Assessing the efficiency of South African medium-sized banks

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Declaration

I, Magdalena Maria Branken, hereby declare that this dissertation, submitted in fulfilment of the requirements for the degree Master of Commerce in Risk Management to the North-West University is my own work, except where acknowledged in the text. It has not been submitted to any other tertiary institution as a whole or in part.

Magdalena Maria Branken

Date: 18/11/2018

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Ek is tot alles in staat deur Hom wat my krag gee.

Fillipense 4:13.

Abstract

The economic growth and stability of any country is strongly dependent of the performance and efficiency of its financial sector, of which the banking industry forms an integral part. South Africa's financial sector is one of the most developed on the African continent, especially the banking industry in which advanced credit and management systems have been implemented. However, as is expected of a developing economy, the country's banking industry is highly concentrated, due to the dominance of the five major banks. Many authors argue that a concentrated banking industry contributes to greater financial instability, which raises concerns regarding the performance and efficiency of the smaller banks. While the efficiency of the large banks in South Africa has been analysed, little is known about the efficiency of the of the medium and small-sized banks in the country.

The focus of this study was to estimate the technical and scale efficiency of the medium-sized banks of South Africa over a 13-year period from January 2004 until December 2017, which consisted of four different business cycle phases. A multi-stage Data Envelopment Analysis (DEA) model was applied using the intermediation approach with an input-oriented measure under the constant returns to scale and variable returns to scale model specifications to determine the efficiency levels of the medium-sized banks. Total deposits, central bank and money, total equity, and South Africa (SA) group and finance were used as inputs, while other liabilities, deposits, loans and advances, and investments and bills were used as the outputs in the analysis. The hierarchal cluster analysis, using the single linkage method was applied to identify the medium-sized banks, which were namely: African Bank Ltd. (AB), Capitec Bank (CB), Deutsche Bank AG (DB), Investec South Africa (IB), JP Morgan Chase Bank (JPM), and The Hongkong and Shanghai Banking Corporation Ltd.-Johannesburg Branch (HSBC).

IB was identified as the most technical efficient bank, followed by JPM and DB as the 2nd and 3rd-most technical efficient banks. AB was ranked 4th, followed by HSBC and CB that were ranked 5th and 6th respectively. In contrast, JPM was identified as the medium-sized bank that generally exhibited the highest scale efficiency, followed by DB as the 2nd-most scale efficient, and AB and HSBC collectively 3rd. CB was ranked 4th, followed by IB which exhibited the highest level of inefficiency. It is concluded that the medium-sized banks show some signs of technical and scale inefficiency, especially in terms of central bank and money, and SA group and finance as inputs. This is somewhat concerning, since inefficient banks are more likely to experience higher levels of exposure to risks. Various recommendations are therefore made that can be considered by the banks to improve their respective efficiencies.

It was also found that the technical and scale efficiency scores did not display a clear correlation with the upward and downward business cycle phase. Often, upward phases correlated with suppressed efficiency scores, while increased efficiency scores were noted for the downward phases, especially during Phase 2 in which the global financial crisis occurred. This behaviour, especially during Phase 2, was also found in other studies on the efficiency levels of the major South African banks and is thought to be due to conservative banking practises that are supported by strict regulatory frameworks that limits foreign risk.

Keywords: Medium-sized banks of South Africa; efficiency measures; technical and scale efficiency, cluster analysis, single linkage method, Data Envelopment analysis (DEA); multi-stage DEA model; input-oriented DEA approach; constant returns to scale; variable returns to scale.

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Abbreviations

Abbreviation	Meaning
AB	African Bank Ltd.
ABSA	Amalgamated Bank of South Africa
AE	Allocative efficiency of an organisation
ANC	African National Congress
ATM	Automated teller machine
ATMs	Automated teller machines
BC	Banking council
BCC	Banker, Charnes, and Cooper, 1984
BIS	Bank of International Settlements
BSC	Balance scorecard
CCA	Contingent claims analysis
CCR	Charnes, Cooper and Rhodes, 1978
CIR	Cost to income ratio
CMAX	Max composite index
CRS	Constant returns to scale
DB	Deutsche Bank AG
DEA	Data envelopment analysis
DMUs	Decision making units
ECB	The European Central Bank
EE	Aggregate economic efficiency
EPS	Earnings per share
EPSCE	Expansion path scale economy
EVA	Economic value added
FNB	First National Bank
FSA	Financial service authority
FSB	Financial services board
FSCA	The Financial Sector Conduct Authority

Abbreviation	Meaning
FSI	Financial stress index
FSI's	Financial stress indices
FSOC	Financial stability oversight committee
GDP	Gross domestic product
HSBC	The Hongkong and Shanghai Corporation Limited-Johannesburg Branch
IB	Investec Bank South Africa
IMF	International monetary fund
JIBAR	Johannesburg interbank agreed rate
JPM	JP Morgan Chase Bank
JSE	Johannesburg Stock Exchange
LP	Linear programming
NBSA	Netherlands Bank of South Africa
NBZA	Nederlandsche Bank voor Zuid-Afrika
NCA	National Credit Act
NCR	National Credit Regulator
NIM	Net interest margin
NIRS	Non-increasing returns to scale
NPM	Net profit margin
NSFR	Net stable funding ratio
OECD	Organisation for economic co-operation and development
P/E	Price to earnings
ROA	Return on assets
ROCE	Return on capital employed
ROE	Return on equity
ROI	Return on investment
RONW	Return on net worth
SA	South Africa
SAFEX	South African Futures Exchange
SARB	South African Reserve Bank

Abbreviation	Meaning
SFA	Stochastic frontier analysis
SSA	Statistics South Africa
SUR	Seemingly unrelated regression
TAT	The total asset turnover
TB	Treasury Bill
TE	Technical efficiency
TFA	Thick frontier analysis
US	United States of America
VIX	Volatility index
VRS	Variable returns to scale

Chapter 1

Introduction

1.1. Introduction

The recent financial crisis has highlighted that global economies are heavily influenced by their respective financial sectors' stability and performance. Sutton and Jenkins (2007:6) define a financial sector as a sector that comprises various types of service businesses such as banks, insurers, and pension funds. Hawkins (2004:179-180) describes South Africa's financial sector as one that consists of different subsectors including investment and banking industries, insurance companies, and security businesses, which contribute to the development status that the sector is known for. The National Treasury of South Africa (2011:1-2) has also stressed the importance of the financial sector of South Africa and its influence on the economy, as it supports economic stability and stimulates economic development which in turn contribute to sustainable economic growth for South Africa. Moreover, an efficient banking industry is of paramount importance for any economy since banks, as financial institutions, facilitate the financial intermediation process between lenders and the borrowers (Gobat, 2012:38). Banks therefore support economic development and financial stability, manage financial disruptions in the economy, and add value to the economy by contributing to employment opportunities and the Gross Domestic Product (GDP) (Butterworth & Malherbe, 1999:5).

Spong *et al*. (1995:1-2) state that the main purpose of every bank is effective utilisation of resources, and therefore efficiency is important for several reasons which include increasing competitiveness within the financial services sector. According to Hughes and Mester (2008:2), banks are important because they help establish procedures for assessing and managing economic risks to organise written contracts, observe economic performance, and to resolve any type of non-performance difficulties.

For these reasons, the banking industry in South Africa is vital to the development and growth of the South African economy, and therefore it requires a good understanding. According to Okeahalam (2001:15), South Africa's financial sector is one of the most developed on the African continent, the banking industry in particular with its advanced credit and management systems. Albeit well-developed, Van der Westhuizen (2014:94) notes that the banking industry in South Africa is extremely concentrated since the industry is dominated by the big five banks. According to Maredza and Ikhide (2013a:2-3), the top five largest banks that control the sector are FNB (First National Bank), Nedbank Ltd., Absa Bank Ltd. (Amalgamated Bank of South Africa), the Standard Bank of South Africa Ltd., and Investec South Africa. The South African Reserve Bank (2011:55-57) affirms that these banks control the leading market share in the economy, namely about 90% of the total banking assets in South Africa (The Banking Association of South Africa, 2014:1-3). A concentrated banking industry is characteristic of a developing country. Considering that various authors such as Okeahalam (2006:103-104), Boyd and De Nicolo (2005:1329) and Boyd *et al.* (2009:4) have found that concentrated banking industries contribute to greater financial instability, this raises concerns about the efficiency of the South African banking industry, especially for the medium-sized banks, which forms the scope of this study.

Since there is no clear international guideline on when a bank should be classified as a small, medium, or large bank, statistical techniques such as cluster analysis (Filipovska, 2017; Ercan & Sayaseng, 2016) are normally used to classify banks based on a certain metric. One such metric is the total assets of banks as suggested by by authors such as Lautenschläger (2016) and Schildbach (2017), which was also used in this study to clasify the South African banks. As a result, it will be shown that local branches of some international banks that may be considered to be "large" banks in the international context, are classified as medium-sized banks[1] in the South African context, since only their operations in South Africa are considered.

Consequently, a medium-sized bank is classified in this study as a bank whose total assets is typically 10 times less than that of the large banks. For the period considered in this study, that is, between January 2004 and December 2017, the average total assets of the medium-sized

[1] More specifically, the medium-sized banks are classified using their asset size per month over the study period considered in this study, and cluster analysis was used to identify the medium-sized banks as discussed in Chapter 4 and Chapter 5.

banks ranged between roughly R21 billion and R34 billion. Considering that the medium-sized banks control a relatively small portion of the total market share, poor performance in these banks can hamper the banking industry's overall performance. A prime example hereof is when African Bank Ltd. caused major upsets throughout the financial system when it exposed itself to credit risk. In 2014 it was announced that African Bank Ltd. had defaulted after awarding credit to clients who could not afford it (Sanchez, 2014), and that the South African Reserve Bank (SARB) offered financial aid to the value of $1.6 billion when it became clear that the bank was headed for a major loss (CNBC Africa, 2014). Since banks are regarded as pivotal organisations within a country's financial sector (Okeahalam, 2006; Spong *et al*., 1995; Levine, 1997), the South African economy would likely have been exposed to systemic risk had the SARB not taken control of African Bank Ltd. in 2014.

According to Ongore & Kusa (2013:238), the financial soundness of a country's banking industry that comprises large, medium, and small-sized banks is vital to its economy, and to this effect efficient and good performing banks will facilitate good economic growth. An organisation's efficiency is an indication of its organisational performance. An inefficient banking industry can induce fluctuations in a country's national income and inflation percentage, which have a direct influence on consumers' quality of life (Jayamaha & Mula, 2011:2).

The concept efficiency can be subdivided under technical efficiency, allocative efficiency, cost efficiency, profit efficiency, and scale efficiency (Van der Westhuizen, 2008:25). Technical efficiency provides a measure of the degree to which a bank is able to minimise the use of its inputs to attain a given level of outputs (Qayyum & Khan, 2007:5). Allocative efficiency, according to Uri (2001:172), is a measure of a bank's capability to use a combination of resources optimally for a given production or technology, and the associated costs. Cost efficiency and profit efficiency are interpreted as the capability of a bank to use its assets in the most optimal way possible to generate profits from its services (Kablan, 2010:4). Mester (2003:5) defines cost efficiency as that which characterises an organisation's cost of operation and compares it to the best-practice costs for the same amount of outputs produced under the same circumstances. Lastly, scale efficiency refers to assessing how cost-effective outputs are produced (Mester, 1994:4). A highly efficient organisation that operates at optimum scale would therefore incur minimum production costs and experience accelerated economic growth, which is an incentive for shareholders and debtors (Hasan *et al*., 2009:4).

The efficiency levels of the dominant banks in South Africa have been studied extensively (Van Heerden, 2007; Van der Westhuizen, 2014; Okeahalam, 2001; Van Heerden & Heymans, 2013; Van der Westhuizen, 2008; Maredza & Ikhide, 2013a). In addition, various studies have been conducted in respect of the levels of efficiency of different branches of the top-ranking banks (Oberholzer & Van der Westhuizen, 2004; Cronjé, 2007). The research method used in most of these studies was the data envelopment analysis approach (DEA). The DEA analysis method was originally developed by Charnes *et al.* in 1978. Färe *et al*. (1985:193) define the DEA model as a model in which linear programming problems are solved to determine the optimum production frontier that envelops the input and output data as a piecewise linear convex curve and through which cost is minimised.

According to Coelli *et al.* (1998:140), the DEA model is a mathematical model that is input-output-oriented and can also be used to separate technical efficiency from scale efficiency. This is important, since Kumbirai and Webb (2010:37) and Oberholzer and Van der Westhuizen (2004:12) have found noteworthy relationships between profitability and various forms of efficiency including allocative, cost, and scale efficiency. Sherman and Ladino (1995:63) state that the DEA performance model will identify the best-practice and most productive group of service units, as well as the less-productive service units relative to the best-practice units. The model can further be used to determine the amount of excess resources used by each of these less-productive units and give an estimation of the extent to which the service outputs of these less-productive units can be increased while utilising only the available resources (Sherman & Ladino, 1995:62).

Despite the numerous studies conducted on the dominant banks in South Africa and their respective branches, comparatively little information is available regarding the efficiency of the medium-sized banks of South Africa (Kumbirai & Webb, 2010:35; Cronjé, 2007:14). As noted above, medium-sized banks play an important role in the banking industry (Ongore & Kusa, 2013:238), which is also highlighted in the example of African Bank Ltd. It is therefore of interest to determine whether the medium-sized banks in South Africa are efficient in respect of profitability and productivity.

1.2. Problem statement

According to Akinboade and Makina (2006:103) it is vital for South African banks to optimally distribute their resources to maximise efficiency and thereby ultimately contribute to sustained economic growth. Even though South Africa's banking industry is generally well-managed, the industry is highly concentrated (Van der Westhuizen, 2014:94), as it is dominated by the top five banks (Van Heerden & Heymans, 2013:730) namely Investec South Africa, the Standard Bank of South Africa Ltd., Nedbank Ltd., Absa Bank Ltd., and First National Bank (FNB). While these banks have been the subject of recent studies (Van der Westhuizen, 2014; Okeahalam, 2001; Van Heerden & Heymans, 2013; Van der Westhuizen, 2008), the performance of the medium-sized banks have not been studied in much detail. In fact, Kumbirai and Webb (2010:35) note that research on the medium-sized banks of South Africa is too scarce to establish the level of banking performance in respect of the efficiency of these banks. Cronjé (2007:14) found that a bank's size and the position will have a definite influence on its efficiency levels.

Hawkins (2004:196) notes that the banking industry that includes the dominant banks as well as the medium-sized banks of South Africa can improve their efficiency levels. Therefore, determining the efficiency of the medium-sized banks in South Africa holds significant value toward attaining the desired improved efficiency. Furthermore, the influence of the different business cycle phases, if any (Erasmus & Makina, 2014), on the efficiency levels of these medium-sized banks and the way in which the efficiency levels of the different banks compare to each other are also of interest. The focus of this study is thus to determine the efficiency levels of the medium-sized banks in South Africa.

1.3. Research Objectives

1.3.1. Aim

The aim of this dissertation is to estimate the technical and scale efficiency levels of medium-sized banks in South Africa over a 13-year period from January 2004 until December 2017, and to determine how the efficiency of these banks compare over the various phases of the business cycle. The 13-year period consisted of four business cycle phases as defined by the

South African Reserve Bank (SARB, 2018b:14), which coincided more or less with the different phases of the global financial crisis, i.e. the pre-crisis phase, the crisis phase, and the post-crisis phase. The four business cycle phases are: an upward phase that spanned 47 months between January 2004 and November 2007 (pre-crisis phase), a downward phase that spanned 21 months between December 2007 and August 2009 (crisis phase), another upward phase that spanned 51 months between September 2009 and November 2013 (post-crisis phase), followed by another downward phase that spanned 49 months between December 2013 and December 2017 (post-crisis phase).

1.3.2. Specific objectives

To reach the aim of this study the following specific objectives have been set:

- To review the South African financial sector with specific emphasis on the importance of banks.
- To explore the various efficiency measures available.
- To distinguish between performance measures and efficiency measures of banks.
- To analyse the efficiency of South-African medium-sized banks using a data envelopment analysis (DEA) model.
- To compare the efficiency levels of the medium-sized banks over various phases of the business cycle.
- To interpret the results obtained in terms of technical and scale efficiency measurements of South Africa's medium-sized banks and make appropriate recommendations.

1.3.3. Research Method

Pertaining to the specific objectives, this research consists of two phases, namely a literature review and an empirical study.

1.3.3.1. Phase 1: Literature review

Firstly, an overview of the financial sector of South Africa will be presented to highlight the importance of the sector to economic growth of South Africa, the degree to which the sector contributes to the economy, and the main players involved in the banking industry of South Africa. The literature review will therefore emphasise how banks play an essential role in economic growth, for which efficient banking operations are imperative. An overview of performance and efficiency measurement with respect to the banking industry will subsequently also be presented. The sources that were consulted for the literature study include:

- the South African Reserve Bank (www.resbank.co.za);
- consulting the following databases:
    - the Financial Services Board (FSB), the Banking Council (BC), and Statistics South Africa (SSA);
- various academic journals from academic databases for information regarding theories such as efficiency and the data envelopment analysis model, which included the following:
    - Science Direct,
    - Sabinet Reference,
    - EBSCOHost,
    - JSTOR,
    - Scopus,
    - Emerald,
    - Econlit,
    - Juta, and
    - SAePublications.

1.3.3.2. Phase 2: Empirical study

To explain the empirical analysis that will be used in this study, this section is subdivided under two different sections, namely the data and the analysis method.

1.3.3.2.1. The data

The data used in this study will include balance sheet data available from the South African Reserve Bank (SARB, 2018d). The balance sheet data known as the DI900 returns report, which are monthly reports that present a formal analysis of the banks' obligations and resources, will be used. The historical DI900s are converted to BA900 reports, which are available for the period January 2004 to December 2017. Data will be collected exclusively for South Africa's medium-sized banks.

1.3.3.2.2. The method

An input-oriented multi-stage DEA model with constant returns to scale (CRS) and the variable returns to scale (VRS) model specifications will be used together with the intermediation approach in this study, from which different inputs and outputs are produced. The DEA method is one of the most common procedures for estimating efficiency levels of any organisation (Van der Westhuizen, 2008:23) and combines all the different input and output data available on the financial institution into a single measurement benchmark for productivity efficiency. Van Heerden and Heymans (2013:734) indicate that the DEA model holds several advantages and is therefore the most suitable for this type of study. These advantages include:

- the ability to solve linear programming problems that generate a non-parametric, frontier curve, or efficiency curve that envelops the input and output data relative to which cost is minimised (Färe *et al*., 1985:53);
- inputs and outputs can be quantified, and multiple inputs and outputs can be considered simultaneously (Kirigia *et al*., 2001:2);
- the results can assist organisations in identifying the best practices in complex service operations (Sherman & Ladino, 1995:62);
- the results can assist organisations in identifying strategies to improve the use of existing resources to increase outputs (Sherman & Ladino, 1995:62).

According to Van der Westhuizen (2008:28-29), six different approaches can be followed when applying the DEA model, of which the most common approach is the production and the intermediation approach. The latter approach is used in this study (Favero & Papi, 1995; Berger & Humphrey, 1997; Mester, 1996, Molyneux *et al*., 1996). The different medium-sized banks' purposes and activities will play an important role in deciding on the different inputs and outputs for the DEA analysis (Van der Westhuizen, 2008:28-29). This study will show that the intermediation approach is the most suitable for this study (Section 4.3.1.1).

Input variables for application in this study will be identified from the studies of Kao and Liu (2004:2355-2356), Yue (1992:36), Van Heerden and Heymans (2013:747), Mlambo and Ncube (2011:10), Kao and Liu (2004:2355), Kamau (2011:15), Wheelock and Wilson (1995:692-693), Elyasiani and Mehdian (1990:163-164) and Kaparakis *et al*. (1994:887).

These variables include[2]: total deposits (1), central bank and money (103), total equity (96) and South Africa (SA) group and finance (111). The monthly total of each input variable (the main entries in the financial return statements) will be used as reported in the BA900 statements. The only exception is the deposits, loans, and advances output variable (item no. 110 in the BA900 statements), from which SA group and finance (item no. 111) will be excluded (subtracted). Following the studies by Van Heerden and Heymans (2013:747), Grmanová and Ivanová (2018:260), Muhammad (2008:11), Wheelock and Wilson (1995:692-693), Elyasiani and Mehdian (1990:163-164), Kaparakis *et al*. (1994:887), and Jayamaha (2012:567), the following output variables can typically be identified for this study on the efficiency of medium-sized banks: other liabilities (80), deposits, loans and advances (110), and investment and bills (195).

According to the research by Zhou and Fan (2010:812-813), the DEA approach is used to evaluate the efficiency frontiers and virtual efficiencies for decision making units (DMUs). DMUs can be regarded as multiple inputs and outputs used in the DEA performance model (Zhou & Fan, 2010:812-813). According to Avkiran (1999:207), the DMUs are used to estimate the relative efficiency, which reflect the efficiency levels of other DMUs. DMUs are formally classified by Acarlar *et al.* (2014:1-2) as typical interpretations that make it possible to indicate errors that must be deleted from measurement process.

The DEA model with the best possible DMUs will be identified in Chapter 4 and used in this dissertation to analyse the medium-sized banks.

1.4. Dissertation outline

The chapters in this dissertation are presented as follows:

Chapter 1 has provided an introduction to the research. It has sketched the background necessary to identify the problem statement and the purpose of this study in addition to giving a summary of the main methods that will be used in this study.

[2] The numbers in parentheses represent the BA900 report item numbers.

Chapter 2 will analyse and discuss South Africa's financial sector with specific reference to the role of banks, their purpose, and the banking indsutry (including different banks) in South Africa. An extensive literature survey will emphasise the importance of South Africa's financial sector. Furthermore, the stability of South Africa's financial sectors will be discussed along with a background on the different economic sectors that serve as macro indicators for financial stability. Advantages and disadvantages of financial stability indicators and statistics regarding the stability of the South African financial sector will then be discussed. Lastly, the main players in South Africa's financial sector and their role in the financial system and contribution to the South African economy will be outlined. This chapter will therefore provide the context for the research setting.

In Chapter 3 the meaning and the importance of efficiency will be analysed. This includes discussions on scale efficiency, scope efficiency, X-efficiency, and cost efficiency with specific reference to the banking industry. The problems involving measuring the efficiency of the medium-sized banks will also be investigated. Bank performance evaluation and the process of bank performance evaluation will subsequently be discussed, in which the importance, role, and development of a performance model for a financial organisation will be highlighted. However, it will be shown that performance measures are associated with many disadvantages and limitations, the most significant being the negative influence of the lack of data on the accuracy of the results. Since efficiency and performance are related, efficiency estimation of the medium-sized banks will be concluded as sufficient for the purpose of this study, and that the data envelopment analysis (DEA) method as the ideal method to be used in this study. The different approaches pertaining to the DEA method will then follow.

In Chapter 4 the cluster analysis method will be used to identify the medium-sized banks for analysis and discussion, and the data envelopment analysis (DEA) method will be reviewed in detail with respect to the use of linear programming methods to construct a non-parametric, piece-wise frontier across the data (Coelli *et al*., 1998:140). Specifically, the different approaches such as the intermediation approach, the production approach, the asset, profit & user-cost approach, the risk management approach, and the value-added approach will be discussed with the relevant inputs and outputs of each. The associated benefits and limitations of the DEA method will be considered next, followed by the guidelines that should be followed for constructing a DEA model. The different DEA model specifications such as the constant returns to scale (CRS) and the variable returns to scale (VRS) will then be discussed, as well as the multi-stage model. The factors that influence the construction of DEA model will be reviewed next, namely slacks, environmental factors, and congestion. The input and output orientation approaches will also be described, followed by a description of the DEA model used in this study to estimate the technical and scale efficiency of the medium-sized banks.

The empirical analysis results will be presented and discussed in Chapter 5, during which the efficiency of the different medium-sized banks of South Africa will be analysed with respect to technical efficiency and scale efficiency over a 13-year period and compared over the various phases of the business cycle.

Chapter 6 will conclude this study, in which the conclusions regarding the efficiency of the medium-sized banks will be discussed and recommendations presented for further studies.

An appendix is provided separately from this dissertation in which the monthly technical and scale efficiency data sets for each phase of the business cycle are given in tabular form.

Chapter 2

The financial sector of South Africa

2.1. Introduction

Before estimating the efficiency of South Africa's medium-sized-banks, a sound understanding of the financial sector of South Africa and the importance of banks in this sector is required, which is the aim of this chapter. This overview coincides with a discussion on the importance of stability in the financial sector, as shown by the work of Drigă and Dura (2014:598) and Bossone (2001:2240-2241). According to Drigă and Dura (2014:598), the financial sector and the stability thereof play a pivotal role in the efficiency of banks, since the financial sector forms an integral part of a country's economy. Banks are therefore considered a key contributing factor to an economy's growth and sustainability. A country's financial sector has an irreplaceable function, since investors and savers depend on stability within the financial sector (Bossone, 2001:2240-2241). Qualitatively, bank efficiency and the stability of the financial sector appear to be interdependent. This interdependence is corroborated by the findings of Levine and Zervos (1996), Gregoric and Kosak, (2007), Armenta (2007) and Allen *et al*. (2014), who have concluded that a stable financial sector, which includes efficient banks, has a greater chance of achieving sustainable economic growth.

An extensive literature survey of the South African financial sector, with specific reference to the role of banks, their importance, and the banking industry of South Africa in general, will be provided in this chapter. The importance of South Africa's financial sector will subsequently be discussed in Section 2.2.1. Attention will be given to aspects such as the contribution of the South African banking industry to the country's gross domestic product (GDP) (Section 2.2.2); the main players in South Africa's financial sector (Section 2.3) and the contribution of each to the South African economy, with a specific focus on the banking industry of South Africa (Section 2.3.1). The general roles and purposes of banks in South Africa will be discussed in Section 2.3.1.1, followed by a discussion on the role of the stock market in South Africa

(Section 2.3.2), and finally the role of the insurance and pension funds industry of South Africa (Section 2.3.3). The regulatory structure of South Africa's financial sector will be explored in Section 2.4 with specific reference to South Africa's financial sector regulatory approach (Section 2.4.1). A discussion on the stability of South Africa's financial sector will follow in Section 2.5 with respect to the different economic sectors that serve as macro-economic indicators (Section 2.5.1), while the advantages and disadvantages of the different financial stability indicators will be discussed in Section 2.5.2. Lastly, South Africa's financial sector stability statistics will be presented in Section 2.5.3.

2.2. The link between the financial sector and the economy

Every country's economy has a financial sector, amongst others, and well-established financial system is necessary to ensure stability in the financial sector. A financial sector can be defined in various ways. Sutton and Jenkins (2007:6) define a financial sector as a sector that comprises various types of service businesses like banks, long-term and short-term insurance companies, and pension funds, which provide different services to consumers on a daily basis. Although a country's financial sector consists of various types of financial corporations, Usman *et al.* (2010:104) have found commercial banks to be the most vital since these banks are responsible for (i) funding an economy, and (ii) the development of the production capabilities within the economy. Within this framework, the focus of this study is on South African banks as part of the country's financial sector.

In any economy, the importance of financial institutions and organisations cannot be overemphasised, since financial institutions like banks, insurance companies and pension funds play a significant role in promoting economic growth (Edison, 2003:36). Gondo (2009:2) asserts that any effective financial system with successful financial institutions in an economy will ensure that the intermediation process between lenders and borrowers takes place with expedience. A well-functioning financial system will also enable investment opportunities in the form of appropriate business opportunities for entrepreneurs and contribute to an effective financial sector (Gondo, 2009:2). Research by Schinasi (2004:6) has shown that other functions associated with a well-established financial system include technological development, business opportunities, and efficient capital provisions, which will enhance the economy of a country. Banks form an important part of an economy's financial system, and according to

Spong *et al*. (1995:1-2) the goal of every bank is to employ their resources in an effective manner. Hughes and Mester (2008:1-2) have also emphasised that banks are essential in generating processes for the evaluation and management of economic risks, organising written contracts and administration, observing economic performance, and resolving any occurrences of non-performance difficulties.

Since the 1980s, financial institutions have become determined to reach high efficiency and performance levels within their business environments (Hartle, 1997:46). Despite this, South Africa's banking industry experienced high levels of stress during 1994, which, according to Mboweni (2004:1), can be attributed to the country's isolation and subsequent political unrest during the national elections. Various researchers mentioned affirm that banks are vital to the positive growth of South Africa's economy, and this leads to the question of whether the banks' performance levels have since recovered.

2.2.1. The importance of South Africa's financial sector

The International Monetary Fund (IMF) (2006:11) describes a financial system as individual sectors that control their efficiency in compliance with consumer requirements. A financial structure that complies with the inherent efficiency requirements and fulfils the main financial institution's roles is highly likely to induce a stable financial sector. According to Hawkesby (2000:38), the specific roles of the financial institutions are important because fulfil their roles efficiently will lead to positive growth opportunities for an economy. The roles with which the financial institutions must comply include, for example, that the financial institutions should ensure that the intermediation processes between lenders and borrowers of funds are successfully performed (Kablan, 2010:6). According to Merton and Bodie (1995:15-20) financial institutions, including banks, are also responsible for overseeing transactions in which different parties, diversification of risks, and the successful provision of important financial information are involved.

Hawkins (2004:1) affirms that a financial sector is significant from a macro-economic and micro-economic point of view, since a stable financial sector contributes to the strength of the economy from a macro-economic perspective, which limits the possibility of failure of the banking industry and the economy as a whole. Therefore, the essence of a balanced financial sector is to maintain a strong relationship between its stability and new development possibilities from within (Hawkins, 2004:8). From a micro-economic point of view, the financial sector contributes to the allocation of resources within the economy and facilitates economic activities within the sector. Moreover, to achieve a stable and successful financial sector that contributes to the economy, it is important to maintain a balance between the macro and micro levels. This has been confirmed by the National Treasury of South Africa (2011:1-2), according to whom the financial sector supports economic stability and stimulates economic development, thus contributing to sustainable economic growth for South Africa. A stable financial sector also leads to economic development, more employment opportunities, and provides the necessary backup for sustainable infrastructure, which will lead to successful improvements in South Africa (National Treasury, 2011:1-2). Potential investors will scrutinise the integrity of a country's financial sector as well as its financial stability to gauge the financial viability of investing in the particular country (Morris, 2010:35). Therefore, a stable financial sector is of paramount importance in a relatively unstable economy, such as that of South Africa, since the economy can be further weakened if the financial sector's stability deteriorates, which can have reverberating effects on the performance trends within the financial sector itself. In confirmation, Usman *et al.* (2010:104) have found the financial sector and the economic growth of a country to be strongly interlinked.

Different worldwide economies are classified by various economic properties which include their financial conditions and financial sectors. As a result, different countries can be referred to as having developed, emerging, and underdeveloped economies. South Africa is known worldwide for having a developing economy with well-established physical and corporate structures (Okeahalam, 2001:15). The study of Okeahalam (2001:15) reveals that despite South Africa's economic classification as a developing country, it is known for having one of the most advanced financial sectors in Africa. This is especially true for the banking industry, which is known for its developed management structures and credit management systems. The National Treasury of South Africa (2011:1-2) has also declared the financial sector in South Africa as crucial for its contributions to the economy in the form of economic stability, economic growth, sustainable economic development, and to the role that the financial sector plays. As specified in Butterworth and Malherbe (1999:8-9), the role of the financial sector in South Africa is essential because it ensures that the right amount of economic resources in the form of capital is being allocated to the correct corporate systems. The financial sector has also been shown to manage economic threats successfully and contribute directly to the South African economy.

The banking industry is especially important for an economy with developing characteristics, such as South Africa. In these countries, the banking industries are known to be highly concentrated, which indicates a higher intensity level in the financial sector (Okeahalam, 2006:103-104). Hughes and Mester (2008:1-2) and Spong *et al*. (1995:1-2) also confirm that banks form a major part of the financial sector in the economy – therefore, it is important that banks operate efficiently and experience financial stability since any deficiencies in a concentrated banking industry will reverberate through the financial sector and the economy. This is corroborated by Levine (1997:688-689), who states that a well-established banking industry and a stable financial sector in an economy will promote economic growth because it stimulates funding opportunities for small and medium enterprises, which in turn contribute to employment opportunities. The financial sector is also responsible for facilitating the mobilisation of capital (Levine, 1997:688-689).

Nevertheless, if South Africa is to experience sustainable economic growth and global investments exposure that will contribute to further economic development, it will be beneficial to also sustain a positive performance trend in its financial sector.

2.2.2. The banking industry's contribution to South Africa's financial sector and the gross domestic product

As already indicated, the financial sector of South Africa comprises the banking industry, financial markets, insurance industry, and pension funds, all of which contribute to South Africa's economic growth (Hawkins, 2004:179-180). Considering that this study focuses on a specific aspect of the banking industry, it will be useful to quantify the banking industry's contribution to South Africa's gross domestic product (GDP) and economic sustainability, which contribute to the financial sector's significance.

Hawkins (2004:180) states that the financial sector's contribution to South Africa's GDP has grown steadily over time and has found the financial sector's contribution to be approximately 20% to the economic activities which are measured in GDP. However, Hawkins (2004:108) has also found that, of the various industries in the financial sector, that is, the financial markets, pension and insurance funds, the banking industry, and business services, the banking industry has contributed a magnificent 35% to the value-added component. For comparison, the insurance sector has contributed 16% to GDP. Clearly, the banking industry is especially significant for its contribution being greater than any other financial role player in South Africa's GDP, and it is therefore key to facilitating financial stability.

2.3. The main players in South Africa's financial sector and their role in the financial sector

The previous section has indicated the main players in the South African financial sector as the banking industry, insurance corporations, and the financial markets (Hawkins, 2004:179-180), which are responsible for the development within the financial sector. Distinguishing between the main financial players in South Africa's financial sector and their respective roles can aid in understanding how each main financial player in South Africa's financial sector contributes to the current success of this sector and to the South African economy. More importantly, perhaps, is determining whether the current performance of the financial sector is sustainable. The following section will present a broad overview of each sector's background and current role in the financial sector.

2.3.1. The banking industry of South Africa

The South African banking industry is considered a major contributor to the country's financial sector and economy. The banking industry consists of several banks, including commercial banks, retail banks, and investment banks. While each of these banks has a different business structure and clients, collectively they form one of the elements pivotal to the financial sector.

At this point, it is useful to review the formal definition of a bank. The Banks Act (94 of 1990) declares that a bank is classified as a public financial institution formally listed as a banking institution in terms of the act. Despite the advanced credit and risk management systems in place, Van der Westhuizen (2014:94) has found South Africa's banking industry to be highly concentrated as it is dominated by the leading five banks of the country. The SARB (2011:55-56) has confirmed Van der Westhuizen's (2014:94) finding by referring to the controlling positions of FNB, the Standard Bank of South Africa Ltd. Nedbank Ltd., Absa Bank Ltd., and Investec South Africa, which dominate the banking industry in South Africa with more than 90% of the total banking assets. The following paragraphs will present a brief history of these banks, preceded by a discussion on the central bank of South Africa – the South African Reserve Bank (SARB).

2.3.1.1. The South African Reserve Bank

This central bank plays a vital role in the banking industry and as such is it useful to take note of how this bank was established and its function in the financial sector and banking industry. The Reserve Bank dates back many years; it was established in 1921 and subject to a government act known as the Currency and Banking Act (31 of 1920). While the Reserve Bank is responsible for issuing bank notes today, commercial banks once issued their own bank notes. Commercial banks ceased issuing bank notes after requesting the South African government to absolve them of this responsibility once it had begun to threaten their financial sustainability. This led to the establishment of the South African Reserve Bank in 1921 (SARB, 2018f). Currently, the Reserve Bank's main function is to limit the weakening of the South African currency but also to perform the following functions (SARB, 2018e):

- To ensure that South Africa's financial sector and the banks within this sector remain stable (and in extreme cases provide financial aid as a last resort) and serve the needs of the population while staying current with international trends.
- To support the government and other economic communities of South Africa in the formulation and implementation of monetary policies.
- To alert the public and all foreign shareholders of any changes and developments in the monetary policy and in current economic circumstances.

It is therefore understandable that the SARB is pivotal to the South African economy. In fact, no economy worldwide, albeit developed, developing, and underdeveloped countries, can function without a central bank.

2.3.1.2. The leading banks in South Africa

Recall that a number of studies (Van Heerden, 2007, Van der Westhuizen, 2014, Okeahalam, 2001, Van Heerden & Heymans, 2013) have indicated South Africa's banking industry to be highly concentrated, with specific reference to the leading banks of South Africa, namely the Standard Bank of South Africa Ltd., Absa Bank Ltd., FNB, Nedbank Ltd., and Investec South Africa. However, the SARB (2018a) indicates that the banking industry of South Africa comprises 15 international bank branches, 13 nationally controlled banks, five international controlled banks, four mutual banks, and 43 representative offices. Research by Okeahalam (2006:103-104) has shown that although the country's banking industry is highly concentrated, it is to be expected of a developing country such as South Africa since other comparatively developing economies are also known to have highly concentrated banking industries. While Beck *et al*. (2006:1599) argue that a concentrated banking industry reduces the risk of a financial crisis, Boyd and De Nicolò (2005:1329) and Boyd *et al.* (2009:4) differ on the matter when stating that a concentrated banking industry contributes to greater financial instability. Evidently, leading banks play an undeniably significant role in the success of the financial sector, and as such it is useful to reflect on the history of these leading banks.

