private growth generated by the private sector will be more inclusive, equitable and poverty reducing" (DFID, 2004, p.2). The DFID therefore acknowledges that there is social welfare that can be realised from CSR. Other international agencies also recognise the importance of socially responsible activities. These include the World Bank and the United Nations that established the Global Compact in 2000.

The current study justifies CSR on both conceptual and empirical grounds. Conceptually, there is a strand of the CSR literature that examines the justifications and benefits of socially responsible activities (Campbell, 2007; Orlitzky et al., 2003). One argument for a firm to consider CSR is to establish good relationships with stakeholders including government and the public. It has been asserted that "if business is to have a healthy climate in which to function in the future, it must take actions now that will ensure its long-term viability" (Carroll and Shabana, 2010, p. 89). Carroll and Shabana (2010) argued in favour of CSR that, it is more practical and beneficial for firms to act in advance or anticipate social issues instead of waiting to react to those issues, which will rather be more expensive for both businesses and society.

Further, CSR activities can raise employees' morale and productivity, increase customer goodwill, enhance firms' image or reputation, increase brand loyalty and advance relations with government agencies that may curtail regulatory costs (Lin et al., 2009a). Firms need to address demands placed on them by other stakeholders besides primary shareholders. For example, a poor reputation perceived by the public may reduce shareholder value due to protests etc. There is vast and growing evidence that show that consumers reward corporate socially responsible businesses (Maignan and Ferrell, 2004). Lundgren (2011) provided 3 key benefits and costs of CSR. First, the authour showed that business customers pay a price premium to, or buy from firms that pursue CSR activities. Second, the author indicated that the capital costs of socially responsible banks are likely to decrease since they assign lower risk to the capital costs (cf. Godfrey, 2005; Heinkel et al., 2001). Also, socially responsible banks are less likely to encounter long-term conflicts with stakeholders. For a discussion on the potential value increasing effects of CSR see Heal (2005) and Becchetti and Trovato (2011). Third, Lundgren (2011) argued that individuals are willing to work for socially responsible firms at a lower salary or work efficiently at the going market rate since the workers will feel comfortable to work in such a firm that is socially responsible.

Lundgren (2011) developed the model from the firm's perspective and not from shareholders and the public perspective. The authour also mentioned three possible costs of engaging in CSR i.e. the actual investment cost of CSR, the cost of advertising the investment and the opportunity cost of CSR. It is also claimed that firms may be less competitive internationally if they engage in CSR activities (Carroll and Shabana, 2010). The likely benefits of CSR in the banking sector are enhancing the growth of socially resposible banking and investment activities.

By socially responsible banking, we mean banking activities with the goal of having a "positive impact on people, the environment and culture by means of banking, i.e. savings accounts, loans, investment and other banking products and services including 'gift money'" (Weber and Remer, 2011, p2). A number of banking institutions comtinue to finance economic activity that engage in sustainable development and CSR activities and offer microcredit to the needy (Morduch, 1999 cited in; Scholtens, 2009). In fact, Scholtens (2009) reviewed 32 main European, North American and Pacific banks regarding several CSR indicators and noted that the social responsibility of banks has significantly improved since 2000.

In the case of the banking sector in Ghana, CSR can also be associated with the concept of the fortune at the 'bottom of the economic pyramid' (BOP) as proposed by Prahalad (2004). The BOP asserts that private organisations are capable of reaping significant financial profits by selling to the poor whilst simultaneously eradicating poverty by improving the lives of billions of people. Figure 1.1 illustrates Prahalad's (2004) notion of the pyramid of the world. Prahalad and Hart (2002) pointed out that most multinational corporation (MNCs) look for consumers at the upper part of the BOP to the total neglect of business potential at the bottom. Nonetheless, while people at the base may be earning below $2000 per annum, they constitute a large market of 4 billion of the population of the world. In Ghana, the GDP per capita at purchasing power parity rates in constant 2005 US $ prices has consistently been below $2000 per year (e.g. $1,474.56 in 2010) based on World Bank public data in Google.

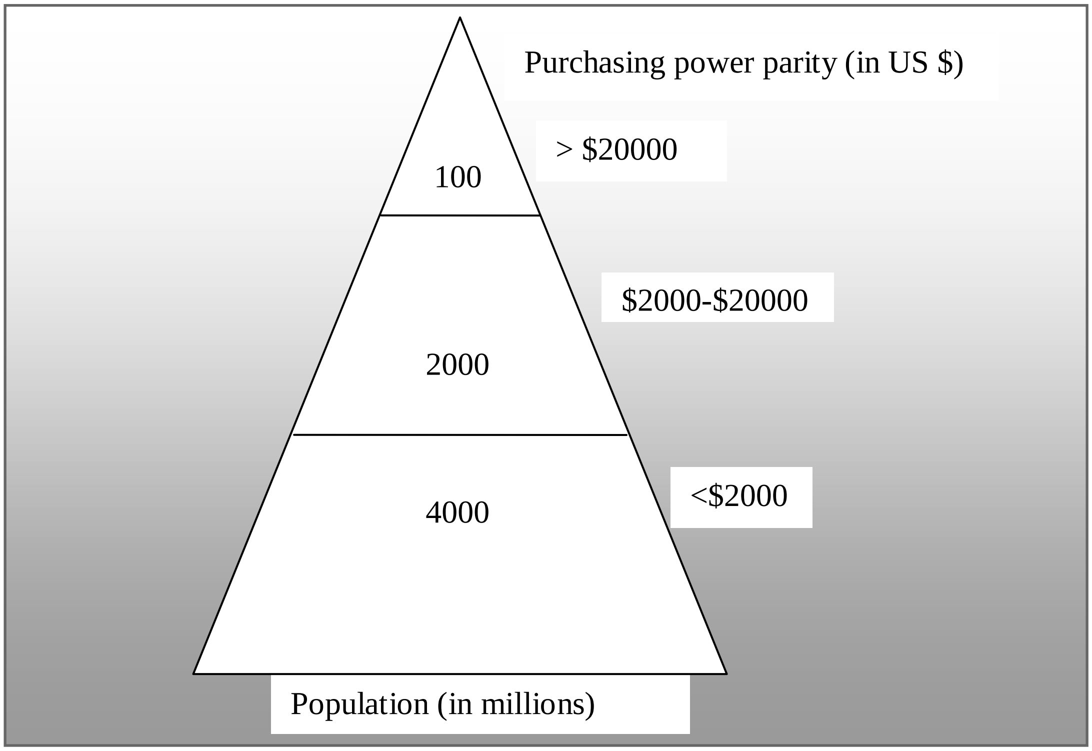

Figure 1.1 The World Pyramid

The fortune at the bottom of the economic pyramid implies that there is much untapped purcharsing power at the base and that businesses that sell to the poor at the base are doing good and should also do well. Arguably, socially responsible banking activities which are normally targeted at serving the worlds needy may be both noble and lucrative endeavours for corporations (Prahalad and Hammond, 2002). This discussion goes to theoretically strengthen the rationale for the a) inclusion of CSR into performance measurement and b) CSR measure that is actually adopted in this study, which is further discussed in chapter 3.

A more direct reason for considering CSR, particularly, in the Ghanaian banking sector is that, according to Ofori and Hinson (2007), African banks endeavour to go beyond their profit-maximising roles by contributing to broader societal goals. To buttress this point, about 87% of firms in Ghana, including banks, view CSR important and 63% think CSR must be all companies' concerns (Ofori and Hinson, 2007; CBN, 2006). The practice of CSR in Ghana is gaining momentum. Besides, the organisers of the Ghanaian annual banking awards – Corporate Initiative Ghana (CIG), KPMG and BOG – do include CSR information such as the amounts spent on CSR by banks as a separate part of the awards (CIG, 2006). An award known as the 'most socially responsible bank' is conferred on a bank that is chosen by the organisers, based on the computations of CIG and information extracted from the public. The public information is obtained from surveys by the organisers where they discover from banks and a sample of the public, questions pertaining to both CSR and profit maximisation of banks (CIG, 2007). Banks' responses to these questions demonstrate their acknowledgement of CSR. More importantly, CSR have been part of the banks activities since 2001. Even before 2001, several banks had been engaging in CSR activities although many of these were not properly recorded. For instance, Ghana Commercial bank (GCB) had been undertaking CSR activities since 1996. Ghanaian banks contribute to the well-being of the whole society and not only satisfy the needs of their primary shareholders by providing exclusively socially responsible products and services. These are achieved through the provision of ethical, social and environmental funds, microcredit and microfinance schemes, free credit access and low-income banking (Prior and Argandoña, 2009). In Ghana, 'focus' or specialised banks - commercial banks, development banks, and merchant banks - were traditionally established with the purpose of serving the financial needs of specific sectors of the economy (Addison, 2003). Some provide savings accounts to customers under the promise that the funds will be used for socially and environmentally responsible activities (Weber and Remer, 2011).

Ghanaian banks contribute resources in order to improve, inter alia, sports, entertainment, agriculture, education, health and environment and also includes customer satisfaction (CIG, 2006). For example, as part of its CSR commitments, the GCB contributed funds towards the Ghana @ 50 celebrations, Ghana heart Foundation, Sickle Cell Foundation, Ghana Education Service, Farmers Day Celebration etc. The bank contributed about half a million GH¢ towards CSR (GCB, 2006). Similarly, in 2006, the Agricultural Development Bank (ADB) made a significant donation of GH¢768.3 million towards Ghana @ 50, the CAN 2008, the Best Farmer Award. The amount was a 409.8% increase from the previous year (ADB, 2006). Standard Chartered Bank Ghana in its 2008 annual report explained their sustainability agenda to include social contribution, governance and environment and climate change as well as engagement in the war against HIV/AIDS. Also, in its 2009 annual report, GCB reported a disbursement of GH¢25.0 million to small and medium scale enterprises. All the CSRs are believed to strengthen the banks' image, attract highly experienced human capital, expand their customer base and foster a healthy relationship between them and other investors and the public.

Moreover, it is claimed that "banking is too important and sensitive to be left to bankers alone – the business strives only on public trust and confidence" (Okeke, 2004, pp.75). Besides, there was the first two-day annual conference of CSR, under the auspices of the CSR foundation, in Accra, Ghana in November 2011. The theme of the conference was 'the new partnership agenda for sustainable development and corporate credibility'. The conference was strategically focused on the extent to which CSR can stimulate socio-economic growth and development. In summary, the growing interest in CSR from shareholders, labour unions, non-governmental organisations, regulators, employees, the media and analysts are further motivations for considering CSR in bank efficiency analysis.

Following the justification and modelling of CSR into the DEA banking intermediation model, this study will also contribute to the banking efficiency and policy literature by investigating the impact that regulatory reforms and efficiency determinants can have on the performance of Ghanaian banks that operate in the dual-objective banking system. Banking industries worldwide have witnessed widespread competition following the deregulation of interest rates, elimination of restrictions on the entry of foreign banks, securitisation, technological innovations and cross-border banking (Staub et al., 2010; Berger, 2007). These factors have increased the need for banks to become efficient. Ghana is not exempt from such competition and regulatory reforms. The Ghanaian banking sector witnessed the introduction of universal banking in 2003, the entry of both private-domestic and foreign banks and listing of banks on the Ghana Stock Exchange. These banking reforms are expected to facilitate competition and efficiency in the industry.

1.3 Motivation

The thesis is motivated by the need to capture banks' multiple goals, particularly, profit maximisation and the potential importance of CSR in banking efficiency assessment. It is argued that incorporating CSR will ensure a more comprehensive bank efficiency evaluation in addition to what is suggested by the existing banking models (see e.g. Berger and Mester, 1997; Tortosa-Ausina, 2002a). Moreover, Paul and Siegel (2006) noted that explicit consideration of CSR in DEA efficiency studies in general is under-investigated. Chapter 5 will comprehensively examine the DEA technique. In brief, the method is a nonparametric, deterministic performance assessment tool for measuring the relative efficiency and productivity change of homogenous Decision Making Units (DMUs) which use multidimensional inputs and outputs. Developed by Charnes et al. (1978) and extended by Banker et al. (1984), DEA applies linear programming techniques to observed input-output correspondences by constructing an efficient production frontier on the basis of best practices. The efficiency of each DMU is then measured in relation to this constructed frontier. The approach can handle multiple inputs and outputs, determine the sources of firm inefficiency, identify appropriate efficient role models for inefficient firms and set targets for them. It has less restrictive assumptions as it allows the data to speak for itself. DEA has seen many developments and applications in operational research (OR) and economics (Emrouznejad et al., 2008).

To the best of our knowledge, only Vitaliano and Stella (2006) have employed to examine the link between CSR rating and productivity pertaining to US community banks. They did not find differences in technical efficiency but observed cost efficiency differences between CSR and non-CSR banks. They also observe that firms appear to recoup the additional cost of being socially responsible. However, whereas they investigated the effect of CSR on the efficiency of US savings banks using a second-stage Tobit analysis, the approach adopted in this study incorporates CSR in the first stage efficiency estimation as a controllable variable and employs a second-stage OLS and quantile regressions.

The study is also motivated by the need to expand the existing literature on banking efficiency assessment to Africa as championed by Berger (2007) since the majority of previous studies focused more on developed countries. The interpretation of the findings might have managerial and regulatory policy implications for banks not only in Ghana or Africa at large, but potentially also worldwide.

Another motivation of this thesis is the need to investigate whether the regulatory reforms introduced in the Ghanaian banking sector have altered the efficiency and productivity of banks. These regulatory changes include banking deregulation and entry of private-domestic and foreign banks, introduction of universal banking and capitalisation and listing of banks on the Ghana Stock Exchange. The effects of the regulatory changes can be considered as environmental factors or bank-specific characteristics that can influence the performance of banks. There is a large body of literature that investigates the differences in the relative efficiency and productivity dynamics among state, private-domestic and foreign banks (Deyoung and Nolle, 1996; Bhattacharyya et al., 1997; Claessens et al., 2001; Berger, 2007; Berger et al., 2009), between universal and focus banks (Vander Vennet, 2002; Laeven and Levine, 2007) and between listed and non-listed banks (Girardone et al., 2009; Ray and Das, 2010). These differential factors - ownership, specialisation and capitalisation types – are usually brought about by regulatory reforms that can make some banks outperform others.

When estimating and comparing performance, the majority of the existing studies measure the efficiency of banks and then typically compare the mean efficiency scores across different banking groups. The comparison of efficiency levels and rankings is however feasible only if banks belong to the same technology. If the banking observations have access to different technologies their efficiency scores cannot be compared as those scores will be measured relative to their group-specific frontiers and not the pooled metafrontier (Bos and Schmiedel, 2007; O'Donnell et al., 2008). The metafrontier analysis of Battese et al. (2004) and O'Donnell et al. (2008), described in chapter 5, can be used to measure and compare the mean efficiency scores of banking subgroups. The average performance of Ghanaian banking groups will be explored using this approach and policy recommendations drawn from the findings.

An alternative technique to the metafrontier analysis is the Global Frontier Differences (GFD) (Asmild and Tam, 2007), which is used in this study to gain insight into the best-practice or frontier differences of different banking subgroups and to explore whether one frontier is better than the other.

The GFD or global frontier shift is practical for drawing conclusions about frontier shifts of a whole sample of firms. This is a first application of the technique for the analysis of banks since the original paper by Asmild and Tam (2007).

The second empirical contribution of the thesis makes a first-hand methodological comparison of the GFD and the metafrontier analysis on the same data set of different banking subgroups and draws policy recommendations for the Ghanaian banking sector.

1.4 Research Aims and Objectives

The previous sections have set the stage for the consideration of CSR in banking efficiency assessment and have discussed the importance of adopting suitable methodologies to investigate average performance and best-practice differences across banking groups. From the findings, appropriate government policy responses can be tailored to specific banks or banking groups to improve performance over time. The key aims and objectives of this study are now delineated from which the research questions are deduced.

The primary aim of the study is to develop suitable banking models for nonparametric efficiency evaluation in a dual-objective banking sector. The novelty of this lies in the way CSR is justified on conceptual grounds and empirically applied to performance analysis of Ghanaian banks in a DEA framework. Additionally, the possible determinants of performance are investigated. Particularly, the study examines the relationship between efficiency and profitability on the one hand and CSR and other bank-specific attributes on the other hand.

The second objective of this study is to investigate whether bank ownership structures, bank specialisation-diversification types and bank capitalisation forms influence the economic behaviour of banks in this dual-objective banking system. This is novel in the way alternative methodologies – the metafrontier analysis and the global frontier differences – are implemented to assess banks' performance in this particular application field of operational research (OR). Based on the findings, important policy recommendations are drawn by bank managers for their own banks and by the Bank of

Ghana for the banking industry. These policies include whether to allow and promote the entry of both foreign and private-domestic banks, whether to encourage the adoption of universal banking instead of focus banking and whether to encourage and support banks to get listed on the GSE. The final purpose of the study emanates from the need to explore the nexus between the favourability locations of Ghanaian banking observations by defining a further decomposition of the global frontier shift, into components that indicate whether an observation is situated in a more or less favourable location in the production possibility set. The favourability and favourability change indices are components of the newly decomposed Malmquist productivity change index and have potentially interesting policy implications, which are illustrated using empirical data on a sample of Ghanaian banking subgroups. The favourability of a bank or banking subgroup means that the local frontier shift observed by the individual bank or banking subgroup is larger or smaller than the global frontier shift due to its attributes making it different in some ways from the global set of banks. It is also argued that by engaging in more CSR, some banking groups can place themselves in `locations that are more favourable or move towards more favourable locations over time. Important regulatory insights are deduced from the analysis.

Based on the above objectives, the following research questions (RQ) are addressed:

1. The first questions are:
    a. What is the relevance of incorporating CSR in DEA banking intermediation efficiency models?
    b. Is there a positive relationship between socially responsible banking and bank efficiency and profitability?

2. What are the overall technical, pure technical and scale efficiencies of Ghanaian banks that co-exist and compete in a dual-objective banking system?
3. What is the relationship between bank ownership types, specialisation forms and capitalisation attributes and bank performance? This examines average performance. In other words,
   a) Are foreign banks on average more efficient than private-domestic and state banks?
   b) Are universal banks on average more efficient than focus banks?
   c) Do listed banks on average outperform non-listed banks?
4. Are the frontiers of foreign (or universal or listed) banks on average, better than the frontiers of private-domestic/state (or focus or non-listed) banks respectively? This examines best-practice performance.
5. Are foreign (or universal or listed) banks on average located in more favourable positions than private-domestic/state (or focus or non-listed) banks? In other words, are some banking subgroups located where the frontier shift is larger than average frontier shift relative to other banking groups? A follow up question is; are some banking subgroups moving towards more favourable locations over time?

Question 1a is answered by the conceptual modelling of CSR in a DEA framework whilst question 1b is explored using multiple regression analysis. Question 2 is answered by running the developed DEA banking intermediation efficiency model. Questions 3(a) to 3(c) examine average performance using the metafrontier analysis. This is interesting in the sense that it will help to make meaningful average efficiency comparisons across banking groups. The approach will be employed to estimate the gap between Ghanaian banking group-specific frontiers and their metafrontier in order to determine the impact of group-specific technological factors on efficiency.

Nevertheless, average performance does not necessarily imply global frontier differences. The global frontier difference (Asmild and Tam, 2007) is further employed to investigate and explain the differences between best-performing banking groups in question 4. The findings from question 4 should be of interest to bank management who must adopt improvement strategies for their respective banks and banking regulators who must create an atmosphere conducive to the implementation of banking sector reforms. Regulators can better understand which banking groups perform better than others perform and can prescribe policies that suit each group. For example, policies designed for state banks might be different from policies designed for foreign banks as the former may focus more on business operations of small and medium scale enterprises in local communities and villages and may engage more in CSR activities. On the other hand, foreign banks may pay more attention to large corporations in the cities and possibly engage less in CSR. If the best-performing foreign banks are found to be better on average than the best-performing state banks, a suitable policy might be the furtherance of deregulation and liberalisation of the banking sector. Similarly, based on the evidence on the relative frontier difference between universal and focus banks, the government can design policies to increase banks' capital requirements and change the operating characteristics of focus banks in order to improve their best-practice operations.

Question 5 attempts to explore whether the particular characteristics of banking subgroups cause some of them to be located in more or less favourable positions or cause them to move towards more or less favourable locations over time relative to the global set of banks. The results could reveal that some banking groups achieve a higher favourability and favourability change than what the global frontier shift purports to show, possibly because those banking groups contribute more towards CSR. Arguably, state banks may be located in more favourable positions than foreign banks possibly due to the greater contribution of CSR by the former than the latter. The intention is to find out whether some banking groups have more technological changes than others and if so, what is driving this change? Possibly, the frontiers of certain banking groups may be improving over time, which is good, but some banks cannot capitalise on that technological improvement because they are located in places within the technology set where the frontier does not improve. Exploring the reason behind such a pattern should help the banking regulator to design appropriate policies for the affected banks.

1.5 Thesis Contributions

The main contributions of the thesis are as follows:

At the conceptual level, the contribution is the development of a framework on how the existing theory of DEA can be adapted to the efficiency analysis of banks that have the dual objective of profit maximisation and corporate social responsibilities.

At the empirical and policy level, the contribution involves the creation of a framework by which the metafrontier analysis and the global frontier difference techniques can be properly applied to investigate the average efficiency and best-practice differences between banking groups that are different in ownership, specialisation and capitalisation forms for effective policy recommendations. This explores the impact of banking reforms on performance using alternative novel techniques.

At the methodological level, the thesis contributes to the productivity analysis literature by defining a further decomposition of the global frontier shift, and favourability and favourability change indices. The indices are used in a particular application field of OR as components of the Malmquist productivity change index. This has interesting policy implications as shown on a sample of Ghanaian banks. The approach is also used to investigate the link between the favourability changes of Ghanaian banks and their CSR.

1.6 Thesis Structure

Chapter 1 has set the stage by highlighting the need to determine the relevance of incorporating CSR into DEA banking efficiency. It has provided a justification for the consideration of CSR activities in banking, particularly in the banking sector. The chapter has set out the motivation underlying the study, outlined the importance of the study and delineated the aims and objectives of the study from which the research questions were deduced. It has provided an overview of the methodological tools required to realise the objectives of the study. Finally, the contributions of the thesis have been explicitly stated.

Chapter 2 contextualises the concept and application of CSR in a DEA environment within the Ghanaian banking system. The macroeconomic and historical backgrounds of the Ghanaian banks are discussed. The chapter also examines the structure of the financial and banking sector in Ghana and the historical objectives of the banks, highlights the various banking acts and directives created to regulate the sector and some specific banking reforms established to facilitate banking soundness, efficiency and competition.

A review of the literature relevant to CSR is presented in chapter 3. The chapter discusses the multidimensional nature of CSR and plausible measures of CSR. The various proxy measures used for Corporate Financial Performance (CFP) in the literature are examined. Particular emphasis is given to studies that investigate the CSR-CFP nexus. The chapter critiques existing studies, identifies the gaps in the literature and hints on how these gaps can be filled using frontier techniques in subsequent empirical chapters.

In chapter 4, models of the financial firm for assessing performance are discussed and developed. Based on the examination of the existing banking efficiency models, a preferred model is selected to assess the performance of banks that operate in a dual-objective banking system. The input and output variables of the intermediation model are examined. The data set and data sources are described. An empirical analysis is performed to justify the pooling of the data set across the years from 2006 to 2008. This is later used in the first and second empirical chapters.

Chapter 5 reviews parametric and nonparametric frontier methodologies used in the efficiency and productivity change measurement with particular attention to the theory of DEA and different versions and extensions of the original DEA model. The chapter examines the Malmquist productivity change index, the metafrontier analysis, the global frontier shift and the favourability and favourability change indices. The chapter uses graphical illustrations to explain the main concepts underlying these techniques. Towards the end of the chapter, a critical and detailed review of studies that apply some of these frontier methodologies, particularly, DEA financial institutions in different countries and for different purposes is presented. Particular consideration is given to studies that investigate the link between bank performance and bank ownership, specialisation and capitalisation.

Chapter 6 combines the model developed in chapter 4 and the DEA technique in chapter 5 to assess Ghanaian banks' performance. The efficiency of two DEA banking models are examined, one model that incorporates CSR (called total model) and another that does not (called reduced model). Subsequently, parametric and nonparametric tests are employed to examine the relevance or otherwise of including CSR in the DEA banking efficiency model. Further, Ordinary Least Squares (OLS) and quantile regressions are performed to investigate the relationship between economic performance, measured by profitability and efficiency indicators, and CSR whilst controlling for other variables.

Chapter 7 investigates the average efficiency and best-practice differences across the identified banking subgroups based on bank ownership, specialisation and capitalisation types using the global frontier difference of Asmild and Tam (2007) and the metafrontier analysis of O'Donnell et al. (2008). The chapter examines and explains both the average performance and the best-practice differences between state, private-domestic and foreign banks, between universal and focus banks, and between listed and non-listed banks. Corresponding policy recommendations for the banking sector are prescribed.

Chapter 8 proposes a novel application of the local favourability and favourability change indices which are components of the 'newly-decomposed' Malmquist index (Asmild and Tam, 2005). The indices are deployed for the first time to investigate whether some banks and banking subgroups are in located in positions that are more favourable and whether they are moving towards locations that are more favourable over time relative to the global technological changes observed by all banks. Research question 5 that asks whether foreign (universal or listed) banks are located in more favourable positions and moving towards more favourable locations over time compared with private (focus or non-listed) banks, is answered in this chapter. Also explored in this chapter is the link between banks' CSR and their favourability and favourability changes.

Finally, chapter 9 summarises the key findings and conclusions from the empirical chapters. It reviews the main conceptual, methodological, and empirical and policy contributions of the study and considers how the regulator and bank managers can draw policy recommendations for the banking industry and individual banks respectively. The final section provides directions for further research.

1.7 Conclusion

The thesis is motivated by the need to capture multiple objectives of banks in DEA banking efficiency analysis. The study is also motivated by regulatory changes and bank-specific factors that can affect their performance. These include the deregulation and privatisation of banks, increasing competition from the entry of foreign banks and growth of private-domestic banks, the introduction of universal banking and the listing of banks on GSE.

Ghana makes a useful case study to examine the achievement of far-reaching financial sector reforms in order to draw policy implications and lessons for the banking sector not only for Ghana but also for developing economies at large.

The findings from the study may be used to inform government policy decisions, improve managerial efficiency and address research issues. The methodological advancement pursued in this study can also be applied to different organisations other than banks.

Chapter 2

Ghanaian Banking System

2.1 Introduction

This chapter provides background to the Ghanaian banking system since the concepts and models developed in the study will be empirically applied using a sample of data on banks in Ghana. The chapter discusses indicators of the macroeconomic environment that are likely to impact on performance of the banks, highlights the structure of the Ghanaian financial and banking sector, examines the key financial developments and regulatory reforms introduced in the sector to ensure prudence and efficiency. The chapter also examines the characteristics of the different banking groups and their objectives historically.

2.2 Contextual Setting

In order to assess the performance of the Ghanaian banking sector, it is appropriate to know the macroeconomic environment and the financial context in which they operate and compete. Figure 2.1 shows the development of selected macroeconomic indicators of the Ghanaian economy between 2004 and 2009. GDP growth was 5.9% in 2005 and rose to 6.4% in 2006, which was more than the world's output growth of 3.55% and 4.06% respectively during the same periods. In fact, since 1985, Ghana's GDP growth rate has been consistently above the World's, and even during the global financial crises. Interestingly, although the economic performances of many African countries were adversely impacted by the global financial crises and the fall in commodity prices in 2007 and 2009, Ghana was not greatly affected by the crises. GDP growth in Africa went down to 5.2% in 2008 from a growth of 6.2% 2007. Within the sub-Saharan Africa, GDP growth was somewhat higher at 5.4% for 2008, but still down from 6.9% recorded in 2007. However, Ghana's GDP increased from 5.7% in 2007 to 7.3% in 2008 (BOG, 2008a). These are good indicators of economic growth and development in the Ghanaian economy. It is expected that banks will thrive in this seemingly stable financial landscape.

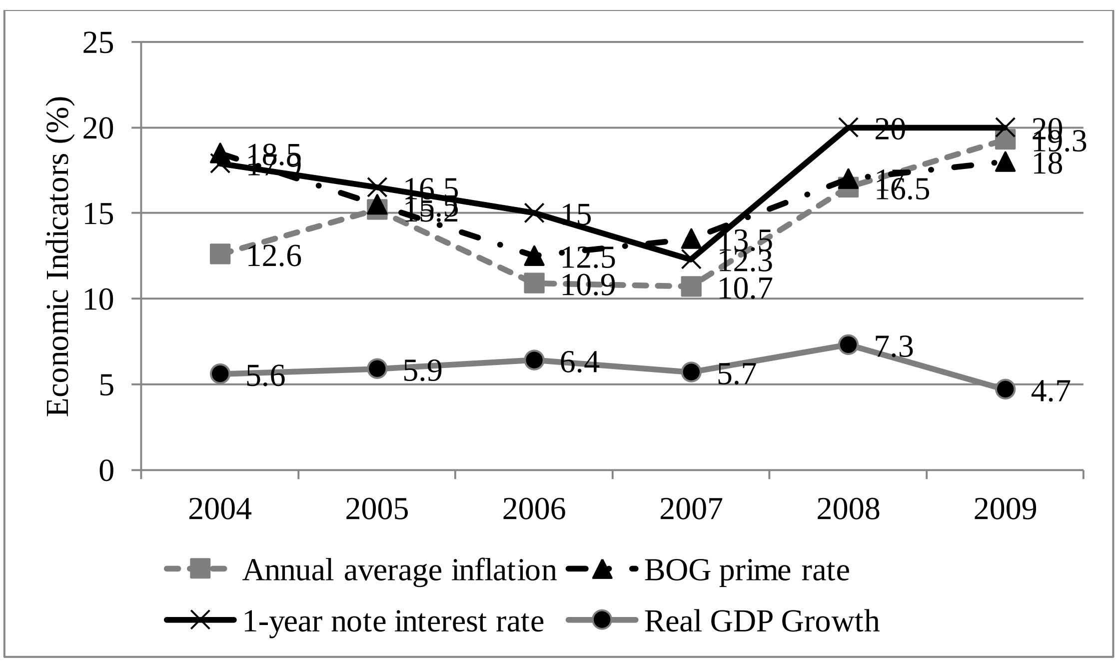

Figure 2.1 Macroeconomic indicators of the Ghanaian economy during 2004-09

2.3 Structure of the Ghana's Financial System

The three main arms of Ghana's financial system are the Bank of Ghana (BOG), the Securities and Exchange Commission (SEC) and the National Insurance Commission (NIC). Under the control of the SEC are the stock market, brokerage firms, investment firms, trustees, and custodians. The NIC regulates insurance companies, insurance brokers and reinsurance companies. The BOG heads the Deposit Money Banks (DMBs) and Non-Bank Financial Institutions (NBFIs) – savings and loans companies, discount houses, finance companies, leasing firms and Forex bureaux. Figure 2.2 depicts the evolution of the number of DMBs and NBFIs from the years 2000 to 2009. The figure shows an increase in the number of banks from 17 in 2000 to 26 in 2009 and in the growth of NBFIs from 37 to 47 over the same periods.

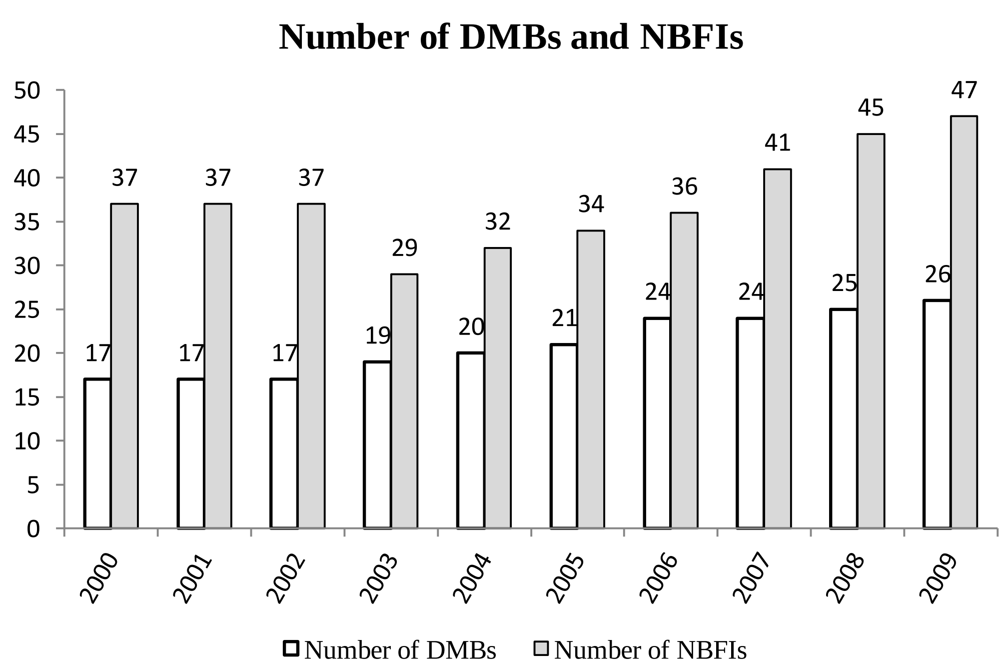

Figure 2.2 Growth of Banks and NBFIs (Source: BOG 2000-09 Annual Reports)

There has also been an increase in the number of bank branches from 360 in 2004 to 706 in 2009. The belief is that the consistent growth should result in a banking system that is competitive, profitable, liquid and solvent (BOG, 2009). The growth of banks is partly due to the entry of both private-domestic Ghanaian banks and foreign banks and not state-owned banks.

2.4 Banking Regulatory Reforms

The Ghanaian banking industry has undergone significant reforms in the last two decades. Recent liberalisation and deregulation in the banking sector to the form of privatisation of state banks, upsurge in banks' minimum capital requirements, increasing banking sector competition partly due to the entry of both foreign and private-domestic banks, the introduction of universal banking and the listing of banks on the Ghana Stock Exchange (GSE). To buttress this point, the Ghanaian banking sector has been undergoing important transformations under the financial sector reforms since 1983 when the Economic Recovery Programme was launched with the aim of controlling interest rates, credit rates and exchange rates (BOG, 1997). The new millennium witnessed the use of the Bank of Ghana's (BOG) prime rate as an anchor for money market rates to signal the government's assessment of inflationary pressures and monetary policy stance. During this period, the Banking Supervision Department of the BOG exercised its supervisory functions to ensure the stability and soundness of the financial system and operated under the directives of the Banking Law 1989 (PNDCL 225) and the Bank of Ghana Law, 1992 (PNDCL 291) (BOG, 1996). For instance, the banking law of August 1989 required banks to maintain a minimum capital base equivalent to 6% of net assets adjusted for risk and to establish uniform accounting and auditing standards. Since 2002, there have been other major developments in the banking industry, as depicted in Table 2.1. These policy initiatives were designed to ensure prudence and efficiency in the banking sector. In addition to the Acts listed in Table 1.2, the banking sector is regulated by the Companies Act 1963 (Act 179) and Bank of Ghana's Notices, Directives, Circulars and Regulations.

Table 2.1 Major developments in the Ghanaian banking industry since 2002

Year	***Key Developments***
2002	The Bank of Ghana Act 2002 (Act 612) was signed into law
2002	Introduction of the Bank of Ghana Prime Rate as the policy rate
2002	Inauguration of The Monetary Policy Committee
2002	Higher denomination notes introduced: GH¢ 10,000 and GH¢ 20,000
2003	Maintenance, transaction and transfer fees charged by banks abolished
2003	Universal banks introduced for banks with ¢70 bil (GH¢ 7 mil) in capital
2004	Banking Act 2004 (Act 673) replaced Banking Law 1989 (PNDC Law 225)
2006	Abolishing of secondary deposit reserves requirement (15%)
2006	Foreign Exchange Act 2006 (Act 723) came into effect
2006	Whistle Blowers Act 2006 (Act 720) was passed
2007	Passage of Credit Reporting Act 2007 (Act 726)
2007	Banking (Amendment) Act 2007 (Act 738) were passed
2007	Abolishing of National Reconstruction Levy
2007	Re-denomination of the cedi (¢10,000 = GH¢1)
2008	Introduction of E-zwich, the biometric smart card
2008	BOG's notice for requirement of minimum stated capital of GH¢60 million to maintain Class 1 banking status

The period 1983-1988 witnessed crises within the Ghanaian financial system. Banks accumulated non-performing assets, encountered default risk, and higher inflation that decapitalised many banks. Nevertheless, in the late 1980s, several African countries, including Ghana, took on the World Bank supported Structural Adjustment Programme (SAP) as part of the financial sector reforms (Sowa, 1993). Measures were introduced to inculcate capital market discipline, license private-domestic banks, increase credits to informal financing, restructure existing banks, liberalise restrictions on interest rates, exchange rates and prices and remove quantitative controls on lending (Aryeetey and Senbet, 2004). The Ghana Stock Exchange (GSE) was created in 1989 to generate liquidity into the financial system by serving as a pivot for the mobilisation of long-term capital through the sale and purchase of shares, bonds, and other securities. These reforms were possible under the Financial Sector Adjustment Program (FINSAP 1 and 2) and were geared towards enhancing efficiency and competitiveness within the banking sector.

2.5 Historical Objectives of Banks

Ghanaian state-owned banks were historically set up by the government to invest in developmental and commercial projects that will otherwise not be financed by private enterprises. It is also asserted, “Without big banks, socialism would be impossible. The big banks are the ‘state apparatus’ which we need to bring about socialism, and which we take ready-made from capitalism. …” (Garvy, 1977, p. 21). The notion of socialism related to banks was accepted globally, particularly in the 1960s and the 1970s when governments nationalised the existing commercial banks and established new banks in Africa, Asia, and

Latin America (La Porta et al., 2002). The socialistic idea of banks emanates from the economic theory of organisations where state organisations are established to address the problem of market failures provided the social benefits exceed the social cost (Atkinson and Stiglitz, 1980; Stiglitz, 1993). Similar to the social theory is the agency theory that provides the reasons for the establishment of state banks. The agency theory argues that banks may be set up to maximise social welfare, albeit, their establishment could lead to resource misallocation and malfeasance (Banerjee, 1997; Hart et al., 1997).

The Ghanaian state banks operated quite well for some time until in the 1980s when this began to alter. As part of the liberalisation process, some state-owned banks, which used to dominate the banking industry, were privatised. For instance, part of the equity of the Ghana Commercial Bank (GCB) was privatised when the bank’s 100% shares were traded on the GSE in 1996 (Brownbridge and Gockel, 1996). As of 2009, the Government of Ghana (GOG) owned only 21.36% of GCB whereas institutions and individuals owned 78.64% (GCB, 2009). Also, in 1994, two of the state-owned banks - Social Security Bank Limited (SSB) and National Savings and Credit Bank – were merged and privatised under the auspices of a World Bank programme. In 1995, the GOG divested its 21% shareholding of this merged bank, after which the bank’s shares were floated on the GSE and subsequently renamed Société Générale - Social Security Bank (SGSSB) in 2003 (Gatsi and Agbenu, 2006). Privatisation was meant to address the problem of substantial non-performing loans and governmental bureaucracies within state banking practices and to increase banking sector competition. Indeed, the private banks would be strictly profit maximising compared to the state banks due to the considerable social dimension of the latter.

Over the years, foreign banks have played crucial roles in the Ghanaian banking industry. For decades, the industry was dominated by Standard Chartered Bank Ghana, SCB (formerly called British Bank of West Africa) and the Barclays Bank Ghana, BBG (formerly called the Colonial Bank) both of which are foreign-owned. As at May 2009, there were 13 foreign-owned banks and 12 domestic-owned banks in the industry (PwC and GAB, 2009). Given the growth in the entry of both private-domestic and foreign banks, it is of policy concern for BOG and bank managers to assess the efficiency of publicly-owned banks (state banks), private-domestic-owned banks (private-domestic banks) and private-foreign-owned banks (foreign banks) in the Ghanaian banking sector in order to identify the sources of their inefficiencies and to address them.

One major regulatory factor that altered the scene of the banking industry was the introduction of the Universal Banking Business Licence (UBBL) in 2003. ‘Universal banking’ is a corporate structure where banks, in addition to their traditional banking operations, are allowed to offer financial service such as selling insurance, underwriting securities and engaging in portfolio management, equity investments, bond trading and financial advice (Benston, 1994; Vander Vennet, 2002). Universal banking has existed in U.S. following the Glass-Stegall Act in 1933 and Gramm-Leach-Bliley Act in 1999 and in Japan following the Financial System Reform Act of 1992 in Japan. Germany is also well-known for this banking type. Universal banking is permitted in the European Union (EU) by the Second Banking Coordination Directive (1989) under the Single Market Programme (Berger et al., 2001). In Ghana, universal banking became a policy concern from 2003. Before examining the historical characteristics of universal and focus banks, it is important to show the classifications of the Ghanaian banking structure.

Figure 2.3 depicts the classification of banks under the auspices of the BOG for the period under study, i.e. from 2006 to 2008. There were 25 banks operating in the country by the end of 2008. However, data unavailability prevents the inclusion of all the banks in the empirical analysis of the study. Figure 2.3 builds the profile of the banks based on whether they are universal banks or focus banks. In total, there were 2 commercial banks, 3 development banks and 16 universal banks. Six of the banks are listed on the Ghana Stock Exchange and they are denoted by asterisks. Some of the banks were state-owned (labelled with superscript 1) whilst others were private-domestic-owned (labelled with superscript 2) and foreign-owned (no superscript).

The ARB Apex Bank is one regulatory body (acting as a central bank) that provides banking and non-banking support to rural and community banks, which are usually located in the villages and the hinterlands of the country. There were 122 of these rural and community banks in 2006. They are not included in the final empirical analysis because the majority of them do not have available and reliable data.

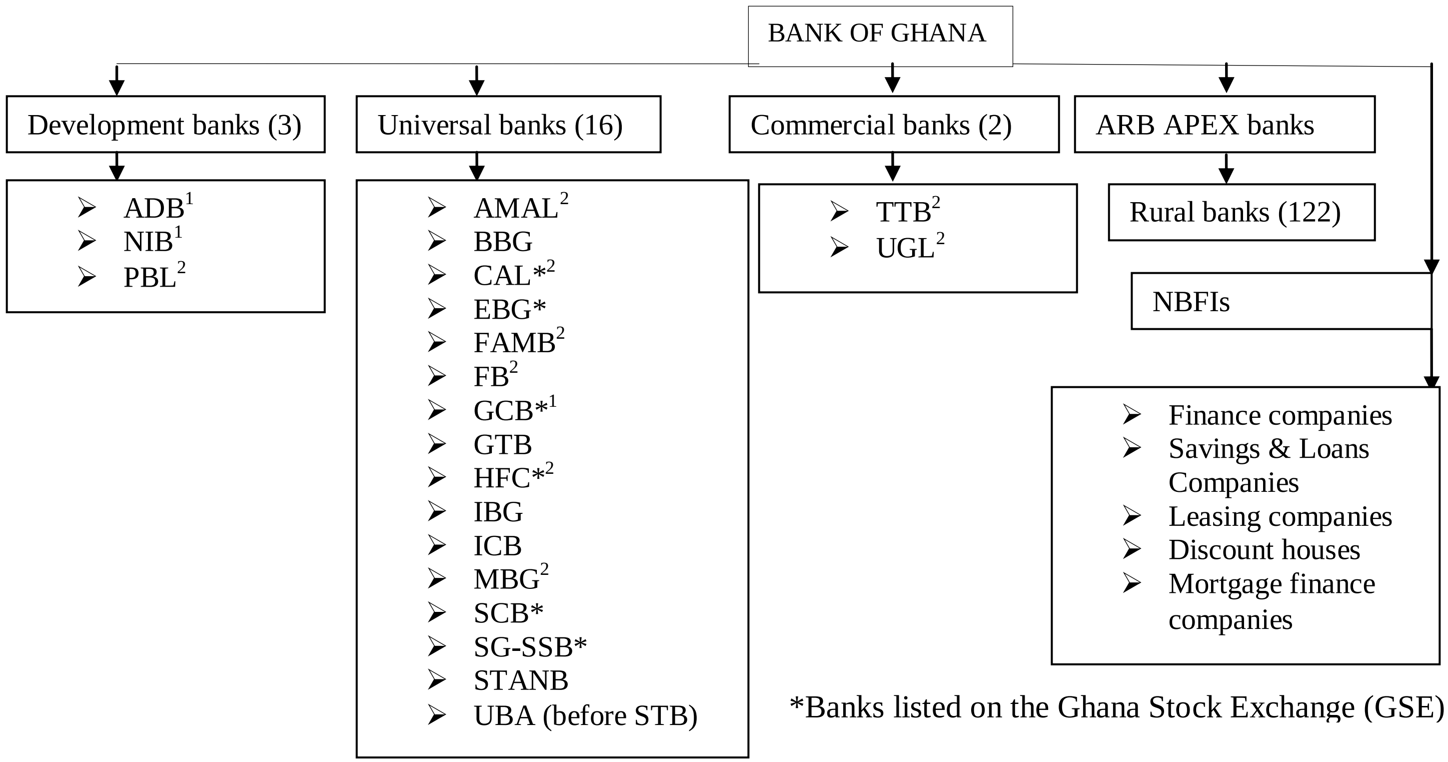

Figure 2.3 Structure of the banking sector, Source: BOG 2006 Annual Report, Ghana Banking Survey and Author's analysis

In Ghana, the ‘focus’ banks - commercial banks, development banks and merchant banks - were historically established with the purpose of serving the financial needs of specific sectors of the economy and providing specialised funds to the needy and small and medium-scale enterprises (Addison, 2003). Focus banks should be distinguished from universal banks in that the former specialise in one thing at a time. Ghanaian c*ommercial banks* were created because it was believed that the existing foreign banks concentrated on foreign business activities without generating enough funds to small-scale businesses and households (Brownbridge and Gockel, 1996). In line with this objective, GCB was created in 1953 to improve credit to indigenous businesses and farmers, to provide loans to households in a socially responsible way and to engage in import and export financing (Aryeetey, 1993). Similarly, SSB began operation in 1977 to provide credit to consumers and businesses. Another group of focus banks that became operative from the 1960s were three government-owned *development banks* that were created by statute with the objective of satisfying the gaps which the commercial banks were expected to fulfil, such as channelling medium-term and long-term financial resources to specific sectors of the economy. In particular, NIB was established in 1963 to promote and strengthen rapid industrialisation in all sectors of the economy through long-term financing (Gockel and Akoena, 2002). The ADB was established in 1965 to provide and administer credit and other banking facilities to the agricultural sector as part of contributing to social welfare and later to accept deposits on current and savings accounts. The Bank for Housing and Construction was launched in 1974 to generate loans for housing and industrial construction (Brownbridge and

Gockel, 1996). Over the years, the development banks broadened their activities and operated mainly as commercial banks. The final group of focus banks were *merchant banks,* which included MBG that was set up in 1971 in Ghana to offer one-stop corporate banking services (Mensah, 1997). In 1990, CAL Merchant Bank was created to mobilise resources in world financial markets and channel them to the Ghanaian market. Other merchant banks included Ecobank Ghana Limited (ECB) and First Atlantic Bank (FAMB) both of which arranged loan syndications, operated brokerage subsidiaries and participated actively in the stock market as Licensed Dealing Members of the Ghana Stock Exchange (Morse et al., 1996). Generally, the institutional characteristics of focus banks show that they were created with the aim of facilitating the growth of the overall economy and the social well-being of small businesses and households.

Nonetheless, the liberalisation of the financial sector gave some of the focus banks opportunities to go beyond the historical banking activities (Addison, 2003). Attempts were made to engage in other financial goings-on such as portfolio management, brokerage and underwriting (Steel and Webster, 1991). The concept of universal banking became a policy debate where it was argued that universal banking would be a multi-faceted solution to address the constraints of development financing, reduce risk and borrowing costs, and stimulate further competition and efficiency in the banking industry (Addison, 2003). The BOG introduced the Universal Banking Business License (UBBL) policy in 2003 and that same year, granted universal banking licences to three banks - ECB, MBG and HFC Ltd.

Converting to universal banking required a minimum capital of 7 million Ghanaian cedis (GH¢) for new and existing Ghanaian banks and GH¢ 60 million for foreign banks (BOG, 2008a, b). The policy was aimed at increasing the capital base of banks in order to accept greater levels of risk, ensure technological innovation and position them to support the oil industry (BOG, 2008a). A question remains though. Has the adoption of universal banking by made Ghanaian focus banks perform better than the remaining specialized banks? The present study will investigate whether universal banks outperform focus banks in terms efficiency and productivity change and hence, whether the UBBL have had a positive impact on banks. It may be that universal banks can add value by taking advantage of cost and revenue scope economies or it may be that focus banks can increase shareholder value by specialising on core businesses and core competencies (Berger et al., 2000a).

Ghana makes a useful case study to examine the achievements of far-reaching financial sector reforms to draw policy implications for the banking sector not only for Ghana but also for developing economies at large. The findings from such a study may be used to inform government policy decisions, improve managerial efficiency and address research issues. Again, Ghana has been well noted to contribute to the cocoa production in the world. Lynn (1998), for instance, indicated that Ghana contributed 36.5% to the world production of cocoa in 1962-1963 and contributed 10% of the world cocoa output in 1983-1984. Ghana was the second world producer of cocoa in 2006-2007 after Côte d'Ivoire, producing 720 thousand tones of cocoa (Ruf, 2007; ICCO, 2007). Ghana is also rich in other natural resources. The revenues generated from the cocoa industry and natural resources must be well intermediated by banks. To ensure that the banking sector carries on its intermediation role efficiently, the performance of banks must be assessed periodically in order to determine areas of performance improvements. In summary, managerial performance evaluation of banks should be of interest not only to academic researchers but also to bank regulators and managers (Fethi and Pasiouras, 2010).

2.6 Conclusion

This chapter has set the stage for the understanding of the financial and the banking system of Ghana. It has been discussed that the historical objectives of the banks were to improve specific sectors of the economy by channelling funds to households and small and medium scale enterprises thereby fulfilling their conventional aim of maximising shareholder value whilst engaging in socially responsible activities. The chapter has also examined the historical characteristics of different banking subgroups, which emanate from the various banking reforms set up to ensure prudence and efficiency. The build up of the profiles of the banks will help in the empirical sections as we examine the performance differences between different banking subgroups.

Chapter 3

CSR, Banking and Performance

3.1 Introduction

The contemporary notion of CSR began with the book "Social Responsibilities of Businessman" by Bowen (1953). The concept and implications of CSR has become popular in both the academic community and the corporate world. This chapter explores the multidimentionality of the CSR concept within the banking sector and the measurement of CSR. The chapter also discusses the measurement of Corporate Financial Performance (CFP) and the relationship between CSR and CFP.

3.2 Defining the Multidimensionality of CSR

CSR has received a great deal of attention in the management and business ethics literature. There is a long-standing disagreement regarding what CSR actually entails (McWilliams et al., 2006). A notable explanation of the concept among opponents of CSR is the definition by Friedman (1970), who claimed from the instrumental theoretical perspective that "the corporate social responsibility of business is to increase its profits". Friedman (1970) argued that societal concerns are not businesses' concerns and that the free market system should eventually decide on such matters. If the free economy is unable to handle such matters, then the government should decide on such matters. The remark by Friedman is accepted in other circles. On the other hand, proponents of CSR, who advance the stakeholder, theory credited with Freeman (1984), argue that a firm's boundary goes beyond the main stakeholders to include any group that is influenced by or can influence the firm to achieve its aims (cf. Frooman, 1997). Freeman (1984) noted that firms that engage in CSR may reduce stakeholders' transactional costs. Several theoretical perspectives on CSR have emerged since the arguments by Friedman and Freeman. Among these perspectives are agency theory, stakeholder theory, competitive advantage theory, resource-based-view of the firm and institutional theory (Freeman, 1984). For instance, the resource-based view of the firm perspective was introduced by Wernerfelt (1984) and improved by Barney (1991) under the assumption that for some businesses, environmental social responsibilities can be seen as resources and capabilities that can result in sustainable competitive advantage (cf. McWilliams et al., 2006). In others words, in order to use efficiently, the main important inputs to generate the desired outputs in an organisation, management ought to tighten their stakeholder relationships. The framework was first theoretically applied to environmental CSR by Hart (1995) and empirically tested on firm level data by Russo and Fouts (1997) who observed that businesses that are highly environmentally and socially responsible had higher financial performance, which they claimed, agreed with the resource-based view.

A recent survey reported 37 definitions associated with CSR (Dahlsrud, 2008). One of the popular definitions is provided by Carroll. The author defined CSR in four parts as including "the economic, legal, ethical, and discretionary [later referred to as philanthropic] expectations that society has of organizations at a given point in time" (Carroll, 1979 p. 500 ; 1991 p. 283). This definition seems to be all-inclusive; it considers not only the social dimension of CSR but also the economic dimension. McGuire (1963, p. 144) remarked that "the idea of social responsibilities supposes that the corporation has not only economic and legal obligations, but also certain responsibilities to society which extend beyond these obligations". Wood (1991) defined CSR that makes it measurable. Wood (1991) viewed CSR as "configuration of principles of social responsibility, processes of social responsiveness, and policies, programs and observable outcomes as they relate to the firm's societal relationships" (Wood, 1991, p. 693). Generally, CSR considers that businesses have both primary obligations to shareholders and secondary obligations to society.

A critical examination of the definitions of CSR points towards a social contract whereby firms are answerable to the demands and expectations of society. A number of authors have used the legitimacy theory to understand this idea of social contract embedded in the concept of CSR (Warren, 2003; McWilliams et al., 2006; Kuznetsov et al., 2009). Organisational legitimacy as explained by Suchman (1995) is a generalised view that, the actions of a (banking) firm are desirable, proper, or appropriate within some socially defined system of norms, values, beliefs, and definitions. The stakeholder theory examined previously integrates some of the building blocks of legitimacy by associating the profitability of businesses with the trust and respect firms receive from all other stakeholders since by social contract, firms and society are equal partners. It appears that Ghanaian banks engage in socially responsible activities in order to earn this trust from customers, government and the whole society.

Recently, Lundgren developed a dynamic microeconomic model of the firm that considers various CSR dimensions. The authors showed that profit-maximising firms undertake cost-benefit analysis of CSR and then contribute towards CSR if stakeholders reward or pressure these firms to be socially responsible. For a literature survey on other constituents of CSR, the reader is referred to Joyner and Payne (2011), Dowell et al. (2002), Matten and Moon (2000), Paul and Siegel (2005), Chapple and Moon (2006) and Carroll and Shabana (2007). As aforementioned in the introductory chapter, consistent with McWilliams and Siegel (2001), this study considers CSR as *voluntary* actions by which banking firms go beyond compliance or the minimum legal requirements and engage in activities "that appear to further some social good, beyond the interests of the firm" (McWilliams and Siegel, 2001 p. 117). The aspect of CSR considered here in the banking industry concerns corporate philanthropy including charitable donations. In developing the theory of the firm in a dual-objective banking system, the author of this thesis has employed the resourced-based theory of the firm. In effect, a simple model is defined where two banks (in our case) generate the same products and services but one bank also generates a social aspect to the product which is valued by some customers and other stakeholders.

It should be noted that socially responsible banking is a multidimensional concept that evaluates different aspects of businesses. The management literature views CSR as a complex, broad, comprehensive construct (Brammer and Millington, 2008). This probably explains why there are several explanations to the concept. It also probably explains why there are debates about whether or not CSR has a positive effect on CFP. Clarkson (1995) indicated that the stakeholder theory can be employed to analyse the multidimensional view of CSR. In table 3.1, a broad list of what can be considered as inclusive of CSR is presented. The list is broad in the sense that it deals with many aspects of society including trade, commerce, finance, sport, agriculture, services, education, industrialization, politics and human rights.

Table 3.1 Common dimensions of CSR evaluated by rating agencies

Product quality	Wage and non wage benefits for firm employees
Transparent business practices	Occupational health and safety
Education improvement	Improvement in staff quality of lives
Agricultural improvement	Human capital development
Environmental performance improvement	Managerial compensation
Health improvement	Commitments to human rights
Poverty relief works	Freedom of association and collective bargaining
Sports improvement	Human rights to equality of opportunity
Support toward cultural activities	Abolition of child labour
Support toward national events	Prohibition of forced labour
Charitable services and philanthropy	Employee volunteer programmes
Waste management	Corporate citizenship/philanthropy
Talent attraction and retention	Corporate governance
Reduction in bribery and corruption	Crisis and risk management

3.3 Measures of CSR

To measure socially responsible activities, several techniques based on subjective weighting of CSR dimensions have been proposed. Common measures of CSR are Fortune reputation surveys, the Kinder, Lydenber, Domini and Company (KLD) Socrates database, the Domini 400 Social Index, Innovest rating method, Sustainable Asset Management (SAM), Moskowitz, Business Ethics, Canadian Social Investment Database (CSID) etc. (Griffin and Mahon, 1997; Simpson and Kohers, 2002; Wu, 2006).

The KLD Socrates database was used by Waddock and Graves (1997), Berman et al (1999), Nelling and Webb (2009), Bouquet and Deutsch (2008) and Becchetti and Trovato (2011). KLD is a reputation measure that rates firms, traded on the US stock exchange, based on 8 factors along a scale of ±2 on the basis of their social performance. Specifically, it is a 'market capitalization-weighted common stock index which monitors the performance of 400 US corporations that pass multiple, broad-based social screens' (Griffin and Mahon, 1997). The 8 factors are product quality, relations, environmental issues, community relations, the treatment of women and minorities, military involvements, nuclear power and South Africa. The first 5 deal more with the stakeholder relations. The *Fortune* reputation index used by Preston and O'Bannon (1997) also assesses the socially responsible activities of firms from a management viewpoint. It is computed from an 8-dimension survey of questionnaire respondents from firms and compiled every year by *Fortune* magazine (McGuire et al., 1988; Griffin and Mahon, 1997; Roberts and Dowling, 2002). Of the two reputational indices, KLD has larger dataset and also passed the many tests of construct validity (Sharfman, 1996).

But there are drawbacks with the reputational indices. Both the *Fortune* and KLD deal with subjective assessments of organisational performance by external audiences who could be biased respecting the information or perception of the businesses they assess since they are subjected to human errors. These CSR-rating agencies base their ratings on qualitative factors using just pluses and minuses without using numbers. In other words, KLD database shows if a business undertakes CSR activities and lists the type of activities. But, it does not document monetary costs of CSR investments. Barnea and Rubin (2010) attributed the difficulty in quantifying the amount of CSR expenditure of U.S. firms to the greater number of studies that employ KLD data. Waddock and Graves (1997) also mentioned another drawback of the KLD, in that, it lacks a weighting scheme for the different dimensions of CSR since all dimensions are given equal weight. Assigning the same weight to different factors makes it difficult to compare different firms from diffent industries. It has even been argued that reputation does not perfectly depend on the strategic posture of a business (Godfrey, 2005). Also, combining the multiple dimensions of the KLD into one index can hide the substance and relevance of specific dimensions of individual firms or industries. Maignan and Ferrel (2000) even argued that the indices are not sufficient in assessing the overall aspects of the business, adding that, both KLD and Fortune index "…suffer from the fact that their items are not based on theoretical arguments" (p. 285). The authors then developed a scale based on corporate citizenship. Another limitation of the KLD database is the fact that it only contains information about U.S. organisations.

Upon reviewing some of the proxy measures of CSR in the literature, Simpson and Kohers (2006) suggested the selection of an all-inclusive measure of CSR. Simpson and Kohers (2002) employed a different CSR metric to investigate the CSR-CFP linkage in the US banking industry. This is the Community Reinvestment Act (CRA) of 1977 rating. Under the CRA, each bank is rated by regulatory examiners for its performance and ability to provide loans to low income earners. Simpson and Kohers (2002) stated that while their index did not represent a perfect measure of CSR, it was a multidimensional and unique measure. This thesis employs a different measure of CSR for Ghanaian banks because of the drawbacks of KLD rating and because the CRA rating is restricted to the US banking industry. The CSR measure in this study was obtained directly from Ghanaian banks' annual reports collated by CIG in collaboration with Deloitte & Touche, PriceWaterhouseCoopers and Westpoint Consulting. The measure of CSR adopted here does not suffer from subjective bias, as it is objectively and quantitatively determined. It is money spent on various societal areas and aggregated as a measure of CSR. The important aspect of the CSR measure adopted in this study is that it has not been used before in any industry analysis. Banks are evaluated on the following categories:

- Programmes to improve the quality of life for the workforce and their families.
- Amount of after-tax profits donated to charity.
- National or local program/ project support including educational improvement, environmental improvement, health, poverty relief, sports, culture, general social upliftment and other areas of improvement.

3.4 Measures of Corporate Financial Performance (CFP)

Like CSR, CFP is said to be multidimensional in the sense that different measures have been used to proxy CFP. There are three broad categories of CFP: accounting-based measures (accounting returns), market-based measures (stock returns) and perceptual (survey) measures (Griffin and Mahon, 1997). Griffin and Mahon (1997), in their survey of 51 studies that explored the CSR-CFP nexus, sorted the CFP measures into 6 categories: profitability (11 measures), asset utilization (7 measures), growth (13 measures), liquidity (6 measures), risk/market (12 measures) and other 20 measures. The authors identified 80 different measures of CFP. The most widely used measures were firm size (via the logarithm of total assets), return on assets (ROA), return on equity (ROE), return on investment (ROI), asset age, asset turnover and 5-year return on sales. Some authors (Preston and O'Bannon, 1997) also used market-based measures including Tobin's *q*, market value to book value, price per share, share price appreciation etc. (Dowell et al., 2000; Bauer et al., 2004; Inoue and Lee, 2011). Tobin's q is the firm's market value of assets divided by the replacement value (cost) of assets. It is commonly employed in economics research to signal intangible value. Wu (2006) in his study of the relationship among CSR, CFP and size, found that accounting-based measures outperformed market-based measures in predicting CSR. Nonetheless, other researchers consider the market-based measures arguing that they relate well with the maximisation of shareholder value (Baum and Thies, 1999).

3.5 The Relationship between CSR and CFP

Among the earliest empirical studies on the CSR-CFP relationship are Bragdon and Marlin (1972), who used Council on Economic Priorities ratings and accounting measures and Moskowitz (1972) who employed reputational indices. Some literature reviews and meta-analyses on studies that examine the CSR-CFP link include Margolis and Walsh (2001), Orlitzky and Benjamin (2001), Orlitzky et al. (2003), Lyon and Maxwell (2004), Wu (2006) and Orlitzky and Swanson (2008). The literature offers inconclusive results on the CSR-CFP nexus (cf. Lundgren, 2011). Some empirical review studies report positive relationship (Cochran and Wood, 1984; McGuire et al., 1988; Margolis and Walsh, 2003; Orlitzky et al., 2003; Wu, 2006; Beurden and Gössling, 2008) whilst others report negative relationship (Griffin and Mahon, 1997; Brammer et al., 2006) and still others report neutral relationships (Aupperle et al., 1985; McWilliams and Siegel, 2000).

Some researchers including Godfrey and Hatch (2007) attributed the mixed findings on CSR-CFP linkage to authors using multiple-industry data sets, aggregated dimensions of CSR (e.g. workers relation, environmental management and corporate philanthropy) and cross-sectional observations. Again, the direction of the CSR-CFP connection may be different because of empirical, methodological and theoretical drawbacks and because of the type of proxy measures used for CFP (Aupperle et al., 1985; Griffin and Mahon, 1997; McWilliams and Siegel, 2000).

The evidence on the direction of the CSR-CFP nexus appears to support a positive relationship. For instance, Roman et al. (1999) reported that 33 studies they reviewed showed a positive CSR-CFP link, 5 showed negative relationship and 14 found neutral relationship. Margolis and Walsh (2003) conducted a meta-analysis of 127 multiple regression studies on the CSR-CFP link over the period of 1972-2002. The authors concluded, "Corporate social performance has been treated as an independent variable, predicting financial performance, in 109 of the 127 studies. In these studies, almost half of the results (54) pointed to a positive relationship between corporate social performance and financial performance. Only seven studies found a negative relationship; 28 studies reported non-significant relationships, while 20 reported a mixed set of findings" (Margolis and Walsh, 2003 p. 274). The authors critiqued the techniques employed and the conflicting use of proxy variables. Orlitzky et al. (2003) also investigated the population of primary studies that examined the CSR-CFP relationship. After correcting for sampling and measurement error, they performed a statistical analysis of the outcomes from 52 studies and found a positive CSR-CFP link. Wu (2006) conducted a meta-analysis of 121 empirical studies exploring the CSR-CFP association and found a positive link implying that socially responsible firms are likely to have more benefits relative to costs. Wu (2006) also found that firm size had no clear effect on either CSR or CFP. More recently, Beurden and Gössling (2008) conducted a meta-analysis of studies that investigate the CSR-CFP nexus and identified many factors that influence this relationship. They found a positive CSR-CFP relationship indicating that “Good Ethics is Good Business”. They also found in about half of the studies that size was a major variable that influenced the CSR-CFP linkage. Overall, earlier empirical evidence appears to champion a positive relationship. A number of justifications are advanced for the positive link. They include the social impact hypothesis (Freeman, 1984), which is supported by the instrumental view of stakeholder theory and the trade-off hypothesis (Vance, 1975). It is also argued that the real expenditures on CSR are smaller compared to the potential gain to the business. For example, the cost of engaging in CSR may be much less relative to the benefits that result. Another reason advanced for the CSR-CFP link is that profitable businesses have available slack resources due to their higher CFP that can be channelled into CSR activities (Waddock and Graves, 1997; Preston and O'Bannon, 1997). This is the slack resources hypothesis. The term “slack resource” implies “potentially utilisable resources” indicating that businesses that do well appear to do good (George, 2005). Besides, Good management theorists contend that good management practice is highly correlated with CSR (Waddock and Graves, 1997).

Some studies suggest a “virtuous circle” between CSR and CFP based on both the slack resources and good management hypotheses (Waddock and Graves, 1997; Nelling and Webb, 2009). This implies that a rise in CFP results in a rise in CSR because good financial performance may lead to more resources that are available to pursue CSR goals. Also, increases in CSR may increase CFP as more CSR activities may increase investor or customer confidence in the firm in question or boost the morale of employees to work hard to cut down costs, thereby generating higher level of CFP.

The issue with many of these CSR-CFP linkage studies is that there is room for methodological improvement. Existing studies are yet to take advantage of the frontier efficiency and productivity change techniques. Specifically, performance can be measured by the theory of frontier efficiency. Exception include Vitaliano and Stella (2006) and Paul and Siegel (2006). The first empirical chapter proceeds in the direction of Paul and Siegel’s (2006) idea and adds to the existing literature by examining the CSR-CFP connection using technical efficiency and profitability indicators as proxies for CFP. The approach used in this study will help to answer the research question 1b that asked whether there exists a direct link between CSR and CFP in the first empirical section of the study.

Another limitation of earlier studies is the use of samples from a multiplicity of industries. This is because each industry has peculiar attributes, different stakeholders and different reasons and methods of engaging in CSR that differentiates it from other industries (Griffin and Mahon, 1997; Rowley and Berman, 2000). Using several industries in a single empirical analysis could confound the choice of suitable proxies for CSR and CFP (Griffin and Mahon, 1997). To the best of our knowledge, no study has examined the CSR-CFP nexus within the Ghanaian banking industry. The approach adopted in this study is also different from most CSR-CFP linkage studies in that, the analysis considers just a single industry, i.e. the banking industry, where firms use similar resources to generate similar products and services. The approach used here does not combine different industries for the analysis, thereby sidestepping the difficulties associated with unobserved firm heterogeneities that may require the analyst to control for several industry differences. Our approach is in line with a recent call by Simpson and Kohers (2002), Godfrey and Hatch (2007) and Beurden and Gössling (2008) for industry-specific studies. Considering CSR within the banking industry is also interesting, especially when compared with the manufacturing sector. The reason is that manufacturing industries may engage in CSR activities because their actions have negative externalities on the environment such as pollution. But the banking industry does not generate such kind of externalities. Hence, CSR is voluntary.

3.6 Conclusion

This chapter has explored the definitional and the multidimensional construct of CSR. The potential costs and benefits of CSR are examined paving the way to justify the concept into DEA banking intermediation model. The chapter has reviewed various measures of CSR and CFP and explored the CSR-CFP nexus literature. The next chapter discusses the need for appropriate specification of inputs and outputs for banking efficiency intermediation model. The chapter examines this issue, noting the importance of CSR.

Chapter 4

Developing Banking Efficiency Models

4.1 Introduction

This chapter examines the major theories of modelling the inputs and outputs of banks for banking efficiency analysis. Deciding on the selection of inputs and outputs is important because whilst the analyst would like to make the selection as comprehensive as possible, this can be at the expense of ensuring discrimination in the efficiency estimates. After reviewing the existing approaches for modelling the financial firm, the study will choose the appropriate model and the corresponding set of input-output variables for the evaluation of the efficiency of Ghanaian banks.

4.2 Theories Underlying the Choice of a Banking Model

A bank is a complex business entity because it produces multiple outputs using multiple inputs. This has led to a long-standing disagreement on the appropriate model of input-output variables with which to analyze the efficiency of banks (Berger and Humphrey, 1992; Soteriou and Zenios, 1999a; Harker and Zenios, 2000). The controversy is not on loans and other earning assets that are generally treated as outputs. The argument is rather on the role of deposit that is on the liability side of the balance sheet. Some researchers consider deposits as outputs due to their connected service to depositors[1] whilst others view them as inputs due to their provision of the funds necessary to make loans or purchase securities. Elyasiani and Mehdian (1990) considered deposits as inputs arguing that banks 'buy' instead of 'sell' deposits and because deposits are used next to other funds to generate loans and investments. To determine if deposits are inputs or outputs, Hughes and Mester (1993) formulated a test by estimating a translog variable cost (VC) function: $VC = f(\mathbf{y}, \mathbf{q}, \mathbf{x}, u, k)$, where $\mathbf{y}$ is a vector of outputs, $\mathbf{q}$ is a vector of output quality variables, u is uninsured deposits, k is financial capital, $\mathbf{x}$ is a vector of inputs other than u and k (and $\mathbf{x}$ includes insured deposits). They then computed $\partial VC/\partial \mathbf{x}$ and $\partial VC/\partial u$. If deposits are inputs then the derivatives should be negative: increasing the use of some input should decrease the expenditures on other inputs. Their results showed that insured and uninsured deposits were inputs of banks in all size categories.

Selecting inputs and outputs for banking efficiency analysis is important as this can affect the efficiency outcomes. The issue is more important in nonparametric analysis than parametric analysis, due to the difficulty in obtaining statistical tests of inputs and outputs in nonparametric analysis. In empirical studies, the choice of a banking efficiency model normally hinges on the analyst's opinion regarding the objectives of the bank, the efficiency concept adopted, the study objectives and data availability (Berger and Mester, 1997). For instance, a banking efficiency analysis that measures technical efficiency will select inputs and outputs that will be different from when the aim is to evaluate cost, revenue or profit efficiency. Table 4.1 presents standard DEA technical and profit efficiency models. A cost efficiency model will usually have the input prices or costs of the technical efficiency model as its inputs whilst the outputs remain the same. Choosing a cost or profit efficiency model is not easy because it also requires the selection of prices for the financial products and services.

Table 4.1 Standard inputs and outputs for banking efficiency

Profit efficiency model		**Technical efficiency model**	
Inputs	*Outputs*	*Inputs*	*Outputs*
Interest expense	Interest income	Labour	Loans
Noninterest exp.	Noninterest exp.	Capital	Other earning assets
		Deposits and/or Equity	Off-balance sheet activities

There are different ways of modelling banking inputs and outputs for efficiency analysis. These are the *production approach* (Benston, 1965; Berger and Humphrey, 1991), the *intermediation approach* (Sealey and Lindley, 1977), the *profitability model*[2] (Berger and Mester 1997), *marketability model* (Seiford and Zhu 1999) and the *portfolio model* (Fama, 1980b). The most commonly used approaches are the production and intermediation approaches both of which have several variations that deal with the role of certain inputs and/or outputs (Tortosa-Ausina 2002). Further applications of these models are included in appendix 2.

4.2.1 Production/Productivity Approach

The production approach was first introduced by Benston (1965) and Bell and Murphy (1968) and further advanced by Berger and Humphrey (1991). It views banks as producing diverse categories of deposits (e.g. savings) and loans (e.g. consumer and commercial) and other services for account holders using physical inputs such as physical capital (K), labour (L), materials, floor space etc. (Mester, 1987; Colwell and Davis, 1992). The outputs are best measured by the number and type of transactions processed within a specified period. This model highlights banks' commercial behaviours where they provide services for account holders, making this approach to be also called *service provision approach* (Bergendahl, 1998). In this approach, the total costs of the bank include only operating expenses neglecting interest expenses paid on deposits and revenues since deposits are regarded as outputs anyway, and only physical inputs are required to carry out transactions or offer other types of services (Camanho and Dyson, 1999).

4.2.2 Intermediation Approach

The intermediation model of Sealey and Lindley (1977) views financial institutions as agents, liaising funds between demand sources (investors) and supply sources (savers), by using inputs such as labour and physical capital (and sometimes equity capital) to convert financial capital such as deposits and other funds/liabilities into loans, securities, investment and other earning-assets. In this sense, the bank is producing intermediation services. The currency (monetary) units of the bank's assets in various categories of loans and investments represent outputs, while inputs accounts for the financial costs involved in liabilities. Both operating and interest costs combine to form total cost of the bank (Ferrier and Lovell, 1990). There are variant subdivisions of the intermediation approach such as *the asset approach* (Sealey and Lindley, 1977), *the user-cost* approach (Hancock, 1985,

1991) and *the value-added* approach (Berger et al., 1987; Berger and Humphrey, 1992)[3] which are discussed next.

4.2.2.1 The asset approach

The asset approach (Sealey and Lindley, 1977) represents the idea of the T-account of the balance sheet and considers banks' role entirely as intermediaries between lenders and savers. It views deposits and other liabilities and real resources as inputs and loans and the asset side of the balance sheet (hence the name 'asset' approach) as exhibiting output attributes since they usually utilize the funds that create most of the banks' receivable returns. The approach considers balance sheet items and therefore does not involve the profit and loss account of banks' financial statements. This implies that other financial products that are gaining grounds but are not on the balance sheet items are ignored by default. Overall, this approach simply considers loans and other earning assets as bank outputs while deposits and other liabilities are viewed as inputs (Tortosa-Ausina, 2002a).

4.2.2.2 The user-cost approach

The concept of the user-cost approach, based on the user-cost of money propounded by Donovan (1978) and Barnett (1980), was empirically applied to financial institutions by Hancock (1985, 1986). Hancock viewed banks as transforming nonfinancial inputs such as labour, capital and purchased materials and services into financial products. She used a profit function to model bank technology focusing on the interest rate and the substitution elasticity of financial products and modelled the revenue or cost function from interest rates, insurance fees, realised capital gain and loss-provision data.

The user-cost approach categorises the inputs and outputs of a banking product based on their net contribution to bank revenue or depending on the signs of their derivatives in a bank profit function. The financial returns on an asset should be greater than the opportunity cost of funds (or the financial cost of liability should be less than the opportunity cost) for the financial product to be deemed as an output (Hancock, 1991). For instance, this approach will consider CSR as an output if the financial returns of CSR are greater than its opportunity costs. Hancock showed that all the assets and liabilities on the balance sheet could have their user costs computed. But, movements in interest rates and service charges may alter the way assets and liabilities are categorised as inputs and outputs. Fixler and Zieschang (1992) utilised this approach to derive an index of banks' output and prices. The approach is difficult to implement in practice due to the generally unobservable asset and capital prices that must be included (Hancock, 1991).

4.2.2.3 The value-added approach

The value-added approach of modelling bank behaviour is attributed to Berger et al. (1987) and Berger and Humphrey (1992). Under this method, activities, like deposit mobilisation and loan offering, which need substantial expenses on labour (L) and physical capital (K), are categorised as outputs and measured in monetary terms, while L, K and purchased funds are classified as inputs (Wheelock and Wilson, 1995). In other words, balance sheet categories, be it assets or liabilities, are outputs that contribute to the bank's value-added.

Wheelock and Wilson (1995) indicated that in real life applications, the user-cost and value-added approaches classify bank inputs the same way, but, only differ in the way they classify deposits; the user-cost approach classifies deposits as an output whilst the value-added approach classifies deposits both as an input and an output.

4.2.3 Profitability/Revenue-Based Model

The profitability model was suggested by Berger and Mester (1997 ; 2003) in the context of SFA profit efficiency and by Drake et al. (2006) in the context of DEA. It has been empirically applied by e.g. Chu and Lim (1998), Avkiran (2000), Ataullah and Le (2006), Sturm and Williams (2004, 2008, 2010), Yao et al. (2008) and Drake et al. (2009). It considers a financial institution as a business unit with the goal of generating income from the current total expenses incurred from running the business (Leightner and Lovell, 1998). Drake et al. (2006) argued that "from the perspective of an input-oriented DEA relative efficiency analysis, the more efficient units will be better at minimizing the various costs incurred in generating the various revenue streams and, consequently, better at maximizing profits" (p. 1451). They reasoned that the profitability approach helps the analyst to capture the diversity of strategic responses by banks during dynamic changes in competitive environment.

4.2.4 The Marketability Approach

The marketability approach was introduced by Seiford and Zhu (1999b) to measure the activities of banks. Seiford and Zhu (1999b) examined both the profitability and marketability efficiency of the top 55 US commercial banks. The marketability approach is a form of a second-stage process that evaluates profit efficiency in the first stage and then the profit efficiency model is used to determine market efficiency in the second stage. In other words, the first stage evaluates a bank's ability to produce profits (outputs) using the current employees, assets and equity (inputs). Then, the market efficiency model considers profits as inputs which are used to maximise such outputs as market value, return to investors and earnings per share (cf. Luo, 2003). The two-stage approach has been extended and applied to Fortune 500 companies (Zhu, 2000), 14 financial holding companies in Taiwan firms (Lo and Lu, 2009), US S&P 500 firms (Lo, 2010), branches of a large Greek bank (Tsolas, 2010) and Taiwanese banks (Liu, 2011). A difficulty with this approach is that, since revenue is already contained in profit, it may be double counting to include both as outputs.

4.2.5 The Portfolio Approach

Fama (1980b) examined banks' activities by considering banks as undertaking both transaction and portfolio roles. Banks issue deposits and use the proceeds to purchase securities. The portfolio method would consider the balance sheet as encompassing both long and short positions that produces profits and employ financings sources to buy earning assets (Clement, 2007). Sealey and Lindley (1977) contended that the portfolio theory is not a suitable model of a bank as it skips the production and cost constraints of the banking firm.

4.2.6 The "Modern Approach"

The so-called modern approach of Freixas and Rochet (1997) incorporates banks' risk management, agency costs, information procession and quality of bank services. The approach introduces banks' quality of services and the probability of bank failure in the estimation of costs (Das and Ghosh, 2006). The approach uses ratio-based CAMEL[4] approach where the individual parts of the CAMEL ratios are derived from banks' financial tables and are used as variables in the efficiency analysis (Das and Ghosh, 2006).

4.2.7 The Risk-Return Approach

Hughes and Moon (1995) and Hughes et al. (1996, 2000) developed the structural model of bank production based on utility maximisation to determine measures of expected risk and return for each bank. The authors used the analysis to measure a stochastic risk-return frontier and efficiency score. This technique views banks as having different risk preferences and hence pursuing alternative goals outside profit maximisation. If managers maximise value instead of profits, then risk matters. Therefore, bank managers may opt for different production combinations and yet by the same token be efficient, contingent on their individual preferences.

For further details on the risk-return approach, the reader is referred to Hughes (1999), DeYoung et al. (2001), Hughes et al. (2001), Hughes et al. (2003) and Koetter (2008).

4.3 Choosing a Banking Efficiency Model

Berger and Humphrey (1997) remarked that the intermediation approach may be more fitting for assessing the whole financial firm since bank managers focus on reducing total costs and not just non-interest costs. The intermediation approach also considers deposits as inputs rather than outputs because deposits are resources utilised together with other funds in making loans and investments (Worthington, 1998). On the other hand, the production approach might be more appropriate for branch efficiency studies (Berger and Humphrey, 1997). Ferrier and Lovell (1990) indicated that the production method is desirable if the goal of the bank is to minimise cost since this approach dwells on banks' operating costs. Conversely, the intermediation style that relates to the overall bank costs is preferable when the goal is about the bank's economic viability.

But, Berger and Humphrey (1997) advised that neither approach is perfect in wholly encapsulating the dual role of financial institutions in providing transactions or document processing services and intermediating between borrowers and lenders. Besides, neither approach is complete since deposits is argued to have both input and output features which are hard to separate in applied efficiency analysis. Instead, the two approaches are complementary. Denizer et al. (2007) used both approaches to assess the bank efficiency in a pre-and-post liberalization setting, drawing on the experience of Turkey. Kenjegalieva et al. (2009a) also used both approaches to evaluate the performance of 13 Eastern European banking systems. Recent studies also incorporate off-balance sheet activities or non-interest income (Sturm and Williams, 2004; Lozano-Vivas and Pasiouras, 2010; Chen and Liao, 2011).

4.4 The Preferred Banking Efficiency Model

Jointly applying both the intermediation and production approaches would be desirable as suggested by Berger and Humphrey (1997). But this is not possible in this study because the production approach requires such data as branch size, computer terminals, teller employee as inputs and number of transactions, counter level deposits and new accounts as outputs, most of which are not available. This study employs the intermediation model of Sealey and Lindley (1977). This is because from the profit maximisation point of view (which is one of the dual objectives adopted in this study), it is the generation of profit rather than service provision that is important and for that, deposit is an input that provides available funding that can then be used to generate profit. Besides, as indicated by Berger and Humphrey (1997) the intermediation approach is more appropriate for assessing the whole financial firm. The preferred model is presented in Table 4.2. In the next section, the inputs and outputs are explained and their selection justified. As can be noted the banks use several banking inputs to produce several banking outputs and because of that, it will be difficult to measure the performance of banks using instruments that compare performance of organisations that employ single inputs to generate single outputs. Chapter 5 will demonstrate why DEA as a frontier is important to easily handle multiple inputs and outputs.

Table 4.2 Banking efficiency model: multiple inputs and multiple ouputs

Inputs	***Outputs***
Labour costs	Loans and advances
Fixed assets	CSR
deposits	Other earning assets

Appendix 2 indicates that most of these variables are typically used for modelling intermediation activities of banks for efficiency analysis.

4.5 Inputs

4.5.1 Labour

In standard microeconomics, labour is commonly considered a resource to the production of an output. Labour is here represented by staff (personnel) expenses and includes wages and salaries, social security fund contributions (benefits), pension expenses, training and other staff costs (provident fund contributions, medical expenses, retirement benefits). An alternative measure of labour is the average number of full-time employees on payroll during a year, as used, for instance, by Luo (2003). But our choice of labour expenses instead of the number of employees indirectly includes quality. Labour expenses are commonly used in the literature (cf. Kenjegalieva et al., 2009a; Murillo-Melchor et al., 2009).

4.5.2 Physical Capital

Physical capital, also a standard input in microeconomics, is represented by the value of fixed assets (FA) which is the book value of all property, plant, machinery, equipment, fixtures and premises purchased directly by the bank or acquired by means of a capital lease measured at cost, less accumulated depreciation and impairment losses. The fixed assets have been used by several authors to proxy physical capital: Havrylchyk (2006), Kenjegalieva et al. (2009a), Chiu et al. (2009) and Assaf et al. (2011a).

4.5.3 Deposits

Deposits involve all customer demand deposits, savings deposits and call deposits as well as current accounts from individuals and corporations. As aforementioned, there is a controversy as to whether deposits are inputs or outputs (Berger and Humphrey, 1997). Deposits are here considered as an input following Hughes and Mester (1993).

4.6 Outputs

4.6.1 Loans and Advances

Loans and advances (shortened as loans) are earning assets that reflect the lending activity of banks, including credits to both businesses and households. Loans, as used in this study, measure the monetary value of the aggregate of corporate and commercial loans, individual loans, residential-mortgage loans and staff loans as well as other loans, less provision for impairment. To account for loan quality, loans and advances are stated at the amount of principal and interest outstanding less any provision for bad and doubtful debts and interest held in suspense.

4.6.2 Other Earning Assets (OEA)

OEA is an aggregate for fees and commissions, derivative assets, trading assets, pledged assets, shares, short-term Government securities (treasury bills or government bonds and other eligible bills), medium-term investment in other securities, investment-in-associated companies (or equity investments), investments in property, investment securities-available-for-sale and other investments. These variables have output characteristics because they are generated using the resources available to the bank.

4.6.3 CSR: Is it an Input or Output?

The monetary value of CSR is the third output variable that has been discussed already in the previous chapter. An input to a DEA model is a resource used to produce an output. Since resources are used to generate the revenues needed to pursue CSR activities the aggregate of the CSR variable is considered as an output in the DEA banking intermediation model of technical efficiency. As will be noted in the methodology chapter, the study will adopt the output orientation of modelling inputs and outputs to measure the performance of Ghanaian banks. This means that the resources will be assumed constant whereas efficiency improvement is assumed to emanate from increasing loans and advances, other earning assets and CSR.

In the case of a developing economy like Ghana, that has reasonably high levels of food and material shortage, the incorporation of CSR implies that it will be against social ethics to minimise inputs in terms of the wages and salaries of employee salaries. Considering CSR as an input and hence reducing the aggregate measure of CSR especially for people at the bottom of the economic pyramid (Prahalad, 2004) will only be seen as socially irresponsible by the society. Therefore, CSR is considered as an output and is maximised together with the other outputs.

Indeed when evaluating DEA cost efficiency model, expenditure on CSR is not an explicit output or input (Vitaliano and Stella, 2006). In that case, CSR can be considered as an independent variable in a regression equation. This analysis is also pursued in the present study to determine the relationship between CSR and CFP.

4.7 Data and Data Sources

The data used in the empirical analysis are collected from banks' annual reports, which include balance sheet and income statements generated in accordance with accounting-reporting standards and cross validated with corresponding data from BOG, KPMG and the organizers of the Ghanaian banking awards, CIG. The result is a total sample of 21 banks for each year, 2006-2008, which, on average, constitutes about 92% of the industry's assets over the study period.

Two banks - Zenith Bank and Bank of Baroda - had been undergoing managerial changes and also had some missing data and were therefore excluded from the analysis. Since BSIC had not completed a full year of operations, it was excluded. Table 4.3 presents a descriptive statistics of the inputs and outputs in each of the 3 years, i.e. 2006, 2007 and 2008 as well as for the years pooled into one data set. The reason behind the pooling of the data set is explained below.

Table 4.3 Summary statistics of 21 banks each. in years 2006-2008

	Variables	***Mean***	***Min.***	***Max.***	***Std. Dev.***
2006					
Inputs	Fixed Assets	7935.72	790.80	24066	1494.115
	Staff expenses	8262.59	837.639	47425.3	2419.204
	Deposits	166839.50	11860.3	634572.7	38132.23
Outputs	Loans	111139.78	3206.22	364538.5	23613.72
	OEA	92733.672	3803.7	□4	22094.65
	CSR	126.26	0.5	768.3	42.124
2007					
Inputs	Fixed Assets	11714.63	1024.386	42913	2357.43
	Staff expenses	12406.34	1466.174	57884.16	3086.41
	Deposits	239407.77	34115.89	839382.573	48662.58
Outputs	Loans	189059.20	12842.462	742696.325	41615.24
	OEA	109812.50	11075.475	336150	20912.79
	CSR	191.02	4.176	787	49.43
2008					
Inputs	Fixed Assets	15537.1	1947.975	57412	2939.97
	Staff expenses	17949.89	2571.799	67714.01	4055.50
	Deposits	321698.77	74221.768	1030106.198	60807.43
Outputs	Loans	261480.68	30839.622	1087118.928	54839.89
	OEA	34502.99	10830.064	389793	23783.23
	CSR	254.24	7.25	1817	95.94
Pooled data					
Inputs	Fixed Assets	11729.15	790.7994	57412	11004.91
	Staff expenses	12872.94	837.639	67714.01	15218.27
	Deposits	242648.68	11860.3	1030106.198	234534.25

Outputs	Loans	187226.55	3206.22	1087118.928	199277.22
	OEA	112349.72	3803.7	389793	101981.11
	CSR	190.51	0.5	1817	306.11
Control Variables	TA	365402	19602.2	1645796.995	343927.10
	LTA*	8.889	6.731	11.12	1.0874
	Leverage*	33.95	9.337	189.81	24.06
	CAR*	24.55	8.298	145.46	17.97
	LR*	0.001916	0.000045	0.0263	0.00349
	PAT*	8395.06	-28574	37004.851	12151.3
	ROA*	0.02297	-0.0782	0.1013	0.03325
	ROE*	0.2033	-0.6918	0.8959	0.2942

Notes: Values are in thousands of Ghanaian cedis (GH¢). *LR is liquidity risk; TA is total assets; LTA is the natural logarithm of total assets; CAR is capital adequacy ratio; PAT is profit after tax; ROA is return on average assets and ROE is return on average equity. *Variables are ratios.

4.8 Analysis for Pooling the Data Set

The data set only contains 21 banks for each year, which, given the number of variables, may lead to poor discrimination of efficiency scores, the well-known curse of dimensionality in DEA. The dimensionality curse happens when there are few observations relative to the number of input and output variables (Thanassoulis et al., 2008). To investigate this potential problem, the analysis follows Wheelock and Wilson (2003) and Wilson (2004) who argued that the Free Disposal Hull estimator (Deprins et al., 1984), that will be examined in the methodology chapter, should be employed as a diagnostic check to verify the dimensionality curse. The curse will usually cause large numbers of FDH efficient observations. Using the FDH estimator, each bank's output-oriented efficiency score relative to its year-specific frontier was measured. It was found that all banks in 2006 and 2008 were FDH efficient and only 1 bank in 2007 was FDH inefficient confirming the dimensionality curse.

Consequently, in measuring the efficiency for each bank in a given year, this study builds a common frontier by pooling the observations from the 3 years in order to estimate a ‘years-common’ instead of a ‘year-specific’ best-practice frontier. By creating a pooled frontier, it is possible to evaluate and compare each of the 63 observations for the 2006-2008 periods relative to the same frontier by treating each bank in each period as a different entity. A common frontier will increase the sample size and hence circumvent the curse of dimensionality. By pooling the data across years, this study implicitly assumes that all banks operate in the same environment during the study period. However, one may argue that since the banks operate in different years, their performances could be affected by the regulatory framework and other macroeconomic indicators existing in those years.

The upper panel of Figure 4.1 displays some macroeconomic indicators that may impact on profitability and efficiency of banks. Various profitability indicators are also shown in the lower panel of the Figure. If there are major macroeconomic changes, then, these should affect banks’ profitability indicators. A pertinent observation from the Figure is that there are no major changes in the macroeconomic or profitability indicators over time that should affect the yearly performance. Furthermore, the sample period is relatively short (2006-2008) with relatively minor changes in banking laws and economic conditions. Therefore, it is safe to assume that all banks operate in the same regulatory and economic environment over the sample period, which validates the pooling of the data set.

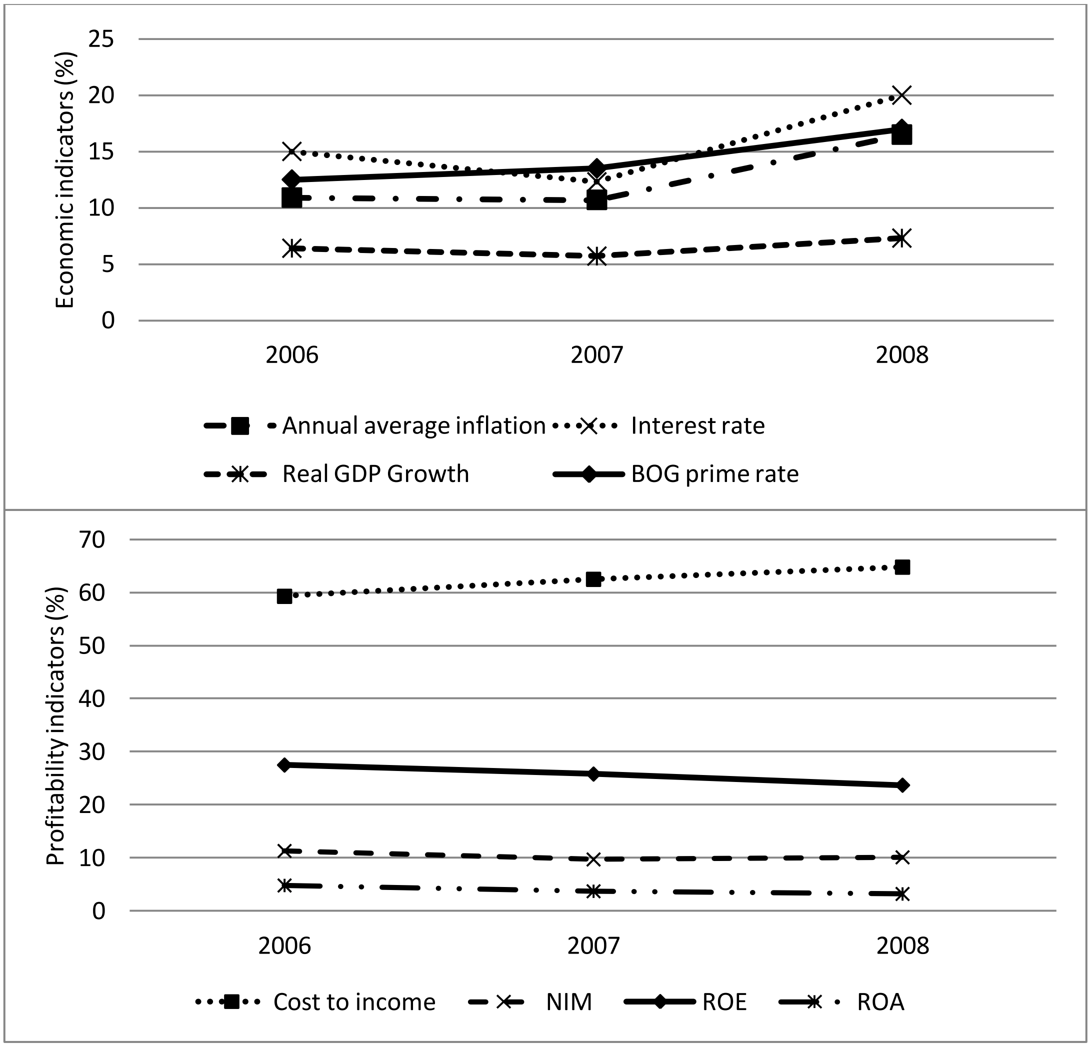

Figure 4.1 Ghana's economic indicators and banks' profitability indicators

Notes: NIM is net interest margin; ROE is return on assets; ROA is return on equity; BOG is Bank of Ghana.

In Table 4.4, the summary statistics of the efficiency scores measured for each year relative to the pooled frontier are presented. It can be observed from this table that the geometric mean efficiency scores for the three years are very similar with differences between the annual averages around 4%. Also, there are fully efficient observations that emerged from each of the three years when the efficiency score were measured relative to the pooled years. These results further support the pooling of the data for the three years into one combined data set.

Table 4.4 Summary of annual efficiency scores relative to pooled frontier

	Score2006	**Score2007**	**Score2008**
Geometric mean	1.18	1.22	1.2
Arithmetic mean	1.22	1.27	1.24
Median	1.012	1.103	1.11
Minimum	1	1	1
Maximum	2.26	2.27	2.72
Stand. Dev.	0.376	0.393	0.393

Further analysis adopts Friedman hypothesis test to examine whether the efficiency scores of banks from each of the three years have been drawn from populations of equal medians. In other words, we test the null hypothesis (Ho) that the distributions of efficiency rankings from each year are the same. This nonparametric test is chosen because the nonparametric efficiency scores are bounded from below at one and hence not normally distributed and because we are dealing with more than two repeated or matched groups[5]. The finding indicates insufficient evidence to reject Ho (Chi-square statistic=1.042, *p*-value=0.594) at a 1% level. It is concluded that the distribution of the efficiency rankings in the different years are not significantly different from each other. The parametric equivalent of repeated measures one-way ANOVA[6] test with sphericity also showed that the mean efficiency scores are not significantly different [$F_{(2, 40)}$ =0.226, *p*-value=0.446 > 0.01]. The implication is that the data set can be pooled together because they could be from the same distribution, the descriptive statistics of shown in the lower panel of Table 4.3, together with some selected control variables (which are later used in the second-stage regression analysis). All variables are measured in thousands of Ghanaian cedis (GH¢).

4.9 Conclusion

This chapter has examined the approaches for modeling the banking firm and adopted the intermediation model to measure Ghanaian bank efficiency, considering their CSR and profit-maximisation goals. The intermediation model may be useful when evaluating the efficiency of banks whereas the production model is suitable to assessing the efficiency of bank branches (Berger and Humphrey, 1997). Besides, the data source has been discussed. The chapter justifies the pooling of the data set and tests the appropriateness of this parametrically and nonparametrically; something which is often ignored in other studies.

[1] Tortosa-Ausina (2002b, p.651) reasoned that deposits may be considered as outputs since most banks raise a large part of their funds from produced deposits, and "offer liquidity, payments, and safekeeping services to depositors to obtain these funds". Deposits are conceived as an added product over which banks compete.

[2] The profitability model is sometimes called the operating approach, income-based approach or profit/revenue approach

[3] It should be noted that while the variants of the intermediation model deal with *the role of inputs and/or outputs* attached to the different liability and asset categories, the main models of production and intermediation concern the *how to measure* inputs and outputs of a banking firm (Tortosa-Ausina, 2002a). Therefore, the long-standing controversy about deposits that was mentioned earlier in the discussion is more pronounced in the intermediation model. The three variants vary, for example in the role attached to deposits.

[4] CAMELS' rating is an acronym for the parts of the state of a bank that are measured. These are Capital adequacy, Asset quality, Management, Earnings, Liquidity and Sensitivity to market risk.

[5] The same subjects, i.e. banks are used repeatedly in each year; hence the name "repeated measures".

[6] Note that the potential problems of ANOVA are the many assumptions it makes such as normality of the data set, equal variance of the sample, independent variances and means etc (Hill and Lewicki, 2007).

Chapter 5

Relevant Review of the Theories, Methodologies and Banking Studies on Efficiency and Productivity Change

5.1 Introduction

This chapter introduces the main concepts and techniques for evaluating the efficiency and productivity change of firms. The approaches belong to a vast literature within operational research and management science, economics and econometrics. However, the focus will be on nonparametric techniques, particularly, on Data Envelopment Analysis (DEA) and its extensions, the Malmquist productivity change index, the metafrontier analysis, the Global Frontier Shift/Difference (GFD) and the local favourability and favourability change indices. These techniques are important for achieving the objectives of the study and for answering the research questions. The chapter also review s the applications of benchmarking tools including ratio analysis and profitability measures and identify their weaknesses. The chapter reviews the application of frontier techniques in the banking efficiency and productivity change literature. Finally, the chapter reviews the literature on the application of frontier methods to investigate the relationship between performance and some environmental factors including bank ownership, specialization and capitalization.

5.2 Conventional Assessment Tools for Banks

In order to measure banks' performance, several techniques have been employed in the banking efficiency literature (Paradi et al., 2011). The conventional approach is to use financial ratios. Financial ratios have been traditionally used to assess banks' performance. Some of the commonly used ratios can be broadly categorized into profitability, liquidity, leverage and gearing ratios (Jones, 2002). Financial ratios are easy to compute and they can offer quick snapshots of organisations' performance for benchmarking (Jones, 2002). They can generate a profile of the economic and operating features of banks. The fact that some previous studies have employed financial ratios to assess banks' performances should imply that ratios are useful in gauging operating performances at least in the initial stages (Whittington, 1980; Brockett et al., 1997). Nonetheless, Sherman and Gold (1985) cautioned that financial ratios are hard to interpret for bank assessment. A single ratio usually uses one input and one output and therefore focuses on just one aspect of the operations of the business without considering information about the other dimensions (Paradi et al., 2011). In applied studies, business performance analysis is not that simple; it involves several complex inputs and outputs which require more than a single ratio or even selected ratios to characterize them (Smith, 1990). Besides, ratios implicitly assume constant returns to scale which implies that since the firms are operating at an optimal scale, size does not matter (Smith, 1990). However, this may not be applicable in every industry, including financial institutions, where competitions are not perfect and there can be different kinds of market power etc. which can alter the scale size of the firms before they are benchmarked against one another (Coelli et al., 2005). For further limitations of financial ratio analysis as it compares with frontier techniques, the reader is referred to Akhavein et al. (1997) and Kohers et al. (2000).

In the banking efficiency literature, efforts have been made to circumvent the drawbacks associated with the use of financial ratios. Some applied efficiency analysts have complemented these ratios with other benchmarking tools such as frontier techniques. For instance, Bauer et al. (1998) suggested that efficiency estimates should be related to the conventional measures of performance such as financial and profitability ratios. By this, bank regulators and managers can have confidence that the efficiency estimates are good performance indicators and not just made-up measures emanating from specific assumptions. Following this suggestion, Weill (2004), when investigating the consistency of efficiency frontier methods on banking samples in 5 European nations, examined the correlations between cost efficiency and four standard performance ratios and found positive correlations. Further discussions on this is provided by Berger and Humphrey (1997), Camanho (1999) and Halkos and Salamouris (2004).

Profitability ratios are commonly used to measure banks' performance. These include net profit, return on assets (ROA), return on equity (ROE) and return on investment (ROI) which is the ratio of net income to invested capital (Sherman and Zhu, 2006). Berger and Humphrey (1997) remarked that frontier approaches are superior to the conventional financial performance measures in that the former simultaneously account for relevant inputs and outputs and their prices. Moreover, Berger et al. (1993) noted that profitability ratios may be confusing efficiency indicators as they do not control for product mix. They added that even if weights associated with profitability ratios are selected, this may be subjective in nature. Simple ratios cannot distinguish between the various aspects of efficiency such as X-efficiency, technical efficiency, allocative efficiency and scale and scope economies. As a results, some modern applied economists, operational researchers and management scientists use frontier methods to measure efficiency and productivity change and to disentangle the effects of environmental factors on performance (Bauer et al., 1998).

5.3 Definitional Constructs in Frontier Techniques

The terms "productivity" and "efficiency" are two different but related concepts. Fried et al. (2008) define *productivity* of a production unit, also called a Decision Making Unit (DMU) in DEA parlance, as the ratio of its output to its input $\left(\text{i.e. } productivity = {}^{y}\!/_{x}\right)$.

Efficiency, on the other hand, is a relative concept. The efficiency of a DMU is defined as the, "observed output to maximum potential output obtainable from the input, or comparing observed input to minimum potential input required to produce the output, or some combination of the two" (Fried et al., 2008, p.8).

The first ratio in the above definition concentrates on outputs (i.e. output-oriented efficiency) whilst the second focuses on inputs (i.e. input-oriented efficiency). The inputs required to make production possible are the resources used during the production process to generate the outputs, which are the products and/or services (see Figure 5.1). The efficiency concept should not be confused with e*ffectiveness*. In the management literature, efficiency is ‘to do things right’ or perform current activities as well as possible whereas effectiveness is ‘to do the right thing’ or choose the proper activities (Golany et al., 1993; Mouzas, 2006; Asmild et al., 2007). Effectiveness is the extent to which an organisation meets its pre-determined goals and hence, serves as a critical part in the management planning and control processes of an organization (Griffin, 2008).

Figure 5.1 The production process

5.4 The Measurement of Efficiency

5.4.1 The Production Possibility Set (PPS)

The production function or the production possibility set, PPS (T) that forms the foundation of efficiency analysis can be employed to comprehend the concept of efficiency. To do that we first formalise the PPS as follows: consider a set of n DMUs $\left[\left(x_j, y_j\right), j = 1, 2, ..., n\right]$ each using $i = 1, ..., m$ inputs denoted by a vector $x_j = (x_j^1, ..., x_j^m) \in \Re_+^m$ to generate r=1,…,s outputs denoted by a vector $y_j = (y_j^1, ..., y_j^s) \in \Re_+^s$. The inputs and outputs are nonnegative real data. The technology can be represented by the set (after dropping the subscript DMU j for simplicity):

$$T = \left\{\left(x, y\right) \in \Re_+^{m+s} \mid x \text{ can produce } y\right\} \qquad (1)$$

The efficient boundary (frontier) of T is used to measure the efficiency of a DMU. Technically inefficient firms operate at locations inside T whilst technically efficient firms operate somewhere along the frontier. Occasionally, the PPS may be characterized by the input (consumption) set or the output (production) set. A feasible output production set $P(x)$ is formally defined as:

$$P(x)=\left\{y\in\Re_{+}^{s} \mid (x,y)\in T\right\} \text{ or } \mathrm{P}(x)=\left\{y \mid x\in L(y)\right\} \tag{2}$$

where $x\in\Re_{+}^{m}$ has output isoquant

$$I(x)=\left\{y\in P(x):\varpi y\notin P(x),\varpi>1\right\} \tag{3}$$

and output efficient subset,

$$E(x)=\left\{y\in P(x):y'\notin P(x),y'\geq y\right\} \tag{4}$$

Consequently, the efficient boundary of equation (2) can be described in radial terms (Farrell, 1957). This is given in the output-oriented space as:

$$\partial P(x)=\left\{y \mid y\in P(x),\phi y\notin P(x),\forall\phi\geq 1\right\} \tag{5}$$

In equation (5), ϕ is the improvement factor that will take a DMU to the efficient frontier and $\phi-1$ is the proportional expansion in outputs that could be achieved by the jth DMU given the input quantities. By construction, $\phi(x,y)\geq 1,\ \forall(x,y)\in T$ and a DMU is efficient if and only if its $\phi(x,y)=1$. If a DMU has $\phi(x,y)\geq 1$, then it is capable of expanding output production. Note that ϕ is the Debreu-Farrell *output-oriented* measure of technical efficiency which is simply the inverse of Shephard (1970) *output distance function* that is defined as:

$$D_O(x,y) = \inf_{\phi}\{\phi > 0 : (x, y/\phi) \in T\} = \left(\sup\{\phi : (x, \phi y) \in T\}\right)^{-1} \quad (6)$$

It follows that $\phi(x,y) = 1/D(x,y)$ where $D(x,y) \leq 1$. D then is the equiproportionate increase in outputs necessary to reach the efficient frontier. It is homogenous of degree +1 and non-increasing in *x* and jointly continuous in (*x*, *y*).

5.4.2 Assumptions Underlying the PPS

The main properties that underlie the PPS are as follows (Banker and Thrall, 1992; Färe and Primont, 1995; Fried et al., 2008):

Axiom 1: *Inclusion of observations.* Each observed firm is included in the PPS i.e. $(x_j, y_j) \in T \ \forall j$.

Axiom 2: *Monotonicity of the technology* or *strong free disposability of inputs and outputs* (i.e. inefficiency is possible). This axiom implies that the extra amount of inputs or outputs can be disposed of or eliminated at no cost. Put differently, it is possible to produce less with more resources. Hence, if $(x,y) \in T$ and $x' \geq x$ then $(x', y) \in T$. Similarly, if $(x,y) \in T$ and $y' \leq y$ then $(x, y') \in T$.

Axiom 3: *Axiom of ray unboundedness* or *constant returns to scale*. If $(x,y) \in T$, then, $(kx, ky) \in T$ for any $k \geq 0$.

Axiom 4: *Convexity*. If $(x,y) \in T$ and $(x', y') \in T$ then $\left(k(x,y) + (1-k)(x', y')\right) \in T$ for any $k \in [0,1]$. Convexity ensures that if two or more data points are attainable (feasible) then a weighted average of the input bundles can similarly produce a weighted average of the corresponding output bundles (Coelli et al., 2005).

Axiom 5: *Minimum extrapolation*. *T* is the (smallest) intersection of all sets satisfying axioms 1-4.

In general, the PPS is required to be closed and bounded which is a technical, mathematical requirement (see Färe and Primont, 1995, p.14). This implies that the PPS includes the boundary and therefore, infinite levels of outputs given inputs cannot be produced. The limit of a sequence of technologically feasible input-output vectors is also feasible (Mas-Colell et al., 1995). Another generic property of the PPS is that no output can be produced without some input(s) (no "free lunch").

5.4.3 Estimating Business Performance

How did economists and operational researchers begin to measure efficiency? Frontier efficiency measurement began with the influential works of Debreu (1951), Koopmans (1951) and Shephard (1953). Debreu (1951) measured efficiency in an output-expanding direction with his *coefficient of resource utilization* whilst Shephard (1953) associated distance functions with technical efficiency measures in an input-conserving direction. Nonetheless, Koopmans (1951) was the first to define *technical efficiency* as follows: "an input-output vector is technically efficient if, and only if, increasing any output or decreasing any input is possible only by decreasing some other output or increasing some other input" (Koopmans, 1951, p. 60). In multiple-input, multiple-output framework, efficiency conveys the idea of the maximum outputs attainable from a given a set of inputs, or the minimum level of inputs needed to generate constant level of outputs. Debreu (1951) and Farrell (1957) treated Koopmans (1951) definition as a relative concept and defined radial measures of *technical efficiency* to be the maximum feasible equiproportionate reduction in all inputs, or the maximum feasible equiproportionate expansion of all outputs. However, there could remain input slacks or output surpluses on individual inputs or outputs respectively. The technical efficiency measure emanating from this does not depend on the unit of measurement. Farrell (1957) in his seminal paper and motivated by Koopmans and Debreu, became the first to practically quantify economic efficiency when he showed how to evaluate and decompose *cost efficiency* (also called overall productive efficiency) into *technical* and *allocative* components. He articulated an apprehension about the ability of individuals to precisely and sufficiently measure prices in order to measure allocative efficiency and hence overall economic efficiency. For detailed discussions on the evolution of frontier analysis, see the collective works of Kumbhakar and Lovell (2000), Førsund and Sarafoglou (2002), Cooper et al. (2004), Coelli et al. (2005) and Daraio and Simar (2007).

Farrell's (1957) original idea is represented in Figure 5.2, showing a set of DMUs producing a single level of output (y) using two inputs (x_1, x_2) and aiming to reduce their inputs. Farrell assumed constant returns to scale (CRS)[7] and a known production possibility set, PPS. In empirical studies however, the PPS is not known and must therefore be estimated from the observed data points of firms before estimating the efficiency scores using the existing frontier approaches. In Figure 5.2, SS' characterizes the smooth isoquant (frontier) of DMUs. If a firm generates a certain amount of output using given amounts of inputs defined by point P, then geometrically, that firm's *technical inefficiency* is characterized by the distance QP which is the equiproportional or radial contraction of all inputs given the output level (Coelli et al., 2005). In other words, the distance QP along the ray OP measures the technical inefficiency of a firm located at point P. Hence, the *technical efficiency* (TE) of firm P is given by the ratio OQ/OP which equals $1-QP/OP$. Note that 0<TE≤1 and that Farrell's (1957) estimate of technical efficiency is the reciprocal of Shephard's (1970) distance function. A value of TE=1 for a firm (like Q which is on the isoquant) implies that the firm is technically efficient. TE encapsulates the amount of "waste" that can be eliminated without the deterioration of any input or output (Cooper et al., 2004). Farrell (1957) went beyond technical efficiency and considered the fact that given information on factor prices and firms' cost-minimising objective in competitive input markets, one can estimate *allocative* and hence, *overall* (*cost*) *efficiency*. Note that instead of allocative efficiency, Farrell (1957) employed the term "price efficiency" and used "overall efficiency" instead of cost efficiency.

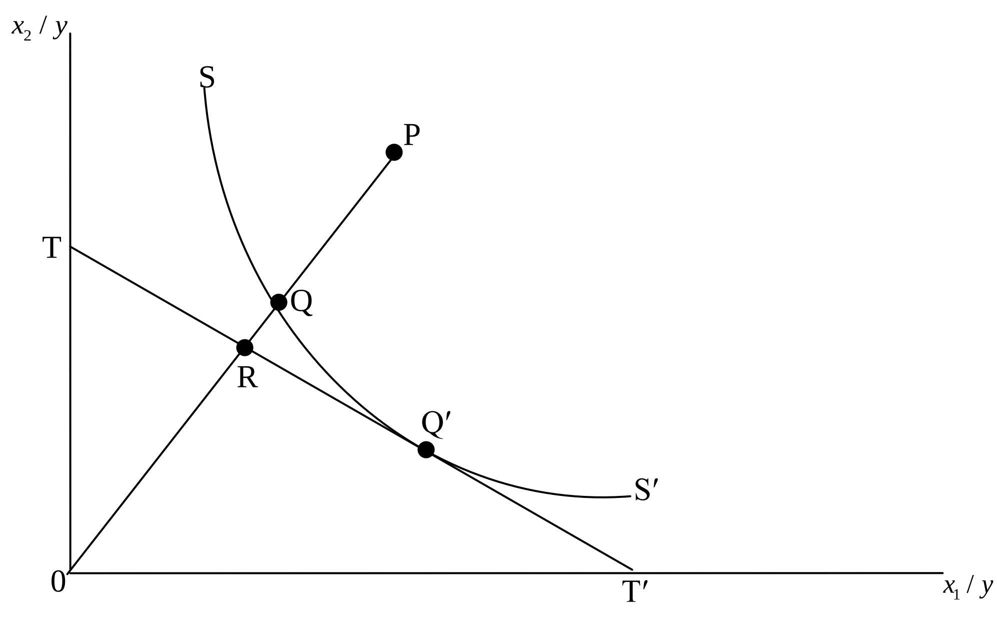

Figure 5.2 Measuring efficiency, Source: adapted from Farrell (1957)

Farrell's (1957) measure of cost efficiency (CE) can be illustrated given the isocost line TT′. The isocost is a straight line with slope equal to the ratio of input prices (i.e. $-P_{x1}/P_{x2}$ where P_{x1} is the price of input $x1$ and P_{x2} is the price of input $x2$); it shows the combination of input factors that will cost the same amount. If the input price ratio, represented by the slope of the isocost line is known, then *allocative efficiency* (AE) and hence, cost efficiency can be computed. AE may be computed as $AE=OR/OQ$ and as aforementioned, $TE=OQ/OP$. Therefore, cost efficiency is the product of technical efficiency and allocative efficiency where $0<TE, AE, CE\leq 1$. Specifically, $CE= OR/OQ\times OQ/OP=OR/OP=TE\times AE$. This is because the distance RQ characterizes the cost reduction that will be realized if production were to take place at the allocatively (and technically) efficient point Q' instead of at the technically efficient, but allocatively inefficient, point Q (Coelli et al., 2005). The cost efficiency represents the minimum expenses needed to generate a given bundle of outputs for fixed prices of inputs used to produce the output bundle and for a fixed technology. Like cost efficiency, Leibenstein (1966) coined the term "X-efficiency" which refers to the predicted minimum costs that would be used if a firm were as efficient as the best-practice firm divided by the predicted actual costs. "X-efficiency" also indicates management's ability to generate revenues and control costs. The *allocative efficiency* (of inputs in the above illustration) entails the efficiency due to choosing the best mix of inputs, given relative prices, to produce the mix of outputs. In other words, it estimates the ability or success of a firm to use the combinations of inputs, given their prices and the technology, in the best possible proportions. In a nutshell, Farrell (1957) made an important contribution to the analysis of efficiency of organizational units by basing his efficiency estimates on radial improvements of inputs and outputs.

Note that the efficiency measurement proposed by Farrell (1957) as explained in the previous section, influenced, inter alia, the regrettably ignored works of Boles (1966) who operationalized a linear programming (LP) formulation of Farrell's convex hull technique. It is worth noting, though, that neither Debreu (1951) nor Farrell (1957) formulated the efficiency computation problem as an LP problem (LLP), albeit Farrell and Fieldhouse (1962) foresaw that they could employ LPP. It was in 1978 that Charnes, Cooper and Rhodes, CCR (1978) used the optimisation method of LP to generalise Farrell (1957) single-output/input technical efficiency measure to the multiple-output multiple-input case. Today, several researchers compute efficiency by comparing actual performance of a firm with the "best-practice" performance positioned on an appropriate frontier. However, in applied studies, the true frontier is unknown, and therefore efficiency estimates must be empirically approximated. The next section examines the available frontier techniques used to achieve this approximation.

5.5 Frontier Methodologies

The main idea of efficiency evaluation is identifying a reference boundary and then measuring the efficiency or inefficiency of an observed firm relative to that boundary. Two classes of frontier methods have been developed and extended to empirically approximate the unknown technology frontier. They are *parametric* (econometric/statistical) and *nonparametric* (mathematical programming) frontier methodologies. These techniques are further subdivided into *stochastic* and *deterministic* frontiers. Figure 5.3 highlights these frontier models and their originators.