The bank with the highest market share, known as the prominent Standard Bank Group, originated in 1862 as the Standard Bank of British South Africa when the Cape (then the Cape Colony) experienced a dramatic increase in exports. In 1883 the Bank changed its name to the Standard Bank of South Africa Ltd., and in the 1960s again to the Standard Bank Group, as it remains known today (Standard Bank, 2018).

Another dominant bank in the banking industry of South Africa, known as the Nedbank Group (Nedbank, 2018), was first established in the 1950s under the name of the Nederlandsche Bank voor Zuid-Afrika (NBZA), which was later changed to the Netherlands Bank of South Africa (NBSA). During the 1970s the bank became known as Nedbank, and after merging with Syfrets South Africa and Union Acceptances it became known as the Nedbank Group Ltd. During the years, Nedbank experienced positive growth and in 2009 bought over Old Mutual's assurance department.

Absa Group Limited (Amalgamated Bank of South Africa) is a result of the merger between Volkskas Bank, Allied Bank, United Bank, and Sage Bank (Akinboade & Makina, 2006:107). In 1992 Absa Bank limited retained all the shares from the Bankorp Group, including Senbank, Bankfin and Trust bank. Absa Bank Ltd. became known as the Barclays Africa Group Limited on 2 August 2013 following a merger with the African operations branch of Barclays PLC before becoming a wholly-owned subsidiary of Barclays PLC with listed preference shares on the JSE. On 11 July 2018 the Barclays Africa Group Limited was renamed back to Absa Group Limited, with Barclays PLC retaining a 14.9% shareholding in the business (ABSA, 2018).

The next of the top four banks, FNB, is also one of the oldest banks in South Africa. FNB was first known as Barclays South Africa. In 1987 Barclays withdrew from South Africa's banking industry as a result of sanctions against the apartheid regime, and their assets were consolidated under FNB. Of course, Barclays would later return to South Africa by acquiring Absa Bank Ltd. and become known as the Barclays Africa group, as already explained above (Ndzamela, 2013). After acquiring Barclay's assets, FNB developed rapidly, and in 1998 the financial services departments of respectively Rand Merchant Bank Holdings and Anglo American merged to form First Rand Limited, which was later listed on the JSE. FNB became a subsidiary of First Rand Bank limited, and as a result FNB, WesBank and Rand Merchant Bank are now divisions of First Rand Bank limited (FNB, 2018).

Investec South Africa is regarded as a prominent bank in South Africa. It has been classified as one of South Africa's best private banks and wealth managers for the past five consecutive years (Investec, 2018). Investec South Africa originated in 1974 in Johannesburg, South Africa, as a small finance business. In 1980 they acquired their banking license, which resulted in the expansion of their services from leasing finance to commercial and specialised banking. Investec South Africa is also listed on the JSE as Investec Holdings Limited.

While it is clear that the leading banks are important with respect to the stability of the financial sector, the other banks should not be excluded as they also form part of South Africa's banking industry, and any deficiencies should be addressed to further enhance the contribution of this sector to the country's economic growth. Considering that banks are important role players in the economy, the role and purpose of banks should also be clarified.

2.3.1.3. The roles and purposes of banks in South Africa

The general roles of banks are a concept that attracted considerable attention following the financial crisis of 2008 and its dramatic effect on worldwide economies (Gorton, 2009:11-12). The key purpose of banks in a financial system can be summarised as follows:

- Applying different resources in the economy and ensuring that the process is completed successfully (Spong *et al*., 1995:1-2).
- Being responsible for the detection of economic risks and resolving any non-performance problems within the economy (Hughes & Mester, 2008:2).

Additionally, banks should also fulfil the following roles in an economy (Allen *et al*., 2014:31-35):

- Solving a variety of informational problems with respect to the economy's lenders and the borrowers.
- Managing and diversifying risks within the economy.
- Taking responsibility for their transformation to maturity through the process of collecting the various deposits available as well as raising funds in the short-term capital markets and investing them in durable assets.
- Taking responsibility for the success of the financial sector, since significant economic crises could result from failing banks (OECD, 2013:6).
- Using their respective securities associates to participate in financing debt instruments that are issued by businesses.

It is imperative that these banks fulfil these important roles in an economy, especially in South Africa, seeing that banks are essential to the success of the financial sector and failing to succeed in their principal roles would result in economic crises. Besides the banking industry, two other industries also play a significant role in the financial sector, namely financial markets and insurance companies (Hawkins, 2004:179-180). The following two sections will present an overview of the importance of these two industries to ensure a comprehensive view of this sector.

2.3.2. The financial markets in South Africa

The South African financial market consists of a variety of participants and markets. According to Van Wyk *et al*. (2012:201) the types of financial instruments used in trading activities for South Africa include money (cash), bonds, foreign exchange, equities, credit, and commodities. It should be noted that the property market does not form part of the financial markets industry since South Africa does not equip formal tradeable property securities. There are thus only two categories in this group, namely property stocks and unit trusts (Van Wyk *et al*., 2012:200). South Africa's financial market is important for its close correlation with positive economic growth prospects for South Africa. The financial markets are classified by Van Wyk *et al*. (2012:3) as an industry responsible for establishing certain arrangements and specific settlements in respect of the issuing and global transaction processes of financial instruments that form part of the South African market.

The equity market is arguably the largest component of the South African financial market, and trading of equities is registered to take place on South Africa's leading stock exchange, namely the JSE. The JSE dates as far as 1887 when the gold expedition in South Africa began. In 1963 the JSE merged with the World Federation of Exchanges and would later become more technologically advanced through an automated trading structure that it would initiate in 1990. In 2005, the JSE became demutualised and registered as an entity under its own name. Another exchange, known as the AltX, was also registered in 2003, which focused specifically on small and standard sized entries together with another stock exchange market known as the Yield X, which traded in interest and currency securities. In 2001, the JSE announced that they would from then on be equipped to facilitate trade in futures while continuing their predominant trading on the South African Futures Exchange (SAFEX). The JSE is a globally classified stock exchange and currently ranks 19th under the largest stock exchange markets in the world and is the largest stock exchange market on the African continent (JSE, 2018). The JSE is also known for offering participants the option of performing trading activities in the primary and secondary markets by using a wide variety of different shares and securities. South Africa's stock exchange is therefore a highly classified stock exchange and a major role player in the South African financial sector, thereby making a positive contribution to the South African economy (JSE, 2018).

2.3.3. The insurance and pension funds industry of South Africa

The insurance industry and pension funds that form part of the financial sector also play a significant role in generating a supply of funds (Hawkins, 2004:202). However, this industry does not influence an economy with the same proportion as the banking industry because, while some insurance companies and pension funds are destined to default, they will not cause a whole economy to fail. In contrast, in the banking industry defaulting banks will result in a greater deal of economic difficulties. Hawkins (2004:179) confirms this by stating that South Africa's concentrated banking industry can be interpreted as stable; however, this implies that the financial sector can easily be disrupted by scenarios that threaten to render South Africa's financial sector significantly unstable.

Bennet and Loubser (2012:360) explain that South Africa's insurance industry is divided into two components, namely life insurance, also known as long-term insurance, and short-term insurance, also known as common insurance. These two insurance industries have the responsibility of always meeting their liabilities and maintaining their assets supplies, which are normally assessed by their regulatory framework. South Africa's insurance industry (long-term and short-term) is known for being dominated by leading insurance companies. The insurance magnates in the long-term insurance industry include Old Mutual, Sanlam, Momentum and Liberty Group, and Investment Solutions (Hawkins, 2004:185). The short-term insurance industry includes Mutual and Federal, Santam, Hollard, and Sasria. These insurance leaders also contribute a good percentage of market share and financial stability to the financial sector, which has been relatively stable (Hawkins, 2004:185).

With respect to the pension funds sector in South Africa, the concept behind pension funds has been defined in 1956 by the Pension Funds Act of South Africa (24 of 1965) as "*any association of persons established with the object of providing annuities or lump sum payments for members or former members of such associations upon reaching their retirement dates or for the dependants of such members or former members upon the death of such members or former members"*. According to George (2006:3), a pension fund is obligated to offer the retiree a cash payment that makes up a third of the total pension fund's balance amount. A pension fund is a provident fund when it meets certain requirements, for example paying the pension fund's whole amount to the retiree when they retire. Interesting to note is that the board of fund manager's loyalty lies with its members in ensuring that they are satisfied and that they receive their required remunerations (Bennet & Loubser, 2012:361).

Although each of the different players in the financial sector of South Africa discussed above is important to South Africa's economy, the banking industry contributes the largest portion (Gondo, 2009:1). In the following section, the financial industry's regulation structure will therefore be further analysed.

2.4. The financial sector's regulatory structure

Any financial crisis can pose damaging consequences to an economy; it is therefore essential for any country to have sound financial regulatory structures in place to support sustainable economic growth. Financial regulation refers to the practice of imposing limitations, rules, and strategies that companies must adhere to. Adhering to these requirements will foster an environment conducive of economic improvement, sustain opportunities for financial stability, and limit exposure to economic risks (Falkena *et al*., 2001:1-3). Grünbichler and Darlap (2003:2) show that financial regulation is normally advantageous for the country that implements a regulatory process and that this financial regulatory process is usually based on the financial soundness of the country's economy, current interest policies, rent strategies, and monopolistic performances within the economy. Clearly, a sound financial regulatory procedure is known to be consistent with certain advantages that aid financial authorities in the identifying problematic areas within the economy. As corroborated in the study of Llewellyn (2006:5), regulating the financial sector supports this identifying procedure and holds other advantages, including:

- offering a supporting role to an economy that stimulates economic improvements,
- supporting the corporations of an economy in being efficient in the distribution of capital between different entities within the economy, and
- instilling public confidence in the financial sector and assisting the public in gauging the stability of the financial sector based on whether economic risks are under control.

Although the advantages of a financial regulatory procedure are clear, the type of regulatory approach used can vary from one economy to another. The application of different types of regulatory structures depends on a country's specific needs for sustaining economic growth. The most well-known financial regulatory methods are (Schmulow, 2015:3-12):

- the institutional method,
- the functional method,
- the integrated method, and
- the twin peaks method.

The main attributes of each of the abovementioned regulatory structures are summarised in Table 2.1 to facilitate convenient comparison. These methods are important when it comes to a country's economic growth, which Table 2.1 also summarises along with their respective advantages and disadvantages and the countries that use these methods.

According to the National Treasury of South Africa (2011:9) the economic crisis of 2008 gave rise to a need for reviewing financial regulation, which at the time had various negative effects on the country's economy including low economic growth and limited economic improvements, thereby limiting employment opportunities. The National Treasury of South Africa (2011:24) lists the aims of the local financial regulatory procedure:

- To maintain consumers' assurance level in the financial sector.
- To ensure financial stability within the financial system of South Africa.
- To guarantee consumers that all the financial institutions are fully licenced to deliver professional services.
- To guarantee consumer protection through the suitable market behaviour process.
- To offer the financial companies within the financial sector support in sustaining financial soundness and stability.
- To administer the most appropriate regulations that will benefit everyone within this sector.

It is clear that each of the abovementioned methods addresses specific needs and objectives with respect to an economy's requirements. A country's financial regulatory structure must be as efficient as possible, as is highlighted in the study of Volcker and Ferguson (2008:22), which states that an efficient regulatory structure encourages stability, safety, and reliability of the financial institutes within the financial sector. An efficient regulatory structure also enhances the process of identifying any risks of insolvency in financial institutions, which improves the functionality of a country's financial sector.

Table 2.1: A comparative summary of various financial regulatory structures

Regulatory methods	Explanation	Countries using the method	Benefits	Limitations
Institutional method	This is the legal method that pays specific attention to a country's official system; consequently, the specific regulator responsible for the official system is also assigned (Schmulow, 2015:4).	China, Mexico, and Hong Kong	• Financial regulation is achieved directly through main functionaries in the financial sector, that is, the banking, insurance, and securities industry (Botha & Makina, 2011:30).	According to Volcker and Ferguson (2008:34), the two main limitations are that: • its principles are focussed on a corporate model that is no longer applicable, and • it limits the mitigation process of systemic risks because it does not have a single official, and it is more difficult to implement.
Functional method	This method consists of variations of products and business enterprises under the financial regulation (Volcker & Ferguson, 2008:24).	France, Italy, and Spain	• Merton (1995:38) indicates one of the major benefits of this approach to be its adjustability of international financial intermediation, which makes circumstances more endurable. • This method also facilitates resilience towards fluctuations in official structures (Volcker & Ferguson, 2008:35).	• Herring and Litan (1994: 144) state that it generates an environment that can give rise to possible arguments among officials. This is because it becomes increasingly difficult to reach consensus on specific procedures as the number of officials involved increases (Wymeersch, 2007:258).

Regulation methods	Explanation	Different countries	Benefits	Limitations
Integrated method	When this method is used, a particular regulator will be liable for financial soundness and commercial behaviour. This method is also known as the financial service authority (FSA) model (Schmulow, 2015:11).	Singapore, Germany, Japan, and Switzerland	• This method is more popular than the functional and institutional methods thanks to its efficient regulatory structures. This is advantageous because it results in exceptional principal directions (Volcker & Ferguson, 2008:36). • According to Mwenda (2006:74) it also creates opportunities for small and intense financial sectors of different countries to increase their economies of scale.	Čihák and Podpiera (2006:10) indicate the following limitations: • The possibility of a specific regulator can give rise to morally hazardous difficulties throughout the financial system. • Not coordinating the rules of the banking industry and the financial markets can hamper opportunities for economies of scale.
Twin peaks method	According to Schmulow (2015:32), this method is demonstrated by two regulators whose goals are to obtain effective market behaviour, systemic stability, and safeguard customers, in addition to having prudential responsibilities.	Canada, Netherlands, Australia, and South Africa	According to Llewellyn (2006:27-28), this method is specifically created for the sole purpose of securing several advantages, which include: • the two regulator's structures, objectives, and mandates are specified, which makes the responsibility process an easy one. • difficult circumstances such as different principles from different management structures that are completely removed.	The International Monetary Fund (IMF) (2007:30) describe some of the limitations of this approach to be the following: • In some cases, criticisms and even justifiable criticisms may be limited due to transgressions in the supervisory structures. • Performing a detailed investigation of criticisms that may arise is a demanding and time-consuming procedure.

2.4.1. South Africa's financial sector regulatory approach

An efficient financial regulatory approach is important for a country's financial system as it can facilitate positive financial growth. The financial regulatory structure must always be consistent and efficient, regardless of whether a country is a developed or developing country. The financial crisis of 2008, while having many negative consequences, prompted countries worldwide, including South Africa, to review their financial regulatory and managerial methods with the purpose of identifying any shortcomings in their specific regulatory approaches.

In July 2011 a specific report was accepted by South Africa's African National Congress (ANC), in which the National Treasury (2013:14) announced that South Africa's financial regulation model would be changed to the twin peaks model. The twin-peaks model approach (Table 2.1) specifies that prudential and market conduct regulation are to be implemented separately. That is, the prudential authority is to be established within the South African Reserve Bank (SARB) through oversight by the Financial Stability Oversight Committee (FSOC), which is to be chaired by the governor of the SARB. The Financial Sector Conduct Authority (FSCA) acts as a stand-alone authority which, together with the National Credit Regulator (NCR), oversees market conduct regulation (Coetzee, 2016:73). According to the National Treasury (2011:29), the twin peaks model's aim is to maintain supervisory stability and governmental simplicity while addressing any essential disagreements between prudential regulations and ensuring the safeguarding of consumers.

To this end, these entities have the following objectives:

- The South African Reserve Bank (SARB)
  - Monitor the sector for any sign of systemic risks and take appropriate action to limit the occurrence of systemic events (National Treasury, 2014:26).
  - As prudential regulator, issue banking licences to banks that meet the specified requirements and monitor the activities of the banks to ensure they meet the prudential requirements and regulations in terms of the Banks Act (94 of 1990) (Coetzee, 2016:70).

- The Financial Sector Conduct Authority (FSCA) (Coetzee, 2016:76; National Treasury, 2014:29):
    - Ensure that financial institutions act fairly towards their clients and specifically aim to prevent consumer loss by:
        - formulating rules on how financial services should be sold and prescribing who can sell these services,
        - enforcing compulsory information disclosures,
        - prescribing guidelines that should be followed to ensure honesty and integrity of financial institutions and their employees,
        - setting guidelines to ensure quality and objectivity of advice,
        - educating the consumer on the cost of credit and promoting financial literacy while also enforcing full credit cost disclosure to protect the consumer against becoming overindebted.
- National Credit Regulator (NCR) (Coetzee, 2016:69):
    - Implement the National Credit Act (NCA), which serves to regulate the conduct of all credit providers.

These financial supervisory structures, as managed by the SARB together with the Financial Stability Oversight Committee (FSOC), are pivotal to ensuring financial stability and the promotion of business confidence in South Africa (Coetzee, 2016:73). The next section will provide an overview of the actual financial stability indicators of South Africa, which will serve as a means for briefly evaluating the efficiency with which the revised financial regulatory model is applied.

2.5. The stability of South Africa's financial sector

Maredza and Ikhide, (2013b:553-554) note that stability of a country's financial sector is a principal requirement for facilitating bank efficiency. According to the SARB (2015:4), financial sector stability is a product of the combined stabilities of the main financial markets and organisations in the economy, a strong financial intermediation process, and restricting financial risks and possibilities of any financial crises. The European Central Bank (ECB) (2007) also defines financial stability as circumstances in which financial institutions and financial markets can resist financial shocks and imbalances that may occur. However, financial fluctuations will place any economic development at risk. According to the IMF (2006:3), financial instabilities occur when:

- the banking industry (one of the main players in the financial sector) is exposed to dramatic shocks that cause banks to fail, which limits investor confidence directly and restricts the influx of investment capital,
- the financial industry is exposed to a group of systemic risks and extreme asset-price movements, which create obstacles for national commercial intermediation and household investments, and
- the financial markets in the industry experience significant interest and exchange rates movements.

It is also important to note that the stability of a country's financial sector is significantly influenced by the business cycle phases (upward and downward business cycle phases). According to Akinboade and Makina (2009:477), a business cycle is described as periodic patterns of economic contraction (recession) and economic growth (recovery or expansion). Any economy is periodically exposed to these phases of growth and recession, the length of which normally varies (Akinboade & Makina, 2009:477). Consequently, bank instability is more likely during downward business cycles phases due to increased credit risk (Ghenimi *et al.*, 2017:246). According to Hawkesby (2000:38), the situation of inadequate financial stability is critical. To illustrate, banks that do not meet the demand for the creation of business opportunities for entrepreneurs, or major banks that fail in the financial intermediation between the lenders and borrowers of funds within an economy, will affect the confidence of a society and the role players within the economy like financial organisations, which could eventually lead to the financial system failing to achieve its principal goals. The possibility of financial instability does not only apply to developing economies but also developed economies, since these are related through international markets and business transactions that can restrict economic progress for all economies involved. Daly (2008:2378) asserts that financial instability results in fundamental economic challenges, which would lead to a sharp decrease in capital flow. This is significant, since, as stated by the IMF (2006:4), the amount of capital and the strength of capital flows are important to all types of organisations within an economy for their contribution to financial stability and serving as a protective cushion for the economy, thus limiting the economy's exposure to financial risks and sudden losses. Economic indicators that can be used as indicators of the stability of a financial sector will be discussed in the next section.

2.5.1. Different economic sectors which serve as macro-economic indicators for financial stability

The performances of various economic sectors can be used as indicators for measuring an economy's stability which, as stated above, impacts the efficiency of the banks. According to Gray and Malone (2008:93-95), four comprehensive sectors serve as measures of financial stability and soundness. These sectors and their components are:

a. The financial sector, consisting of:

- assets, namely loans provided to the commercial and sovereign sector, and financial warranties, and
- liabilities, namely credits and equity, because when the financial guarantees from the authorities become a substantial risk factor it is an indication that illiquidity problems could occur;

b. The commercial sector, consisting of:

- assets, namely assets from private organisations without the consideration of the open traded equity, and
- liabilities, namely the non-payment values that are detracted from the put option and the call options that are on the commercial assets;

c. The sovereign sector, consisting of:

- assets, namely international currencies, economic and other public assets, and
- liabilities, namely domestic currency liabilities, any international currency obligations, and government warranties;

d. The household sector, consisting of:

- assets, namely public savings, incomes, investment funds, financial resources and real estate. The assets are normally, mutual funds, annuities and pension funds, and
- liabilities, namely debt equity.

These different economic sectors and the specific manner in which each can be used as macro-economic indicators will be discussed in the subsequent sections. To this end, the contingent claims analysis (CCA) approach (Gray *et al*., 2007) is used to assess an economy, which is viewed as a set of interrelated balance sheet equations of the four aggregate sectors, i.e. the corporate, financial, household, and sovereign sectors. The principles of contingent claims as applied to the analysis of single firms are therefore applied to an aggregate of firms in each of these four sectors. In essence, the CCA method is used to evaluate the credit risk and sovereign guarantees against the risk to default for each sector of an economy, through which the financial risks of each sector and an economy as a whole can be analysed and managed (Gray *et al*., 2007).

2.5.1.1. The financial sector

As mentioned, the financial sector is a sector that can be regarded as a major institution with different banks, insurers, and investment funds (Gray *et al*., 2007:8). The CCA balance sheet equation, Equation (2.1), can be used to measure this sector's stability (Gray *et al*., 2007:10), which gives an aggregate amount for the whole financial sector:

$$A_F + \alpha P_F = E_F + (\bar{B}_F - (1-\alpha)P_F) \qquad (2.1)$$

where:

- $0 < \alpha < 1$
- A_F= Assets of the financial sector;
- αP_F = Contingent financial support from the government;
- E_F = Equity within this sector;
- $\bar{B}_F$ = The value of default-free debt;
- $(\bar{B}_F - (1-\alpha)P_F)$ = The value of risky debt/deposits in the financial sector;

In Equation (2.1), the government's guarantee to banks, which can also be modelled as an implicit put option (Merton, 1977:4), is expressed as a fraction (α) of the total (P_F). The remainder, i.e. $(1 - \alpha)P_F$, is credit risk that remains in the debt and deposits of the financial sector (Gray *et al*., 2007:10). Gray *et al.* (2011:149) state that a volatile economy and any fluctuations in the national interest rates will place the financial sector's stability under stress, since the financial sector and the economy are interlinked. It is also important to note that the commercial and financial sectors are connected and can influence one another. According to Gray and Malone (2008:102-103), any stress experienced by the financial sector can be caused by fluctuations in the share market, economic recessions, or liabilities that are not hedged. Furthermore, the depreciation of the national currency will spread through the financial sector and to the government and lead to an increase in the credit risk that is prevalent in the banking industry.

2.5.1.2. The commercial sector

The commercial sector is a sector can be considered to include all financial organisations like insurance companies and private equity institutions (Gray *et al*., 2007:8). This sector's CCA balance sheet equation is given by Equation (2.2) (Gray *et al*., 2007:10):

$$A_c = E_c + (\bar{B}_c - P_c) \quad (2.2)$$

where:

- A_c = The assets within this sector;
- E_c= Equity in this sector;
- $\bar{B}_c$= Default-free value of the debt;
- P_c= Expected losses associated with the debt;
- $(\bar{B}_c - P_c)$ = Risky liabilities.

Gapen *et al.* (2004:4) reveal that corporate disasters are more likely to appear in developing markets with more severe consequences than developed markets because in a developing market financing is less diversified and more likely to be influenced by unexpected capital losses and severe fluctuations in the global exchange rates and interest rates.

2.5.1.3. The sovereign sector

Gray *et al*. (2007:10) defines this sector as the relevant government parties, although this sector's asset values are difficult to evaluate. For this reason, a related regulatory process is used for the estimation of this sector's assets values and risk exposures. The CCA balance sheet equation given in Equation (2.3) can be used to assess the financial risk of the sovereign sector (Gray *et al*., 2007:11):

$$A_S = R_{MA} + A_G + A_{Other} + M_{BM} + (\bar{B}_{SLC} - P_{SLC}) + (\bar{B}_{SFX} - P_{SFX}) + \alpha P_F \quad (2.3)$$

where:

- A_S = Group of assets;
- R_{MA} = International currency funds;
- A_G= Net fiscal assets based on different current tax values and present incomes;
- A_{Other} = Additional public resources and assets;
- M_{BM} = Base money;
- $(\bar{B}_{SLC} - P_{SLC})$= Local-currency liabilities;
- $(\bar{B}_{SFX} - P_{SFX})$= International-currency liabilities;
- αP_F = Financial guarantees/contingent liabilities.

In South Africa, this sector plays a vital role in debt ratings (Gray *et al*., 2007:11); however due to the limitations associated with quantifying this aspect, not many financial stability measurement indicators are available.

2.5.1.4. The household sector

The household sector of an economy contains much of the combined wealth of the public (Gray *et al*., 2007:11). De Haan *et al*. (2012:405) state that the strength of this sector is evaluated through the ratio of assets relative to liabilities, which is known as the net assets ratio. The net asset ratio (total assets to total liabilities) combines total earnings, consumptions, debt services, and principal payments ratio.

Equation (2.4) is used as a measure of the household sector's financial stability (Gray *et al*., 2007:11):

$$A_H = A_{FIN} + A_L + E_{H,RE} \qquad (2.4)$$

where:

- A_H = The household sector's net worth;
- A_{FIN} = The sum of the financial prosperity within this sector;
- A_L = The present value of the labour incomes;
- $E_{H,RE}$ = The equity of the real estate within this sector.

In South Africa, this sector plays an essential role in consumption within the economy, as this sector is responsible for buying the final goods and services that will result in an increase in the GDP (Gray *et al*., 2007:11).

2.5.2. Different financial stability indicators including their advantages and disadvantages

In reaction to the current global economic difficulties and the past international financial crises of the 1990s (the Asian crisis) and the 2000s (the subprime crisis in 2008), a stronger emphasis has been made on the concept of financial stability within an economy. Claessens *et al.* (2010:75) indicate that nearly every country worldwide has been affected. Developed economies such as the United States of America, Ireland, Iceland, the United Kingdom, and the Netherlands were highly affected, and almost immediately most of the emerging economies such as South Africa, China, India, and Mexico experienced intense levels of financial strain through financial spill overs. These effects led financial institutions worldwide to be more cautious and prompted the establishment of global financial institutions such as the International Monetary Fund (IMF), which is responsible for monitoring the global financial system and making recommendations to help stabilise the international monetary system.

According to the IMF (2006:6), financial stability indicators were thus set in place to detect any financial distresses that may occur and to protect major financial sectors, organisations and government sectors that serve pivotal financial institutions. According to Gersl and Hermanek (2007:69), such financial stability indicators need to accomplish certain objectives that include increased awareness of the important role of financial stability and the financial soundness of a financial sector. Since the financial industry ensures production within an economy, monitoring global trading activities and managing business agreements are crucial for measuring the financial soundness and financial stability within the financial industry (Philippon, 2015:1408).

While macro-economic indicators are used globally as measurement tools for financial stability, other financial indicators are used as financial stability financial structures. A country will benefit from identifying and analysing these measurement techniques along with their associated benefits and drawbacks. According to Jakubík and Slačík (2013:102), the most commonly used techniques for characterising financial stability are early warning systems (Section 2.5.2.1), macro-stress testing (Section 2.5.2.2), and financial stress indices (Section 2.5.2.3).

2.5.2.1. Early warning systems

Jakubík and Slačík (2013:102-103) maintain that the group known as the primary warning systems usually consists of any possible primary indicators with the ability to predict the possibility of a financial crisis. This concurs with the study by Berg *et al*. (2004:19), in which early warning systems was defined as indicators selected from records that have been constructed from the efficient evaluation of an extensive amount of studies. Consequently, early warning systems should be capable of warning against any financial crises that could occur and thereby allow the authorities enough time to respond to these warning signs. Furthermore, different types of financial crises can affect the financial sector and its stability (Claessens & Kose, 2013:11-18). These types of financial crises include currency, foreign and domestic debt crises, and banking crises. A currency crisis entails the depreciation in the value of a country's currency (Claessens & Kose, 2013:12). Foreign debt crises arise when, for one, sovereigns default and the international lenders cannot seize collateral from another country, or at least when a sovereign no longer honours its debt obligations (Claessens & Kose, 2013:15). Under these circumstances sanctions are often imposed on the borrowing country, thereby restricting its access to international markets. Domestic debt crises, in which debt is owed by the government to domestic creditors, are rarely averted without adverse economic consequences (Claessens & Kose, 2013:16). High inflation rates are often imposed by governments as results of their abuse of control over currency issuance, and in so doing, reducing the real value of the government debt. The outcomes are significant and most often involve currency crashes (Claessens & Kose, 2013:17). Lastly, banking crises arise where banks are inherently fragile; problems experienced by individual banks can quickly spread to the whole banking system (Claessens & Kose, 2013:18).

Early warning systems represent one measure together with macro stress testing (Section 2.5.2.2) and financial stability indices (Section 2.5.2.2), that is used by policymakers to gauge financial instability. While warning systems play a vital role in the indication of financial stability, they do not come without their drawbacks. According to Cheang and Choy (2009:41-46), early warning systems have benefits and drawbacks which can respectively enhance or restrict the measurement of financial stability. A study by Babecký *et al*. (2011:6) has clearly indicated benefits, which include that the specific scale of the real costs of the economy is described, and these indicators are protected against small variations in the dependent variables contained within the measurement models. The drawbacks associated with these early warning system financial stability indicators include that they can only be applied as accompanying instruments since they are not able to estimate the particular start and end dates in which these financial crises are likely to occur when compared with more comprehensive financial stability indicators. Also, unlike other comprehensive financial stability indicators, early warning systems are not able to simultaneously assess the financial risks that the financial system is exposed and give an estimation of the economy's risk absorption ability (Jakubík & Slačík, 2013:103). Other drawbacks of early warning systems, according to Babecký *et al.* (2011:6), include that they have a limited ability to signal direct yes or no signs to the government regarding the possibility of financial crashes within the economy, and that circumstances related to only certain specific financial crises can be detected using this type of signal technique.

2.5.2.2. Macro stress tests

Another class of indicators commonly used in the financial stability environment is stress testing and financial indices. Swinburne (2007:60) states that the concept of stress testing can be described through two central methods known as:

- the top-down approach, with an aggregate system model consisting of the procedure in which an outside organisation (not part of the specific financial sector), for example the IMF or the Reserve Bank, performs diagnostic tests that help evaluate different financial shocks and the potential impact of each on a financial sector's level of profits, flexibility, and creditworthiness; and
- the bottom-up approach, in which a selection of different individual financial organisations is used to aid in estimating the impact of shocks on a specific financial sector's revenues and solvency ratios according to predefined estimation models.

Any financial stress test, whether macro or micro, comprises four vital measurement fundamentals which, according to Borio *et al.* (2014:4), are defined as:

- the first fundamental, which quantifies an economy's risk factors,
- the second fundamental,
- the third fundamental, which provides a model that can track the impact of shockwaves throughout an entire financial structure. For example, macro stress test can be used to measure solvency of a group of financial institutions by determining the level of capital when the financial institutions have significant risk exposure, that is, during a certain

shock period. This would be done by applying the third fundamental in the form of a set of reduced form and/or structural relationships, and

- the fourth fundamental, which provides a measure of the outcome. For example, the solvency, that is, the level of capital (outcome) of a group of financial institutions experiencing a recession (the shock), can be assessed using a macro stress.

These fundamentals of macro stress tests are graphically illustrated in Figure 2.1, which indicates the steps of a usual macro stress test that an institution can use to measure its financial stability while taking counterparty credit risks and liquidity risks into account.

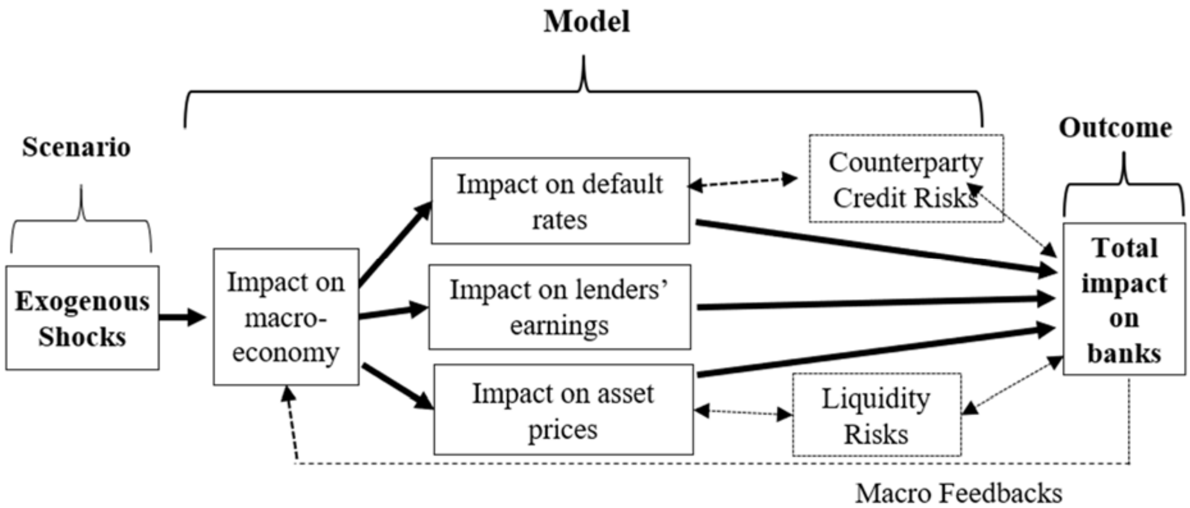

Figure 2.1: Schematic overview of the structure of macro stress tests (Borio *et al.*, 2014:5).

In Figure 2.1, the solid lines represent the mechanisms most popularly performed by banks as stress tests, while the dotted lines symbolise the feedback elements (Borio *et al.,* 2014:5). The results of macro stress tests can be complex since, as Henry *et al*. (2013:7-8) explain, these macro stress testing models have the necessary capacity to assess any type of financial risk and the impact thereof on the financial sector stability. Furthermore, these models are also capable of calculating the magnitudes of the possible risks identified. Macro stress testing can therefore be used in the evaluation of large fluctuations in the macro-economy of a country together with the impact thereof (Blaschke *et al*., 2001:4). Van Lelyveld (2009:1) describes these underlying macro-stress tests as having certain advantages, which are known to be used by different financial institutions. These financial institutions include financial authorities, reserve banks, and commercial banks, who use these macro-stress tests to investigate circumstances that will lead to changes in economic structures. These changes include:

- a sharp fall in macro-economic activities,

- disruptions in economic models,
- failures of important financial structures, and
- any changes in investment performances.

Schmieder *et al*. (2011:67) describe other advantages of these macro stress tests as supporting the ability to perform inclusive creditworthiness tests. These tests can be used to obtain relevant information for identifying the most risk-sensitive economic circumstances and allow for the necessary communication to users to assist them in making informed decisions. Lastly, these tests are useful in identifying the main risk drivers in the financial system and the problems associated with such risk drivers (Henry *et al*., 2013:7-8).

These macro stress tests play a major role in the banking industry, and the central bank of a country normally uses these tests in their financial stability analyses. Despite these advantages are also some associated restrictions, as emphasised by Borio *et al*. (2014:6), namely that they are not the most suitable early warning device for signalling any financial danger because it has been known to give false signals of financial safety in the past.

Borio *et al*. (2014:12) make it clear that macro stress tests are more appropriate for managing different crises and not the weaknesses within the financial system that lead to the occurrence of certain crises. It is therefore important for policymakers to consider these advantages and disadvantages when using macro stress testing as a financial stability measurement tool.

2.5.2.3. Financial stress indices (FSIs)

One of the most common financial stability measurements is financial stress indices (FSIs). FSIs are used to measure financial stress experienced by various authorities of developed, developing, and emerging countries. Financial stress is a negative indicator of economic growth and can severely restrict economic growth. According to Illing and Liu (2006:243), occurrences that lead to uncertainties for economic policymakers and the total economy are examples of financial stress an economy can experience. In such events, an economy will be exposed to fluctuating prospects of growth and incur definite losses.

An economy will experience shocks and shockwaves when its financial structure shows signs of weakness, and fluctuations will be experienced in the economy as a result. These conditions serve as tools for estimating the level of stress that an economy is exposed to (Illing & Liu 2006:245). The transmission of shocks and shockwaves will impact the financial markets such that they will experience different stages of financial weakness that will eventually result in a crisis, as illustrated in Figure 2.2.

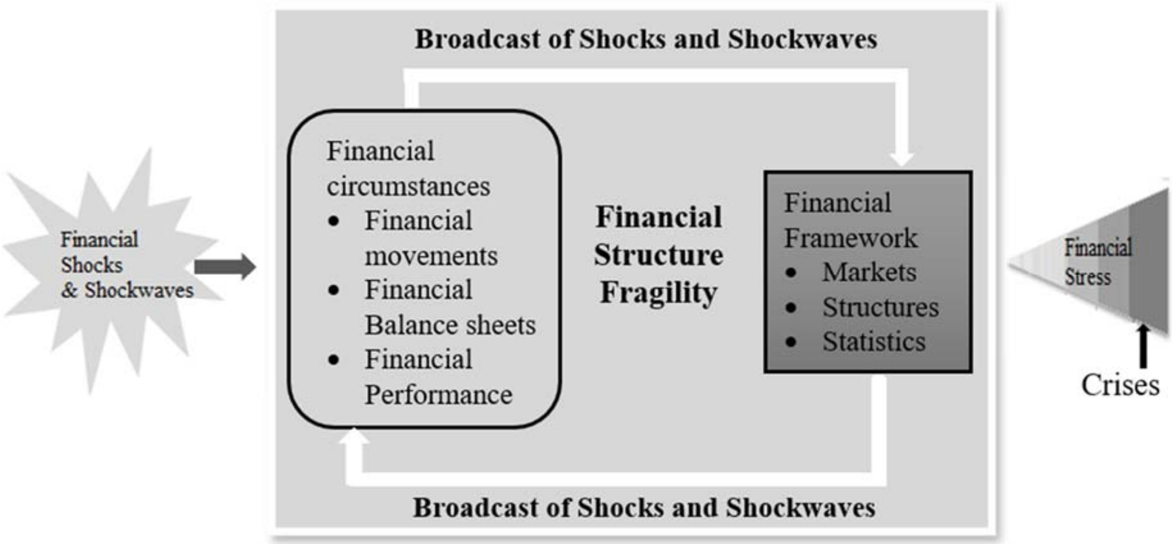

Figure 2.2: Schematic illustration of a financial stress situation (Illing & Liu, 2006:245).

Hakkio and Keeton (2009:6-9) explain that events of financial stress will occur when one of the following is observed:

- If debt increases and uncertainty arises regarding the fundamental value of essential assets of an economy.
- If investors' actions become increasingly unpredictable, since this will lead to more frequent price fluctuations and a deterioration in the value of assets.
- An overall decline in the economy, which curbs enthusiasm among investors toward having high-risk portfolios and assets, as such portfolios would require these investors to have more income to accommodate the risky assets, which is less unlikely in an unfavourable economy. This results in an increased likelihood of financial stress as significant fluctuations are bound to occur because of supply and demand variations.

Cevik *et al*. (2013:610) also agree with this concept of financial stress and describe it as a realistic and dangerous threat, since it has the potential to impose major difficulties and weaknesses on the financial structures of an economy, which in turn will result in a definite decline in economic growth. This establishes the necessity for policymakers to prioritise strategies that will prevent the occurrence of financial stress.

In response, economic agents have become more involved in the process of assessing financial stress by using a financial stress index (FSI). FSIs are indices originally created for the purpose of capturing present signs of multi-structural uncertainties in a financial system, specifically in the banking industry (SARB, 2015:36). The main goal of an FSI is to monitor an economy and detect any signs of economic fluctuations and instability, and as such can also be used as a predictive tool (Holló *et al.*, 2012:4). According to Cardarelli *et al.* (2011:80), FSIs are characterised by three different sub-indices. These three sub-indices are usually related to changes in the banking, foreign exchange, and shares index environments and can forecast any increased probability of financial stress observed in an economy. Still, it is important for FSIs to have appropriate measurement variables for financial stress testing since it is essential for the derived results and accurately evaluating the predicted level of financial stress (Cardarelli *et al.*, 2011:80).

A study done by Balakrishnan *et al.* (2011:45) has acknowledged that conditions of an economy will influence the choice of variables for an emerging country such as South Africa. To this effect, Balakrishnan *et al.* (2011:45) recommend that certain essential variables be included in an FSI if it is required to produce the most appropriate results regarding the credit situations in, for example, the banking and exchange industries. These recommended variables are shares, market yields, shares market time, fluctuating returns, and unpredictability of the share's returns, beta of the banking industry, and an exchange market index. These variables aid in estimating the level of financial stress exposure when circumstances arise like major fluctuations in asset prices, an increased level of uncertainty regarding risks in the economy and financial system, and changes in the economy's liquidity (Balakrishnan *et al.*, 2011:45). Furthermore, Holló *et al.* (2012:2) have found that other elements, such as a financial intermediary sector and certain relevant markets including the bond, money, foreign exchange, and the equity markets, should be included when conducting an evaluation of financial stress. They have also found that financial and asset expenses can be unreliable when it comes to the estimation of financial stress in an emerging economy, since signs of sovereign risks and a high level of debt may be present.

The use of FSIs for the evaluation of South Africa's financial stability levels have therefore become an invaluable tool in recent years in assisting the authorities to evaluate appropriate strategies. According to the SARB (2015:36-37), South Africa's FSI consists of five comprehensive measurements, which are used to create a common index to measure signs of weaknesses in the South African financial sector. South Africa's FSI has also been developed using a two-level structure procedure, which consists of the variance-equal methods together with methods for transforming certain variables to eliminate any present inconsistencies in the measurement units (SARB). More specifically, South Africa's FSI is constructed from the variables summarised in Table 2.2 (SARB, 2015:37).

Globally, FSIs are commonly used as financial indicators; however, this mathematical approach has advantages and restrictions. According to Brave and Butters (2011:22), the benefits associated with FSIs are that they are expedient indicators for the assessment of a country's financial fluctuations, since FSIs can capture major changes in the financial history and current circumstances of a country. These FSIs can also assess how financial markets are connected, which is a key property since it can be seen as a measurement of the overall financial stability circumstances (Brave & Butters, 2011:37). Other advantages of these FSIs include that it supports authorities and policymakers in the analyses of any improvements and changes in numerous parts of a financial system's financial stress level. Furthermore, despite their stress analysis characteristics, FSIs also embody a single quantifiable measurement tool which enables any forecasting of financial instability in a country's financial system (SARB, 2015:36).

Despite the FSIs' advantages, they can also pose significant restrictions, and if this is the case it could be more beneficial to use the early warning system technique or macro stress testing for calculating financial instability. The recent SARB review (2015:36), for example, reports that it is not clear whether FSIs can yield accurate predictions with the prevalent economic stress circumstances in South Africa. Other drawbacks also include the following (SARB, 2015:36-37):

- FSIs should preferably be conducted with high frequencies.
- FSI variables are standardised, so the stress levels of any threatening situation can only be compared to similarly documented events of deviations from the mean.

- The significance of results derived from FSIs depend on the timespan over which the analysis is performed.

Table 2.2: Overview of South Africa's financial stress index (FSI) variables

Markets	Variables	Explanations
Funding (subsidy)	1. Government bond spread 2. Interbank liquidity spread 3. Borrowing costs 4. Treasury yield spread	1. The 10-year non-government bonds produce a lesser government bond yield. 2. Johannesburg Interbank Agreed Rate (Jibar) minus yields on 3-month Treasury bills (TB). *Note: The Jibar rate refers to the money market rate which is estimated as the average interest rate for other banks that sell and buy money. 3. Repo rate (the rate that the Reserve Bank uses to lend money to other commercial banks) minus the yields on 3-month TBs. 4. Moving average of 3-month TBs minus yield on ten-year bonds.
Equity	1 CMAX- all share index 2. VIX	1. The amount to which the all-share index has dropped over the previous year. 2. Uncertainty in share prices.
Foreign Exchange	1. US dollar ($) /Rand (R) volatility index 2.Euro (€) / Rand (R) volatility index 3. Sovereign bond spread	1. Uncertainty about the Rand's(R) value relative to value of the US dollar ($). 2. Uncertainty about the Rand's (R) value relative to value of the Euro (€). 3.(South African Bond Yield) – (US Bond yield).
Real estate	1. CMAX: Absa House Price Index 2. CMAX: Commercial real property prices	1. The extent of the property's prices in the real Absa House Price Index and how it deteriorated over the previous year. 2. The extent of listed commercial property's prices and how it deteriorated over the previous year.

Adapted from SARB: (2015:37)

It is therefore important to note that each financial stability indicator discussed in the preceding paragraphs have certain advantages as analysis tools that assist economic policymakers; however certain limitations must also be acknowledged when used for the evaluation of the financial stability of an economy.

2.5.3. South Africa's financial sector stability statistics

When this study was conducted, the South African economy was under significant stress by various factors. According to the SARB (2015:5), the recently experienced labour unrest and the exceptionally high unemployment rate have made a significant impact on the economic growth. The IMF (2014:12) states that the electricity shortage in South Africa greatly restricts the possibility of positive economic growth. Additionally, Statistics South Africa (SSA, 2018) has also experienced the effects and after-effects of the global financial crisis of 2008 and still experiences difficulties.

Regardless of the difficult economic circumstances currently prevailing in South Africa, the IMF (2014:10-13) has made it clear, after having reviewed the stability results, that South Africa's financial sector is quite large and still exhibits refined features which continue to be resilient. The IMF's financial stability review results can be summarised as follows:

- A rapid increase in growth was experienced by the non-bank financial intermediaries in South Africa in recent years, since it constitutes approximately two thirds of the country's total financial assets.
- Long-term life insurance funds assets contributed 64% to the GDP, which is almost all of the insurance industry's assets.
- In the total view of the financial sector, the unit trusts and the collective investment schemes was the fastest growing sections because their assets equalled 42% of the GDP.
- The main source of finance in South Africa was national deposits, which had been measured at 87%. A total of 60% of the national deposits were contributed by non-bank financial intermediaries.
- The equity and bond markets' market capitalisation were respectively 288% and 57% of South Africa's GDP, which shows that these markets are able to compete with those of a developed economy. Interestingly, the non-financial intermediaries in South Africa have been an attractive investment opportunity for investors, which resulted in a total of 34% contribution to the country's GDP (both bonds and equity market) and is the highest even among other developing economies.
- The household sector's liabilities reached a shockingly high figure in 2008 at the time of the international financial crisis known as the "credit crunch". An extraordinary growth in the credit of the private sector from 2003 to 2006 caused household liabilities

to grow to 83% of the total national income. Fortunately, the growth rate in household liabilities has experienced a sharp decline in recent years.

- The corporate sector experienced an increase in total debt, mainly because of the funding of large infrastructure developments by the public sector. This debt had risen to 47% of the GDP.

From the IMF and the International Financial Reporting system it is clear that the performance and stability of South Africa's financial sector remain substantial and strong.

A country's financial sector and its banks depend on each other for sustainable economic growth and to avoid the occurrence of economic crises. Drigă and Dura (2014:598) confirm this statement in affirming that a financial sector's stability is important with respect to factors like interest rates, unemployment rates, the domestic gross product, and economic growth, among others. They also state that stability statistics provide useful information on the stability of a country's financial sector and how the level of stability can influence the banking industry. This is because bank performance is highly sensitive to stability within the financial sector. Rossi *et al*. (2004:77) also note that a financial sector's stability can have a dramatic influence on bank efficiency because of the close relationship that exists between the financial sector and the banking industry. This implies that banks are more efficient when the financial sector is stable since their exposure to risks is limited, resulting in sustainable economic growth.

Also apparent, as stated by Kiselakova and Kiselak (2013:121-122), is that financial statistics serve as good indicators for potential investors, and that if the financial sector experiences significant instability, banks will be subject to liquidation, which can lead to an economic recession. This will, of course, affect investors negatively and thereby limit the opportunities for sustainable economic growth, as was the case in the worldwide financial crisis (Alfaro *et al*., 2004:107-108).

Another study by Kumo *et al*. (2014:9) has found the financial sector stability information to reveal that South Africa's financial sector is well developed and has sophisticated structures and processes in place which benefit financial stability. According to Kumo *et al.* (2014:9), the financial sector's development has revealed that:

- the asset value of the financial sector of South Africa amounts to more than R6 trillion, which is positive since it exceeds most of the developing economies and is therefore a comprehensive sector;
- South Africa's financial sector consist of other industries in addition to the banks, and that these industries are both long and short-term orientated. Examples include pension funds, insurance companies, and unit trusts. This sector's resources and assets improved in 2013 by 19% on a year-on-year basis; and
- overall, South Africa was categorised third out of 148 countries regarding financial market improvements in a survey done for 2013 to 2014, as reported in Schwab's (2013:43) clarification.

According to the SARB (2014:21), the Ernst and Young Service Index has indicated stability in the confidence of South Africa's financial sector throughout 2013, which can be seen in the index variation between 69 and 73 points. Kumo *et al*. (2014:10) also confirm that the aggregate capital competence calculation had increased by 15.6%, which verifies that South Africa's banking industry (which is part of the financial sector) had persisted in maintaining financial steadiness throughout 2013.

It is quite surprising for a developing country such as South Africa to have a relatively stable financial sector despite its economic and political circumstances like the high unemployment rates and labour disruptions. Nonetheless, the SARB (2015:2) states that any concerning changes and regulations that could harm the stability and soundness of the financial sector in South Africa will be constantly monitored. If any negative developments arise, the authorities have stated that they would respond duly to ensure that the stability of the financial sector is maintained (SARB, 2015:2).

2.6. Summary

As noted in Section 2.1, the aim of this chapter has been to provide extensive background information on South Africa's financial sector, its link with South Africa's economy (Section 2.2), and the importance of each of the financial players, namely banks (Section 2.3.1) the financial market (Section 2.3.2), the insurance industry, and pension funds (Section 2.3.3).

This literature review has concluded that South Africa's financial sector, of which the major players are the banking industry, insurance and pension funds, and the financial markets, is of key importance for fostering economic growth and ensuring economic stability.

It is, however, also clear that the banking industry is the major contributor to South Africa's financial industry. Nonetheless, all the financial players (Section 2.3) and financial regulatory methods, which include the institutional, functional, integrated, and the Twin Peaks methods (Section 2.4), also contribute to achieving and maintaining financial stability. It is also clear that South Africa's banking industry is highly concentrated and dominated by the leading banks, namely Absa Bank Ltd., the Standard Bank of South Africa Ltd., Nedbank Ltd., FNB, and Investec South Africa. Some authors have found such a high level of market concentration to negatively affect the financial stability of banks.

According to the SARB (2018a), South Africa's banking industry consist of 15 international bank branches, 13 nationally controlled banks, five internationally controlled banks, four mutual banks, and 43 representative offices. Bearing this in mind, the concentrated nature of the South African banking industry is not surprising and is to be expected of a developing country such as South Africa. It is also evident from the literature survey that a significant number of studies have been done to characterise the efficiency of the leading banks in South Africa. However, no evidence could be found in literature to indicate that the efficiency of medium sized banks in South Africa has been previously characterised, which is the focus of this study.

The different financial regulatory structures of various countries have subsequently been discussed in Section 2.4, including the implementation of the Twin Peaks method that has been recently implemented in South Africa. Subsequently, the influence of the regulatory structures on the financial stability of South Africa has been discussed in Section 2.5 with respect to macro-economic indicators such as the financial, commercial, sovereign, and household sector. In respect of financial stability indicators, early warning systems, macro stress tests, and financial stress indices have also been identified in Section 2.5. Finally, an overview of South Africa's financial stability position has been given.

The efficiency measurements of the medium size banks will be addressed in Chapter 3, where performance evaluation will be discussed, specifically in relation to its role (Section 3.2.1), the types of performance measures (Section 3.2.2), and the limitations (Section 3.2.3). Different efficiency measures like operational efficiency (Section 3.3.1), scale efficiency (Section 3.3.2), scope efficiency (Section 3.3.3), X-efficiency (Section 3.3.4), cost efficiency (Section 3.3.5), standard profit efficiency (Section 3.3.6), and alternative profit efficiency (Section 3.3.7) will be discussed. Finally, the efficiency measurement process will be reviewed.

Chapter 3

Performance measurement and bank efficiency

3.1. Introduction

The importance of financial stability and bank efficiency were discussed in Chapter 2. The aim of this study is to estimate the scale and technical efficiency of South African medium-sized banks. To this effect, this chapter will provide the literature background of the performance and efficiency measures that are used in banking institutions. The aim of this chapter is therefore to provide a review of the various performance (Section 3.2) and efficiency (Section 3.3) measurement methods toward identifying the most appropriate measures for analysing medium-sized banks in South Africa.

Bank performance measurement and efficiency measurement are two distinct concepts. Performance measurement refers to the evaluation of every individual's performance within the organisation relative to the organisation's goals, objectives and mission (Mcdonell & Rubin, 1991:56). Performance measurement in banks may be defined as the evaluation of the shareholders' wealth and thus the extent to which the market value of the bank's common shares is maximised (Mester, 2003:3). Efficiency, on the other hand, is measured relative to a certain benchmark and can thus be viewed as the deviation between current performance and desired performance. Efficiency is regarded as one aspect of an organisation's total performance (Mester, 2003:3). Efficiency and performance can be seen as complimentary concepts that are used to evaluate an organisation, although this chapter will show that efficiency measures are preferred above performance measures for aim of this study, which is to characterise the efficiency of banks (Lovell, 1993:4-5).

This chapter is structured such that firstly the role of performance measurement will be discussed in Section 3.2.1, followed by a discussion of the most used performance measures in

Section 3.2.2, and finally the limitations of performance measurements. The various forms of efficiency will then be discussed in Section 3.3, followed by a summary of the factors that influence the efficiency measurement process in Section 3.4. The efficiency measurement process will be described in Section 3.5 together with the potential complications that may be encountered during the efficiency measurement of banks, which will be summarised in Section 3.6. Finally, Section 3.7 will conclude that the use of efficiency measures is most suited for this study.

3.2. Performance measures

As already noted, bank performance may be regarded as a reflection of the success with which a bank utilises investor capital to maximise the market value of its corporate shares (Mester, 2003:3). Performance measurement of banks is therefore important to various parties involved in the economy, including investors, shareholders, borrowers, and regulators (Dufera, 2010:5-6). This is because performance measurement assists investors and shareholders in identifying when to invest their capital in a country's economy or when to withdraw it. It also supports regulators in efficiently formulating their regulatory approaches, or to make adjustments to their regulatory approaches when needed.

According to Brignall *et al*. (1991:6-8, 19-22), the leading financial performance measures that are used to determine whether an institution is performing as it should are based on a broad range of economic, consumer, employer, ecological, and internal business factors. Dufera (2010:12) notes that traditional financial and economic measures are based on an institution's financial statements, that is, critical and important financial data and statistics, that are normally analysed by professional accountants. According to Laeven (1999:2) bank performance measures can be divided into two groups, namely comprehensive bank ratios, which relates to resources or cost revenues, and frontier type measurements, which gauge the proximity of a bank's efficiency relative to the efficiency frontier. Additionally, Hartle (1997:65) also elucidates certain aspects associated with effective performance measurement that should be kept in mind; these are effective planning, a well-developed measurement system, and the revision of performance measures.

Performance measurement is therefore of value since it facilitates the implementation of performance improvement strategies, aids in the estimation of efficiency, and assists in establishing further improved future performance measurement procedures (Hartle, 1997:66). It can therefore be concluded that bank performance measures, including the procedures used, play an important role in the finance industry.

3.2.1. The role of performance measurement in a financial institution

Effective performance measurement, according to Chompukum (2012:3), still requires attention for its importance in the commercial industry. Effective performance measurement is therefore explained as the procedures set in place to support personnel in their roles, assist the financial organisation in achieving certain levels of output, and assist in identifying the appropriate outputs that should be measured (Ramlall, 2003:58). A study by Armstrong (2006:3-4) has found that performance measurement also motivates personnel to contribute to operational efficiency, efficient resource management within the institution, and efficient contribution to achieve the institution's financial goals. The concept behind an effective performance measurement system is vital for achieving these objectives (Armstrong, 2006; Ramlall, 2003). Research by Kimball (1997:25, 36-40) identified the specific conditions that must be met for a performance measurement system to be classified as effective, and it includes a system that is:

- stable in terms of the institution's objectives, activities, values and employees;
- focussed on the consumers and suitable for the internal and external surroundings;
- a combination of bottom-up and top-down efforts;
- connected throughout the institution;
- dedicated not only to the institution's expenses but also their resource management and their various inputs;
- devoted to the provision of action-orientated advice; and
- compassionate about the relevant learning systems of the institution.

It should be noted that every institution's performance measurement procedures will differ, since shareholders and management structures view them differently, have different objectives, activities, and circumstances, and encounter different business environments (Bikker, 2010:141). In this regard, performance measures normally consist of two types of measures known as financial measures and non-financial measures (Kaplan & Norton, 2001:3). The following section will provide an overview of the types of performance measures.

3.2.2. Types of performance measures

Ittner and Larcker (1998:205) note that managerial decisions regarding the choice of performance measures and methods of a company are skewed by perceptions of the success of the different performance measures and whether they are capable of accurately reflecting the information required to establish a company's level of efficiency. As already mentioned, performance measurement methods comprise two categories of measures known as financial and non-financial measures. Measures that form part of these two categories are known as "traditional" methods, which measure aspects like share returns, profitability, and budgets (Ittner & Larcker, 1998:206).

3.2.2.1. Financial performance measures (fundamental analysis)

Financial ratios together with the DuPont Model and the economic value added (EVA) model form part of the components used for performing fundamental analyses. Spooner (1984:80) defines fundamental analysis, which includes the use of financial ratios, as a method in which analytical statistics are used to analyse a country's commercial sectors and service provider industry. According to Marx *et al*. (2010: 75), the fundamental analysis approach is based on the evaluation of the business environment, macroeconomic influences and detailed business factors that can influence an institution's risk-return relationship for a specific venture or business opportunity. Fundamental analysis has traditionally been used to assist investors in estimating performance levels of institutions (Mubashir, 2013:1-2). Abad *et al.* (2004:231) note that fundamental analysis can be applied in two different ways. More specifically, in one approach the fundamental analysis focusses on evaluating a company's financial statements (income and balance sheets) to support analysts in their projections of the share prices market values. In the second approach, fundamental analysis is used to analyse a company's shares and the market value that the shares are most likely to reach under ideal market conditions. The latter approach is also known as the normative approach (Abad *et al.*, 2004:231).

3.2.2.1.1. Traditional financial ratios

Financial ratios are used to assess the performance of bank profitability and the efficiency with which bank operations are performed (Moin, 2008:20). According to Al-Shammari and Salimi (1998:5), these financial measures usually take an organisation's financial ratio into account together with its benchmark ratio. Otley (2002:8) notes that financial ratios are a traditional method of measure performance and offers the advantage of assessing prospective growth or current financial distress of an organisation. Traditional financial ratios are normally associated with the following concepts:

- Paying any existent debt (short and long-term), in other words the liquidity;
- The profitability status;
- The growth potential of a firm;
- Asset quality.

Formally, this category of financial ratios consists of (Darun, 2013:3; Fairfield & Yohn, 2001:372; Sinkey, 1992:43; Moussu and Petit-Romec, 2013:4; Cîrciumaru *et al.*, 2010:1-2; Busch & Memmel, 2014:1; Almazari, 2013:288; Burger & Moormann, 2008:86-87; Firer, 1993:43; Delen *et al.*, 2013:3972; Avkiran, 2011:330; Dennis, 2006:62; Chen & Yeh, 1998:402):

- the return on assets (ROA);
- the return on equity (ROE);
- the net interest margin (NIM);
- the earnings per share (EPS);
- the price earnings ratio (P/E);
- the return on investment (ROI);
- the cost- income ratio (CIR); and
- liquidity ratios, such as the quick ratio and the current ratio.

In the matter of measuring bank performance, the American Accounting Association (1966:1) explains that the first step in relative bank performance evaluation can be achieved by using financial ratios and ratio analyses. However, critique against the use of financial ratios in the estimation of bank performance is also found in the literature, as discussed in Section 3.2.3. This has motivated the use of financial ratios in conjunction with more advanced models such as the DuPont and economic value added (EVA) models, for which the subsequent sections will offer a discussion.

3.2.2.1.2. The DuPont Model

The DuPont Model is used for identifying specific relationships between the rate of return and various influencing factors and to express these relationships in the form of mathematical models. This model can subsequently be used to identify the appropriate action that should be taken to increase a company's performance levels (Cîrciumaru *et al*., 2010:1-2). The DuPont Model was developed by Brown in 1912 with the focus on characterising a firm's profitability by using the net profit margin (NPM) and on characterising the firm's efficiency by using the total asset turnover (TAT). When combined in the DuPont Model, these two indicators yield the firm's return on assets (ROA) (Liesz, 2002:1-2). The DuPont Model can also be adapted to yield a modified DuPont Model that includes all the important financial ratios for performance measurement (Almazari, 2012:86).

At the time the DuPont Model was conceived, maximising ROA was a common corporate goal; the discovery that ROA depends on both profitability and efficiency precipitated the development of a planning system to control organisations' operating decisions. This financial analysis method dominated until the 1970s (Blumenthal, 1998). Subsequently, financial management shifted its focus to maximising return on equity (ROE) (Gitman *et al*., 2011:15), which led to the development of the modified DuPont Model, also known as the DuPont Identity. According to Liesz and Maranville (2008:22), the use of debt, otherwise known as leverage, became the third element of importance. Leverage was therefore incorporated into the modified DuPont Model together with the NPM and TAT (the other two elements) as the leverage or equity multiplier (Almazari, 2012:87; Liesz & Maranville, 2008:23). The equity multiplier describes an organisation's leverage situation, and therefore describes how the organisation's liabilities are being applied as a financing strategy relative to its assets (Isberg, 1998:18). Mathematically, the equity multiplier is defined as the total assets available per unit of invested equity, where a high value indicates that an organisation is financed by debt (Kalluci, 2011:9-10). The equity multiplier is therefore an important metric of the overall financial position of an organisation.

Isberg (1998:12) and Eveleth *et al*. (2011:758-759) confirm that the DuPont analysis can be used as an effective benchmark for general performance measurement, since the following aspects are incorporated in the analysis:

- The company's profitability status;

- The company’s operating efficiency;
- The company’s leverage status.

The net profit margin (profitability), the total asset turnover (efficiency), and the equity multiplier (leverage) are all used to measure these factors (Eveleth *et al*., 2011:758-759).

Nevertheless, the DuPont Model is characterised by many disadvantages, especially when used to measure the performance of banks. For example, the model cannot be used to “approve” or “disapprove” leverage that pertains to preferred shares in a firm’s capital structure (Liesz & Maranville, 2008:23). Yet many companies use preferred shares to promote their capital, even though leveraging preferred shares is not desirable.

Another disadvantage associated with the DuPont Model is that it cannot be used for forecasting or tracing relevant costs. The DuPont Model also does not allow for the inclusion of increasingly prominent intangible assets its return calculations. However, the expandable DuPont models do allow for some flexibility in this regard, since the ROI can be combined with other measures that give an indication of the growth prospects (Blumenthal, 1998).

3.2.2.1.3. The economic value-added (EVA) model

Having considered the disadvantages of the DuPont model, Panigrahi *et al*. (2014:282) advise that the economic value-added model (EVA) also be assessed as an additional performance measurement tool, since it provides an overview of a company’s residual income. Stated differently, the EVA model is used to measure the difference between a company’s cost of capital and return on that capital (Dagogo & Ollor, 2009:41). The EVA model therefore relies heavily on the company’s accounting system (Horngren *et al*., 2006:830). The results of an EVA analysis provide shareholders with valuable information on their returns, where higher returns correlate with better performance. The EVA model is used by managers to identify strategies for improving a company’s performance in all areas, while it is used by shareholders to assess the value of a company (Chan, 2001:10).

The EVA model is characterised by the following limitations:

- It is vital to fully comprehend the business and its operations for the EVA model to reflect a clear picture (Van der Poll *et al*., 2011:137);

- The model cannot be used to measure the financial performance of industries like technology-intensive industries (Wood, 2000:49), since these industries tend to experience accelerated growth with significant fluctuations;
- It is used as a long-term measurement tool and cannot be used as a short-term measurement tool (Shil, 2009:174).

3.2.2.2. Non-financial performance measures

While financial ratios, the DuPont analysis model, and the economic value-added model (EVA) are known as performance measures, another group of measures known as non-financial performance measures can also be used. An overview of such non-financial performance measures will be provided here to illustrate the differences between the financial and non-financial performance measures. In this respect, non-financial performance measures are measures capable of quantifying a company's long-term performance. These non-financial performance measures normally include primary measurements that are able to provide information about future performances (Hofmann, 2001:1-2).

These non-financial performance measures consist not only of the data envelopment analysis (DEA) model (Section 4.3.3) but also the stochastic frontier analysis (SFA) (Anderson *et al*., 1999; Battese & Coelli, 1995; Vitaliano & Toren, 1994), the thick frontier analysis (TFA) (Berger & Humphrey, 1991; Berger & Humphrey, 1997), and the balance scorecard (BSC) (Kaplan & Norton, 1992; Kaplan & Norton, 2001). However, only the DEA falls under the scope of this study; its applicability will be highlighted in Chapter 4.

Kaplan and Norton (2001:11) observe that these types of performance measures have become widely known and consist of certain measurement elements that include customer satisfaction, innovation, on-time delivery, market share, product/service quality, and productivity. Specific advantages that motivate the use of these measures are namely that non-financial measures:

- serve as appropriate measurements of managerial performance (Johnson *et al.*, 1995:705);
- accurately predict long-term performance and assist in long-term decision making and planning (Johnson & Kaplan, 1987:259);
- quantify causes rather than effects (Johnson & Kaplan, 1987:256-257);

- serve as an important source of information on the reasons behind a company's failure (Kaplan & Norton, 1996:85);
- cannot be easily manipulated (Singleton-Green, 1993:52);
- are conveniently used for measuring the changing technological environment and as such assist in successfully achieving the necessary competitive advantages (Eccles, 1991:133-134).

Berry *et al*. (2005:93-94) and Van Heerden and Heymans (2013:733) recommend the use of both financial and non-financial ratios since one single measurement value is insufficient for relating a company's performance levels with its shareholders' satisfaction levels.

3.2.3. Limitations associated with performance measures

Although performance measures are useful in gauging the success of banks, certain restrictions are inherently associated with performance measurement (Barbu & Boitan, 2012:1516). These restrictions can skew results by the inclusion of historical data. Considering that data acquisition has undergone developments of improvement, including historical data that might then not have been as reliably measured by present standards could result in a biased interpretation. Kaplan and Norton (2001:3) also observe this restriction and have found operational performance measures to be more reliable over relatively short periods and less reliable over longer periods. This is because only short-term circumstances are considered in financial ratios while long-term effects such as the effects of managerial decisions and actions are ignored (Clark, 1997:25-26). Another major disadvantage is that financial ratios are unable to reflect the relationship between assets and the output of these assets (Avkiran, 1997:225). Additionally, financial ratios only focus on the value of shares, but the shares' current prices are not reflected in the share values, the implication being inaccurate share-return estimations (Greig, 1992:413-414).

Koch and MacDonald (2003:170) further report that the use of traditional financial ratios is associated with some inherent weaknesses, including that they:

- ignore characteristics like financial strategies that differ from one institution to another;
- do not take into account the total amount of assets, since these are considered as less significant; and

- are not able to provide comprehensive statistics on the contribution of the various activities of the bank to the establishment of shareholder value.

Considering these restrictions, Brown and Mitchell (1993:729-732,735-736) have found that appropriate performance measures should be selected based on specific benchmark criteria, such as:

- using measures that can link an entity's commercial activities with its tactical procedures and business plans;
- performance measures should be able to account for the cost of business activities and the relationship between various business activity costs.

Isberg (1998:11-12) supports the notion that the DuPont analysis method is preferred when considering the limitations of traditional performance measurements, because it provides a true reflection of not only the return on investment (ROI) but also a bank's total operating efficiency. However, Ajmera (2012:58) notes that the DuPont model, like traditional financial ratios, relies on accounting data, which may be or have been exposed to manipulation by key players and yield biased results. Care must therefore be taken to use high-fidelity data. Panigrahi *et al*. (2014:282) have also found that traditional financial ratios such as earnings per share (EPS), return on assets (ROA), return on net worth (RONW), and return on capital employed (ROCE), are sensitive to financial distress. The authors therefore recommend that the economic value-added model (EVA) be used instead. The EVA model is preferred because it yields valuable information about a company's residual income, which is used to inform shareholders on their returns.

Nonetheless, Van der Westhuizen (2006:4) has found the lack of available data to have a negative effect on the accuracy of these financial performance measures, since each performance benchmark only uses a subsection of applicable data. This shortcoming can result in biased performance measurements that allow for scenarios like a bank that can be regarded as efficient according to one measure while being inefficient according to a different performance measure. It is therefore vital that a single performance benchmark enables estimation of the total performance based on all the accessible inputs and outputs of the bank (Van der Westhuizen, 2006:4).

Recognisably, care should be taken to circumvent the inherent restrictions associated with traditional financial performance measures to ensure accurate results. This has motivated the use of the DuPont analysis model in combination with the EVA model for evaluating bank performance. However, Bodie *et al*. (1998:235-237) concede that although such a multifaceted fundamental analysis procedure is commonly used within the financial sector, fundamental analysis alone is not always effective. This observation is important since statistics are integrated with a company's equity prices, which makes it difficult to obtain reliable and unbiased results. Efficiency measurements are therefore of equal significance and will be discussed in the following section.

3.3. Efficiency measures

As noted previously, an organisation's efficiency is measured relative to a certain benchmark and is thus expressed as the deviation between current performance and desired performance, thus seen as an aspect of an organisation's total performance (Mester, 2003:3). Bank efficiency is of paramount importance for the banking industry since it contributes to the performance measurement process of banks. Fiordelisi *et al*. (2011:1316) also note that bank efficiency gives an indication of the financial strength of a particular bank, and that banks with lower efficiencies are more likely to experience higher levels of exposure to risks. According to Andries (2011:39), available information on a bank's level of performance can aid in the expansion of its competitiveness in the market and can therefore lead to improved efficiency overall. The shareholders' wealth is also maximised as efficiency increases (Clark, 1996:344); therefore, bank performance and efficiency are narrowly connected.

The process of estimating bank efficiency further depends on a bank's local environment and market share. Košak and Zajc (2006:28-29) confirm the notion that bank efficiency is influenced by the type of ownership, that is, whether it is privately owned or state owned and whether it is part of a developing or first world economy, and by extent also the market which it serves. Since some efficiency measures include the use of traditional financial indicators based on balance sheet analysis, bank efficiency is also determined by its overall financial standing.

Mester (2003:2-6) explains that efficiency measurement can be done according to various categories that include: scale and scope efficiency, X-efficiency (which consists of technical and allocative efficiency), cost efficiency, standard and alternative profit efficiency, and lastly, operational efficiency together with various financial percentages. Following the study of Mesa *et al*. (2014:80-81), the determinants of bank efficiency or factors that influence bank efficiency include:

- the total value of assets which are directly related to a bank's efficiency ratio;
- the size of a financial entity, since the relationship between efficiency and institution size is not maintained for entities with total assets higher than $25 billion;
- diversification, where banks with a higher level of diversification are thought to be less efficient. This perception is based on the assertion by Wagner (2010:385-386) that financial crises are more likely at higher levels of diversification since it increases the similarities between banks, thereby leaving different banks exposed to the same risks;
- debt, because the more indebted a bank is, the lower its efficiency; and
- wholesale funding, since higher efficiencies have been observed with banks that have higher wholesale funding ratios. This is thought to be associated with the stricter requirements of professional lenders, which in turn demand better strategies to be implemented and thereby attaining higher efficiency ratios.

In respect of diversification and wholesale funding as determinants, it should be noted, however, that conflicting views are also found in literature. One conflicting view on diversification is mentioned in Section 3.3.2. In respect of wholesale funding, the Basel Committee on Banking Supervision has noted that a significant exposure to wholesale funding was one of the factors that contributed to banking systems experiencing significant stress during the global financial crisis of 2007–2008 (BIS, 2011:8-9). This was due to a loss of unsecured wholesale funding and therefore a decline in liquidity during the rapid market reversal. This situation contributed to the Basal Committee implementing internationally harmonised global liquidity standards. In this regard, the liquidity coverage ratio and the net stable funding ratio (NSFR) was developed to promote resilience to liquidity disruptions over periods of one month and one year respectively (BIS, 2011:9).

It is therefore important to use the appropriate type of efficiency measurement to ensure that an accurate indication of bank efficiency is obtained. In other words, the efficiency measurement method should yield results that are not biased or influenced by external factors. Berger and Mester (1997:897) note that selecting the appropriate type of efficiency measurement method is a difficult task, although the various aspects that are to be addressed in the measurement process should be used as guidelines to simplify the selection process. The various types of efficiency measures that are available will therefore be discussed in the subsequent sections.

3.3.1. Operational efficiency

Operational efficiency of financial institutions like banks is well-studied and has been used increasingly in recent years for its ability to yield a good indication of overall bank performance (Berger & Mester, 1997:896). Dymski (1999:64) classifies a bank as being operationally efficient when its employees provide efficient client service and when it makes optimal use of technological resources to maximise outputs. The maximisation of outputs supports the bank in attaining financial stability by being cost-effective. Allen and Rai (1996:656) note that difficulties are commonly experienced in measuring operational efficiency due to random errors and systemic deviations from the production frontier that occur frequently and which place limitations on the measurement process. The criteria used to determine whether a financial institution can be classified as being operationally efficient include the following:

- The institution must have optimised its output combination such that it is characterised, or has the potential to be characterised, by scale and scope economies (see Sections 3.3.2 and 3.3.3);
- The institution must have optimised its input combination such that it has no, or only a limited number of, input usage (technical X-inefficiency) and limited non-optimal proportions of inputs (allocative X-inefficiency).

Despite the difficulties associated with the measurement of this broad type of efficiency, it is classified as a beneficial efficiency index. Wang and Lu (2014:256) agree that it is beneficial because it can be used to identify reasons for operational inefficiencies. A study by Van Rooij (1997:10) explains that operational inefficiency arises when an institution misuses its inputs, which contributes to technical inefficiency (Section 3.4.4.2).

3.3.2. Scale efficiency

A bank's scale efficiency is defined as the ratio of the estimated minimum average costs and the actual average costs, both adjusted to be on the X-efficient frontier (Berger & Mester, 1997:926). Scale efficiency also quantifies an institution's total expenses relative to its size (Van Heerden, 2007:55). An increase in scale efficiency can be expected when, for example, the size of a specific bank grows significantly from the growth of its total capital and assets (McAllister & McManus, 1993:404). In other words, scale efficiency is size-dependent.

According to Hughes and Mester (2013:561) the size of a bank plays an important role in scale efficiency, because larger banks should experience scale economies from their respective credit and liquidity risks when providing loans and receiving savings from depositors. These savings are, however, diversified, and the diversification of savings relates to a reduced risk for the same level of revenue. Because the risks are diversified, the expenses associated with managing these risks reduce, thus enabling banks to have liquid assets as resources. However, as also noted in Section 3.3, some authors (Baele *et al*., 2007; Wagner, 2010) express doubts about whether the income from diversification justifies the increased costs associated with implementing such a strategy.