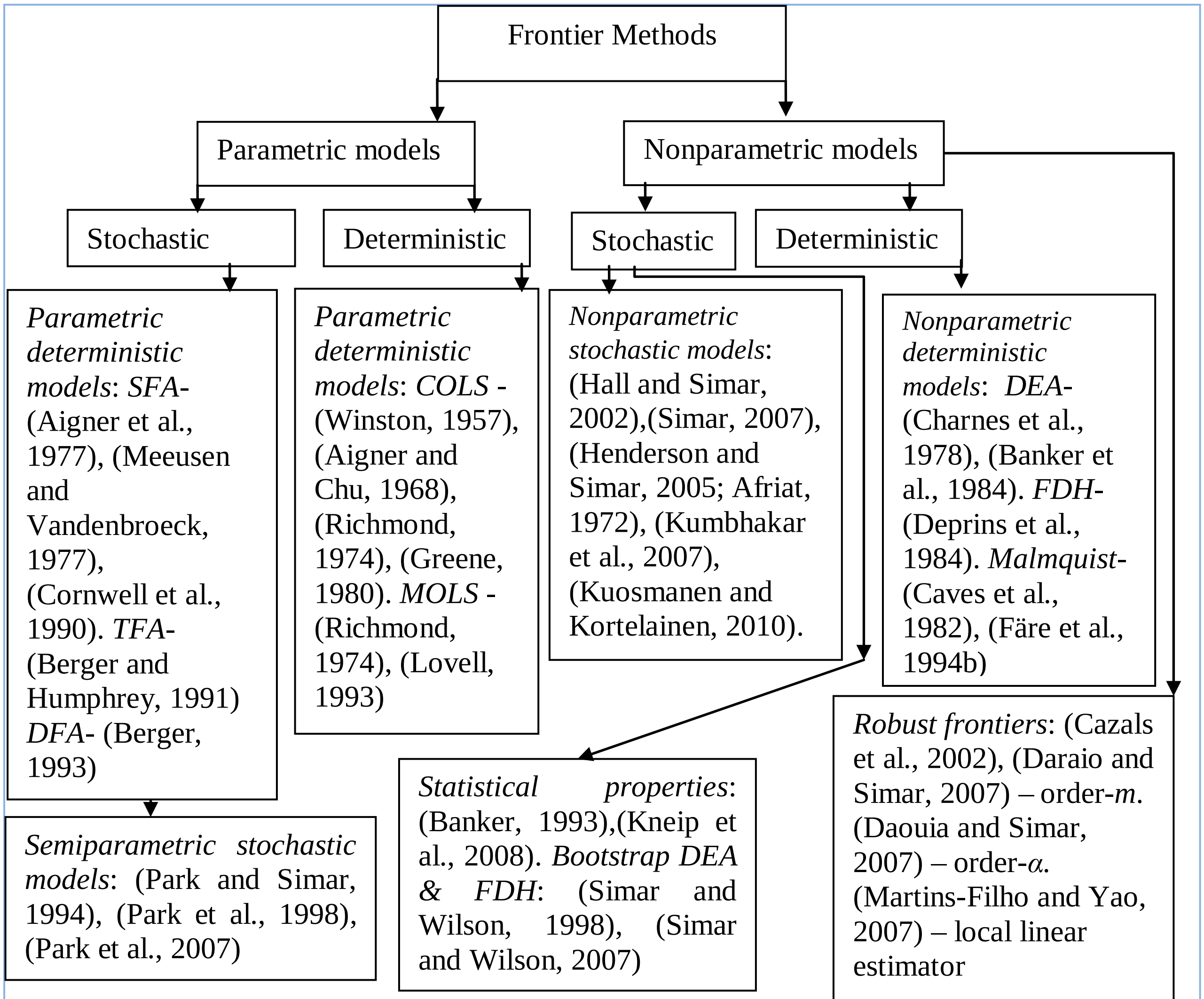

Figure 5.3 Categorisation of frontier techniques

5.5.1 Parametric and Semi-Parametric Frontier Estimators

Parametric and nonparametric techniques vary in the assumptions they make about the shape of the technology frontier and the existence of a random error term (Bauer et al., 1998). Parametric techniques assume that a specific functional form of the efficient frontier (such as a production, cost, revenue or profit function that defines the production possibility set, denoted by *T*) is pre-specified *a priori* and then estimate the parameters of the model. The specification of the functional form can be Cobb-Douglas, constant elasticity of substitution, translog, normalised quadratic, generalised Leontief or fourier flexible form (Kumbhakar and Lovell, 2000). The techniques assume a probability distribution for the inefficiency – such as half normal, truncated normal, exponential and gamma distributions (Coelli et al., 2005).

The *parametric deterministic models* (Aigner and Chu, 1968) are deterministic because they ignore random variation including measurement error and attribute all variations to one-sided inefficiency. LP and quadratic programming are used to estimate the parameters that would constrain the residuals to be nonnegative. They include *corrected ordinary least squares* (COLS) recommended by Winston (1957) and applied to panel data by Simar (1992) and *modified OLS* (MOLS), suggested by Richmond (1974) and Lovell (1993). Both methods apply a two-stage approach to correct the OLS intercept. The reader is referred to Greene (2008), Ruggiero (2007) and Jensen (1995) for further discussions of these models.

Figure 5.4 graphically illustrates the OLS regression and compares it with other parametric deterministic and parametric stochastic frontier models in a one input (labour) one output (CSR) framework. The dots indicate input-output combinations or observed firms. The firm, Q, is inefficient with output inefficiency determined by measuring how far away (vertically) it is relative to the various parametric frontier curves in the graph. The COLS technique is shown as above the OLS curve with all deviations of say, Q, attributable to inefficiency whereas the MOLS is shown as between the OLS and the COLS curves. Note that both COLS and MOLS are sensitive to outliers and/or extreme values.

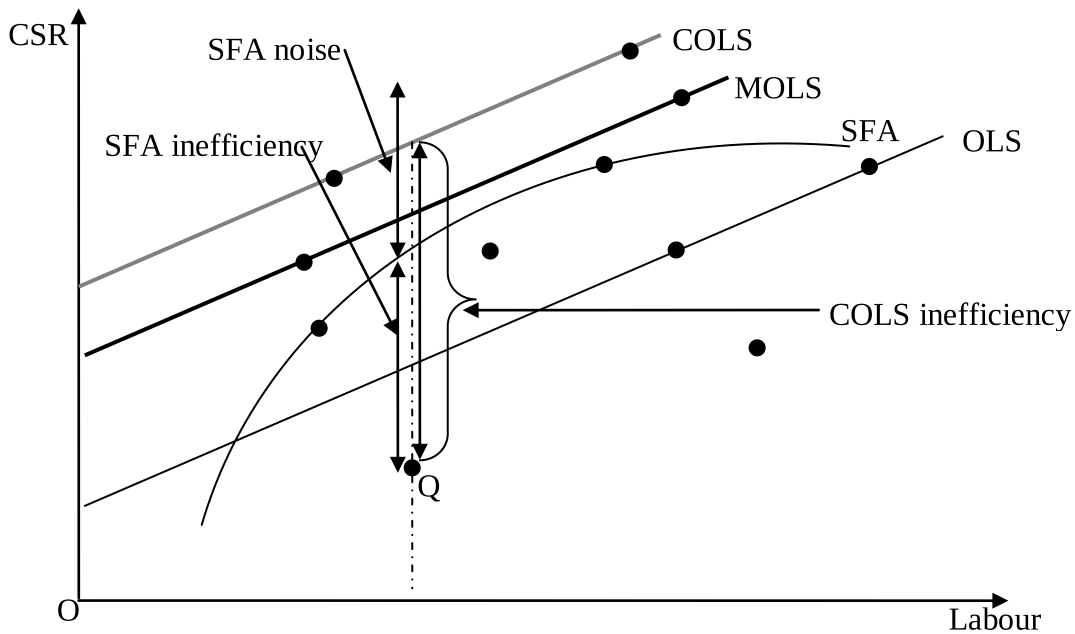

Figure 5.4 Parametric deterministic and stochastic production frontier estimators

There are three main parametric stochastic frontier techniques in the literature which specify a functional form for the production, cost, revenue or profit frontier (Berger and Humphrey, 1997). They are *Stochastic Frontier Analysis*, SFA (Aigner et al., 1977; Meeusen and Vandenbroeck, 1977), *Thick Frontier Analysis*, TFA (Berger and Humphrey, 1991; 1992), and *Distribution-Free Approach,* DFA (Berger, 1993). The models allow noise when measuring inefficiency but they vary on how they model the disturbance error term. SFA assumes that deviations from the production frontier are due to one factor under management control and another factor outside management control. It specifies a functional form of the production relationship among inputs, outputs and environmental variables and then allows for noise. The error term is said to be "composed" of two variables, one being random error that accounts for unintended omitted variables, measurement errors etc (see Coelli et al., 2005). The other component captures inefficiency.

In Figure 5.4, the SFA noise is depicted as the vertical distance above the SFA curve. The SFA inefficiency is depicted as the vertical distance below the SFA curve relative to the observed inefficient unit, Q. The random error is assumed to follow a symmetric distribution such as normal distribution whilst the inefficiency term is assumed to follow a one-sided distribution (asymmetric), usually half-normal but can also be a truncated normal distribution (Stevenson, 1980), and exponential or gamma distribution (Greene, 1990). The SFA has been extended to time-invariant technical inefficiency in panel data (Pitt and Lee, 1981; Schmidt and Sickles, 1984) and time-varying inefficiency (Cornwell et al., 1990; Battese and Coelli, 1992, 1995). The TFA specifies a functional form and assumes that deviations from predicted performance values within the lowest and highest performance quartiles of observations correspond to random error whereas deviations in predicted performance between the lowest and highest quartiles signify inefficiency (Berger and Humphrey, 1997). Since TFA examines average production, it does not consider efficient firms, while large efficient firms tend to be removed when there is decreasing returns to scale. An advantage of TFA is that it does not impose any distributional assumptions on either inefficiency or noise and reduces the effect of extreme values in the data. A drawback is that it does not provide point estimates of inefficiency ratings for individual firms except for the entire industry (see Greene, 2008). Wagenvoort and Schure (2006) applied TFA to analyze cost inefficiency in the banking industry and showed by means of simulation that their approach outperforms the popular SFA. The DFA is an alternative to the traditional SFA in the presence of panel data. It is “distribution free” as no specific distributional assumptions for the inefficiencies or random errors are made. Berger (1993) remarked that the noise term of the composed error term is by definition random and should be expected to average out over time whilst the inefficiency term for each firm is persistent and constant (stable) over time (cf. Berger and Humphrey, 1997).

The key advantages of the parametric approaches are the economic interpretation of the parameters (as they endeavour to differentiate the effects of noise from inefficiency) and their statistical properties. The key drawback is that they require specification of explicit functional forms of the efficient frontier and the distribution of the inefficiency terms (Seiford and Thrall, 1990). There is also the issue of misspecification errors that may be encountered which can lead to inconsistent results. Misspecification may arise from the use of an unsuitable functional form for the production frontier, the presence of serial correlation between the inputs and technical efficiency and measurement errors on the production factors (Giannakas et al., 2003). Parametric models also face the difficulty of handling multiple inputs and multiple outputs. Such several variables are common in banking industries.

Conversely, the deterministic nonparametric techniques do not assume any particular functional form for the best-practice frontier function but allow the observed data to ‘speak for itself’. Put differently, they assume that all observations belong to the PPS and that all deviations from the production frontier are attributable to the one-sided distribution termed "inefficiency". Hence, they omit a symmetric random-noise error component (Kumbhakar and Lovell, 2000). These techniques either are estimated by means of LP techniques or by adjusting them to least squares approaches which require the residuals to be non-positive. Their main advantage is the ability to handle multiple inputs and multiple outputs and ability to circumvent the difficulty associated with the effects of misspecification of the functional form of both technology frontier and inefficiency. However, a key limitation of the nonparametric techniques is that they attribute all deviations from the efficient frontier to inefficiency, disregarding random noise. Other drawbacks are the difficult economic interpretation of the unknown frontier and the so-called "curse of dimensionality"[8]. A comprehensive treatment of the nonparametric methods is provided through the collective works of Färe et al. (1994b), Coelli et al. (2005), Cooper et al.. (2007) and Fried et al. (2008). The core frontier techniques are discussed below. It must be mentioned that DEA is the most commonly used technique in empirical studies. It is also the approach adopted in the present study to assess the efficiency and productivity change of Ghanaian banks.

Recently, some *semi-parametric stochastic frontier* models have been developed, both to relax some of the restrictive assumptions of the completely parametric SFA and to bridge the gap between DEA and SFA (cf. the recent survey by Kuosmanen and Kortelainen, 2007). Specifically, Park et al. (1998) considered semi-parametric efficient estimation of SFA by generalising Park and Simar (1994) and, considering panel data, specified a parametric form for the frontier function. In general, the series of papers referenced in Park et al. (2007) considered the semi-parametric stochastic frontier models under various assumptions and dynamic specifications, with the nonparametric part dealing with the distribution of the inefficiency component. These models are related to the *nonparam*etric *stochastic estimators* developed to handle noise in nonparametric frameworks as proposed by Hall and Simar (2002) and Kumbhakar et al. (2007) and extended by Simar (2007) to multivariate frontiers providing stochastic versions of nonparametric estimators. The basic reason behind these estimators is their ability to circumvent the perceived drawbacks of nonparametric deterministic estimators (discussed below) that do not random noise in the data. In a different setup, Kumbhakar et al. (2007) recommended a general approach for nonparametric stochastic frontier models using local maximum likelihood methods. For further discussions on the nonparametric stochastic estimators, the reader is referred to Daraio and Simar (2007) and Kuosmanen and Kortelainen (2010). It should be mentioned however that developments are still underway in these areas to further bridge the gap between parametric and nonparametric frontier approaches.

5.5.2 Nonparametric Deterministic Frontier Estimators

There are two main *nonparametric deterministic techniques* for estimating production frontiers. They are Data Envelopment Analysis (DEA) (Charnes et al., 1978; Banker et al., 1984) and Free Disposal Hull (FDH) (Deprins et al., 1984). These estimators do not assume any particular functional form for the frontier. DEA assumes free disposability of inputs and/or outputs[9] and the convexity of the PPS[10] whilst FDH only assumes free disposability. It is argued in the efficiency literature, in support of the FDH, that convexity breaks down when some commodities are not continuously divisible (Coelli et al., 2005). A general outline of the FDH methodology can be seen in Tulkens (1993), Bogetoft et al. (2000), Cherchye et al. (2001) and Leleu (2009).

One drawback of these estimators is that since they envelop all the data points, they are sensitive to outliers or extreme values. This is because the efficient frontier is derived by sample observations, which are extreme points. Another drawback is that the efficiency results from these approaches are not easy to interpret in terms of the sensitivity of the production of output to particular inputs (shape of production function, elasticities, etc.), and inference for the measures of interest (confidence intervals, hypothesis tests) is not easy to obtain (Simar and Wilson, 2008). Subsequent sections of this chapter will examine the DEA estimator in detail, as it is the approach adopted in the present study.

5.5.3 Statistical Properties of Nonparametric Estimations

Although the conventional nonparametric deterministic estimators (DEA/FDH) are very popular as they require few assumptions on the technology frontier, they are limited by their deterministic nature because noisy data cannot properly be handled and they also face the problem of not allowing subsequent statistical inference to be made. Nonetheless, recent developments have been made to overcome or at least reduce these problems. For instance, Banker (1993) proved that under certain assumptions, the DEA estimator is a consistent, maximum likelihood estimator with a known rate of convergence (towards the unknown estimator) whilst Banker (1996) surveyed several possibilities including hypothesis tests on returns to scale, input substitutability and model specification and about variation in efficiency relative to the production frontier. More recently, statistical inference has become available by using asymptotic results (Simar and Wilson, 2000b) or by applying bootstrapping (Simar and Wilson, 1998; 2000a; 2007; Kneip et al., 2008).

5.5.4 Robust (Partial) Frontier Estimators

DEA and FDH are known to be sensitive to outliers and extreme values which may unreasonably influence the efficiency scores of the firms under (Cazals et al., 2002) . This is because the estimators are based on the idea of enveloping all the observed data points. The research analyst therefore has to detect the influential observations if warranted and then perhaps delete them if they result from corrupted data (Simar and Wilson, 2008).

Recently, two alternative nonparametric techniques that claim to circumvent the sensitivity of the envelopment approaches to outliers have been advanced. One is by Cazals et al. (2002) and Daraio and Simar (2007) who proposed the order-*m* approach, where *m* can be seen as a trimming parameter. The other is by Aragon et al. (2005) and Daouia and Simar (2005; 2007) who advanced the order-α approach analogous to conventional quantile functions but modified to suit the frontier problem. These new estimators are based on the concept of estimating "partial frontiers", as opposed to the traditional idea of "full frontiers" (i.e. the boundary of the PPS) that envelops all the data points. The local linear frontier estimator of Martins-Filho and Yao (2007) is also robust to the presence of outliers. Notwithstanding the evolution of all these estimators, the traditional DEA is preferred in this study as will be justified shortly.

5.6 Data Envelopment Analysis (DEA)

DEA estimates and compares the relative efficiency of homogenous Decision Making Units (DMUs) which use similar multidimensional inputs to produce multiple outputs. The DMUs can be banks, bank branches, schools, hospitals, airlines, bank branches, mutual funds, utility companies etc.

The technique measures efficiency relative to an unobserved true frontier by identifying a subset of efficient 'best-practice' DMUs that are used to construct the frontier which envelopes all observed DMUs. Then, the relative efficiency of each DMU is measured by the distance with respect to the boundary of the PPS by either increasing the outputs or reducing the inputs or both. The output-oriented efficiency estimate equals one for efficient DMUs and greater than one for inefficient ones.

Figure 5.5 graphically demonstrates the DEA technique for the output-oriented framework with two-output (CSR and loans) and fixed-input (deposits) banks. Hence, the outputs are normalised in order to illustrate them on a two-dimensional diagram. The DEA frontier is illustrated by the piecewise linear connecting lines, AEC, and the horizontal and vertical dashed lines. The FDH frontier is also shown by the stepped connecting lines, AGEHCD and it envelopes the data more tightly than the DEA frontier.

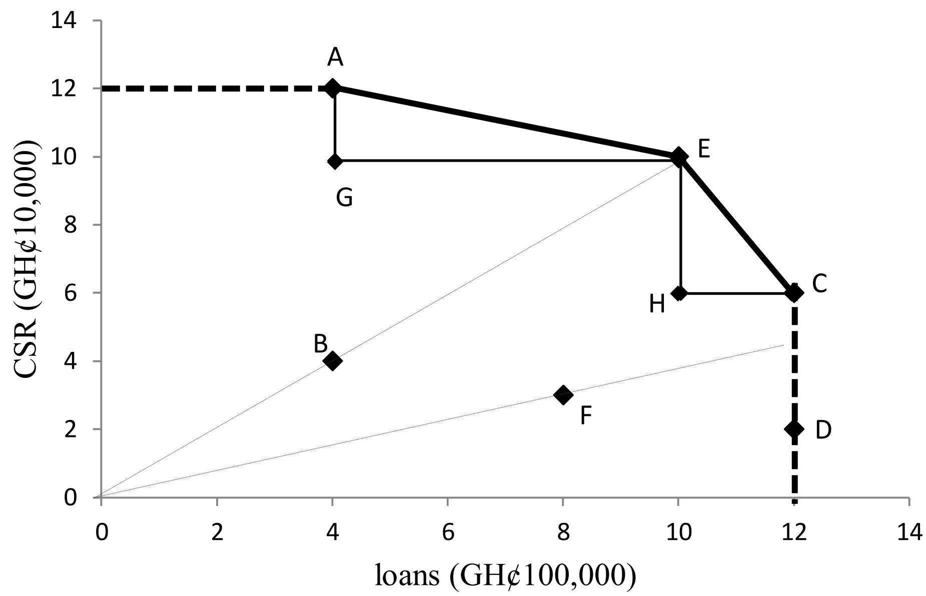

Figure 5.5 Measuring Efficiency using DEA

The output bundles located on the frontier dominate all the production bundles that are located in the interior of the boundary of the PPS, making the former efficient. This is because these banks on the piecewise envelopment frontier can generate the maximum level of CSR and loans given the input level compared to those banks inside the PPS. For instance, A dominates B since it uses the same labour to generate more CSR than B, despite both producing the same amount of loans. B, or any other inefficient bank, can radially expand its outputs, in order to be efficient. Note that the inefficiency or efficiency of a production unit can be measured assuming different orientations, which the DEA analyst will have to decide upfront. The *input-conserving orientation* aims at minimising the inputs in a radial fashion whilst producing a given level of outputs. The *output-augmenting orientation* (which is being considered in Figure 5.5) measures the maximum radial expansion in all outputs that is feasible with given technology and inputs. The output-oriented technical efficiency of B, in Figure 5.5, is given by the ratio OE/OB. Färe, Grosskopft and Lovell (1985b) defined *hyperbolic measure* of technical efficiency that simultaneously reduces inputs and increases outputs along the hyperbolic path. In this orientation, the maximum equiproportionate scaling of outputs (upward) and inputs (leftward) is sought whilst preserving the mix within inputs and within outputs in this movement. But, the hyperbolic measure is not always easy to apply due to non-linearities, implying that it cannot be solved as LP (Bogetoft and Otto, 2011). Chambers et al. (1996, 1998) also proposed the *directional distance function* (DDF) from the notion of the benefit function in consumer theory and the shortage function in production analysis (Luenberger, 1992). The DDF restricts movements toward the frontier by specifying *a priori* the direction to be followed and then seeking the maximum non-radial contraction of inputs and augmentation of outputs in that direction (Fried et al., 2008). Both the directional and hyperbolic efficiency measures are appealing in the context of profit efficiency. The DDF is also useful when dealing with joint production of good (desirable) and bad (undesirable) inputs and/or outputs. Nonetheless, the input or output orientations are the most widely used in empirical studies. Choosing a particular type of orientation depends on the type efficiency concept used, on the managerial objectives of the business under evaluation and on the variables that are under management control.

In the present study, the output orientation will be employed to measure the performance of Ghanaian banks. The inputs are taken as given whilst outputs are increased radially as much as possible within the PPS. The output orientation is adopted since the CSR concept incorporated here implies that it may not be desirable to reduce inputs, specifically, employee salaries in a developing country like Ghana (with relatively high levels of poverty). From CSR perspective, activities that lead to unemployment are not socially responsible. Instead, banks should aim at increasing both their CSR commitments and shareholder value in order to attract customers and investors and to create a good image in the society. Besides, firms in competitive environments, like the banking industry, are usually output-oriented (Mohamed, 2009). Also, banking intermediation models are usually output-oriented. In fact, many previous studies, as can be observed from the appendix 2, that examine the managerial efficiency of banks used the output-oriented measure of DEA (e.g. Ataullah and Le, 2006; García-Cestona and Surroca, 2008; Kenjegalieva et al., 2009a; Assaf et al., 2011b).

5.6.1 Reasons for Choosing DEA

The current study will use the DEA technique and variations of it to estimate the technical efficiency, productivity change, global frontier differences and local favourability and favourability change indices of Ghanaian banks in a dual-objective banking system. There are a number of reasons for selecting this particular frontier method above other approaches. First, unlike the SFA or other parametric approaches, DEA can capture the interaction among multiple inputs and multiple outputs simultaneously (Charnes et al., 1978). The banking industry employs several inputs such as employees, deposits, financial and physical capital, borrowings and interest expenses to produce several outputs including loans, investments, interest income, CSR and fees and commissions. For this reason, it may be difficult to use the parametric techniques as they only account for single-output technologies at a time.

Second, DEA can be used to easily decompose profit, cost, and revenue efficiencies into several components including overall technical, pure technical and scale efficiencies, in order to determine the specific sources of efficiencies in a particular industry, such as the banking industry.

Third, DEA avoids the need to specify a functional relationship between the input and output variables as reflected in the production function. It therefore considers the firm as a black box without the need to know the basics of the underlying technological process. In other words, DEA allows the 'data to speak for themselves'. DEA also circumvents the need to specify a distributional functional form for the inefficiency term. Such assumptions can create specification errors (Cummins et al., 2010) which make DEA very flexible as opposed to the parametric frontier models.

5.6.2 Drawbacks of DEA

The envelopment estimator is not without some limitations. DEA is "deterministic" in the sense that all the observations are considered as being feasible with probability one. In other words, DEA contains no statistical noise but assumes that all frontier deviations are due to inefficiency. The "deterministic" nature of DEA means that in the case of noisy data in the Data Generating Process (DGP), there is an identification problem (i.e. we are unable to identify the part of the production technology, which is due to random error, and the part, which is due to inefficiency). Still, developments are underway in terms of stochastic DEA (Simar, 2007; Kuosmanen and Kortelainen, 2010), asymptotic results (Kneip et al., 2008) or bootstrapping (Simar and Wilson, 1998; 2007).

Another drawback of DEA estimator is that it is sensitive to measurement error due to outliers or missing explanatory variables. This is because DEA, like FDH, envelopes all the data points. Even so, there are recent developments on partial frontiers such as the order-*m* estimator that provides a robust estimator of the efficiency scores, sharing the same asymptotic properties as the envelopment estimators but being less sensitive to outliers. There is also the order-α estimator. It is argued that with the partial frontiers, the curse of dimensionality for the envelopment estimator may be overcome as they have root-*n* speed of convergence where *n* is the number of firms being evaluated (Daraio and Simar, 2007). Note however that partial frontiers are conditional measures. That is, the efficiency score in an input (output) orientation depends on the output (input) levels of the DMU under evaluation. Also, the computation of partial frontier may be time-consuming particularly for large sample size. This is because finding a suitable value of *m* or α may require several tries.

5.6.3 The Multiplier and Envelopment DEA Formulation

In order to formally define the original CCR (1978) DEA estimator, the study notes that efficiency can be defined, for complex business processes where DMUs employ multiple inputs to produce multiple outputs, as:

$$\text{Efficiency} = \frac{\text{total weighted outputs}}{\text{total weighted inputs}} \tag{7}$$

To maximize efficiency, equation (7) from the original idea of the CCR model is solved mathematically the same way as minimizing (8) below. That is, in a mathematical parlance, the output-oriented efficiency of a target DMU_o (x_o, y_o) is determined by working out the following ratio of virtual input to virtual output (Charnes et al., 1978) assuming CRS:

$$\min_{u,v} g_o = \frac{\sum_{i=1}^{m} v_i x_{ij_o}}{\sum_{r=1}^{s} u_r y_{rj_o}}$$

subject to

$$\frac{\sum_{i=1}^{m} v_i x_{ij}}{\sum_{r=1}^{s} u_r y_{rj}} \geq 1, \quad j = 1,...n, \tag{8}$$

$$u_r, v_i \geq 0; \quad \forall r,\ r = 1,...,s,\ ;\ \forall i,\ i = 1,...,m$$

where $y_{rj}, x_{ij} \geq 0$ are observed values for each of $r = 1,...,s$ outputs and each of $i = 1,...,m$ inputs for every DMU. Note that u_r and v_i are the weights (multipliers) assigned to output *r* and input *i* respectively (for the DMU under analysis) and these weights are the unknown variables to be determined. A strict formulation would substitute $u_r, v_i \geq 0$ with $\frac{u_r}{\sum_{r=1}^{s} u_r y_{rj_o}}, \frac{v_i}{\sum_{r=1}^{s} u_r y_{rj_o}} \geq \varepsilon > 0$, where ε is a positive infinitesimal non-Archimedean number used to guarantee that all inputs and outputs included in the DEA estimator are accounted for when measuring efficiency (Ali and Seiford, 1993a).

The estimator (8) minimizes the ratio of the weighted sum of inputs to the weighted sum of outputs of the target DMU, subject to the condition that similar ratios representing the efficiency measures for each DMU be greater than or equal to one.

In the linear programming problem (LPP) for each DMU, the constraints are the same, while the ratio (represented by g_o in equation 8) to be minimized is changed. Equation (8) is sometimes called the CCR model after the authors who first developed it. In practice, instead of (8), the following output-oriented *multiplier* model (9) is usually solved under CRS[11]:

$$
\begin{aligned}
&\min_{v_i, u_r, g_o} g_o = \sum_{i=1}^{m} v_i x_{io} \\
&\text{subject to} \\
&\sum_{r=1}^{s} u_r y_{ro} = 1 \\
&\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} u_r y_{rj} \geq 0 \quad \forall j, \quad j = 1, \ldots, n \\
&u_r, v_i \geq 0 \\
&\forall r,\ r = 1, \ldots, s, \quad \forall i,\ i = 1, \ldots, m
\end{aligned}
\tag{9}
$$

Let the optimal value of the LPP in (9) be denoted by g^* and the corresponding weights be, u^* and v^*. g^* is the DEA efficiency estimate assigned to the evaluated DMU. Note that the efficiency measure is "units invariant", i.e., it is independent of the units (scale) of measurement of the input and output variables provided the units are the same for every DMU (Ali and Seiford, 1993a). Unit invariance is different from translation invariance[12]. The measure of efficiency that is obtained in (9) is a relative measure bounded at one, $g^* \geq 1$. If and only if $g^*=1$ is the *j*th DMU efficient; otherwise, it is inefficient.

The input and output weights, or shadow prices (u_r and v_i) in equation (9) are the relative value system for each firm that makes that firm as efficient as possible, consistent with the idea that the resulting value system is feasible for all other firms on the understanding that none achieves an efficiency rating below one (Allen et al., 1997). These weights (v_i, u_r)

are not pre-set to specific values but are found as a solution to the optimization problem. This implies that DMUs can freely select the weights in a way that maximizes their efficiency and shows them in the best possible light. The freedom of choice of weights makes the DEA technique a powerful tool for identifying inefficiency because if a unit can freely choose weights to make it as efficient as possible but still does not become efficient compared to other units using the same set of weights, then, this obviously shows that the unit concerned is indeed inefficient.

The advantage of freely choosing weights can however be a drawback. This is because managers of DMUs who have inside knowledge of their organisations may not be pleased to see that some of the selected variables have been completely ignored (Thanassoulis et al., 2008). For instance, a bank may be regarded as efficient by ignoring certain key activities and put greater weight on the areas that it does best. This has led to the imposition of weight restrictions or production trade-off in the DEA literature as a way to limit the flexibility DMUs have in assigning weights to outputs and inputs (Thompson et al., 1986; Thompson et al., 1990; Wong and Beasley, 1990; Allen et al., 1997; Podinovski, 2004b ; 2007).

The LP dual problem to the multiplier model (9) can be stated as the following dual envelopment model (Charnes et al., 1978):

$$\phi^* = \max_{\lambda_j, \phi_o} \ \phi_o$$

subject to

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{io} \qquad \forall i, \quad i = 1, 2, \ldots, m; \tag{10}$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq \phi_o y_{ro} \quad \forall r, \quad r = 1, 2 \ldots, s;$$

$$\lambda_j \geq 0 \qquad \forall j, \quad j = 1, \ldots, n.$$

where the λ values are the intensity variables or coefficients assigned to DMUs. Those DMUs with non-zero λ values $\left(\lambda_j^* > 0\right)$ are the ones that serve as efficient referents or role models for the target DMUo. The LPP must be solved *n* times, one for each DMU, to obtain the efficiency scores for all DMUs. In the literature, equation (10) is considered the *envelopment* (primal) estimator whilst (9) is the *multiplier* (dual) form. The envelopment LPP maximizes ϕ which increases the output levels y_{ro} radially to ϕy_{ro}. This is subject to the constraint that (i) the weighted sum of inputs for the other DMUs is less than or equal to the inputs of the DMU under evaluation and (ii) the weighted sum of outputs of the other DMUs is greater than or equal to the outputs of the DMU under evaluation.

Notice that the optimal values of (10) are λ^* and $\phi^* \geq 1$ and units for which $\phi^*=1$ ($\phi^*>1$) are boundary or efficient (inefficient) units. Also, by duality, $g^*=\phi^*$. The program identifies a comparator or projection point $\left(x_0^*, y_0^*\right)$ that generates the maximum output levels of DMUo given the inputs. This comparator is a composite or amalgamated DMU that corresponds to a linear combination of efficient DMUs $\left(\sum_{j=1}^{n} \lambda_j^* x_{ij}, \sum_{j=1}^{n} \lambda_j^* y_{rj}\right)$ such that, when $\phi^* > 1$, dominates DMUo $\left(x_{io}, y_{ro}\phi_o\right)$.

5.6.4 Target Values and Slacks

The efficiency score from (10) is usually called "Farrell efficiency measure" which assumes strong free disposability. However, the efficiency score from (10) ignores the presence of non-zero slacks that was identified to be the vertical and horizontal dashed lines in Figure 5.5. If the efficiency measure of a DMU has non-zero slacks, then that DMU is said to be "mix inefficient" or "weakly efficient" (even if it was technically efficient) and therefore not Pareto-efficient (Cooper et al., 2007). Normally, solving the envelopment estimator (10) gives the efficient input-output targets (represented by the benchmarks for inefficient DMUs). The target values are generally defined for output orientation as:

$$\left\{ \begin{array}{ll} \hat{x}_{io} = \sum_{j=1}^{n} \lambda_j^* x_{ij} = x_{io} - s_i^{-*}, & i = 1, 2, ..., m \\ \hat{y}_{ro} = \sum_{j=1}^{n} \lambda_j^* y_{rj} = \phi_o^* y_{ro} + s_r^{+*}, & r = 1, 2..., s \end{array} \right\} \tag{11}$$

where s^- and s^+ are the slacks representing the input excesses and the output shortfalls respectively. The target values are not necessarily radial targets since they can contain optimal non-zero slacks s_i^{-*} and s_r^{+*}. The issue of target-setting is useful for managers, sometimes even more useful than the efficiency scores obtained (Thanassoulis et al., 2008).

As abovementioned, the presence of non-zero slacks can cause some efficient units to be weakly efficient. The unachieved outputs and the underutilized inputs show the extent to which individual input and output variables could be contracted or expanded on top of the radial changes indicated by the efficiency estimate (Tone, 2001). By the complementary slackness conditions of LP[13], non-zero slacks in the envelopment estimator correspond to zero weights in the multiplier estimator and vice-versa (Cooper et al., 2007).

In order to determine possible non-zero slacks (or guarantee that the targets lie on the efficient part of the frontier), the second-stage LPP in (12) is solved, after the first stage estimator (10) is solved for ϕ^* (Chang and Guh, 1991):

$$
\begin{aligned}
&\max_{\lambda_j, s_i^-, s_r^+} \sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+ \\
&\text{subject to} \\
&\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{io}, \quad \forall i,\ i = 1,\dots,m; \\
&\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = \phi_o^* y_{ro}, \quad \forall r,\ r = 1,\dots,s; \\
&\lambda_j,\ s_i^-,\ s_r^+ \geq 0, \quad \forall j,\quad j = 1,\dots,n.
\end{aligned}
\qquad (12)
$$

where the slack variables are used to convert the inequalities in (10) to equalities in (12). Note that since the optimal ϕ^* is solved from (10), it is not influenced by any decision on s_i^{-*} and s_r^{+*}. The slacks are obtained from the solution to (12) where the target levels in (11) are used on the right hand side of (12). The discussion above implies that a specific DMU is efficient if and only if $\phi^* = 1$ and all slack variables are zero, i.e. $s_i^{-*} = s_r^{+*} = 0 \ \forall i, r$ (Charnes et al., 1978).

It is to be observed that models (10) and (12) represent a two-stage process in the following (13) envelopment DEA model (see e.g. Zhu, 2009) and corresponding dual (multiplier) problem in (14):

$$\max \ \phi_o + \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right)$$

subject to

$$\begin{aligned}
&\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{io}, \quad \forall i,\ i = 1,\dots,m; \\
&\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = \phi_o y_{ro}, \quad \forall r,\ r = 1,\dots,s; \\
&\lambda_j,\ s_i^-,\ s_r^+ \geq 0, \quad \forall j, \quad j = 1,\dots,n.
\end{aligned} \tag{13}$$

$$\min_{v_i, u_r, g_o} g_o = \sum_{i=1}^{m} v_i x_{io}$$

subject to

$$\begin{aligned}
&\sum_{r=1}^{s} u_r y_{ro} = 1 \qquad \forall r,\ r = 1,\dots,s; \\
&\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} u_r y_{rj} \geq 0, \quad \forall j \quad j = 1,\dots,n; \\
&u_r, v_i \geq \varepsilon, \qquad \forall i,\ i = 1,\dots,m.
\end{aligned} \tag{14}$$

where ε is the non-Archimedean element which allows the maximization over ϕ_o to pre-empt the optimization of the slacks. The standard procedure is to find out the non-zero slacks using the infinitesimal ε in a two-stage procedure in order to guarantee Pareto-efficiency (cf. Chang and Guh, 1991; Ali and Seiford, 1993b).

5.6.5 Returns to Scale

The DEA formulations considered so far, whether envelopment or multiplier models, assume CRS and are called CCR models (Charnes et al., 1978). The CRS assumption may not be always valid in practical situations where financial constraints, imperfect competition, regulatory reforms among others could cause DMUs to operate at a scale that is not optimal (Coelli et al., 2005). Hence, the technological set can display different Returns to Scale (RTS) characteristics. Banker et al., BCC (1984) modified the CCR (CRS) model into VRS model which allows for DMUs to be compared to other DMUs of similar size. The VRS assumption allows the technology to exhibit not only CRS but also decreasing returns to scale (DRS) whereby outputs increase less than proportionately with inputs and increasing returns to scale (IRS) whereby outputs rise more than proportionally with inputs. The CCR model considered so far can be reformulated to account for the different RTS properties. This is stated for the output-oriented multiplier model in (15a):

$$\min_{v_i, u_r, w, g_o} g_o = \sum_{i=1}^{m} v_i x_{io} + w$$

subject to

$$\sum_{r=1}^{s} u_r y_{ro} = 1 \qquad (15a)$$

$$\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} u_r y_{rj} + w \geq 0, \quad \forall j \quad j = 1,...,n$$

$$u_r, v_i \geq \varepsilon > 0, \quad \forall r,\ r = 1,...,s, \quad \forall i,\ i = 1,...,m$$

where w is the variable whose sign can be used to portray the situation of RTS. w is "free in sign" and can be positive or negative or zero (Banker et al., 1984). Consequently, w=0, w is free, $w \leq 0$ and $w \geq 0$ for CRS, VRS, non-decreasing returns to scale (NDRS) and non-increasing returns to scale (NIRS) technology types respectively. $\varepsilon > 0$ is the non-Archimedean infinitesimal defined earlier.

The corresponding output-oriented envelopment model is shown in (15b):

$$\max_{\lambda_j, s_i^-, s_r^+, \phi_o} \quad \phi_o + \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right)$$

subject to

$$\begin{aligned}
&\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{io}, \quad \forall i,\ i = 1,\ldots,m; \\
&\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = \phi_o y_{ro}, \quad \forall r,\ r = 1,\ldots,s; \\
&\lambda_j,\ s_i^-,\ s_r^+ \geq 0, \quad \forall j, \quad j = 1,\ldots,n. \\
&\lambda_j \in T
\end{aligned} \tag{15b}$$

where T is the production technology which can exhibit CRS (Charnes et al., 1978) or VRS (Banker et al., 1984). Depending on T, different technological sets can be defined to the extent that returns to scale are concerned (Fried et al., 2008). The original CCR model dealt with CRS where $T = \{\lambda_j \geq 0\}$. Other technological constraints that can be adjoined to (15b) to make it correspond to (15a) are: $\sum_{j=1}^{n} \lambda_j = 1$, $\sum_{j=1}^{n} \lambda_j \geq 1$ and $\sum_{j=1}^{n} \lambda_j \leq 1$ for VRS, NDRS and NIRS technologies respectively.

5.6.6 Scale Efficiency

The BCC (1984) model measures returns to scale efficiency in its dual multiplier formulation (Cooper et al., 2007). The notion of scale efficiency can be explained using Figure 5.6, which shows the CRS frontier represented by the thick connecting lines from the origin through ABCD for a single output/input case. The VRS frontier is shown by the connecting lines EBFG. Moving along the VRS frontier from E to G raises the average productivity of efficient DMUs until it reaches its maximum at B, after which the average productivity begins to fall. CRS-efficient units are those with the highest average productivity. DMU H is inefficient under both CRS and VRS with an output-oriented efficiency score relative to the CRS frontier computed as $\phi_H^{CRS} = OF''/OH$ and relative to the VRS as $\phi_H^{VRS} = OF'/OH$.

Based on CRS and VRS classification, one can determine how far a unit's scale size is away from the "optimal" size referred to as the "most productive scale size" (=MPSS) (Banker, 1984)[14]. This distance of a unit's scale size from the MPSS reflects the unit's scale efficiency (SE), i.e. the deviation of the VRS technology from the CRS technology. The SE is defined for DMU "H" as: $SE = \frac{OF''}{OH} \Big/ \frac{OF'}{OH} = \frac{OF''}{OF'} = \frac{\phi_H^{CRS}}{\phi_H^{VRS}}$. Hence, SE is the ratio of CRS "overall technical" efficiency to that of VRS "pure technical" efficiency. This implies that $\phi_H^{CRS} = \phi_H^{VRS} \times SE$ where $\phi_o^{CRS} \leq \phi_0^{VRS}$. SE=1 means that the DMU is fully scale efficient; otherwise it is inefficient.

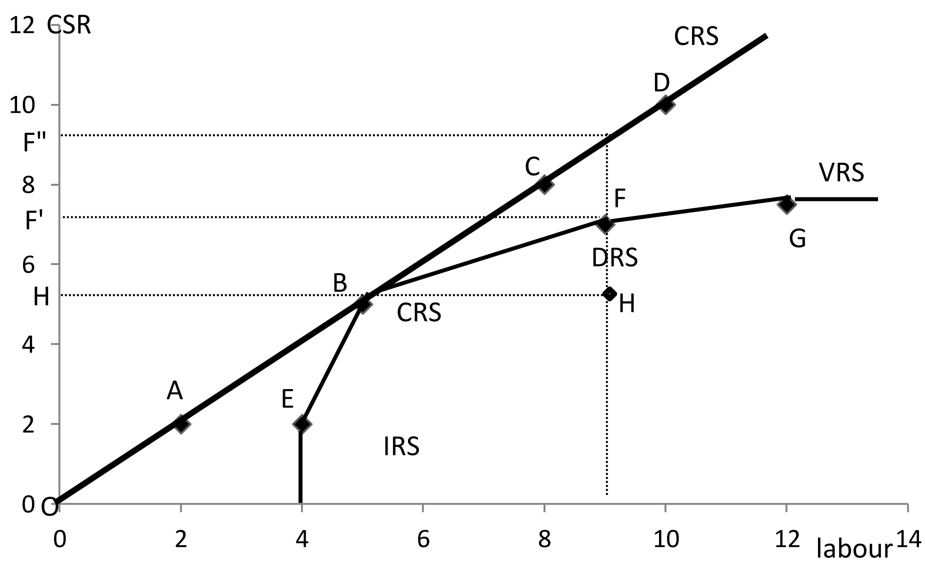

Figure 5.6 Illustration of IRS, CRS, DRS RTS and scale efficiency

5.6.7 Characterizations of RTS

It may be recalled that *w* in the multiplier formulation or $\sum_{j=1}^{n} \lambda_j$ in the envelopment formulation can be set to different values depending on the type of RTS. Several approaches have been proposed to determine RTS types (Banker, 1984; Färe et al., 1985a; Banker and Thrall, 1992; Seiford and Zhu, 1999a) and global RTS (Podinovski, 2004a).

As indicated earlier, to determine the type of RTS of DMUs located at specific parts of the VRS frontier, Banker (1984) suggested the addition of *w*, the free variable into the multiplier estimator which corresponds to the convexity constraint, $\sum_{j=1}^{n} \lambda_j = 1$ in the envelopment estimator. But Banker's (1984) characterization fails when the DEA formulations have alternate optimal solutions. Banker and Thrall (1992) dealt with this issue by generating the following characterizations of RTS (for the multiplier VRS estimator) based on the value of *w** for the output-oriented (11):

- $w^* = 0$ in some alternate optima $\Rightarrow$ CRS holds on DMUo locally;
- $w^* < 0$ in all alternate optima $\Rightarrow$ DRS holds on DMUo locally;
- $w^* > 0$ in all alternate optima $\Rightarrow$ IRS holds on DMUo locally

Similarly, in the output-oriented envelopment DEA (12), the rules for the nature of RTS are (Banker and Thrall, 1992):

- $\sum_{j=1}^{n} \lambda_j = 1$ in *some* alternate optima $\Rightarrow$ CRS holds for DMUo locally;
- $\sum_{j=1}^{n} \lambda_j > 1$ in *all* alternate optima $\Rightarrow$ DRS holds for DMUo locally;
- $\sum_{j=1}^{n} \lambda_j < 1$ in *all* alternate optima $\Rightarrow$ IRS holds for DMUo locally

In Figure 5.6, DMU B operates at the MPSS and is said to exhibit CRS. DMU E exhibits IRS and DMUs F and G exhibits DRS. The reader is referred to Banker et al. (1996) regarding the second stage LPP employed to test if the above conditions hold in all alternate optima (cf. Banker et al., 2004). Färe et al (cf. Banker et al., 2004) proposed another approach for treating RTS using ratios of radial measures. The approach adds to the CRS and VRS models another DEA model whose frontier exhibits non-increasing returns to scale, NIRS. There is also the non-decreasing returns to scale, NDRS, but this has been less applied (1985a). Under the NIRS model, DMUs can be scaled only up but not down whereas under the NDRS model, DMUs can be scaled only down but not up.

Both the NIRS and NDRS are shown in Figures 5.7 and 5.8 as the thick frontier lines and the area below and to the right of the frontiers. The NIRS and NDRS play an important role in testing the type of returns to scale. If the efficiency estimate is computed from each of these models, one can draw the following conclusions regarding the nature of RTS (Thanassoulis et al., 2008):

- If the CRS, VRS, and NIRS estimators generate exactly the same efficiency score, then the DMU lies, or is projected, on a boundary region exhibiting local CRS.
- If the CRS and NIRS efficiency estimates are both equal and lower than the VRS efficiency estimate, then the DMU lies, or is projected, on an IRS region of the boundary
- If VRS and NIRS efficiency estimates are both equal and higher than the CRS efficiency estimates, then the DMU lies, or is projected, on a DRS region of the boundary.

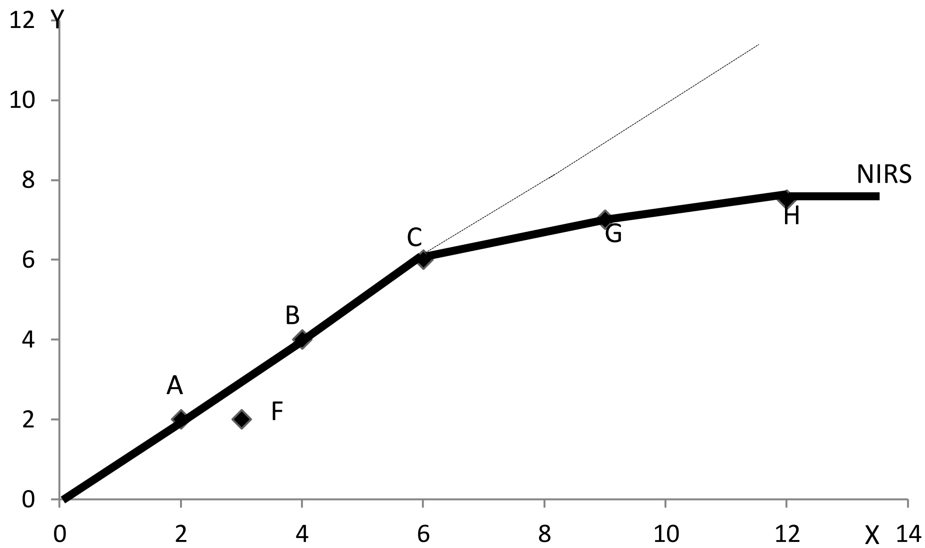

Figure 5.7 Illustrating Non-increasing returns to scale

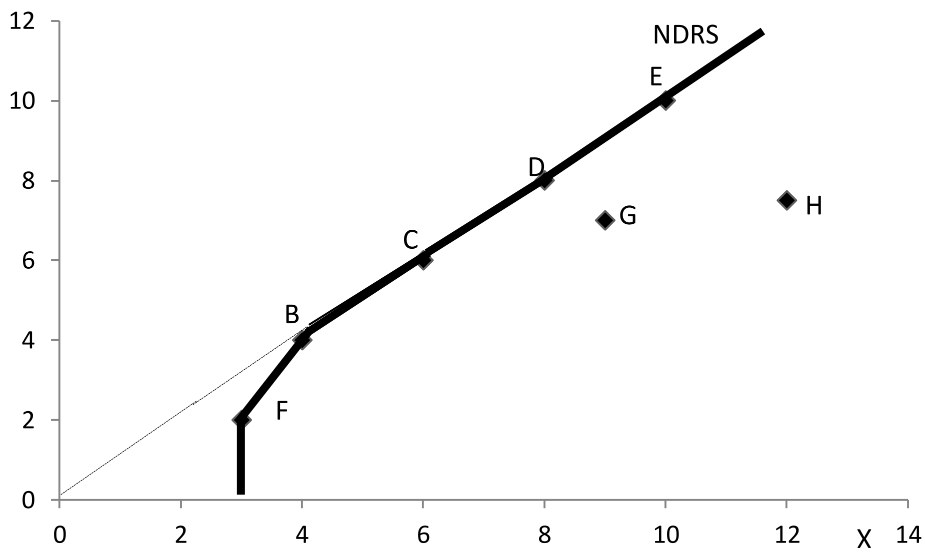

Figure 5.8 Illustrating Non-decreasing returns to scale

5.6.8 Extensions of CCR DEA Estimator

There are several extensions to the original CCR model. The additive model of Charnes et al. (1985b) is one of these extensions. It is a nonradial, nonoriented measure that is valuable for determining Pareto-efficient DMUs. It selects the benchmark unit by considering the possible input decreases and output expansions concurrently. The additive model is translation invariant but not unit invariant (Lovell and Pastor, 1995).

There is also the class of “multiplicative models” of Charnes et al. (1982) that allow piecewise log-linear or Cobb-Douglas envelopment but have not been applied much in the literature.

Other extensions include the Russell measure of technical efficiency (Färe et al., 1983b; Färe et al., 1985b), the analysis of ‘exogenously fixed’ or nondiscretionary inputs and outputs (Banker and Morey, 1986a) and categorical variables (Banker and Morey, 1986b), the range-adjusted measure (Cooper et al., 1999), the enhanced Russell measure model (Pastor et al., 1999) that has properties of completeness and units invariance but not translation invariance, the slack-based model of Tone (2001) that preserves the units invariance property in the additive model, the super-efficiency-model (Andersen and Petersen, 1993) that ranks efficient DMUs, the geometric distance function (Portela and Thanassoulis, 2007b), the incorporation of value judgements or *a priori* knowledge (Dyson and Thanassoulis, 1988; Thompson et al., 1990; Allen et al., 1997) and window analysis (Charnes et al., 1985a). For further discussion on these models see Fried et al. (2008) and Cooper et al. (2007; 2011).

5.7 Dynamic Efficiency and Productivity

At the onset of this chapter, productivity was defined as y/x for the single-input-single-output situation. This is a partial productivity measure such a labour productivity. In the presence of one observation in two time periods, $\left(x^0, y^0\right)$ and $\left(x^1, y^1\right)$, productivity change equals (Färe et al., 2008):

$$\text{Productivity change} = \frac{y^1/x^1}{y^0/x^0} = \frac{y^1/y^0}{x^1/x^0} \tag{16}$$

If the ratio in equation 16 is above 1, then productivity has increased over time. If it is below 1, then productivity decline has occurred. The above partial productivity measure is easy to compute. Nonetheless, in real life, things are not that simple as DMUs use many inputs to generate many outputs as observed in the banking industry. The applied researcher may therefore aggregate inputs and outputs to arrive at a single measure of productivity change. Coelli and Perelman (2000) indicated that this can lead to aggregations problems. One way to deal with multiple inputs and outputs is to employ radial distance functions.

Shephard (1953) and Malmquist (1953) independently pioneered the distance function idea in the field of economics. Shephard (1953) applied it to production theory whereas Malmquist (1953) introduced the input distance function in the context of consumption theory. Distance functions can be employed to define a variety of index numbers such as Laspeyres (1871), Paasche (1874), Fisher (1922), Törnqvist (1936) and Hicks-Moorsteen (Diewert, 1992). Distance functions can provide a means to aggregate inputs and outputs where necessary in order to compute a productivity change index (cf. Shephard, 1970; Lovell, 2003).

Two definitions of productivity change indexes based on distance functions exist. The first index called Malmquist productivity change index was introduced by Caves, Christensen, and Diewert, CCD (1982) and is based on the ratios of output distance functions or on the ratios of input distance functions.

The second called Hicks-Moorsteen index considers productivity index as ratio of a Malmquist quantity index of outputs to a Malmquist quantity index of inputs. This method is due to Diewert (1992) and Bjurek (1994; 1996). Färe et al. (1998) remarked that the Malmquist productivity change index coincides with the Hicks-Moorsteen index if and only if the technology is inversely homothetic[15] and exhibits CRS.

The CCD (1982) version is more popular than the Bjurek (1994; 1996) version, possibly because it was proposed a decade earlier; it has been related to other productivity indices such as Fisher and Törnqvist and it decomposes into other components (Lovell, 2003). Consequently, the focus of this section will be based on the Malmquist productivity change index. For detailed discussions on the index, the reader is referred to Färe, Grosskopf, Lindgren, and Roos, FGLR (1994a), Fare, Grosskopf, Norris and Zhang, FGNZ (1994c), Färe et al. (1998), Tone (2004) and Färe et al. (2008).

5.8 The Malmquist Productivity Change Index

CCD (1982), inspired by Malmquist (1953), proposed the Malmquist productivity change index[16]. The index has Shephard's (1970) distance functions as the basic building blocks. The first empirical application of the index was by Nishimizu and Page (1982) using a parametric technique. Within the nonparametric DEA framework, Färe et al. (1992; 1994c) combined the ideas of Farrell efficiency measurement and CCD (1982) productivity change measurement to define the Malmquist index. This index is also called adjacent index as a way to differentiate it from the base-period Malmquist index of Berg et al. (1992), introduced in order to impose circularity[17] (Althin, 2001). Both the adjacent and the base-period indices estimate efficiency change the same way; the technical change is however estimated differently. This study will concentrate on the adjacent index, which measures productivity change between two periods instead of just examining a snapshot of performance at one particular time. An advantage of the index is its ability to handle multiple inputs and outputs with minimal assumptions and without information on input or output prices and its ability to decompose productivity change into efficiency change (catch-up effect) and technological change (frontier shift effect). The LPP for the output-oriented efficiency score $\phi^t\left(x_j^t, y_j^t\right)$ for a DMU j in time period t can be defined as:

$$
\begin{aligned}
&\max \phi^t\left(x_j^t, y_j^t\right) \\
&s.t. \\
&\sum_{j=1}^{n} \lambda_j^t x_{ij}^t \le x_{io}^t \qquad i = 1,\dots,m \\
&\sum_{j=1}^{n} \lambda_j^t y_{rj}^t \ge \phi y_{ro}^t \qquad r = 1,\dots,s \\
&\lambda_j^t \ge 0 \qquad j = 1,\dots,n
\end{aligned}
\tag{17}
$$

where λ_j^t is the intensity variable defined in (10) and $\phi^t\left(x_j^t, y_j^t\right)$ is measured relative to period t technology frontier (the superscript t of ϕ). It measures how far the observation is from period t technology frontier and hence is called own-period efficiency. The reference technology can also be from another period e.g. t+i. For simplicity, the subscript j is omitted. The efficiency score $\phi^{t+i}\left(x^{t+i}, y^{t+i}\right)$ evaluates the efficiency of the same DMU but in period t+i against t+i technology frontier where t is substituted by t+i. Before the Malmquist productivity change index can be computed, two mixed-period or inter-temporal efficiency scores in addition to (17) and $\phi^{t+i}\left(x^{t+i}, y^{t+i}\right)$ have to be estimated. The first is the efficiency score of DMU $\left(x^{t+i}, y^{t+i}\right)$ measured against the frontier technology t in the LPP:

$$
\begin{aligned}
&\max \phi^t\left(x^{t+i}, y^{t+i}\right) \\
&s.t. \\
&\sum_{j=1}^{n} \lambda_j^t x_{ij}^t \le x_{io}^{t+i} \qquad i = 1, \ldots, m \\
&\sum_{j=1}^{n} \lambda_j^t y_{rj}^t \ge \phi y_{ro}^{t+i} \qquad r = 1, \ldots, s \\
&\lambda_j^t \ge 0 \;\; ; \lambda_j^t \in T^t \qquad j = 1, \ldots, n
\end{aligned}
\tag{18}
$$

The second is for a DMU in period t whose cross-period efficiency score is measured against $t+i$ technology frontier:

$$
\begin{aligned}
&\max \phi^{t+i}\left(x^t, y^t\right) \\
&s.t. \\
&\sum_{j=1}^{n} \lambda_j^{t+i} x_{ij}^{t+i} \le x_{io}^t \qquad i = 1, \ldots, m \\
&\sum_{j=1}^{n} \lambda_j^{t+i} y_{rj}^{t+i} \ge \phi y_{ro}^t \qquad r = 1, \ldots, s \\
&\lambda_j^{t+i} \ge 0 \qquad j = 1, \ldots, n
\end{aligned}
\tag{19}
$$

Note that although $\phi^t\left(x^t, y^t\right) \geq 1$ since DMU $\left(x^t, y^t\right)$ must be feasible in period t technology, $\phi^t\left(x^{t+i}, y^{t+i}\right) >=< 1$ since DMU $\left(x^{t+i}, y^{t+i}\right)$ may or may not be feasible in period t technology. FGLR (1992; 1994a) defined the output-oriented Malmquist productivity change index between periods t and $t+i$ as the geometric mean of the four efficiency scores above[18]:

$$M\left(x^t, y^t, x^{t+i}, y^{t+i}\right) = \left[\frac{\phi^t\left(x^t, y^t\right)}{\phi^t\left(x^{t+i}, y^{t+i}\right)} \times \frac{\phi^{t+i}\left(x^t, y^t\right)}{\phi^{t+i}\left(x^{t+i}, y^{t+i}\right)}\right]^{1/2} \tag{20}$$

M is the geometric mean of two efficiency ratios where one is the efficiency change measured relative to period t technology frontier and the other is the efficiency change measured relative to period $t+i$ technology frontier. A value of M greater than (less than/equal to) one denotes productivity growth (decline/stagnation) respectively. An important characteristic of the Malmquist index is that it can decompose the productivity change into two components, one measuring technical efficiency change, EC (catching up) and another capturing technical/technological change or innovation, TC (frontier shift). The decomposition of (20) was introduced by FGLR (1992; 1994a) and given as:

$$M\left(x^{t+i}, y^{t+i}, x^t, y^t\right) = \underbrace{\frac{\phi^t\left(x^t, y^t\right)}{\phi^{t+i}\left(x^{t+i}, y^{t+i}\right)}}_{\text{EC}} \times \underbrace{\left[\frac{\phi^{t+i}\left(x^{t+i}, y^{t+i}\right)}{\phi^t\left(x^{t+i}, y^{t+i}\right)} \times \frac{\phi^{t+i}\left(x^t, y^t\right)}{\phi^t\left(x^t, y^t\right)}\right]^{\frac{1}{2}}}_{\text{TC}} \tag{21}$$

The EC measures the change in the output-oriented measure of technical efficiency between periods t and $t+i$. In other words, it measures how much closer (or farther away) a DMU is from the technology frontier. The EC is >=<1 according to whether technical efficiency improves, stagnates or deteriorates between periods t and $t+i$. The square root term (TC) estimates how much the production frontier shifts over time and shows whether the benchmark technology frontier is progressing, stagnating or declining. TC thus indicates the effect of process or product innovation, among other things, on productivity change. TC >1 shows progress in the technology frontier around the DMU being evaluated from period t to $t+i$ whereas TC ≤1 indicates the status quo and regress respectively in the technology frontier. TC >1 does not necessarily mean that a DMU actually pushed the overall frontier outward. A unit contributes to an outward shift of the whole frontier only if its observed input-output combination lies outside the frontier for the previous period [with $\phi^t\left(x^{t+i}, y^{t+i}\right)<1$] , reflecting super-efficiency, *and* is on the frontier for the current period [with $(\phi^{t+i}x^{t+i}, y^{t+i})=1$] (Ray and Desli, 1997).