It is important to understand when a bank will be more likely to be scale inefficient. Cullinane *et al*. (2006:357) state that scale inefficiency is destined to occur within an organisation when the returns to scale fluctuates. Fukuyama (1993:1103) emphasises the significance of scale efficiency when noting that it correlates with the long-term price-taking economic equilibrium, which indicates that the financial company is functioning at a constant returns to scale level. He further notes that any inconsistencies from long-term economic equilibrium is an indication that a firm is exposed to scale inefficiency.

Chatterjee (2003:268) describes that there are different methods for measuring scale economies but that it is usually measured through the costs incurred by the organisation relative to its outputs while its product levels are held constant. According to Berger *et al*. (1993:118) another method for measuring scale economies is known as the Expansion Path Scale Economy (EPSCE). The EPSCE method quantifies the effects associated with altering scale or changes in the product variety by taking the average of the output levels from the appropriate banks (Berger *et al*., 1993:118).

Mester (1994:4) states that when a financial institution like a bank is classified as operating at constant returns to scale, that is, at neither increasing nor decreasing economies of scale, it implies an impartial increase in the bank's outputs with a certain increase in its inputs. Mester (1994:4) further explains that when this occurs it results in a decrease in production costs. On the other hand, when a bank is classified as operating at scale diseconomies (increasing or decreasing returns to scale), it refers to the condition where a bank's outputs increase disproportionally with a certain increase in its inputs (Mester, 1994:4). To illustrate, the relative cost of personal computers used for accounting can be reduced when the scale of operations increases, since the cost of the equipment can be spread out over a larger number of accountants. In other words, the cost of production per unit will have been reduced (Mester, 1994:4), which is referred to as increasing returns to scale. It can therefore be concluded that scale efficiency has a noteworthy effect on a bank's cost of production. Amid various other existing efficiency concepts is scope efficiency, will be discussed in the following section.

3.3.3. Scope efficiency

An institution is characterised as having scope efficiency when it is able to deliver high-quality products in a cost-effective manner (Van Rooij, 1997:1). According to Mester (1994:4-5) it is necessary for a bank to combine appropriate products such that a high-quality product line is obtained toward being scope efficient.

Scope efficiency is typically associated with scope economies. Scope economies in a bank, or in any other organisation, can be explained as the total costs associated with the joint production of the variety of products of a single bank or organisation compared to the total costs associated with the production of the same products by two or more other banks and/or organisations respectively (Mukherjee *et al.*, 2004:138). Mathematically, scope economies of an organisation with combined production of a variety products can be explained through Equation (3.1) (Moschandreas, 2000:102):

$$C(X,Y) < C(0.Y) + C(0.X) \tag{3.1}$$

where

- $C(X,Y)$ = The combined production of products (X and Y) and the costs associated;
- $C(0.Y)$ = Cost of product (Y); and

- $C(0.X)$ = Cost of product(X).

This mathematical definition confirms that scope economies refers to the cost efficiency in respect of the combined production of a variety of products by an organisation. It is also well-known that any type of organisation can be exposed to scope diseconomies. Wang *et al*. (2006:12) state that scope diseconomies is destined to occur when the costs associated with the joint production of products are higher in comparison with the individual production of these products. Scope diseconomies can also be explained through a mathematical equation as shown in Equation (3.2), from which it is clear that the joint production organisation's cost is higher and its profits lower when conditions of scope diseconomies are prevalent (Moschandreas, 2000:102):

$$C(X,Y) > C(0.Y) + C(0.X) \tag{3.2}$$

where the same definitions as in Equation (3.1) apply. It can therefore be concluded that being scope efficient is beneficial to the organisation wanting to maximise its profits by lowering the costs of the combined production of certain products.

3.3.4. X-efficiency

The concept of X-efficiency was first introduced by Leibenstein (1966:398) to serve as a measure of the extent to which an institution uses its resources (Harker & Zenios, 2000:15). These resources include technology resources, labour resources, capital assets, and other relevant resources that are required for producing cost-effective outputs. According to Soteriou and Zenios (1999:1222), X-efficiency is regarded as one of the most common measures of an institution's performance for its ability to offer insight into the service-profit chain and to quantify an institution's performance in terms of the quality of its products. Attaining the condition of X-efficiency can be influenced by various factors, as explained by Frantz *et al.* (2015:70) and Mester (2003:3):

- The management team of the institution is seldom in a position of ownership, which can lead to a set of circumstances known as the agency problem. This term refers to the situation in which some form of disagreement exists among the institution's shareholders and its managers, which limits the institution's possibility to be X-efficient.

- The institution's employers themselves determine the level, quality, and effort of work and services that are provided by the institution, which limits the institution's possibility to be X-efficient.
- X-inefficiency is observed when institutions use incorrect input combinations to deliver certain outputs, which is also known as allocative inefficiency. Also, when institutions fail to efficiently make use of their inputs, the chances of attaining X-efficiency significantly diminish.

As a result, it can be concluded that this type of efficiency, categorised as X-efficiency, consists of two types of efficiency, namely allocative and technical efficiency. Coelli *et al.* (1998:5) note that these two types of efficiency, allocative and technical efficiency collectively, offer a comprehensive economic measurement instrument. Thanassoulis (1999:4) further explains that an institution's efficiency is associated with relevant inputs that involve two components, namely the intermediation and production efficiency measurement. Intermediation efficiency determines technical and allocative efficiency, and production efficiency measurement only quantifies technical efficiency. Since allocative and technical efficiency are such important factors in the X-efficiency concept, both allocative and technical efficiency need to be measured, which will be discussed subsequently.

3.3.4.1. Allocative efficiency

In the 1950s allocative efficiency was defined as an index of the efficiency with which a firm uses an assortment of its inputs to produce its outputs; this is also known as price efficiency (Farrell, 1957:254-255). According to Brissimis *et al*. (2006:5), allocative efficiency is defined reflecting an organisation's level of competence in making use of its inputs in the most optimal manner. Brissimis *et al*. (2006:5) state that the sum of allocative efficiency and technical efficiency is known as a general economic efficiency measurement benchmark. Forsund *et al*. (1980:6-7) define allocative efficiency mathematically for measurement purposes as:

$$\frac{f_i(X^0)}{f_j(X^0)} = \frac{w_i}{w_j} \qquad (3.3)$$

where:

- X^0= The input set;
- w_j = The input price of X_j;
- f_j = Marginal product of X_j input set;

- w_i = The input price of X_i; and
- f_i = Marginal product of X_i input set.

It is clear that Equation (3.3) relates the input prices (w_i) and (w_j) with the respective input sets $f_i(X^0)$ and $f_j(X^0)$, and that the input sets should be equalised with the relevant price of the outputs. It follows from this statement that allocative efficiency prevails when a firm's input mixtures are matched by the market price ratios.

Although allocative efficiency is important for commercial firms, it is also important for the banking industry of a country, because when the banking industry is efficient it indicates that the banks within the industry efficiently use the correct combination of inputs. Tsionas *et al*. (2015:135) agree that allocative efficiency is important for banks but note that it is vital to understand that the size of a bank will have a definite effect on the efficiency measurement's results. In this respect Tsionas *et al*. (2015:135) note that it is not uncommon for smaller banks to experience higher allocative efficiency than medium and larger sized banks, since it is easier for smaller banks to regulate their assets and the allocation thereof. The exposure of smaller banks to non-optimal deposit rates are also limited.

While allocative efficiency is clearly an important and useful efficiency measure, it also requires an understanding of the reasons for allocative inefficiency, that is, when allocative inefficiency occurs and what it signifies. According to Van Heerden (2007:58), allocative inefficiency is destined to occur under certain circumstances, including the use of the incorrect input mixtures for the purpose of delivering specified product combinations. Mester (2003:5) also notes that allocative inefficiency, specifically with respect to banks, will occur when an inappropriate combination of inputs is used to produce the outputs. Allocative efficiency and inefficiency are further explained with the help of Figure 3.1 up to Figure 3.4 as adapted from Tutulmaz (2014:6).

Allocative efficiency is an input-oriented approach and can be explained on the input-input map. Referring to Figure, 3.1 the plotted points X_1 and X_2 are known to reflect relative prices that are almost equal to the relevant market prices, which implies that this action reflects the concept of allocative efficiency. The only reason that these points are somewhat different is that the plotted point, X_2, is known to be technically inefficient because it uses more inputs. Points y_1 and y_2 represent the goods in the business market.

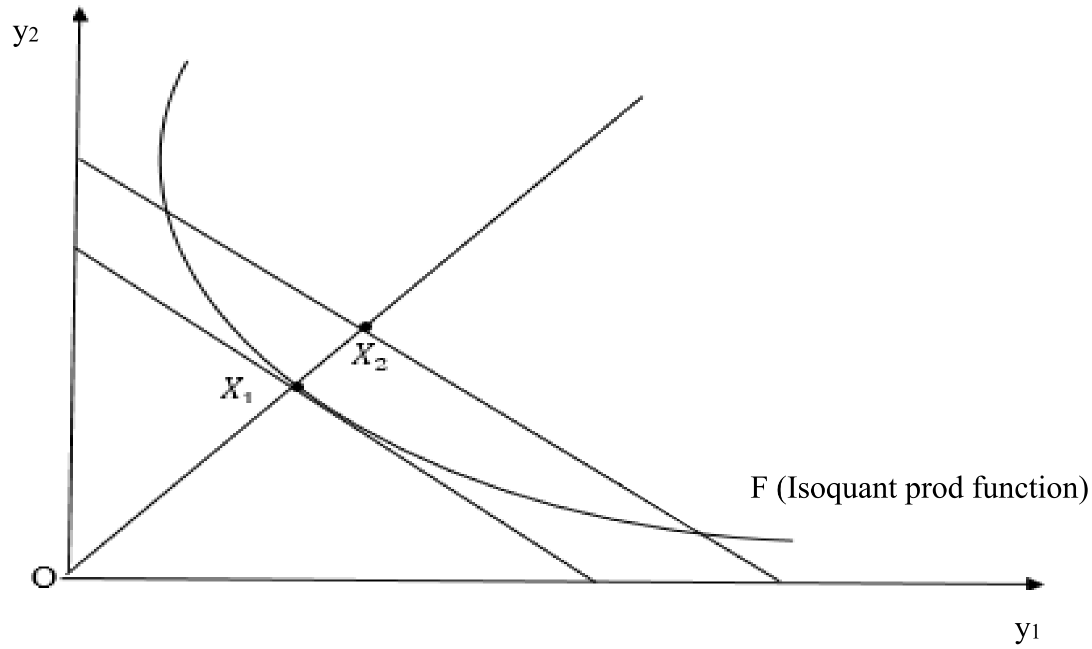

Figure 3.1: Allocative efficiency – input-oriented approach (Tutulmaz, 2014:6)

For explanation purposes of technical efficiency and allocative efficiency, Figure, 3.2 is relevant.

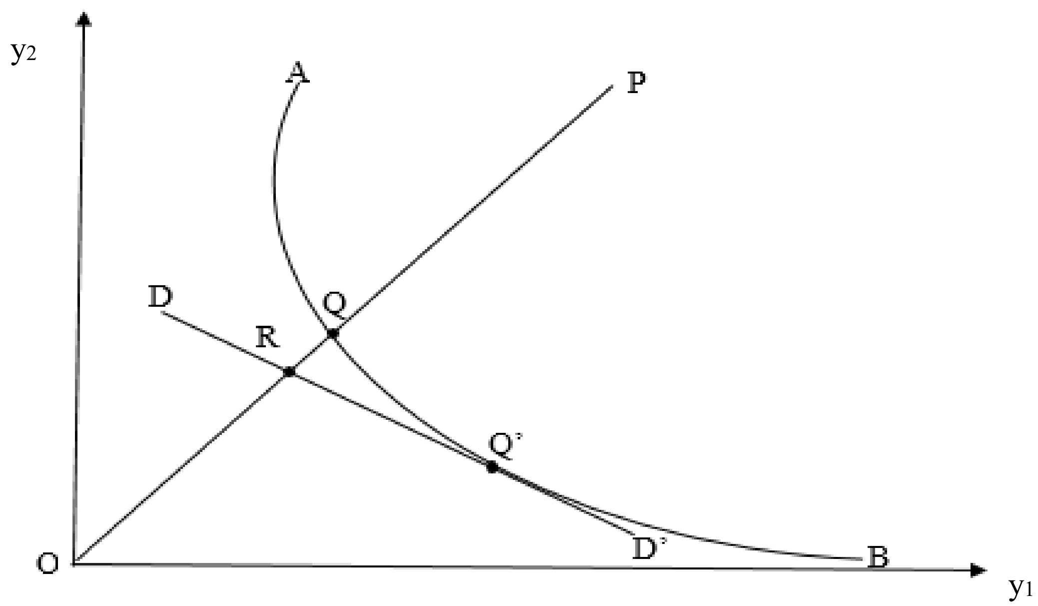

Figure 3.2: Allocative and technical efficiencies – input-oriented approach (Tutulmaz, 2014:6).

The AB curve in Figure 3.2 presents a frontier among all the firms in the business environment, for example a production frontier in the business environment. The axes y_1 and y_2 represent the goods in the business market. The line DD represents the relative price in the business environment. Points Q and Q' in Figure 3.2 are both technical efficiency. Point Q also represents allocative efficiency (refer to Figure 3.1), whereas point Q' represents technical efficiency. The distance of RP presents a reduction in cost when a firm at point P moves to point R, which is technically impossible because it is under the AB curve. Point P, or the line OP, is therefore seen as a definition of allocative efficiency.

Efficiency ($Eff_p = \frac{OP}{OR}$) can thus be divided into two parts, namely:

- $\frac{OQ}{OP}$ = The amount of inefficiency which is derived from the technical inefficiency when it is present;
- $\frac{OR}{OQ}$ = The amount of inefficiency denotes a certain situation where even the technical efficiency point is inefficient because of the inefficient distribution (allocation).

It is also important to note that similar investigations can be performed when an output-oriented approach is done. For explanation purposes of allocative efficiency in the output-oriented approach, see Figure 3.3.

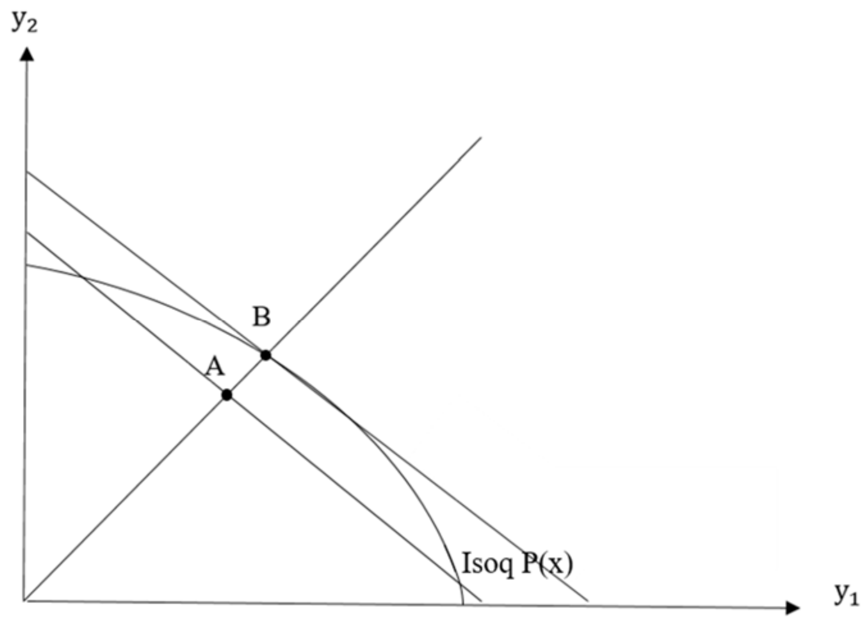

Figure 3.3: Allocative efficiency – output-oriented approach (Tutulmaz, 2014:6).

When allocative efficiency is viewed from the output-oriented approach (Figure 3.3), points A and B replicate the distribution of the production output in the exact manner, and since the distribution/allocating fraction is equal to the ratio of the market price percentages, both A and B are output-allocatively efficient. However, A is technically inefficient due to its lower output level. The output-oriented approach is illustrated in Figure 3.4, in which allocative inefficiency (P) is illustrated. The axes y_1 and y_2 represent the goods in the business market. In this case, the efficiency ratio, $(Eff_p = OP/OR)$ is less than 1, which translates into inefficiency. In the output-oriented approach, allocative inefficiency therefore consists of:

- $\frac{OP}{OQ}$ = The amount of inefficiency caused by technical inefficiency when it is present.
- $\frac{OQ}{OR}$ = The amount of inefficiency refers to a certain situation where allocative inefficiency is present.

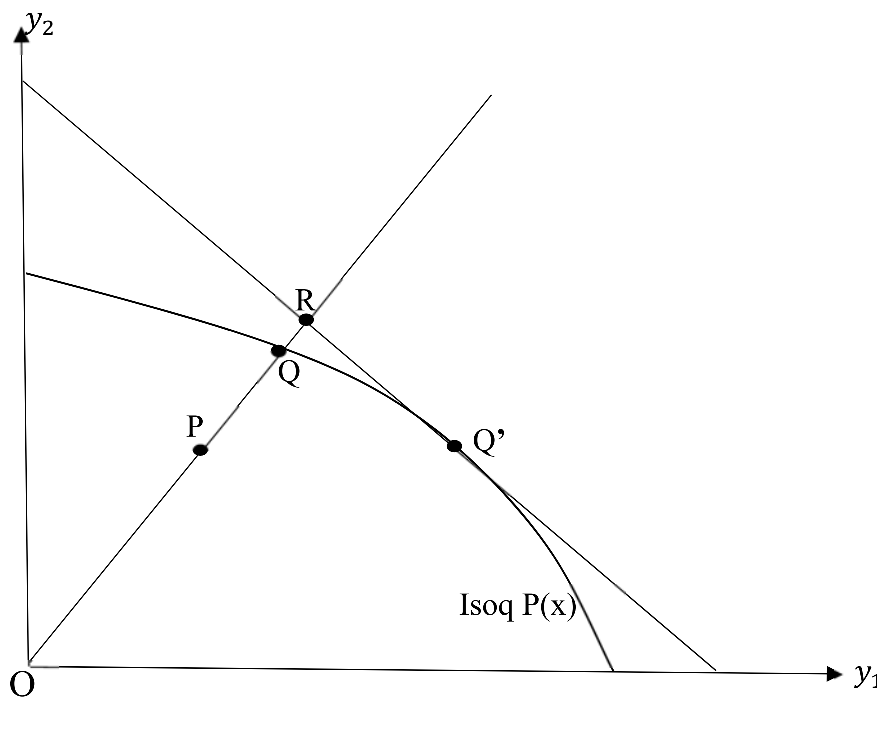

Figure 3.4: Allocative inefficiency according to the output-oriented approach (Tutulmaz, 2014:6).

3.3.4.2. Technical efficiency

Technical efficiency of an institution is associated with the production of outputs. In other words, when a firm is technically efficient, it reaches its output levels using the least amount of inputs such as labour, capital, and loanable funds (Sathye, 2001:621). It can be further defined as a proportional measurement of the extent to which an institution can successfully develop its inputs to produce outputs, characterised by the institution's production probability frontier (Kumar & Gulati, 2008:35). According to Bhattacharyya *et al*. (1997:333), technical efficiency is a bank's capability to transform resources into various financial services. Pasiouras (2008:302) states that banks can experience a higher level of technical efficiency when they operate internationally and that an overall increased level of technical efficiency is expected with a larger number of branches. Although a large number of branches is an indication of an increase in efficiency, efficiency does not improve with an increased quantity of ATMs (Automated Teller Machines).

A bank is classified as being technically inefficient when there is an overuse of inputs, for example when a bank has too many tellers and branches producing their products and rendering services to clients (Van Heerden, 2007:57). Kumar and Gulati (2008:35) explain that technical inefficiency within a bank also occurs when the bank is functioning below its production possibility frontier, which can be interpreted as an indication of the maximum quantity of outputs that can be created with a specified quantity of inputs.

3.3.5. Cost efficiency

Cost efficiency is a well-known and applied concept when analysing a bank's performance. Fethi and Pasiouras (2010:198) define cost efficiency as the competence with which banks deliver certain services to consumers without the misuse of available funds. Cost efficiency can also be interpreted as a bank's costs relative to the minimum costs that allow the bank to produce outputs under the same conditions (Fuentes & Vergara, 2003:8). As noted by Maranga (2010:3), cost efficiency and scale efficiency can be easily confused. To discern, cost efficiency measures an organisation's costs relative to the costs associated with the best-practice organisation that produces similar outputs, while scale efficiency determines whether an organisation is operational at its lowest position on their long-term regular cost curve.

A variety of advantages is associated with the assessment of cost efficiency, including that a bank has the ability to create different opportunities for extra cash flows, which in turn produces investment prospects for different products, markets, expertise, and technologies. These investment prospects offer benefits to a bank's shareholders, lead to improved banking services with lower banking costs and finally to increased growth opportunities (Arthur D. Little Global, 2008:1). When a bank or financial institution is not cost efficient (or cost inefficient), the bank and/or the financial institution is in danger of experiencing a financial crisis that will limit its growth opportunities (Arthur D. Little Global, 2008:1). According to Mester (2003:7) it is important to recognise that the idea of cost efficiency is a result of a specific cost function, which specifies that the variable costs are dependent on different factors, such as:

- the price of the variable inputs;
- the amount of variable outputs;
- a fixed group of outputs and inputs;
- environmental factors;
- random errors; and
- efficiency.

The cost function can thus be derived and summarised as (Mester, 2003:5):

$$\ln C_i = \ln f(y_i, \mathrm{w}_i, \mathrm{z}_i, \mathrm{h}_i) + \ln u_i + \ln v_i \qquad (3.4)$$

where

- C_i represents the measurement of all the variable costs;
- y_i signifies the vector of quantities of variable outputs;
- w_i represents the vector of the prices of variable inputs;
- z_i specifies the quantities of any fixed netputs (inputs or outputs not capable of fluctuating rapidly);
- h_i is the specific set of environmental variables that may affect performance (such as regulatory boundaries);
- $ln\ u_i$ designates an inefficiency factor that may increase costs above the best-practice level; and
- $ln\ v_i$ denotes the random error that may yield temporary high or low costs.

The inefficiency factor ($ln\, u_i$) includes technical and allocative inefficiency. Technical inefficiency occurs when there are more outputs to produce (y_i), and allocative inefficiency results from a failure to respond to the price of inputs (w_i) (Mester, 2003:5). The term $ln\, u_i + ln\, v_i$ reflects the combined error, where $ln\, v_i$ is also known as a two-sided error term for having positive and/or negative characteristics. However, the term $ln\, u_i$ reflects a positive, one-sided error term as inefficiency indicates greater costs (Mester, 2003:5).
Berger and Mester (1997:898-899) explain cost efficiency for a bank (b) as the assessed costs required to produce the bank's output vector if it is considered to be just as efficient as a best-practice bank when facing similar exogenous variables (w, y, z, v). This is defined mathematically in Equation (3.5):

$$CostEFF^b = \frac{\hat{C}^{\min}}{\hat{C}^b} = \frac{\exp\left[\hat{f}(w^b, y^b, z^b, v^b)\right] \times \exp\left[\ln \hat{u}_c^{\min}\right]}{\exp\left[\hat{f}(w^b, y^b, z^b, v^b)\right] \times \exp\left[\ln \hat{u}_c^b\right]} \qquad (3.5)$$

where

- $\frac{\hat{C}^{\min}}{\hat{C}^b}$ is the minimum cost relative to banks b's costs,
- $\hat{f}(w^b, y^b, z^b, v^b)$ reflects the exogenous variables,
- $\ln \hat{u}_C^{min}$ and $\ln \hat{u}_C^b$ reflect the combined error term with
- $\hat{u}_C^{min}$ as the minimum variable costs
- $\hat{u}_C^b$ across all the banks.

The fraction $\hat{C}^{\min}/\hat{C}^b$ is known as the cost efficiency fraction and reflects the amount of assets and/or costs that are being used in an efficient manner. For example, a cost efficiency percentage of 60% (0.6) indicates that the specific bank is 60% efficient and 40% cost inefficient in relation with a best-practise institution exposed to similar circumstances. The value of cost efficiency therefore varies between zero and one (0, 1), where a value of one (100%) is representative of the best-practice financial institution.

It can therefore be concluded that cost efficiency is related to financial growth, and it gives an indication of how profitable the financial institution and/or bank is. A high cost efficiency will therefore reflect in higher revenues and lower prices, which in turn exhibit an institution's competitiveness and financial performance.

3.3.6. Standard profit efficiency

Standard profit efficiency refers to how efficiently a bank exploits its profits, and therefore to what degree it is able to minimise its service delivery costs to maximise profits (Maudos *et al.,* 2002:34). Standard profit efficiency is regarded as a very beneficial efficiency index and it is not the same as cost efficiency (Berger & Mester, 1997:936). Standard profit efficiency is also interpreted as the institution's proximity to the most optimum level of profits for specific input and outputs prices (Delis *et al*., 2009:194). Mester (2003:6) further states that an institution's standard profit inefficiency is often the result of poor decisions regarding output prices, indicating that the organisation did not perform at the level of best practice. Mathematically, standard profit efficiency is defined using the standard profit function as shown in Equation (3.6) (Mester, 2003:6).

$$\ln(\pi + \theta)_i = \ln(p_i, w_i, z_i, h_i) - \ln u_{ni} + \ln v_{ni} \qquad (3.6)$$

where:

- π indicates the organisation's generated variable profits;
- θ is an added constant to an organisation's profit, which gives the natural logarithm a positive value;
- p_i reflects the vector of prices of the flexible outputs;
- w_i reflects the vector of prices of the flexible inputs;
- $z_{i,}$ reflects the fixed amount of inputs or outputs that is not able to adjust rapidly – these inputs and outputs are also known as netputs;
- h_i represents a collection of environmental variables that can affect the organisation's performance;
- $\ln u_{ni}$ refers to the reduced profits caused by the present inefficiency; and
- $\ln v_{ni}$ is the error term of the function.

Berger and Mester (1997:900) further explain standard profit efficiency by using the following example: When an organisation spends two additional dollars to increase income by four dollars, while all other costs and prices remain constant the organisation has the opportunity to be more profit efficient but will be less cost efficient. Evidently, while standard profit efficiency is a broad efficiency measure, it is more comprehensive than the cost efficiency measure since it explains output and input errors. This feature also enables standard profit efficiency to quantify the total technical efficiency scores more accurately than the cost efficiency measure can (Delis *et al*., 2009:194).

3.3.7. Alternative profit efficiency

This type of efficiency is an alternative to standard profit efficiency and is used when difficulties are experienced with the assumptions that underlie standard cost and profit efficiency respectively. Delis *et al*. (2008:6) explain that alternative profit efficiency enables measurement of how well the bank is able to maximise its profits relative to its output levels rather than its output prices. Delis *et al*. (2008:6-7) go on to relate that the alternative profit efficiency function uses the same dependent variable as the standard profit function (Equation (3.6)), but with the independent variables being similar to those used in the cost function (Equation (3.4)). These aspects are summarised in Equation (3.7) (Berger & Mester, 1997:901):

$$\ln(\pi + \theta) = f(y, \mathrm{w}, \mathrm{z}, \mathrm{h}) - \ln u_{a\pi} + \ln \in_{a\pi} \quad (3.7)$$

where:

- π, θ as defined in eq. (3.6) above;
- y reflects the vector of quantities of variable outputs;
- w, z, h as defined in eq. (3.6) above;
- $lnu_{a\pi}$ reflects the inefficiency term that decreases the institution's amount of profits; and
- $ln \in_{a\pi}$ is the function's random error term.

The alternative profit efficiency also uses a dissimilar inefficiency term ($lnu_{a\pi}$) and random error term ($ln \in_{a\pi}$) compared to those used in the cost function (Equation (3.4)). Since the alternative profit efficiency function contains similar variables as those used in the standard profit and cost efficiency functions, it means that when the assumption inherent to the cost and standard efficiency are valid, estimating the alternative profit efficiency function is not needed. From the discussion presented in the preceding sections it is clear that various types of efficiency measurements are available to assist in the efficiency assessment of banks or financial institutions. The following section will discuss different factors that can potentially influence a bank's performance and efficiency measurement results, while the specific method used in this study will be explained in Chapter 4.

3.4. Factors that influence the efficiency and performance measurement of a bank or a company

Research by Siyaka (2006:16), Isik and Hassan (2002:273), and Berger and Mester (1997:936), among others, has been conducted to understand the various elements that can influence an institution's efficiency and performance levels. According to Siyaka (2006:16) and Berger and Mester (1997:936), common influential factors include the bank's ownership structure, the size of a bank, and the bank's supervision systems. These will be subsequently reviewed.

3.4.1. Bank size

Isik and Hassan (2002:273) consider a bank's size to be a vital driving force of any deviation in efficiency and conclude that banks should meet the requirements for a specific bank size such that scope and scale can be maximised. Different views exist on the probability of a positive relationship between the size of a bank and its efficiency. Berger and Mester (1997:936) conclude that a bank's size influences its cost efficiency, with smaller banks being more efficient in terms of profit efficiency than larger banks. Berger and Mester attribute this to the fact that profitability percentages are higher for smaller banks.

However, despite the findings of Berger and Mester (1997:936) and Berger *et al*. (1993:317-319), Srivastava's (1999:32) results suggest an opposite trend, namely that India's medium-sized banks are more profit efficient than their smaller and larger counterparts. Kaparakis *et al.* (1994:890-891) also report that smaller banks are not more efficient than medium-sized banks and instead found them to be more efficient in terms of profitability than larger banks. Kaparakis *et al*. (1994:890-891*)* attributed this to the fact that smaller banks' competitive edge is not as expanded in the small banking industry, which allows these banks to pay lower interest rates on deposits that they receive while receiving higher interest rates from borrowers – a notion confirmed by Wetmore and Chukwuogor-Ndu (2006:124).

It can therefore be concluded that the influence of a bank's size on its efficiency has not been clearly established, and, as noted by Berger and Mester (1997:936), while an increase in bank size yields the necessary leverage to control its expenses, it does not necessarily translate to the generation of comparatively higher incomes and profits.

3.4.2. Supervision and/or ownership structure

Boubakri *et al*. (2005:2038-2039) found a clear relationship between a bank's ownership and supervision structures and its efficiency. Zouari and Taktak (2012:11-12) have also found that efficient ownership and supervision structures are necessary elements for maximising the performance levels of local, international, or state entities, which is especially true for the banking industries of developing countries. According to Shleifer and Vishny (1997:754-755) different management and ownership structures have pivotal effects on a bank's supervision and it is therefore understandable that supervision and ownership structures have different focus areas, for example:

- Some bank ownership structures focus more on the shareholders, their interests, and the advantages that they will gain from their investments.
- Other bank ownership structures are more in favour of their own survival and long-term sustainability.

Shleifer and Vishny (1997:754-755) have found that shareholders play an important role, as they have a major and direct impact on a bank's performance and efficiency. Rahman and Reja (2015:483) have found intensely focussed ownership structures to be advisable, especially in developing countries such as South Africa. The studies of Moldenhauer (2006:25), Chen *et al*. (2003:281-282) and Davies *et al*. (2005:658) present results that support the notion that a specific ownership style is necessary for ensuring a financial institution's effective performance. While Chen *et al*. (2003:281-282) and Davies *et al*. (2005:658) recommend a managerial ownership style, Moldenhauer (2006:25) suggests an insider ownership style.

Different views exist regarding whether family ownership is beneficial for performance and efficiency. Villalonga and Amit (2006:390) define family ownership in respective of the total amount of shares of all different types that are held by the family relative to the aggregate amount of outstanding shares. Maury and Pajuste (2005:1815) and Villalonga and Amit (2006:399) have found that family ownership and/or management is able to enhance the performance levels of a business. This is supported by the findings of Gürsoy and Aydoğan (2002:23) who have found that family ownership can minimise a business's exposure to risks. However, Gürsoy and Aydoğan (2002:23) note that lower exposure to risks can result in low performance levels, which stands contrary to the findings of Rahman and Reja (2015:484-485), who found the concentration of capital within the family-owned business to have the tendency to result in an excessive amount of risks and limited profit growth strategies. It is therefore clear that many different views exist on family-managed firms and family-owned businesses and the effects that such ownership and management structures have on performance and efficiency levels.

Various studies have also been conducted to investigate government ownership structures (Micco *et al*., 2007; Iannotta *et al*., 2007; La Porta *et al*., 2002). The results obtained again differ with the subsequent interpretations. Micco *et al.* (2007:220) have found that whether government ownership and management is positive or negative depends on whether the country is a developed or developing country. Micco *et al.* (2007:221-222) conducted this study on different types of banks, for example investment and commercial banks, throughout 179 countries worldwide. The results show that government ownership has led to low cost efficiency and higher costs compared to privately owned banks in these developing countries (Sub-Saharan African region, South Asian region and the Middle Eastern region). The study by Iannotta *et al*. (2007:2127) concludes that government-owned banks have lower profits than privately owned banks, and that this has also led to lower performance levels. La Porta *et al*. (2002:290) have found that government-owned banks normally tend to follow sluggish routes to financial improvements and experience low performance levels with low efficiency characteristics as a result. La Porta *et al*. (2002:290) have further discovered that government ownership of banks is normally present in countries where the gross income per capita is very low, in countries where weak financial structures are applicable, and where the government tends to be incompetent.

However, other results from the studies of Rahman and Reja (2015) and Razaka *et al*. (2008) respectively contradict the aforementioned results. The results of Rahman and Reja (2015:486) indicate that government-owned banks, such as different banks in Malaysia, are typically characterised by enhanced performance levels. Also, Razaka *et al*. (2008:18) have found that government-owned banks have higher performance levels because of lower average confidence in privately owned banks in countries where the public is of the opinion that the government-owned structures will offer more support during difficult financial times. It is therefore clear that various relationships exist between government ownership structures and efficiency and performance levels, which seem to depend on region.

Institutional ownership structures, according to Hartzell and Starks (2003:2372), are beneficial to the efficiency of organisations since they stimulate effective management structures that lead to increased performance. Maury (2006:339) also considers this type of ownership to influence the relationship between two factors such as the ownership structure and the financial company's value, whereby the improved decision structures of the company and the company's control systems cause the company's performance level to increase exceptionally.

Foreign ownership structures, as noted by Mian (2003:28-30), lead to a variety of benefits in favour of the bank. These benefits include increased capital, increased availability of financial resources, limited exposure to risks, diversification of the applicable risks, the ability to offer excellent services to multinational firms, and an in-depth knowledge of the local banking environment with the implementation of exceptional skills. Based on these benefits, Mian (2003:28-30) considers foreign ownership structures to be more effective toward the bank's performance levels than national ownership banks. Bonin *et al*. (2005:51-52) agree with this finding and state that foreign ownership of banks results in higher cost-efficiency, an overall higher quality of services, and by extent better performance.

In contrast Claessens *et al*. (2001:908-909) argue that foreign ownership structures are beneficial for banks' performance levels, but only to a limited degree. This is based on their results, which indicate that only banks in developing countries, for example South Africa and Brazil, are likely to benefit from this type of ownership in respect of their profits and not so much the banks in developed countries. It can therefore be concluded that this type of ownership structure has a positive relationship with bank performance and efficiency, albeit only significant in developing countries.

It is clear that the abovementioned factors have definite influences on the banks' performance and efficiency levels, although the correlation and extent of the influence vary from one region to another. The process of bank efficiency measurement will be discussed in the following section.

3.5. Efficiency measurement and potential complications

Various techniques and methods are currently available for measuring bank efficiency (Burger & Moormann; 2008:92-93). In the past, performance ratios were used for estimating performance levels (Paradi *et al.*, 2011:316). However, as already stated (Section 3.2.3), significant limitations are associated with traditional performance methods, which are also used in fundamental analysis, and the realisation of these limitations has led to the development of more appropriate measurement techniques (Alrafadi & Md-Yusuf, 2011:622) that include parametric and non-parametric techniques.

Murillo-Zamorano (2004:35) state that deciding which type of model to use is not based on the best method, but rather on the type of method most appropriate to account for the prevailing conditions. According to Murillo-Zamorano and Vega-Cervera (2001:266) parametric models are techniques that consist of deterministic and stochastic models. Deterministic models are models that include the total number of observations and are able to identify the total scope between the observed level of production and the maximum amount of production (Murillo-Zamorano & Vega-Cervera, 2001:266). Stochastic models, in contrast, are able to distinguish between technical efficiency and the statistical noise (Murillo-Zamorano & Vega-Cervera, 2001:266). According to Burger and Moormann (2008:92) the stochastic frontier analysis models are the most commonly used models when applying parametric methods in studying efficiency. Murillo-Zamorano (2004:35) further note that non-parametric models (techniques) are used to determine the production frontier together with the efficiency values that correspond to the constructed frontiers. This approach is traditionally known as the data envelopment analysis (DEA) model, and according to Cooper *et al*. (2004:36) it is one of the most commonly used models in the non-parametric category. It is also the approach that is followed in this study, and it will be described in more detail in Chapter 4.

The main element required for an efficiency analysis is the production function of the applicable method (Burger & Moormann, 2008:92-93). Theoretically, the production function enhances and improves the measurement procedure, whereby the most significant inputs and outputs that should be used in the efficiency measurement process can be identified. Various approaches exist with which to identify the inputs and outputs, including the intermediation approach, the asset approach, the production approach, the value-added approach, and the user-cost approach. Efficiency scores are then generated using efficiency measures such as the data envelopment analysis (DEA) and stochastic frontier analysis (SFA) methods.

Nonetheless, defining the appropriate inputs and outputs in the banking industry remains a challenge (Mlima & Hjalmarsson, 2002:12). Difficulties in identifying appropriate inputs and outputs and limitations regarding the availability of data can lead to complications during bank efficiency analyses, since efficiency scores are strongly influenced by the choice of inputs and outputs. One aspect that complicates the selection of bank outputs is the implicit pricing of bank services (Berger & Humphrey, 1992:252). An example is deposits on which revenue is paid at below market interest rates, based on the deposit balances. Revenues can therefore be hard to accurately quantify and is therefore an unreliable indicator of outputs (Avkiran, 2006:284); moreover, it is becoming increasingly difficult to identify the deposit balances. The fact that most outputs are "multi-products" further complicates the measurement of outputs (Colwell & Davis, 1992:5). Here, "multi-products" refer to services that cannot be separated or priced individually, for example the safekeeping and accounting services in a current account. The role of deposits has also been debated in the literature, as some authors (Yue, 1992:36; Kao & Liu, 2004:2355-2356; Kamau, 2011:15; Van Heerden & Heymans, 2013:747) have suggested that deposits is classified as an input in an intermediation approach. In a value-added approach, deposits can be viewed as an output since it is related to the creation of value-added and opportunity costs to the client. However, Mester (1994:6) concludes that deposits should be treated as an input.

Another aspect to consider is that technical and scale efficiency are two important factors in the efficiency measurement of an organisation, and it is vital to use the correct combination of inputs and outputs to quantify both the technical and scale efficiency (Thanassoulis, 1999:4). However, the inputs and outputs cannot be directly compared since they differ greatly. This is because banks provide a diverse number of services such as saving accounts, credit services, mortgages and other financial advisory services that require the use of the banks' labour, equipment, and deposits.

In terms of efficiency measurement of banks, Berger and Humphrey (1992:245) note that because the banking industry is a highly regulated industry, a resultant degree of inherent inefficiency may at times hamper accurate analysis of bank efficiency. However, if accurately estimated, efficiency scores can help identify the factors (not the inputs or outputs) that contribute to the estimated level of performance (Schaffnit *et al.*, 1997:284).

3.6. Summary

The aim of this chapter has been to provide an overview of bank performance (Section 3.2) and bank efficiency (Section 3.3) measurements, and to explore the difference between the two concepts as well as the role and significance of each. Performance measurement is accomplished through the application of specific performance measures (Section 3.2.2), the process of which is known as fundamental analysis. Bank performance refers to the extent to which the market value of the bank's common shares is maximised. In contrast, efficiency is used to measure the level of outputs relative to an amount of inputs and can be measured using various efficiency measurement methods (Section 3.3).

Since fundamental analysis is characterised by various limitations and as a result not always effective on their own, it has been recommended that efficiency analyses be used in conjunction with fundamental analysis (Section 3.2.3). Nonetheless, efficiency and performance have been found to be associated, since a high level of performance indicates a high efficiency and vice versa. In other words, shareholders' wealth is also maximised as efficiency increases. Moreover, efficiency provides an indication of the financial strength of a firm, which is of paramount importance for the banking industry, seeing that a bank with lower efficiency is more likely to experience higher levels of exposure to risks. Furthermore, the lack of available data has had a negative effect on the accuracy of performance measures, as each performance benchmark only uses a subsection of applicable data, which can lead to inaccurate results. Having taken these aspects into consideration, efficiency measurement has been found to be sufficient for the purpose of this study, that is, to characterise the level of risk that each of the medium-sized banks are exposed to, if any, and to determine the aspects of each bank's operations that can be improved to lower their risk exposure.

Despite the advantages of the various efficiency measurement indices, various factors should be considered during bank efficiency measurement to ensure accurate, unbiased results (Section 3.4). Additionally, the various efficiency indices (Section 3.5) are characterised by some limitations, and care should still be taken during efficiency measurement to ensure that the appropriate indices are correctly implemented. For this purpose, Chapter 4 will reveal that the data envelopment analysis (DEA) method, as also mentioned in this chapter, is the most suitable for this study for its flexibility and numerous other advantages (Section 4.3.3).

Chapter 4

Research method

4.1. Introduction

Chapter 3 discussed various techniques available for measuring bank efficiency and emphasised its significance for banks. It found that a high efficiency is characteristic of a high level of performance and the other way around. Considering that fundamental analysis is characterised by various disadvantages and limitations, efficiency measurement of medium-sized banks it will be shown in this chapter as a sufficient measurement for this study. The data envelopment analysis (DEA) method is identified in this chapter as the most suitable for estimating the efficiency of the medium-sized banks in South Africa and thus for addressing the aim of this study (Section 1.3).

In brief, the cluster analysis method (Section 4.2) with which the medium-sized banks of South Africa have been identified will be discussed in addition to the subsequent DEA method used to estimate the technical and scale efficiencies of these banks (Section 4.3). The relevant inputs and outputs used in the DEA approach will be described in Section 4.3.1 under the intermediation approach (Section 4.3.1.1), during which these inputs and outputs used in this study will also be motivated. The input-oriented approach will subsequently be discussed in Section 4.3.2, followed by relevant background of the DEA in Section 4.3.3 to motivate its applicability to quantifying bank efficiency. Next will follow a summary of the benefits and limitations associated with the method in Section 4.3.3.1 and the guidelines for the construction of a DEA model in Section 4.3.3.2. The model specifications and the type of DEA model used in this study will be reviewed in Section 4.3.3.3, that is, the constant returns to scale (CRS) and the variable returns to scale (VRS) model specifications (Section 4.3.3.3.1) and the multi-stage DEA model (Section 4.3.3.3.2). Thereafter, factors that influence the results of the DEA approach will be discussed in Section 4.3.4, followed by a summary of specific DEA model as implemented in this study (Section 4.4.1) before presenting the applicable data in Section 4.4.2.

4.2. Cluster analysis

Everitt *et al*. (2011:3) characterise cluster analysis as a multivariate method used for classifying a sample of subjects based on a set of measured variables into various groups such that comparable subjects are placed in an identical set. In other words, cluster analysis is essentially a means of categorising subjects or finding similar groups in a dataset (Kaufman & Rousseeuw, 2009:1). Cluster analysis is also known as a procedure for classification, pattern recognition, and numerical arrangement, which enable application of the method to various fields like economics, engineering, market research, geography, sociology, geology, criminology, and medicine (Rencher & Christensen, 2012:502).

Various advantages motivate the use of clustering analysis, which include that:

- it is an efficient process for organising large dataset samples (Everitt *et al*., 2011:3);
- it delivers a compact description of similar or dissimilar patterns in data while focussing on fundamental patterns in the dataset (Everitt *et al*., 2011:3);
- both qualitative and quantitative information and data can be analysed (Peeters & Martinelli, 1989:42);
- each datum in a dataset is assigned an equal weighting (Peeters & Martinelli, 1989:42);
- a set of natural groups in a dataset together with the interrelated information of each group can be identified (Yuan *et al*., 2016:102).

Despite the benefits of using the cluster analysis method, it should be noted that this analysis method has no mechanism for differentiating between appropriate and inappropriate variables. Care should therefore be taken to ensure that only valid data and variables are used in a cluster analysis (Sarstedt & Mooi, 2014:275).

4.2.1. Cluster analysis procedure

According to Halkidi *et al*. (2001:107-108), cluster analyses is done according to the steps shown in Figure 4.1, which will subsequently be discussed:

Step one: Collect a dataset.

Step two: Feature selection: The purpose of the feature selection phase is to identify the correct features according to which the analysis must take place.

Step three: Clustering algorithm: In this step an algorithm is chosen with the purpose of generating results for an appropriate clustering system for a dataset. Specifically, a proximity measure and a clustering criterion should be specified. These two aspects determine the efficiency of the clustering analysis in defining an appropriate clustering scheme that is applicable to the dataset being analysed. A proximity measure quantifies the degree of similarity between two data points (i.e. feature vectors). Care should be taken to ensure that all the features that have been selected contribute to the calculation of the proximity measure with equal weighting so that some features do not dominate others. The clustering criterion should also be defined, which can be expressed as a set of rules. For this, the type of clusters expected for the dataset being analysed should be considered because this can assist in defining an accurate clustering criterion that will produce clusters that fit the data well (Halkidi *et al*., 2001:108).

Step four: Validation of the results: The accuracy of the clustering algorithm results should be validated with appropriate standards and methods (Rezaee *et al*., 1998:237).

Step five: Interpretation of the results: The clustering analysis results should be combined with other empirical analyses results to reach an accurate conclusion (Halkidi *et al*., 2001:108).

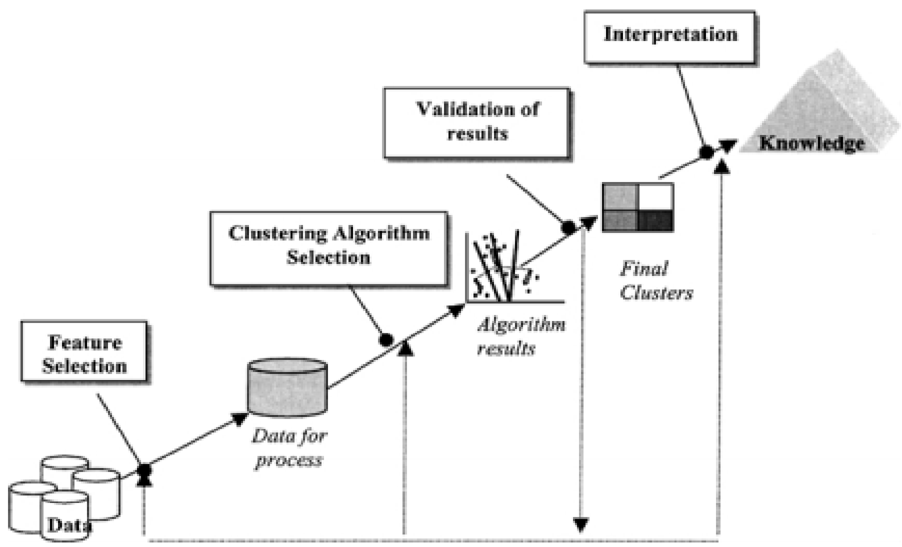

Figure 4.1: Steps in the clustering analysis method (Halkidi *et al*., 2001:108).

4.2.2. The measurement of distance

The dataset (interval, ordinal, or categorical) that is used, and the type of data greatly determine which measure of distance, like proximity measures, should be applied (Iglesias & Kastner, 2013:581). The Euclidean distance is the most common distance measure for quantifying similarities with respect to interval data, i.e. timeseries data (Lu & Kao, 2016:234; Iglesias & Kastner, 2013:581), and it is also the measurement method used in this study. The Euclidean distance (Equation (4.1)) refers to the geometric distance between points in a multidimensional space. For p variables, $X_1, X_2, \dots, X_p,$ in a sample of *n* subjects, the observed data for subject *i* is designated as $x_{i1}, x_{i2}, \dots, x_{ip},$ while the observed data for subject *j* is designated as $x_{j1}, x_{j2}, \dots, x_{jp}$:

$$d_{ij} = \sqrt{(x_{i1} - x_{j1})^2 + (x_{i2} - x_{j2})^2 + \cdots + (x_{ip} - x_{jp})^2} \tag{4.1}$$

According to Bora *et al*. (2014:2502) the Euclidean distance measurement, as seen in Equation (4.1), is generally calculated from raw data. Bora *et al*. further mention that the benefit of using the Euclidean distance is that the distance measurement between objects is not influenced by the addition of other objects to the cluster analysis, even for outliers. Even so, the accuracy of the measurement is influenced significantly where there are differences in scale between the objects, although transforming the dimensions such that the different objects have similar scales can overcome this issue (Bora *et al*., 2014:2502). A simple example is where distance is measured in centimetres for some objects while in millimetres for other objects. The resulting Euclidian would then be biased by those dimensions with a larger scale. It is therefore normally advisable to take the standard Euclidean distance measurement benchmark, which is to square the Euclidean distance measurement results, since objects that are further apart would be emphasised to a progressively greater extent (Bora *et al*., 2014:2502).

Despite the various types of clustering methods available, the two most widely used approaches are the non-hierarchical clustering and hierarchical clustering approaches (Everitt *et al*., 2011; Halkidi *et al*., 2001; Bradley & Fayed, 1998; Rencher & Christensen, 2012:502; Pham *et al*., 2018:213). However non-hierarchical cluster analysis is not applicable to timeseries data (the type of data applicable to this study) (Keogh & Lin, 2005:157), in which case a hierarchical cluster analysis method should be used (Everitt *et al*., 2011:71; Mantegna, 1999:155-156; Halkidi *et al*., 2001:110).

Hierarchical methods are therefore frequently used for the analysis of financial data and have also been used in this study. Specifically, the agglomerative, single-linkage method has been used in this study, which will be briefly reviewed in the subsequent section.

4.2.3. The agglomerative single-linkage hierarchical method

According to Everitt *et al*. (2011:71) timeseries data are not separated into specific clusters in a single step during hierarchical clustering analysis; rather, the classification involves a series of partitions. This may run from a single cluster that contains all individual subjects to n clusters, each containing a single subject. Hierarchical clustering is explained by Keogh and Lin (2005:157) as a method that produces a nested hierarchy of similar groups of objects, which is derived from a pairwise comparison of distances between the various objects. Hierarchical methods represent one possible way to identify appropriate clusters in the data in a computationally efficient way, since it is not always feasible to evaluate all possible clustering possibilities for a dataset, especially a large dataset. The possible number of ways in which a set of n items can be grouped into g clusters is given by Equation (4.2):

$$N(n,g)=\frac{1}{g!}\sum_{k=1}^{g}\binom{g}{k}(-1)^{g-k}k^{n} \tag{4.2}$$

Equation (4.2) can be approximated by $g^n/g!$, which still yields numerous possibilities even for moderate values of n and g.

The advantage of the hierarchical clustering analysis method is that the parameters, such as the number of clusters, do not need be provided as in the case of the non-hierarchical k-means method. Keogh and Lin (2005:157) summarise the basic hierarchical clustering algorithm as follows:

1. The pairwise distance between all objects is calculated and stored in the distance matrix.
2. The two most similar objects/clusters are identified from the distance matrix.
3. The two objects/clusters are joined to produce a cluster that consists of at least two objects.
4. Update the matrix by calculating the distances between this new cluster and all other clusters.
5. The algorithm is repeated iteratively from Step 2 until all objects have been assigned to a cluster.

As noted by Kaufman and Rousseeuw (2009:1), hierarchical methods can further be divided into agglomerative methods and divisive methods. The agglomerative single-linkage method has been used in this study. In agglomerative methods, the subjects are assigned to their own separate clusters. Similar clusters, like those closest in proximity as determined from distance measurements, are then then combined iteratively until all the subjects have been merged as a single cluster (Everitt *et al*., 2011:71; Sharma *et al*., 2017:139). The optimal number of clusters is then identified from the different cluster solutions. The process of identifying which cluster(s) should be included at each stage of the analysis can be done by six different methods (Everitt *et al*., 2011:260). Differences between the various agglomerative methods exist due to differences in how the measure of distance is defined, that is, the distance between individual subjects and a group of subjects, or two groups of individuals (Everitt *et al*., 2011:73). The single linkage method has been employed in this study and is a very simple agglomerative hierarchical method, also known as the nearest neighbour method (Halkidi *et al*., 2001:124). According to Rencher and Christensen (2012:506) the nearest neighbourhood method refers to the minimum distance between two clusters, point A and point B, as described by Equation (4.3):

$$D(A,B) = \min\{d(y_i\, y_j), for\ y_i\ in\ A\ and\ y_j in\ B\} \qquad (4.3)$$

where the Euclidean distance is given by $d(y_i, y_j)$ (Equation (4.1)) between the vectors y_i and y_j. It is further explained that after each step in the nearest neighbourhood method, the distance as given by Equation (4.3) is estimated for each cluster pair, and those with the smallest distances are then merged. After combining two clusters the process is repeated, during which distances between all pairs of clusters are calculated, and the pair with the smallest distance is again merged into one cluster. The results of the single-linkage hierarchical clustering analysis method are presented as a dendrogram, or tree-like structure (Everitt *et al*., 2011:88). A dendrogram is a mathematical representation that illustrates the merged clusters at each stage of a procedure as well as the distance between the clusters at the time the merging is performed.

The results of the cluster analysis will be presented and discussed in Section 5.2, and the method used to analyse the resulting medium-sized banks (Section 5.2) in terms of technical and scale efficiency will be discussed in the following sections.

4.3. Measuring bank efficiency

The relevance of efficiency measurement has been noted in Section 3.3 as well as the potential complications associated with measuring bank efficiency (Section 3.5). These complications include the difficulty in identifying the appropriate inputs and outputs to use in the DEA analysis method, since the efficiency scores are strongly influenced by the choice of inputs and outputs. The identification of the inputs and outputs will be discussed in Section (4.3.1), followed by a discussion of the input-oriented measure as used in the DEA method (Section 4.3.2). The DEA technique will be reviewed in Section 4.3.3 in respect of its benefits (Section 4.3.3.1), the constructing guidelines (Section 4.3.3.2), and the type of DEA model and model specifications used in this study (Section 4.3.3.3). Lastly, the limitations and factors that influence the DEA model results will be discussed in Section 4.3.4.

4.3.1. Inputs and outputs

Alrafadi and Md-Yusuf (2011:622) state that identifying the most significant inputs and outputs to use in the DEA method can be challenging. This notion is supported by Mlima and Hjalmarsson (2002:12) who explain that this is a result of banks offering numerous business services and products, which complicates defining the most appropriate inputs and outputs of a specific bank. Van der Westhuizen (2008:28-29) agrees that the specific inputs and outputs that should be used in the DEA analysis are strongly influenced by the specific activities and services that the bank or institution is engaged in. It has also been noted by numerous researchers that the selection of appropriate inputs and outputs for efficiency analysis are subject to the availability of data (Cronjé & De Beer, 2010: 295; Nenovsky *et al*., 2008:15-16; Brettenny & Sharp, 2016:1-2).

According to Van der Westhuizen (2008:28-29), depending on the activities and services that the bank is engaged in, the DEA analysis can be implemented through six different approaches. These different approaches are the intermediation approach, the production approach, the asset approach, the profit or user-cost approach, the risk management approach, and the value-added approach. Although there are six different approaches, the two most commonly known approaches are the intermediation and the production approach (Aly *et al*., 1990:214). The intermediation approach has been applied in this study since it enables determining the success with which banks convert their resources into deposits, loans, and other necessary outputs (Chaffai, 1997:324).

4.3.1.1. The intermediation approach and relevant inputs and outputs

The intermediation approach was first introduced by Sealey and Lindley (1977:1251-1253, 1255-1258) and focusses on the total amount of expenses, operating costs, and interest costs. Favero and Papi (1995:388) have found that the intermediation approach is a highly suitable method when bank activities comprise a large amount of securities and treasuries that have been acquired from other commercial organisations and converted into various financial instruments such as loans, mortgages, and other financial investments. It can also be noted that the performance of the entire financial organisation can be evaluated through the intermediation approach and not only certain levels as is the case with many of the other approaches (Berger & Humphrey, 1997:197).

Mester (1996:1033-1034) and Molyneux *et al*. (1996:152) indicate that the intermediation approach is favoured above the production approach for the following reasons:

- It is a much more focussed, all-inclusive approach that takes the total amount of expenses, including interest expenses, into account;
- It benefits from the superiority of the data used;
- In the intermediation approach, deposits are regarded as inputs and not as outputs, since financial institutions such as banks tend to purchase deposits rather than sell them and deposits make up a portion of the funds that is normally used as mortgage and other financial reserves.

Molyneux *et al*. (1996:157) recommend the intermediation approach as the most effective for evaluating an entire bank, since financial institutions are regarded as mediators between the supply of and demand for funds in this approach. Proper implementation of the intermediation approach requires appropriate definition of the inputs and outputs for which certain guidelines are available. According to Avkiran (2006:286), the choice of inputs and outputs can be based on the correlation between them when efficiency estimation with an efficiency model is implemented. Kamau (2011:15) also states that appropriate inputs and outputs can be derived from the specific intermediary function that a bank fulfils within its country's economy. In this context, the intermediary role refers to the procedure in which borrowed funds (received from savers) and advancing funds (received from borrowers) are transformed from one to the other (Kamau, 2011:15).

The inputs and outputs identified as the most appropriate for this study will be motivated in the subsequent paragraphs and are based on previous studies in which these inputs have also been applied. The appropriate inputs and outputs as identified in the various studies cited in this discussion will be summarised in Section 4.4.2.

Yue (1992:36) studied the use of various inputs and outputs in the intermediation approach to estimate efficiency, and has found that total deposits, among other inputs, is an appropriate input, while total loans (loans and advances in this study) is an appropriate output for use in this approach. Yue (1992) interprets total loans as an output in the intermediation approach and defines it as the nett value of all loans and leases. Mlambo and Ncube (2011:10) have also used total deposits as an input and total loans and advances as an output in their study, in which the intermediation approach had also been applied. The rationale is that banks are seen as the intermediaries between depositors and borrowers in the intermediation approach, and finances (lending) provided to banks and non-financial organisations are regarded as outputs. Kao and Liu (2004:2355), who have also applied total deposits as input and total loans as an output in their study, define total deposits as all deposits and the accounts, and total loans as all short and medium-term loans. Kamau (2011:15) has also defined deposits as inputs in the intermediation approach, while any type of financial assistance given to debtors and creditors, e.g. the lending of funds, has been considered as appropriate outputs.

Kaparakis *et al*. (1994:887) highlight total equity as an essential input for bank efficiency measurement, since total equity and efficiency have been found to be strongly coupled. Inefficient banks therefore have lower levels of equity, which implies that the financial positions of such banks are not secure. Total equity has therefore also been used as input in this study.

According to Van Heerden and Heymans (2013:747), other relevant inputs associated with the measurement of technical and scale efficiency of banks in South Africa are central bank and money and South Africa (SA) group and finance. The importance of central bank and money as input for DEA efficiency analysis using the intermediation approach and an input-oriented model is also highlighted by Van Heerden and Heymans (2013:747), and it consists of cash (notes and coins) and reserves held by a commercial bank in accounts at the central bank. These reserves are also listed on the central bank's balance sheet as liabilities. The use of SA group and finance as input is motivated by Van Heerden and Heymans (2013:747) as being related to total interbank and intergroup financing structures of the South African banks (SARB, 2018c:1068). In other words, interbank funding includes any funds received by the bank being analysed from other banks in the Republic of South Africa (SARB, 2018c:1097).

With respect to the outputs that can be used when the intermediation approach is applied, various studies have identified other liabilities, deposits, loans and advances, and investments and bills as appropriate (Van Heerden & Heymans, 2013:747, Grmanová & Ivanová, 2018:260; Muhammad, 2008:11; Jayamaha, 2012:567; Kuo *et al*., 2006:10). According to Van Heerden and Heymans (2013:735) other liabilities as outputs can be understood as letters of credit and guarantees on behalf of clients, committed undrawn facilities, bankers' acceptances, and underwriting exposures. Deposits, loans, and advances are viewed as an output, since it consists of the loans and advances given to other banks and customers (Grmanová & Ivanová, 2018:260). Investments and bills, which is also considered as output in this study, can be understood as investments that involve profits and losses from buying and selling stocks and bills (Kuo *et al*., 2006:10).

In summary, total deposits, total equity, central bank and money, and SA group and finance have been identified as appropriate for this study, while other liabilities, deposits, loans and advances, and investment and bills have been identified as appropriate outputs for the DEA efficiency analysis of the medium-sized banks. In addition to the studies cited in the preceding discussion, the inputs and outputs have also been used in other studies, such as those of Kaparakis *et al*. (1994:887), Wheelock and Wilson (1995:692-693), and Elyasiani and Mehdian (1990:163-164). The relevant input-oriented measures used in the DEA analysis in this study will be discussed in the following section.

4.3.2. An input-oriented measure

Coelli *et al*. (1998:62) note two main measures that are relevant with respect to the DEA linear programming (LP) methodology. These two measures are known as input-oriented measure and the output-oriented measure, which indicate whether an organisation is focused on an input production technology or an output production technology. Since the intermediation approach with an input-oriented model has been used in this study, the outputs were kept constant in the analyses, and therefore only the input-oriented measures are applicable.

Coelli *et al*. (1998:62) define an input-oriented measure as a characteristic production technology employed by an organisation intended for the production of a specified output combination with the least amount of inputs. A graphical representation of efficiency measurement as it relates to an input-oriented organisation with two respective inputs, namely x_1 and x_2, and an output (y), is shown in Figure 4.2.

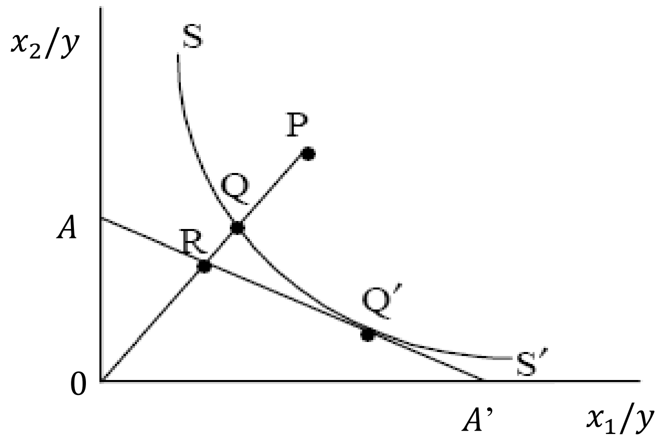

Figure 4.2: A graphical explanation of an input-oriented measure (Coelli *et al*., 1998:135; Farrell, 1957:254).

The graphical depiction of Figure 4.2 represents an organisation that is totally efficient, as can be deduced from the curve SS’, which is also referred to as the production function (Coelli *et al*., 1998:134-135). Formally, a production function characterises the maximum technological capability of a firm, or in other words, represents the limit of the obtainable outputs from the available inputs. An organisation such as the one represented by point P would therefore experience technical inefficiency, since the inputs can be decreased to yield the same level of output(s) (in an input-oriented approach). The degree of technical inefficiency is represented in Figure 4.2 as the distance QP, which also represents the quantity by which the inputs need to be decreased. More specifically, the ratio $\frac{QP}{0P}$ signifies the relative amount by which the input needs to decrease for the organisation to become efficient. Conversely, the degree of technical efficiency (TE) of an organisation can be quantified as $TE_i = \frac{0Q}{0P}$. This ratio assumes a value between zero and one, with zero being interpreted as total inefficiency and one as total efficiency. Point Q in Figure 4.2 therefore represents 100% technical efficiency since it lies on the isoquant, or the efficient production function.

Following the study by Coelli *et al*. (1998:135-136), the isocost line, i.e. line AA', represents the input-price relation. If this input-price relation is known, allocative efficiency can be measured. Allocative efficiency of an organisation (AE) is quantified by the ratio $AE_i = \frac{0R}{0Q}$, and the line RQ indicates the amount of production expenses that should be eliminated before an organisation can increase its AE from point Q to Q' (Figure 4.2). Adding the TE and AE together yields the aggregate economic efficiency (EE) measurement.

However, the accuracy of these efficiency measures depends on the definition of the efficient production function. In this regard two options are available; that is, to specify a theoretically efficient production function or an empirical function based on the best results observed in practice (Farrell, 1957:255). The drawback with a theoretically efficient production function is that it is difficult to estimate such a function for a complex process, thus the accuracy of the function decreases as the complexity of the production process increases. Such a theoretically efficient production function is also likely to represent an unattainable ideal. Therefore, Farrell (1957:255) concludes that it is more practical to compare performances with the best attainable observations in practice, that is, empirical data. However, estimating an efficient production function from input and output observations of the firms included in the analysis presents a problem within itself. This is because the input-output observations of the various firms will form a scatter of points, and the efficient production function will be represented by an isoquant. The problem now lies in estimating this isoquant curve from the scatter diagram. This problem is overcome by assuming that the efficient production function, or isoquant curve, is convex to the origin and has no positive slope as shown in Figure 4.2. The convexity assumption is frequently made in economic theory. Practically, this isoquant curve is constructed using non-parametric (based on the observations), piece-wise linear convex functions such that no observed point lies to the left or below it (Farrell, 1957:255). The DEA technique, in which these linear programming problems are solved, will be discussed in the next section with specific reference to its application in this study.

4.3.3. The data envelopment analysis technique

The data envelopment analysis (DEA) technique was first acknowledged after Charnes *et al.* (1978:432) published their research, although it had already been introduced in 1957 by Farrell (1957:264-265), who also introduced the concepts of efficiency and frontier estimation. When the DEA model was recognised in 1978, it was clear that the basic concept behind this technique was proposing an effective methodology that would be able to identify the best practice decision-making units (DMUs) capable of forming an efficient frontier. Since being first presented, various improvements have been made to the DEA methodology to improve its practical applicability for efficiency measurement of banks and other entities like universities, hospitals, and airports (Avkiran, 1999:208). As a result, this technique has become increasingly popular as a tool for efficiency measurement.

According to Murillo-Zamorano (2004:35), the DEA technique is a non-parametric approach that is mathematically oriented and thus used to process data in a manner that assists in the creation of a production frontier and the subsequent estimation of appropriate efficiency scores. The production frontier is used as a benchmark for measuring a bank's efficiency and productivity with respect to specified inputs and outputs (Avkiran, 1999:206). The production frontier can therefore be understood as the maximum value of outputs attainable with an equivalent given amount of inputs; in other words, the same amount of outputs cannot be achieved with a smaller amount of inputs (Halkos & Salamouris, 2004:205).

Recall, however, that the aim of this study is to estimate the efficiency levels, that is, scale and technical efficiency of the medium size-banks in South Africa. In that view, Maletić *et al.* (2013:845) note that the DEA model significantly simplifies the processing and interpretation of relevant statistics, thus making it an invaluable technique for efficiency estimation. As such, the DEA model has been used in various other studies that focussed on bank efficiency measurement (Van der Westhuizen, 2008; Van Heerden, 2007; Avkiran, 1999; Golany & Storbeck, 1999; Sherman & Ladino, 1995; Halkos & Salamouris, 2004), and to this effect it has also been used in this study.

The DEA technique will be reviewed and discussed in more detail in the following sections, with a specific focus on technical, scale, and allocative efficiency measurement of banks. The subsequent sections have been structured such that the benefits and limitations of the DEA method will be discussed in the next section (Section 4.3.3.1), after which the process of constructing a DEA model will be discussed in Section 4.3.3.2. The type of DEA model used in this study will be discussed in Section 4.3.3.3.

4.3.3.1. The benefits and limitations of the DEA method

As noted previously, the DEA method is known for being an efficiency measurement benchmark with which multiple output firms like banks can be evaluated. Banks are regarded as multiple output organisations for their variety of outputs in the form of deposits, interest earnings, and non-interest earnings (Sherman & Ladino, 1995:61). Studies on bank efficiency measurement using the DEA method have been undertaken, and various benefits of the method have consequently been noted in the literature. For example, the DEA method is beneficial for measuring bank efficiency, since single efficiency scores are generated which simplify comparison between different banks (Cronje, 2002:34-37). Akeem and Moses (2014:469) note that using the DEA method for efficiency measurement is particularly useful because previous assumptions are made towards the production function's form. Instead, the best production function can be estimated without a priori input, thereby resulting in an accurate production function. Another advantage associated with the DEA method is its flexibility with regard to the cost function of any bank (Mester, 1994:9).

According to Yang (2009:771), the DEA method is the preferred measurement method for measuring bank efficiency because information is organised in a manner that allows efficiency levels to change as time progresses. Furthermore, the DEA model also serves to define the best-practice DMUs (Favero & Papi, 1995:387), and it is capable of identifying possible indicators of insolvency. The method can therefore be used to distinguish between failing and non-failing organisations (Premachandra *et al.*, 2009:412-413).

Sherman and Ladino (1995:62) have found the DEA method to be especially beneficial for efficiency measurement since it can be used to identify:

- the best-practice and most productive service units;
- the less productive service units compared with the best-practice units;
- the amount of excess resources used by the less productive units;
- strategies for improving the use of existing resources to increase service outputs in the less productive units; and
- the set of best-practice service units most similar to the less productive units.

Although the DEA method can be used for the identification of inefficiency in decision-making units (DMUs) through comparing the inefficient DMUs and equivalent but more efficient DMUs, Avkiran (1999:207) maintains that this practice is less than ideal. Rather, Avkiran (1999:207) recommends using similar DMU performance values for comparisons. Therefore, the DEA method is more suited for efficiency measurement than other regression methods since individual inefficient DMUs are identified and appropriate measures required for improving the efficiency of each DMU are also identified (Sowlati & Paradi, 2004:261).

The DEA method has been found to be applicable in measuring the efficiency of organisations influenced by difficulties in respect of their business operations, or those exposed to government rules and regulations (Van der Westhuizen, 2008:24). While the DEA method admittedly also has limitations, the method is still preferred over conventional financial ratios because it allows for multiple inputs and outputs to be considered, whereas financial ratios are restricted to a limited number of inputs and outputs (Thanassoulis *et al*., 1996:242)

The advantage of a DEA model, and more specifically the multi-stage DEA model used in this study (Section 4.3.3), includes the ability to analyse each bank individually relative to sample averages or parametric populations. Thus, the model can adjust for exogenous variables that are beyond the control of the DMUs, and it accommodates multiple inputs and outputs without the need for homogeneous measurement units. It also does not require any assumptions of a functional form relating inputs to outputs and can focus on observed best-practice frontiers rather than on central tendency properties of frontiers. Furthermore, it provides insight into the input and output quantities that inefficient banks must achieve in order to operate on the efficient frontier, and it produces a single efficiency estimate for each bank in terms of its respective input-output relationships (Charnes *et al*., 1978:429-444; Nunamaker, 1988:255-256). The multi-stage DEA model is therefore appropriate for this study, as it overcomes two main shortcomings of the commonly used two-stage LP process (Knox Lovell & Pastor, 1995:148-150; Coelli *et al*., 1998:148). First, the two-stage LP process maximises the sum of slacks where it should be minimised, and it identifies the furthest point of efficiency while the nearest point is desired. Second, the two-stage LP process is not invariant to the units of measurement, while the multi-stage model is.

One of the main limitations of the DEA method is that unpredictable statistics can lead to biased results (Avkiran, 1999:207). To illustrate, Mester (1994:9) has found that the DEA method cannot be performed on banks whose costs are undervalued, as such banks would then be identified as being the most efficient banks compared with other banks that are considered as less efficient. Another disadvantage is that the DEA method is indifferent to bank risk factors, and their potential effect on efficiency is therefore ignored. Additionally, Eisenbeis *et al*. (1999:6) caution that deviations from the efficiency frontier are classified in the DEA analysis as results of inefficiency, and it makes no allowance for noise in the standard models.

The next section (Section 4.3.3.2) will detail the specific DEA model used in this study together with the inputs and outputs used in performing the subsequent analyses.

4.3.3.2. Constructing guidelines for a DEA model

According to Golany and Storbeck (1999:16), the following three major steps can be followed for constructing a DEA model:

- Select the appropriate decision-making units (DMUs) and their measurement units. This should be based on the chosen approach and the level of the productivity estimation.
- Identify the relevant inputs and outputs for the model in a manner that will allow for effective efficiency measurement.
- Establish the mathematical formulation for the DEA model and obtain relevant efficiency scores.

A more detailed description of the DEA model construction process is presented by Sigala *et al*. (2005:68), which is summarised in Figure 4.3.

Additional guidelines that go hand in hand with the construction of a DEA model also exist. For example, Golany and Storbeck (1999:16) state that the grouping of DMUs and their unit weighting factors cannot be finalised before the construction of the model has been well-defined. In respect of the second step, as prescribed by Golany and Storbeck (1999:16), Zhou and Fan (2010:812-813) indicate that the DMUs are commonly multiple inputs and outputs that are specific to every organisation. This is corroborated by Berg *et al.* (1991:140), who have found DMUs to be highly sensitive to the types of inputs and outputs that are chosen. Acarlar *et al*. (2014:3) mention that DMUs can be divided into two groups – an influential group of DMUs and a non-influential group of DMUs.