Note that the technical change in (21) is actually specific to the observation being assessed in that it is the geometric mean of the frontier shift observed by the unit at time t and at time $t+i$. The mean of these individual frontier shifts are usually reported and explained in a number of empirical studies as the frontier shift for the whole population. Hence, the above indices are assumed local in nature. The next section will consider global indices, particularly, the global frontier shift, which are helpful when making conclusions about productivity changes for a whole population instead of individual units (Asmild and Tam, 2007). Figure 5.9, adapted from FGNZ (1994c), graphically illustrates the output-oriented Malmquist productivity change index in a single-input, single-output case. The two thick straight lines, CRS^t and CRS^{t+i} represent the CRS technology frontier in periods t and $t+i$ respectively.

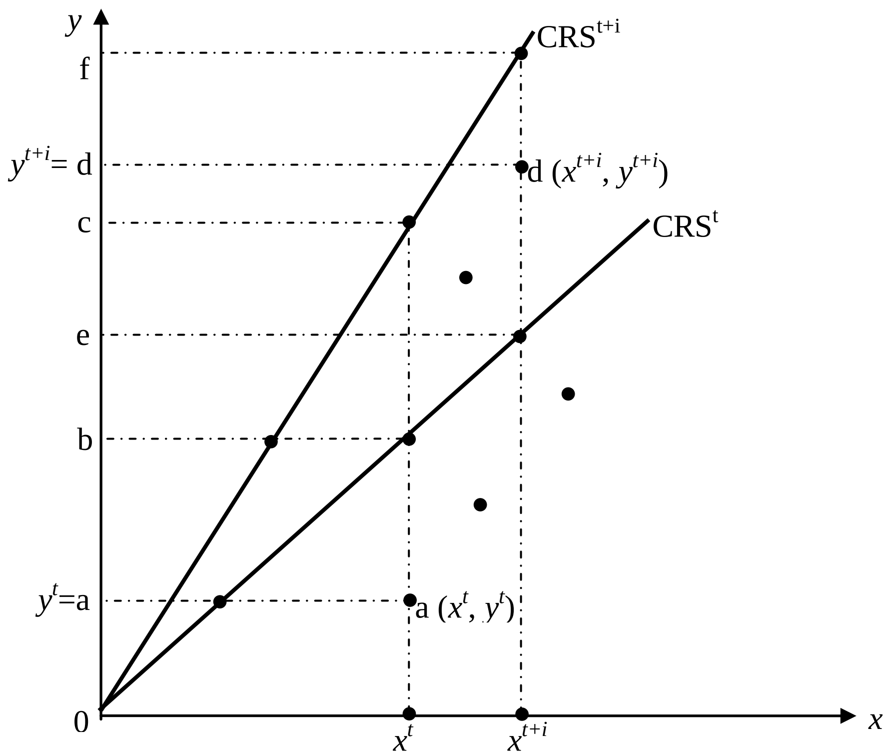

Figure 5.9 The Malmquist output-based productivity index

Points *a* (x^t, y^t) and *d* (x^{t+i}, y^{t+i}) represent the DMU under evaluation in *t* and *t+i* respectively. Point *a* is technically inefficient with output-oriented technical efficiency score of *0b/0a* when it is projected unto the CRS^t frontier. Similarly, the efficiency score of *d* measured against its own-period CRS^{t+i} frontier is *0f/0d*. Note that some observations enveloped by CRS^{t+i} frontier (such as *d*) are located outside the CRS^t frontier, resulting in a (super) efficiency score <1 for the output-oriented case (Andersen and Petersen, 1993). Comparing unit *d* relative to *a* shows that technological change has occurred. Using the Figure and equations (20) and (21), *M* is given as:

$$M = \left[\frac{0b/0a}{0e/0d} \times \frac{0c/0a}{0f/0d} \right]^{\frac{1}{2}}, \text{ with } EC = \frac{0b/0a}{0f/0d} \text{ while } TC = \left(\frac{0f/0d}{0e/0d} \times \frac{0c/0a}{0b/0a} \right)^{\frac{1}{2}}$$

FGNZ (1994c) estimated the Malmquist index relative to the "benchmark" CRS technology. But FGNZ (1994c) suggested that "in principle, one may calculate the index relative to any type of technology (i.e. satisfying any type of returns to scale)" (p. 74). They therefore expanded the decomposition of the EC component into "pure technical efficiency change" component, PTEC (estimated relative to the VRS technology) and a residual "scale efficiency change" component (SEC), which captures the deviation between the VRS and CRS technologies. SEC deals with changes in a DMU's technical efficiency related to the growth in the DMU's size. That of the TC component remained the same.
The reason for decomposing the first part of (21) is that the "best-practice" technology may exhibit VRS and so redefining both parts on such technologies may provide some important economic understanding (FGNZ, 1994c).

Other decompositions include those of Ray and Desli, RD (1997), Grifell-Tatjé and Lovell (1999), Wheelock and Wilson (1999) and Balk (2001). One argument initiated by RD (1997) is that the use of CRS and VRS by FGNZ (1994c) within the same decomposition of Malmquist index raises issues of internal consistency. RD argued that the TC of FGNZ (1994c) measures frontier shift under CRS but the PTEC and the SEC measures are derived from VRS technology. RD (1997) contended that the TC correctly depicts frontier shift if CRS is assumed to hold. But there is no scale change under CRS. The authors modified the decomposition using the VRS technology as the benchmark and then measured TC by the ratio of VRS distance functions. Färe et al. (1997b) replied arguing that RD's (1997) technical change component measured the boundary shift in the VRS technology "but that shift is not the change in maximal average product. Computationally, the RD method may pose some difficulties (including …. ‘infeasible solution’ …) since their technical change component includes mixed-period distance functions computed under VRS” (Färe et al., 1997b, p.1041). Färe et al. (1997b) contention was that the frontier shift is only measurable under CRS technology and that cross-period efficiency scores calculated against the VRS technology can lead to infeasibility problems in the RD decomposition unlike in the FGNZ decomposition. The reader can see that there are disagreements in the decomposition of the Malmquist index. Bert Balk even proposed many decompositions comprising the suggested four-part decomposition of Balk (2001) which criticized RD (1997) for not differentiating between scale efficiency change and the input mix or output mix effects.

Only the Malmquist indices under CRS and VRS technologies have been examined. But one can also consider NIRS and FDH and even different directions of measuring efficiency of a DMU including radial, non-radial, hyperbolic or directional distance (see e.g. Tulkens and Vanden Eeckaut, 1995). Note that the efficiency estimates and hence the Malmquist index and its components can be influenced by the type of RTS technology particularly under VRS than under CRS (cf. Grifell-Tatjé and Lovell, 1995; 1999; Ray and Desli, 1997; Balk, 2001). For instance, Grifell-Tatje and Lovell (1995) showed using a straightforward algebraic example that the VRS technology-based index defined by Caves et al. (1982) disregarded the role of scale economies toward productivity change and hence biased the productivity change. Färe and Grosskopf (1996) indicated that with the CRS assumption, a logical technological reference is achieved for the frontier shift even in the presence of VRS[19]. Coelli and Rao (2005) indicated that it is crucial to impose CRS upon any technology when calculating the Malmquist index; otherwise, the resulting measures may not correctly reflect productivity changes due to scale economies. In short, the Malmquist index suffers from LP infeasibility problems when the cross-period efficiency scores are estimated relative to a VRS technology implying that for some DMUs, one cannot compute technical change (Bjurek, 1996; Oh, 2010; Pastor et al., 2011).

To keep away from the infeasibility issue, most empirical studies estimate the cross-period efficiency scores relative to a cone/CRS technology (see also Ray and Mukherjee, 1996; Ray and Desli, 1997; Färe et al., 2008). Pastor et al. (2011) recently proposed a new biennial Malmquist index which avoids LP infeasibilities under VRS, measures technical change and does not need to be recomputed when a new time period is added to the data set. The biennial Malmquist index is, however, not transitive/circular as it is constructed from a series of overlapping two period technologies. This weakness is common to all Malmquist indices proposed by Caves et al. (1982) and extended by FGNZ (1994c), Ray and Desli's (1997) and Balk (2001, 2005) apart from the global Malmquist index of Pastor and Lovell (2005) which is understandable since it considers a single technology. Note that Balk (1998) was able to prove that Hick-neutral frontier shift is a necessary and sufficient condition for the transitivity of the Malmquist index (see also Balk, 2001, 2005).

Other extensions of the Malmquist productivity change index are provided in the literature. For instance, Färe et al. (1997a) decomposed the TC into (i) output-biased technical change OBTC (ii) input-biased technical change IBTC and (iii) a magnitude or neutral component MATC as: $TC = OBTC \times IBTC \times MATC$. Moreover, Färe et al. (2001) decomposed the Malmquist index when the underlying technology satisfies subvector homotheticity.

Grifell-Tatjé and Lovell (1999) investigated the productivity change and decomposed profit change into operating efficiency effect, technical change effect, scale effect, resource mix effect and product mix effect. Bauer (1990), using a parametric approach and Balk (1997), using index numbers approach, decomposed productivity change in order to identify the contribution of allocative efficiency change. Similarly, Maniadakis and Thanassoulis (2004) developed a cost Malmquist index which considers allocative inefficiency. The index is appropriate when the goal is to minimize cost and when input–output quantity and input price data are available. For further details on the extensions of the Malmquist productivity index, the reader is referred to Färe et al. (1998), Balk (2001, 2005) and Färe et al., (2008). The next sections examine other nonparametric techniques that will be employed to address some of the research questions 3 and 4 posed in the introductory chapter.

5.9 The Metafrontier Analysis

When firms have access to different technologies it may be difficult to compare their efficiency scores measured against their group-specific frontiers (O'Donnell et al., 2008). In order to compare efficiency levels and rankings, a pooled frontier or a common benchmark is required (Bos and Schmiedel, 2007). Some studies estimate a pooled frontier and control for systematic heterogeneity (Bos et al., 2009) or (unobserved) technology differentials (Koetter and Poghosyan, 2009) that are expected to affect efficiency across firms in the same industry within a country or in different countries. Within SFA literature, some studies focus on group-specific temporal variations in efficiency (rather than individual temporal variations) (Lee, 2006, 2010). Within the DEA literature, firms' technology heterogeneity entails differentials in economic infrastructure, existing resource endowment and other social and environmental characteristics, which have been explored via the metafrontier analysis (Battese and Rao, 2002; Battese et al., 2004; O'Donnell et al., 2008).

The metafrontier technique originated from the metaproduction function proposed by Hayami and Ruttan (1970) who indicated that "the metaproduction function can be regarded as the envelope of commonly conceived neoclassical production functions" (p. 82). The metafrontier analysis was introduced by Battese and Rao (2002), refined by Battese et al. (2004) in parametric context and extended by O'Donnell et al. (2008) in nonparametric DEA framework. These authors showed that if different groups of firms (or regions/countries) have different technologies, then the metafrontier is needed to compare efficiency across different firms. They noted that the population of DMUs can be divided into K (> 1) groups (k=1,…,K), where each group (k) has specific features (i.e. technology, exogenous factors or regulations) distinct from other groups. The groups can be periods, regions, countries etc. The group k technology set can be defined as:

$$T^k = \{(x_k, y_k) \in \Re^{m+s} \mid x_k \text{ can produce } y_k\} \qquad (22)$$

where (x_k, y_k) is the input-output combinations for a DMU in group k. O'Donnell et al. (2008) also defined a metatechnology set that contains all DMUs:

$$T^M = \{(x, y) \in \Re^{m+s} \mid x \text{ can produce } y\} \qquad (23)$$

where all variables are as defined in (22). The superscript *M*, attached to *T* indicates the metatechnology to distinguish it from the group *k* technology. The boundary of this unrestricted metatechnology set is the *metafrontier*, an overarching function that gives the maximum amount of output a DMU can radially expand given input levels. The efficiency score of each DMU is estimated parametrically or nonparametrically relative to the metafrontier. Using DEA, the output-oriented efficiency score of DMU j measured against the metafrontier is $\phi_j^M\left(x_j, y_j\right)$ which is called the *metaefficiency* (ME). The boundaries of the group-specific output sets are the *group frontiers* all of which are enveloped by the metafrontier. That is, the within-group frontiers are nested inside the overarching metafrontier. The group analysis estimates the group-*k* frontier and measures the efficiency score of each DMU in each group relative to that group's frontier. The resulting efficiency score $\phi_j^k\left(x_j, y_j\right)$ of a DMU in group *k* is its *group efficiency* (GE).

From the ME and GE, the metatechnology ratio, MTR (O'Donnell et al., 2008) or the technology gap ratio, TGR, (Battese et al., 2004) can be defined. The output-oriented TGR for group-*k* DMUs is:

$$TGR^k\left(x_j, y_j\right) = \frac{\phi_j^M\left(x_j, y_j\right)}{\phi_j^k\left(x_j, y_j\right)} \tag{24}$$

TGR is the difference in the technology within the reach of a *k*-th group relative to the technology within the reach of all *K* groups (O'Donnell et al., 2008). The distance between the group frontier and the metafrontier is ascribed to the greater technological features of the "best-practice technology" (Battese and Rao, 2002).

Figure 5.10 illustrates the metafrontier analysis for the output-oriented DEA framework with two-output and fixed-input banks for 3 hypothetical banking groups - state, domestic and foreign – each group having 4 banks. The analysis can easily be extended to the input-oriented framework. In the next section, the global frontier difference (GFD) approach of Asmild and Tam (2007) will be illustrated using the same hypothetical data. The S's represent individual state banks whilst SS' is the corresponding group frontier; the D's are domestic banks with DD' depicting the corresponding group frontier; and finally, the F's are foreign banks where FF' indicates their corresponding group frontier.

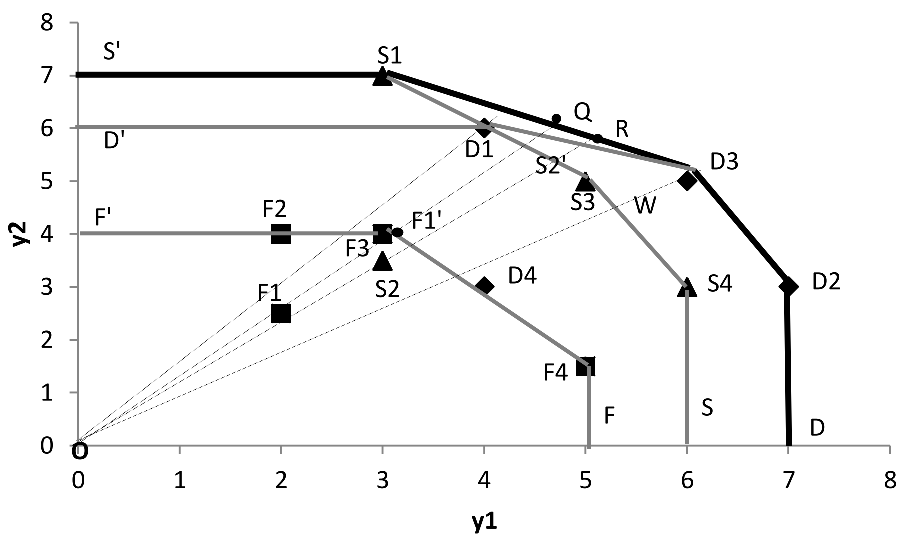

Figure 5.10 Metafrontier, group frontiers, metatechnology ratios

The metafrontier is represented by the thick connecting lines S'S1D3D2D. Note that bank (or data point) F1, one of the foreign banks has an output-oriented efficiency score of OF1'/OF1=1.55 when evaluated relative to the foreign frontier, FF'. Similarly, the state bank S2, when measured against SS' has an efficiency score of OS2'/OS2=1.54. The scores 1.55 and 1.54 are the GE for banks F1 and S2 respectively when measured against their respective group frontiers. But the GE scores of the two DMU are incomparable as they operate under different group technologies and hence their efficiencies are measured relative to different best-practice banking frontiers. The efficiency estimates can only be compared if they are measured against the metafrontier, resulting in the metaefficiency score, ME.

The ME for bank F1 is OQ/OF1=2.35 whilst the ME for bank S2 is OR/OS2=1.64 where both scores also depict the two banks as inefficient. The difference between the ME and the GE scores of a DMU can be analyzed using the TGR of that unit. The TGR for bank F1 is OQ/OF1'=OF1'/OF1×OQ/OF1'=1.51. The TGR value of 1.51 shows that F1 is about 33% closer to the metafrontier unlike bank S1 which is actually on the metafrontier (with TGR=1). In conclusion, when measured against the metafrontier, the order of *average* performance, from the highest performance to the lowest, is from domestic (ME=1.15) to state (ME=1.21) to foreign (ME=1.73) banks. The average ME result is not surprising because two of the domestic banks are located on the metafrontier and hence their GE=ME; only one state bank is on metafrontier and none of the foreign banks is on the metafrontier. The results also coincide with the average TGRs which increases from 1.01 for domestic banks to 1.07 for state banks and finally to 1.53 for foreign banks. In this output-oriented efficiency score which is greater or equal to 1, as the TGR rises, the gap between the group frontier and the metafrontier widens (2007).

In the literature, there have been extensions to the metafrontier approach. For instance, Oh and Lee (2010) proposed a metafrontier Malmquist index which accounts for group heterogeneity based on the global Malmquist index of Pastor and Lovell (2005).

5.10 The Global Malmquist and the Global Frontier Shift

The Global Frontier Shift/Difference (GFS/GFD) is a component of the Global Malmquist index developed by Asmild and Tam (2007) for drawing conclusions about productivity changes, particularly frontier shifts for an entire sample of DMUs instead of individual DMUs. The commonly used Malmquist index of CCD (1982) generate indices such as frontier shift for each individual DMU. To conclude about productivity changes for the entire sample, these individual indices are usually aggregated using weighted or unweighted means and interpreted in a number of empirical studies as the frontier shift for the entire sample of DMUs. The GM or more specifically, the GFS or global technological change component of the GM can directly measure overall changes.

Asmild and Tam (2007) indicated 4 merits of the GFS:

- The GFS generate better estimates of the mean distance between two frontiers than the conventional aggregation possibly due to the additional observations incorporated in the aggregation. This is especially so for sparsely populated data sets and for frontiers that change shape over time.
- The global indices can be measured even when the observed DMUs in each period are different without disregarding information by only including the matched pairs in the analysis.
- The GFS can be measured irrespective of whether the difference between frontiers is related to time-periods or group. Unbalanced panels as well as balanced panels can also be used.

- Unlike the Malmquist index of FGNZ (1994c), the global Malmquist and its component, the global frontier shift better estimate the true underlying frontier shift.

Unfortunately, a drawback of the global indices is that they are computed from all sample observations in every time period and thus are sensitive to including extra observations (either being additional DMUs or more time periods) to the data set. For instance, adding new data or time periods could move the frontier and may thereby affect the computational findings.

The GFS approach recognizes that the frontier shift component of the standard Malmquist index is specific to the observed units being assessed, since it is the geometric mean of the technical change observed by this particular unit at time t and at time $t+i$. Nevertheless, a frontier shift can be thought of as being a global phenomenon and most applied studies report and explain the average of the individual frontier shifts as the technological change for the total sample of DMUs (Asmild and Tam, 2007).

Asmild and Tam (2007) defined the global Malmquist index and decomposed it into global efficiency change and global frontier shift. To explain these indices, consider $j = 1, 2, ..., n$ DMUs observed in z periods $t = 1, ..., z$. The DMUs in a given time period use m inputs, $x_j \in \Re_+^m$ to produce s outputs, $y_j \in \Re_+^s$. Hence, the input and output matrices in each time period, X^t and Y^t are of dimension $m \times n$ and $s \times n$ respectively. Let $\overline{X}$ and $\overline{Y}$ be the vectors of the input X^t and output Y^t matrices. The output-oriented technology index number for each period is defined as:

$$\mathrm{TI}^{t}\left(\overline{X},\overline{Y}\right)=\left(\prod_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t}\left(x_j^{\tau},y_j^{\tau}\right)\right)^{1/(n\times z)} \tag{25}$$

where τ captures all DMUs in the data set in all time periods. For instance, for z=1 τ will capture all periods 1, 2 and 3 even when the frontier shift being estimated is that between periods 1 and 2. Equation (25) is the geometric mean of the efficiency scores of all DMUs in the data set in all periods measured relative to period *t* frontier. Similarly, the geometric mean of the efficiency scores for all DMUs from all time periods relative to period *t+i* frontier technology is TI^{t+i}. The mean distance between the *t* and *t+i* frontiers, or the global frontier shift (GFS) between them, is thus given by:

$$\mathrm{GFS}\left(t,t+i;\overline{X},\overline{Y}\right)=\frac{\mathrm{TI}^{t+i}\left(\overline{X},\overline{Y}\right)}{\mathrm{TI}^{t}\left(\overline{X},\overline{Y}\right)}=\left(\frac{\prod_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t+i}\left(x_j^{\tau},y_j^{\tau}\right)}{\prod_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t}\left(x_j^{\tau},y_j^{\tau}\right)}\right)^{1/(n\times z)} \tag{26}$$

GFS>1 implies that the frontier, on average, has improved from period *t* to period *t+i*. Nonetheless, a global improvement does not necessarily mean that all sections of the frontier have improved since the period-specific frontiers can intersect. Individually observed frontier shifts will differ because the frontiers are likely not to be parallel. This phenomenon is further discussed in the next section. Computing the GFS is different from computing the traditional frontier shift, which only utilizes data from two, typically adjacent, periods at a time. But the GFS utilizes all the observations from all periods to estimate the mean distance between two frontiers. Therefore, the global frontier shift index provides a better estimate of the true overall frontier shift than the traditional frontier index, since the GFS uses more data points (at least if there are more than two time periods) than the geometric mean of the individual shifts. This is especially so for sparsely populated data sets where including extra data points in the computation have a greater effect on accuracy. The global efficiency change index, GEC between periods t and $t+i$ is defined as (2007):

$$\mathrm{GEC}\left(t,t+i;(X^{t},Y^{t}),(X^{t+i},Y^{t+i})\right)=\prod_{j=1,\dots,n}\left[\frac{\phi^{t}\left(x_{j}^{t},y_{j}^{t}\right)}{\phi^{t+i}\left(x_{j}^{t+i},y_{j}^{t+i}\right)}\right]^{1/(n)} \tag{27}$$

GEC is the geometric mean of the individual efficiency changes or catching up component, between periods t and $t+i$ for all the n observations within the sample. It measures on the average, ability of DMUs to increase, decrease or stabilize efficiency between the two periods given the existing technology. Accordingly, a value of GEC >1 indicates average improvement in the efficiency. GEC<1 indicates average deterioration in efficiency from periods t to $t+i$. Finally, the adjacent global Malmquist productivity change index, GM is defined as:

$$\mathrm{GM}\left(t,t+i;\overline{X},\overline{Y}\right)=\prod_{j=1,\dots,n}\left[\frac{\phi^{t}\left(x_{j}^{t},y_{j}^{t}\right)}{\phi^{t+i}\left(x_{j}^{t+i},y_{j}^{t+i}\right)}\right]^{1/(n)}\times\left(\frac{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t+i}\left(x_{j}^{\tau},y_{j}^{\tau}\right)}{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t}\left(x_{j}^{\tau},y_{j}^{\tau}\right)}\right)^{1/(n\times z)} \tag{28}$$

This thesis adapts the GFS or preferably, the global frontier difference (GFD) in order to measure the frontier differences between Ghanaian banking groups. Recall the definition of the target DMU j $(j=1,\dots,n)$ observed among n DMUs. Assume the n observations each belong to one of two groups $\left(g^{1},g^{2}\right)$, which contain n^{1} and n^{2} observations respectively such that $n=n^{1}+n^{2}$ since the groups are mutually exclusive in each analysis. The observations will be sorted such that g^{1} contains the observations $n^{1}=1,\dots,n^{1}$ and g^{2}

contains the remaining observations $n^2 = n^1+1,...,n$. This implies that n^1 is the number of observations in group one $\left(g^1\right)$, n^2 is the number of observations in group two $\left(g^2\right)$, n is the total number of observations and g captures each of the G groups. The GFD is computed between two groups at a time, say, g^1 and g^2. Note that the 2 groups, g^1 and g^2 can be domestic and foreign banks, or universal and focus banks etc. Although, each analysis only considers the case of two groups, the analysis could be done with more groups such as in the case of state, domestic and foreign banks where G=3.

The technology index number, TI for group 1 is given by:

$$\mathrm{TI}^{g^1} = \left(\prod_{\substack{j=1,...n^1 \\ g=1,...,G}} \phi^{g^1}\left(x_j^g, y_j^g\right) \right)^{1/n} \tag{29a}$$

where $x_{j\in g}$ and $y_{j\in g}$. Equation 29a measures the efficiency of all units in all groups $\left(x_j^g, y_j^g\right)$ relative to the group one, g^1 frontier; indeed, some of the units will not be in group one and may therefore be located outside the group one frontier, thereby having output-oriented super-efficiency scores of less than 1. The technology index number for group 2 is given by:

$$\mathrm{TI}^{g^2} = \left(\prod_{\substack{j=1,...n^2 \\ g=1,...,G}} \phi^{g^2}\left(x_j^g, y_j^g\right) \right)^{1/n} \tag{29b}$$

Accordingly, the GFD between the two groups, g^1 and g^2 is:

$$\text{GFD}\left(g^1, g^2\right) = \frac{\text{TI}^{g^2}}{\text{TI}^{g^1}} = \frac{\left(\prod_{\substack{j=1,\dots n^1 \\ g=1,\dots,G}} \phi^{g^1}\left(x_j^g, y_j^g\right)\right)^{1/n}}{\left(\prod_{\substack{j=1,\dots n^2 \\ g=1,\dots,G}} \phi^{g^2}\left(x_j^g, y_j^g\right)\right)^{1/n}} \tag{30}$$

The GFD>1 indicates that group 2 frontier is, on average, better than the group 1 frontier. This implies that the geometric mean of the output-oriented efficiency of all units estimated against the group 2 frontier is higher (i.e. relatively worse efficiencies) than the geometric mean of the efficiency of all units relative to the group 1 frontier (i.e. relatively better efficiencies). Hence, the ratio of the technology index of group 2 (numerator) to that of group 1 (denominator) will generate a GFD>1, indicating that the group 2 frontier on average outperforms the group 1 frontier. Conversely, if that GFD<1, it will imply that the group 2 frontier is on average worse than the group 1 frontier. GFD=1 will mean the frontiers of the two groups are, on average, equal in performance.

Figure 5.10 illustrates the GFD approach. When computing the GFD using the figure, ignore the metafrontier curve S'S1D3D2D and consider only the other three group frontiers. The GFD is calculated between two groups, say, between the frontiers of state banks and foreign banks. To compute this particular example, first, estimate efficiency of all 12 banks against each banking group's frontier. Second, take the geometric mean of all the scores in each group. Finally, evaluate the ratio of the geometric means. The complete results are displayed in Table 5.1.

Table 5.1 The GFD results

DMU	TI^{g^S}	TI^{g^D}	TI^{g^F}
S1	1.00	0.86	0.57
S2	1.54	1.60	1.07
S3	1.00	1.07	0.69
S4	1.00	1.13	0.74
D1	1.00	1.00	0.67
D2	0.86	1.00	0.66
D3	0.88	1.00	0.62
D4	1.36	1.55	0.97
F1	2.22	2.29	1.55
F2	1.67	1.50	1.00
F3	1.43	1.45	1.00
F4	1.20	1.40	1.00
Geometric mean	**1.21**	**1.27**	**0.84**
	TI^{g^D}/TI^{g^S}	TI^{g^D}/TI^{g^F}	TI^{g^S}/TI^{g^F}
GFD	**1.05**	**1.51**	**1.44**

Columns 2 to 4 show the technology indices (TI) of state TI^{g^S}, domestic TI^{g^D} and foreign TI^{g^F} banks respectively. For instance, TI^{g^S} measures the mean efficiency scores of all 12 banks relative to the state technology frontier. The “Geometric mean” row represents the geometric means of the three technology indices. For instance, the geometric mean of the efficiency scores of all 12 banks measured against the domestic frontier equals 1.27. The last two rows are important; specifically, the last row shows the GF between the domestic and state banking frontiers, between the domestic and foreign banking frontiers, and between the state and foreign banking frontiers. The GFD between the domestic banks’ frontier and the state bank’s frontier is 1.27/1.21 = 1.05 which depicts worse average efficiency (worse output expansion factors) for the domestic frontier than the state frontier. This is not surprising because part of the domestic frontier envelopes the state frontier more than part of the state frontier envelopes the domestic frontier. Hence, the domestic frontier is on average 5% better than the state frontier. Similarly, the GFD of 1.51 between domestic and foreign frontiers indicates that the best-practice domestic banks are on average 51% better than the best-practice foreign banks. And the GFD between the state frontier and the foreign frontier is 1.21/0.84 = 1.44 implying that the best-performing state banks are on average 44% better than the best-performing foreign banks.

The section concludes, noting that, similar to the GFD, the metafrontier analysis considers group differences, with or without balanced panel data. However, the metafrontier analysis is different from the GFD approach because the efficiency of individual observations is not measured relative to the GFD whereas efficiency of individual observations is measured relative to the metafrontier. In both the GFD and the metafrontier analysis, DMUs' efficiencies are measured relative to the group-specific frontiers. But, there is a difference here too; when calculating the group efficiency scores under the metafrontier analysis, the efficiency of *only* firms in *one* group are measured relative to that group-specific frontier. Under the GFD approach, it is the efficiency of *all* firms in *all* groups measured relative to one group-specific frontier. Note also that the global Malmquist index of Asmild and Tam (2007) is different from the "global Malmquist" index proposed by Pastor and Lovell (2005) which is actually based on the metafrontier. In other words, the global Malmquist index of Pastor and Lovell (2005) use the data of all DMUs in all periods of the sample to construct a single global frontier. As there is just one global benchmark technology, there is no need to compute the geometric mean. This makes the global Malmquist index of Pastor and Lovell (2005) transitive/circular since there is only one single technology (Pastor et al., 2011). The global Malmquist of Pastor and Lovell (2005) is also immune to LP infeasibilities when estimating mixed-period efficiency scores.

Nevertheless, adding a new time period to the data set requires a recalculation of the global Malmquist index of Pastor and Lovell (2005) (and also the GFD), an outcome of which is that the new observation from another period manipulates the measurement of productivity change between the two periods. In short, the global Malmquist index of Pastor and Lovell (2005) does not maintain previous productivity change computations after including additional time periods, what Pastor et al. (2011) called a sort of "relevance of irrelevant alternatives" property.

5.11 The Favourability and the Favourability Change Indices

The global Malmquist index, particularly, the global frontier shift, GFS discussed above is helpful for drawing conclusions about productivity changes of an entire population as it indicates whether or not the frontier on average improves from one time period to another. The GFS provides a better estimation of the true frontier shift "especially for sparsely populated data set and for frontiers that change shape over time" compared with the frontier shift of the traditional Malmquist productivity change index (Asmild and Tam, 2007, p. 137).

A potentially important issue is that GFS measures the frontier shift of an entire population of DMUs but not the local shift experienced by individual DMUs. That being the case and following Asmild and Tam (2005), this section proposes a further decomposition of the traditional adjacent Malmquist index into technical efficiency change, GFS, local favourability index and local favourability change components. The components have potentially interesting policy implications, which are demonstrated using the empirical data on Ghanaian banks.

Specifically, the decomposition separates the GFS from variations attributable to favourability and favourability changes. This is interesting because through these components, the true sources of the Malmquist productivity change index could be ascertained. That is, since the GFS is the same for each DMU, it may be informative to know the favourability locations of individual DMUs by virtue of their different group characteristics. The difference from the GFS observed by individual DMUs may be due to non-parallel technology frontiers reflecting the existence of non-Hicks-neutral frontier shifts. The concept of the favourability and the favourability change components are now explained. A novel application of the model is deployed in chapter 8 to a sample of banks and banking subgroups in Ghana.

5.11.1 Decomposing the Traditional Adjacent Malmquist Index

When considering time differences rather than group differences, the GFS indicates whether the frontier on average improves from one period to another. Nevertheless, average improvement over time does not automatically imply that all parts of the frontier are improving. This is because the frontier shifts of a DMU may be different from the average shift. The favourability index concerns whether the local frontier shifts observed by individual DMUs are larger or smaller than the global frontier shift (GFS). An individual unit can undergo a (local) change that is below or above the global change. If the local change were above the global change, then that would be said to be in a favourable location in the PPS whereby the improvement potential exceeds the average and vice-versa (Asmild and Tam, 2005). Define the output-oriented local favourability index for the (location of the) observed unit $\left(x^t, y^t\right)$ when the frontier moves from period t to t+i as[20]:

$$F^{t,t+i}\left(x^t, y^t; \overline{X}, \overline{Y}\right) = \left(\frac{\phi^{t+i}\left(x^t, y^t\right)}{\phi^t\left(x^t, y^t\right) \mathrm{GFS}\left(t, t+i; \overline{X}, \overline{Y}\right)} \right) \tag{31}$$

where GFS is the global frontier shift; $\phi^{t+i}\left(x^t, y^t\right) >=< 1$ is the output-oriented efficiency score of the target DMU in period *t* measured relative to period *t* frontier and $\phi^{t+i}\left(x^t, y^t\right) >=< 1$ is the output-oriented efficiency score of the same DMU in period *t* but measured relative to period *t+i* frontier. If $F^{t,t+i}\left(x^t, y^t; \overline{X}, \overline{Y}\right)$ is greater than 1, it means that the location of the DMU at time *t* is favourable in the sense that the technological progress in that location is higher than average.

The change in favourability that the DMU gains by moving from its location in period *t* to the new location in period *t+i* is given by:

$$\left(\frac{F^{t,t+i}\left(x^{t+i}, y^{t+i}; \overline{X}, \overline{Y}\right)}{F^{t,t+i}\left(x^t, y^t; \overline{X}, \overline{Y}\right)} \right)^{1/2} = \left[\frac{\phi^{t+i}\left(x^{t+i}, y^{t+i}\right) \Big/ \left(\phi^t\left(x^{t+i}, y^{t+i}\right) \times \mathrm{GFS}\left(t, t+i; \overline{X}, \overline{Y}\right)\right)}{\phi^{t+i}\left(x^t, y^t\right) \Big/ \left(\phi^t\left(x^t, y^t\right) \times \mathrm{GFS}\left(t, t+i; \overline{X}, \overline{Y}\right)\right)} \right]^{1/2} \tag{32}$$

where the numerator is the favourability of the new location and the denominator is the favourability of the old location (defined in 31). The value of this ratio explains whether the DMU has moved to a more favourable location. These definitions mean that the output-oriented adjacent Malmquist index between periods t and $t+i$ can be decomposed as:

$$M\left(x^{t+i}, y^{t+i}, x^t, y^t\right) = \underbrace{\frac{\phi^t\left(x^t, y^t\right)}{\phi^{t+i}\left(x^{t+i}, y^{t+i}\right)}}_{\text{EC}} \times \underbrace{\left(\frac{\prod_{\substack{j=1,\ldots,n \\ \tau=1,\ldots,z}} \phi^{t+i}\left(x_j^\tau, y_j^\tau\right)}{\prod_{\substack{j=1,\ldots,n \\ \tau=1,\ldots,z}} \phi^t\left(x_j^\tau, y_j^\tau\right)}\right)^{\frac{1}{n\times z}}}_{\text{GFS}}$$

$$\times \underbrace{F^{t,t+i}\left(x^t, y^t; \overline{X}, \overline{Y}\right)}_{\text{FI}} \times \underbrace{\left(\frac{F^{t,t+i}\left(x^{t+i}, y^{t+i}; \overline{X}, \overline{Y}\right)}{F^{t,t+i}\left(x^t, y^t; \overline{X}, \overline{Y}\right)}\right)^{\frac{1}{2}}}_{\text{FCI}} \tag{33}$$

where the EC term is the popular efficiency change index defined in (21). The GFS is the global frontier shift or innovation defined in (26). The $F^{t,t+i}\left(x^t, y^t; \overline{X}, \overline{Y}\right)$ from expression (31) is the favourability index (FI) for the observed unit at time period t which point towards the favourability of the previous position of DMU$\left(x^t, y^t\right)$ and the final square root term (the ratio) from expression (32), measures the change in favourability (FCI) obtained by moving to the new location $\left(x^{t+i}, y^{t+i}\right)$ in the PPS. Observe that multiplying the FI and the FCI results in the geometric mean of the favourability of the old and of the new location (Asmild and Tam, 2005). The reader is referred to appendix 1 for a mathematical proof of proposition 1 that shows that the 'newly-decomposed' Malmquist productivity change index in equation (33) equals the traditional Malmquist productivity change index in equation (21) and hence the technical change component is equivalent to the product of the GFS, FI and FCI.

The elements of the favourability discussed in this section are associated with the notion of the bias of technical change (TC) component of the Malmquist index suggested by e.g. Färe et al. (1997a) and Lovell (2003), representing the deviation from the TC. That is, these indices reflect the actual contribution of technological change to productivity change. Färe et al. (1997a) decomposed the TC component of the Malmquist index into the product of a magnitude index (MI) or neutral component, an output bias index (OBI) and an input bias index (IBI). Their MI term estimates the magnitude of the technological change along a ray using data for period *t* (1997a). The OBI estimates the ratio of the magnitude of frontier shift along the ray through y^{t+i} relative to the magnitude of the frontier shift along the ray through y^t, keeping the level of inputs constant at x^{t+i} (Färe et al., 1997a). The IBI measures the geometric mean of the shift in the technology between periods *t* and *t+i* assessed at the period *t* input-output bundles and the technology shift observed at period *t+i* input levels given the output levels. Färe et al. (1997a) proposed that OBTC=1 implies output neutral TC while IBTC=1 implies input neutral TC. If they are both 1, i.e., OBTC*IBTC=1, then TC will equal the MI and the TC is then said to be Hicks-neutral (cf. Färe et al., 2008).

Like the input and output biases which measure the divergence from the technical change in the isoquant and the output possibility set respectively, the favourability and favourability change indices measure divergence from the global frontier shift and can therefore be decomposed into changes in the input subspace and changes in the output subspace (cf. Asmild and Tam, 2005). This is an interesting avenue for further research.

5.11.2 An Illustrative Example

To illustrate the GFS, FI and FCI in an output-oriented framework, consider a data set of 4 DMUs P, Q, R and S each observed in periods 1 and 2 as shown in Figure 5.11 with 2 outputs and a fixed input. The global frontier shift is illustrated by the dotted line. This line is for illustrative purposes only since it does not represent an actual frontier like frontier 1 or frontier 2. The GFS is just a number indicating the length of the mean frontier shift (Asmild and Tam, 2005). To estimate the components of the 'newly-decomposed' Malmquist index, particularly the GFS and the favourability and favourability change indices, the technology index for periods 1 and 2 will be computed. Let $\phi^1\left(Q^1\right)$ be the output-oriented efficiency score of DMU "Q" radially measured against frontier 1 and $\phi^2\left(Q^1\right)$ be the efficiency score of the same DMU "Q", but this time, measured relative to frontier 2. In the Figure, $\phi^1\left(Q^1\right)=1$ which is the same as ϕ^2 for Q^2 since both frontiers intersect at the data point $Q^1 = Q^2$.

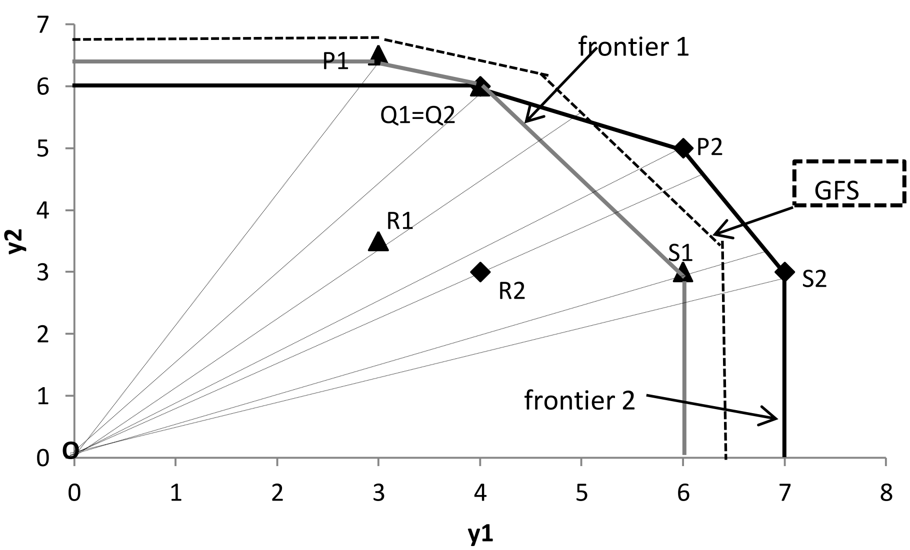

Figure 5.11 Local Favourability and Favourability Change Indices

Note that some observations are likely to be located outside some of the frontiers they are compared to, such as "P^2" is located outside frontier, 1 resulting in its super-efficiency score of $\phi^1(P^2) = 0.857$ when measured in relation to frontier 1. This is what might occur when estimating mixed-period DEA efficiency scores. The period 1 technology index (equation 25), representing the geometric mean of efficiency scores of all firms in all periods relative to frontier 1 is given by:

$$\begin{aligned} TI^1 &= \prod_{\substack{j=1,\dots,8 \\ \tau=1,2}} \phi^1\left(x_j^\tau, y_j^\tau\right) \\ &= \left[\phi^1\left(P^1\right)*\phi^1\left(P^2\right)*\phi^1\left(Q^1\right)*\phi^1\left(Q^2\right)*\phi^1\left(R^1\right)*\phi^1\left(R^2\right)*\phi^1\left(S^2\right)*\phi^1\left(S^2\right)\right]^{1/8} \\ &= \left[(1)*(1)*(1)*(1)*(1.5)*(1.33)(1)*(0.857)\right]^{1/8} = 1.05 \end{aligned}$$

The technology index for period 2 is also given by:

$$\begin{aligned} TI^2 &= \prod_{\substack{j=1,\dots,8 \\ \tau=1,2}} \phi^2\left(x_j^\tau, y_j^\tau\right) \\ &= \left[\phi^2\left(P^1\right)*\phi^2\left(P^2\right)*\phi^2\left(Q^1\right)*\phi^2\left(Q^2\right)*\phi^2\left(R^1\right)*\phi^2\left(R^2\right)*\phi^2\left(S^2\right)*\phi^2\left(S^2\right)\right]^{1/8} \\ &= \left[(0.923)*(1)*(1)*(1)*(1.6)*(1.55)(1.13)*(1)\right]^{1/8} = 1.13 \end{aligned}$$

Consequently, the GFS between frontiers 1 and 2 is given by:

$$\text{GFS} = \left(1, 2; \overline{X}, \overline{Y}\right) = \frac{\prod_{\substack{j=1,\dots,8 \\ \tau=1,2}} \phi^2\left(x_j^\tau, y_j^\tau\right)}{\prod_{\substack{j=1,\dots,8 \\ \tau=1,2}} \phi^1\left(x_j^\tau, y_j^\tau\right)} = 1.07$$

The GFS of 1.07 indicates that on average the frontier improves by moving 7% forward as indicated by the dotted line in the Figure. Therefore, observations generally have worse efficiencies (higher output expansion factors) relative to frontier 2 (with a mean of 13%

improvement potential) than when compared with frontier 1 (with a mean of 5% improvement potential). Nonetheless, from the graph, the frontier shift is not Hicks-neutral[21] or parallel because observations Q^1 and Q^2 are positioned where the frontier shift is less than the average. Observations P^1, R^1 and S^1 are located around the average frontier shift (with S^1 being slightly above average and R^1 slightly below average) whilst P^2, R^2 and S^2 are located where the frontier shift is larger than the average. Since the frontiers are not parallel and some of the observations can experience a higher or lower than average frontier shift, we can determine the local favourability and favourability changes for individual observations. The local favourability index (equation 32) for observation Q^1 for a change from period 1 to 2 is computed as:

$$F^{1,2}\left(Q^1;\overline{X},\overline{Y}\right)=\left(\frac{\phi^2\left(Q^1\right)}{\phi^1\left(Q^1\right)*\mathrm{GFS}\left(1,2;\overline{X},\overline{Y}\right)}\right)=\left(\frac{1}{1*1.07}\right)=0.932$$

The value of 93.2% indicates that Q^1 is located in an unfavourable position where the technological progress is about 7% less than the mean. This is the same for Q^2. Consequently, the favourability change obtained by "moving" from Q^1 to Q^2 is given by:

$$\frac{F^{1,2}\left(Q^2;\overline{X},\overline{Y}\right)}{F^{1,2}\left(Q^1;\overline{X},\overline{Y}\right)}=\frac{0.932}{0.932}=1$$

which supports the fact that the favourability does not change when no move occurs. From Q^1 or Q^2 perspective, the frontier has not changed at all resulting in a FCI of 1; both Q^1 and Q^2 are efficient relative to both frontiers. Therefore, the 'newly-decomposed' Malmquist productivity change index for DMU "Q" between time periods 1 and 2 (which equals 1) can be decomposed into a neutral catching up (EC=1), a positive GFS of 1.07, a negative local favourability index $\left[F^{1,2}\left(Q^1;\overline{X},\overline{Y}\right)=0.932\right]$ and a neutral favourability change given by $F^{1,2}\left(Q^2;\overline{X},\overline{Y}\right)/F^{1,2}\left(Q^1;\overline{X},\overline{Y}\right)=1$.

Table 5.2 presents the results of the elements of equation (33) for the 4 DMUs. From Figure 5.11, we can see that the radial output-oriented efficiency score of S^1 measured relative to frontier 1 is 1.00 and its output efficiency relative to frontier 2 is 1.13. Therefore, from S^1's standpoint the frontier has improved by 1.13/1.00 = 1.13. The frontier improvement observed by S^1 is bigger than the mean shift of 1.07 resulting in a favourability > 1, specifically 1.13/1.07=1.06 as shown in the table. From P^2's or S^2's position, the frontier has improved by 1.00/0.86=1.17 leading to the biggest favourability >1 of 1.09. P^2 also shows the biggest favourability change index equal to 1.12.

From the figure, R^1 and R^2 are inefficient relative to both frontiers 1 and 2 and they observe frontier shift equal to and greater than the mean shift respectively whereas $Q^1$and Q^2 are efficient relative to both frontiers 1 and 2 and observe frontier shifts less that the mean. Hence, the favourability observed by a unit has nothing to do with whether or not it is efficient. Notice that both Q^1 and Q^2 have the same negative favourability index indicating that they are in unfavourable locations in the output possibility set in the sense that they are located where there is less than average technological change. Even though the frontier on average is shifting over time they might not have been able to capitalize on that.

Table 5.2 Results of the new decomposed Malmquist index

	P	***Q***	***R***	***S***
Efficiency Change	1.00	1.00	0.97	1.00
Technical Change	1.04	1.00	1.11	1.15
Malmquist index	1.04	1.00	1.08	1.15
Global frontier shift	1.07	1.07	1.07	1.07
Old favourability	0.86	0.93	0.99	1.06
New favourability	1.09	0.93	1.08	1.09
Favourability Change	1.12	1.00	1.04	1.01

5.12 Nonparametric Kernel Density Estimation (KDE)

In the empirical section of this study, the distribution of efficiency scores will be analyzed using nonparametric KDE. The approach complements the DEA technique since they are both nonparametric. In the first instance, efficiency scores are measured using DEA; in the second instance, nonparametric regression or KDE are used as suggested by Tortosa-Ausina (2002a). The analysis is related to that of Deaton (1989) who employed nonparametric regression and bivariate KDE to investigate the association between the price of rice and income distribution in Thailand. The use of this approach is gathering momentum in DEA efficiency analysis (see Tortosa-Ausina, 2002a, 2004; Balaguer-Coll et al., 2007; Kravtsova, 2008; Illueca et al., 2009; Kenjegalieva et al., 2009a; Glass et al., 2010). Regarding the importance of these approaches, Quah (1997) and Kumar and Russell (2002) noted that they may reveal more information than simply considering the mean or standard deviation. Koenker (2002) discussed the relevance and the interesting aspect of "this form of semiparametric statistical method" drawing on the contributions of Galton, Edgeworth and Frisch. Koenker (2000) argued that "there is more to econometric life than can be captured by the philosophy of the Gaussian location shift" (Koenker, 2000, p. 353). Koenker (2000) claimed that the analysis complements the statistical relationship between variables and supports the quantile regression approach that is also employed in this study. The nonparametric KDE is a smoothed histogram of the observed efficiency estimates. Histogram has historically been used to illustrate the density of data. Other examples of nonparametric regression estimations employ orthogonal series, naïve estimator or penalized maximum likelihood estimators (Tortosa-Ausina, 2002a). But most of them do not always smooth the data properly like the kernel estimator (Tortosa-Ausina, 2002a). Following Tortosa-Ausina (2002a), the following density function is estimated:

$$\hat{f}_K(x) = \frac{1}{nh}\sum_{i=1}^{I} K\left(\frac{x-\phi^*}{h}\right) \tag{34}$$

where n is the number of sample observations, x is the point of evaluation, i.e. x specifies the number of points at which the density estimate is to be evaluated. ϕ^* is the estimated efficiency score for each DMU. h is the kernel bandwidth or the smoothing parameter which controls the smoothness of ϕ^* (Tortosa-Ausina, 2002a). K is the kernel function that satisfies $\int_{-\infty}^{+\infty} K(t)dt = 1$. There are different kernel functions that can be selected - triangular, rectangular, epanechnikov, biweight etc. For simplicity, the analysis follows others (Tortosa-Ausina, 2002a; Balaguer-Coll et al., 2007) and uses the Gaussian kernel, which is expressed in the univariate situation as:

$$K(t) = \frac{1}{\sqrt{2\pi}} e^{-u^2/2} \tag{35}$$

The kernel estimate sets a probability mass with the size of $1/n$ in the shape of the kernel, which is then scaled by h, and centred on each data point (Tortosa-Ausina, 2002a). However, the kernel ignores the fact that efficiency scores are truncated from below at a lower bound of 1 and that some of the scores can be 1, which can cause a false mass at 1. To handle this issue, the study uses the Silverman's (1986) reflection method . The choice of h is important because it can drive how many values are included in estimating the density at each point (see StataCorp, 2009). If the h is too small, it will result in sinuous curve or bumps and if it is too big, it will smooth away main features of the data. In order to get round the problem of bias towards boundaries of bounded support, the study follows Tortosa-Ausina et al. (2008) and use Silverman's (1986) reflection method to generate densities for the efficiency scores that ranges between 0 and 1 making the upper bounds in the corresponding confidence intervals to always ≤ 1. That is, Silverman's (1986) estimator approaches the boundary problem by "reflecting" the data at the frontiers (Silverman, 1992). It is the "optimal" automatic width used in Stata (see StataCorp, 2009).

5.13 Empirical Banking Efficiency and Productivity Studies

This section reassesses the banking efficiency and productivity evaluation literature. The review will examine the key applications and results of frontier techniques, particularly DEA, for analyzing bank performance in different countries. More importantly, the section reviews the applied frontier studies that investigate the relationship between performance and such bank-specific environmental factors as bank ownership, specialization and capitalization. The gathered information will help to answer the research questions, analyse the empirical chapters of the study, and discuss the pertinent findings relative to earlier studies.

The banking efficiency literature begun with Benston (1965). That of DEA applied to depository financial institutions has been growing since the eighties[22]. Specifically, the first application of DEA was by Sherman and Gold (1985) to 14 U.S. bank branches. Since then, banking efficiency studies has thrived. Most efficiency studies deal with developed countries. For example, banking efficiency studies exist for US (Seiford and Zhu, 1999b; Mukherjee et al., 2001; Wheelock and Wilson, 2009), Australia (Sturm and Williams, 2010), Canada (Stanton, 2002) and New Zealand (Avkiran, 2009b). There are also a number of bank efficiency surveys in Europe (Goddard et al., 2001; 2007; Pasiouras, 2008b). Among the European nations studied are Spain (García-Cestona and Surroca, 2008), Italy (Girardone et al., 2004), Switzerland (Rime and Stiroh, 2003), Germany (Behr, 2010), Greece (Pasiouras, 2008a), Sweden (Bergendahl and Lindblom, 2008) and 13 EU countries (Brissimis et al., 2010). Similarly, there are some bank efficiency studies in transition economies including Hungary (Hasan and Marton, 2003a), Poland (Havrylchyk, 2006), 10 new EU states (Mamatzakis et al., 2008), 15 East European countries (Fries and Taci, 2005), 17 transition economies (Grigorian and Manole, 2006), 12 Central and Eastern European countries (Yildirim and Philippatos, 2007), 13 Eastern European nations (Kenjegalieva et al., 2009a) and 10 newly acceded EU countries (Delis and Papanikolaou, 2009). Compared with developed countries, there are fewer but a growing number of banking efficiency studies on emerging economies. These include Indonesia, Korea, Malaysia, Philippines, and Thailand (Williams and Nguyen, 2005), China (Berger et al., 2009), Singapore (Sufian, 2007), Malaysia (Sufian, 2009), Japan (Fukuyama and Weber, 2009), Hong Kong (Drake et al., 2006), Taiwan (Chiu et al., 2009), Pakistan (Bonaccorsi di Patti and Hardy, 2005), 6 Gulf cooperation council countries (Srairi, 2010), Brazil (Staub et al., 2010), 16 Latin American countries (Carvallo and Kasman, 2005) and 20 Latin American nations (Figueira et al., 2009).

Berger (2007), building on the earlier comprehensive international survey of Berger and Humphrey (1997) on efficiency of depository financial institutions, recognized few banking efficiency studies on Africa. Berger's (2007) survey, however, concentrated on applied studies that provide international comparisons of bank efficiency. The survey by Berger and Humphrey (1997) covered 130 studies in 21 countries and included 41 DEA applications. Only two of the single-nation efficiency studies surveyed were from Africa, namely Tunisia (Chaffai, 1994, 1997). Berger and Humphrey (1997) suggested the need for more studies to estimate and compare bank efficiencies from different economies. Moreover, Fethi and Pasiouras (2010) reviewed 196 DEA and DEA-like bank efficiency studies published between 1998 and early 2009. However, more than 75% of the studies surveyed by Fethi and Pasiouras (2010) focused on efficiency and productivity issues of banks in developed countries. More recently, Paradi et al. (2011) provided a survey of 162 DEA applications to banks and 63 applications to bank branches, from 1997 to 2010 and covering 43 countries. The existing surveys in the literature indicate a shortfall of studies on African economies possibly due to the difficulty in obtaining reliable and comprehensive data. The present study fills the literature gap in a unique way through primary data collection on Ghanaian banks. It can also be observed that the detail review of the banking efficiency studies, in a table format, in appendix 2 excluded CSR as either an output or an input. This omission is addressed in the present study. The table in appendix 2 provides a survey of the efficiency studies applied to depository financial institutions and/or their branches in the literature. The survey focuses on studies after 1997 (unless for illustrative purposes) as a way of building on the earlier banking international survey of Berger and Humphrey (1997). The table contains information about author(s), the year the paper was published, the frontier technique used (and if it is DEA, the returns to scale adopted), the type of efficiency measure, the efficiency score, the inputs and outputs chosen, the type of banking modelling specification selected, the orientation type, the number of observations, country and sample period. Most of the rest of the contents should be self-explanatory to the reader.

5.13.1 Evidence on Bank Efficiency in Africa

There are comparatively few single-nation banking efficiency studies conducted into the efficiency of African banking systems. Hauner and Peiris (2008) investigated the effect of banking sector reforms on efficiency, measured by DEA, and on competition, measured by Panzar and Rosse’s (1987) model, for 14 Ugandan banks from 1999 to 2004 using quarterly data. They found that competition has significantly risen and has been associated with a rise in efficiency. Okeahalam (2006) evaluated the productive efficiency of 61 bank branches in South Africa using Bayesian SFA and found every bank operating at increasing returns to scale. Ayadi and Hyman (2006) assessed the performance of 10 Nigerian banks using DEA and discovered poor bank management over the period 1991-1994. None of these studies included CSR to determine its potential importance. Besides the single-nation banking efficiency studies in Africa, there have been few inter-country studies recently. Possibly, the first cross-country banking efficiency study on Sub-Saharan African, SSA is by Chen (2009). He used SFA to study 71 banks in 10 SSA middle-income countries and found that banks could save about 20%–30% of their total costs if they were to operate efficiently. However, his study neither included Ghana nor used DEA. Kablan (2010), in contrast, analyzed the cost efficiency of 137 banks in 29 SSA countries, including Ghana, using SFA. He found the average cost efficiency to be 70%. But, both cross-country studies did not consider the relevance or otherwise of CSR, a literature gap pursued in the present study.

5.13.2 Efficiency and regulatory Policies

Most of the frontier efficiency techniques have been applied to depository financial institutions to evaluate the association of performance with observable attributes of banks and to address regulatory policy issues. These exogenous and regulatory factors include studies that investigate the effect of off-balance sheet activities on efficiency (Pasiouras, 2008a), financial institutional failure (Demyanyk and Hasan, 2010), bank consolidation (Wheelock and Wilson, 2004), effects of mergers on bank efficiency (Hahn, 2007) and impact of financial deregulation on performance (Denizer et al., 2007). Others are the link between competition and efficiency (Hauner and Peiris, 2008), relation between financial reforms and efficiency (Zhao et al., 2010), linkage between financial integration and efficiency (Casu and Girardone, 2010), impact of risk on bank efficiency (Hughes, 1999; Koetter, 2008). Finally, we have the relationship between management quality and efficiency (DeYoung, 1998), impact of financial crisis on bank efficiency (Sufian, 2009), and bank branch efficiency (Portela and Thanassoulis, 2007a). The following subsections summarises the general conclusions from studies that explore the link between performance and bank ownership, specialisation and capitalisation. The information will help to answer the research questions 3, 4 and 5 posed at the introductory chapter.

5.13.3 Evidence on Bank Efficiency and Ownership Type

Concerning the purpose of banking efficiency studies, many examined the ownership effect on performance to compare the different bank ownership types – state, domestic and foreign. The available studies reported inconsistent findings. For emerging economies, most widespread findings are that, typically, foreign banks are the most efficient, followed by private-domestic banks and finally, state banks. For example, foreign banks were found outperforming domestic banks in Uganda (Hauner and Peiris, 2008), Malaysia (Sufian, 2009), Argentina (Berger et al., 2005), China (Berger et al., 2009), Ukraine (Kyj and Isik, 2008), Romania (Asaftei and Kumbhakar, 2008), Kyrgyzstan (Brown et al., 2009) and cross-countries including 17 transition countries (Grigorian and Manole, 2006), 28 developing economies (Berger et al., 2004), 70 countries (Chen and Liao, 2011) and 107 countries (Barth et al., 2004). It is argued that the penetration of foreign banks helps to generate better financial services, increase banking competition and concentration and generally creates a favourable atmosphere wherein the whole banking sector is driven directly or indirectly towards efficiency. Specifically, using DEA on 52 banks in Poland over the 1997-2001 period, Havrylchyk (2006) found foreign-greenfield banks (that have been created as new entities) to be more efficient than domestic banks while foreign takeover banks (that acquired domestic institutions) had not improved their efficiency.

Micco et al. (2007) noticed that state-owned banks operating in the developing countries over the 1995-2002 period were inclined to suffer lower profitability and higher overhead costs than privately-owned banks.

But the trend is different in developed economies. Claessens et al. (2001) examined the performance differences between foreign and domestic banks in 80 countries during 1988-1995. They found foreign banks to have higher profits than domestic banks in developing economies while the opposite was true in developed economies. It was argued that branch expansion of foreign banks and the competition they brought into the industry could have positively affected the banking sector. Unfortunately, the study by Claessens et al. (2001) neither included Ghana nor considered CSR. Besides, Claessens et al. (2001) employed accounting ratios with weighted least squares regression but not frontier techniques. Even the 92 countries study by La Porta et al. (2002) neither included Ghana nor considered CSR. Regardless, the general conclusion from the comparison studies is the same; that private institutions are more technical-cost-and-profit-efficient than state institutions. The reason is attributable to the *principal-agent theory* and *public choice theory* (Clarke et al., 2003; Figueira et al., 2009). The *principal-agent theory* concerns how a principal designs incentive schemes for the agents. Without capital market discipline, owners' influence over management breaks down because the latter are permitted to pursue their own agenda. Under this theory, private firms' managers encounter better incentives to pursue profit-maximization schemes than state firms' managers since the private capital markets scrutinizes the performance of private managers more than public managers (Boycko et al., 1996; Ohlsson, 2003). Under the *public choice theory*, government ministers and civil servants pursue vote and budget maximization objectives that may result in inefficiency (Shleifer and Vishny, 1997; Otchere and Chan, 2003).

Some studies on the X-efficiency of US banks usually find domestic US banks to be more efficient than foreign banks (Deyoung and Nolle, 1996; Berger et al., 2005). Berger (2007) argued that the advantage of domestic banks in US is that, they serve multinational corporations and customers by establishing offices where their home-country customers have foreign affiliates. They may also diversify risk, penetrate capital markets and have the competence to provide some services to multinational clients (Berger et al., 2005).

So, why are foreign banks in developed countries generally *less* efficient than the host-country banks? It is argued that foreign banks in U.S. trade both cost and profit efficiencies for rapid expansion of market share as they finance their rapid growth by relying on purchased funds, which are more costly than core deposits (Sufian, 2011). In answer to the above question, Berger et al. (2000b) developed and tested two alternative hypotheses to explain the performance differences: the home field advantage hypothesis and the global advantage hypothesis. The *home field advantage hypothesis* predicts that foreign banks underperform their domestic peers due to: (i) difficulty in monitoring banks from a distance, (ii) supervisory and regulatory differences and (iii) differences in language, culture, currency, other country-specific market features, bias against foreign institutions, or other explicit or implicit barriers (Berger et al., 2000b). Under the *global advantage hypothesis,* foreign banks can rise above cross-border hurdles and benefit from competitive advantage compared with domestic banks. This is possible by (i) spreading their best-practice policies (ii) utilising more advanced technologies and (iii) recruiting highly educated manpower that can adapt to these technologies to provide quality services and obtain diversification of risks that allow them to undertake higher-risk investments with higher expected returns (Berger et al., 2000b). Note however that the underperformance of foreign banks in domestic developed countries is common to U.S. but not in every developed country. For instance, Sturm and Williams (2004), using parametric and nonparametric approaches during 1988-2001, reported that foreign banks were more efficient than domestic Australian banks. Vennet (1996) similarly observed no performance differences between foreign and domestic banks in the EU. And Berger et al. (2000b) reported that foreign (US) banks were more efficient than domestic banks in three of the five developed nations (France, Germany, Spain, the United Kingdom, and the US) they examined, leading to a rejection of the global advantage hypothesis.

When state banks were included in the comparative analysis, several studies found them to be underperforming other banks. For example, Ariff and Can (2008) observed for 28 Chinese banks during 1995-2004 that joint-stock banks (national and city-based), on average, appeared to be more cost-and-profit-efficient than state banks. Iannotta et al. (2007) studied 181 large banks in 15 European nations during 1999–2004 and found that government-owned banks displayed lower profitability than privately-owned banks. The reader is also referred to studies in United Arab Emirates (Al Shamsi et al., 2009), Taiwan (Chen, 1998), Spain (García-Cestona and Surroca, 2008) and Turkey (Mercan et al., 2003).

Nonetheless, some studies found state banks to be more efficient than private banks in India (Bhattacharyya et al., 1997; Sathye, 2003; Ray and Das, 2010), Brazil (Staub et al., 2010), Germany (Altunbas et al., 2001a), Turkey (Isik and Hassan, 2003), Taiwan (Chiu and Chen, 2009), Greece (Delis et al., 2009) and Switzerland (Dietrich and Wanzenried, 2011). For instance, Das and Ghosh (2006) found that Indian-state banks outperformed foreign-and-private-domestic banks, attributing this to government-borrowing programs that the state banks pursue which help them to generate fee-based income and hence become more efficient than foreign banks. Besides, foreign banks may be underperformed due to difficulties in administering their organisations from afar, dealing with the social, political and regulatory pressures and accessing "soft" qualitative information about local conditions (Buch, 2003; Berger et al., 2005).

The above discussion shows mixed results regarding the relative performance of foreign, private-domestic and state banks. The present study sheds some empirical light on the matter by investigating the efficiency-ownership linkage of Ghanaian banks. Besides, a potential drawback of most of the empirical studies has been the absence of considering CSR. Omitting the dual-or-multiple-objectives of banks might affect the efficiency results and hence incorporating CSR in banking efficiency assessment may be important.

5.13.4 Evidence on Bank Efficiency and Specialisation Type

Is it healthier for banks to offer a diversity of products or focus on narrow range of products at a time? Proponents of strategic focus banking argue that the cost of producing products and services may well decrease when banks specialize in that type of production activity

(Isik and Hassan, 2003). The applied literature that explores the association between universal banking or product diversification and bank efficiency is recent and rather limited. Hitherto, Isik and Hassan (2003) reported a negative relationship between product diversity and efficiency arguing that focus banks were more cost efficient than universal banks as extra resources may be needed to diversify which might not pay off in certain situations. Laeven and Levine (2007) examined the impact of diversification on the valuation of 836 banks across 43 countries during 1998–2002. They realized that the market values of financial conglomerates undertaking multiple lending financial services activities were lower than they would be if they were decomposed into financial intermediaries that focused on individual activities. Their findings are consistent with theories that stress intensified agency problems in financial conglomerates that undertake multiple activities and show that scope economies are not sufficiently large to produce a diversification premium. The results of Cummins et al. (2010) indicated that strategic focus was superior to product diversity in the US insurance industry during the period 1993-2006. Similar findings have been found by Hunter et al. (1990), Berger and Humphrey (1991), Ferrier et al. (1993), Servaes (1996), Lamont and Polk (2002) and Huang and Wang (2004). It is argued that financial institutions should pay more attention to narrow businesses at a time in order to take advantage of the expert opinions of management and reduce agency problems, leaving investors to diversify on their own (Berger et al., 2010).

Other studies find contradictory results. Some authors noted that there is a lack of empirical studies that explicitly evaluate the gains from diversification (Benston, 1994). Arguably, since banks are highly leveraged, those that diversify lower their chance of costly financial distress (Berger et al., 2010). Proponents of universal banking contend that such a banking activity acknowledges debt coinsurance (Lewellen, 1971), efficiently allocates resources by establishing internal capital markets (Jones and Hill, 1988), disciplines corporate management, allows for scale and scope economies[23] across financial services, and encourages financial stability and economic development (Vander Vennet, 2002).

Studies that argue that universal banking positively affect efficiency include Rose (1989) who recommended that universal banking may reduce the risk to banking returns. Templeton and Severiens (1992) observed that diversifying into other financial services lead to marginal decreases in unsystematic risk, an observation that supported the predictions of the portfolio theory. Hauner and Peiris (2008) showed that efficiency rises with the degree of portfolio diversification among Ugandan banks during the 1999-2004 period. Similarly, Vander Vennet (2002), using parametric techniques to study 2,375 EU banks from 17 nations during 1995-96 concluded that universal banks were more revenue-cost-and-profit efficient than focus banks. The author argued that the revenue efficiency of universal banks was due to their ability to handle moral hazards through monitoring. Recently, Chronopoulos et al. (2011) found strong evidence to suggest that universal banks were more likely to be cost- and profit-efficient within the 10 ‘EU transition countries’ during the 2001-2007 period. Similar conclusions are made in the literature (Dietsch, 1993; Huang and Wang, 2001; Maudos et al., 2002; Aguirre et al., 2008).

From the discussion above, the efficiency literature on focus banking vis-à-vis universal banking is centred on US and some European banks with very few studies in developing economies. Earlier studies also omitted the CSR in their analysis. They also did not employ alternative techniques such as the global frontier difference. This study fills the literature gap by investigating the average efficiency and best-practice differences between focus and universal banks in a fast-growing developing economy, namely, Ghana.

5.13.5 Evidence on Bank Efficiency and Capitalisation Type

Several studies on stock markets and bank efficiency exist. But, few studies explore the relationship between bank performance and capital market performance (see Liadaki and Gaganis, 2010; and Kothari, 2001 for a literature review). Exceptions include Chu and Lim (1998) who used DEA to assess the relative cost and profit efficiencies of 6 Singapore-listed banks during the period 1992-1996. The authors observed that percentage change in the price of bank shares has a positive relationship with the percentage changes in profit rather than cost efficiency. Kirkwood and Nahm (2006) employed DEA to evaluate the cost and profit efficiencies of Australian banks during 1995-2002. They reported that changes in profit efficiency statistically and significantly influenced banks' stock returns. Pasiouras et al. (2008) also examined the association between the technical efficiency of Greek-listed banks, measured by DEA and share price performance measured by the cumulative annual stock price returns and found a significant positive relationship. See also Guzmán and Reverte (2008) for similar conclusions on Spanish banks. The first cross-country study on the efficiency-stock performance linkage is probably Beccalli et al. (2006) who evaluated the cost efficiency of publicly-listed banks in France, Germany, Italy, Spain and the UK. Using SFA and DEA, they estimated bank stock performance using annual stock returns in the year 2000. The overall results suggested that stocks of X-efficient banks outperformed their inefficient peers.

Girardone et al. (2009) used SFA to examine the cost efficiency of listed and non-listed banks in EU-15 during 1998-2003 and observed that listed banks were more cost efficient than non-listed banks when both were measured relative to the EU metafrontier. Ray and Das (2010) also utilized DEA to estimate the cost and profit efficiencies of 68-71 Indian banks during the post-reform period (1997-2003) and found that profit efficiency of the listed banks were higher than that of non-listed banks. Using SFA, Liadaki and Gaganis (2010) examined the link between the cost and profit efficiencies of 117 EU-15 listed banks and their stock price returns during 2002-2006. They found that changes in profit efficiency were positively related to stock returns. They, however, found no evidence of a significant relationship between cost efficiency and stock returns. Finally, Kasman and Kasman (2011) examined the relationship between technical efficiency, scale efficiency and productivity change and stock performance of 13 listed commercial banks in the Turkish stock exchange over the period 1998-2008. They reported a positive and significant effect of changes in the three measures of performance on stock returns. In summary, the available studies in the literature find a positive link between performance and stock returns or find that listed banks outperform non-listed banks.

Once again, a limitation of the available studies in this area is the omission CSR, non-use of global frontier difference method or their evaluation of Ghanaian banks. In the case of the exclusion of CSR, this may be due to the multidimensional nature of the concept and the difficulty in obtaining proxy variables to measure CSR. Again, quite often, the different methodologies employed, the different features of banking subgroups, and regulatory reforms have caused conflicting findings is several studies. This makes the general findings of some countries in Africa hard to come by. Also, absent from the literature are studies that explore the impact of favourability on productivity change. Policy prescriptions for the banking sector should consider all the relevant factors that can affect the performance of the banks. This thesis adds to the existing literature in the context of a dual-objective Ghanaian banking system.

5.14 Conclusion

The present chapter has introduced the main theories and techniques developed for evaluating the efficiency, productivity change, GFD, favourability and favourability change of DMUs. The existing frontier methods, be it parametric or nonparametric have been examined. Whereas the former require a specification of a specific functional form, the latter are deterministic and do not rely on particular functional forms for the frontier. The study employs the nonparametric DEA approach because of its ability to handle multiple inputs and outputs and its ability to allow the data to speak for itself with minimal assumptions. The chapter examined the basic DEA models and noted the use of the Farrell efficiency measure since it is the reciprocal of the Shephard distance function.

Furthermore, Malmquist productivity change index, its decompositions and some important extensions were described. The chapter considered the metafrontier analysis and the global frontier differences, both of which consider both time and group differences and are applicable to unbalanced panels. The chapter consider further decompositions of the global frontier shift into components that show whether an observed unit is situated in a more or less favourable location in the production possibility set. The techniques introduced in this chapter are applied in the empirical chapters of this thesis. Some have interesting regulatory implications for the Ghanaian banking sector. Particularly, the KDE is employed to analyze the distribution of efficiency scores later in chapter 6. The standard DEA is also empirically applied to determine the relevance of CSR in chapter 6. The metafrontier analysis and the global frontier differences are deployed in chapter 7 to investigate the average efficiency and frontier differences among different banking subgroups in the dual-objective banking system of Ghana. The thesis also proposes a novel application of the favourability and the favourability change indices in chapter 8.

This chapter also reviewed the applications of frontier techniques, especially DEA, to the performance analysis of banks. It has surveyed the banking efficiency literature in different parts of the world and has noted the very few studies undertaken in African contexts and in Ghana in particular. None of the studies explicitly considers the performance analysis in a dual-objective banking system. Exceptions included Vitaliano and Stella (2006). The chapter has explored the association between banking efficiency and bank-specific variables such as ownership, specialization and capitalization. The thesis adds to this body of literature by investigating how these factors relate to bank performance between different banking groups in a nonparametric framework.

[7] The production technology (T) exhibits CRS if $y \in T$ means that that $\beta y \in T$ for any scalar $\beta \geq 0$. In such a case, T will be a cone.

[8] The curse of dimensionality, typical of nonparametric techniques, implies that when the data set includes a number of input and output variables, the analysis requires very large sample size in order to obtain a reasonable estimation precision (Daraio and Simar, 2007a). The dimensionality curse can also be an issue in parametric models.

[9]Free disposability implies that it is possible with the same production technology to reduce outputs while maintaining the level of inputs and to augment inputs while maintaining outputs at the given level.

[10] A production function is convex if the weighted mean of any two combinations that can be produced can itself be produced (Farrell, 1959).

[11] The Charnes-Cooper transformation (Charnes and Cooper, 1962) for linear fractional programming transforms equation (8) into an LPP by setting the denominator to 1 and moving it to a constraint and minimising the numerator for the output-oriented LPP in (9).

[12] The efficiency measure is "translation invariant" if it is independent of an affine translation of the input and output variables. For detailed discussion on which DEA estimators are unit and translation invariant, the reader is referred to Ali and Seiford (1990) and Pastor (1996).

[13] The complementary conditions (Nering and Tucker, 1993) hold between the optimal values of the multiplier model (v^*, u^*) and of the envelopment model (λ^*, s^{-*}, s^{+*}): $v^* s^{-*}=0$ and $u^* s^{+*}=0$. This implies that if any component of v^* or u^* is positive then the corresponding component of s^{-*} or s^{+*} should be zero, and conversely with the allowable possibility that both components may be simultaneously zero (Cooper et al., 2007).

[14] Actually, Färe, Grosskopf and Logan (1983a) were the first to define scale efficiency.

[15] An inverse-homothetic technology exists if and only if the technology is simultaneously input-homothetic and output-homothetic (cf. Shephard, 1970; Färe and Primont, 1995). Output homotheticity means that if the output mix is held fixed, the marginal rate of transformation between outputs does not change as input changes. This implies that the output expansion path is linear.

[16] Productivity change index can be computed using parametric or nonparametric frontier methodologies. The current discussion will focus on the nonparametric approach.

[17] Circularity or transitivity implies that "the index from 1 to 3 is equal to the product of the index from 1 to 2 and the index from 2 to 3" (Berg et al., 1992, pp.215-216).

[18] Fare et al. (2008) showed under the CRS single-input single-output case that productivity change given as the ratio of average products could be defined as the ratios of output distance functions. We use efficiency scores, which are the reciprocals of the distance functions and define the Malmquist index under several inputs and outputs.

[19] But the VRS assumption may be useful when profit efficiency is the aim of the study and when there are some negative data (Portela and Thanassoulis, 2010).

[20] Note that in $\phi^t\left(x^t, y^t\right)$, the superscript after the observation (x, y) indicates the data point that is being evaluated and the superscript after the ϕ indicates the frontier against the observation is being measured relative to.

[21] The traditional meaning of Hicks neutrality is that of a parallel shift in a radial fashion of the isoquant along the capital-labour ratio.

[22] For empirical applications of efficiency and productivity analysis in different sectors and departments of the economy, see Fried et al. (2008) and the bibliometric study of Emrouznejad et al.(2008)

[23] Scope economies in banking can come about as a result of several factors "(i) fixed costs, emanating from computer equipment, branch offices, or collection of information on customers financial standing, can be spread across several products and services; (ii) diversification and adjustment of maturities of deposits and loans can be used to reduce the portfolio and the interest rate risks; (iii) customers enjoy the cost economies of being served with several products and services at one bank, which allows banks to extract some of this additional consumer surplus by charging higher fees for their services" (Lang and Welzel, 1998 pp. 68-69).

Chapter 6

Banking Efficiency with CSR

6.1 Introduction

The previous chapter detailed the DEA frontier technique and various extensions of it. The DEA approach is used in this empirical chapter to evaluate the relative efficiency of Ghanaian banks using the data set of 63 banking observations over the period 2006-2008. The chapter explores if there is a significant difference between the rankings of a total DEA model (with CSR) and a reduced DEA model (without CSR) in order to determine if the inclusion of CSR is important for efficiency assessment. As a further analysis, second-stage OLS and quantile regressions are performed to determine whether there is a positive relationship between CSR and Corporate Financial Performance (CFP) measured by profitability and efficiency indicators. Also, the overall technical efficiency (OTE), pure technical efficiency (PTE) and the scale efficiency (SE) of Ghanaian banks are estimated and discussed. The findings suggest that considering CSR in bank efficiency assessment is not only important on conceptual grounds, but also, socially responsible banking have positive link with financial performance. The next examines the empirical results and discussions.

6.2 Empirical Results

In order to certify that the inputs and outputs of the DEA model are isotonic, their inter-correlations are calculated and shown in Table 6.3. Usually, high correlations between inputs and outputs are preferred (Avkiran, 2006). From the Table, it can be observed that all the correlation coefficients between an input and an output pair are above 0.5 and significant at 1%. The highly significant positive correlation implies that the variables pass the isotonicity test.

Table 6.1 Pearson correlation coefficients

	FA	SE	Deposits	Loans	OEA	CSR
Fixed Assets (FA)	1					
Staff expenses (SE)	0.831**	1				
Deposits	0.799**	0.920**	1			
Loans	0.824**	0.935**	0.943**	1		
OEA	0.653**	0.742**	0.891**	0.737**	1	
CSR	0.577**	0.637**	0.690**	0.675**	0.638**	1

Notes: **Correlation is significant at the 0.01 level (2-tailed). N=63

6.3 Empirical Results

The present analysis adopts the VRS model instead of the CRS because Ghanaian banks differ in terms of operational activities, size classes and capitalization. For instance, the 8 biggest banks own 76% of the industry's total assets (GHS 5,517,041.28) whilst the 14 smallest banks own the remaining 24% (GHS 1,696,427.4). CRS may not always be realistic in empirical applications since imperfect competition, leverage concerns, certain regulatory changes, non-performing loans, among others, may cause a bank to operate at sub-optimal scale (Coelli et al., 2005). Notwithstanding this, the VRS results will be corroborated with the results from the CRS assumption. An extra appealing characteristic of CRS is its ability to permit the computation of the global frontier difference (to be empirically applied in detail in the next chapter) without the problem of infeasible mixed-period efficiency scores. The empirical study evaluates the managerial efficiency of Ghanaian banks using the standard DEA-VRS estimator (equation 15b) with CSR (the total model) which includes a further output and without CSR (the reduced model). The selection of inputs is common to both models. First, the efficiency scores and their rankings from both the total model and the reduced model are presented. Second, the second-stage OLS and LAD multiple regression analyses are discussed. Third, the findings on the overall technical efficiency scores (OTE), pure technical efficiency scores (PTE) and scale efficiency scores (SE) based on the chosen total model are presented and discussed.

6.3.1 Univariate Analysis of Efficiency Scores

Table 6.2 presents efficiency scores for each of the 63 banking observations and their corresponding rankings from the total and the reduced models. The last rows in the table also show the summary statistics including the minimum, maximum, standard deviation, skewness and geometric means. The geometric means are computed because using arithmetic means to summarize normalized benchmark scores may lead to wrong conclusions (cf. Roberts, 1990). The findings indicate the existence and degree of output inefficiency, which is the potential for banks to increase outputs given the input levels. The mean efficiency score of 1.20 from the total model shows that, during the period under consideration, the average Ghanaian bank would have to increase all outputs to 120% of what it is currently producing. The least efficient bank, UGL08 is capable of expanding all output production by 172% in order to be as efficient as the best-practice banks in the industry. The table also shows that the mean efficiency score from the total model is very close to that of the reduced model and so are their medians and standard deviations. Given these similar results, one may be tempted to argue that there is not much reason for including CSR. However, the total model generated about 7% more efficient banks than the reduced model, which shows the bias that can be incurred if CSR is not considered. To elaborate on this point, it will be useful to consider the effect on individual banks, of omitting the CSR variable.

To determine the relevance of CSR in the definition of outputs, the study examines the differences in the rankings of the individual observations. That is, the study investigates how much a bank improves (or impairs) its rank position when considering the total rather than the reduced model. The results of this analysis are shown in the last 2 columns of Table 6.2. It is observed that the ranks for 28 out of the 63 banking observations change between the two model specifications.

The findings suggest that the relative performances of some of the banks might be underestimated or overestimated if CSR is not considered. Specifically, the rankings of First Atlantic Merchant Bank (FAMB07), Agricultural Development Bank, ADB (ADB06, ADB07 and ADB08), Standard Chartered Bank (SCB07), Stanbic Bank (STANB07), Fidelity Bank (FB08), International Commercial Bank (ICB07), Ecobank Ghana Limited (EBG07), Merchant Bank Ghana (MBG07) and Prudential Bank Limited (PBL07) are important to notice, since the relative rankings of these banks change. There may be good reasons why some of these banks change their rankings. For instance, ADB is an agricultural development bank created to improve the agricultural sector by giving donations (CSR) to farmers to purchase agricultural implements and fertilizers as well as providing resources for developing the cocoa industry. CSR has been an integral part of the banks' operations and hence, ignoring that output's contribution to its performance would implicitly mean punishing the bank when estimating its efficiency. Therefore, an efficiency comparison, which ignores CSR, could be seen as being unfair to such a bank.

It is also interesting to note the difference in the efficiency ranking of FAMB07 between the two DEA models. The efficiency score and ranking of FAMB07 increased substantially when explicitly acknowledging the CSR activities it undertakes. The bank has been undertaking CSR activities since its incorporation in 1994. This may explain why it gets a better efficiency estimate and ranking from including CSR since without it, the bank is being penalized for diverting resources into CSR.

Note though that any significant difference in the efficiency score between the total and reduced models is not surprising; it is a methodological consequence of adding more variables to a DEA model. The difference in the efficiency rankings of some banks after including CSR is however important as it may provide empirical support for the relevance of CSR, such that the justification is not only on conceptual grounds. Hence, failure to include such variables in the DEA model specification may lead to biased results.

Table 6.2 Efficiency scores and rankings from reduced and total models

Observations	**Reduced model**	**Total model**	**Rank from Reduced**	**Rank from Total**
ADB06	1.126	1	34	1
AMAL06	2.214	2.214	60	60
BBG06	1.082	1.012	28	26
CAL06	1.232	1.232	42	44
EBG06	1.288	1.249	48	47
FAMB06	1	1	1	1
FB06	1	1	1	1
GCB06	1.192	1.189	40	40
GTB06	1	1	1	1
HFC06	1	1	1	1
IBG06	1	1	1	1
ICB06	1	1	1	1
MBG06	1.140	1.140	35	36
NIB06	1.654	1.654	55	55
PBL06	1.352	1.352	52	52
SCB06	1	1	1	1
SGSSB06	1	1	1	1
STANB06	1.124	1.124	33	35
TTB06	1.171	1.171	38	39
UBA06	2.260	2.260	61	61
UGL06	1	1	1	1
ADB07	1.286	1.202	47	41
AMAL07	1.792	1.792	57	57
BBG07	1	1	1	1
CAL07	1.103	1.103	30	32
EBG07	1.013	1.013	22	27
FAMB07	1.142	1	36	1
FB07	1	1	1	1
GCB07	1.113	1.107	32	33
GTB07	2.071	2.071	59	59
HFC07	1.060	1.060	26	29
IBG07	1	1	1	1
ICB07	1.340	1.224	51	43
MBG07	1.010	1.010	21	25
NIB07	1.430	1.430	53	53
PBL07	1.273	1.273	45	49

SCB07	1.017	1	23	1
SGSSB07	1.234	1.234	43	45
STANB07	1.051	1	25	1
TTB07	1	1	1	1
UBA07	1.905	1.905	58	58
UGL07	2.267	2.267	62	62
ADB08	1.031	1.031	24	28
AMAL08	1.588	1.588	54	54
BBG08	1	1	1	1
CAL08	1.074	1.074	27	30
EBG08	1	1	1	1
FAMB08	1	1	1	1
FB08	1.109	1.109	31	34
GCB08	1	1	1	1
GTB08	1	1	1	1
HFC08	1.145	1.145	37	37
IBG08	1.717	1.717	56	56
ICB08	1.274	1.266	46	48
MBG08	1.084	1.084	29	31
NIB08	1.300	1.300	49	50
PBL08	1.245	1.245	44	46
SCB08	1.000	1.000	1	1
SGSSB08	1.320	1.320	50	51
STANB08	1.187	1.170	39	38
TTB08	1	1	1	1
UBA08	1.204	1.204	41	42
UGL08	2.723	2.723	63	63
Min	**1**	**1**		
Max	**2.723**	**2.723**		
Geometric mean	**1.211**	**1.199**		
Stand. dev	**0.378**	**0.382**		
Std. error	**0.048**	**0.048**		
Median	**1.113**	**1.103**		
Skewness	**2.118**	**2.138**		
Kurtosis	**4.218**	**4.238**		
Efficient Banks	**20**	**24**		

Notes: Reduced model (R) is efficiency scores from the reduced model without CSR; total model (T) is efficiency scores from the model including CSR; Rank from R or T are efficiency rankings from the reduced and total models respectively.

In order to investigate whether the change in ranks from including CSR is significant, the nonparametric Wilcoxon matched-pairs signed-rank test (Wilcoxon, 1945) is employed to test the null hypothesis (Ho) that the median of the differences between the total model and the reduced model are zero. At 1% level of significance, the study observes a significant difference in the efficiency rankings between the total model and the reduced model using both the sign test (Z statistic=-3.474, *p*-value=0.000) and the related-samples Wilcoxon signed-rank test (Z statistic= -3.598, *p*-value=0.0003). The Ho of the sign test is that the median difference is zero, without assuming anything about the distribution (StataCorp, 2009). As a robustness check, the parametric equivalent of the paired t-test confirmed the significant difference between the efficiency rankings of the total and the reduced models at 1% significance level (t-test= -2.711, *p*-value=0.009). It is important to mention that most of the banks whose efficiency ratings improved when using the total model are African-owned banks. They include ADB06, FAMB07 and ICB07. This result may indicate that these African banks have certain characteristics, such as strong emphasis on CSR, that differentiate them from their foreign counterparts and thus ignoring their CSR activities may lead to an unfair assessment of their performance rankings. In the next chapter, the study will explore, among other things, the frontier differences between banking subgroups based on their ownership, specialization and capitalization characteristics.

At this stage we can state that, an answer to the research question 1 (RQ1) is provided. The question was: what is the relevance of incorporating CSR in DEA banking intermediation models? The conclusion is that the rankings based on the efficiency estimates change significantly with the incorporation of CSR into the DEA banking intermediation model.

6.3.2 Nonparametric Analysis of Efficiency Distribution

Figure 6.1 displays the difference in the efficiency distributions from the total model and the reduced model using the nonparametric kernel density estimation obtained by estimating equation (34) in the methodology chapter. Note that the vertical axis is the measured probability density function of the efficiency distribution whilst the horizontal axis is the efficiency scores. The estimated kernel densities show evidence of bimodality as depicted by the two peaks at about 0.5 and 0.98 for the total model and about 0.55 and 0.95 for the reduced model. There is a slightly similar peak for the total model and for the reduced model (with the total model being slightly above the reduced model especially towards the maximum efficiency level). The figure also appears to support the difference in the distribution of efficiency between the total and the reduced models.

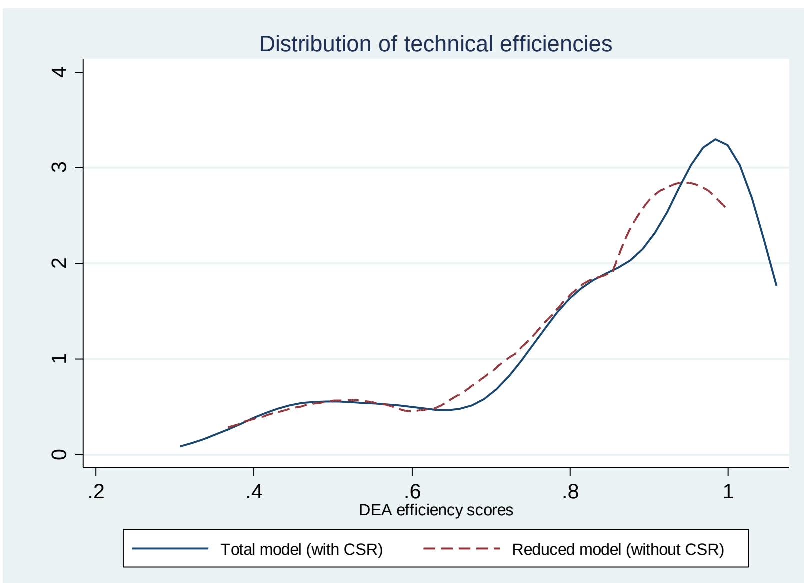

Figure 6.1 Kernel densities (kernel = gaussian, h = 0.0609)

6.3.3 Multivariate Analysis

In this study, CSR is modelled as an additional output. Alternatively, CSR can be specified as an environmental variable. Following the existing literature that examine the CSR-CFP nexus (Russo and Fouts, 1997; Waddock and Graves, 1997; Margolis and Walsh, 2003; Orlitzky et al., 2003; Beurden and Gössling, 2008), and studies that regress DEA banking efficiency estimates against bank-specific variables in the second stage (Havrylchyk, 2006; Kenjegalieva et al., 2009a), the current study investigates the impact of CSR and other control variables, as exogenous variables, on bank efficiency and profitability.

Table 6.3 presents the Pearson's correlation coefficients and generates initial evidence that supports the positive CSR-CFP nexus. The study uses the accounting based measures of return on average assets (ROA) and return on average equity (ROE). ROA is a proxy for profit after tax divided by average total assets and ROE is profit after tax divided by average total equity. Both are used to capture banks' short-term profitability. As majority of the banks in the sample did not have their common stock listed on the GSE, market returns are not used to proxy CFP. Only 8 banks had their shares traded on the GSE in 2008 and 6 banks in 2007 and in 2006. Simpson and Kohers (2002) and Inoue and Lee (2011) also used accounting-based measures instead of market-based measures. One control variable considered is the natural logarithm of total assets (LTA) to control for bank *size* (see e.g. McWilliams and Siegel, 2000). It is argued that bigger institutions are more likely to be socially responsible than smaller institutions (McWilliams and Siegel, 2001; Waddock and Graves, 1997). *Leverage ratio* (LEV), representing capital structure, is expressed as the ratio of banks' debt level (total liabilities) to total assets. Leverage is believed to affect the

CSR-CFP nexus in the sense that organizations with significant amount of debt than equity may act differently from those with low debt when it comes to investing in CSR (Waddock and Graves, 1997). *Liquidity risk* (LR) or lending intensity, proxied by the ratio of total loans and advances to total deposits, is the capability of banks to raise funds in order to finance cash flows at specific points in time. Banks that are more liquid are more likely to be socially responsible. *Capital Adequacy Ratio* (CAR) expressed as the ratio of banks' total equity to total assets is used as a proxy for bank capitalization or capital strength.

The findings indicate that CSR is positively and significantly ($p<0.01$) correlated with the three profitability indicators - profit after tax (PAT), ROA and ROE - with a correlation coefficient of 0.555 in all cases. It is interesting to see that CSR is positively (0.267) and significantly ($p<0.05$) correlated with the DEA efficiency score from the reduced model suggesting that bank efficiency is positively associated with CSR. Size is found to be positively correlated with CSR which partly coincides with previous empirical studies that argue that bigger banks tend to have larger CSR engagements than smaller banks because larger banks might have better existing inputs to sustain CSR goals (Stanwick and Stanwick, 1998; Pava and Krausz, 1996). Note also that size is positively and significantly associated with PAT, ROA and ROE which is consistent with studies that show that size positively affects CFP and hence larger firms are more profitable than smaller ones (Goll and Rasheed, 2004; Ruf et al., 2001). Leverage is negatively (but insignificantly) correlated with CSR indicating that the higher a bank's level of debt financing the lower its ability to engage in CSR activities. Liquidity risk is positively correlated with CSR. CAR is negatively (but insignificantly) correlated with CSR implying that banks that are highly capitalized with respect to their risk might be less likely to contribute towards CSR. There was no need to control for the industry as is done in other studies, due to the homogeneity of our sample.

Table 6.3 Correlations matrix

	LEV	CAR	LR	LTA	PAT	ROA	ROE	DEA	CSR
LEV	1								
CAR	.938**	1							
LR	-0.184	-0.203	1						
LTA	-.290*	-.332**	-0.049	1					
PAT	-0.05	-0.042	0	0.643**	1				
ROA	-0.05	-0.042	0	0.643**	1.000**	1			
ROE	-0.05	-0.042	0	0.643**	1.000**	1.000**	1		
DEA	0.222	0.125	0.177	0.175	0.311*	0.311*	0.311*	1	
CSR	-0.093	-0.126	0.250*	0.585**	0.555**	0.555**	0.555**	0.284*	1

Notes: N=63; ** p<0.01; * p<0.05.

The correlation analysis is complemented by regression analyses using CSR as the independent variable whilst controlling for other bank-specific independent variables, as determinants of CFP. Two profitability indicators (ROA, ROE) and one efficiency indicator (DEA technical efficiency from the reduced model) are used as proxies for CFP. Each of these three variables is separately used as a dependent variable in the multiple regression analysis. The complete empirical model is:

$$\mathrm{DEA}_i\left(\mathrm{ROA}_i \text{ or } \mathrm{ROE}_i\right) = \beta_0 + \beta_1 CSR_i + \beta_2 LTA_i + \beta_3 LEV_i + \beta_4 CAR_i + \beta_5 LR_i + \varepsilon_i$$

where DEA_i is the DEA efficiency score for the ith observation $i = 1,...,n$. β is the vector of parameters to be estimated for each independent variable; ε_i is the error term distributed as $N\left(0,\sigma^2\right)$ and CSR_i, LTA_i, LEV_i, CAR_i and LR_i are the CSR, log of total assets, leverage ratio, capital adequacy ratio and liquidity ratio variables respectively for the *i*th observation.

In the case of DEA efficiency estimates being the dependent variable, many studies estimate the two-stage approach whereby efficiency estimates are obtained via nonparametric means in the first stage. The second-stage generally consists of regressing the stage-one DEA efficiency estimates on some environmental variables (uncontrollable covariates) that are assumed to have *a priori* theoretical link with the efficiency estimates obtained in the first stage. Simar and Wilson (2007) claimed, based on their survey of the literature that several studies apply Tobit regression models due to the censored nature of DEA scores (which are bounded from below on the left at 1, $\phi^* \geq 1$). Simar and Wilson (2007) argued that the efficiency scores generated by DEA in the first stage are serially correlated with (dependent on) the inputs and outputs of the first-stage analysis in a complicated and unknown way (in a statistical sense). They also contended that the first-stage dependency issue implies that the stochastic error term of the Tobit regression is also correlated with the environmental variables. The consequence is that the second-stage parameters will be biased. The use of maximum likelihood in the stage-two analysis means that this correlation vanishes asymptotically (leading to consistent estimates). However, this occurs at a very slow rate (which may yield invalid inference). Hirschberg and Lloyd (2002) and Xue and Harker (1999) had previously proposed a bootstrap approach to handle the correlation issue but Simar and Wilson (2007) critiqued their "naive" bootstrap technique for resampling without considering the peculiar distributions of efficiency scores derived via nonparametric DEA approach. Simar and Wilson (2007) therefore proposed a double-bootstrap approach to construct left-truncated bias-corrected DEA estimates in order to make inferences possible. More recently, Banker and Natarajan (2008) and McDonald (2009) argued that OLS offers consistent estimates in the second-stage regression. McDonald (2009) showed that the estimates are not generated from a censoring process but from fractional data and hence Tobit regression is inconsistent with the data generating process. Saxonhouse (1976) noted that heteroskadasticity can emerge if estimated parameters are used as dependent variables in the second-stage analysis. McDonald (2009) showed that if White's (1980) heteroskedastic consistent standard errors are calculated, large sample tests can be performed which are robust to heteroskedasticity and the distribution of the disturbances. Since Simar and Wilson's (2007) technique is computationally intricate coupled with its downsides recognized by McDonald (2009) and the arguments proposed by Banker and Natarajan (2008) as well as the endorsement of OLS by Hoff (2007), the study here adopt the OLS approach. Following McDonald (2009) and others (Sufian and Habibullah, 2009; Saranga and Phani, 2009; Banker et al., 2005; Cummins et al., 2010) the second-stage regression is estimated in this study using OLS whilst heteroskedastic-robust standard errors (or the White-Huber-Eicker standard errors) are computed in order to adjust for cross-section heteroskedasticity (Greene, 2003). The White test is easily implemented in Stata using the "regress" and "robust" *commands*.

In addition to the OLS regression, nonparametric regression techniques are used where the efficiency scores are estimated in the first stage, whilst the stage-two approach looks at the impact of correlates. Specifically, since there may be influential observations, like outliers, in the data set, especially for small sample like ours, the study employs a semi-parametric approach, the least absolute deviation (LAD) estimator, also called median regression and compares it with the OLS. Whereas OLS considers averages, the LAD estimates the median of the dependent variable, conditional on the values of the dependent variable over all observations making it more robust to outliers (see Koenker and Bassett, 1978; Greene, 2003; Cameron and Trivedi, 2005). This approach was therefore used to investigate the robustness of the results and to correct the outlier-sensitivity deficiency that may exist in OLS. The LAD uses linear programming methods to minimize the sum of the absolute residuals instead of the sum of squares of the residuals (as in OLS). The LAD is also useful in small samples (Cameron and Trivedi, 2005). And the data set used in the present study is relatively small thereby justify the use of the LAD to complement the OLS. The analysis follows others (Sengupta, 1995; Bonaccorsi di Patti and Hardy, 2005) and computes the LAD for the sample of Ghanaian banks. The parameter estimate can be computed using the quantile regression (qreg) procedure in Stata or Proc Quantreg in SAS (StataCorp, 2009; SAS, 2003).

Table 6.4 presents the result of the OLS regression using ROA, ROE and DEA estimates as the dependent variable (one at a time) and CSR as the independent variable, controlling for size, leverage, capital adequacy ratio and liquidity risk. The corresponding LAD results are presented in table 6.5. The analysis examined the presence of multicollinearity between the independent variables by first checking the variance inflation factors (VIF). Most researchers (e.g.Chatterjee and Hadi, 1986) use informal rules of thumb for the VIF, suggesting that multicollinearity is present and worrisome if the biggest VIF exceeds 10 and if the average of all VIFs considerably exceeds 1. The VIFs obtained in this study are all < 2 whilst the average of all VIFs is 1.45. Therefore, multicollinearity was not a critical issue in the regression. The model performs reasonable well and the results for most of the independent variables were consistent in both the OLS and the LAD regressions. The OLS R^2 representing the overall fit for the regression equation was almost 47% for the case where ROA and ROE were the dependent variable and 18% when the DEA estimate was the dependent variable. The LAD R^2 for the ROA, ROE and DEA were 43%, 43% and 10% respectively. The *F*-statistic for each of the models indicates that the parameter coefficients are jointly significant at the 1% level. The finding from the OLS regression shows that the null hypothesis of no relationship between CSR and ROA and ROE is rejected at the 1% level of significance indicating that CSR has a significant and positive relationship with ROA and ROE. One explanation of this finding may be the slack resources hypothesis (Waddock and Graves, 1997) that assumes that businesses do more CSR when these activities do not reduce costs. Regarding the link between CSR and the DEA estimate, the coefficient is positive although insignificant. This is so irrespective of the positive correlation between the DEA score and the two profitability indicators. This may be due to the nonparametric nature of the DEA estimate relative to the parametric characteristic of the profitability ratios. The DEA efficiency estimates were calculated from specified inputs and outputs using LPP and hence the estimate for each observed bank will depend on other banks. This is not the case for the profitability indicators - ROA and ROE. The calculation of these profitability ratios for each observation does not depend on the rest of the other observations. Interestingly however, when the DEA reduced model is regressed only on CSR (excluding all the control variables), CSR is found to be significant at the 1% significance level. In the LAD estimation, 0.9 is the median of the DEA efficiency score. The finding supports the positive CSR-CFP nexus as reviewed in the literature (Margolis and Walsh, 2003; Orlitzky et al., 2003; Wu, 2006; Beurden and Gössling, 2008). As in the correlation results, size has a positive effect on ROA and ROE in both the LAD and the OLS estimations. About half of the studies reviewed by Beurden and Gössling (2008) observed a significant impact of size on CSR. Size is also positive but insignificant relative to the DEA score. The finding on size implies that, overall, bigger banks are more profitable (and may or may not be more efficient) than smaller banks.

The coefficient of leverage (LEV) is negative and insignificant relative to the profitability indicators implying that banks with more financial debt have lower ROA and ROE. It is also significantly negative relative to the DEA score across estimations, indicating that highly leveraged firms may experience lower efficiency levels (Capon et al., 1990). Strangely enough though, mixed results for the coefficient of liquidity ratio (LR) are found; while it is negative relative to ROA and ROE in the OLS model, it is positive relative to the LAD estimation (though not significant). Nonetheless, in both estimations, the LR has a positive effect on DEA efficiency score implying that the more liquid a bank is the more likely it is efficient but not profitable. The possible explanation is that deposits may or may not be properly used to generate loan requests. CAR is also observed to show mixed results. CAR shows a positive but insignificant relationship with profitability but negative relationship with efficiency.

The important finding for the current analysis is that CSR especially shows the expected positive signs and is, generally speaking, statistically significantly different from zero.

Table 6.4 Multivariate OLS regression analysis

	OLS Dependent variables		
Exp. Vars.	**ROA**	**ROE**	**DEA**
Constant	-0.11*** (.0383, -2.89)	-0.981*** (0.34, -2.89)	0.4 (0.33, 1.18)
CSR	0.0000324*** (0.000011, 2.99)	0.00029*** (0.0001, 2.99)	0.000086 (0.00006, 1.41)
LTA	0.0143*** (0.0047, 3.05)	0.126*** (0.0414, 3.05)	0.04 (0.033, 1.08)
LR	-0.459354 (0.5795, -0.79)	-4.06 (5.13, -0.79)	9.74** (4.04, 2.41)
CAR	0.00007 (0.00007, 1.01)	0.0006 (0. 0006, 1.01)	-0.0007 (0. 0006, -1.24)
LEV	-2.92e-06 (0.0001, -0.03)	-0.00003 (0.0009, -0.03)	0.004*** (0.0014, 2.77)
R^2	0.4654	0.4654	0.188
Adjusted R^2	0.4185	0.4185	0.117
F-Statistic	10.59***	10.59***	5.01***

Values in parenthesis are robust standard errors and t-statistics respectively.* Indicates statistical significance at10% level. **Indicates statistical significance at 5% level. ***Indicates statistical significance at the 1% level.

Table 6.5 Multivariate LAD analysis

	LAD Dependent variables		
Exp. Vars.	ROA	ROE	DEA
Constant	-0.12 *** (0.015, -8.22)	-1.06*** (0.13, -8.22)	0.37 (0.29, 1.25)
CSR	0.000031*** (3.49e-06, 8.8)	0.0003*** (0.000031, 8.83)	0.00001 (0.00006, 0.15)
LTA	0.02 ***(0.002, 10.27)	0.14*** (0.013, 10.27)	0.05 (0.03, 1.57)
LR	0.12 (0.18, 0.65)	1.03 (1.59, 0.65)	9.05 **(3.55, 2.55)
CAR	0.00005 (0.00003, 1.4)	0.0004 (0.0003, 1.4)	-0.001(0.0006, -1.58)
LEV	-0.00006 (0.00009, -0.72)	-0.0005 (0.0006, -0.72)	0.003** (0.002, 2.01)
Pseudo R^2	0.43	0.43	0.1036

Notes: Values in parenthesis are robust standard errors and t-statistics.* Indicates statistical significance at10% level. **Indicates statistical significance at 5% level. ***Indicates statistical significance at the 1%.

6.3.4 Technical and Scale Efficiency of Ghanaian Banks

In this last empirical section, DEA efficiency scores of Ghanaian banks under both CRS (equation 13) and VRS (equation 15b) using the total model, are estimated. The distribution of the efficiency results are presented in Table 6.6. Recall from the methodology chapter, the overall technical efficiency score decomposes into two parts. First, the pure technical efficiency (PTE), deals with managers' ability to generate the maximum level of outputs given the inputs. That is, PTE measures managerial efficiency devoid of any scale effects and hence, implies managers' ability to avoid waste. The second, scale efficiency (SE), gives information about exploiting economies of scale by operating at the "most productive scale size" (Banker, 1984). The answer to research question 2 (RQ2) in the introductory chapter is provided here. It asked "what are the overall technical, pure technical and scale efficiencies of Ghanaian banks that co-exist and compete in a dual-objective banking system?" Specifically, the average PTE for Ghanaian banks was about 120%, indicating that, to be efficient, the average Ghanaian bank should increase all outputs by 20% of what they currently are. The mean PTE score (and the standard deviation) of Ghanaian banks indicate that many of the banks are producing close to the efficient frontier which is led by FAMB06, FB06, IBG06, ICB06, SGSSB06, IBG07, TTB07, EBG08 and GTB08. But, there is still some room for improvement. Since they can improve outputs, management should generate better combinations of loans, CSR and other earning assets during the day-to-day operations of the banks. This will require experienced workforce and seasoned management. It appears that overall technical inefficiency is, on average, driven by pure technical inefficiency than scale inefficiency. The results for the returns to scale (RTS) are presented in the last column of the table showing 14 banks operating under CRS, 36 operating under DRS and 13 operating under IRS. Hence, the majority of the banking observations in our sample over the study period appear to be big, operating under DRS. In the next chapter, the investigation will be improved, using the metafrontier technique, as we analyse and discuss the findings by bank type. This is because the differences between banking subgroups in the link between efficiency and CSR might be an interesting story. For example, state banks would have different CSR levels relative to foreign banks.

Table 6.6 Efficiency estimates

Observation	**OTE**	**PTE**	**SE**	**RTS**
ADB06	1.00	1.00	1.00	Constant
AMAL06	2.52	2.21	1.14	Increasing
BBG06	1.35	1.01	1.33	Decreasing
CAL06	1.27	1.23	1.03	Decreasing
EBG06	1.43	1.25	1.14	Decreasing
FAMB06	1.00	1.00	1.00	Constant
FB06	1.00	1.00	1.00	Constant
GCB06	1.59	1.19	1.33	Decreasing
GTB06	1.52	1.00	1.52	Increasing
HFC06	1.32	1.00	1.32	Increasing
IBG06	1.00	1.00	1.00	Constant
ICB06	1.00	1.00	1.00	Constant
MBG06	1.42	1.14	1.25	Decreasing
NIB06	2.26	1.65	1.37	Decreasing
PBL06	1.39	1.35	1.03	Increasing
SCB06	1.01	1.00	1.01	Decreasing
SGSSB06	1.00	1.00	1.00	Constant
STANB06	1.29	1.12	1.15	Increasing
TTB06	1.29	1.17	1.10	Increasing
UBA06	2.56	2.26	1.13	Increasing
UGL06	2.15	1.00	2.15	Increasing
ADB07	1.76	1.20	1.46	Decreasing
AMAL07	1.81	1.79	1.01	Increasing
BBG07	1.59	1.00	1.59	Decreasing
CAL07	1.25	1.10	1.14	Decreasing
EBG07	1.33	1.01	1.31	Decreasing

FAMB07	1.00	1.00	1.00	Constant
FB07	1.04	1.00	1.04	Decreasing
GCB07	1.59	1.11	1.44	Decreasing
GTB07	2.46	2.07	1.19	Increasing
HFC07	1.17	1.06	1.11	Increasing
IBG07	1.00	1.00	1.00	Constant
ICB07	1.27	1.22	1.03	Increasing
MBG07	1.29	1.01	1.28	Decreasing
NIB07	2.08	1.43	1.45	Decreasing
PBL07	1.28	1.27	1.01	Decreasing
SCB07	1.20	1.00	1.20	Decreasing
SGSSB07	1.70	1.23	1.38	Decreasing
STANB07	1.00	1.00	1.00	Constant
TTB07	1.00	1.00	1.00	Constant
UBA07	1.93	1.91	1.01	Decreasing
UGL07	2.42	2.27	1.07	Increasing
ADB08	1.54	1.03	1.49	Decreasing
AMAL08	1.70	1.59	1.07	Decreasing
BBG08	1.78	1.00	1.78	Decreasing
CAL08	1.39	1.07	1.29	Decreasing
EBG08	1.00	1.00	1.00	Constant
FAMB08	1.00	1.00	1.00	Constant
FB08	1.11	1.11	1.00	Decreasing
GCB08	1.38	1.00	1.38	Decreasing
GTB08	1.00	1.00	1.00	Constant
HFC08	1.15	1.14	1.00	Decreasing
IBG08	2.21	1.72	1.29	Decreasing
ICB08	1.27	1.27	1.01	Decreasing
MBG08	1.33	1.08	1.22	Decreasing
NIB08	1.98	1.30	1.53	Decreasing
PBL08	1.46	1.24	1.17	Decreasing
SCB08	1.41	1.00	1.41	Decreasing
SGSSB08	1.94	1.32	1.47	Decreasing
STANB08	1.47	1.17	1.26	Decreasing
TTB08	1.00	1.00	1.00	Constant
UBA08	1.40	1.20	1.17	Decreasing
UGL08	2.83	2.72	1.04	Decreasing
Geometric mean	**1.41**	**1.20**	**1.18**	
Arithmetic mean	**1.47**	**1.24**	**1.20**	
Stand. dev	**0.47**	**0.38**	**0.23**	

6.4 Conclusion

Besides their obvious profit-maximization goal, banks may have corporate social responsibilities typically not considered in the DEA banking efficiency literature. This study has developed a novel DEA banking model, which directly incorporates banks' CSR contributions into an intermediation-type model, to allow for this dual-objective banking setting. The study adopted a quantitative estimate of CSR unique to the banking industry that has not been employed in earlier studies. The monetary values of CSR from the annual reports of banks were used to proxy CSR and were incorporated as an additional output.

Motivated by the scanty banking efficiency studies in African countries, the efficiency ratings of 63 Ghanaian banking observations are evaluated over the period 2006-2008. The key contribution was the investigation of the potential impact of CSR on the banks' estimated technical efficiency. Comparing the results from two different DEA models, the total (with CSR) and the reduced (without CSR) models enabled us to ascertain the consequences of incorporating CSR or not in a banking efficiency analysis. The overall results indicated that the inclusion of CSR has a significantly positive link with the technical efficiency rankings of Ghanaian banks as indicated by the Wilcoxon matched-pairs-signed-rank test and the paired t-test. This implies that some banks might have designed their policies and programmes to include CSR activities to such an extent that ignoring this factor in the banking efficiency analysis will indirectly penalize such banks, leading to biased conclusions. In an alternative analysis, to estimate the CSR-CFP nexus, the study separately employed ROA, ROE and DEA efficiency score from the reduced model, as proxies for CFP (dependent variable) and considered CSR as an exogenous variable, together with other bank-specific variables, in a second-stage OLS and LAD regressions. The majority of empirical studies have found a positive CSR-CFP linkage although there have been few negative and neutral relationships (Margolis and Walsh, 2003; Orlitzky et al., 2003; Beurden and Gössling, 2008). The findings in this chapter indicate that CSR has a positive and significant link with CFP. The results are consistent with many of the earlier studies that employed different measures of CSR such as KLD and Fortune indices. Finally, it was observed that larger banks contributed more towards CSR while highly leveraged banks may find it harder to be socially responsible. Generally, the present analysis indicates that CSR activities are not only positively related to profitability but possibly also, with efficiency. Bank managers may find that integrating the social and environmental concerns into their firm policies, corporate strategies and mainstream business operations can have a positive association with their profitability and efficiency.

It should be mentioned that there could be a reverse to the finding i.e. banks which are socially responsible might experience bottom-line benefits. There could be a "virtuous circle" of CSR-CFP nexus (Waddock and Graves, 1997; Nelling and Webb, 2009). That is, the causality could go either way. Again, the CSR and CFP measures could be lagged by one year to establish if there is a lag in the execution of social responsibility programmes (Blackburn et al., 1994). In that case, the Granger causality method can be used to test for bi-directional causality. Data unavailability precludes a consideration of these factors. These issues of causality and implications of lags are yet to be explored in future research.

Chapter 7

Evaluating the Average Efficiency and Frontier Differences of Ghanaian Banking SubGroups

7.1 Introduction

The previous chapter evaluated Ghanaian banks' efficiency using DEA, by comparing the total model with the reduced model. Wilcoxon matched-paired signed-rank test, OLS and LAD regressions provided evidence for the incorporation of CSR into DEA banking intermediation model. The present chapter goes beyond the previous by focusing on specific banking subgroups. It makes a novel application of the metafrontier analysis of O'Donnell et al. (2008) and the global frontier differences (GFD) of Asmild and Tam (2007) to investigate banks' production behaviour and to compare the best-practice gaps across different Ghanaian banking subgroups. Specifically, the study explores whether foreign banks outperform private-domestic and state banks. Next, the study examines the universal banking hypothesis that encourages banks to produce several products and services versus the strategic focus hypothesis which says that businesses can increase performance if they do one thing at a time (Vander Vennet, 2002; Berger et al., 2000a). Finally, the study examines whether firms listed on the stock market outperform those that are not listed. To draw policy recommendations for banking regulators, the study analyses bank group-specific heterogeneity emanating from diversity in ownership, specialisation, and capitalisation structures of Ghanaian banks. To the best of our knowledge, to date, no study has examined all the seven different organizational forms of banks in Africa. The study is motivated by recent regulatory policies including the introduction of universal banking licence in 2003, the introduction of increases in banks' minimum capital requirement and discussions on the removal of restrictions on the entry of foreign banks. The remainder of the chapter is organised as follows: the next section checks for outliers in the efficiency scores. Following that is brief applied studies on banking efficiency studies that consider banking subgroups; then, the data for the different banking groups are presented and described. Subsequently, the results from the metafrontier analysis and the GFD are discussed after which conclusions and policy recommendations are provided.

7.2 Detection of Outliers

As aforementioned in chapter 5, DEA efficiency scores are somewhat sensitive to outliers since the technique is an extreme point and deterministic method. Outliers are considered here 'as observations that do not fit in with the pattern of the remaining data points and are not at all typical of the rest of the data' (Gunst and Mason, 1980). This definition is in connection with parametric regression analysis whereby the outlier is located above or below the fitted line. Outliers can be caused by measurement or typographical errors in the data, invalid observations or even outstanding practices or attributes of the data points. In nonparametric DEA, the extreme efficient observations or best-practice banks form the constructed frontier and hence exert influence on the rest of the data points. In such a case, outliers are influential observations (Wilson, 1995). There is another aspect of outlier detection in the literature using both efficient and inefficient frontiers, which are worth considering especially in post DEA analyses such as statistical testing, second stage regressions and distribution analysis (Chen and Johnson, 2010; Johnson and McGinnis, 2008). The present study does not consider the inefficient outlying observations, as we do not undertake such post analyses.

The presence of outliers or atypical boundary units, caused by observations that support the frontier, requires data screening and outlier detection. Some authors have examined the impact of influential observations. Wilson (1995) used the super-efficiency method or the leave-one-out efficiency estimate, originally pioneered by Banker et al.(1989) and Andersen and Petersen (1993). Other methods for identifying outliers using statistical tests, partial frontiers, bootstrapping and fuzzy clustering and high breakdown procedures exist (Pastor et al., 2002; Cazals et al., 2002; Simar, 2003; Sousa and Stošić, 2005; Seaver and Triantis, 1995).