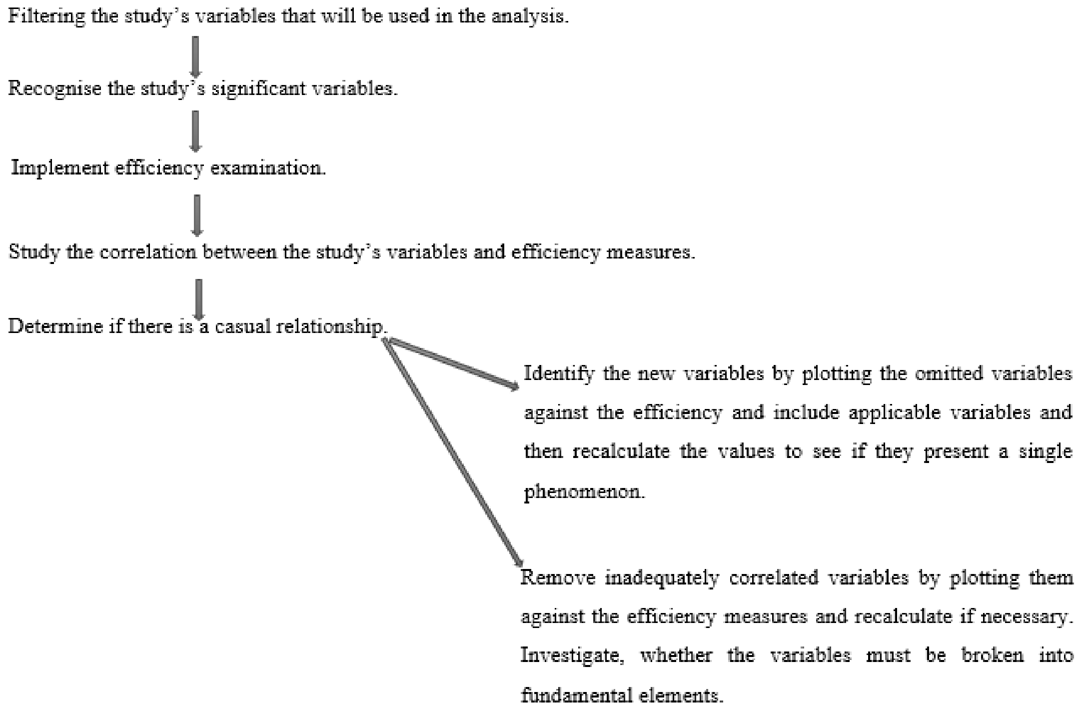

Figure 4.3: An illustration on how to approach the DEA methodology (Sigala *et al*., 2005:68).

To distinguish between efficient and inefficient financial organisations (among for example banks), certain guidelines should be followed to obtain the most appropriate DMUs for a specific efficiency measurement. According to Bowlin (1998:18), using three times the sum of the inputs and outputs as the amount of DMUs can be applied as a rule of thumb for estimating the required amount of DMUs when constructing a DEA model. In contrast, Dyson *et al*. (2001:248-249) advise to take only twice the amount of input and output combinations. In consideration of these guidelines, the number of DMUs used in this study will be explained in detail in Section 4.4.2. Further discussion on the selection of appropriate DMUs will follow with reference to the graphical representation of the DEA model of Avkiran (1999:207), as shown in Figure 4.4.

Avkiran (1999:207) explain that the DMUs, L, M and N (Figure 4.4) are efficient, and that these efficient DMUs portray the efficiency frontier (in accordance with the preceding discussion). Cronje (2002:39) notes that the efficiency frontier clearly envelops all the additional data points (hence the term data envelopment analysis), and that the DMU of point K is regarded as inefficient. To improve efficiency, efforts should be focussed on moving point K to point K' on the efficiency frontier.

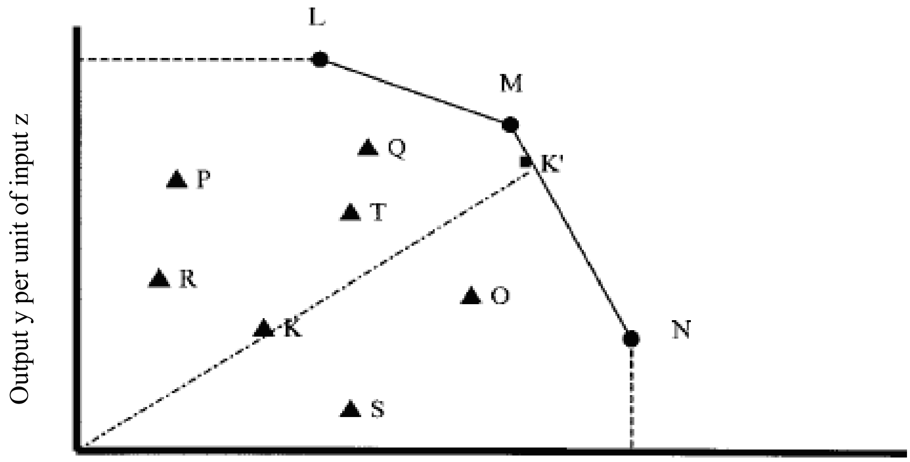

Figure 4.4: A graphical representation of a DEA model that shows the efficient frontier (Avkiran, 1999:207).

In summary, several steps and guidelines should be considered in constructing a rigorous DEA model. Of particular importance is the number and group of DMUs used in the model, which should be carefully chosen since the final results are significantly affected by the DMUs used in the model. To complete the discussion on the construction of the DEA model used in this study, the DEA model specifications and the multi-stage DEA model used in this study will be discussed in the next section.

4.3.3.3. DEA model specifications and the multi-stage model

The DEA method is commonly used for assessing the relative efficiency of a mutual set of inputs and outputs and is especially useful for comparing similar organisations' productive efficiencies or DMUs. According to Martić *et al*. (2009:38), efficiency measurement, in using the DEA method, is achieved through linear programming assignments for each DMU under assessment using a specific DEA model.

The DEA method is subject to the constant returns to scale (CRS) and the variable returns to scale (VRS) specifications, with a variety of methods and theories combined into one of the many models available (Charnes *et al*., 2013:23-24). For this study, the multi-stage model with a CRS and a VRS specification has been used, as will be subsequently motivated. First, however, the DEA model specifications will be discussed for both the CRS and VRS frontiers, followed by an overview of the multi-stage DEA model.

4.3.3.3.1. The CRS and VRS model specifications

Any DEA model is specified according to various linear programming specifications, and the two most prominent model specifications in any DEA model are the constant returns to scale (CRS) (Charnes *et al*., 1978:437) and the variable returns to scale (Banker *et al*., 1984:1086-1088), which will subsequently be discussed.

4.3.3.3.1.1. The CRS specification

Research by Kočišová (2013:313) and Avkiran (1999:211) explain CRS as a proportionate rise in outputs in response to a rise in the inputs. The CCR model is an example of a model that follow a CRS approach (Charnes *et al*., 1978:437). CRS can only be achieved with a CCR model if the model's DMUs function at their optimal size (Kočišová, 2013:313).

Coelli *et al*. (1998:150) indicate that an application of a duality in linear programming will result in an equivalent envelopment that is applicable to the CRS DEA input-oriented model, as it can be seen in Equation (4.4). Note that here, and in the subsequent model specifications and types, the inputs (*K*) and outputs (*M*) of each of the *N*-banks are first defined and denoted respectively for the *i*-th bank by vectors x_i and y_i. The output matrix $(M \times N)$ is denoted by *Y* and the input matrix $(K \times N)$ is denoted by *X*.

$$\min_{\theta,\lambda} \theta, \tag{4.4}$$

Subject to:

$$\begin{aligned} &-y_i + Y\lambda \geq 0, \\ &\theta x_i - X\lambda \geq 0, \\ &N1'\lambda = 0, \\ &\lambda \geq 0. \end{aligned}$$

where:

- θ represents a scalar and the value of θ is the efficiency score for the *i*-th firm.
- λ represents *Nx1* vector of constants.
- $N1'\lambda=1$ represents the convexity constraint.

This will satisfy $\theta \leq 1$, with a value of 1 corresponding with a technically efficient firm. This problem must be solved for all N firms, while a value for θ is obtained for each DMU (Farrell, 1957:258-259).

4.3.3.3.1.2. The VRS specification

According to Kočišová (2013:313), the constant returns to scale (CRS) method will not function correctly under the conditions of imperfect competition and constraints on finance, which limit the DMUs. Coelli *et al.* (1998:150) explain that this requirement of the CRS model specification will lead to companies being classified as never being able to function at an optimal scale. Therefore, the BCC model was developed by Banker *et al.* (1984:1086-1088), which applies the variable returns to scale (VRS) and as such, accounts for the problem of perfect competition restraint. Variable returns to scale (VRS) is explained by Avkiran (1999:211) as the disproportional increase (or decrease) in outputs when the inputs increase (or decrease). The following VRS DEA model can be estimated with an input as well as an output-oriented approach, where an input-oriented VRS DEA is illustrated in Equation (4.5). Here, the inputs are minimised while the outputs are kept constant (Zhu, 2014:12):

$$\theta^* = \min \theta \tag{4.5}$$

Subject to:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta x_{io} \qquad i = 1,2,...,m;$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{ro} \qquad r = 1,2,...,s;$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0 \qquad j = 1,2,...,n.$$

where:

- θ^* represents the input-oriented efficiency score of DMU_o.
- DMU_o represents one of the n DMUs under evaluation, and x_{io} and y_{ro} are the ith input and the rth output for DMU_o respectively.

Since $\theta = 1$ is the optimal value to Equation (4.5), $\theta^* \leq 1$. If $\theta^* = 1$, the current input levels cannot be reduced proportionally, which indicates that the DMU_o lies on the frontier. However, if $\theta^* < 1$, then DMU_o is dominated by the frontier.

Another important aspect regarding the application of the DEA method is that scale efficiency can be measured with the application of a VRS and CRS approach, as shown in Figure 4.5.

When the CRS approach is used, the point P and the corresponding distance PPc in Figure 4.5 indicate the degree of technical inefficiency (Coelli *et al.*, 1998:150-151). However, when a VRS approach is applied, the degree of technical inefficiency is reflected by the distance PPv in Figure 4.5. The difference between Pc and Pv results from scale inefficiency, however no indication of whether the firm is operating at increasing or decreasing returns to scale can be deduced from this measure. Thus, an additional model is executed according to non-increasing returns to scale (NIRS), which is accomplished by replacing $N1'\lambda = 1$ with $N1'\lambda \leq 1$ in Equation (4.4) to overcome this limitation. To determine whether a firm is operating at increasing or decreasing returns to scale, the non-increasing technical efficiency scores (TE) are compared with the VRS TE scores. Increasing returns to scale exits when the two scores are not equal, while decreasing returns to scale is present when the two scores are equal. In the example shown in Figure 4.5, Point Q is equal, and Point P is unequal.

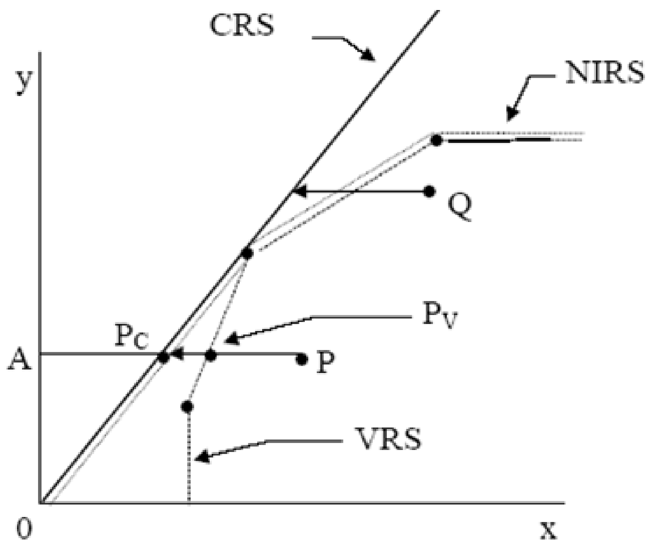

Figure 4.5: Illustration of how to calculate scale economies (Coelli *et al.*, 1998:152).

Using these models makes it possible to determine whether a bank is functioning at increasing or decreasing returns to scale. More specifically, this is accomplished by performing a comparison between the non-increasing returns to scale technical efficiency (TE) totals and the variable returns to scale technical efficiency totals (Coelli *et al.*, 1998:151-152). If the two totals differ, an increasing returns to scale is indicated, whereas a decreasing returns to scale is indicated when the two totals are equal. These principles are illustrated in Figure 4.5 through point P, which is differing, and Point Q, which is corresponding.

The CRS and VRS model specifications as described in the preceding paragraphs were implemented in the multi-stage DEA model, which will subsequently be discussed.

4.3.3.3.2. The multi-stage DEA Model

The multi-stage DEA LP model is able to do an evaluation of the total efficiency score of an entire process (Aminuddin *et al*., 2017:1) and is the DEA model used in this study, as already mentioned. This is done using the DEAFrontier software, a DEA add-in for Microsoft Excel® developed by Zhu (2016). In this model, K represents the number of inputs and M the number of outputs for each of the N banks. These inputs and outputs are represented by the vectors x_i and y_i respectively for the ith bank. The $M \times N$ output matrix is represented by Y, and the $K \times N$ input matrix by X. The constant returns to scale, input-orientated, multi-stage DEA model can thus be illustrated by the following steps provided by Coelli (1998:144-145), with minor changes to this approach being required when applying a variable returns to scale approach:

Step 1: Perform a radial LP process with the form as given in Equation (4.6):

$$\underset{\theta,\lambda}{Minimise}\, \theta \qquad (4.6)$$

Subject to:

$$\begin{aligned} &-y_i + Y\lambda \geq 0, \\ &\theta x_i - X\lambda \geq 0, \\ &\lambda \geq 0, \end{aligned}$$

where:

- $\theta$is a scalar.
- λ represents a $N \times 1$ vector of constants.

This process continues N-times, which leads to a θ for each of the respective banks.

Step 2: Perform a second-stage LP to maximise the sum of any remaining slacks according to Equation (4.7)

$$\underset{\lambda, OS, IS}{Maximise}\ (M1'OS + K1'IS) \qquad (4.7)$$

Subject to:

$$-y_i + Y\lambda - OS = 0,$$
$$cx_i - X\lambda - IS = 0,$$
$$\lambda \geq 0, OS \geq 0, IS \geq 0$$

where:

- cx_i is the input vector of the i-th bank, which was multiplied by the scalar (θ) from Step 1.
- OS represents a $M \times 1$ vector of output slacks, IS represents a $K \times 1$ vector of input slacks.
- K1 and M1 are the respective $K \times 1$ and $M \times 1$ vectors of ones, respectively.

This process is continued N times, after which all the banks with no slacks and those with a technical efficiency score of $\theta = 1$ are identified and classed as "efficient banks" This process is also repeated for all the relevant banks with non-zero slacks, which are added to the "banks with slacks" category. The "banks with slacks" set is then used to estimate a sequence of radial movements based on projected points estimated in Step 1 to obtain the projected point on the efficient frontier. Conversely, the "efficient banks" will only be used as a reference in the LP estimations from this stage forward (Coelli*,* 1998:144).

Step 3: Perform a sequence of K LPs to determine all input dimensions with slacks from the i-th bank in the 'banks with slacks' category. Note that this step will not be achievable when any of the inputs is zero. Each LP will accommodate contractions in only one of the inputs, which is used to identify the presence of potential slacks within these inputs. Accordingly, the LP for the j-th input of the i-th bank is defined in Equation (4.8) (Coelli, 1998:145):

$$\underset{\theta, \lambda}{Minimise}\ \theta \qquad (4.8)$$

Subject to:

$$-y_i + Y_e\lambda \geq 0,$$
$$\theta cx_i^j - X_e^j\lambda \geq 0,$$
$$cx_i^{\neq j} - X_e^{\neq j}\lambda \geq 0,$$
$$\lambda \geq 0,$$

where:

- cx_i^j signifies the *j*-th input for the *i*-th bank in the dataset, which was multiplied by the scalar (θ) from Step 1.
- X_e^j represents the $1 \times N_e$ vector for the *j*-th input of all the banks that are classified as efficient.
- $cx_i^{\neq j}$ represents the $(K-1)\times 1$ vector for the inputs of the *i*-th bank in the dataset, however the *j*-th input that is contracted is excluded by being multiplied by θ as obtained in Equation (4.6).
- $X_e^{\neq j}\lambda$ represents the $(K-1)\times N_e$ matrix for the inputs of the efficient banks in the dataset, however the *j*-th input is excluded.
- N_e indicates the number of efficient banks (from Step 2); Y_e represents the outputs matrix for the efficient banks, where λ has a dimension of $N_e \times 1$.

Step 4: Perform an LP process for *i*-th bank in the 'banks with slacks' category to define a radial reduction in all the inputs identified from Step 3 to have slacks. This estimation is illustrated in Equation (4.9) (Coelli, 1998:145):

$$\underset{\theta,\lambda}{Minimise}\,\theta \tag{4.9}$$

Subject to:

$$-y_i + Y_e\lambda \geq 0,$$
$$\theta cx_i^s - X_e^s\lambda \geq 0,$$
$$cx_i^{ns} - X_e^{ns}\lambda \geq 0,$$
$$\lambda \geq 0$$

where:

- s signifies the subset of inputs that have possible slacks present.
- ns represents the remaining inputs that were used. Note that this particular step's radial reduction for the inputs starts by applying the projected point (y_i, cx_i) that was already estimated during Step 1.

Step 5: It is still possible for some input slacks to remain after the radial reduction in the previous step. To overcome this problem, Steps 3 and 4 must be repeated with the projected point (which was already identified during Step 4) until no remaining input slacks are present.

Step 6: A radial expansion is conducted in the output slack dimensions until no output slacks remain. This can be accomplished by taking the projected points of the ith banks (as estimated in Step 5) and repeating Steps 3 through 5. The final projected point from this step (which will be invariant to the units of measurements that were chosen) will be on the efficient surface. The slacks can then be estimated by subtracting the final projected point in this step from the projected point that was obtained in Step 1. Also, the peers of the ith banks can be identified from the λ vector of the final projected point (Coelli, 1998:145).

4.3.4. Limitations and factors that influence the DEA model results

As already mentioned, the DEA method is a powerful linear programming technique preferred for estimating organisational efficiency, as it is more advanced than traditional financial ratios. However, specific factors can influence the construction of a DEA model. These factors include (i) whether slacks are present, (ii) relevant environmental factors, (iii) and input congestion, all of which will be discussed in the following sections.

4.3.4.1. Slacks

Slacks are an important part of the DEA method, which exist only when certain situations, such as in the absence of an infinite sample size, are prevalent in an alternative frontier construction method (Coelli *et al*., 1998:176). Slacks can be categorised as input or output slacks. An input slack is observed when an efficient organisation can further decrease its inputs to produce a given level of outputs.

Conversely, an output slack is observed when an organisation can increase its outputs with a given amount of inputs. An input-slack can be graphically illustrated as shown in Figure 4.6.

point C and point D on Figure 4.6 represent efficient organisations, whereas points A and B represent inefficient organisations. In the case of Figure 4.6 there exists uncertainty regarding whether point A' is an efficient point or not, since the input (x_2) can be reduced with an amount CA' without reducing the output, which is representative of an input slack (Coelli *et al.*, 1998:142).

Zhu (2014:17-18) interprets slacks under a variable returns to scale (VRS) input and output orientation (Figure 4.7) and has analysed the role thereof in respect to the efficiency frontier. As an example, consider the case of one input (X) and one output (Y) in a VRS input-oriented model as shown Figure 4.7.

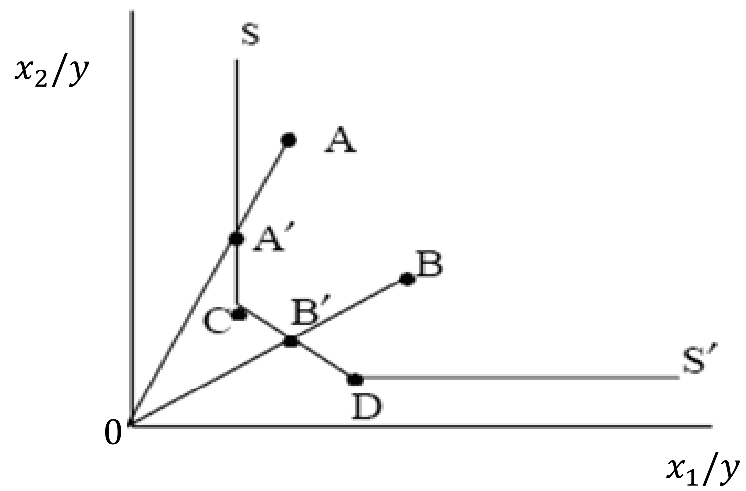

Figure 4.6: Graphical explanation of an input slack (Coelli *et al.*, 1998:143).

The DMUs that fall within the cross-hatched section can cause an output DEA slack when their values coincide with the VRS frontier as a result of a decline in the input. For example, moving the DMU from point H to point G, which represent a VRS frontier point, will result in an output DEA slack (Zhu, 2014:17). However, the output of Point G can nevertheless be increased to Point A by using the same input level. Additionally, the DMUs of points I and E can be regarded as being inefficient under the VRS model for an input-oriented approach. Point I lies on the efficiency frontier and is relatively efficient under the VRS model for an output-oriented approach. This is because although the DMU of Point I has an efficiency score of 1 in an output-oriented model, its input can be reduced to point F to still yield the same output (Zhu, 2014:17-18).

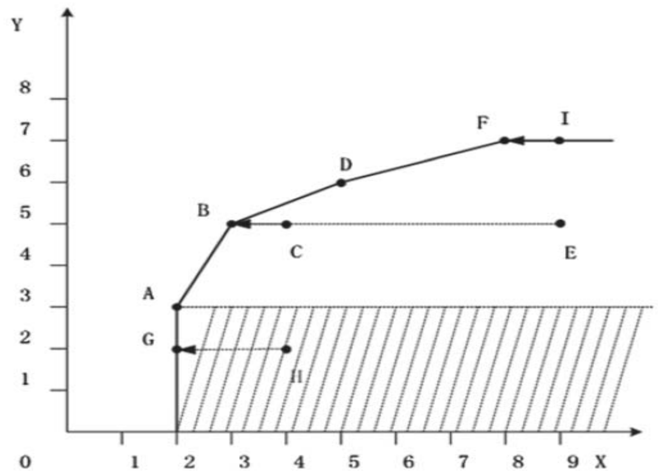

Figure 4.7: A graphical explanation of a DEA slack under input orientation (Zhu, 2014:18).

An output slack can be explained through the graphical illustration shown in Figure 4.8 for output y_1 relative to input y_2. The model depicted in Figure 4.8 also represents an output-oriented DEA model since the observations Q and P lie beneath the curve. According to Coelli *et al*. (1998:159), an output slack will occur when a production point can be increased in value to coincide with the curve as illustrated in Figure 4.8. This occurs when, for example point P is projected to point P' on the curve, which however does not coincide with the efficiency frontier because the production (y_1) can be further increased by an amount AP' without the use of additional inputs.

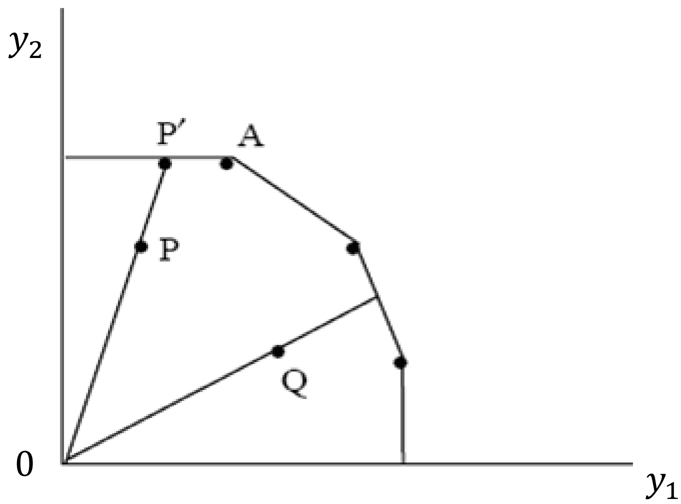

Figure 4.8: Graphical explanation of an output slack (Coelli *et al*., 1998:159).

Zhu (2014:18-19) explains slacks under a VRS output orientation in relation to the efficiency frontier as shown graphically in Figure 4.9. In this case (Figure 4.9) two outputs are present. In this output-oriented VRS model all the DMUs (for example Point E and F) that lie in the cross-hatched section are characterised as non-zero DEA slack quantities. The DMUs of points A and I are classified as being only slightly efficient, since slacks are present in both cases. Points D and J are inefficient and do not have any output DEA slacks.

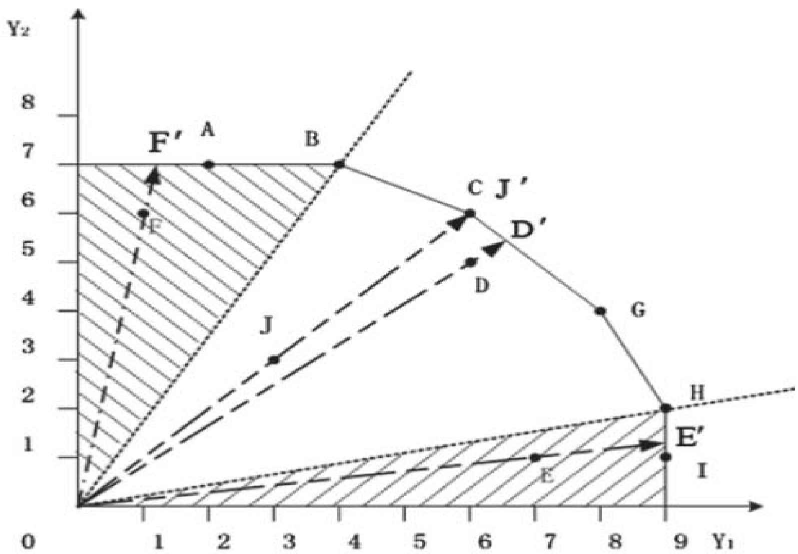

Figure 4.9: A graphical explanation of a DEA slack under output orientation (Zhu, 2014:18).

In the following section (Section 4.3.4.2), environmental factors will be discussed in relation with their application in a DEA model.

4.3.4.2. Environmental factors

Environmental factors significantly affect the results of the DEA method, since these factors directly affect an organisation's efficiency levels. Fried *et al*. (1999:251-252) note that environmental factors do not include an organisation's traditional inputs and are not under its management's control. Examples of such environmental factors that are not under management's control include government regulations, labour union power, and ownership differences (Coelli *et al*., 2005:191).

Various techniques also exist whereby environmental factors can be accommodated in a DEA model, as recommended by Coelli *et al.* (1998:167):

- Technique 1:
    - The identified environmental effects are categorised from the most influential to the least influential on efficiency (Coelli *et al*., 2005:191).

- The efficiency of the *i*th firm is compared with a firm in the same sample with similar environmental variables (Banker & Morey, 1986:519).

- Technique 2:
  - This technique is based on the distribution of the data within the sample between public-samples and sub-samples and performing of the DEA model with each sub-sample.
  - Assign all the data points observed onto the respective efficiency frontiers (Charnes *et al*., 1981:676).
  - Solve a single DEA model with the assigned efficiency frontiers and evaluate any variance in the mean efficiency of the sub-samples (Coelli *et al*., 2005:191).

Coelli *et al*. (2005:191) have found, however, some disadvantages associated with these two techniques. Firstly, organisations may show efficiency when the comparison set is reduced, however this reduces the selective power of the DEA analysis. While only one environmental effect can be included, Technique 1 has the additional disadvantage of requiring the a priori direction in which the environmental effect influences the efficiency albeit that some environmental factors behave unpredictably in this sense. Technique 2 also has the disadvantage of requiring the included environmental factors to be categorical variables.

Other possible techniques are:

- Technique 3:
  - In this technique the environmental variables are included directly under the DEA (linear programming) formulation, in which an environmental variable is classified as either a discretionary or a non-discretionary factor. In other words, the effects of some environmental factors are inherent to certain inputs and outputs and reflect as such. Therefore, one way in which environmental factors can be accounted for in the DEA method is through careful selection of input and output variables in which the effect of certain environmental factors is inherently incorporated.
  - An example of discretionary inputs is teller hours (operational costs). Examples of non-discretionary inputs include economic activities, market size, and

economic position of the area; these are factors over which an organisation has no direct control (Golany & Storbeck, 1999:17-18).

- Another example in the South African context is the National Credit Act (34 of 2005), which requires banks to lend responsibly to household clients to prevent their clients becoming overindebted (Erasmus & Makina, 2014:31). This is reinforced by Basel I (BIS,1988), Basel II (BIS, 2004), and Basel III (BIS, 2011), which stipulate that banks should also maintain a specified level of capital adequacy. These regulations would therefore affect loans and advances, effectively limiting this output in some degree to maintain the required capital adequacy.

In the current environment of rapid change ascribed to technological advances, operations are also affected; according to Golany & Storbeck (1999:25-26), the DEA method is the right analysis tool to use in an ever-changing environment. This is because the DEA model can be adapted to meet the changing needs of management, while also encouraging managers to define how they view their businesses (Golany & Storbeck, 1999:25-26).

Technique (3), can be further subdivided under three different alternatives, namely Techniques 3a, 3b, and 3c:

- *Technique 3a:*
  - If any form of uncertainty arises from the direction of the environmental factor, said environmental factor may be included in the LP. Such a scenario is represented by Equation (4.10), which also reflects a VRS input-oriented LP problem (with symbols as defined previously):

$$Min_{\theta,\lambda} = \theta, \qquad (4.10)$$

Subject to the conditions:

$$-y_i + Y\lambda \geq 0,$$

$$\theta x_i - X\lambda \geq 0,$$

$$-z_i + Z\lambda \geq 0,$$

$$N1'\lambda = 1$$

$$\lambda \geq 0,$$

In Equation (4.10) the L-environmental variables, denoted by the (L×1) vector, z_i for the *i*th organisation and by the (L×1)-matrix (Z) for the full dataset are added to the model of Equation (4.10). With the addition of $z_i - Z\lambda = 0$ the equation can make appropriate provisions for the present environmental variables (denoted by L) (Coelli *et al*., 2005:192). However, it is crucial to only compare the *i*th organisation with another organisation with the same environmental variable (Coelli *et al*., 2005:193).

- *Technique 3b:*
  - The environmental factors are incorporated in the equation as discretionary inputs.
  - $\theta z_i - Z\lambda \geq 0$ is added in Equation (4.10) for the inclusion of the environmental effects as discretionary inputs. However, the environmental effects are treated as normal inputs.

The advantage of this technique is that the organisation is inherently subject to comparison with other organisations that are exposed to the same environmental effects. The disadvantage of this technique is that the direction in which the environmental effect influences efficiency should be known a priori. Therefore, environmental effects may be scaled down with the factor θ just as a normal input would be. However, this approach is not always accurate, and therefore Coelli *et al*. (2005:192-193) recommended that environmental effects that negatively influence the efficiency be classed as fixed variables, i.e. non-discretionary variables. Thereafter the environmental variables can be added to the LP formulation.

- *Technique 3c:*
  - After addition of the non-discretionary effects, Equation (4.10) is used with the addition of the term ($z_i - Z\lambda \geq 0$) (Coelli *et al*., 2005:193).
  - With this technique, organisations within similar environments are compared.

Unfortunately, techniques 3a to 3c also have some disadvantages – it is vital that the environmental effects be uninterrupted, and a priori knowledge on the positive or negative influence of the environmental influences is required. If the direction in which an environmental factor influences an organisation's efficiency is unknown, a two-stage DEA model is recommended to assist in determining this (Coelli *et al.,* 2005:193).

- *Technique 4:*
    - This is a two-stage technique in which the environmental factors can be included in a DEA analysis. It is also used for estimating the direction in which variables influence efficiency, after which a single-stage model as explained in Technique 3 is applied.
    - Only the traditional inputs and outputs are considered in the first stage (Coelli *et al.*, 1998:170), and the efficiency scores are treated as indices with which a linear regression is performed to explain the variation in the scores.
    - In the second-stage, the results from the first-stage regression, i.e. the efficiency scores, are regressed with respect to the environmental variables. The direction in which the environmental variable influences the efficiency is then deduced from the coefficients of the resulting regression. A standard hypothesis test is used to test the significance of the relationships.

A limitation of Technique 4 is that a strong correlation between the various environmental factors from the first stage and the second stage variables will yield biased results. Furthermore, only radial inefficiency is considered in this technique, while slacks are not considered. Fried *et al.* (1999:251) propose a solution to this limitation in which a seemingly unrelated regression (SUR) system of equations is used to account for the slacks. Coelli *et al.* (2005:195) note that the two-stage approach of Technique 4 is especially useful in assessing the influences of management factors on efficiency. These factors include experience, education, and training, which can be incorporated in the second-stage regression.

4.3.4.3. Congestion

Congestion, in an economic context, is circumstances in which a reduction in inputs is experienced while experiencing an increase in outputs. The same principle applies when a reduction in outputs occurs while an increase in inputs is experienced (Zhu, 2014:354). An isoquant graph, which has negative characteristics (Figure 4.10), can be used to further explain the occurrence of congestion (Coelli *et al.*, 2005:195). In the isoquant graph shown in Figure 4.10, an increase in inputs (X_1) would lead to an increase in the quantity of the outputs (X_2), as represented by the curves A-A' and B-B'. When input congestion occurs, the opposite results, and the isoquant curve will mirror the isoquant curve shown in Figure 4.10. In other words, an increase in the level of inputs would result in a decrease in the quantity of the outputs. In the case of more than one input, input congestion can cause an isoquant curve to “bend backward” to obtain a positive slope at a certain point (Coelli *et al*., 2005:195). According to Coelli *et al*. (1998:171-173), the use of excessive inputs is a result of conditions that are not under the control of the firm, such as the staff reductions through labour unions and governments that control input levels.

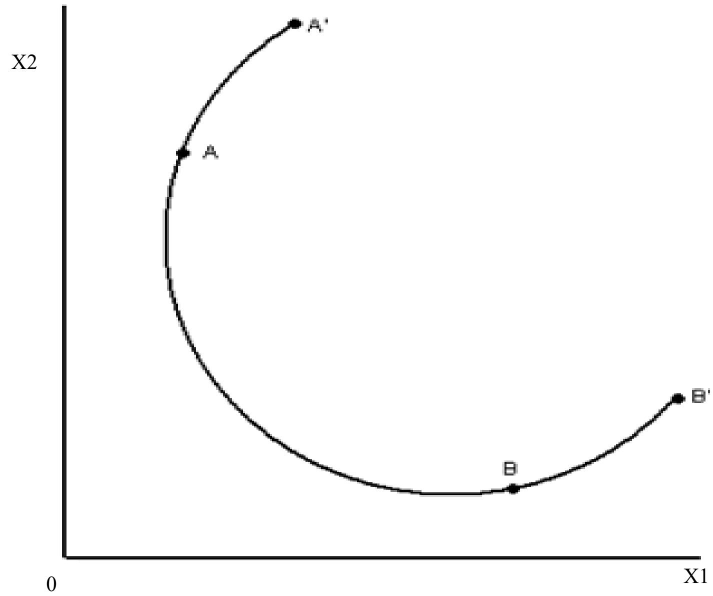

Figure 4.10: A graphical explanation of an isoquant graph subject to input congestion (Coelli *et al.,* 1998:18).

However, Coelli *et al*. (2005:197) also note that positive signs of congestion can often be misleading, since any identified congestion inefficiencies could simply be caused by insufficient data points at the margins of the isoquants. Therefore, the measurement of scale efficiency can be influenced by this factor.

Although congestion clearly influences scale efficiency, Wang and Zha (2014:8809) caution that where congestion is involved it might be difficult to identify which input is responsible for the observed behaviour. Furthermore, Wang and Zha (2014:8809) also note that little work has been done in literature as far as distinguishing between inefficiency and congestion is concerned, since some researchers identify congestion as a type of inefficiency in itself (Wei & Yan, 2004:642-643), while others interpret congestion to include inefficiencies. The latter has the effect of exaggerating the extent of congestion (Tone & Sahoo, 2004:770-771). Since banks’ products are integrated and there is a general lack of consensus in the literature regarding the appropriate method to be used to accurately measure input congestion, the effect of congestion has not been considered in this study. In this case the advice of Coelli *et al.* (2005:197) is taken, that is: "unless there are strong reasons for suspecting congestion, one should not go looking for it as it will often be found whether or not it actually exists."

4.4. The DEA model applied in this study

As is clear from the previous section, the DEA method has some disadvantages, however the associated advantages outweigh the disadvantages. Furthermore, the DEA method provides the means for identifying best-practice DMUs in multiple service firms like banks, and it is able to estimate the relative efficiencies of multiple inputs and outputs (Van Heerden, 2007:120). These advantages further motivate the use of the DEA method in this study, and in the following section (Section 4.4.2) the applicable data used in this study will be outlined briefly.

4.4.1. Method

The multi-stage DEA model has been used in this study (Section 4.3.3.3) with constant returns to scale (CRS) and the variable returns to scale (VRS). According to Coelli *et al*. (1998:144) this model can be used to overcome two shortcomings of the more commonly used two-stage LP process. The first shortcoming is that the two-stage LP process maximises the sum of slacks where it should be minimised, and it identifies the furthest efficiency point instead of the nearest point. The second shortcoming is that the two-stage LP process is not invariant to the units of measurement. Kočišová (2013:313) have found, however, that the CRS is influenced by the perfect competition restraint, which limits the obtained efficiency scores. For this reason, Coelli *et al*. (1998:150) recommend estimating a DEA model with both CRS and VRS specifications and generating a comparison of the respective efficiency scores. The efficiency scores generated from the CRS framework represent the technical efficiency while also characterising the inefficiencies related to the size of the operations and the organisation's input-output combination. In contrast, the efficiency scores generated from the VRS framework represent pure technical efficiency without characterising the scale efficiency (Avkiran, 1999:211). A potential scale inefficiency measurement may therefore be obtained by taking the difference between the CRS and VRS efficiency scores.

Furthermore, with the selection of inputs and outputs, the intermediation approach has been followed (Section 4.3.1.1) together with an input-oriented perspective in this study to determine the efficiency with which inputs were used by the different banks to achieve a specific level of outputs (Mester, 1996:1033-1034; Molyneux *et al*., 1996:152; Favero & Papi, 1995:388; Berger & Humphrey, 1997:197). The input-oriented approach (Section 4.3.2) was applied in this study with the CRS and the VRS model specifications (Section 4.3.3.3.1).