This study employs the super-efficeincy DEA model of Andersen and Petersen (1993) to investigate the presence of outlying observations. The approach was originally developed to rank the boundary observations. Under the super-efficency model, the unit under evaluation is excluded from the reference set (or constraint set) of the original DEA models. It is equivalent to adding the contraint λ_i=0 to equation (10) which prevents the observation from serving as a benchmark. This helps to determine the impact of such an exclusion (any discordant behaviour) on the efficiency estimates of the other units or their average efficiency scores. Note that in this output orientation, the super-efficency score is less than 1. Also, since the analysis uses the CRS model, infeasibility of the LLP does not occur paving the way for the efficient units to be ranked. But under VRS, there is an infeasibility of the constraint set leading to undefined super-efficiency scores for some units.

The present study follows Wilson (1995) by providing a diagnostic test of super-efficient outliers through the investigation of the super-efficiency scores. The findings of the detection are presented in Table 7.1. Of the the 63 banking observations, 14 were ostensibly efficient and their super efficiency scores were computed as shown in column 2 of the table. These observations can impact on the measurement of the efficiency scores of other observations or the mean scores. For example, observations IBG07, FAMB06, FAMB08 and SGSSB06 each influence the measured efficiency of 37, 36, 29 and 10 other observations. Wilson (1995) questioned how many other observations are affected by these 14 potential outliers and what the effect of their deletion on the efficiency scores of the other observations will be. Note that there was no masking effect of outliers, whereby information about an efficient observation from the standard DEA score is lost because of the censoring problem.

To check for influential observations, potentially very high super efficiency scores were excluded one at a time from the basic model after which super efficiency was recomputed for the remaining observations. Upon dropping a potential super-efficient (SE) outlier, the ensuing efficiency estimates were geometrically average and contrasted with the geometric mean of the estimates from the full sample, which was 1.303. These mean values after deleting the corresponding atypical observations are shown in column 4. The percentage of the absolute value (ABS) of the difference in the two geometric means after dropping the potential SE outlier is show in the last column. The mean efficiency after dropping the very high super efficiency scores did not change substantially in all cases. Therefore, the analysis was not continued for the remaining boundary observations that were closer to 1 (i.e. less super efficient). The highest change was about 9% whilst the lowest was 0.45%. This was low compared to that of Wilson (1995). The findings are not different when the highest potential inefficient outliers were deleted one at a time or deleted together. Besides, a nonparametric Wilcoxon (1945) signed-rank test was performed after the deletion of each potential super efficient outlier. In every case, the *p*-value was above 0.15 indicating that there was no substantial difference in the means of the efficiency scores before and after the deletion of a potential atypical observation. To ensure the analysis was comprehensive, the very high super efficiency scores were deleted together iteratively up to the 6th highest super efficiency score (i.e. observation TTB07). Again, this showed no substantial difference in the means when compared to the mean of the full sample. It is therefore argued that insufficient evidence exist to determine if the 14 atypical observations are due to measurement error or are just remote observations. There may not after all be a need to employ sophisticated methods of outlier detection since the simple approach showed that the efficiency estimates were not significantly affected by the presence of outliers.

The author is happy to accommodate a banking observation from the sample for atypical behaviour even if such an observation is statistically proven a very influential one. This is a matter of judgement and a matter of the approach used. It is the belief of the author that DEA by its very nature is an outlying technique and behaviour from an observation that does not conform to the norm of the sample may have a story to tell. Hence, their accommodation instead of deletion is ideal. Explaining why outliers exist in the first place and exploring the impact of their influence on the rest of the sample should be pursued instead of merely removing every outlier found. In the currently analysis, the data set from the annual reports of banks was carefully checked for measurement or coding errors to ensure that such problems do not arise. The analysis will therefore proceed with the 63 observations.

Table 7.1 Detection of outliers

Banking observation	**Super efficiency scores**	**No. of observations whose efficiency is determined by the SE outlier**	**Geomean after deleting the potential SE outlier**	**ABS of difference between the mean after deletion and the original mean (%)**
SGSSB06	0.350	10	1.327	2.397
IBG06	0.503	5	1.319	1.598
FAMB08	0.531	28	1.262	4.098
IBG07	0.576	37	1.217	8.575
ADB06	0.689	6	1.311	0.876
TTB07	0.705	5	1.307	0.450
ICB06	0.735	9	**	**
FAMB06	0.773	36	1.272	3.067
FB06	0.778	3	**	**
EBG08	0.835	0	**	**
TTB08	0.845	20	**	**
FAMB07	0.883	2	**	**
GTB08	0.941	0	**	**
STANB07	0.950	1	**	**
Most inefficient outliers				
AMAL06	2.518		1.289	1.377
UBA06	2.557		1.288	1.409
UGL08	2.826		1.286	1.617

7.3 Previous Findings on Banking Group Analysis

Several studies investigate the determinants of efficiency and productivity change in order to execute appropriate strategies and policies for banks in a country or banks in different countries for wealth creation. Some of the efficiency determinants considered in the literature are bank-specific factors including profitability and loans to assets and bank-specific characteristics based on ownership, size, specialization etc. (Fethi and Pasiouras, 2010). Some studies examine the relationship between bank organizational forms (i.e. banks classified into different groups) and bank performance. For instance, Grifell-Tatjé and Lovell (1997) employed Malmquist index to explore the determinants of productivity change in Spanish banking industry from 1986 to 1993 accounting for the contribution of scale economies. They observed that commercial banks reduced their productivity growth compared with savings banks. They attributed actual productivity growth of savings banks to managerial improvement. Using DEA, Ariff and Can (2008) studied the cost and profit efficiency of 28 Chinese commercial banks from 1995 to 2004. They compared the efficiency of three banking subgroups - 4 state-owned banks (SOCBs), 9 national-joint-stock banks (JSCBs) and 15 city banks (CCBs) - and found JSCBs on average to be the most cost-and-profit efficient followed by CCBs and then SOCBs. Isik (2008) also used DEA and Malmquist index to explore the X-efficiency and productivity growth of de novo banks (i.e. banks that were 10 or less years) vis-à-vis established banks (i.e. banks that were more than 10 years old) in Turkey during the 1988-1996 period. Isik (2008) found that de novo banks experienced more efficiency and productivity growth than established banks. He also reported that, from both static and dynamic standpoint, foreign de novo banks performed better than domestic de novo banks.

More recently, Grifell-Tatjé (2011), using DEA, investigated the economic and financial performance of three Spanish organisational forms – commercial banks, savings banks and financial cooperatives (CFIs) – during 1994-2004 periods. The author tested three hypotheses relating to performance variation. The first was that commercial banks dominated the other organisational forms; the second was that competition would narrow the performance gaps and the third was that recipients of operating profits fared better at commercial banks and workers fared better at savings and CFIs. The first hypothesis was supported based on economic but not financial dominance. The second was not supported. The first part of the third hypothesis was supported but the second part was not, suggesting that labour fared better at commercial banks. Grifell-Tatjé (2011) concluded on lack of convergence in performance among the three organisational forms. Closer to the current study, Frimpong (2010) utilised DEA to measure the technical efficiency of 22 Ghanaian banks in 2007 and realised that private-domestic banks were the most efficient, followed by foreign banks and finally, state banks. Also, closer to this study, Kontolaimou and Tsekouras (2010) used the metafrontier analysis to investigate the productive efficiency of 1540 cooperative banks as compared to their commercial (541) and savings (735) counterparts in 6 European nations from 1997 to 2004, whilst accounting for technology heterogeneity induced by different ownership forms. They noticed that unlike cooperative and savings banks whose group frontiers fell below the European metafrontier suggesting the presence of significant technology gap, TG, commercial banks defined the metafrontier. Based on their decomposition of the TG into input-and-output-invariant components, Kontolaimou and Tsekouras (2010) attributed the TG between cooperative banks' frontier and the metafrontier to the level and the composition of outputs instead of inputs.

For other banking subgroup efficiency studies, the reader is referred to Canhoto and Dermine (2003) and Delgado et al. (2007). The current study adds to this body of literature by investigating not only the average performance of different banking subgroups that operate in a dual-objective banking system, but also, their frontier differences. The study attempts to disentangle the bank-subgroup-specific factors that make the frontiers of some banking subgroups better than others do. That makes our study the first to use GFD approach after the original paper by Asmild and Tam (2007). There are important regulatory policy lessons expected from the analysis.

7.4 Data

The banking market is segmented based on different banking types. The summary of the inputs and outputs as well as other bank-specific variables for the different banking subgroups are presented in Table 7.2 for bank ownership types, in Table 7.3 for bank specialisation forms and in Table 7.4 for bank capitalisation types (i.e. whether a bank is publicly traded on the GSE or not). The data set, whereby banking observations in different years are treated as separate observations, is made up of 9 state banks, 27 private-domestic banks and 27 foreign banks based on ownership; 52 universal banks and 11 focus banks based on bank specialization; and 18 listed and 44 non-listed banks categorized under bank capitalization. The descriptive statistics indicate big standard deviations for some of the variables highlighting the fact that banks may be different in terms of scale size even within subgroups. Statistical tests are performed to determine the presence of significant differences in the means of the inputs, outputs and other variables between the three ownership types, between the means of listed and non-listed banks and between the means of universal and focus banks. Each variable is tested separately using the one-way ANOVA for the ownership types and the t-Test for the specialisation and capitalisation types. The null hypothesis (H0) is that the means of the variables of the different banking subgroups all come from the same population while the alternative (H1) is that the means of the variables of the subgroups are not equal. The H0 is rejected in the case of ownership and capitalisation types for most of the variables indicating that the means of variables of the three ownership-banking groups and the means of the variables of two capitalisation types are significantly different. But the means of variables of focus and universal banks are equal except for other earning assets where the means of the two subgroups are different.

Observe in Table 7.2 that the average state bank has CSR of GH¢453.05 thousands and total assets of GH¢680,775.5 thousands compared to corresponding figures of GH¢208 and GH¢ 388,492.7 for the average foreign bank and corresponding figures of GH¢70 and GH¢218,273.9 for the average private-domestic banks. State banks, on average, bigger generate more loans and are more socially responsible compared with foreign and private-domestic banks. Recall the historical objectives of the banks based on ownership structures. State-owned banks were created by government to finance developmental and commercial projects that will otherwise not be financed by private enterprises. It is also asserted that the socialistic view of banks was universally accepted, particularly in the 1960s and the 1970s when the authorities nationalised the existing commercial banks and created new banks in Africa, Asia, and Latin America (La Porta et al., 2002). State banks are established to address market failure, termed as the social theory (Stiglitz, 1993) and to maximise social welfare, termed as agency view (Hart et al., 1997). In Ghana, the state banks, by virtue of their ownership attributes, might potentially have stronger remit in terms of social objectives and outcomes, as they might be seen as an instrument for obtaining government social objectives. The privatisation and liberalisation of state banks led to the entry of both private-domestic and the foreign banks into the country. This was meant to facilitate banking sector flexibility and competition, and to further the progress of efficiency operational autonomy. Privatisation was also aimed at addressing the problem of substantial non-performing loans and governmental bureaucracies within state banking practices. A number of banking sector reforms became operative since the 1980s in Ghana to liberalise the banking sector. These include the deregulation of interest rates, newly designed prudential norms, and measures to reduce bad loans. These policies appeared to have enhanced the profit motive of the private-domestic and foreign banks.

Table 7.3 displays initial evidence of significant differences in input, output and other variables between listed and non-listed banks. The average listed bank contributes GH¢312.6405 thousand towards CSR compared with the average non-listed bank that contributes GH¢141.6514 thousand. Hence, listed banks are more likely than non-listed banks to contribute towards CSR and experience higher ROA and ROE. Since its establishment in 1989, the Ghana Stock Exchange (GSE) has been buying and selling bonds, shares and other securities. To be listed on the GSE means that a bank must grow its capital base. It is therefore not surprising that listed banks are on average bigger (based on total assets) than non-listed ones. The efficiency of these banking subgroups needs further exploration in order to ascertain whether being listed has a relationship with performance.

Table 7.2 Descriptive statistics for bank ownership types: 2006-2008

	Bank Ownership Types						
	State banks		**Domestic banks**		**Foreign banks**		
No. of observations	9		27		27		
Variable definition	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**anova-Test[a]**
Inputs							
Fixed assets	24551.99	8854.61	6434.94	4143.47	12749.07	12664.92	*****
Labour	33281.50	20693.56	5677.74	3800.68	13265.29	14420.90	*****
Deposit	444180.00	311545.10	132254.60	80621.01	285865.70	257197.00	****
Outputs							
Loans	390073.00	320350.70	109892.40	77107.15	196945.20	191369.80	****
CSR	453.05	346.62	66.30	66.47	227.20	375.21	****
OEA	160972.90	94868.36	63392.06	36285.66	145099.70	127645.00	****
Other Variables							
Profit after tax	12559.72	19295.08	4405.60	4960.40	10996.30	13541.79	**
Total assets	680775.50	449776.20	213159.00	117431.20	412520.80	381086.40	****
Total equity	94873.55	58690.46	23293.63	28029.71	41456.03	35637.58	*****
ROA[b]	0.034	0.053	0.012	0.014	0.030	0.037	**
ROE[b]	0.304	0.467	0.107	0.120	0.266	0.328	**
NII	52814.98	40304.29	12970.45	9331.44	29063.28	29635.55	****
Leverage ratio[b]	21.22	6.73	39.02	18.76	29.65	12.32	****
CAR[b]	13.68	3.35	25.75	10.75	26.98	24.56	
Liquidity ratio[b]	0.0026	0.0016	0.0012	0.0010	0.0024	0.0051	
LTA	10.22	0.67	8.45	0.65	8.89	1.20	*****

Notes: Values are in thousands of Ghana cedis (GH¢). OEA is other earning assets, ROA is return on average assets, ROE is return on average equity, NII is net interest income, CAR is capital adequacy ratio and LTA is the log of total assets. *Significant at the 10% level; **Significant at the 5% level; ***Significant at the 1% level; ****Significant at the 0.1% level; *****Significant at the 0.01% level. [a]anova-test for statistical significance of differences among the means of the three ownership types. [b]Variables are not in monetary values but in ratios.

Table 7.3 Descriptive statistics for listed and non-listed banks

Bank Capitalisation Types					
	Listed banks			**Non-listed banks**	
No. of observations	18			45	
Variable definition	**Mean**	**Std. Dev.**	**t-Test**	**Mean**	**Std. Dev.**
Inputs					
Fixed assets	16030.25	9551.194	**	10008.71	11171.88
Labour	20742.74	19492.73	***	9725.022	12002.62
Deposit	393721.7	294282.3	****	182219.5	176004.6
Outputs					
Loans	298772.3	256959.8	****	142608.3	152708.6
CSR	312.6405	459.7212	**	141.6514	204.5515
OEA	188489.9	123853.4	*****	81893.65	73537.62
Other variables					
Profit after tax	18196.22	12741.94	*****	4474.597	9503.225
Total assets	591877.1	402484.6	****	274812.2	273333.6
Total equity	67816.06	51119.37	***	30698.08	34854.47
ROA[b]	0.0497978	0.034871	*****	0.0122457	0.0260076
ROE[b]	0.4405523	0.3084974	*****	0.1083353	0.2300844
NII	44487.74	34333.96	****	17988.14	21491.03
Leverage ratio[b]	30.92935	12.61359		33.07041	17.32501
CAR[b]	27.61481	30.00415		23.32766	10.10292
Liquidity ratio[b]	0.0014989	0.0013522		0.0020823	0.0040409
LTA	9.450999	1.111422	***	8.664332	1.004003

Notes: All variables are as defined in table 7.2.

[a]t-test for statistical significance of differences between universal and focus banks.

**Significant at the 5% level; ***Significant at the 1% level; ****Significant at the 0.1% level; *****Significant at the 0.01% level.

Table 7.4 Descriptive statistics for universal and focus banks

Bank Specialisation Types					
	Universal banks			**Focus banks**	
No. of observations	52			11	
Variable definition	**Mean**	**Std. Dev.**	**t-Test**	**Mean**	**Std. Dev.**
Inputs					
Fixed assets	11818.38	11454.44		11307.30	9027.23
Labour	13653.98	16269.55		9180.75	8231.91
Deposit	264073.40	250669.90		141367.90	83115.27
Outputs					
Loans	203624.60	214280.60		109708.30	63482.45
CSR	196.79	318.10		160.80	252.45
OEA	123196.50	107196.20	**	61073.92	48711.40
Other variables					
Profit after tax	9162.51	13154.12		4767.14	3931.48
Total assets	394861.20	367167.00		226141.30	141376.70
Total equity	43161.06	45520.43		32520.68	29808.18
ROA[b]	0.025	0.036		0.013	0.011
ROE[b]	0.222	0.318		0.115	0.095
NII	27624.96	30427.08		15795.23	9507.25
Leverage ratio[b]	33.31	16.53		28.45	13.47
CAR[b]	25.52	19.05		19.96	11.16
Liquidity ratio[b]	0.0019	0.0038		0.0019	0.0016
LTA	8.92	1.13		8.76	0.92

Notes: All variables are as defined in table 7.2.

[a]t-Test for statistical significance of differences between listed and non-listed banks.

**Significant at the 5% level; ***Significant at the 1% level; ****Significant at the 0.1% level; *****Significant at the 0.01% level.

It should be noted that the banks could also be distinguished as either focus or universal by virtue of their specialisation attributes, irrespective of their ownership structures. Until the Universal Banking Business Licence (UBBL) in 2003, most of the banks were focused on one thing at a time as commercial banks, development banks, and merchant banks. The objective was for these banks to serve the financial needs of specific sectors of the economy through the provision of funds to the disadvantaged households and small and medium-scale enterprises (Addison, 2003). Interestingly, from Table 7.4, two out of the first three banks to achieve the minimum capital requirement of GH¢7 million and to be given universal banking licence were listed banks. This appears to indicate that the bigger the bank the more likely it is to be listed and be socially responsible. Unlike the case of bank ownership and capitalisation types where initial indications of differences are found, from Table 7.4, it is yet to be found whether there are significant differences between universal and focus banks using their input and output variables. This nonetheless is the initial analysis. Further investigation is contained in the empirical section.

7.5 Empirical Results

7.5.1 Findings on Average Efficiency Scores

The analytical section here will construct the pooled metafrontier using the best-performing Ghanaian banks irrespective of group type. Hence, all banks face the same environment or technology and each bank's "metaefficiency" (ME) is estimated with respect to the metafrontier, where ME was given in the methodology chapter as $\phi_j^M\left(x_j, y_j\right) \geq 1$. The efficiency score of each bank relative to its subgroup-specific frontier is also estimated resulting in the subgroup efficiency (GE) where GE was given in the methodology chapter as $\phi_j^k\left(x_j, y_j\right) \geq 1$. The technology gap ratio (TGR) is computed according to equation (24). Note that all equations are consistent for each specific bank but not necessarily so for the univariate summary measures given in Table 7.5.

The subgroup frontier analysis assumes that although the banking subgroups (e.g. state, private-domestic and foreign banks) face identical legal and regulatory environment, they could have distinct characteristics, organisational forms and different objectives. Accordingly, estimating efficiency relative to the subgroup frontiers may help disentangle the bank-specific effects on performance and reveal differential information about each banking subgroup. This also creates the opportunity to obtain the potential TGR (Battese et al., 2004) or the metatechnology ratios which is the would-be increase in outputs of a bank for emulating the best-practice metatechnology (O'Donnell et al., 2008). The TGR can also be seen as the difference in the technology accessible to a bank in one subgroup relative to the technology accessible to all banks pooled together (O'Donnell et al., 2008). Note that the ME or the GE scores are the overall technical efficiency scores (OTE), i.e. the efficiency measure under the CRS assumption. The reason is to make the metafrontier approach comparable to the GFD, which unlike under VRS, avoids LP infeasibilities when the mixed-period efficiency scores are estimated relative to the CRS (cf. Grifell-Tatjé and Lovell, 1995; 1999; Ray and Desli, 1997; Balk, 2001).

Table 7.5 presents the summary statistics of the output-oriented technical efficiency scores measured relative to each subgroup-specific frontier and relative to the metafrontier. The descriptive statistics are geometric means instead of arithmetic mean (cf. Roberts, 1990; Fleming and Wallace, 1986), the coefficient of variation (CV) and the maximum values which indicates the least efficient banking observation. The CV is just the standard deviation divided by the geometric mean (henceforth average or mean). The table is split into 3 parts, A, B and C, each part representing the summary of efficiency scores of the ownership, specialisation and capitalisation types respectively. Columns 2 and 3 show the metaefficiency (ME) and the group efficiency (GE) results respectively whilst column 4 summarises the TGR result for each banking subgroup. The TGR reflects the technology differentials caused by different specialisation features, different ownership structures and different capitalisation characteristics of the banking subgroups. Notice that overall, each subgroup's average GE is relatively more efficient (i.e. closer to one in the output-oriented efficiency score) than the ME suggesting that the individual subgroup frontiers coincide with or are enveloped by the metafrontier, a phenomenon proven by Elyasiani and Mehdian (1992). It is important adding that since the GE scores are estimated relative to separate frontiers, the scores cannot be directly compared across banking subgroups.

Yet, *within* each group, interesting findings can be gathered. From the average GE scores in the table, it can be seen that, to be efficient, the average state (private-domestic or foreign) bank should increase all output production to 105% (124% or 127%) of what it is currently producing using the technology frontier defined by the best-practice state banks in Ghana. Corresponding average values for focus and universal banks are 101% and 136% and respective values for listed and non-listed banks are 108% and 145%.

Table 7.5 Summary statistics of GE and ME measures of Ghanaian banks

PART A	**Metaefficiency (ME)**	**Group Efficiency (GE)**	**TGR**
State banks			
Geomean	1.645	1.047	1.571
CV	0.234	0.055	0.222
Max	2.261	1.145	2.081
Domestic banks			
Geomean	1.362	1.235	1.103
CV	0.367	0.316	0.108
Max	2.826	2.516	1.441
Foreign banks			
Geomean	1.389	1.272	1.092
CV	0.325	0.307	0.087
Max	2.557	2.263	1.379
PART B	**Metaefficiency (ME)**	**Group Efficiency (GE)**	**TGR**
Focus banks			
Geomean	1.669	1.097	1.521
CV	0.370	0.109	0.264
Max	2.826	1.276	2.222
Universal banks			
Geomean	1.362	1.354	1.006
CV	0.299	0.303	0.024
Max	2.557	2.557	1.147
PART C	**Metaefficiency (ME)**	**Group Efficiency (GE)**	**TGR**
Listed banks			
Geomean	1.319	1.082	1.219
CV	0.190	0.165	0.110
Max	1.944	1.652	1.454
Non-listed banks			
Geomean	1.45	1.446	1.003
CV	0.359	0.356	0.009
Max	2.826	2.813	1.047

Also, the relatively low GE score of 105% for the state banks (indicating high performance within them) coupled with the relatively low CV or dispersion (6%) for this GE score suggest that large similarities exist *within* the group of state banks, a finding which may lend support to the impact of knowledge spillovers within the state banking group. Kontolaimou and Tsekouras (2010) observed high technical efficiency and low dispersion for the cooperative bank type they studied, reflecting significant similarities among the cooperative banking firms identified and attributed it to knowledge spillover effects. The average private-domestic and foreign banks both showed relatively high output-oriented GE scores (more inefficiency) vis-à-vis high CV suggesting considerable variations within each of these two banking groups.

As aforementioned, however, the efficiency scores measured relative to each group-specific frontier are not comparable across different banking groups (O'Donnell et al., 2008). To ascertain if the common metafrontier was a reasonable choice for comparing efficiency scores, the study determines if the *rankings* and not the *levels* are maintained across frontiers (Kyj and Isik, 2008). In other words, focusing on the GE makes sense only if there is a significant difference between the rankings of the GE and ME scores. Following Kyj and Isik (2008) the nonparametric Spearman's rank correlation is used to test the null hypothesis that the rankings of the GE and the ME scores are identical. The results indicate a significantly positive correlation between the rankings of individual ME and GE scores based on ownership types (0.79), specialisation types (0.81) and capitalisation types (0.92) at the 1% level. Arguably, it is appears reasonable to base the rest of the discussion on the ME findings.

The ME findings assume that all banks - regardless of which group they belong to - operate under a pooled metatechnology frontier constructed by the best-performing banks and thus, the scores are comparable. Considering first, part A of Table 7.5, on average, to be efficient, private-domestic banks would have to increase all outputs by 36% whilst state banks would have to increase all outputs by 65% suggesting that private-domestic banks are on average more efficient than state banks. Frimpong (2010) measured the technical efficiency of Ghanaian banks in 2007 and did conclude that private-domestic banks were the most efficient, followed by foreign banks and finally, state banks. The finding that private-domestic banks outperform state banks is in line with that of Kumbhakar and Wang (2007) who noted that the 10 joint-equity-privately-owned Chinese banks outperformed the 4 wholly state-owned banks during 1993-2002 (see also Fries and Taci, 2005; Berger et al., 2005). This finding is consistent with the principal-agent theory where bank managers are given incentives to maximise shareholder value (Boycko et al., 1996; Figueira et al., 2009). A possible reason for the underperformance of state banks is the presence of bureaucracies, political interferences and capital market indiscipline (Altunbas et al., 2001a). Civil servants of state banks are likely to pay much attention to government matters and budget maximisation objectives to the possible neglect of increasing bank efficiency as indicated by the public choice theory (Otchere and Chan, 2003; Tabak and Tecles, 2010). Again, Ghanaian state banks might potentially have profound social goals and dimensions, since they might be recognised as a tool for achieving government social agenda. This is consistent with the social theory and agency view. This also might influence the efficiency scores, in the sense that state banks might provide banking services in “unprofitable” areas for financial inclusion and economy growth and developmental goals.

From Table 7.5, the average performance between private-domestic banks and foreign banks indicates that the former is slightly more efficient compared with the latter. The literature tends to report this particular finding in developed countries such as U.S. whereby foreign banks underperform domestic U.S. banks (Berger, 2007). For a developing country like Ghana, it will imply that the finding is consistent with the home field advantage hypothesis of Berger et al. (2000b) that posits that the parent institutions of foreign banks in a domestic country (like Ghana) might find it difficult to supervise and monitor their banks from afar. There may be communication difficulties, cultural and regulatory differences that might make it harder for foreign banks to operate efficiently in a host economy (Berger et al., 2000b).

Nevertheless, since most of the studies that indicate that foreign banks are less efficient compared with domestic banks are found in developed countries, the opposite result found here for the developing country, Ghana, should be taken with caution. Further insight into the result reveals that the difference in the efficiency estimates of private-domestic and foreign banks is quite small (about 3%) for it to be generalised. Additional understanding into the result can be achieved by examining the TGR for private-domestic and foreign banks. The averages of the estimated TGR for state, private-domestic and foreign banks are 157%, 110% and 109% respectively. The TGR for private-domestic and foreign banks shows only 1% difference making it difficult to generalise that foreign banks are completely more technologically advanced than the private-domestic banks. Recall that the TGR indicates the position of the group-specific frontier relative to the metafrontier suggesting the relative technology available to banks in comparison with the potential technology. It could be that foreign banks rather perform better than private-domestic banks as evidenced in the literature (Havrylchyk, 2006; Berger et al., 2010). It could also be that the two banking groups are equally efficient.

To buttress this, the two-sample Wilcoxon rank-sum (Mann-Whitney) test, U (Wilcoxon, 1945; Mann and Whitney, 1947) is adopted to test for the difference between the efficiency scores of private-domestic and foreign banks as recommended by Brockett and Golany (1996). The null hypothesis is that the two banking groups have the same distribution of efficiency estimates. The test is a nonparametric equivalent of the independent samples t-test and it is utilised here because the efficiency estimates are not normally distributed and the theoretical distribution of efficiency estimates is not generally known with certainty. The result of the Wilcoxon Mann-Whitney test indicates no significant difference (U=713; p-value=0.613 > α=0.05) between the efficiency estimates of private-domestic and foreign banks. It is therefore safe to conclude that none of the two banking groups on average outperforms the other. Vander Vennet (1996) examined the performance effects of 492 mergers and acquisitions between European Commission credit institutions in the period 1988-1993 and reported that domestic and foreign banks showed signs of similar efficiency levels.

Regarding state banks, the average estimated TGR of 157% suggests the presence of substantial technology gap. The average TGR of 157% implies that even if the average state bank was counted as one of the efficient banks defining the state-banking frontier, it should still be possible to expand output production by 57% by borrowing the metatechnology. The implication of this finding coupled with the finding in Table 7.6 that there is only 1 (7%) efficient state bank among the best-performing banks on the metafrontier, suggests that the state banking frontier is on average more distanced from the metafrontier than the frontiers of the other two ownership banking groups. Comparatively, there are 6 (43%) private-domestic and 7 (50%) foreign banks defining the metafrontier. Besides, 67% of all the leading private-domestic banks and 78% of all the leading foreign banks are also heading the entire banking sector. In this case, the foreign banks are the leaders rather than the private-domestic ones. But the state banking firms are followers. Based on the discussion, the research question 3a posed in the introductory chapter that asked “are foreign banks on average more efficient than private-domestic and state banks?” can be answered. It is reasonable to speculate that both private-domestic and foreign banks are on average more efficient (on average located closest to the metafrontier) than state banks. Foreign banks on average are equal in performance relative to private-domestic banks.

Next is the discussion on bank specialisation types. Part B of Table 7.5 summarises the average ME results of focus and universal banks. To be efficient, the average focus bank would have to expand all output production to 167% of what it is currently producing given the input levels. Conversely, to be efficient, the average universal bank has to increase all output production to only 136% utilising the available inputs. Therefore, the average universal bank appears to be more efficient than the average focus bank. Further interesting insight into the analysis can be gained by comparing the drivers of the metaefficiency score, particularly, the technology gap ratio, TGR. The means of the estimated TGR for focus and universal banks are 152% and 100% respectively which show that the average TGR is the key driver of metaefficiency of the average focus bank and not the GE score.

The average estimated TGR of 152% for focus banks shows the presence of bigger technology gap for this group suggesting that, had the average focus bank been part of the leading banks within the focus-banking group, it would still have had to increase output production by 52% via the pooled metatechnology.

Table 7.6 Efficient banks on the metafrontier and the group frontiers

	N	Banks on GF[1]	Banks on MF[2]	%[3]	%[4]
Ownership types					
State banks	9	4	1	7	25
Private-domestic	27	9	6	43	67
Foreign banks	27	9	7	50	78
All	63	22	14	100	64
Specialization types					
Focus banks	11	5	2	14	40
Universal banks	52	12	12	86	100
All	63	17	14	100	82
Capitalization types					
Listed banks	18	10	2	14	20
Non-listed banks	45	12	12	86	100
All	63	22	14	100	64

Notes: N is the total number of banking observations per group. [1]The number of banks defining the group frontier (GF). [2]The number of banks defining the metafrontier (MF). [3]The percentage of group-specific banks on the MF relative to total banks on MF. [4]The percentage of group-specific banks on the MF relative to total banking observations on GF.

From Table 7.6, only 14% out of the 14 banks that define the metafrontier (i.e. have efficiency score of 1) are focus banks; the remaining 86% are universal banks. Besides, a whole 100% of all the leading universal banks also constructed the metafrontier for the entire banking market. The universal banking group appears to create the whole technological paradigm and shape the technological trajectories of the entire banking sector (Dosi, 1993; Kontolaimou and Tsekouras, 2010). Accordingly, the focus-banking frontier is on average more distanced from the metafrontier compared with the universal banking frontier whose greater part coincides with the metafrontier.

From the present analysis of bank specialisation types, Ghanaian banks that diversify into several areas of operations relatively outperform their more specialist peers given that both share the same technology. The research question 3b posed in the introductory chapter that asked "are universal banks on average more efficient than focus banks?" is answered in the affirmative. The finding is consistent with that of Vander Vennet (2002) who reported on 2,375 EU banks that financial conglomerates were more cost-revenue-and-profit efficient than their more non-universal competitors likely because of the ability of the former to handle moral hazards through monitoring. The result agrees with the related literature in both developing and developed nations (Landskroner et al., 2005; Hauner and Peiris, 2008; Chronopoulos et al., 2011). At this stage, it is reasonable to remark that based on the results of bank specialisation types, universal banks are on average relatively more managerially efficient and more technologically advanced compared with focus banks. The finding appears to be consistent with the introduction of the universal banking policy adopted by banks in the first place. This banking type should therefore be encouraged.

From part C of Table 7.5, the mean metaefficiency score for listed banks is 132% indicating that they should increase output production by 32% using the global knowledge represented by the metatechnology whilst the average non-listed bank's ME score of 145% implies that it should expand output production by 45%. This implies that listed banks outperform non-listed banks. Ray and Das (2010) applied DEA to evaluate the cost and profit efficiency of 71 Indian banks and observed that listed banks were more profit-efficient than non-listed banks. The authors remarked that listed banks are expected to be well-capitalised and expected to put in more effort to maximise shareholder value and hence become more efficient than non-listed banks. Being listed on the stock market can openly enforce supplementary disclosure and corporate governance norms for enhanced market discipline (cf. Yildirim and Philippatos, 2007; Ray and Das, 2010).

It is important to account for the potential unobserved technological differences so that the analyst doest not wrongly attribute the impacts of group-specific heterogeneity to inefficiency (Kounetas et al., 2009). To make an informed statement on the full picture, the discussion on the ME estimates should be made in conjunction with the GE score and the estimated TGR. The average ME score for non-listed banks can be traced from the GE score of 145% and then from the TGR of 100% whilst corresponding values for the average listed banks are 108% and 122%. Notice that the average estimated TGR for listed banks is the main source of their “meta-inefficiency”. Examining the mean TGR for each bank capitalisation type reveals the presence of high technology gap for the average listed bank implying that, had the average listed bank been among the efficient banks within the listed banking group, it would have further expanded output production by 22% using the global metatechnology. Recognising from Table 7.6 that only 14% of the 14 leading banks are listed banking leaders suggests that the metafrontier is almost completely defined by the 12 global leading non-listed banks. Again, 100% of all the leading non-listed banks within that group also defined the metafrontier for the entire banking sector. Consequently, the non-listed banking group appears to define the entire technological paradigm and describe the technological trajectories of the entire banking sector made up of the two banking capitalisation groups (Dosi, 1993; Kontolaimou and Tsekouras, 2010). This finding implies that if the standard DEA approach had been used instead of the metafrontier analysis here (which has helped determine the source of the ‘meta-inefficiency’ of listed banks as being the unobserved technological differences), the effects of heterogeneity might wrongly be attributable to inefficiency (Kounetas et al., 2009).

In the case of non-listed banking groups, the average GE score is reflected in the high inefficiency of the ME score. There is comparatively high mean GE score of 145% (indicating greater inefficiencies) coupled with high coefficient of variation (0.356) in this GE score for the average non-listed bank. It can therefore be inferred that within the non-listed banking group, there are appropriability conditions (Cohen and Levinthal, 1989) but the knowledge or technology spillovers from the best-performing banks are yet to become publicly available to and be exploited by other banks in the industry (cf. Kontolaimou and Tsekouras, 2010).

The overall empirical finding on the ME indicates that listed banks on average outperform non-listed banks. The finding from the TGR coupled with the knowledge that 100% of all the efficient banks within the non-listed banking group also shaped the metafrontier provides further information that, on average, a greater part of the non-listed banking frontier is tangent to the metafrontier. In short, it appears listed banks are more efficient but less technologically advanced compared with non-listed banks. The research question 3c at the introductory chapter concerning whether listed banks on average outperform non-listed banks is answered in the affirmative.

7.5.2 Findings on the Global Frontier Differences (GFD)

The previous section evaluated the average performance of Ghanaian banks using the metafrontier analysis. This is a growing practice in the banking efficiency literature. To boot, the present analysis determines the best-practice or frontier differences between Ghanaian banking groups. The GDF technique used here is an alternative means of gaining insight into the frontier differences of different banking groups and exploring whether the frontiers overlap or one frontier is better than the another frontier. This is novel as it is the first application of the GFD since the original study by Asmild and Tam (2007).

In computing the GFD, the analysis here adopts the constant returns to scale (CRS) technology assumption as in the previous section. As aforementioned in the methodology chapter, Grifell-Tatje and Lovell (1995) used a straightforward algebra to demonstrate that, in practice, the Malmquist index estimated under VRS technology departs from the average product definition of total factor productivity.

Coelli and Rao (2005) upheld the CRS assumption emphasising that it is important to impose CRS upon any technology that is employed to estimate efficiency scores when calculating the Malmquist index or other related indices; if not, the resulting measures may not correctly reflect the productivity changes resulting from scale economies. In order to avoid LP infeasibility problems associated with calculating cross-period efficiency scores, the CRS technology is employed in this empirical analysis (cf. Ray and Mukherjee, 1996; Ray and Desli, 1997; Grifell-Tatje and Lovell, 1999; Balk, 2001).

The estimation of the GFD is based on equation (30) of the methodology chapter. Table 7.7 shows the technology indices (TI) for state banks, private-domestic banks and foreign banks. Note that TI^s is the technology frontier for state banks (where state is represented by the superscript "s" attached to TI) and describes the geometric mean of the estimated output-oriented efficiency scores of all observations relative to the "state technology frontier". Similar definitions are used for TI^d and TI^f for private-domestic and foreign technology frontiers respectively.

The last three rows of the last four columns show the geometric means of the efficiency scores of the 63 observations measured relative to each bank-group-specific frontier. The ratios of these means indicate the respective GFD observed between the frontiers of private-domestic and state banks (TI^d/TI^s), between the frontiers of foreign and private-domestic banks (TI^f/TI^d) and between the frontiers of foreign and state banks (TI^f/TI^s). Note that when the output-oriented efficiency scores of all observations are estimated against a group-specific frontier, the mixed-period efficiency scores can be >=<1 indicating inefficient, efficient or super-efficient scores respectively.

The GFD findings are presented in the last row of the last three columns of Table 7.7. The GFD between the private-domestic banking frontier and the state banking frontier (TI^d/TI^s) is 2.074, reflecting worse than average output-oriented efficiency scores (1.202) for private-domestic banks compared with state banks (0.579). Consequently, the frontier for the private-domestic banks is on average 107.4% better than the frontier for the state banks. Also, the GFD between the foreign banks and the state banks (TI^f/TI^s) is 2.132 indicating that the best-practice foreign banks are on average 113.2% better than the best-practice state banks.

A likely explanation for the better frontier of foreign and private-domestic banks than the frontier of state banks is that the former possess better technology and marketing skills, better access to capital and better risk management methods. They also tend to provide better salaries and hence attract highly motivated manpower (Isik, 2008). Since both foreign and private-domestic banks are privately-owned, arguably, the competition generated by the entry of foreign banks (particularly foreign Nigerian banks) into the Ghanaian banking industry may have motivated private Ghanaian banks to appropriate the possible benefits of the technology spillovers and thereby operate on a similar frontier with the foreign banks.

From Table 7.7, the GFD between foreign banks and private-domestic banks is 1.028 indicating that the best-performing foreign banks are on average more or less equal to the best-performing private-domestic banks. The result is consistent with both the *global advantage hypothesis* and the *home field advantage hypothesis* of Berger et al. (2000b). A possible explanation for this finding is that in developing economies like Ghana, foreign banks could be technologically advanced in gathering and assessing “hard” quantitative information (Berger et al., 2005). Private-domestic banks could also use their ability to absorb the diffusion of technology (brought about by the entry of foreign banks) using automated teller machines, telephone banking, internet banking and other forms of financial innovation. Both private-domestic and foreign banks tend to use more advanced technologies which potentially help them to operate on similarly advanced frontiers.

The GFD findings support the results of the metafrontier analysis obtained in the previous section, particularly, the TGR results. This is not surprising since both the TGR and the GFD consider gaps between frontiers. In both cases, the outcomes are similar. Additionally, they both outperform state banks in terms of best-practice gap or frontier differences. A possible explanation for this is that private-domestic and foreign banks in Ghana spread their best-practice policies and use more advanced technologies (Berger et al., 2000b).

The research question 4 (RQ4) posed at the introductory chapter that asked "are the frontiers of foreign banks on average better than the frontiers of private-domestic/state banks" can be answered. The findings here suggest that on average, the frontiers of both foreign and private-domestic banks are more or less equal but they are both on average better that the frontier of state banks.

Table 7.8 shows the technology indices for focus banks (TI^f) and universal banks (TI^u) and the technology indices for listed banks (TI^l) and non-listed banks (TI^{nl}). TI^f denotes the geometric mean of the estimated output-oriented efficiency scores of all banks with respect to focus banking frontier. The technology indices (TI^u, TI^l, TI^{nl}) of the other banking groups are defined similarly. The last three rows of the last four columns show the geometric means of all the 63 observations measured against each group-specific frontier. The table also depicts the respective ratios of the means (indicating the respective GFD) calculated between the frontiers of universal and focus banks (TI^u/TI^f), and non-listed banks and listed banks (TI^{nl}/TI^l).

Table 7.7 Technology indices, their ratios and GFD of bank ownership types

Bank	$\mathbf{TI^s}$	$\mathbf{TI^d}$	$\mathbf{TI^f}$	**Bank**	$\mathbf{TI^s}$	$\mathbf{TI^d}$	$\mathbf{TI^f}$
ADB06	1	0.59	0.684	MBG07	0.665	1.172	1.162
AMAL06	0.793	2.516	2.204	NIB07	1	1.649	1.977
BBG06	0.685	1.187	1.143	PBL07	0.304	1.201	0.931
CAL06	0.477	1.098	1.2	SCB07	0.533	1.158	1.073
EBG06	0.437	1.375	1.258	SGSSB07	0.986	1.626	1.511
FAMB06	0.331	1	0.711	STANB07	0.473	0.862	1
FB06	0.162	1	0.725	TTB07	0.402	1	0.607
GCB06	1.145	1.585	1.509	UBA07	0.743	1.917	1.599
GTB06	0.657	1.521	1.336	UGL07	0.973	1.823	2.416
HFC06	0.539	1.032	1.211	ADB08	1	1.198	1.517
IBG06	0.282	0.298	1	AMAL08	0.515	1.701	1.373
ICB06	0.315	0.694	1	BBG08	1.059	1.688	1.652
MBG06	0.696	1.235	1.324	CAL08	0.73	1.062	1.269
NIB06	1.123	1.794	2.114	EBG08	0.446	0.802	1
PBL06	0.527	1.235	1.173	FAMB08	0.205	1	0.518
SCB06	0.393	0.972	1	FB08	0.425	1.087	1.002
SGSSB06	0.076	0.35	1	GCB08	1	1.156	1.144
STANB06	0.599	1.245	1	GTB08	0.197	0.913	1
TTB06	0.943	1.269	1.105	HFC08	0.643	1	1.129
UBA06	1.107	2.185	2.263	IBG08	1.114	1.925	1.988
UGL06	0.87	1.862	1.975	ICB08	0.628	1.146	1.225
ADB07	1.09	1.18	1.526	MBG08	0.9	1.222	1.114
AMAL07	0.729	1.756	1.545	NIB08	1.028	1.606	1.877
BBG07	0.764	1.378	1.525	PBL08	0.482	1.232	1.283
CAL07	0.457	1.112	1.175	SCB08	0.665	1.405	1.019
EBG07	0.447	1.324	1.179	SGSSB08	1.119	1.699	1.88
FAMB07	0.375	1	0.794	STANB08	0.636	1.219	1.428
FB07	0.255	1	0.895	TTB08	0.465	1	0.646
GCB07	1.053	1.37	1.259	UBA08	0.358	1.403	1.212
GTB07	0.76	2.403	2.234	UGL08	1.209	1.961	2.826
HFC07	0.506	1	1.084	**Geomean**	**0.579**	**1.202**	**1.235**
IBG07	0.329	0.505	1		$\mathbf{TI^d/TI^s}$	$\mathbf{TI^f/TI^d}$	$\mathbf{TI^f/TI^s}$
ICB07	0.586	0.976	1.103	**GFD**	**2.074**	**1.028**	**2.132**

Notes: TI^s, TI^d, TI^f are technology indexes relative to state banks' frontier, domestic banks' frontier and foreign banks' frontier respectively.

Table 7.8 TI and GFD of bank specialization and capitalization types

Bank	TI^f	TI^u	TI^l	TI^{nl}	Bank	TI^f	TI^u	TI^l	TI^{nl}
ADB06	1	0.684	0.671	1	MBG07	0.924	1.29	0.996	1.29
AMAL06	1.565	2.518	2	2.518	NIB07	1.154	2.081	1.615	2.075
BBG06	0.963	1.254	0.935	1.345	PBL07	1	1.285	0.841	1.256
CAL06	0.766	1.27	1.005	1.252	SCB07	0.703	1.2	1	1.2
EBG06	0.935	1.426	1.114	1.429	SGSSB07	1.078	1.697	1.348	1.697
FAMB06	0.503	1	0.578	1	STANB07	0.64	1	0.687	1
FB06	0.499	1	0.621	1	TTB07	1	0.631	0.465	1
GCB06	1.27	1.583	1.351	1.586	UBA07	1.052	1.933	1.399	1.933
GTB06	0.809	1.521	0.999	1.521	UGL07	1.276	2.416	1.823	2.307
HFC06	0.736	1.321	1.032	1.309	ADB08	0.846	1.541	1.149	1.541
IBG06	0.266	1	0.267	1	AMAL08	1.087	1.701	1.225	1.701
ICB06	0.4	1	0.522	1	BBG08	1.168	1.777	1.438	1.777
MBG06	0.901	1.421	1.168	1.421	CAL08	0.788	1.389	1	1.389
NIB06	1.169	2.261	1.746	2.261	EBG08	0.456	1	1	0.835
PBL06	1	1.391	1.067	1.391	FAMB08	0.401	1	0.454	1
SCB06	0.608	1.01	1	1.01	FB08	0.601	1.113	0.894	1.113
SGSSB06	0.243	1	1	0.35	GCB08	0.911	1.383	1	1.383
STANB06	0.915	1.22	0.85	1.29	GTB08	0.497	1	0.699	1
TTB06	1	1.287	1.001	1.287	HFC08	0.591	1.146	1	1.146
UBA06	1.052	1.933	1.927	2.557	IBG08	1.378	2.209	1.786	2.209
UGL06	1.237	2.149	1.647	2.142	ICB08	0.809	1.274	1.051	1.274
ADB07	1.022	1.75	1.064	1.761	MBG08	0.95	1.326	0.971	1.326
AMAL07	1.389	1.805	1.356	1.805	NIB08	1.016	1.983	1.564	1.983
BBG07	0.972	1.595	1.243	1.595	PBL08	0.958	1.459	1.206	1.417
CAL07	0.748	1.253	1	1.239	SCB08	0.936	1.378	1	1.405
EBG07	0.931	1.329	1.083	1.329	SGSSB08	1.022	1.944	1.653	1.944
FAMB07	0.472	1	0.723	1	STANB08	0.819	1.467	1.159	1.472
FB07	0.491	1.04	0.701	1.04	TTB08	0.747	1	0.558	1
GCB07	1.099	1.59	1.094	1.59	UBA08	0.713	1.403	1.009	1.403
GTB07	1.333	2.462	1.737	2.431	UGL08	1.272	2.826	1.961	2.813
HFC07	0.693	1.174	1	1.174	**Geomean**	**0.813**	**1.38**	**1.013**	**1.38**
IBG07	0.373	1	0.462	1			**TI^u/TI^f**		**TI^{nl}/TI^l**
ICB07	0.668	1.103	0.747	1.265	**GFD**		**1.698**		**1.362**

Notes: TI^f is technology index relative to focus banks' frontier; TI^u is technology index relative to universal banks' frontier; TI^l is technology index relative to listed banks' frontier; and TI^{nl} is technology index relative to non-listed banks' frontier.

The GFD between universal and focus banking frontiers is estimated to be 1.698 indicating that the frontier for the universal banks is on average 69.8% better than the frontier for the focus banks. This is consistent with the TGR findings related to bank specialisation type since both the TGR and GFD determine best-practice gaps. Prior studies generally investigate average performance but the approach adopted in this study does not only examine average performance and technology gaps but also the frontier differences between banking groups. Overall, the findings concerning bank specialisation types based on the GFD (and the TGR in the previous section) suggest that it makes sense to adopt universal banking since the best-performing universal banks on average tend to be better than the best-performing focus banks. A possible reason might be the technological advances pursued by universal banks that generate diversified products and services and use various financial innovations such as derivatives and securitisations as compared with focus banks.

The result presented in the last row of the last column of Table 7.8 shows the GFD between listed banks' frontier and non-listed banks' frontier. The technology index of listed banks (TI^{l}) which is 1.013 represents the geometric mean of the efficiency estimates of all banks measured against the listed banking frontier. Similarly, TI^{nl} depicts the geometric mean of the efficiency scores of all banks measured against non-listed banking frontier. The ratio of the two geometric means, the GFD, between non-listed banks and listed banks is 1.362 indicating that the best-practice non-listed banks are on average 36.2% better than the best-practice listed banks. Once again, the consistency between this finding and the finding of the average TGR based on bank capitalisation types is not coincidental since both the TGR and the GFD evaluate best-practice gaps. The GFD result is different from the average ME result, which showed that listed banks outperformed non-listed banks. The difference in the ME compared with the GFD finding is due to the idea that the technical efficiency measured relative to the metafrontier does not consider frontier gaps directly whereas the GFD does. Still, the TGR revealed considerable technology gap between the listed banking frontier and the metafrontier. A possible reason for the better frontier of non-listed banks relative to that of listed banks may be attributable to a recent report by Osei (2002)who examined the weak-form efficient market hypothesis in the case of the Ghana Stock Exchange but rejected the random walk hypothesis indicating that the GSE is weakly inefficient. The GSE is probably yet to fully mature to take advantage of the possible financial innovations that can make the frontier of those banks listed on it appear better.

7.6 Conclusions and Policy Recommendations

The Ghanaian banking sector has seen the introduction of the Universal Banking Business Licence in 2003, the increase in banks' minimum capital requirement, the allowance of the entry of foreign banks and the listing of banks on the GSE. These are regulatory changes designed to "encourage a more competitive, 'product innovation' and dynamic banking system capable of effective intermediation on the scale needed to support growth in an expanding economy" (BOG, 2006; 2004, p. 47). Using two alternative techniques, this chapter has investigated both the average metaefficiency and global frontier differences between different Ghanaian banking groups during the 2006-2008 periods.

To compare banking groups' average performance, the metafrontier analysis of O'Donnell et al. (2008) was used to measure the efficiency score of banks assuming that they all belong to the same metatechnology. And to account for banking group-specific heterogeneity, the TGR was estimated. The GFD of Asmild and Tam (2007) was adopted as an alternative approach, useful for drawing conclusions about best-practice differences between different banking subgroups. From a methodological viewpoint, using the GFD to estimate the distances between Ghanaian banking groups has undoubtedly provided additional and important information by supporting and strengthening the findings from the metafrontier analysis, particularly, the TGR. It is important that both approaches have been applied to the data set. If only the metafrontier analysis had been applied without support from an alternative technique, the findings and the conclusions may be challenged. A comparative analysis of alternative nonparametric methods applied on the same data set has strengthened the overall conclusions.

The conclusion emerging from bank ownership types is that foreign and private-domestic banks are equally good in terms of average performance and technological advancement suggesting that the benefits of Ghanaian banking privatisation go hand in hand with the benefits experienced by foreign banks. Both banking groups are on average more efficient and more technologically advanced than state banking group. Moreover, foreign banks' frontier is on average more or less the same as private-domestic banks' frontier. The best-performing banks in both banking groups are on average better than the best-performing state banks, a finding which is in line with the agency theory hypothesis that says that private firms tend to be better compared with public firms by virtue of capital market discipline (Fama, 1980a). Speculating on this result, it is argued here that in order to be among the best-performing banks that define the Ghanaian banking frontier, managers of state banks should emulate private banks and appropriate the possible benefits of technological spillovers from them. Managers of state banks should train their staff in areas of information technology and marketing research, ensure proper business ethics and properly manage undue bureaucracies and political interferences. A possible policy recommendation that can be drawn from the result is that the government and the Bank of Ghana should continue to open up the Ghanaian banking industry not only to foreign competition but also to private-domestic competition in order to improve overall efficiency and innovative practices in the industry.

Regarding bank specialisation types, the empirical finding suggests that on average, Ghanaian universal banks are relatively more managerially efficient and technologically advanced than focus banks. Possible technological heterogeneity reflecting differences among group characteristics are disentangled by the estimation of the TGR suggesting that the greater part of the focus banking frontier is situated away from the global metafrontier. Also, the best-practice universal banks are on average better than the best-practice focus banks. The introduction of the universal banking policy by the Bank of Ghana may be a first step in the right direction. Policy measures should be designed not only to encourage the sustainability of the UBBL in Ghana but also to ensure that the banking firms are indeed offering the full diversity of products and services and do not resort to the focus banking activities.

Finally, the result obtained from the bank capitalisation types implies that listed banking firms on the Ghana Stock Exchange are more efficient but less technologically advanced compared with non-listed banking firms. Besides, the best performing non-listed banks are on average better than that the best performing listed banks. Possible policy recommendations that can be drawn here are that the central Bank of Ghana should liaise with the supervisory body of the GSE (i.e. the Securities and Exchange Commission) to devise policy measures for a well-functioning capital market since capital market efficiency can trickle down to the banking sector.

Chapter 8

Decomposing Malmquist Indices into Favourability and Favourability Change Indices

8.1 Introduction

The methodology chapter examined the DEA-based Malmquist index that estimates productivity over time. Section 5.8 of that chapter decomposed the Malmquist index into the catching-up or efficiency change (EC) component and the frontier shift or technical change component (Färe et al., 1992; Färe et al., 1994c). Section 5.10 of that chapter introduced the global Malmquist index and its decomposition into the global efficiency change and the global frontier shift (GFS) as proposed by Asmild and Tam (2007). The indices are useful when making statements about productivity changes of a population as a whole, rather than individual observations. The GFS provides a better estimation of the true frontier shift ‘especially for sparsely populated’ data set ‘and for frontiers that change shape over time’ compared with the frontier shift of the traditional Malmquist productivity change index (Asmild and Tam, 2007, p. 137). The GFS is also useful for measuring group differences and not just changes over time. This aspect was demonstrated in the previous chapter to estimate the frontier differences between Ghanaian banking groups by investigating the impact of bank capitalisation, ownership and specialisation on performance.

The present chapter proposes a novel application of the newly-decomposed Malmquist index into EC, GFS, local favourability index and the local favourability change index (Asmild and Tam, 2005) as discussed in section 5.11 of the methodology chapter . This is novel in the sense that by computing the favourability and favourability change, the drivers of the Malmquist index could become more revealing. It should be possible to determine whether the deviations from the GFS are attributable to banks' favourable location in the technology set (i.e. whether a bank is in a location with larger than average frontier shift) and whether the bank or banking group is moving towards a more or less favourable locations over time. To pursue the analysis, the dataset is not pooled together as in the previous chapter. Dynamic performance analysis requires a balanced panel data. Therefore, to illustrate the efficacy of the newly decomposed Malmquist index a sample of 21 banks each from period 2006 to 2008 are used.

This chapter contributes both to methodology and to application of the favourability and the favourability change indices as components of the Malmquist index. The methodological contribution is that the study demonstrates the value of not only the GFS but also, the four-part components of the 'newly-decomposed' Malmquist index - efficiency change, global frontier shift and the indices of favourability and its change. Consequently, the study determines whether some Ghanaian banking subgroups are located in favourable positions. The intuition is that a particular bank can experience a (local) change, which is smaller or larger than the global change. If the local change is larger than the global change, then that bank is said to be in a favourable location in the technology set in which case the improvement potential is higher than the mean (Asmild and Tam, 2005). The opposite is true if the local change is smaller than the global change. At the application level, to the best of the authour's knowledge, this is the first time this type of analysis is undertaken in practice. The interesting aspect of the analysis for the evaluation of productivity change of Ghanaian banks is that it may help to investigate whether some banking subgroups, by adopting CSR practices, place themselves in more favourable locations in the technology set than others banking subgroups. Arguably, a particular bank, by being listed on the GSE, by becoming a universal bank or by having a greater percentage of foreign ownership, may experience a higher than average frontier shift (i.e. be located in a favourable position) and move towards more favourable locations over time. The chapter first uses DEA to measure the standard Malmquist index and its two-factor decompositions. Subsequently, the four-factor components of the 'newly-decomposed' Malmquist index is used to examine the productivity change of Ghanaian banking subgroups over time. The aim is a) to determine whether some individual banks and banking subgroups are in favourable locations and moving towards locations that are more favourable and b) to explore the association between banks' CSR contributions and their favourability and favourability changes.

8.2 Empirical Analysis of Ghanaian Banks: at Bank Level

8.2.1 Findings on Standard Malmquist index

The new decomposition of the Malmquist index into EC, GFS, local favourability index and the local favourability change index is illustrated on a data set of 21 Ghanaian banks for the periods from 2006 to 2008. The estimation of the standard Malmquist productivity change index (M) and its components is based on expression (21). Table 8.1 presents the indices for every pair of years for each bank. The last row of the table reports the geometric means (average) of the findings. Recall that values above 1 indicate improvements or progress whilst values below 1 reflect productivity deterioration or regress. From the table, the average productivity decline in 2006/07, 2007/08 and 2006/08 are 95.4%, 95.9% and 97.6%, driven mainly by efficiency decline, innovation decline and both efficiency and innovation decline respectively. Corresponding rates of productivity declines are 4.6%, 4.1% and 2.4%. During 2006/07, 2007/08 and 2006/08, 8, 14 and 9 out of 21 banks experienced productivity declines respectively. Accordingly, 6 more banks experienced productivity in during 2007/08 than in 2006/07. The productivity decline over the whole sample period (2006/08) was mainly due to 1.5% deterioration in efficiency and a slight 0.9% decline in innovation.

Focusing on individual banks' results reveals that AMAL had the biggest productivity growth of 50% during the 2006/07 period, majority of which was due to efficiency improvements other than the improvement in innovation. AMAL's efficiency change was the maximum during the 2006/2007 period indicating that this bank progressed very much in moving closer to the frontier. In that same period, SGSSB had the least productivity decline of 35.6% due to efficiency decline of 69% and innovation decline of 51.6%. During 2007/08, GTB saw the biggest productivity growth (126.7%). Further examination revealed that GTB had the biggest percentage increase in loans and advances (about 221%) and the largest percentage increase in other earning assets (about 577%) during the 2007/08 period. It however saw 33% percentage reduction in CSR. IBG had the lowest productivity change of 34.4% during period 2007/08. The source of productivity change for both GTB and IBG was efficiency change. Between 2006 and 2008, the highest and lowest productivity change was observed by banks UBA and SGSSB respectively. Productivity change was attributable to improvement in efficiency for UBA and decline in both efficiency and innovation for SGSSB.

Table 8.1 Malmquist productivity change index and its components

	2006/07			***2007/08***			***2006/08***		
Bank	**MI**	**EC**	**TC**	**MI**	**EC**	**TC**	**MI**	**EC**	**TC**
ADB	0.532	0.622	0.855	0.998	1.399	0.713	0.766	0.871	0.88
AMAL	1.499	1.416	1.058	1.094	0.986	1.11	1.517	1.397	1.086
BBG	0.838	0.67	1.251	0.89	1.034	0.861	0.757	0.693	1.094
CAL	1.007	1.062	0.948	0.931	1.039	0.896	1.044	1.103	0.947
EBG	1.084	0.999	1.086	1.282	1.169	1.096	1.59	1.168	1.361
FAMB	1.066	1	1.066	1.198	1	1.198	1.19	1	1.19
FB	0.819	1	0.819	0.945	0.985	0.959	0.88	0.985	0.893
GCB	1.128	0.926	1.218	1.16	1.323	0.877	1.349	1.225	1.101
GTB	0.588	0.812	0.724	2.267	1.873	1.21	1.42	1.521	0.934
HFC	1.217	0.92	1.323	0.891	1.087	0.82	1.127	1	1.127
IBG	1.005	1	1.005	0.344	0.525	0.657	0.298	0.525	0.569
ICB	0.769	1	0.769	0.877	0.99	0.885	0.718	0.99	0.725
MBG	1.099	0.848	1.295	0.96	0.992	0.967	1.04	0.842	1.235
NIB	1.089	1.009	1.079	1.03	1.176	0.876	1.203	1.187	1.014
PBL	1.196	1	1.196	0.914	0.877	1.041	0.944	0.877	1.076
SCB	0.892	0.933	0.957	0.86	0.791	1.087	0.79	0.738	1.071
SGSSB	0.356	0.69	0.516	0.79	0.853	0.927	0.394	0.588	0.67
STANB	1.258	1	1.258	0.751	0.881	0.853	1.062	0.881	1.206
TTB	1.485	1	1.485	0.852	1	0.852	1.396	1	1.396
UBA	1.266	1.52	0.833	1.391	1.269	1.096	1.682	1.929	0.872
UGL	0.879	0.91	0.966	0.813	1.185	0.686	0.922	1.079	0.855
Geomean	**0.954**	**0.949**	**1.006**	**0.959**	**1.038**	**0.924**	**0.976**	**0.985**	**0.991**

Further examination of individual banks reveals that during 2006/07, BBG experienced deterioration in efficiency of 67% but saw a technical progress of 125.1% resulting in overall productivity decline of 83.8%. In contrast, over the same period UBA improved productivity by 26.6% by increasing efficiency by 52% despite reducing innovation by 16.7%. The results appears to be consistent with that of Rezitis (2008) who studied the impact of acquisition activity on the efficiency and productivity of Greek banks during periods from 1993 to 2004 and observed productivity decline for merger banks during the period after merging.

The four banks that had the highest percentage increase in CSR from 2006 to 2007 and from 2007 to 2008 were UGL, EBG, HFC and UBA. Most of these banks had positive productivity growth over the whole period. UBA, the bank with the highest productivity growth during 2007/2008 period is one of these banks that contributed the greatest percentage increase in CSR. Conversely, SGSSB that contributed the lowest percentage increase in CSR experienced productivity decline in 2006/07 period. SGSSB had 55% decreases in the average percentage contribution to CSR during 2006/07 and 2007/08.

8.2.2 Bank Innovators

The analysis identifies those banks that shift the production frontier over time, what Fare et al. (1994c) called 'innovators'. Identifying the same innovators in every year could provide extra indication about those banks that invested in process or product innovation and hence defined the efficiency estimates of other banks. An innovator is identified by Fare et al. (1994c) as one having: $\left\{ \mathrm{TC}^{i} > 1;\ \phi_{o}^{t}\left(x^{t+i}, y^{t+i}\right) < 1 \text{ and } \phi_{o}^{t+i}\left(x^{t+i}, y^{t+i}\right) = 1 \right\}$, where TC^{i}

represents the technical change of the *i*th bank whilst the second and the third terms are the estimated output-oriented technical efficiency scores of the *i*th bank. The analysis identified FAMB, IBG, PBL, STANB and TTB as the innovators in period 2006/2007, EBG, FAMB and GTB as the innovators in period 2007/2008 and EBG, FAMB, HFC and TTB as the innovators in period 2006/2008. All these banks contributed to the frontier shift during each pair of years. But only FAMB determined the frontier in every pair of year. FAMB is therefore the major innovator on average.

8.2.3 Results of the Newly-Decomposed Malmquist Index

Tables 8.2, 8.3 and 8.4 present the findings for individual banks and their averages on the 'newly-decomposed' Malmquist index (M) broken down into efficiency change (EC), global frontier shift (GFS) and the proposed favourability (FI) and favourability change (FCI) indices for periods 2006/07, 2007/08 and 2006/08 respectively. The estimation of the M is based on expression (33) of the methodology chapter where GFS was given by expression (26), the favourability index by expression (31) and the favourability change index by expression (32). M>=<1 denotes productivity progress, stagnation and regress respectively. Recall that the GFS is the geometric mean of the output-oriented efficiency score of all DMUs in all time periods measured against period $t+i$ frontier divided by the geometric mean of the output-oriented efficiency score of all units in all time periods estimated against period t frontier. GFS>1 indicates that the frontier on average has improved from period t to period $t+i$. GFS<=1 indicates regress and no change respectively. In Table 8.2, GFS=1.07 during the 2006/2007 period is the ratio of the technology index for year 2007 (TI^{2007} =1.17) to the technology index for year 2006

(TI^{2006}= 1.10) where TI^{2007} indicates the geometric mean of the output-oriented efficiency scores of all banks in all time periods measured relative to 2007 frontier. GFS=1.07 indicates a mean frontier improvement of 7% from 2006 to 2007. The GFS is the same for each bank because it indicates the average frontier shift from one period to another for the whole banking industry.

Table 8.2 Newly-decomposed Malmquist index with its components (2006/07)

		2006/2007				
Bank	**M**	**EC**	**GFS**	**Old Favourability index**	**New Favourability index**	**Favourability change index**
ADB	0.532	0.622	1.067	0.553	1.161	1.450
AMAL	1.499	1.416	1.067	0.944	1.041	1.050
BBG	0.838	0.670	1.067	1.132	1.215	1.036
CAL	1.007	1.062	1.067	0.925	0.853	0.960
EBG	1.084	0.999	1.067	1.012	1.023	1.006
FAMB	1.066	1.000	1.067	0.642	1.553	1.556
FB	0.819	1.000	1.067	0.595	0.990	1.290
GCB	1.128	0.926	1.067	0.595	1.339	1.173
GTB	0.588	0.812	1.067	0.642	0.717	1.057
HFC	1.217	0.920	1.067	1.140	1.347	1.087
IBG	1.005	1.000	1.067	0.471	1.883	1.998
ICB	0.769	1.000	1.067	0.616	0.844	1.171
MBG	1.099	0.848	1.067	1.238	1.190	0.980
NIB	1.089	1.009	1.067	0.990	1.032	1.021
PBL	1.196	1.000	1.067	1.108	1.133	1.011
SCB	0.892	0.933	1.067	0.847	0.949	1.059
SGSSB	0.356	0.690	1.067	0.245	0.955	1.975
STANB	1.258	1.000	1.067	0.977	1.423	1.207
TTB	1.485	1.000	1.067	1.129	1.715	1.233
UBA	1.266	1.520	1.067	0.892	0.683	0.875
UGL	0.879	0.910	1.067	0.804	1.021	1.127
Geomean	**0.954**	**0.949**	**1.067**	**0.783**	**1.108**	**1.176**

In Table 8.3, GFS=0.94 during 2007/08 indicates that the frontier on average moves 6% backwards. The fact that this average frontier shift is not evenly distributed (reflecting non-Hicks neutral shift) is apparent from the values of individual banks' favourability where some have favourability index above 1 and others, below 1. For the whole 2006/08 period in Table 8.4, GFS=1 indicates that on average the frontier does not move at all during the period. This may be evident from the recognition that the frontier on average moves 7% forward during 2006/07 and then 6% backwards during 2007/08 and hence, over the entire period, the frontier barely moves.

Comparing the GFS for the pairs of years with the traditional aggregation obtained as the geometric mean of the individual frontier shifts (technical changes, TC) in Table 8.1 shows interesting differences. For instance, in 2006/07, the mean of the TC is 100% whilst the GFS is 107% reflecting a 7% more shift for the GFS. Corresponding values (TC and GFS) during 2007/08 are 92.4% and 93.8%, indicating 1.4% further shift in the case of the GFS. Respective values over the 2006/08 period are 99.1% and 100%, showing a 0.9% increase for the GFS. This trend where the GFS outperforms the geometric mean of the standard individual technical changes is caused by the fact that the computation of the GFS includes more data points (in our case, $n \times z = 21 \times 3 = 63$) than when computing the geometric mean of the individual frontier shifts (in our case, $n \times 2 = 21 \times 2 = 42$). Consequently, as shown in a simulation by Asmild and Tam (2007), the GFS provides a better measurement of the true frontier shift than the traditional aggregation via the geometric mean of the individual frontier shifts.

Table 8.3 Newly-decomposed Malmquist index with its components (2007/08)

		2007/2008				
Bank	**MI**	**EC**	**GFS**	**Old Favourability index**	**New Favourability index**	**Favourability change index**
ADB	0.998	1.399	0.938	0.706	0.819	1.077
AMAL	1.094	0.986	0.938	1.190	1.178	0.995
BBG	0.890	1.034	0.938	0.895	0.942	1.026
CAL	0.931	1.039	0.938	1.008	0.907	0.948
EBG	1.282	1.169	0.938	1.028	1.330	1.137
FAMB	1.198	1.000	0.938	0.813	2.007	1.572
FB	0.945	0.985	0.938	0.930	1.124	1.099
GCB	1.160	1.323	0.938	0.959	0.912	0.975
GTB	2.267	1.873	0.938	1.125	1.481	1.147
HFC	0.891	1.087	0.938	0.808	0.946	1.082
IBG	0.344	0.525	0.938	0.493	0.995	1.420
ICB	0.877	0.990	0.938	0.944	0.945	1.000
MBG	0.960	0.992	0.938	1.029	1.035	1.003
NIB	1.030	1.176	0.938	0.936	0.933	0.999
PBL	0.914	0.877	0.938	1.236	0.998	0.899
SCB	0.860	0.791	0.938	1.065	1.263	1.089
SGSSB	0.790	0.853	0.938	1.033	0.946	0.957
STANB	0.751	0.881	0.938	0.938	0.882	0.969
TTB	0.852	1.000	0.938	0.654	1.262	1.389
UBA	1.391	1.269	0.938	1.175	1.162	0.995
UGL	0.813	1.185	0.938	0.755	0.709	0.969
Geomean	**0.959**	**1.038**	**0.938**	**0.919**	**1.056**	**1.072**

Note that the efficiency changes of individual banks for the pairs of years in Table 8.1 are identical to the individual efficiency changes for the pairs of years in Tables 8.2, 8.3 and 8.4 for the ‘newly-decomposed’ Malmquist index. Hence, no further comment will be made on the efficiency changes as they have already been discussed.

Table 8.4 Newly-decomposed Malmquist index with its components (2006/08)

		2006/2008				
Bank	**MI**	**EC**	**GFS**	**Old Favourability index**	**New Favourability index**	**Favourability change index**
ADB	0.766	0.871	1	0.676	1.144	1.301
AMAL	1.517	1.397	1	0.948	1.243	1.145
BBG	0.757	0.693	1	1.167	1.024	0.937
CAL	1.044	1.103	1	0.919	0.975	1.030
EBG	1.590	1.168	1	1.018	1.818	1.337
FAMB	1.190	1.000	1	0.644	2.199	1.848
FB	0.880	0.985	1	0.766	1.041	1.166
GCB	1.349	1.225	1	0.968	1.251	1.137
GTB	1.420	1.521	1	0.820	1.062	1.138
HFC	1.127	1.000	1	0.944	1.345	1.193
IBG	0.298	0.525	1	0.267	1.211	2.131
ICB	0.718	0.990	1	0.647	0.813	1.121
MBG	1.040	0.842	1	1.168	1.304	1.057
NIB	1.203	1.187	1	0.952	1.078	1.064
PBL	0.944	0.877	1	1.129	1.024	0.952
SCB	0.790	0.738	1	0.861	1.329	1.242
SGSSB	0.394	0.588	1	0.336	1.336	1.996
STANB	1.062	0.881	1	1.188	1.223	1.015
TTB	1.396	1.000	1	1.136	1.714	1.228
UBA	1.682	1.929	1	0.960	0.791	0.908
UGL	0.922	1.079	1	0.866	0.843	0.986
Geomean	**0.976**	**0.985**	**1**	**0.826**	**1.188**	**1.199**

Recall that the (old) favourability index greater (less) than 1 implies that at the given time period $\left(x^t, y^t\right)$, the bank is located in a favourable (unfavourable) position. Similarly, the (new) favourability index greater (less) than 1 implies that at the given time period $\left(x^{t+i}, y^{t+i}\right)$, the bank is located in a favourable (unfavourable) position. Finally, a favourability change index, FCI >1 (<1) reflects the gain (loss) in favourability that the bank achieves by moving from period *t* to the new location (i.e. period *t+i*) in the PPS. Put differently, the FCI shows the variation in favourability observed by a bank by moving from the old location to the new location. FCI` is computed as the geometric mean of the ratio of the new FI to that of the old FI.

During 2006/07 period (Table 8.2), banks SGSSB and MBG experienced the minimum and maximum favourability indices equal to 24.5% and 123.8% respectively. For the period 2007/08 (Table 8.3), IBG was in the least favourable location (FI=49.3%) whilst AMAL was in the most favourable location (FI=119%). And for the sample period of 2006/2008 (Table 8.4), IBG again had the lowest FI of 26.7% whereas STANB had the highest FI of 118.8%. Average favourability rose from 78.3% in 2006/07 to 91.9% in 2007/08 periods. Across the whole sample period of 2006/08, banks were on average in unfavourable locations (FI=82.6%). Specifically, during 2006/07, 15 banks were located in an unfavourable location; during 2007/08, 12 banks were located in unfavourable locations and for the period 2006/08, 15 banks were located in unfavourable locations.

Over the period 2006/07, the favourability change index (FCI) shown in the last column of Table 8.2 reveals that UBA (with FCI=87.5%) moved towards the least favourable location whereas IBG (with FCI=199.8%) moved towards the most favourable location. Over the 2007/08 period, PBL moved towards the least favourable location whereas FAMB moved towards the most favourable location. Over the sample period from 2006 to 2008, PBL moved towards the least favourable location whilst IBG moved towards the most favourable location. The last finding means that although IBG was in the least favourable location, it was the bank that moved towards the most favourable location over time.

Note that irrespective of the pairs of years under consideration, the average FCI is greater than 1. Focusing on each pair of year, 18 individual banks had FCI>1 during 2006/07, 12 moved towards more favourable locations during 2007/08 and 17 moved towards more favourable locations during 2006/08. Recall that the average favourability index was consistently less than 1 during the whole sample period indicating that the banks were on average located in unfavourable locations or in locations that were smaller than the average frontier shift. This implies that despite the fact that individual banks were on average located in unfavourable positions, they were moving toward more favourable locations over time as indicated by the consistently positive average FCI.

Further examination reveals that on average the deterioration in productivity by 4.6%, 4.1% and 2.4% emanated from 21.7%, 8.1% and 17.4% reduction in favourability during periods 2006/07, 2007/08 and 2006/08 respectively. For the period 2007/08, the average productivity decline was also partly due to the 6.2% deterioration in the GFS and during period 2006/08, the average productivity decline was also due to the 5.1% efficiency decline. It may be recalled that the productivity decline from the standard Malmquist index and its efficiency change and technical change components during 2006/08 (Table 8.1) was attributed greatly to efficiency decline. Nonetheless, the present newly decomposed components reveal that the true sources of productivity decline is not because the overall frontier is shifting but because on average, majority of the individual banks are in unfavourable locations with lower than average frontier shift.

8.3 Empirical Analysis of Ghanaian Banks: at Subgroup Level

The banks are segmented into different subgroups in order to ascertain which subgroup has higher favourability and favourability change although they all observe the same GFS. The importance of such subgroup analysis becomes apparent in the context of policymaking. It may be that the frontier for one banking subgroup is better than that of another banking subgroup but the latter subgroup may be located in a more favourable position and/or may be moving towards a more favourable location over time indicating that their part of the frontier is shifting. In that case, it cannot be ruled out completely that the latter subgroup is not important in the industry. Policy measures may then have to be oriented in the direction of creating the platform for the latter subgroup to invest in better technology and human capital necessary to increase outputs and push their frontier closer to that of the leaders in the industry. The question that is explored in this section is: are some Ghanaian banking subgroups located in more or less favourable locations than others and are some of the subgroups moving towards more or less favourable locations over time?

The summary of subgroup results are displayed in Table 8.5. The reported values are the geometric means of individual FI and FCI in each banking subgroup for the pairs of years. The study investigates if banking subgroups (e.g., state banks) experience more or less shifts than the GFS experienced by all banks. Note that unlike the computation of the GFS that uses all the data points, irrespective of the time period, the computation of the FI and FCI for say 2006/2007 uses only 2006 and 2007 data and then relative to the GFS.

Table 8.5 Results of the GFS, FI, and FC

BY OWNERSHIP TYPE				***BY SPECIALISATION TYPE***			
State banks				**Focus banks**			
Summary	GFS	FI	FCI	Summary	GFS	FI	FCI
2006/07	1.07	1.07	1.20	2006/07	1.07	1.04	1.16
2007/08	0.94	0.93	1.02	2007/08	0.94	0.91	0.97
2006/08	1.00	1.00	1.16	2006/08	1.00	0.95	0.99
Domestic banks				**Universal banks**			
Summary	GFS	FI	FCI	Summary	GFS	FI	FCI
2006/07	1.07	1.07	1.23	2006/07	1.07	0.97	1.18
2007/08	0.94	1.00	1.09	2007/08	0.94	1.02	1.08
2006/08	1.00	1.08	1.16	2006/08	1.00	1.00	1.23
				BY CAPITALISATION TYPE			
Foreign banks				**Listed banks**			
Summary	GFS	FI	FCI	Summary	GFS	FI	FCI
2006/07	1.07	0.91	1.23	2006/07	1.07	1.01	1.17
2007/08	0.94	1.02	1.07	2007/08	0.94	1.01	1.03
2006/08	1.00	0.93	1.26	2006/08	1.00	1.03	1.29
				Non-listed banks			
				Summary	GFS	FI	FCI
				2006/07	1.07	0.99	1.18
				2007/08	0.94	0.99	1.09
				2006/08	1.00	0.99	1.16

Notes: GFS, FI and FC represent global frontier shift, favourability index and favourability change index respectively. All results are the geometric means.

Based on findings of ownership types, it can be observed that during the 2006/07 period, the average state, private-domestic and the foreign banks are in locations of positive favourability, positive favourability and negative favourability (average of 1.07, 1.07 and

0.91) respectively. The average state and private-domestic banks are therefore located where the frontier shift is 7% better than the 7% average (GFS=1.07) whereas the average foreign bank is located where the frontier shift is 9% worse than the 7% global shift. In contrast, during the same period, the changes in favourability of the three banking subgroups show interesting differences. Specifically, the average foreign and private-domestic banks are moving towards more favourable locations over time (FCI=1.23) than the average state bank (FCI=1.20). Generally, during this period, the private-domestic banks appear to be ahead of their peers in the sense that they are in locations that are more favourable and moving towards locations that are more favourable over time.

During the 2007/08 period, the average state, private-domestic and foreign banks are located in unfavourable location, neutral location and favourable location respectively. On average, they all moved towards locations that are more favourable with the private-domestic and foreign banks leading. Over the whole sample period, state, private-domestic and foreign banks are on average located in positions of neutral favourability (FI=1), positive favourability (FI=1.08) and negative favourability (FI=0.93) respectively. Corresponding values for the favourability changes show movements towards locations that are more favourable by all banking subgroups during the sample period. This means that even though foreign banks are on average located in unfavourable positions during the 2006/08 period, they are generally moving towards locations that are more favourable over time.

Recall in the previous chapter that foreign and private-domestic banks were found to be equal in terms of average performance and frontier differences. Their frontiers were on average more or less the same but both banking groups were on average found to more efficient and had better frontiers than that of state banks. Nonetheless, the finding from the FI and FCI show that in general, unlike the average state and domestic banks, the average foreign bank appears to be located in an unfavourable position. Also, all banking subgroups are on average moving towards locations that are more favourable. The implication from the ownership types analysis is that a banking subgroup can have a better frontier but the frontier may not be moving over time whereas another subgroup can have a worse frontier but that frontier may be moving over time and may therefore eventually ‘reach’ the better frontier ‘just over time’. GFS is therefore about not only who has the better frontier but also which part of the frontier is moving over time.

Recall the research question 5 (RQ5) posed at the introduction of this study “are foreign banks on average located in more favourable positions than private-domestic/state banks?” The follow up question was “are some banking subgroups moving towards more favourable locations over time?” Based on the discussion so far, the first part of the question can be answered in the negative. An affirmative answer can also be provided for the second part of the question. Specifically, during the sample period of 2006/08 albeit foreign banks are on average located in unfavourable locations, they are on average rapidly moving towards more favourable locations relative to their peer banking groups.

Next is the discussion on the findings of bank specialisation types, also shown in Table 8.5. Recall that the GFS for each pair of periods is the same as when considering the ownership types. That is 1.07, 0.94 and 1 during the periods 2006/2007, 2007/2008 and 2006/2008 respectively. The findings during 2006/2007 period indicate that the average focus bank is in a location of positive favourability (FI=1.04) whereas the average universal bank is located in an unfavourable position where the technological improvement is 3% less than the 7% average. Conversely, a look at their favourability changes shows that universal banks are on average moving towards more favourable locations (FCI=1.18) by slightly more than the focus banks who are also on average moving towards more favourable locations over time. A reverse trend occurs during the 2007/08 period. Particularly, focus banks are on average located in unfavourable positions (FI=0.91) where the technological improvement is 9% less than average. Conversely, universal banks are on average located in favourable position. The universal banks on average experience positive favourability during this 2007/08 period because whereas the global frontier shifted 6% backwards, the average universal banks moved 2% forward. The FCI result shows that universal banks, unlike the focus banks, are on average moving towards locations that are more favourable over time.

During the whole period of 2006/08, focus banks on average have negative FI of 0.95 where the improvement in technology is 5% less than the neutral average shift. The reason behind this is that the frontier for the focus banks on average moves backwards whereas the average frontier barely shifts. In contrast, universal banks on average, are located in positions of neutral favourability. Note however that individual universal banks will be located in different parts of the Ghanaian banking technology set with some located where the frontier shifts are larger, smaller or around average. Evidently, universal banks are generally moving towards more favourable locations (FCI=1.23) over time whilst focus banks are generally moving towards less favourable locations over time. The fact that universal banks' FCI exceeds 1 always means that although some of the GFS are negative, the individual universal banks (unlike focus banks) are by and large moving towards locations that are more favourable.

The research question 5 (RQ5) was "are universal banks on average located in favourable locations compared with focus banks?" The follow-up question was "are some banking subgroups moving towards more favourable locations over time?" From the above discussion, both the first and second parts of the question can be answered in the affirmative.

Recall the findings on the metafrontier and the global frontier differences showed that the average universal bank outperformed the average focus bank and universal banks' frontier on average was better than focus banks' frontier. The analysis of favourability and favourability change has shown that universal banks' frontier is not only better but also universal banks are on average located in favourable positions and moving faster towards more favourable locations over time relative to focus banks.

Finally, the findings on bank capitalisation types are also displayed in Table 8.5. During the 2006/07 period, listed banks are on average located in slightly more favourable positions (FI=1.01) than non-listed banks which have negative local favourability of 0.99. Similar trends where the average listed bank has positive FI (1.01) and the average non-listed bank has negative local favourability (0.99) can be found during either period 2007/08 or 2006/08, except that in period 2006/08 listed banks are on average located where the technological improvement is 3% more than the neutral average. The favourability changes for listed (non-listed) banks during periods 2006/07, 2007/08 and 2006/08 on average are 1.17 (1.118), 1.03 (1.09) and 1.29 (1.16) respectively. It appears that the mean FCI for listed banks over the whole period (FC=1.26) outweighs that of non-listed banks (FC=1.16). Arguably, on average, over the entire period, listed banks tend to experience greater FI and FCI than non-listed bank.

The movement towards more favourable locations by both listed and non-listed banks is evident by the fact that during every pair of years, the average FCI>1, reflecting the fact that although some of the mean GFS are negative and others are neutral, the individual listed and non-listed banks are by and large moving towards more favourable locations over time. The above discussion can help to answer research question 5 (RQ5) put forward at the introduction of this study "are listed banks on average located in favourable locations compared with non-listed banks?" The succeeding question was "are some banking subgroups moving towards more favourable locations over time?" From the above investigation, the first and second parts of the question can be answered in the affirmative.

8.4 Relating CSR with Favourability and Favourability Change

In an exploratory analysis, the study examines the relationship between CSR and FI and FCI using scatter plots and correlation tests. A good proxy for CSR is useful in this type of analysis. Using the absolute amount of CSR is not ideal since a positive link will just be a size effect (i.e. big banks do more CSR than small banks) which is not surprising. Also, just determining the relevance of one variable might not show the entire story; the analysis is best illustrated in a six dimensional space reflecting the 3 inputs and the 3 outputs. But this is beyond the scope of the exploratory analysis here. Hence, the relative measure of CSR is used and is calculated as: CSR as a percentage of all outputs = (amount of CSR / total amount of outputs) × 100, where total outputs are CSR, loans and advances, and other earning assets. This proxy for CSR as a mix of the other outputs in each year is separately plotted against the favourability index of the corresponding year. Nonetheless, since the favourability change index deals with pair of years, the average of CSR as a percentage of all outputs is used as a proxy for CSR whereby the average of CSR as a percentage of outputs from two separate years are calculated.

Figures 8.1-8.6 present the scatter plot of the relationship between CSR and favourability and favourability change. Note that the x-axis represents CSR as a percentage of all outputs whilst the y-axis denotes the favourability index for each year (or the x-axis is the average of CSR as a percentage of all outputs when the y-axis denotes favourability change). Note also that the old favourability index for say period 2006/2008 is labelled for 2006 (Figure 8.5) since it reflects the favourability of the old location (2006) relative to the frontier of 2008 and then compared with the GFS. The study explores the correlation between CSR and FI and between CSR and FCI using the nonparametric Spearman's rank correlation coefficient test (Spearman, 1904) which is calculated on the ranks and average ranks. The parametric equivalent, the Pearson product moment correlation coefficient (Pearson and Filon, 1898) is used as a robustness check. In this case, it makes sense to also use the Pearson correlation as a check because the CSR proxy on the x-axis is a ratio variable. The values in the parenthesis are the level of significance. The power of the Pearson correlation is seen from the fact that when the correlation is positive (negative), it indicates a more positive (negative value) than the correlation coefficient from the Spearman.

Figures 8.1, 8.3 and 8.5 show a negative correlation between CSR and favourability. But the association between CSR and favourability change tells a different story. Figure 8.2 shows positive association between CSR and FCI during the 2006/2007 period. Banks with high CSR appear to have high favourability change during this period. Figure 8.4 shows evidence of positive relationship between CSR and FCI during the 2007/2008 period although the relationship is not significant. Again, the Pearson correlation shows a higher coefficient than the Spearman's. Figure 8.6 also shows evidence of positive linkage between CSR and FCI during 2006/2008 sample period even though the association is not significant.

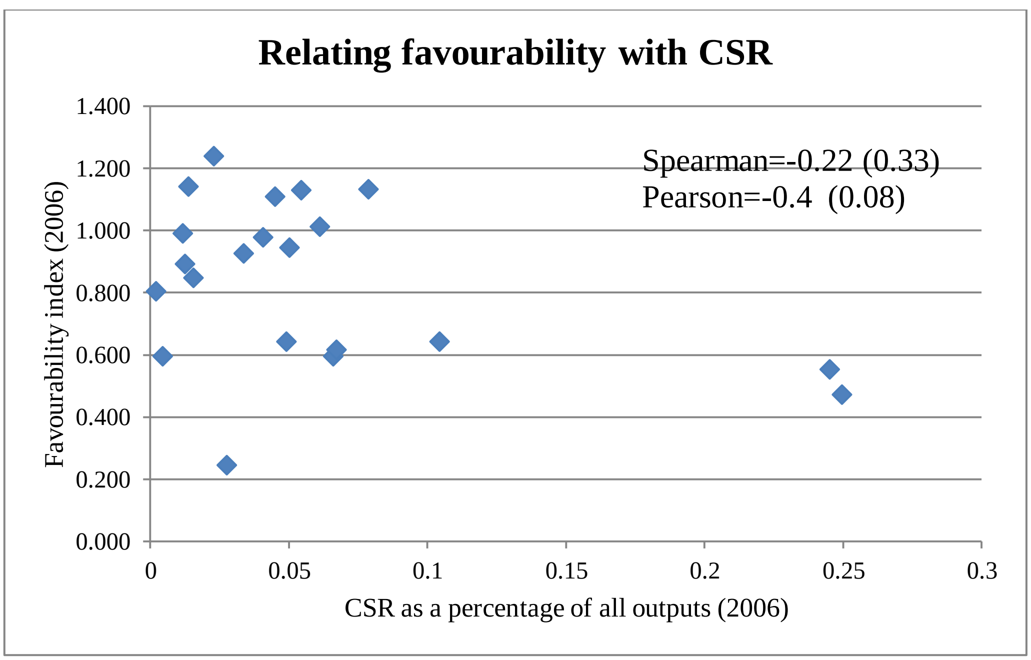

Figure 8.1 Scatter plot of CSR and favourability (2006)

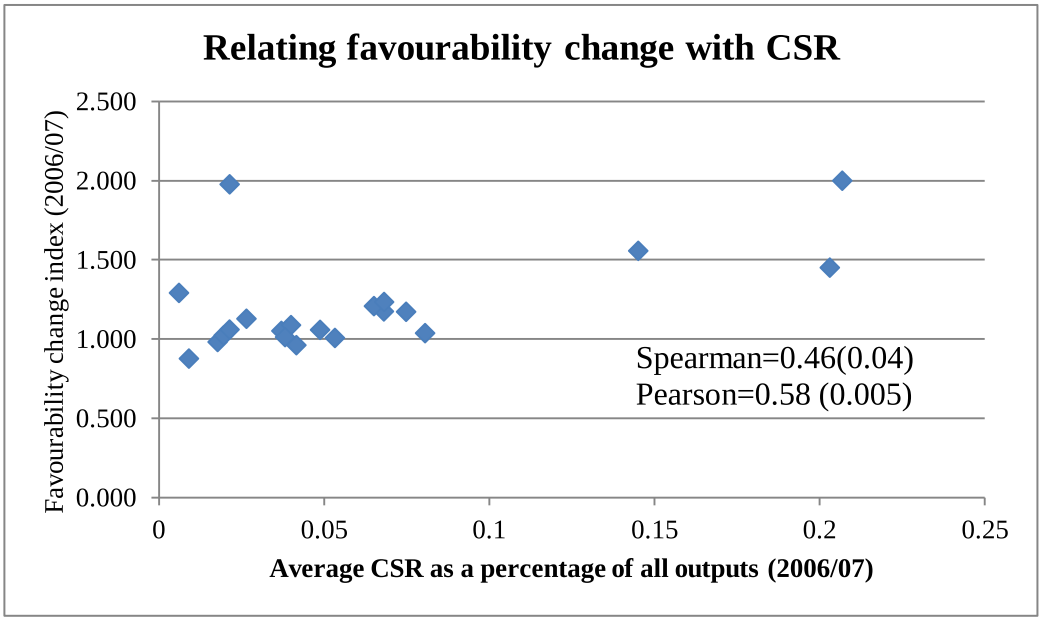

Figure 8.2 Scatter plot of CSR and favourability change (2006/2007)

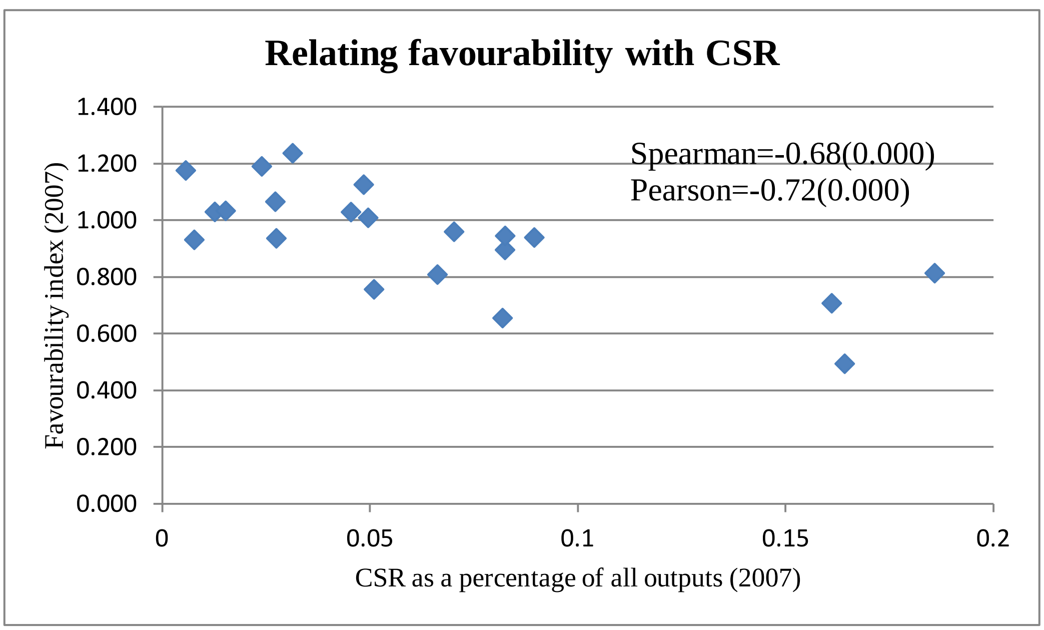

Figure 8.3 Scatter plot of CSR and favourability (2007)

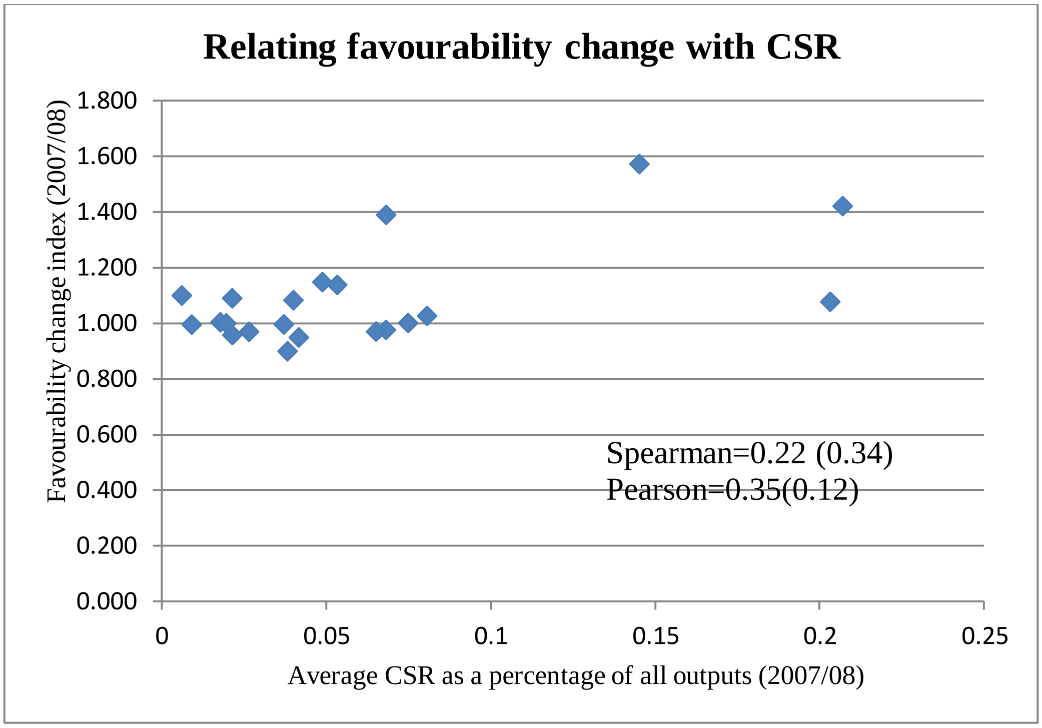

Figure 8.4 Scatter plot of CSR and favourability change (2007/2008

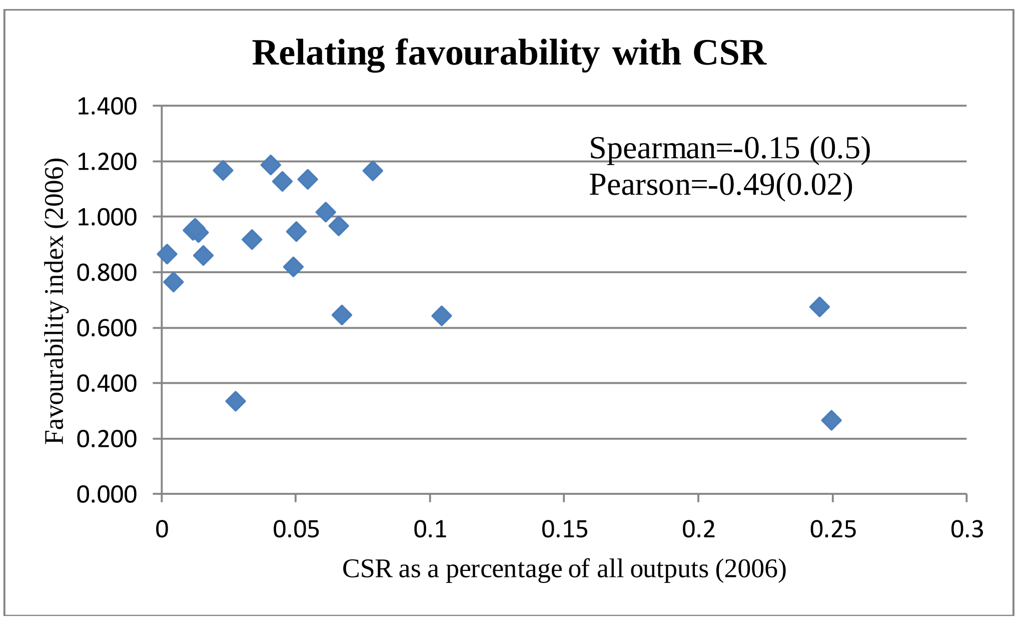

Figure 8.5 Scatter plot of CSR and favourability (2006)

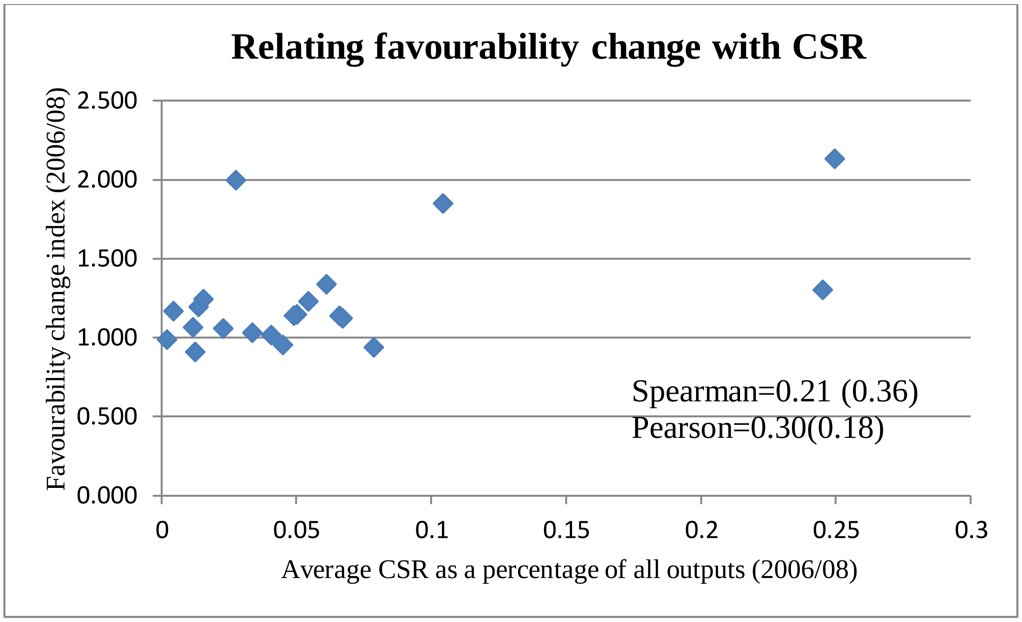

Figure 8.6 Scatter plot of CSR and favourability change (2006/2008)

In general, although the findings indicate a negative relationship between CSR and favourability, the exploratory analysis appear to provide initial indication of a positive relationship between CSR and favourability change.

8.5 Conclusion

Despite the extensive literature on efficiency and productivity change (cf. Paradi et al., 2011) no study has empirically investigated the impact that global frontier shifts and favourability and favourability change can have on productivity change. Neither has any study examined the relationship between CSR and favourability changes of DMUs. This chapter has suggested a novel adaptation of these indices on the production behaviour of Ghanaian banks. The concept of the GFS is useful for making conclusions about technological changes of an entire population of firms. Nonetheless, average technological improvement over time does not necessarily imply that all parts of the frontier are improving. Favourability concerns whether the size of individual frontier shifts are above or below the GFS. It could deal with whether a particular firm or a subgroup of firms is located in favourable position relative to the average technological changes. Favourability change on the other hand concerns whether a firm has moved towards more favourable locations in the production space. With these indices, the sources of productivity change could prove useful. It should be possible to explore if the effects arising from the overall GFS are disentangled from the effects attributable to whether individual DMUs are located in favourable positions or whether these DMUs, over a certain period of time, are moving towards locations with larger than the mean frontier shift. The intuition could be helpful to investigate whether some banks, by engaging in more CSR activities, place themselves in more favourable locations or move towards favourable locations than other banks.

Focusing on Ghanaian individual banks and banking subgroups over the period 2006/08, the chapter has examined the relevance of the 'newly-decomposed' Malmquist index. The study also has also explored the link between CSR, and favourability and favourability change of Ghanaian banks. Overall, it appears that the decline in productivity is attributable mainly to deterioration in efficiency and slightly to decline in innovation. FAMB is constantly seen as an innovator during the sample period. Further examination shows that the technological decline is on average, attributable to unfavourable locations of banks. But they are on average moving towards more favourable locations over time as indicated by the consistently positive average favourability change.

Banks are also classified under different banking subgroups in order to investigate whether a subgroup is located in more favourable locations and moving towards more favourable locations. Focusing on bank ownership types, the general observation was that even though foreign banks are on average located in unfavourable locations compared with state and private-domestic banks, they are on average rapidly moving towards more favourable locations over time. The overall conclusion on bank specialization types was that universal banks are on average located in more favourable positions and moving towards more favourable locations over time relative to focus. Finally, the result on bank capitalization types showed that that listed banks are on average located in more favourable positions and moving towards more favourable locations over time than focus banks.

The final exploratory analysis investigated the relationship between CSR and favourability and favourability change. The conclusion was that banks that contribute more towards CSR activities appear to be on average located in unfavourable positions but moving towards more favourable locations over time.

Chapter 9

Conclusions and Directions for Future Research

9.1 Introduction

The introduction of this thesis indicated that the banking industry of several countries have witnessed growing competition following the financial sector liberalisation, deregulation of interest rates, cross-border banking, innovation in information technology and the entry of both foreign and private-domestic banks. The ensuing competition among banks implies that those that continuously become inefficient or fail will be forced to exit the market at some point. Banking efficiency assessment is one means of identifying the best and worst performing banks leading to appropriate policy prescriptions to address any possible failures. To evaluate efficiency and productivity change, the multiple objectives of individual players need to be taken into consideration thereby providing a comprehensive evaluation. Particularly, the incorporation of Corporate Social Responsibilities (CSRs) into banking efficiency model was one of the key motivations of this study. The other motivation was to examine if the regulatory reforms introduced in the Ghanaian banking sector have impacted on the efficiency and productivity change of banks for effective policy recommendations. These regulatory reforms took the form of financial deregulation leading to the entry of private-domestic and foreign banks, introduction of universal banking license and listing of banks on the Ghana Stock Exchange.

The current study has contributed to the discussion on the performance assessment of depository financial institutions in four respects. First, the study has examined the multidimensional nature of CSR and developed a suitable DEA banking efficiency model for measuring the performance of banks that have the dual objective of CSR and profit maximisation. Second, it has empirically estimated the CSR-CFP nexus using both nonparametric and parametric approaches. Third, it has used novel techniques to investigate the impact of bank ownership, specialisation and capitalisation on bank performance in Ghana. Fourth, the study has proposed a 'newly-decomposed' Malmquist index, the components of which are useful for determining the favourability and favourability change of firms.

The newly decomposed Malmquist index and its components were used to explore whether some banking subgroups are located in favourable positions and moving towards locations that are more favourable based on their subgroup characteristics. The method was also used to explore the association between banks' CSR and their favourability and favourability changes. Policy recommendations are drawn and regulatory insights deduced from the study. The underlying principles of CSR, global frontier differences and the favourability and favourability indices advanced in this study are not only applicable to banking but also to other organisations.

9.2 Main Objectives and Overall Discussion of Results

The thesis reviewed the CSR literature and discussed the difficulty associated with defining multidimensional CSR concept. CSR was explained as *voluntary* actions undertaken by firm's management, beyond compliance or the minimum legal requirements (and beyond direct interest of shareholders) to further some social good (McWilliams and Siegel, 2001). The study distinguished itself from the existing literature that implicitly consider banks only as profit-maximizing firms and largely ignore the multiple goals of banks (García-Cestona and Surroca, 2008) including the potential importance of CSR. It was argued that the banking efficiency models should incorporate both the traditional profit-maximisation and CSRs goals leading to a banking system termed in this thesis as "dual-objective". The study discussed the various approaches for specifying input-output variables of the financial firm. Although the intermediation model was adopted, other approaches such as the profitability and the marketability can be used. A measure of CSR peculiar to the banking industry that has not been employed in earlier studies is adopted. It uses the monetary values of CSR obtained from banks' annual reports as a proxy for CSR and as an additional output. Banks outputs were loans and advances, CSR and other earning assets. The inputs were employee expenses, fixed assets and total deposits.

The data set was sourced from individual banks annual reports over the sample period and cross-validated with similar data from the central Bank of Ghana. To carry out the analysis, a justification for pooling the data set of 21 banks for each of the 3 years (2006, 2007 and 2008) was made. Data pooling was performed to handle the possible dimensionality curse of DEA. The Free Disposal Hull (FDH) was used as a diagnostic check and large numbers of FDH efficient observations confirmed this dimensionality curse paving the way for the justification of pooling the data set. The appropriateness of this was tested parametrically (using ANOVA test) and nonparametrically (using Friedman's test). This justification is often ignored in other studies. The conclusions from the tests indicated that it was appropriate to pool observations from the three years into one data set

The efficiency scores were calculated using DEA. The key advantage of DEA is its ability to handle multiple inputs and outputs without the need to specify specific functional forms. To estimate the output-augmenting efficiency of banks, two DEA banking intermediation models were run, one model that includes CSR (total model) and another without CSR (reduced model). Comparing the outcomes of the two models helped to determine the relevance of incorporating CSR into a banking efficiency analysis. To investigate the potential effect of CSR on the performance rankings of individual banks, their efficiency rankings were computed from both the total and reduced models. It was found that, out of the 63 banking observations, 28 altered their efficiency rankings, an indication that CSR may be important for some banks. One particular bank that considerably improved its ranking position from 34th in the reduced model to 1st in the total model was ADB, an agricultural bank that had integrated CSR in its operations for many years through the provision of funds to farmers and households. Ignoring the CSR actions of such a bank would penalise the bank resulting in biased conclusion. Using the nonparametric Wilcoxon matched-pairs-signed-rank test and its parametric equivalent of paired t-test, the first empirical analysis confirmed that there was a significant difference in the technical efficiency rankings between the total model and the reduced model. The outcome justified the need for a suitable definition of input and output variables that reflect the overall objectives of banks prior to performance analysis.

The result was similar to that of Rogers (1998)who found for US banks that the omitting nontraditional output understated bank efficiency and Tortosa-Ausina (2003) who reported that Spanish banks' cost efficiency was enhanced with the inclusion of nontraditional activities. The difference though with our analysis and these authors was that whereas they considered nontraditional outputs, the present study considered CSR.

For robustness check, the study also employed correlation analysis and second-stage OLS and LAD regressions to investigate the relationship between CSR, and profitability indicators (measured by ROA and ROE) and efficiency indicator (DEA scores from the reduced model). To the best of our knowledge, this is the first empirical analysis that has explicitly addressed such a link using both financial ratios and frontier efficiency measure in the banking efficiency measurement and business ethics literature (see e.g. review of studies by Paul and Siegel, 2006; Beurden and Gössling, 2008). The empirical results indicated that CSR had a positive link with both profitability and efficiency. In sum, not accounting for CSR as an additional output or exogenous variable in banking intermediation model might bias the efficiency findings. The incorporation of CSR in the DEA performance analysis of banks is one of the key contributions of the thesis.

The second contribution of the thesis provides new evidence on the relationship between performance and bank ownership, specialisation and capitalisation in the dual-objective banking system of Ghana. There are inconclusive findings in the literature on these drivers of performance. These bank-specific attributes could have emerged from such financial sector reforms as the introduction of universal banking licence, rising deregulation and privatisation of banks, decreasing restrictions on the entry of foreign and private-domestic banks and the growth in listing banks on the Ghana Stock Exchange. The available evidence of bank-specific characteristics on performance tend to focus primarily on US and other developed countries with very less perceptions and discussions on the banking markets in developing economies. This has been the first attempt to assess and explain not only the efficiency levels but also the best-practice differences between banking groups in terms of rigorous, nonparametric double approaches of empirical investigation. Put differently, unlike previous studies (Vander Vennet, 2002; Berger et al., 2009, 2010; Liadaki and Gaganis, 2010; Chen and Liao, 2011; Assaf et al., 2011a), this study employed the nonparametric metafrontier analysis (O'Donnell et al., 2008) and the global frontier differences, GFD (Asmild and Tam, 2007) for the investigation. The metafrontier analysis measures the efficiency of DMUs relative to a common frontier while accounting for group heterogeneities. The GFD is useful for drawing conclusions about productivity changes, particularly frontier shift for an entire sample of DMUs instead of individually observed DMUs. For sparsely populated data set and frontiers that change shape over time, the GFD provides a better estimate of the average distance between two frontiers compared with the traditional aggregation of frontier changes approach (Asmild and Tam, 2007). The GFD is also useful for analysing both time and group differences in the presence of either balanced or unbalanced panel data set. The technique as adapted in this thesis to investigate whether the best-performing banks in one group are on average better than the best-performing banks in another group.

The banking groups were classified under 9 state, 27 private-domestic and 27 foreign banks based on ownership; 52 universal and 11 focus banks based bank specialisation; and 18 listed and 44 non-listed banks using bank capitalisation. Initial tests of differences in the means of inputs and outputs and other control variables between banking groups using ANOVA and t-test revealed some differences between the variables across banking groups.

In the metafrontier analysis, the ‘metaefficiency’ of banks was estimated under the assumption that all banks had access to the same metatechnology. To separate possible effects of bank-specific attributes on performance, the ‘group efficiency’ of each bank was estimated. Thereafter, the TGR for each bank was estimated as the difference in the distance between the group frontier and the metafrontier (O’Donnell et al., 2008) The GFD (Asmild and Tam, 2007) was also selected as an alternative approach. It was computed as the ratio of the geometric mean of the efficiency scores of all banks relative to one group-specific frontier the geometric mean of the efficiency scores of all banks relative to another group-specific frontier. From a methodological standpoint, using the GFD to estimate the distances between Ghanaian banking groups unquestionably provided further insights on the best-practice differences across banking groups thereby strengthening the results of the metafrontier analysis, particularly, the TGR results. The interesting aspect of this methodological cross-checking is that had only the metafrontier analysis been applied without support from the GFD, the results and the conclusions may be subject to challenge. A comparative analysis of alternative nonparametric techniques applied on the same data set strengthened the overall findings.

The overall results based on bank ownership types was that foreign and private-domestic banks were on average equally good regarding their average performance and technological gaps. Both banks were on average more efficient and more technologically advanced than state banks. This finding was found to be consistent with the results of Frimpong (2010) who reported that both Ghanaian private-domestic and foreign banks outperformed state banks in the year 2007. The finding was also found to be in line with that of Berger et al. (2005) who evaluated Argentinean banks. It was also found that, there was only 1 state bank compared with 6 (43%) private-domestic and 7 (50%) foreign banks that defined the metafrontier suggesting that the state banking frontier was on average more distanced from the metafrontier than the frontiers of the private-domestic and foreign banks. Similar conclusions from the GFD findings also emerged. Specifically, the best-performing foreign banks were on average equal best-performing private-domestic banks. But, both appeared to be on average 113% and 107% better than the best-performing state banks respectively. The overall findings suggested that the benefits of Ghanaian banking privatisation were similar to the benefits experienced from foreign banking entry. A likely policy recommendation that could be drawn from the result was that the Bank of Ghana should eliminate restrictions on the entry of banks into the banking industry and freely open up the banking industry to both foreign and private-domestic competition to ensure overall efficiency and technological innovation in the industry.

The conclusion from bank specialisation forms was that universal banks were on average more efficient and technologically advanced than focus banks. The finding that universal banks outperformed focus banks was consistent with the results of the assessment of 2,375 EU banks from 17 nations over during 1995-1996 conducted by Vander Vennet (2002) and that of 165 banks in 10 EU countries during 2001-2007 conducted by Chronopoulos et al. (2011). The TGR results suggested that the greater part of the focus-banking frontier was located far away from the pooled metafrontier. The universal banking group appeared to have created the entire technological paradigm and shaped the technological trajectories of the entire banking sector (Dosi, 1993; Kontolaimou and Tsekouras, 2010). The TGR finding was reinforced by GFD results. Specifically, on average, universal banks frontier was found to be 70% better than focus banks' frontier. The implication of these results was that the introduction of universal banking in 2003 by the BOG was a step in the right direction. Policy recommendations that could be drawn from this was that the BOG should design policy measures that will ensure the sustainability of universal banks in Ghana and ensure that banks are indeed offering the full diversification of products and services without recourse to focus banking activities. Recent trends in the banking industry show that the BOG has succeeded in this area in the sense that all the banks had become universal by 2011.

The conclusion emerging from bank capitalisation types suggested that listed banks were on average more efficient but less technologically innovative compared with non-listed banks. The finding that listed banks outperform non-listed was found to be consistent with the result of the cost and profit efficiency measurement of 71 Indian banks conducted by Ray and Das (2010). Nonetheless, only 2 efficient listed banks were among the 14 leading banks that defined the metafrontier. This implied that, the non-listed banks appeared to have constructed the whole technological paradigm and described the technological trajectories of the entire banking industry composed of the two banking capitalisation types. However, it appeared that the technology within the non-listed banking group had not been fully diffused to all banks in the industry. Supporting the result of the best-practice gap, the GFD finding showed that the best-practice non-listed banks were on average 36.2% better than the best-practice listed banks. One policy measure could be discussions between the BOG and the Securities and Exchange Commission, which supervises the GSE, on ways to introduce technological innovation into the GSE.

The final objective of the thesis is to contribute to the productivity literature by suggesting a ‘newly-decomposed’ Malmquist productivity change index. The index decomposes into efficiency change, global frontier shift, favourability index and favourability change index. The study a) makes a novel application of these indices to Ghanaian banks and banking subgroups and b) explores the relationship between CSR and banks’ favourability and favourability changes. The analysis proceeded in two ways. First, the dynamic performance of Ghanaian banks are measured using the standard Malmquist index (Caves et al., 1982) and decomposed into its root components of efficiency change (catching up) and technical change (frontier shift). The popularity of the Malmquist index is due to its ability to handle multiple inputs and outputs by relying on flexible assumptions without information on input or output prices, and its ability to decompose productivity change into efficiency change and technological change. The analysis used the balanced panel of 21 Ghanaian banks from 2006 to 2008 periods. Overall results showed a rate of productivity regress of 2.4% that was mainly attributable to efficiency decline and slightly to innovation decline. The results appeared to be in accord with the decrease in productivity for Greek merger banks during 1993–2004 as found by Rezitis (2008). On average, FAMB determined the frontier in each year and was thus the main bank innovator. Second, the analysis estimated dynamic performance of Ghanaian banks using the ‘newly-decomposed’ Malmquist index and its additional components. The efficiency change component for individual banks was identical to the individual efficiency changes of the standard Malmquist. The global frontier shift (GFS) component was useful for drawing conclusions about the frontier shift for the entire population of banks. The index could be used with balanced or unbalanced panel data set. The GFS for the whole sample period was about 1 indicating that on average, the frontier did not move at all between 2006 and 2008. This was not surprising because during the first empirical analysis in chapter 6, it was shown using Friedman test that there was not significant differences in the efficiency scores in each of the years. This was used to justify the pooling of the data set and to explore the CRS-CFP nexus. Comparing the GFS value with the standard average frontier shifts during the same period obtained by traditional aggregation of the individual frontier shifts (technical changes) showed a 0.9% increase for the GFS. In all pairs of periods, the GFS was found to have outperformed the geometric mean of the standard individual technical changes.

The last two components of the 'newly-decomposed' Malmquist index were the favourability and the favourability change indices. The usefulness of these indices was demonstrated on Ghanaian banks and banking subgroups based on ownership, specialisation and capitalisation. These indices were novel additions to the drivers of productivity change. This was the first time the approach was being applied in the productivity literature and certainly the first in the banking industry or in a dual-objective banking system like Ghana. It was noted that average improvement over time did not necessarily mean that all parts of the frontier were improving, as the frontier shift was not necessarily parallel. Hence, the result due to the overall GFS could be disentangled from the effects emanating from whether individual banks or banking subgroups were located in favourable positions and whether those banks were moving towards locations that are more favourable over time. If the local shift observed by a bank was found to be greater than the global shift, the bank would be said to be located in a favourable position whereby the improvement potential was more than the average and vice-versa (Asmild and Tam, 2005). An advantage of the favourability and favourability change indices as applied to Ghanaian banks was their ability to investigate whether some banking subgroups, because of their bank-specific attributes, are located in favourable positions and moving towards locations that are more favourable. Possibly, if a bank was listed on the GSE or became a universal bank or had majority of foreign shareholders, it may undergo a higher than average frontier shift (i.e. be located in a favourable position) and/or move towards more favourable locations. It was also argued that some banking subgroups could gain higher favourability and favourability change by contributing more towards CSR. As a result, the final analysis explored the association between these indices and banks' CSR.