4.4.2. Data

The data used in this study is available at the South African Reserve Bank (SARB, 2018d). Historical DI900 reports that were converted to BA900 reports by the South African Reserve Bank (SARB, 2018d) for the period of 168 months (January 2004 and December 2017) have been applied. This period consisted of four business cycle phases as defined by the South African Reserve Bank (SARB, 2018b:14), which varied according to the number of observations and months. Moreover, each of the four phases coincided more or less with the different phases of the global financial crisis, that is, the pre-crisis phase (Phase 1, an upward phase), the crisis phase (Phase 2, a downward phase), and the post-crisis phase (Phase 3, an upward phase, and Phase 4, a downward phase). From the six different DEA approaches, the intermediation approach has been identified as the most suitable for this study (Section 4.3.1.1). The applicable inputs and outputs, i.e. the DMUs for this study are as follows:

- Inputs: Based on the research by Yue (1992:36), Van Heerden and Heymans, (2013:747), Mlambo and Ncube (2011:10), Kao and Liu (2004:2355), Kamau (2011:15), Wheelock and Wilson (1995:692-693), Elyasiani and Mehdian (1990:163-164), and Kaparakis *et al*. (1994:887) and highlighted in Section 4.3.1.1. The following input variables have been chosen (BA900 item no.) [3]:
    - Total deposits (1),
    - Central bank and money (103),
    - Total equity (96), and
    - South Africa (SA) group finance (111).
- Outputs: Based on the research by Van Heerden and Heymans (2013:747), Grmanová and Ivanová (2018:260), Muhammad (2008:11), Wheelock and Wilson (1995:692-

[3] The monthly total of each input variable (the main entries in the financial return statements) is used as reported in the BA900 statements. The only exception was the deposits, loans and advances output variable (item no. 110 in the BA900 statements), from which SA group and finance (item no. 111) is excluded (subtracted).

693), Elyasiani and Mehdian (1990:163-164), Kaparakis *et al*. (1994:887), and Jayamaha (2012:567) and highlighted in Section 4.3.1.1. The following output variables have been chosen (BA900 item no.):

- Deposits, loans and advances (110),
- Other liabilities (80), and
- Investment and bills (195).

Following the DEA analysis, as explained in Section 4.4.1, the efficiency scores of each bank were used for comparing the efficiency levels.

4.5. Conclusion

The background on methods of cluster analysis (Section 4.2) and measuring bank efficiency (Section 4.3) have been reviewed in this chapter, and the specific methods used in this study, namely the hierarchical single linkage cluster analysis method (Section 4.2.3) and the DEA approach for estimating bank efficiency (Section 4.3.3) have been discussed and motivated. In terms of the DEA method, the inputs and outputs used for the efficiency estimations (Section 4.3.1) and the intermediation approach used (Section 4.3.1.1) have been discussed, followed by the input-oriented method (Section 4.3.2). Additionally, the DEA technique (Section 4.3.3) has been discussed with respect to the benefits and limitations of the technique (Section 4.3.3.1), followed by the guidelines for constructing a DEA model (Section 4.3.3.2), the CRS and the VRS model specifications (Section 4.3.3.3.1), and the multi-stage DEA model (Section 4.3.3.3.2). The limitations and factors that influence the DEA model results have also been reviewed (Section 4.3.4), which included the use of slacks (Section 4.3.4.1), environmental factors (Section 4.3.4.2), and congestion (Section 4.3.4.3).

Following the discussion as outlined above, the DEA method has been identified as a suitable method for this study, mainly due to its flexibility and the fact that it can be used to identify the best-practices in complex circumstances. The DEA method is also capable of identifying possible signs of insolvency and is therefore able to distinguish between failing and non-failing banks. Furthermore, the DEA method can be applied in quantifying relevant inputs and outputs with dissimilarities in their measurement units and can also be used to identify the various inputs and outputs simultaneously (Section 4.3.1).

The application of the hierarchical, single linkage cluster analysis method will be discussed in Chapter 5, through which the medium-sized will be identified. These banks will be analysed subsequently using the DEA model described in this study (Section 4.4). Specifically, technical and scale efficiency will be estimated according to the intermediation approach with the CRS and the VRS model specifications in using a multi-stage DEA model with the input and output-oriented approaches.

Chapter 5

Results and Discussion

5.1. Introduction

The hierarchical agglomerative cluster analysis with the single linkage method as discussed in Chapter 4 will be applied in this chapter to identify the medium-sized banks (Section 4.2.3). From the cluster analysis results as will be discussed in Section 5.2, the following banks will be identified as medium-sized banks in South Africa: African Bank Ltd. (AB); Capitec Bank (CB); Deutsche Bank AG (DB); Investec South Africa (IB); JP Morgan Chase bank (JPM); and The Hongkong and Shanghai Corporation Limited-Johannesburg Branch (HSBC). A brief background of each of these banks are provided in Section 5.2.1, and subsequently, the technical and scale efficiency of these banks will be analysed using the data envelopment analysis (DEA) method (Section 4.3.3).

The DEAFrontier software, which is a DEA add-in for Microsoft Excel® developed by Zhu (2016), has been used in this study (see Section 4.3.3) with the input-oriented approach and multi-stage DEA model that included variable returns to scale (VRS) and constant returns to scale (CRS) model specifications. Historical DI900 reports that were converted to BA900 reports by the South African Reserve Bank (SARB, 2018d) were used as inputs/outputs to the DEA analysis on the six medium-sized banks, the results of which will be discussed in Section 5.3. The period considered in this study spanned 168 months between January 2004 and December 2017 and consisted of four business cycle phases. The overall and input-specific technical and scale efficiency results will be discussed in Section 5.3.1 and Section 5.3.2 respectively, in which the efficiency estimates across the six banks will be compared for each of the four business cycle phases included in this study. The inputs considered in this study are total deposits, central bank and money, total equity, and South Africa (SA) group and finance. The outputs relative to the efficiency estimates were measured, which include other liabilities, deposits, loans and advances, and investment and bills, based on the works of Yue, (1992:36), Van Heerden and Heymans, (2013:747), Grmanová and Ivanová (2018:260), Muhammad (2008:11), Jayamaha (2012:567), Mlambo and Ncube (2011:10), Kao and Liu (2004:2355), Kamau (2011:15), Wheelock and Wilson (1995:692-693), Elyasiani and Mehdian (1990:163-164) and Kaparakis *et al*. (1994:887). Finally, the findings of the DEA analysis results will be summarised in Section 5.4, in which the conclusions will be presented.

5.2. Cluster analysis results

Using the single linkage method (nearest neighbourhood method), the hierarchal cluster analysis was conducted in two stages on the total assets of all the South African banks over the 168-month study period. First, the analysis was performed on all the South African banks, including the top five banks. The results show that, except for Investec South Africa (IB), the top banks were assigned to one cluster as expected, while IB was assigned to its own cluster followed by all the other South African banks. In the second cluster analysis, the top five banks, i.e. Absa Bank Ltd., FNB, Nedbank Ltd., The Standard Bank of SA Ltd., and Investec South Africa, were excluded based on the results of the first analysis on their average total assets being typically 10 to 100-fold greater than that of the other banks as is clear from Table 5.1, in which the banks have been arranged in ascending order according to their total average assets.

The results of the second hierarchal cluster analysis are shown in the dendrogram of Figure 5.1, which confirms the observation from Table 5.1 that Deutsche Bank AG (DB), the Hongkong and Shanghai Banking Corporation Ltd. - Johannesburg branch (HSBC), Capitec Bank (CB), JP Morgan Chase bank (JPM), and African Bank Ltd. (AB) can be regarded as medium-sized banks. Note that IB, which is also regarded as one of the top five banks in South Africa, had the lowest amount of average total assets with less than half that of Nedbank Ltd., who in turn was the smallest of the other four major banks by total average assets. Moreover, IB was assigned to its own cluster and not to the same cluster as the other four major banks during the first cluster analysis stage. For these reasons IB was also included for the efficiency estimations under medium-sized banks in the DEA approach. Therefore, IB is also regarded as one of the medium-sized banks in South Africa in this study.

Table 5.1: Average total average assets of South African banks in Rm for the period January 2004 to December 2017 (SARB, 2018d).

No.	Bank	Tot. average assets (R bn)	Cluster membership
11	Habib Overseas Bank Ltd.	0.78	1
9	GBS Mutual Bank	0.82	1
4	Bank of Taiwan South Africa branch	1.15	1
20	The SA Bank of Athens Ltd.	1.55	1
12	HBZ Bank Ltd.	2.45	1
18	State Bank of India	2.86	1
15	Sasfin Bank Ltd.	2.89	1
2	Albaraka bank Ltd.	3.02	1
5	Bidvest Bank Ltd.	3.04	1
21	Ubank Ltd.	3.47	1
10	Grindrod Bank Ltd.	4.69	1
14	Mercantile Bank Ltd.	6.55	1
16	Societe Generale - Johannesburg	7.97	1
3	Bank of China Ltd. - Johannesburg	11.7	1
7	China Construction Bank Corporation - Johannesburg	13.0	1
17	Standard Chartered Bank	18.1	1
8	Deutsche Bank AG	20.6	2
19	The Hongkong and Shanghai Banking Corporation Ltd - Johannesburg	25.2	2
6	Capitec Bank	26.2	2
13	JP Morgan Chase bank	31.0	2
1	African Bank Ltd.	33.6	2
*	Investec South Africa	223	
	Nedbank Ltd.	558	
	FirstRand Bank Ltd.	636	
	Absa Bank Ltd.	664	
	The Standard Bank of SA Ltd.	824	

*The last 5 banks are not assigned a number or to a cluster group since these were not included in the second cluster analysis stage, of which the results are subsequently shown.

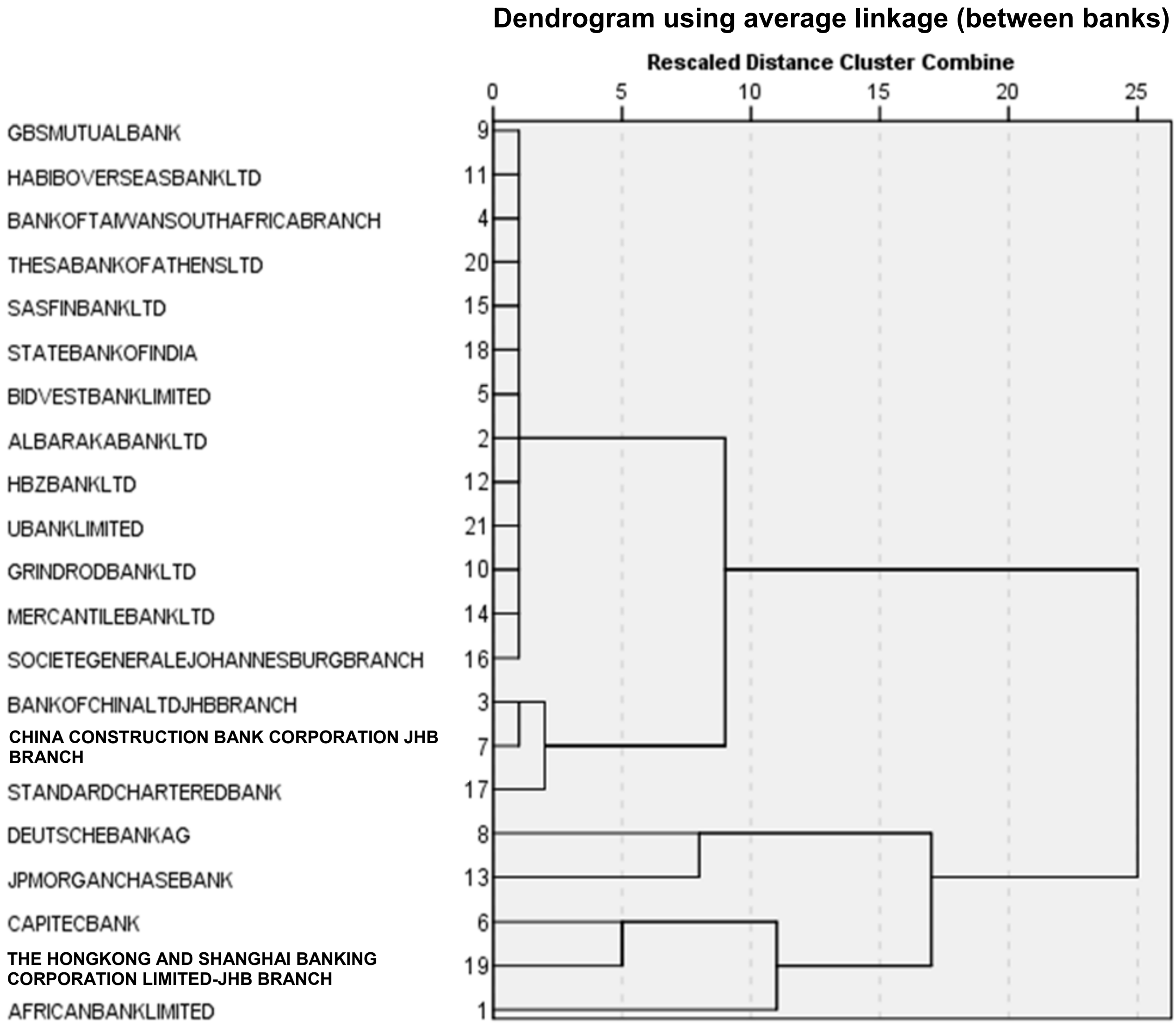

Figure 5.1: The hierarchal cluster analysis results excluding the top five banks in South Africa. Source: compiled by author.

A brief overview of these medium-sized banks will be given in the subsequent paragraphs.

5.2.1. Background on the medium-sized banks

5.2.1.1. African Bank Ltd. (AB)

African Bank Ltd. is consumer-business oriented, and part of their business activities consists of providing certain facilities and products to consumers. The branches of this bank are distributed throughout South Africa, with its head office situated in Midrand, Johannesburg, and is also a locally controlled bank. Even though the bank offers a variety of services, they were prompted to develop a new business model with a new mission and values after being placed under the SARB's curatorship in August 2014 (CNBC Africa, 2014). This transition occurred when the bank faced major systemic risk that raised concerns about the economy's safety and the stability of the other South African banks (African Bank, 2018).

5.2.1.2. Capitec Bank (CB)

Capitec bank was first established on 1 March 2001, and it was listed on the Johannesburg Stock Exchange (JSE) on 18 February 2002. Capitec Bank offers a variety of cost-effective banking services to their clients with easy access to automated teller machines (ATMs) and remote banking at any time. Capitec bank is a locally controlled bank in South Africa with an active client base of 10 million customers and 826 branches throughout South Africa (Capitec Bank, 2018).

5.2.1.3. Deutsche Bank AG (DB)

Deutsche Bank AG South Africa is a well-known financial institution in South Africa and established itself in South Africa with a representative office in 1979. It has become more successful over the years and has since expanded its financial services to reach a larger target market in South Africa. The Deutsche Bank AG South Africa has more than 130 employees and is fully integrated with its global network in addition to being recognised as an international investment bank in South Africa. The bank represents a branch of the well-known foreign bank, and offers a full range of banking services including (Deutsche Bank AG, 2018):

- corporate banking,
- corporate finance,
- capital markets advisory,
- foreign exchange,
- global transaction banking, and
- equity research and trading.

5.2.1.4. JP Morgan Chase Bank (JPM)

JP Morgan Chase Bank also operates as a branch of a foreign bank, and its legacy dates to 1799. It has become a well-known investment bank in South Africa, and its branches are mainly located in Johannesburg and Cape Town. The bank is a leading bank with exceptional leadership and it offers a variety of products and business services that support the specific needs of different individuals like entrepreneurs, high net worth individuals, and business corporates (JPM, 2018).

5.2.1.5. The Hongkong and Shanghai Banking Corporation Limited (HSBC)

The Hongkong and Shanghai Banking Corporation Limited (HSBC) is an international group, with HSBC Africa functioning as a branch of this foreign bank. HSBC focusses on offering their clients international reach and connectivity that include in-depth local knowledge. The HSBC Africa group was established in Sub-Saharan Africa in 1981 but reached the South African market in 1995. The year 2003 saw an increase in demand for a corporate bank in Johannesburg, South Africa, and in 2007 the Johannesburg office became a branch of HSBC, which has been incorporated with Hong Kong. The activities of HSBC in Africa include international banking and banking services to international and local corporates (HSBC, 2018).

The results of the DEA with respect to the technical and scale efficiency of the medium-sized banks will be presented and discussed in the next section.

5.3. The efficiency of South African medium-sized banks

The result of the efficiency estimations of the medium-sized banks from 2004 to 2017 will be discussed in this section according to the business cycle phases as defined by the South African Reserve Bank (SARB, 2018b:14) and the number of observations as given in Table 5.2.

Table 5.2: Business cycle phases

Phase #	Phase range	Phase	# Observations	# Months
1	Jan 2004 - Nov 2007	Upward	282	47
2	Dec 2007 - Aug 2009	Downward	126	21
3	Sep 2009 - Nov 2013	Upward	306	51
4	Dec 2013 - Dec 2017	Downward	294	49

Source: SARB (2018b:14).

Each of the four phases coincided more or less with the different phases of the global financial crisis, i.e. the pre-crisis phase (Phase 1), the crisis phase (Phase 2), and the post-crisis phase (Phase 3-4). Of further of interest to study is the efficiency of the medium-sized banks over these various business cycle phases, for which a lower efficiency can be expected during downward phases and a higher efficiency during upward phases (Abel & Le Roux, 2016:7).

As explained in Section 4.3.1.1, the intermediation approach in the DEA method was used for being identified as the most appropriate for this study (Berger & Humphrey, 1997:34; Karray & Chichti, 2013:596; Molyneux *et al*. 1996:152). Furthermore, the inputs and outputs listed in Table 5.3 were used (as discussed in Section 4.3.1.1) to estimate technical and scale efficiency.

Table 5.3: Applicable inputs and outputs used in this study in the intermediation approach of the DEA method.

Inputs	Item no.*	Outputs	Item no.*
Total deposits	1	Other liabilities	110
Central bank and money	103	Deposits, loans and advances	80
Total equity	96	Investments and bills	195
South Africa (SA) group finance	111		

*Item no. represent the BA900 report item numbers (SARB, 2018d).

The average percentage of each of these inputs available to each bank during each phase is summarised in Figure 5.2 – Figure 5.4 respectively, from which it is clear that the input distribution of the medium-sized banks was generally dominated by total deposits (note the differences in scale).

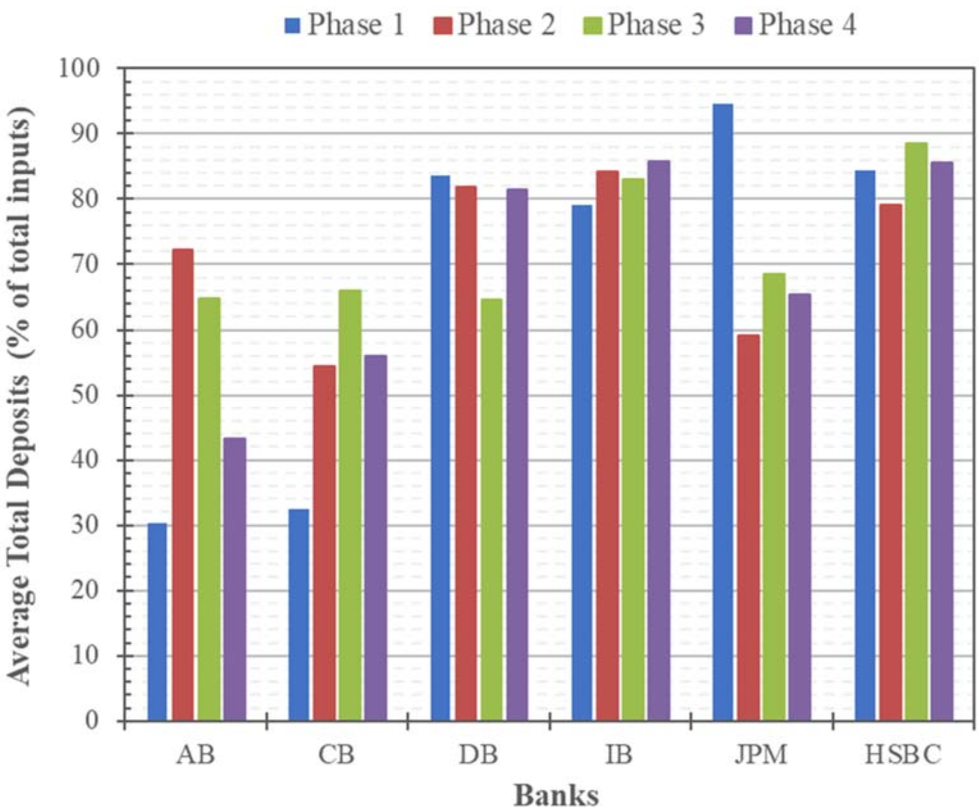

Figure 5.2: Average total deposits expressed as a percentage of the total average inputs for each medium-sized bank during each phase. Source: compiled by author.

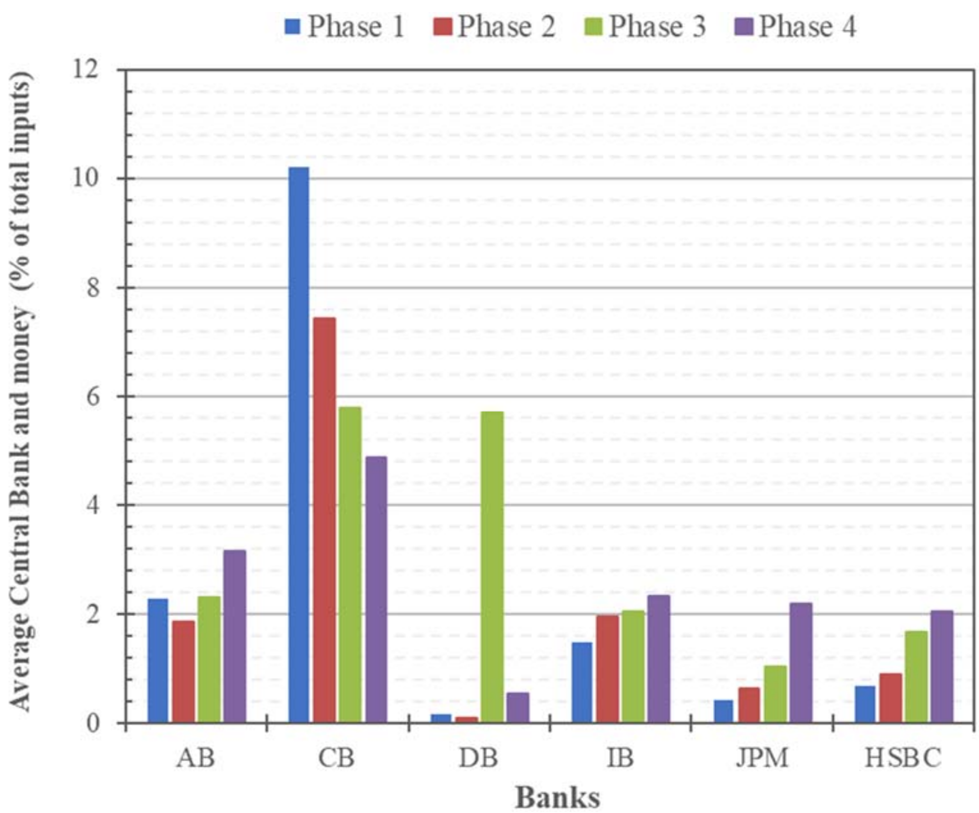

Figure 5.3: Average central bank and money as a percentage of the total average inputs for each medium-sized bank during each phase. Source: compiled by author.

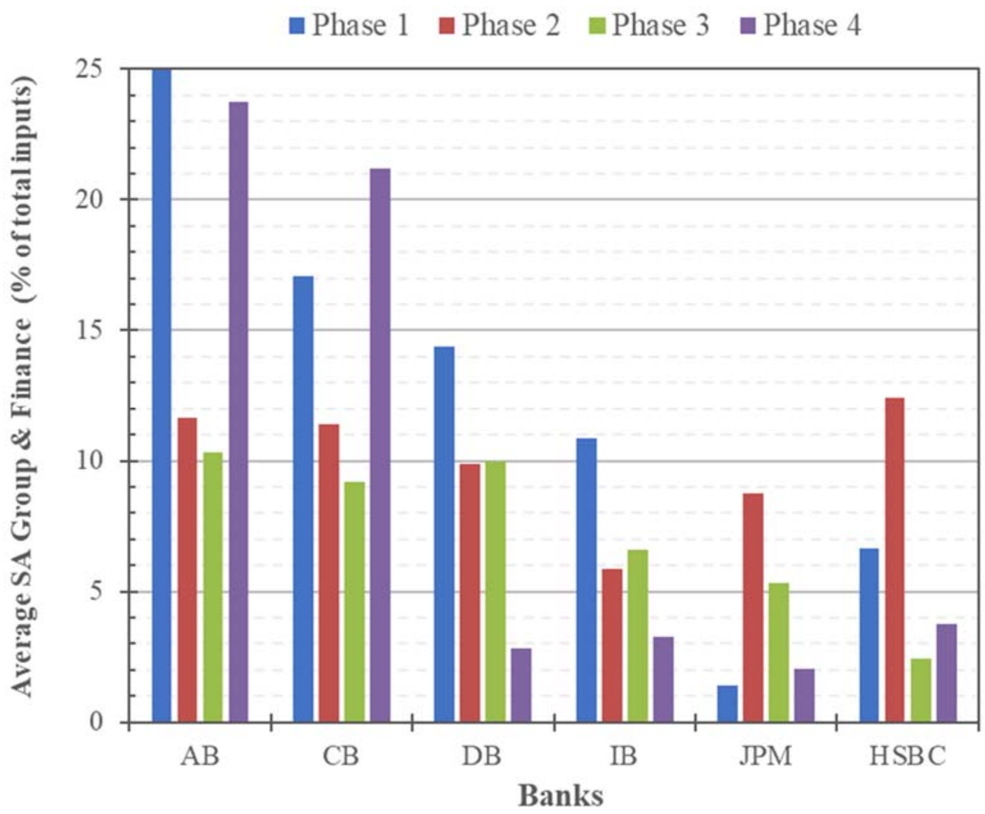

Figure 5.5: SA Group and finance as a percentage of the total average inputs for each medium-sized bank during each phase. Source: compiled by author.

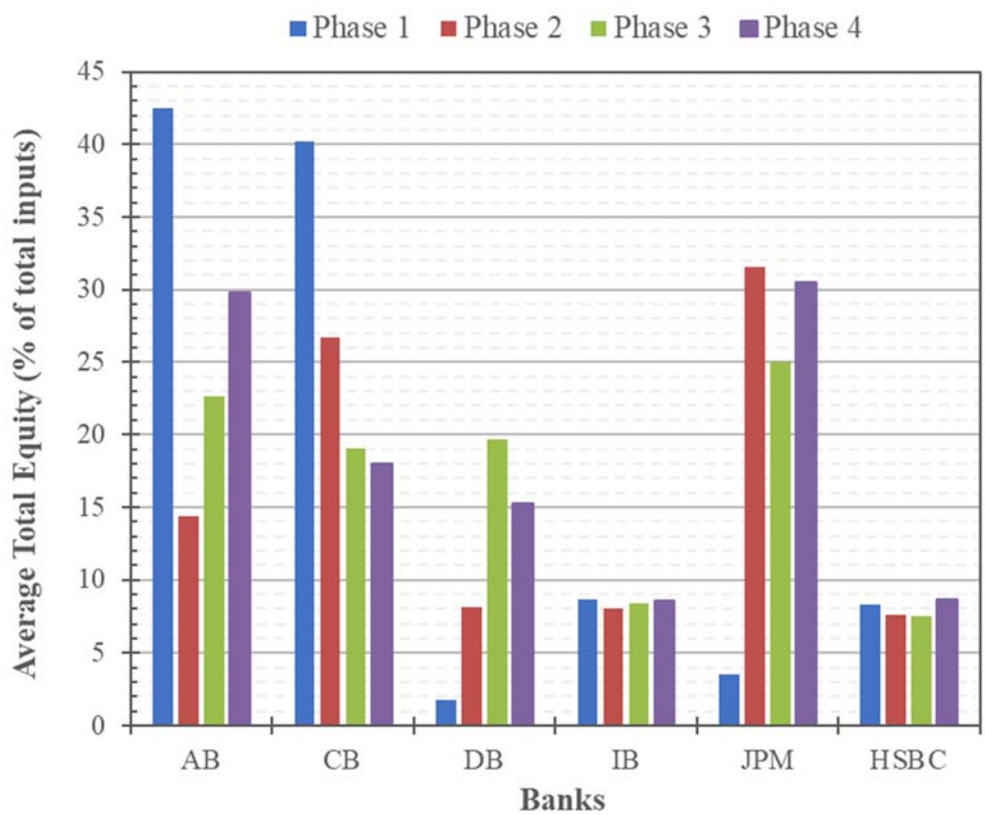

Figure 5.4: Total equity as a percentage of the total average inputs for each medium-sized bank during each phase. Source: compiled by author.

Central bank and money typically constituted around only 2% of the medium-sized banks' total inputs, except for CB in all four phases and for DB in Phase 3 which contributed between 4.9% and 10% of these banks' total inputs. The total input distribution of AB, CB, DB, and JPM also included between 14% and 43% total equity (excluding DB in Phase 1 and 2, and JPM in Phase 1). During Phase 1 the total inputs of AB and CB comprised mostly total equity. AB, CB, and DB in Phase 1, and AB and CB in Phase 4 also had access to between 15% and 25% of SA Group and finance as input, while in all other cases this input constituted roughly only 10% of the input distribution of the medium-sized banks. Clearly, the inputs of the medium-sized banks are unequally distributed, with total deposits making up the majority of the banks' inputs. Total deposits were followed by total equity and SA Group and finance as inputs, then by central bank and money, which is clearly the least utilised input during all four business cycle phases.

The resulting efficiency estimates of each bank for each month in each business cycle phase are shown in tabular format in Appendix A (Table A.1 – A.40). This chapter will present the results in the form of column graphs, while the average technical and scale efficiency of each bank will be reported in tabled summaries and discussed accordingly. The technical and scale efficiency of the medium-sized banks will also be further analysed according to the DEA analysis applied with respect to each of the four individual inputs, that is, total deposits, central bank and money, total equity and South Africa (SA) group, and finance.

5.3.1. Technical efficiency estimates

As noted in Section 4.3.3, a multi-stage model (Section 4.3.3.3.2) has been applied using constant returns to scale (CRS) and variable returns to scale (VRS) model specifications while following an input-oriented approach to estimate the technical efficiency scores of the medium-sized banks. The results with respect to the overall technical efficiency (Section 5.3.1.1) (taking all inputs into consideration) and the input-specific technical efficiency scores (Section 5.3.1.2) will be discussed in the following sections toward evaluating the efficient use of each input individually.

5.3.1.1. Overall technical efficiency estimates

The average overall technical efficiency estimates for all the banks analysed are summarised in Table 5.4 for each of the four phases defined in Table 5.2. The results reported in Table 5.4, which are represented graphically in Figure 5.6, indicate that DB, IB and JPM consistently experienced high technical efficiencies of 90% and higher, while AB, CB and HSBC generally experienced lower overall technical efficiencies that also varied significantly across the various phases. Furthermore, DB was able to further increase its technical efficiency from Phase 1 to Phase 4, whereas IB's technical efficiency reached a plateau in Phase 2. This indicates that these two banks, especially DB, were able to use their available inputs with increasing efficiency. JPM, however, experienced a decrease in its technical efficiency from Phase 1 to Phase 4 but managed to maintain its technical efficiency at 90% (Phase 4) and can further increase its technical efficiency by 10% without changing its outputs.

Table 5.4: Average overall technical efficiency estimates for Phase 1 – 4. Source: compiled by author.

Bank	Phase 1	Phase 2	Phase 3	Phase 4
African Bank Ltd. (AB)	0.87	0.59	0.81	0.96
Capitec Bank (CB)	0.64	0.83	0.71	0.45
Deutsche Bank AG (DB)	0.91	0.95	0.98	0.99
Investec South Africa. (IB)	0.92	0.97	0.97	0.97
JP Morgan Chase bank (JPM)	0.95	0.94	0.91	0.90
The Hongkong and Shanghai Corporation Limited-Johannesburg Branch (HSBC)	0.77	0.74	0.90	0.71

*AB - African Bank Ltd.; CB - Capitec Bank; DB - Deutsche Bank AG; IB -Investec South Africa; JPM - JP Morgan Chase bank; HSBC - The Hongkong and Shanghai Corporation Limited-Johannesburg Branch.

It can also be seen from Figure 5.6 that AB was able to increase its technical efficiency in Phase 4 after experiencing a large decrease in its technical efficiency from Phase 1 to Phase 2. However, after experiencing an increase in technical efficiency from Phase 1 to Phase 2, CB experienced a sharp decrease in its technical efficiency during Phase 3 and especially during Phase 4. This indicates that CB's efficiency in using its available inputs had decreased progressively, and it should aim at increasing its technical efficiency by 55% going forward. HSBC experienced a significant increase in technical efficiency to 90% during Phase 3, but that this was not sustained during Phase 4. HSBC should therefore also aim at increasing its technical efficiency by up to 29% through the more efficient use of the available inputs.

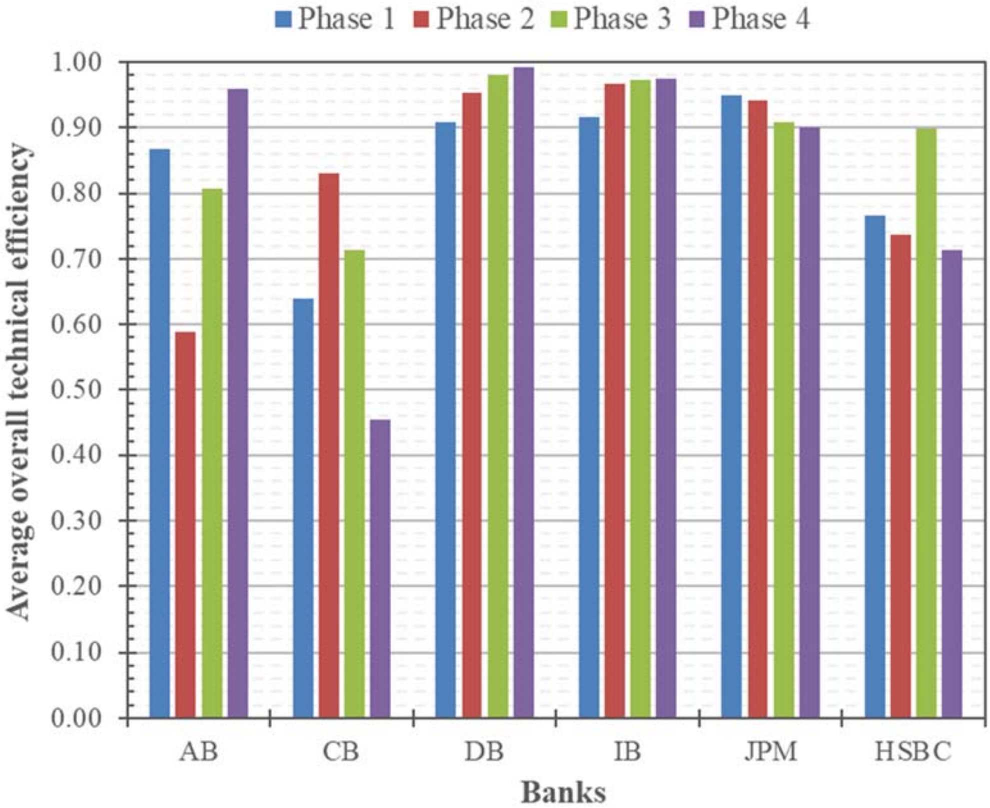

Figure 5.6: Average overall technical efficiency estimates of all the medium-sized banks included in this study for Phase 1 – 4. Source: compiled by author.

It is further of interest to note that the consistently high technical efficiencies of DB, IB and JPM were accompanied by low standard deviations (the relative degree of variation in the respective data sets) across all four phases when compared to that of the other banks (Figure 5.6). Of these three banks, the overall technical efficiency of JPM had the largest standard deviations, which increased from 7% to 10.4% and which correlate with the decrease in its technical efficiency from Phase 1 to Phase 4 (Figure 5.6). A larger standard deviation correlates with a larger degree of fluctuation (volatility) in the technical efficiency scores, indicating that JPM was less successful in applying its inputs in a consistently efficient manner. Furthermore, CB and HSBC both experienced excessive variations in their respective technical efficiencies during Phase 1, as is clear from the large standard deviations of 21% for each bank (Figure 5.6). The high volatility in the technical efficiency scores therefore correlate with the relatively low technical efficiencies of these two respective banks during Phase 1. Also, worth noting is that the latter case coincided with an upward business cycle phase. Except for these two banks (CB and HSBC) the volatility in the overall technical efficiency of the other banks did not show any particular correlation with the upward and downward business cycle phases.