Overall, individual banks' results revealed that IBG and STANB were located in the least and the most favourable positions respectively during the sample period 2006/08. On average, individual Ghanaian banks were located where the frontier shifts were smaller than the neutral average. 15 banks were located in unfavourable locations. However, favourability changes were consistently greater than 100% indicating that even though individual banks were on average located in unfavourable positions, they were moving towards locations that were more favourable over time. An example was bank IBG in 2006/08 that was located in the least favourable position but moved towards the most favourable location.

It was also found that during the whole sample period, using the 'newly-decomposed' Malmquist index, productivity decline was on average mainly attributable to decline in favourability rather than the neutral global frontier shift or the slight decline in the efficiency change. Hence, using the newly decomposed Malmquist index, the main source of productivity was identified which would not have been possible if only the standard Malmquist index had been used.

From the analysis of bank ownership types, foreign banks appeared to have been located in unfavourable positions compared with both state and private-domestic banks. But, on average, all banking subgroups were moving towards locations that are more favourable over time with foreign banks having slight urge over the others. From the analysis of bank specialisation types, the overall conclusion was that universal banks were on average located in favourable positions and moving towards more favourable than focus banks, which were barely moving. The conclusion from the bank capitalisation types was that, on average, listed banks appeared to be located where the frontier shift was larger than average and were moving towards more favourable locations over time than non-listed banks.

The final exploratory analysis associated CSR with favourability and favourability change. Scatter plots and Spearman's and Pearson's correlations were employed to investigate whether banks that engage more in CSR are also located in favourable positions and if not, whether they are moving towards more favourable locations over time. The overall findings generated preliminary suggestions of indirect linkage between CSR and favourability, but a direct linkage between CSR and favourability change.

The summary of policy recommendations were that the banking industry should be opened to both foreign and domestic competition, that, the universal banking policy appeared to have had positive impact on the industry and that banks could expect to witness favourable outcomes if they get listed on the Ghana Stock Exchange. Also, banks may not clearly notice a positive link between their CSR contributions and favourability locations in the short run. Nonetheless, there are positive linkages in the long run.

9.3 Core Contributions of the Study

A summary of the key contributions of the thesis are as follows:

- At the conceptual level, the contribution deals with the development of a framework on how the existing theory and method of DEA can be adapted to the analysis of the efficiency of banks that have the dual objective of profit maximisation and corporate social responsibilities
- At the empirical and policy level, the contribution is the creation of a framework by which alternative techniques can be implemented to investigate both average efficiency and best-practice differences between banking subgroups that differ in ownership, specialisation and capitalisation forms for effective policy recommendations. This bridges the missing link between theory and application.
- At the methodological level, the contribution is the proposal of a novel deployment of the favourability and favourability change indices for the analysis of the efficiency and productivity change across banking groups over time. The method is

used in a particular application field to decompose the Malmquist productivity change index into four components and to explore the missing link between the favourability changes of banks and their CSR

- Expansion of the banking efficiency and productivity change literature to Africa as championed by Berger (2007) since most of the previous studies concentrate on developed countries
- Contribution to the CSR-CFP literature through the investigation of the relationship between social responsibility, and efficiency and profitability using parametric and nonparametric approaches
- An exploration into the relationship between CSR and favourability and favourability change indices
- A first time evaluation of the impact of bank ownership types, specialisation forms and capitalisation types on bank performance in the Ghanaian banking industry
- A mathematical reformulation of the global frontier differences for the analysis of banking groups
- A mathematical proof that the 'newly-decomposed' Malmquist productivity change index (33) is equivalent to the traditional adjacent Malmquist productivity change index (21) and therefore the technical change component is equal to the product of the global frontier shift, the favourability index and the favourability change index
- Some policy recommendations regarding the opening of the banking industry to both foreign and private-domestic competition, the continuance of universal banking licence and the listing of banks on the Ghana Stock Exchange

9.4 Directions for Further Research and Developments

The limitations of the present study could be examined in the context of future researches that are proposed in this final section. This thesis set out to evaluate the performance of banks in a single nation, Ghana. It would be interesting to extend the study to a cross-country banking efficiency and productivity change analysis of the 6 English-speaking countries of the West African Monetary Zone - Ghana, Nigeria, Gambia, Guinea, Sierra Leone and Liberia - that are on the verge of forming the common currency called Eco by the year 2015.

It will be interesting to investigate whether full integration of financial and banking industries can be realised, particularly, learning from the experiences of the European Union. It is important to determine convergence in banking industries across these nations, which will facilitate the movement towards the successful adoption of the Eco. In so doing, the σ- and β-convergence indicators can be employed (Mamatzakis et al., 2008). Another means of exploring the convergence criteria could be the use of the nonparametric kernel density estimation. Such analysis will require substantial efforts in terms of additional data collection and efforts in accounting for country-specific environmental factors that may affect performance. But the analysis and efforts may provide a holistic assessment of the performance of West African banks in an integrated social responsibility landscape.

Moreover, the study made use of one concept of efficiency i.e. “technical efficiency”. This is a motivation for further research into the assessment of the costs and benefits of CSR in the perspective of both profit and cost efficiencies. Cost efficiency is a more inclusive concept than technical efficiency given that it comprises both technical and allocative efficiency. An even broader concept that provides more relevant information for bank managers is profit efficiency as it incorporates the impact of the choice of vector of production on both cost and revenues (Maudos and Pastor, 2001; Berger and Mester, 2003). Thereafter, cost and profit efficiency levels can be compared across banking subgroups. Indeed, estimating all types of efficiency concepts is relevant for a complete understanding into the efficiency and productivity variations among organisational units. The estimation of profit efficiency implies that future research should also use the profitability model of bank modelling and compare it with the intermediation model adopted in this study to address research issues.

Coupled with that, alternative frontier techniques such as the order-*m* (Cazals et al., 2002), the stochastic estimators(Kumbhakar et al., 2007) and bootstrapping (Simar and Wilson, 2007) could be explored as robustness checks in order to bridge both parametric and nonparametric approaches. These novel partial frontier estimators do not suffer from dimensionality curse and the stochastic estimators allow for greater flexibility for random noise. The bootstrap approach also provides statistical insights into performance analysis. These could offer further substantiation of the findings and lift the confidence of banking regulators and managers to draw relevant policies from the findings.

In the first empirical analysis in chapter 6, it was found during an examination of the output weights that most of the banks (41 banking observations) were putting zero weights on the CSR variable in the DEA analysis although CSR was conceptually considered to be an important variable. Therefore, an important area for further research would be to incorporate weight restrictions (Thompson et al., 1986; Allen et al., 1997) constructed on the basis of realistic production trade-offs between inputs and/or outputs by means of the trade-off approach (Podinovski, 2004b). This should consider prior knowledge of bank managers on the perceived relative importance of inputs and outputs in the technology process thereby preserving the radial nature of efficiency. This analysis is likely to improve discrimination of efficiency estimates.

The favourability and favourability change indices proposed in this thesis are related to the input bias and output bias technical change components that measure the departure from the technical changes within the spaces of the isoquant and the output possibility set respectively. In a similar vein, the elements of the favourability and its change estimate the departure from the global frontier shift. It would therefore be useful in future research to decompose the favourability indices into changes in the input subspace and changes in the output subspace. Such decomposition will provide additional information regarding the contribution of the levels of inputs and outputs on the favourability and the favourability change indices. Individual firms can determine whether they should pay more attention to reduce inputs or to increase outputs. The catching up component can also be decomposed into its usual components of pure efficiency change and scale efficiency change as in Fare et al. (1994c).

Other issues that will be subjects of future research are: accounting for nontraditional items and off-balance activities (i.e. letters of credit, acceptances, guarantees and performance bonds and contingent liabilities), expanding the sample period to include many years, examining the effects of other bank-specific variables such as size on performance and extending the global Malmquist index into a cost global Malmquist productivity change along the lines of Maniadakis and Thanassoulis (2004).

The measurement of efficiency and productivity change of banks with corporate social responsibilities undertaken in this thesis has hopefully laid a solid foundation towards the pursuit of the above future studies.

Appendix 1

Proposition 1: The decomposed Malmquist productivity change index $M\left(x^{t+i}, y^{t+i}, x^t, y^t\right)$ in equation (33) equals the traditional Malmquist productivity change index $M\left(x^{t+i}, y^{t+i}, x^t, y^t\right)$ in equation (21) and hence the technical change component, TC $\left[\frac{\phi^{t+i}\left(x^{t+i}, y^{t+i}\right)}{\phi^t\left(x^{t+i}, y^{t+i}\right)} \times \frac{\phi^{t+i}\left(x^t, y^t\right)}{\phi^t\left(x^t, y^t\right)}\right]^{\frac{1}{2}}$ is equivalent to the product of the global frontier shift GFS, the favourability index FI, and the favourability change index FCI.

Proof

$$M\left(x^{t+i}, y^{t+i}, x^t, y^t\right) = \underbrace{\frac{\phi^t\left(x^t, y^t\right)}{\phi^{t+i}\left(x^{t+i}, y^{t+i}\right)}}_{\text{EC}} \times \underbrace{\left[\frac{\phi^{t+i}\left(x^{t+i}, y^{t+i}\right)}{\phi^t\left(x^{t+i}, y^{t+i}\right)} \times \frac{\phi^{t+i}\left(x^t, y^t\right)}{\phi^t\left(x^t, y^t\right)}\right]^{\frac{1}{2}}}_{\text{TC}}$$

and

$$M\left(x^{t+i}, y^{t+i}, x^t, y^t\right) = \underbrace{\frac{\phi^t\left(x^t, y^t\right)}{\phi^{t+i}\left(x^{t+i}, y^{t+i}\right)}}_{\text{EC}} \times \underbrace{\left(\frac{\prod\limits_{\substack{j=1,\ldots,n\\ \tau=1,\ldots,z}} \phi^{t+i}\left(x_j^\tau, y_j^\tau\right)}{\prod\limits_{\substack{j=1,\ldots,n\\ \tau=1,\ldots,z}} \phi^t\left(x_j^\tau, y_j^\tau\right)}\right)^{\frac{1}{n\times z}}}_{\text{GFS}}$$

$$\times \underbrace{F^{t,t+i}\left(x^t, y^t; \overline{X}, \overline{Y}\right)}_{\text{FI}} \times \underbrace{\left(\frac{F^{t,t+i}\left(x^{t+i}, y^{t+i}; \overline{X}, \overline{Y}\right)}{F^{t,t+i}\left(x^t, y^t; \overline{X}, \overline{Y}\right)}\right)^{\frac{1}{2}}}_{\text{FCI}}$$

Hence, TC = GFS * FI * FCI

This implies that

$$\underbrace{\left[\frac{\phi^{t+i}\left(x^{t+i},y^{t+i}\right)}{\phi^{t}\left(x^{t+i},y^{t+i}\right)}\times\frac{\phi^{t+i}\left(x^{t},y^{t}\right)}{\phi^{t}\left(x^{t},y^{t}\right)}\right]^{\frac{1}{2}}}_{\text{TC}}=\underbrace{\left(\frac{\prod\limits_{\substack{j=1,\ldots,n\\ \tau=1,\ldots,z}}\phi^{t+i}\left(x_j^{\tau},y_j^{\tau}\right)}{\prod\limits_{\substack{j=1,\ldots,n\\ \tau=1,\ldots,z}}\phi^{t}\left(x_j^{\tau},y_j^{\tau}\right)}\right)^{\frac{1}{n\times z}}}_{\text{GFS}}$$

$$\times\underbrace{F^{t,t+i}\left(x^{t},y^{t};\overline{X},\overline{Y}\right)}_{\text{FI}}\times\underbrace{\left(\frac{F^{t,t+i}\left(x^{t+i},y^{t+i};\overline{X},\overline{Y}\right)}{F^{t,t+i}\left(x^{t},y^{t};\overline{X},\overline{Y}\right)}\right)^{\frac{1}{2}}}_{\text{FCI}}$$

Recalling the components of FI and FCI in equation (31) and (32) and substituting in the equation above yields,

$$\underbrace{\left[\frac{\phi^{t+i}\left(x^{t+i},y^{t+i}\right)}{\phi^{t}\left(x^{t+i},y^{t+i}\right)}\times\frac{\phi^{t+i}\left(x^{t},y^{t}\right)}{\phi^{t}\left(x^{t},y^{t}\right)}\right]^{\frac{1}{2}}}_{\text{TC}}=\underbrace{\left(\frac{\prod\limits_{\substack{j=1,\ldots,n\\ \tau=1,\ldots,z}}\phi^{t+i}\left(x_j^{\tau},y_j^{\tau}\right)}{\prod\limits_{\substack{j=1,\ldots,n\\ \tau=1,\ldots,z}}\phi^{t}\left(x_j^{\tau},y_j^{\tau}\right)}\right)^{\frac{1}{n\times z}}}_{\text{GFS}}$$

$$\times\underbrace{\left(\frac{\phi^{t+i}\left(x^{t},y^{t}\right)}{\phi^{t}\left(x^{t},y^{t}\right)\text{GFS}\left(t,t+i;\overline{X},\overline{Y}\right)}\right)}_{\text{FI}}$$

$$\times\underbrace{\left[\frac{\phi^{t+i}\left(x^{t+i},y^{t+i}\right)\Big/\left(\phi^{t}\left(x^{t+i},y^{t+i}\right)\times\text{GFS}\left(t,t+i;\overline{X},\overline{Y}\right)\right)}{\phi^{t+i}\left(x^{t},y^{t}\right)\Big/\left(\phi^{t}\left(x^{t},y^{t}\right)\times\text{GFS}\left(t,t+i;\overline{X},\overline{Y}\right)\right)}\right]^{1/2}}_{\text{FCI}}$$

Further substituting for GFS gives us,

$$
\underbrace{\left[\frac{\phi^{t+i}\left(x^{t+i},y^{t+i}\right)}{\phi^{t}\left(x^{t+i},y^{t+i}\right)}\times\frac{\phi^{t+i}\left(x^{t},y^{t}\right)}{\phi^{t}\left(x^{t},y^{t}\right)}\right]^{\frac{1}{2}}}_{\text{TC}}=\underbrace{\left(\frac{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t+i}\left(x_j^{\tau},y_j^{\tau}\right)}{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t}\left(x_j^{\tau},y_j^{\tau}\right)}\right)^{\frac{1}{n\times z}}}_{\text{GFS}}
$$

$$
\times\underbrace{\left(\frac{\phi^{t+i}\left(x^{t},y^{t}\right)}{\phi^{t}\left(x^{t},y^{t}\right)\left(\frac{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t+i}\left(x_j^{\tau},y_j^{\tau}\right)}{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t}\left(x_j^{\tau},y_j^{\tau}\right)}\right)^{\frac{1}{n\times z}}}\right)}_{\text{FI}}
$$

$$
\times\underbrace{\left[\frac{\phi^{t+i}\left(x^{t+i},y^{t+i}\right)\Big/\left(\phi^{t}\left(x^{t+i},y^{t+i}\right)\times\left(\frac{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t+i}\left(x_j^{\tau},y_j^{\tau}\right)}{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t}\left(x_j^{\tau},y_j^{\tau}\right)}\right)^{\frac{1}{n\times z}}\right)}{\phi^{t+i}\left(x^{t},y^{t}\right)\Big/\left(\phi^{t}\left(x^{t},y^{t}\right)\times\left(\frac{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t+i}\left(x_j^{\tau},y_j^{\tau}\right)}{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t}\left(x_j^{\tau},y_j^{\tau}\right)}\right)^{\frac{1}{n\times z}}\right)}\right]^{1/2}}_{\text{FCI}}
$$

Re-arranging,

$$\underbrace{\left[\frac{\phi^{t+i}\left(x^{t+i},y^{t+i}\right)}{\phi^{t}\left(x^{t+i},y^{t+i}\right)}\times\frac{\phi^{t+i}\left(x^{t},y^{t}\right)}{\phi^{t}\left(x^{t},y^{t}\right)}\right]^{\frac{1}{2}}}_{\text{TC}}=\left(\frac{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t+i}\left(x_j^{\tau},y_j^{\tau}\right)}{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t}\left(x_j^{\tau},y_j^{\tau}\right)}\right)^{\frac{1}{n\times z}}$$

$$\times\left(\frac{\phi^{t+i}\left(x^{t},y^{t}\right)}{\phi^{t}\left(x^{t},y^{t}\right)\left(\frac{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t+i}\left(x_j^{\tau},y_j^{\tau}\right)}{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t}\left(x_j^{\tau},y_j^{\tau}\right)}\right)^{\frac{1}{n\times z}}}\right.$$

$$\left.\times\frac{\phi^{t+i}\left(x^{t+i},y^{t+i}\right)}{\phi^{t}\left(x^{t+i},y^{t+i}\right)\times\left(\frac{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t+i}\left(x_j^{\tau},y_j^{\tau}\right)}{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t}\left(x_j^{\tau},y_j^{\tau}\right)}\right)^{\frac{1}{n\times z}}}\right)^{1/2}$$

$$\times\left(\frac{\phi^{t}\left(x^{t},y^{t}\right)\times\left(\frac{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t+i}\left(x_j^{\tau},y_j^{\tau}\right)}{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t}\left(x_j^{\tau},y_j^{\tau}\right)}\right)^{\frac{1}{n\times z}}}{\phi^{t+i}\left(x^{t},y^{t}\right)}\right)^{1/2}$$

Removing brackets and cancelling the GFS terms in the square brackets yields,

$$\underbrace{\left[\frac{\phi^{t+i}\left(x^{t+i},y^{t+i}\right)}{\phi^{t}\left(x^{t+i},y^{t+i}\right)}\times\frac{\phi^{t+i}\left(x^{t},y^{t}\right)}{\phi^{t}\left(x^{t},y^{t}\right)}\right]^{\frac{1}{2}}}_{\text{TC}}=\cancel{\left(\frac{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t+i}\left(x_j^{\tau},y_j^{\tau}\right)}{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t}\left(x_j^{\tau},y_j^{\tau}\right)}\right)^{\frac{1}{n\times z}}}\times\frac{\phi^{t+i}\left(x^{t},y^{t}\right)}{\phi^{t}\left(x^{t},y^{t}\right)\cancel{\left(\frac{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t+i}\left(x_j^{\tau},y_j^{\tau}\right)}{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t}\left(x_j^{\tau},y_j^{\tau}\right)}\right)^{\frac{1}{n\times z}}}}$$

$$\times\frac{\left[\phi^{t+i}\left(x^{t+i},y^{t+i}\right)\right]^{\frac{1}{2}}}{\left[\phi^{t}\left(x^{t+i},y^{t+i}\right)\right]^{\frac{1}{2}}\times\cancel{\left(\frac{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t+i}\left(x_j^{\tau},y_j^{\tau}\right)}{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t}\left(x_j^{\tau},y_j^{\tau}\right)}\right)^{\frac{1}{n\times z}\times\frac{1}{2}}}}\times\frac{\left[\phi^{t}\left(x^{t},y^{t}\right)\right]^{\frac{1}{2}}\times\cancel{\left(\frac{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t+i}\left(x_j^{\tau},y_j^{\tau}\right)}{\prod\limits_{\substack{j=1,\dots,n\\ \tau=1,\dots,z}}\phi^{t}\left(x_j^{\tau},y_j^{\tau}\right)}\right)^{\frac{1}{n\times z}\times\frac{1}{2}}}}{\left[\phi^{t+i}\left(x^{t},y^{t}\right)\right]^{\frac{1}{2}}}$$

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

$$=\frac{\phi^{t+i}\left(x^{t},y^{t}\right)\left[\phi^{t+i}\left(x^{t},y^{t}\right)\right]^{-\frac{1}{2}}}{}\times\frac{\left[\phi^{t+i}\left(x^{t+i},y^{t+i}\right)\right]^{\frac{1}{2}}}{\left[\phi^{t}\left(x^{t+i},y^{t+i}\right)\right]^{\frac{1}{2}}}\times\frac{\phi^{t}\left(x^{t},y^{t}\right)^{-1}\left[\phi^{t}\left(x^{t},y^{t}\right)\right]^{\frac{1}{2}}}{}$$

$$=\frac{\left[\phi^{t+i}\left(x^{t+i},y^{t+i}\right)\right]^{\frac{1}{2}}}{\left[\phi^{t}\left(x^{t+i},y^{t+i}\right)\right]^{\frac{1}{2}}}\times\frac{\left[\phi^{t+i}\left(x^{t},y^{t}\right)\right]^{\frac{1}{2}}}{\left[\phi^{t}\left(x^{t},y^{t}\right)\right]^{\frac{1}{2}}}$$

$$=\left[\frac{\phi^{t+i}\left(x^{t+i},y^{t+i}\right)}{\phi^{t}\left(x^{t+i},y^{t+i}\right)}\times\frac{\phi^{t+i}\left(x^{t},y^{t}\right)}{\phi^{t}\left(x^{t},y^{t}\right)}\right]^{\frac{1}{2}}$$

$\therefore \text{TC}=\text{GFS}\times\text{FI}\times\text{FCI}$

Appendix 2

Notes to the Appendix 2

AE: allocative efficiency

CiE: cost inefficiency

COLS: corrected OLS

CRS: constant RTS

D: deposits

DDF: Directional Distance function

DEA: Data Envelopment Analysis

DFA: Distribution Free Analysis

EE: economic efficiency

EU: European Union

FA: fixed assets

FEM: Fixed Effects Model

Financial capital: interest expenses on borrowed funds divided by borrowed funds

GLS: Generalized Least Squares

GMM: Generalized Method of Moments

K: Physical capital, FA, or expenses on FA divided by FA

KDE: kernel density estimation

L: employees’ number or labour expenses divided by employees’ number

LLP=loan loss provision;

M: Malmquist

OBS: Off-Balance Sheet activities

OEA: other earning assets

OLS: Ordinary Least Squares

PAT: profit after tax

PBT: profit before tax

PE: profit efficiency

PTE: Pure Technical Efficiency

ROA: return on assets

ROE: return on equity

RTS: Returns to Scale

SBM: slack-based model

SE: scale efficiency

SFA: Stochastic Frontier Analysis

TA: total assets

TC: total cost

TE: technical efficiency

TFA: Thick Frontier Analysis

Tobit: Tobit Regression

VRS: Variable RTS

WLS: Weighted Least Squares

WRs: Weight Restrictions

XE: X-efficiency

XiE: X-inefficiency

Note that the efficiency score is given in percentage like 0.92 or 92%. If efficiency is 0.98 (98%) then inefficiency is 0.2 (2%). Some authors indicate efficiency scores, others indicate inefficiency scores.

Author (year)	Method and RTS	Efficiency measure & estimate	Inputs	Outputs	Banking modeling process	Orientation	Sample; Country; Study Period
(Abdul-Majid et al., 2010)	SFA, 2nd stage,	Output distance estimate=1.21	Equity; D; total operating expense	Loans; OEA	intermediation	output	111 banks; 10 Islamic countries; 1996–2002
(Al Shamsi et al., 2009)	DEA, wls	TE=0.8 AE=0.68 CE=0.55	L; K; D	Loans; investments	intermediation	input	22 banks; UAE; 2002
(Assaf et al., 2011b)	DEA, vrs, bootstrap	TE=0.92-0.99	L; K; D	Customer loans; OBS; securities; interbank loans	intermediation	output	9 banks; Saudi Arabia; 1999-2007
(Assaf et al., 2011a)	Malmquist, parametric distance; bootstrap	M=1.0012	L; K; D	Loans; securities	asset	output	291 banks, 2037 observations; Japan; 2000-2006
(Altunbas et al., 2001b)	SFA	XiE 0.2-0.25, SE 0.05-0.07	Price of L; Price of funds; Price of K	Loans, Securities, Off-balance sheet items	intermediation	input	4104 banks, EU 1989-1997
(Ariff and Can, 2008)	DEA, tobit	CE=0.798 PE=0.505	Loanable funds; L; K; TC- interest and operating costs	loans, investments ; profit (=total income - total costs)	intermediation	Input & output	28 banks China 1995–2004
(Asmild and Tam, 2005)	DEA crs, window anal., Malmquist	TE=0.68 M=0.9-1.15	L; K; Other non-interest expenses	Loans, deposits	Production	input	5 banks; Canada; 1981–2000

(Ataullah and Le, 2006)	DEA, 2^{nd} stage OLS and GMM	TE=0.68; 0.77	interest expenses; operating expenses	loans and advances; investments. Interest income; operating income	Intermediation / profitability	Output	43-47 banks; India; 1992–1998
(Athanassopoulos and Giokas, 2000)	DEA-crs, vrs	TE=0.8	Labour hours, branch size, computer terminals, operating expenditure	No. of transactions (credit, deposit, foreign receipts)	Production	input	47 branches Greece 1988-94
(Avkiran, 1999)	DEA	XE=0.79-0.91; 0.37-0.8	L; D; interest expense; non-interest expense	net loans; net interest income; non-interest income	intermediation	input	16-19 banks; Australia; 1986-1995 Small sample
(Avkiran, 2009a)	DEA vrs, SBM; NSBM, nonoriented	PE=0.02-16.5	interest expense; non-interest expense;	interest income; non-interest income	intermediation	output	15 banks; UAE; 2005
(Barr et al., 2002)	DEA,WRs	CE=0.3	L; K; other noninterest exp; interest exp; D	Loans; interest income; noninterest income	intermediation	input	US banks; 1984-1998
(Bergendahl, 1998)	DEA-crs, vrs	CE=0.7	Personnel cost; material cost; Credit losses	Loans; Deposits; Gross revenues	Service provision; risk management.	input	48 Nordic banks: Denmark, Finland, Norway, Sweden; 1992/93
(Bergendahl and Lindblom, 2008)	DEA, crs	PE=0.6-0.76 Serv. Eff= 0.59–0.76	Personnel expense; Credit losses; Non-interest expenses	Loan volume; Deposit volume; OEA; bank branches	Production; service provision	input	85-88 Banks; Sweden; 1997-2001

(Berger and Mester, 2003)	TFA	[1]CP=0.87-1.08 PP=0.99-1.24	TC; purchased funds; deposits; L; K; equity	TP; Consumer loans; Business loans; Real estate loans; Securities; OBS	intermediation	input & output	14,095- 8855 observations; US banks; 1984-97
(Bonaccorsi di Patti and Hardy, 2005)	DFA. Translog, gls, ols	PE=-0.02-0.66 CE=0.74-0.9	TC; L; K; purchased funds; equity	Profit; loans; OEA	intermediation	input & output	33-46 banks; 545 observations; Pakistan; 1981-2002
(Bonin et al., 2005b)	SFA, translog, 2nd stage	CE=0.79 PE=0.45	TC; K; funds;	TP; Deposits; loans; liquid assets; investments	User cost	input & output	59 banks; 451 observations; Bulgaria, Czech, Croatia, Hungary, Poland Romania. 1994-2002
(Bonin et al., 2005a)	SFA, translog, 2nd stage	CE=0.43 PE=0.74	TC; K; funds;	Deposits; loans; liquid assets; investments	User cost	input & output	225 banks; 856 observation; 11 transition countries; 1996-2000
(Bos and Kool, 2006)	SFA, 2nd stage	PE=0.95; CE=0.91	public relations; L; K; housing; financial capital	retail loans; wholesale loans; mortgages; provisions	intermediation	Input Output	401 banks; Netherlands; 1998-99
(Bos and Schmiedel, 2007)	SFA, translog	CE=0.7 pooled; 0.8 single; 0.8 Meta; PE=0.4; 0.6; 0.6	TC; L; K; financial capital; equity/TA	TP; loans; investments; OBS	intermediation	Input output	Over 5000 banks; 9544 observations; 15 Euro nations;1993–2004
(Brissimis et al., 2008)	DEA, Malmquist,	CE=0.65 TFP=1.1	operating expenses; deposits and short-term	Loans; securities;	intermediation	Input	10 CEE countries; 364 banks;1994–2005

[1] CP= cost productivity, PP= profit productivity

	Bootstrap		funding				
(Carbó Valverde et al., 2007)	DFA	CE=0.48 (no truncation); CE=0.73-0.8 (truncation)	TC; L; K; material exp;	ATM; Branches; deposits	Production	input	153 large banks; 10 European countries; 1996-2002
(Casu and Girardone, 2004)	DEA, vrs; SFA (fourier flexible)	CE=0.85-0.86; 0.6-0.7 PE=0.54-0.91	TC; L; K;	Loans; OEA; OBS	intermediation	Input output	2,363 observations ; France, Germany, Italy, Spain, UK; 1993-97
(Casu et al., 2004)	Malmquist DEA & SFA	M=0.95-1.1 Cost M=0.95-1.1	L; K; D	Loans ; securities	intermediation	output	France, Germany, Italy, Spain, UK; 1994-2000
(Chaffai et al., 2001)	Malmquist, SFA, GLS, 2nd stage	M=0.28-2.28	L; K; interest expense	Loans; OEA; deposits;	Production	output	595 banks; France, Germany, Italy, Spain; 1993-97
(Chen et al., 2005)	DEA-vrs	XE 0.43-0.58	interest expenses, non-interest expenses, price of D, price K	loans, deposits, non-interest income	intermediation	Input	43 banks China 1993-2000
(Chen, 2002)	DEA, CCDEA, SFA	TE=0.92 TE=0.93 TE=0.78	L; assets; D; branches	Loans; investments; non-interest revenue; interest revenue	intermediation	Input output	39 banks; Taiwan; 1994-2000
(Chiu and Chen, 2009)	DEA, sbm; SFA	TE=0.94-0.71	L; K; D;	Loans; investments; non interest revenue	intermediation	Input/ output	29 banks; Taiwan; 2002-2004
(Chiu et al., 2009)	DEA, vrs, sbm; Malmquist	TE=0.95 & 0.91; M=4.9	L; K; D	Loans; investments	intermediation	Input/ output	43 banks; Taiwan; 1998-2002
(Chronopoul	DEA,	CE=0.73	L; K; D; equity	Loans; OEA; OBS	intermediation	Input/	629 observations; 10

os et al., 2011)	bootstrap	PE=0.37		revenues		output	New EU member states;2001-2007
(Cook et al., 2000)	DEA	TE=0.1-1	service staff; sales staff; support staff; other staff	counter level deposits; transfers between accounts; retirement savings plan openings; mortgage accounts opened	Production	Input	20 bank branches; Canada;
(Cuesta and Zofío, 2005)	Hyperbolic SFA, translog	TE=0.9 tech. prog-1.35%	D; Bank deposits; L expense; K	Loans; Bond, cash & other assets; Noninterest income	intermediation	Hyperbolic	77 to 34 banks Spain; 1985-98
(Delis et al., 2009)	DEA; SFA	CE=0.84 sfa PE=0.45 sfa CE=0.81 sfa CE =0.64 dea	TC; L price; funds price; equity; K	PBT; loans; OEA	intermediation	input	28 Greek banks; 1993-2005
(Denizer et al., 2007)	DEA, ccr, bcc	TE=0.87–0.51; SE=0.75 -0.93 & 0.81-0.96	K; financial capital; operational expenses; interest & fees; D	Deposits; noninterest income; loans; banking income	Both intermediation & production	input	29-50 banks; Turkey; 1970-94
(Drake and Hall, 2003)	DEA, ccr, bcc	TE=0.72 SE=0.93	General expenses; K; D; Loan loss prov.	Loans & bills; Liquid assets & investments; other income	intermediation	input	149 banks, Japan, 1997
(Drake et al., 2006)	DEA, vrs, SBM, tobit	TE=0.61 vrs; TE=0.52 sbm	Employee exp; other non-interest exp; LLP. K; L; Deposits; LLP	net interest income; net comm. Income; other income. Loans; OEA	Profitability/ intermediation	input & output	413 observations; Hong Kong; 1995-2001
(Drake et al., 2009)	DEA, SBM	TE=0.67-0.78, (I); TE=0.24-0.33 (P); TE=	D; operating exp; provisions; non-interest exp; other	Loans; OEA; Net comm.., fee & trading income;	profit/revenue; production; intermediation	Input	1109 banks; Japan; 1995–2002

		0.55-0.69 (PR)	operating exp.	Other operating income; Net interest income			
(Elyasiani and Mehdian, 1990)	COLS	TE=0.88 SE=0.72 CE=0.64	L; K; D	Revenue=loans 7 investment	intermediation	output	144 US Banks; 1985
(Elyasiani et al., 1994)	DEA, ols	TE=0.83-0.83 AE=0.93 CE=0.76-0.8	L; K; loanable funds; TC	Real estate loans; Commercial & industrial Loans; Consumer loans; D; Securities;	intermediation	Input & output	203 ,US sample Banks, 1983-87
(Erdem and Erdem, 2007)	DEA, ols	TE=0.45-0.78 AE=0.81-0.90;EE=0.33-0.65	L; K; interest bearing liabilities	PBT	intermediation	Input	10 Banks, Turkey, 1998-2004
(Favero and Papi, 1995)	DEA, crs, vrs, ols	TE=0.79-0.91	L; L; D	Loans; investments; noninterest income; D	intermediation & asset	Input	174 banks, Italy, 1991
(Fries and Taci, 2005)	SFA, second-stage	CE=0.42-0.82	TC=interest & operating expenses; L; FA	Loans; deposits	intermediation	Input	289 banks , 15 East EU, 1994-2001
(Frimpong, 2010)	DEA, ccr	TE=0.74	Deposits; Total expense	Loans & advances; investments	intermediation	Input	22 Banks, Ghana 2007
(García-Cestona and Surroca, 2008)	DEA	OTE=0.75-0.83; TE=0.80-0.84 AE=0.94-0.99	Employees expenditure; Depreciation expenses; Operating expenses	Loans ; Ave. balance of deposits; HHI; PAT; Interest rates for overdrafts; Charitable-social	production	Output	226 savings banks; Spain; 1998-2002

				programs;			
(Girardone et al., 2004)	SFA, Fourier, logistic regression	CE=0.85-0.87 SE=0.78-0.86	L; D; financial capital	Loans; securities	intermediation	Input	1958 bank observation; Italy; 1993-1996
(Glass et al., 2010)	DDF, DEA, bootstrap	TE=0.015-0.76, TE=0.02-0.99	Salaries & related expenses; K; Management expenses	Loans; investments; Bad debt write-offs	intermediation	Input/ output	388 credit unions; Ireland
(Golany and Storbeck, 1999)	DEA, WRs	TE=0.8-0.89; Overall=0.65	Teller labour; nonteller L; Retail sq ft.; Marketing; Employment rate	Loans; deposits; depth; satisfaction	production	output	US bank 182 bank branches, 2nd ¼ of 1992 1993 3rd 1/4
(Grigorian and Manole, 2006)	DEA, 2nd stage	TE=05-0.6; 0.4-0.7	Labour; FA; Interest expenses	Revenues; net loans; liquid assets;	Profit maximization & service provision	Input	1074 banks in 17 transition economies; 1995-98
(Grifell-Tatje and Lovell, 1999)	Malmquist DEA	M=709	FA; L; Deposits & liabilities	Ave. loans & investments; Ave. deposits;	intermediation	output	59-61 banks, Spain, 1987-94
(Halkos and Salamouris, 2004)	DEA, crs, vrs	Ratio model =0.77; CRS=09-0.93 VRS=0.94-0.98	interest expenditure; TA; L; operating expenses;	(interest income; net profit). Return difference of interest bearing assets; ROE; ROA; Profit/loss per employee; Efficiency ratio; NIM;	intermediation	output	15-18 banks, Greece, 1997-99
(Hao et al.,	SFA,	CE=0.89	TC; L; K; funds	Loans & securities;	intermediation	input	19 banks; Korea;

2001)	translog, 2nd stage		interest; equity	deposits; fee income			1985-95
(Hauner, 2005)	DEA, 2nd stage ols	CE=0.63 SE=0.96 M=1	Interest-bearing funds; L (interest rate; ave. exp per employee)	Loans to banks; Loans to customers; fixed-interest securities	production	input	97 banks, Germany & Austria, 1995-99
(Hasan and Marton, 2003b)	SFA, translog	CE=0.71 PE=0.66	TC; Borrowed funds; L	ATP; Loans; OEA; noninterest income; interest bearing borrowed funds	intermediation	Input/ output	193 banks; Hungary; 1993–1998
(Havrylchyk, 2006)	DEA, 2nd stage ols	CE= 0.53-0.73 AE= 0.7-0.88 TE= 0.76-0.83, SE= 0.88 -0.91, PTE= 0.84- 0.93	D; K; L	Loans; Treasury bonds; OBS	intermediation	input	52 banks, Poland, 1997-2001
(Ho and Zhu, 2004)	DEA, ccr,	TE=0.71-1; Effectiveness= 0.15-1	Capital stocks; Assets; branches; L; Sales; D	Sales; D; Net income; Interest income; Noninterest income	intermediation profitability	output	41 banks, Taiwan, 2001
(Huang and Wang, 2002)	SFA, DFA, DEA - crs, vrs	EE=0.68 (SFA, DFA) EE=0.58-0.87 (DEA)	D; L; K; (Interest; Salaries; capital exp./K)	Investments; Short-term loans; Long-term loans	intermediation	input	22 banks, Taiwan, 1982-87
(Huang, 2007)	SFA, multiple comparis on best	EE=0.6	TC; D & borrowings; L; K net of Depreciation	Investments; Loans	intermediation	input	22 banks, Taiwan, 1998-2001
(Isik and Hassan,	DEA, 2nd stage ols	CE=0.72 AE=0.87	L; K; funds; D	Short-term loans; Long-term loans;	intermediation	Input	149 Banks, Turkey,

2002)		TE=0.82 SE=0.88		other earning assets			1988, 92, 96
(Isik and Hassan, 2003)	DEA, crs, vrs, 2nd stage ols	CE=0.72; AE = 0.87; TE= 0.82; SE=0.88 PTE=0.92	L; K; funds;	Short-term loans; Industrial & individual loans;Long-term loans; OBS; OEA	intermediation	Input	149 Banks, Turkey, 1988, 92, 96
(Isik, 2008)	DEA	XE=0.79, 0.85 SXE=0.81, 0.88 M=1.21-1.61	L; K; loanable funds;	short-term loans; long-term loan; OEA	intermediation	Input	794 observations, ; Turkey; 1981–1996
(Jemric and Vujcic, 2002)	DEA, crs, vrs,	TE=0.45-0.79; TE=0.78-0.87	Interest cost; commissions; L; K; D;	Interest and related revenues; non-interest revenues; securities	intermediation & operating	Input	264 Banks, Croatia, 1995-2000
(Kablan, 2010)	SFA	CE=0.76	TC; deposits; K; L: equity; NPL;	Loans;	Intermediation & value-added	Input	137 banks; 29 countries of SSA
(Kenjegalieva et al., 2009b)	DEA, vrs, bootstrap	TE=0.75-0.88	L; FA; LLP; Deposits & short-term funding	loans'; other earning assets; Deposits & short-term fund; net commission, net fee and net trading income; other income	Intermediation, production	output	603 banks, Czech, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia & Slovenia 1999-2003
(Kenjegalieva et al., 2009a)	DEA, 2nd stage, bootstrap	TE=81.7-90.9 TE=78.6-91.3 TE=77.2-87.2	Deposits; (I) L; (I, PR, P) K; (I) Other operating expenses; (PR, P)	Loans, (I, P); OEA, (I, P); Net interest rev., (PR); Other Income, (I, PR,P) Comm. & fees, (I,	Intermediation profit/revenue, production	output	159 banks; CEE; 1998-2003

				PR, P); Deposits, (P); LLP, (I, PR, P)			
(Koutsomanoli-Filippaki et al., 2009)	SFA, Luenberger productivity indicator.	TiE=0.28-1.53 L=-0.35-1.43	L; K; equity	Loans; OEA; Borrowed funds	Value-added	DDF	186 Banks; 871 observations; 10 CEE; 1998-2003
Kraft (Kraft et al., 2006)	SFA, fourier	CE=1.37	TC; L; K; funds Assets; capital	Enterprise (E) loans; household (H) loans; E deposit; H deposits	intermediation	Input	363 observations; Croatia; 1994-2000
(Krishnasamy et al., 2004)	DEA, M	M=1.051	L; total assets (excluding loans & advances)	Deposits; Loans & advances	Intermediation	output	10 banks; Malaysia; 2000-01
(Kumbhakar and Tsionas, 2008)	SFA, local maximum likelihood	CE=0.9	TC; L; K; purchased funds; deposits in total transaction accounts; deposits in nontransaction accounts	instalment loans; real estate loans; business loans; funds 7 securities; other assets	intermediation	Input	3,691 banks; U.S.; 2000
(Kumbhakar and Wang, 2007)	SFA, Input distance function, TFP	TE=0.47-0.9 TFP=1.044	Borrowed funds; FA; L;	Loans; OEA;	Intermediation	Input	14 banks; 132 observations; China; 1993-2003
(Kwan, 2006)	SFA, 2nd stage, ols	XE=0.45-0.29	L; K; borrowed money (their prices)	loans for finance; loans for non-trade-related financing; earning	intermediation	Input	59 banks; Hong Kong; 1992-99

				assets			
(Kyj and Isik, 2008)	DEA, 2nd stage,	TE=0.45 PTE=0.62 SE=0.78	L; K; funds	Loans; investment securities	Intermediation	Input	883 observation, about 150 banks; Ukraine; 1998-2003
(Lensink et al., 2008)	SFA, translog	CE=NA	TC; price of funds; price of L;	Loans; securities. Bank & country specific variables	Intermediation	Input	2095 commercial banks; 105 countries;1998–2003
(Lin et al., 2009b)	DEA	TE=0.55 PTE=0.67 SE=0.82	Staff No.s; interest expense; D operating amount; current deposit operating amount	loan operating amount; interest revenue; operating revenue; earning	intermediation	Input	117 bank branches; Taiwan; 2006
(Liadaki and Gaganis, 2010)	SFA	CE=0.91 PE=0.79	TC; cost of deposits; price of K; price of L	Profit before tax; customer loans; OEA; non-interest income	intermediation	Input / output	171 banks ; EU-15 2003–2006)
Liu (Liu, 2009)	DEA	TE=0.41	Deposits; Interest Expenses; non-interest expenses	Loans; interest income; Non-interest income.	intermediation	output	24 banks; Taiwan;
(Lozano-Vivas and Humphrey, 2002)	Malmquist DEA, SFA	M=-0.08	Deposits; borrowed funds; equity capital; other liabilities;	Loan; securities; cash & reserves; physical K	intermediation	output	Banks, Spain, 1986-91
(Lozano-Vivas et al., 2002)	DEA	TR=0.37-0.85	personnel expenses; noninterest expenses	loans; deposits; OEA	Value-added	Input	612 banks; 10 European economies; 1993
(Lozano-Vivas and Pasiouras,	SFA, multi-product	CE=0.87 PE=0.77	TC; cost of funds; K; L; equity	Loans; OEA; OBS; non-interest income; PBT	intermediation	Input/ output	752 banks; 87 countries; 1999-2006

2010)	translog						
(Luo, 2003)	DEA, crs, vrs	OTE=0.88-0.95;PTE=0.93-0.97; SE=0.95-0.97	L; TA; Equity. (revenue and profit)=m	Revenue; profit; (market value; EPS; stock price)=m	Profitability; marketability	Input	245 banks; US; 2000
(Margono et al., 2010)	SFA, parametric TFP	CE=0.7 SE=0.7-0.97 TFP=-0.015 to -0.064	TC; L; funds; K	Loans; securities	intermediation	Input	134 Banks; Indonesia; 1993-2000
(Matousek et al., 2008)	SFA	CE=0.83 Inefficiency=0.14	TC; L; financial capital; K	Loans; OEA;	intermediation	Input	23 Banks; Turkey; 2000-05
(Maudos and de Guevara, 2007)	SFA, 2nd stage	XE=0.86	TC; L; K	Loans, deposits	production	Input	29744 banks; 15 European economies; 1993–2002
(Maudos and Pastor, 2003)	DEA spearman's	CE=0.871 PE=0.574, 0.425	Deposits & funds; L; K; TC	loans & OEA, securities; operating profit	intermediation	input & output	50 to77 banks, Spain, 1985-96
(Maudos et al., 2002)	fixed effects; random effects; SFA; DFA, 2nd stage	CE=0.5-0.87 (DFA); 0.17-0.87 (FE); 0.36-0.88 (RE) PE=0.11, 0.05, 0.12	TC; Funds costs; L; K; equity;	Loans; OEA; deposits; operating profit	intermediation		832 banks; 10 EU countries; 1993–96
(McEachern and Paradi, 2007)	DEA, ccr	TE=0.76; TE=0.7-0.96	Interest; remuneration costs; ''other''. Managers; Tellers;	interest revenue; non-interest revenue. Teller transactions;	Profitability; Productivity	Input	138 bank branches; 11/2001-08/2003

			Personal banking offers and PBO staff	New accounts opened			
(Hamim et al., 2008)	DEA, vrs	TE=0.58 or 0.79 CE=0.46 or 0.78	D; Overhead expenses	Earning assets	intermediation	Input	288 banks, Malaysia, 1997-2003
(Mostafa, 2009)	DEA, crs, vrs ; probabilistic neural network	TE=0.31, 0.43	Assets; equity	Net profit; ROA; ROE	Profitability	output	85 Arab banks; 2005
(Mukherjee et al., 2001)	DEA, crs, vrs, Malmquist, 2nd stage, 2-way random effect	MPI=4.5% TE= 0.88	Transaction deposits; non-transaction deposits; equity; L; K	Comm.. & industrial loans; customer loans; real estate loans; investments; noninterest income	intermediation	Input	201 US banks; 1984-90
(Murillo-Melchor et al., 2009)	DEA, 2nd stage; Malmquist, bootstrap	M=0.97-0.99	L; K; borrowed funds	customer loans; D; OEA; Securities & equity investments; noninterest income	intermediation	Input	3,997 banks; 14 EU economies; 1995–2001
(Nikiel and Opiela, 2002)	DFA, translog, 2nd stage	CE=0.61 PE=0.78	TC; interest on funds; labour price; K; equity; OBS	Profit; loans; securities; NPL	intermediation	Input/ output	43 banks; Poland; 1997-2000
(Oliveira and Tabak, 2005)	DEA, vrs	TE=0.95-0.97	market risk; market risk translated by the betas	Stocks' profitability	profitability	output	41 economies; 1996-2002

(Paradi and Schaffnit, 2004)	DEA, vrs	TE=0.94; effectiveness= 0.86; cost effectiveness= 0.51	Staff; IT; premises; other non-interest expenses (NIE). staff, equipment, rent, NIE	D; loans (L); operating services; Account maintenance; D; L; operation. Services	production	Input, output	90 bank branches; Canada; 1995
(Park and Weber, 2006)	DDF, DEA, Malmquist	Inefficiency=0.004-3.09; M=0.466	K; D; L; NPL; equity; interest expense; noninterest exp.	Loans; securities; deposits; interest income; noninterest income; fees	intermediation & production; 5 models	DDF	14-26 banks Korea, 1992-2002
(Pasiouras, 2008b)	DEA, 2nd stage, tobit	OTE=0.67 PTE=0.71 SE=0.95	D; TC; equity.	Loans; OEA; non-interest income.	intermediation	output	715 banks; 95 countries; 2003
(Pasiouras, 2008a)	DEA, vrs, tobit	TE=0.95-0.98; SE=0.97-0.98	L; K; deposits; LLP; non-interest	Loans; OEA; OBS; Net interest income; Net comm.. income; Other operating Income.	Intermediation / profitability	Input/output	10 Banks; Greece; 2000–2004
(Pasiouras et al., 2008)	DEA, crs, vrs, 2nd stage	TE=0.93 (crs); TE=0.97 (vrs); SE=0.95	Interest expenses; total operating expenses.	total income= interest income+ other operating income	profitability	output	12-18 Banks; 78 observations; Greece; 2001-05
(Pasiouras et al., 2009)	SFA, translog cost, 2nd stage	CE=0.88; PE=0.77	Borrowed funds; K; L (their costs)	Loans; OEA; deposits;	value added	Input, output	615 banks; 74 countries; 2000-04
(Porembski et al., 2005)	DEA,, Sammon's mapping	TE=0.84-0.98; SE=0.9-0.97	Employees; Office space	Private demand D; Business demand D; Time D ; Saving D, Credits; Bearer securities;	production	Input output	140 Bank branches; Germany; 1998

				Recourse guarantees; bonds; Investment D; Insurances; Contributions to building society			
(Ramanathan, 2007)	DEA, crs, vrs; Malmquist	TE=0.9 crs; TE=0.94 vrs SE=0.96 MPI=1.00	FA; D; short-term funds; equity; L;	Loans; OEA	intermediation	output	55 banks; GCC (Bahrain, Kuwait, Oman, Qatar, Saudi, UAE); 2004 & 2000-2004
(Rao, 2005)	SFA, , 2nd stage, translog, fourier, fixed effect	CE=0.8; 0.75; 0.9	TC; D; L	Investments; loans; OBS	intermediation	Input	37 banks; 1998-2001; UAE;
(Ray and Das, 2010)	DEA, 2nd stage KDE	CE=0.9-0.94 PE=0.43-0.64	Funds; L; K; Quasi-fixed inputs=equity	Investments; Earning advances; Other income	asset	Input output	68-71 Banks; India; 1997-2003
(Ray, 2007)	DEA	TE(vrs)=0.9 SE=0.98 Size efficiency <0.9/33 cases	Borrowed funds; L; K; Equity	Credit; Investments; Other income	intermediation	output	68-73 Banks; India;1997–2003
(Resti, 1997)	DEA (crs, vrs), SFA	CE=0.694-0.698 CE=0.665-0.69 (crs); CE=0.73-0.76	Operating cost; L; K	D; loans; Non-interest income	Value added	Input	270 banks; Italy; 1988-92
(Rezitis, 2008)	SFA, MPI,	TE=0.80 M=0.63-3.17	L; K	D; loans & advances	production	output	10 Banks; Greece; 1993–2004

	output distance function						
(Rossi et al., 2009)	SFA, DFA, TFA	CE=0.88-0.93; PE=0.3-0.43	TC; L; K; funds; risk preferences	Profit; loans; D; other assets & securities	intermediation	Input output	96 Banks; Austria; 1997-2003
(Saha and Ravisankar, 2000)	DEA, 2nd stage ols	TE=0.06-0.3	Interest exp; K; Establishment exp; non-establishment exp;	D; advances; investments; non-interest income	intermediation		25 banks; Indian; 1992-95
(Sathye, 2001)	DEA, anova	XE=0.58 TE=0.67 AE=0.85	L; K; loanable funds	Loans; deposits	intermediation	Input	29 Banks; Australia; 1996
(Sathye, 2003)	DEA, vrs	TE=0.62, 0.83	interest exp; non-interest exp. Deposits; staff.	net interest income; non-interest income. loans; non-interest income	intermediation	Input	94 Banks; India; 1997-98
(Sherman and Rupert, 2006)	DEA	TE=0.8	Teller FTEs; Platform FTEs; Manager FTEs; Other expenses; D; Service quality	Teller transactions; New accounts; Night deposits; Safe deposit visits; ATMs serviced; Loans	production	Input	217 bank branches; US; 1998
(Soteriou and Stavrinides, 1997)	DEA	TE=0.79	clerical personnel; managerial personnel; computer terminals; working space	personal accounts; savings accounts; business accounts; credit application accounts; Service quality	production	Input & output	28 Bank branches; Cyprus; 07/1994 - 12/1994
(Soteriou and Zenios,	DEA, crs, vrs	CE=0.48-0.9	TC	Current savings accts; Foreign	production	Input	28-39 Bank branches;

1999b)				company accts; Credit application accts; Interbranch transactions; Loan initialization; Loan renewals			Cyprus; 1994
(Srairi, 2010)	SFA, translog, 2nd stage	CE=0.56 PE=0.71	TC; prices of K, L & funds	PBT; Loans; OEA	intermediation	Input /output	71 banks; Gulf Cooperation council; 1999-2007
(Staub et al., 2010)	DEA, 2nd stage (Baltagi & Wu, Tobit & Dynamic models)	CE=0.45 AE=0.67 TE=0.63	operational exp. net of personnel exp; personnel exp; interest rates exp.	loans net of provision loans; Investments; deposits.	intermediation	Input	127 Banks; Brazil; 2000-07
(Sturm and Williams, 2004)	DEA, Malmquist, SFA	TE=0.73-0.94	L; deposits & borrowed funds; equity. Interest exp; non-interest exp	Loans; OBS activity; net interest income; non-interest income	intermediation	Input	39 banks; Australia; 1988–2001
(Sturm and Williams, 2010)	SFA, parametric input distance function, 2nd stage	TE=.71-0.87	L; D; equity; Interest & noninterest expenses	Loans; OBS. Interest & noninterest income	Intermediation /revenue based	Input	12-26 banks; Australia; 1988–2001
(Sufian, 2007)	DEA, window analysis	TE=0.88	D; K;	Loans; Other Income	asset	output	6 Banks; Singapore; 1993-2003
(Sufian,	DEA, crs,	TE=0.33-0.57;	D; L; K.	Investments (I);	Intermediation	Output/	171 Banks; Malaysia;

2009)	vrs, 2nd stage (tobit)	TE=0.55-0.9; TE=0.75-0.9	interest exp; K. interest exp; other operating exp; K.	loans (L). Deposits; I; L. interest income; non-interest income.	; value added; operating	input	1995–1999
(Sufian and Habibullah, 2009)	DEA, 2nd stage (OLS, FEM)	TE=0.61-0.97 PTE=0.71-1.0 SE=0.7-0.98	Deposits, L, K; interest expense,	Loans, investments; deposits; interest & noninterest income	Intermediation valued-added, operating	input	31 banks; Korea; 1992-2003
(Tabak and Tecles, 2010)	Bayesian SFA; translog	CE=0.88-0.9 PE=0.94-0.96	TC; L; K.; purchased funds	Loans; deposits; OEA; OBS; PAT	Intermediation	Output/ input	67 banks; 389 observation; India; 2000-2007
(Tecles and Tabak, 2010)	Bayesian SFA; translog; DEA	CE=0.66 PE=0.75	TC; L; K.; purchased funds	Loans; deposits; investment	Intermediation	Output/ input	156 banks; Brazil; 2000-2007
(Thoraneenitiyan and Avkiran, 2009)	DEA/SFA, SBM, 2nd stage, tests	TE=0.5; 0.15-0.85	D; L; K.	Loans; investments & OEA; fee income; OBS	intermediation	Output/ input, non-oriented	110 banks; 550 observations; Indonesia, South Korea, Thailand, Malaysia, Philippines ; 1997-2001
(Tortosa-Ausina, 2002b)	DEA	XE=0.53-0.79; 0.75-0.84	L; K; Funding	Loans; OEA; D	intermediation	Input	116-121 banks; Spain; 1985–1995
(Tortosa-Ausina, 2003)	DEA	CE=0.66-0.74; 0.8-0.91	L; K; Funding	Nontraditional output; Loans; OEA; fee-generated income	Intermediation	Input	120-162 banks; Spain; 1986-1997
(Tortosa-Ausina, 2004)	DEA	CE=0.72-0.78; AE=0.78-0.87;	L; K; Funding	Loan; Securities; Non-traditional output	Asset	Input	137-165 banks; Spain; 1992, 97 , 98

		TE=0.84-0.92					
(Tortosa-Ausina et al., 2008)	DEA, crs, Malmquist TFP; Bootstrap	M=1-1.19	L; K; purchased funds (D)	Loan; Core deposits; non-interest income	Intermediation	output	50 Savings banks; Spain; 1992–1998
(Weill, 2003)	SFA, 2nd stage; tobit	CE=0.7 & 0.62	TC; L; K; borrowed; TA funds. Other are equity,	Loan; Investments.	Intermediation	input	47 banks; Czech & Poland; 1997
(Weill, 2004)	SFA, DFA, DEA	CE=0.66-0.84; CE=0.44-0.67; CE=0.4-0.78	TC; L; K; borrowed funds	Loan; Investments	Intermediation	input	688 banks: France, Germany, Italy, Spain, Switzerland; 1992–1998
(Weill, 2007)	SFA, DFA, 2nd stage; ols	CE=0.55-0.69; CE=0.23-0.41	TC; L; K; borrowed funds	Loan; Investments	Intermediation	input	955 banks; 17 European countries; 1996-2000
(Weill, 2009)	SFA, DFA, fourier flexible	CE=0.70	TC; L; K; borrowed funds. TA	Loan; investments	Intermediation	input	14447 observations; 10 EU nations; 1994-2005
(Wheelock and Wilson, 1999)	DEA; Malmquist TFP	TE=0.41-0.88; M=0.82-1.02	L; K; purchased funds	Real estate loans; commercial. & industrial loans; consumer loans; all other loans; demand deposits	Intermediation	Output	11,387 to 14,108 banks; US; 1984–1993
(Wheelock and Wilson, 2008)	Hyperbolic quantile, DEA, FDH	TE=1.12; 1.07 (DEA); TE=1.02(fdh);	L; Materials, Software, Equipment & Support; Transit; Facilities	Checks; End points	production	Hyper-bolic	45–48 US Federal Reserve check processing offices; 4405 quarterly observations, 1980–2003

(Wheelock and Wilson, 2009)	Hyperbolic quantile Malmquist, DEA, FDH	M=0.8-1.2; 0.8-1.1	Purchased funds; D; L; K; Equity;	Consumer loans; Business loans; Real estate loans; Securities; OBS	Intermediation	Hyper-bolic	11,993, 9,585, & 6,075 US banks' observations; 1985, 1994 & 2004
(Worthington, 1998)	SFA, translog	CE=0.81	TC; K; L; deposits. Assets; equity; branches; agencies; time; comer	Loans; securities.	Intermediation	Input	22; building societies; Australia; 1992-1995
(Yang, 2009)	DEA, vrs	TE=0.45-0.84	Administrative FTE; Service FTE; Sales FTE.	Money-in & out balance. No. of money-in & out accounts. etc	production	input	758 bank branches; Canada; 2005
(Yao et al., 2008)	DEA, crs, vrs, Malmquist	TE=0.85; M=5.6	Interest Expense; Non-interest Expense	Interest Income Non-interest Income;	profitability	input	15 banks; China; 1998–2005
(Yildirim and Philippatos, 2007)	SFA, DFA, 2nd stage (GLS fixed-effects)	CE=0.77, sfa; CE=0.72, dfa; PE=0.66; 0.51	TC; L; K; borrowed funds; equity	Loans; investments; deposits	value-added	Output/ input	325 banks; 2042 observations ; 12 CEE economies; 1993–2000
(Yildirim, 2002)	DEA	OTE=0.9; PTE=0.96 SE=0.93	demand deposits; time deposits; interest expense; non-interest expense	Loans; interest income; noninterest income	Intermediation	Output	Banks; 594 Observations; Turkey; 1988-99

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