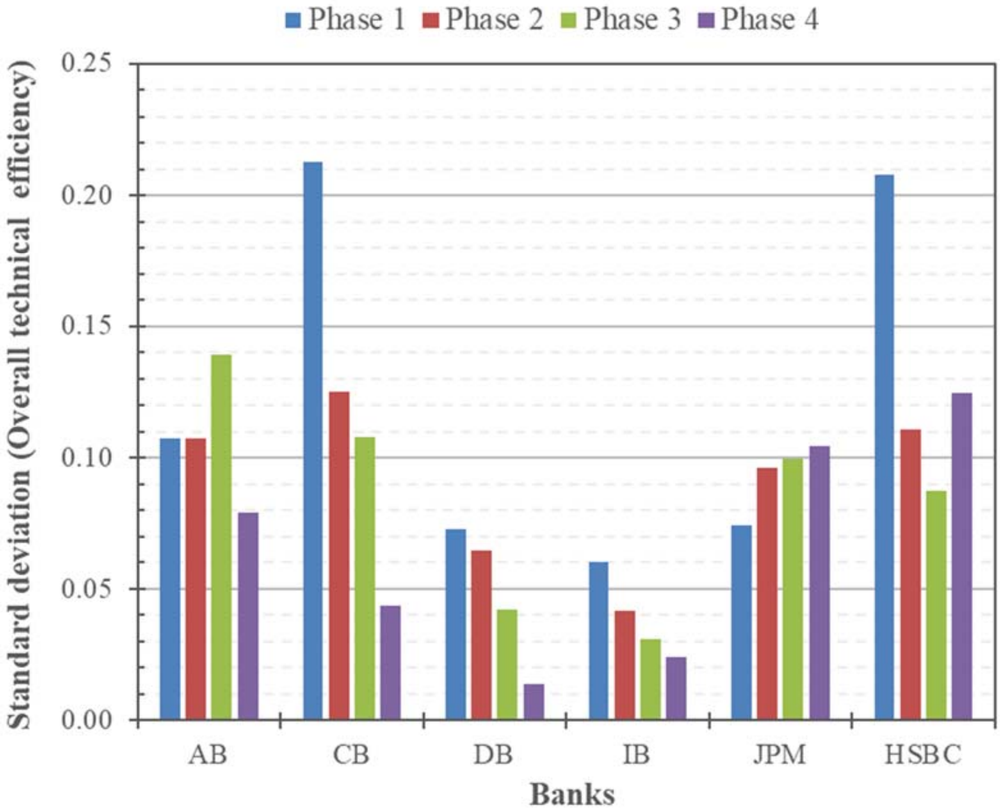

Figure 5.7: Standard deviation with respect to the overall technical efficiency estimates. Source: compiled by author.

During the whole evaluation period of 168 months that spanned January 2004 to December 2017, DB and JPM experienced the most instances of full technical efficiency, i.e. during a total of 77 months each out of the 168 months. In contrast, CB and HSBC operated at full technical efficiency during a total of only six and 13 months respectively, while AB and IB exhibited full technical efficiency during a total of 39 and 49 months respectively. These results correlate with those presented in Table 5.4 and Figure 5.6 in that DB, IB and JPM, in this order, were the best performing banks in respect of overall technical efficiency over all phases of the business cycle.

Going forward from December 2017, these banks only need to increase their technical efficiency by 3% to 10% by improving the utilisation of their respective inputs. AB, CB, and HSBC, however, require more significant improvements in their technical efficiency while also focussing on consistently achieving their current level of outputs, that is, keeping the output level constant while reducing their use of inputs.

Moreover, there is no clear correlation between the overall technical efficiency of the medium-sized banks and the upward and downward business cycle phases (Table 5.2) – to illustrate, the successive upward and downward phases were only mirrored in the overall technical efficiency of AB during the first three phases, but in Phase 4 (a downward business cycle phase) AB experienced a significant increase in its overall technical efficiency. This significant increase in efficiency in Phase 4 occurred during a downward business cycle phase that was also the phase during which AB had defaulted and received support from the SARB (Bonorchis, 2016), most likely resulting in improved banking strategies and systems. AB was the only bank to experience a large decrease in its overall technical efficiency during Phase 2, that is, during the global financial crisis before having acquired access to the financial and managerial support from the SARB. AB was known to provide loans to clients who were not credit worthy (Sanchez, 2014:1), which contributed to its downfall in 2014. The fact that it was the only bank to experience a large decrease in Phase 2 during the financial crisis might have been an early warning signal that the bank was not financially sound.

In contrast, CB was the only bank to experience a significant increase in its overall technical efficiency during the downward phase of Phase 2. Makhaya and Nhundu (2015:19-20) note that CB experienced strong growth from 2008 that stood in contrast to other banks in the low-income market. This apparent growth was attributed by CB's executives to regulatory requirements (for example the National Credit Act (34 of 2005)), funding, and internal initiatives (Makhaya & Nhundu, 2015:19-20). In addition to the environmental factors (regulatory requirements) and increased funding, it would seem that these internal initiatives had made it possible for CB to apply its inputs more efficiently, thereby achieving the higher efficiency indicated in the downward business cycle phase of Phase 2.

The seemingly counterintuitive results, that is, the general lack of correlation between efficiency and the downward and upward business cycle phases, have also been noted by Shirvani *et al*. (2011:7-9) and Erasmus and Makina (2014:315). Erasmus and Makina, for example, who studied the technical efficiency of the major banks in South Africa between 2006 and 2012 and have found that the efficiency of the major banks had not been significantly influenced by the global financial crisis. The reason put forward was that the South African financial system is strictly regulated by, for example, the Basel Committee's global capital and liquidity rules, that is Basel I (BIS, 1988), Basel II (BIS, 2004), and Basel III (BIS, 2011), and the National Credit Act (34 of 2005). The fact that South African banks have conservative practices that conform to these regulations, coupled with prudential regulation of foreign exposure, limits the overall foreign risk (Erasmus & Makina, 2014:315). It would therefore appear that the medium-sized banks may also benefit from these regulatory aspects in respect of increased resilience, at least to an extent, under external economic conditions.

The technical efficiency of each bank for each phase will be further analysed in the following sections with respect to the input-specific technical efficiency scores. These scores were obtained by performing the DEA analysis with respect to each of the four individual inputs considered, namely total deposits, central bank and money, total equity and South Africa (SA) group and finance.

5.3.1.2. Input specific technical efficiency estimates

5.3.1.2.1. Total deposits

The average technical efficiency estimates of total deposits for the medium-sized banks are summarised in Table 5.5 for each of the four phases defined in Table 5.2.

Table 5.5: Average technical efficiency estimates of total deposits for all the medium-sized banks for Phase 1 – 4. Source: compiled by author.

Bank	Phase 1	Phase 2	Phase 3	Phase 4
African Bank Ltd. (AB)	0.79	0.57	0.71	0.88
Capitec Bank (CB)	0.29	0.66	0.58	0.32
Deutsche Bank AG (DB)	0.35	0.64	0.44	0.56
Investec South Africa. (IB)	0.90	0.96	0.94	0.97
JP Morgan Chase bank (JPM)	0.75	0.75	0.68	0.70
The Hongkong and Shanghai Corporation Limited-Johannesburg Branch (HSBC)	0.25	0.43	0.35	0.24

*AB - African Bank Ltd.; CB - Capitec Bank; DB - Deutsche Bank AG; IB -Investec South Africa; JPM - JP Morgan Chase bank; HSBC - The Hongkong and Shanghai Corporation Limited-Johannesburg Branch.

The results shown in Table 5.5, also illustrated in Figure 5.8, indicate that IB and JPM experienced technical efficiencies of 68% and upward during the four phases, in comparison with CB, DB and HSBC's consistently lower technical efficiency scores during each of the four phases. Note, however, that DB was able to use its total deposits more effectively from Phase 1 to Phase 4 since its technical efficiency had increased significantly from 35% in Phase 1 to 56% in Phase 4 after peaking at 64% during Phase 2. Nonetheless, DB can still increase its technical efficiency with respect to its total deposits by 44% from Phase 4 onwards. CB and HSBC, however, need to increase the use of their total deposits substantially to improve their respective technical efficiencies by 68% and 75% from Phase 4 onwards.

In comparison, IB can increase its technical efficiency by only 3% to reach full technical efficiency going forward from Phase 4 without changing its output level. JPM can improve its technical efficiency of deposits by 30% from Phase 4 onwards. On the other hand, AB managed to reach an average technical efficiency of 88% for its total deposits in Phase 4 after reaching a low of 57% in Phase 2. Going forward from Phase 4, AB can therefore adjust the use of its total deposits in aiming to improve its technical efficiency by 12%.

Concerning the business cycle phases, all the medium-sized banks, except for AB, experienced an increase in average technical efficiency with respect to total deposits from Phase 1 to Phase 2, i.e. the crisis period (downward phase). IB is notable for having achieved high efficiency consistently; JPM, a local branch of a foreign bank, for not having increased its technical efficiency by much (IB) or remaining unchanged (JPM) from Phase 1 to Phase 2; and the less well-performing banks CB and DB for having experienced a more noticeable increase in technical efficiency scores. HSBC, also a relatively poorly performing bank in this case, experienced a smaller increase in its efficiency from Phase 1 to Phase 2. Therefore, it is possible that IB and JPM's market presence led to growth and innovation for the smaller banks through enhanced competition (Claessens *et al*., 2001:908; Claessens & Laeven, 2005:179-180). This correlates with the increase in the percentage contribution of total deposits to CB's input distribution, while that of DB decreased slightly (Figure 5.2). Consequently, CB had access to a larger amount of deposits possibly brought on by improved strategies and customer services (Makhaya & Nhundu, 2015:19-20) and by simultaneously using their input more efficiently. On the other hand, DB used its slightly decreased deposits much more efficiently.

Except for the drop in the efficiency scores of CB and HSBC from Phase 3 to Phase 4, that is, from an upward to a downward phase, the changes in the average technical efficiency scores appear to be mostly out of sync with the business cycle phases. The increase in the average technical efficiency score of AB with respect to total deposits in Phase 4 is especially notable for occurring in the downward business cycle phase when it defaulted and subsequently received financial and managerial support from the SARB in 2014 (Bonorchis, 2016), which would have led to improved internal strategies and systems. Comparing ABs input distribution (Figure 5.2) with its technical efficiency scores (Figure 5.8) in terms of total deposits shows that its efficiency scores were higher when total deposits made up a smaller percentage of its input distribution, as is the case in Phase 4. Since appointing managers (Bonorchis, 2016) to oversee the operations of AB in addition to providing financial aid, SARB managers can be considered as having been successful in improving the internal systems that led to improved technical efficiency.

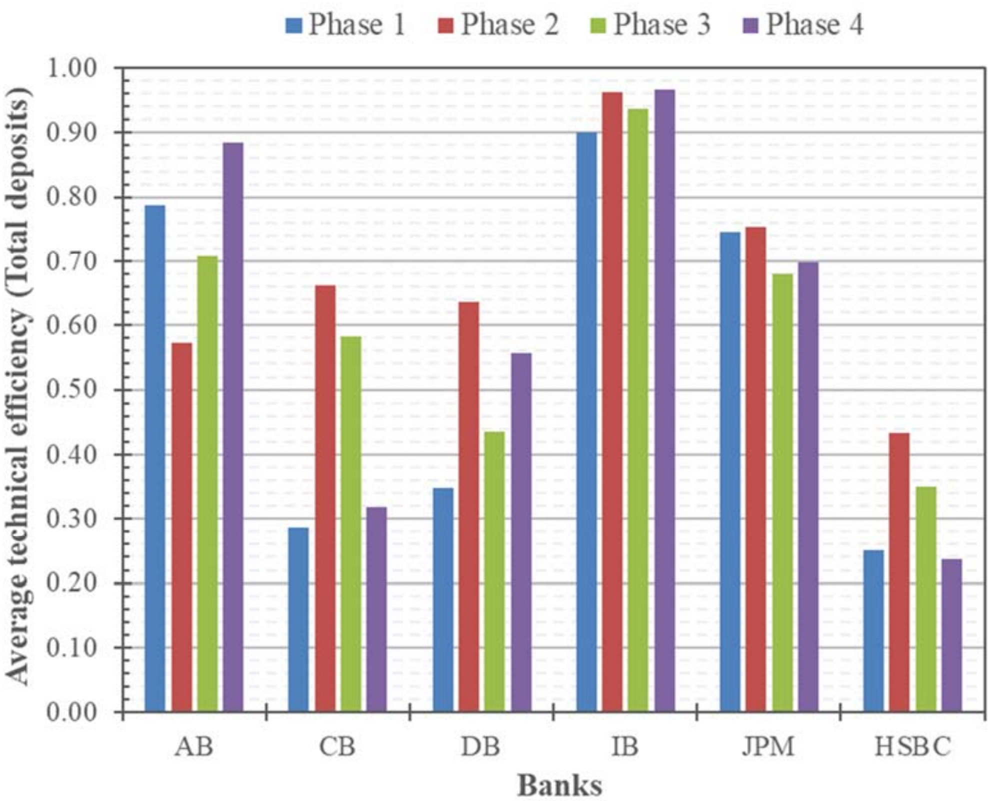

Figure 5.8: Average technical efficiency estimates with respect to total deposits of all the medium-sized banks for Phase 1 – 4. Source: compiled by author.

It is therefore clear from Table 5.5 and Figure 5.8 that IB was consistently the best performing bank in applying its total deposits. In addition, the standard deviation in the average technical efficiency estimates of each bank in each phase as illustrated in Figure 5.9 also show that IB consistently used its total deposits at near-optimum levels during each respective phase, especially in Phase 4 where its consistency was at its highest. In contrast, the average technical efficiency with respect to total deposits of the other medium-sized banks were characterised by significantly higher standard deviations of 8% and higher (Figure 5.9). Such high standard deviations indicate that these medium-sized banks, including JPM, were not able to maintain a consistent level of utilisation of their total deposits.

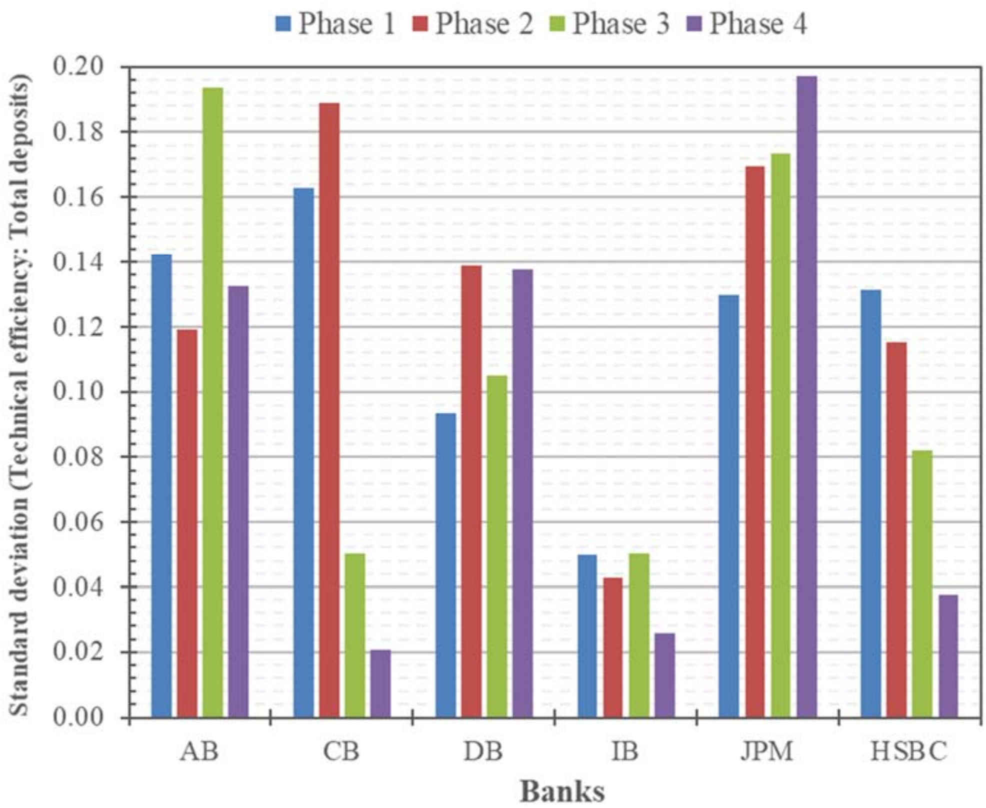

Figure 5.9: Standard deviation of technical efficiency estimates (total deposits). Source: compiled by author.

Concerning the total duration of the study period, i.e. a total of 168 months (January 2004 to December 2017), IB and JPM experienced full technical efficiency of total deposits during 28 and 21 months respectively. AB and CB reached full technical efficiency with respect to their total deposits during 11 and two months respectively out of the total of 168 months. DB and HSBC had the fewest instances of full technical efficiency, as DB experienced full technical efficiency during only one month while HSBC did not reach full technical efficiency even once during the 168-month period. This implies that HSBC needs to review its internal systems to determine the cause of its inefficiency (Cronje, 2003:32). These figures also correspond with the technical efficiency estimations reported in Table 5.5 and Figure 5.8, namely that IB and JPM made the most efficient use of their respective total deposits, although IB was able to do so more consistently.

5.3.1.2.2. Central bank and money

The average technical efficiency estimates of central bank and money as input for the medium-sized banks are given in Table 5.6 for each of the four phases defined respectively in Table 5.2.

Table 5.6: Average technical efficiency estimates of central bank and money for Phase 1 – 4. Source: compiled by author.

Bank	Phase 1	Phase 2	Phase 3	Phase 4
African Bank Ltd. (AB)	0.00	0.06	0.21	0.50
Capitec Bank (CB)	0.00	0.02	0.02	0.17
Deutsche Bank AG (DB)	0.00	0.36	0.25	0.29
Investec South Africa. (IB)	0.63	0.92	0.73	0.95
JP Morgan Chase bank (JPM)	0.21	0.41	0.27	0.31
The Hongkong and Shanghai Corporation Limited-Johannesburg Branch (HSBC)	0.04	0.08	0.00	0.28

*AB - African Bank Ltd.; CB - Capitec Bank; DB - Deutsche Bank AG; IB -Investec South Africa; JPM - JP Morgan Chase bank; HSBC - The Hongkong and Shanghai Corporation Limited-Johannesburg Branch.

The results from Table 5.6 are reported graphically in Figure 5.10, from which it is clear that IB was the only medium-sized bank to use this input with relatively high efficiency (63% and higher) during the four phases considered. AB, CB, DB, and HSBC each exhibited technical inefficiency in one of the four phases and generally showed poor technical efficiencies that ranged from a minimum of 2% to a maximum of 50%. Of these four banks, AB showed the best overall improvement in technical efficiency of central bank and money as input, as its technical efficiency improved from being inefficient in Phase 1 to 50% in Phase 4. AB's trend of increasing technical efficiency also continued in the two downward business cycle phases (Phase 2 and Phase 4). This improvement is especially notable given that central bank and money constituted only between 1.8% and 3.2% of its total inputs (Figure 5.3). However, central bank and money comprised between 10% and 4.9% of the total inputs for CB, while its technical efficiency for this input reached a maximum of 17% in Phase 4. CB should therefore aim at improving its use of this input significantly. In this respect, DB, JPM and HSBC can also improve the use of this input; IB was the most successful at using this limited resource (see Figure 5.3). AB's relatively high technical efficiency score in Phase 4 might have been facilitated by the SARB's managerial oversight (Bonorchis, 2016) as also noted under total deposits as input (Section 5.3.1.2.1).

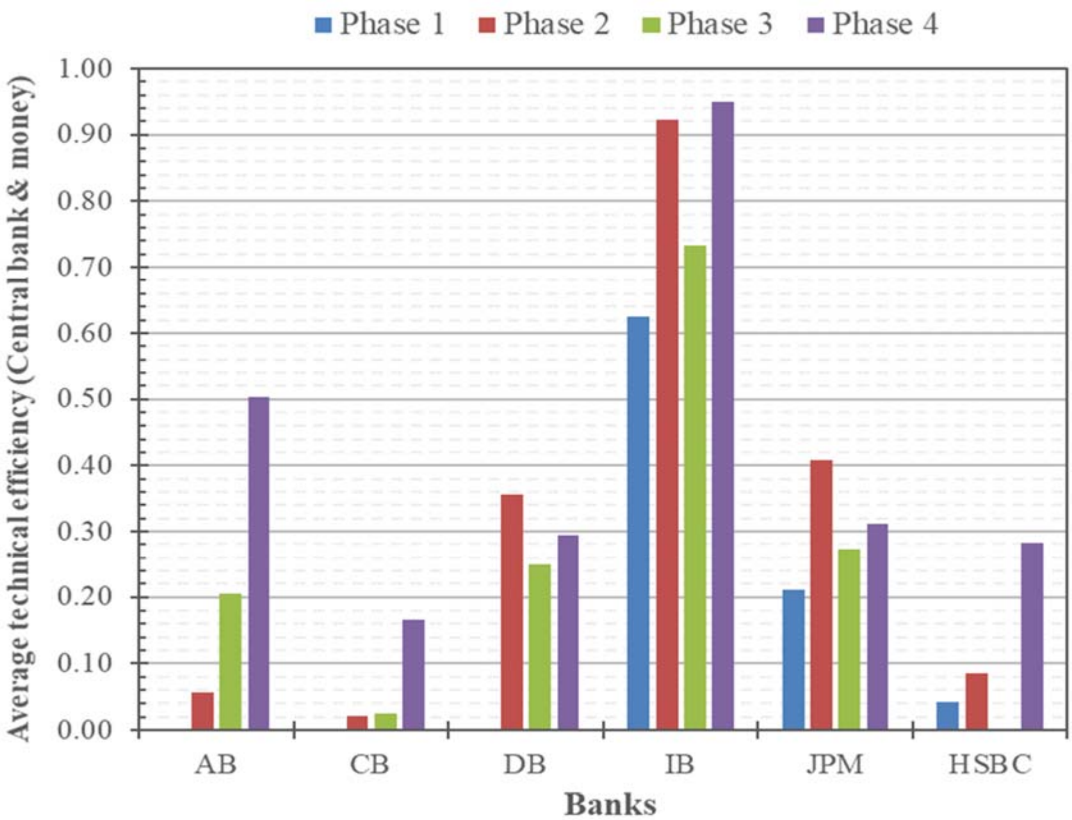

Figure 5.10: Average technical efficiency estimates of central bank and money of the medium-sized banks for Phase 1 – 4. Source: compiled by author.

Although JPM was the only other medium-sized bank other than IB to show non-zero average technical efficiencies for each of the four phases, its technical efficiency scores ranged between only 21% and 41%. As the best performing bank with respect to central bank and money as input, IB can increase its technical efficiency by only 5% going forward from Phase 4 and therefore only needs to make small adjustments in its use of this input. This is especially notable considering that central bank and money contributed only about 2% of the input distribution in respect of the four inputs considered. All the other medium-sized banks need to make substantial adjustments in their respective use of this input to improve their average technical efficiency scores in the future.

Specifically, AB can achieve an average increase of 50% in technical efficiency of central bank and money. CB, DB, JPM and HSBC can improve their average technical efficiencies by 83%, 71%, 69%, and 72% respectively by more efficiently using central bank and money as input without changing their respective outputs.

Interestingly, all the medium-sized banks experienced a significant increase in their respective average technical efficiency scores for central bank and money in going from the upward phases (Phase 1 and 3) to the downward phases (Phase 2 and 4). Again, this is significant, especially for Phase 2 which coincided largely with the crisis period. In addition to the possible reasons cited in Section 5.3.1 for the poor correlation between the efficiency scores and the business cycle phases, a time-lag effect could be at play. In other words, the effects of each business cycle phase might only reflect in the subsequent phase. The average technical efficiency scores of IB in Figure 5.10 are a prime example of such a time-lag effect.

The standard deviations in the average technical efficiency estimates of central bank and money as input are shown in Figure 5.11, from which IB's consistency (decrease in the standard deviation) was found to have improved with its increase in technical efficiency from Phase 1 to Phase 4. In general, the standard deviations of the average technical efficiencies of the other medium-sized banks were relatively high (10% and higher), indicating substantial fluctuations in technical efficiency during each phase. Instances in which the standard deviations of the average technical efficiency of AB and CB were less than 5% indicated that the technical efficiency had been consistently poor during the respective phases for these two banks. This is concerning as it points to a complete lack of appropriate systems or even competence that restrict the efficient use of central bank and money as input.

The high standard deviations in terms of the average technical efficiency scores of JPM in each of the four phases (between 22% and 36%) also correlate with the low technical efficiency scores of this medium-sized bank (Figure 5.10). In other words, JPM should aim at improving the consistency and efficiency with which the central bank and money input is use while keeping their outputs constant. In some cases, such as for IB across all four phases, for CB and DB in Phases 3 and 4, and for HSBC in Phases 1 and 2, the standard deviations increased or decreased in tandem with the respective upward and downward business cycle phases.

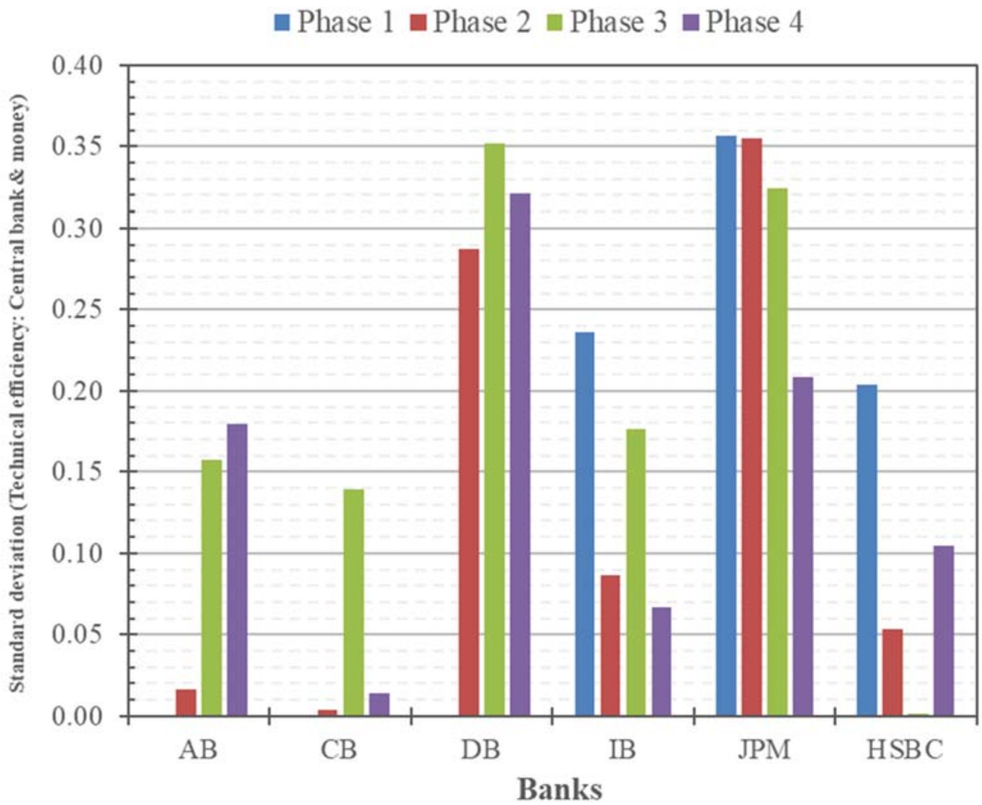

Figure 5.11: Standard deviation with respect to technical efficiency estimates (central bank and money). Source: compiled by author.

Within the 168-month period that constituted the four phases considered in this study, IB reached full technical efficiency under central bank and money as input during a total of 27 months. IB again outperformed the other banks in this regard, since JPM operated at full technical efficiency during a total of 19 months, and DB exhibited full technical efficiency in 10 instances. The other three medium-sized banks were not able to reach full technical efficiency even once during the four phases considered. This is a point of great concern as it could point to the possible presence of internal inefficiencies related to incompetence, fraud, or internal system failures (Cronjé, 2007:11).

5.3.1.2.3. Total equity

The average technical efficiency estimates for total equity as input of the medium-sized banks are reported in Table 5.7 for each of the four phases defined in Table 5.2 and are also shown graphically in Figure 5.12.

Table 5.7: Average technical efficiency estimates of total equity for Phase 1 – 4. Source: compiled by author.

Bank	Phase 1	Phase 2	Phase 3	Phase 4
African Bank Ltd. (AB)	0.12	0.30	0.30	0.39
Capitec Bank (CB)	0.56	0.55	0.30	0.27
Deutsche Bank AG (DB)	0.90	0.91	0.79	0.96
Investec South Africa. (IB)	0.76	0.95	0.95	0.90
JP Morgan Chase bank (JPM)	0.83	0.74	0.65	0.66
The Hongkong and Shanghai Corporation Limited-Johannesburg Branch (HSBC)	0.70	0.70	0.61	0.70

*AB - African Bank Ltd.; CB - Capitec Bank; DB - Deutsche Bank AG; IB -Investec South Africa; JPM - JP Morgan Chase bank; HSBC - The Hongkong and Shanghai Corporation Limited-Johannesburg Branch.

In general, the average technical efficiency score of all the medium-sized banks for total equity as input was at least above 60% over all four phases, except for AB and CB. DB and IB made the most efficient use of this input, as they collectively exhibited technical efficiencies of between 76% (IB during Phase 1) and 96% (DB during Phase 4). JPM and HSBC achieved relatively high average technical efficiencies of at least 70% in Phases 1 and 2, while HSBC was able to maintain its technical efficiency of 70%, except in Phase 3, and JPM's average technical efficiency declined from 83% in Phase 1 to 66% in Phase 4.

In contrast, AB and CB were characterised by significantly lower average technical efficiencies of total equity than the other four medium-sized banks, While AB's average technical efficiency peaked at 39% in Phase 4, which is when the SARB provided them with financial and managerial support (Bonorchis, 2016) and which evidently led to reduced internal inefficiencies and more effective utilisation of the input, CB's average technical efficiency declined from 56% in Phase 1 to 39% in Phase 4. Moving forward from Phase 4, DB and IB can therefore, on average, improve their technical efficiencies slightly by 4% and 10% respectively by optimising their use of total equity as input. JPM and HSBC can significantly improve their technical efficiencies by 44% and 30%, while AB and CB can aim for more drastic improvements of respectively 61% and 73% on average.

Again, as with the overall technical efficiency and the other input-specific technical efficiency scores, no consistent pattern can be discerned by which to determine the influence of the different business cycle phases on the efficiency scores. For example, the average technical efficiencies of the banks in Phase 2 (crisis phase) show no signs of being influenced by this event relative to their respective efficiency scores in the other business cycle phases. In some instances, as is the case with the previously discussed input-specific efficiency scores, the opposite response in technical efficiency to a particular business cycle phase is observed. A notable example, as mentioned above, is the increase in the technical efficiency of AB from 30% in Phase 3 (an upward phase) to 39% in Phase 4 (a downward business cycle phase).

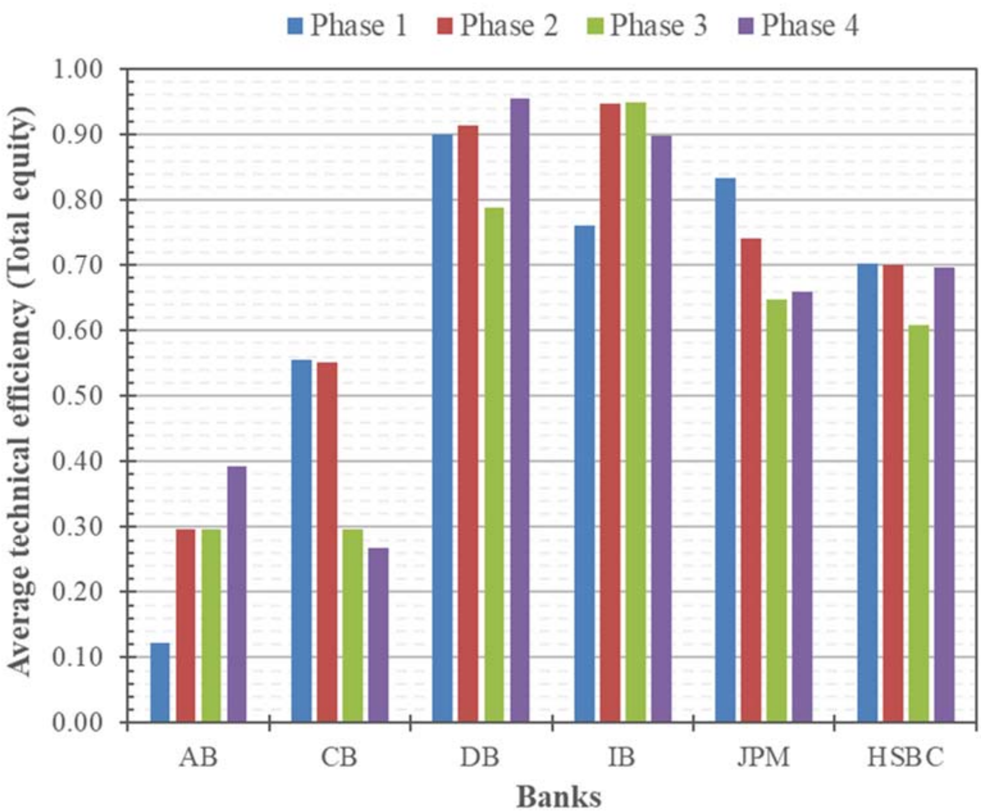

Figure 5.12: Average technical efficiency estimates with respect total equity of the medium-sized banks for Phase 1 – 4. Source: compiled by author.

As with the notable increase in AB's technical efficiency scores of total deposits and central bank and money, this could again have been influenced by the support that AB received from SARB after defaulting in 2014 (Fin24, 2014). However, as noted by Cronjé (2007:11), it is very difficult for analysts not affiliated with a bank to assess the effects of external and internal factors on the profitability, and therefore also on the efficiency, of a bank, since these factors can only be quantified through analysis of detailed bank records. Another possible reason for the observed effects of a downward business cycle phase in a subsequent phase might be reduced capital. Basel I (BIS, 1988), Basel II (BIS, 2004), and Basel III (BIS, 2011) prescribe minimum requirements for promoting capital conservation to build sufficient buffers that can be used during downward business cycle phases. Although this might have been the case with the medium-sized banks, a downward business cycle phase such as Phase 2 (the financial crisis period) would partially drain any capital buffers. These banks would then revert to capital conservation to replenish the capital buffers as required by Basel and focus less on using it to achieve higher output targets.

The corresponding standard deviations of the average technical efficiency estimates given in Table 5.7 and Figure 5.12 are reported graphically in Figure 5.13

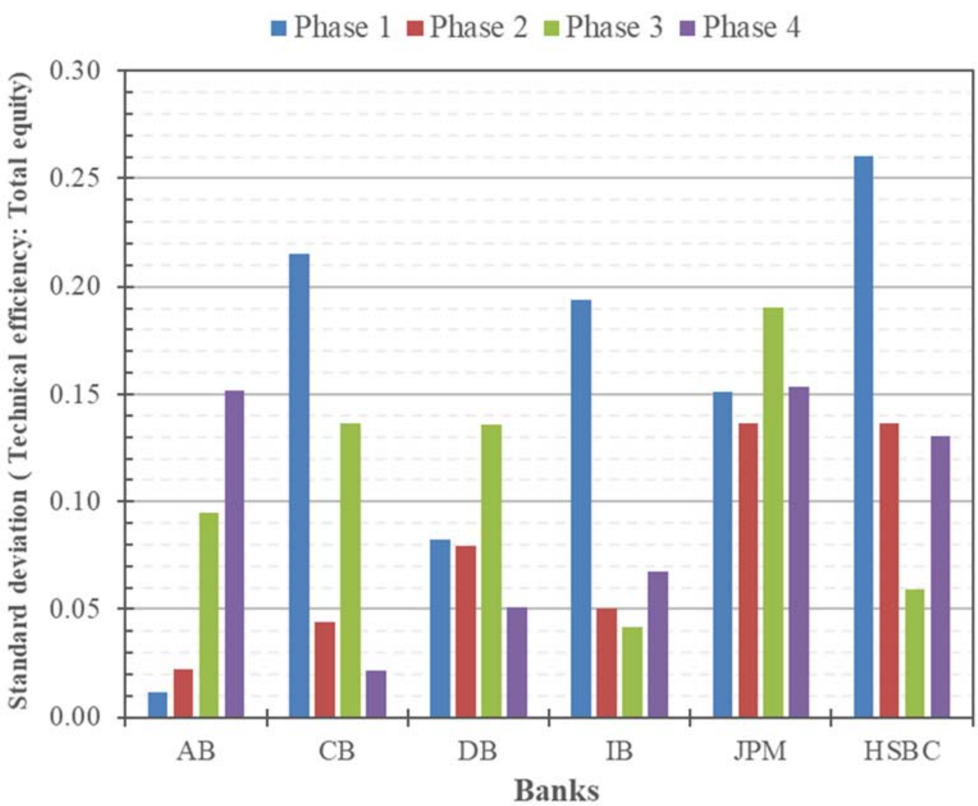

Figure 5.13: Standard deviation of technical efficiency estimates (total equity). Source: compiled by author.

Although the standard deviation in the average technical efficiency of DB and IB were relatively high, i.e. 14% for DB in Phase 3 and 19% for IB in Phase 1, these two banks operated the most consistently relative to their average technical efficiencies in the other three phases.

In contrast, the standard deviations of the average technical efficiencies for the other banks were significantly higher, ranging between 9% and 26% apart from a few individual cases where lower standard deviations were observed. In formulating strategies for improving efficiency, the banks should also aim to improve the level of consistency with which this input is used to reduce the volatility of their efficiency scores, as this will also contribute to improved average efficiency scores.

It is further apparent from Figure 5.13 that CB, IB, and HSBC experienced significantly increased volatility of the efficiency scores during the first upwards phase (Phase 1), and the same was true for CB, DB and JPM in the second upwards phase (Phase 3). In other instances, less volatility was experienced in the downward phases, e.g. in Phase 2 for AB, CB, and IB; and in Phase 4 for CB, DB and IB.

In respect of total equity as input, DB and IB exhibited full technical efficiency during 26 and 27 months out of the total 168-month study period, which correlate with their high average technical efficiencies. JPM exhibited full technical efficiency of total equity as input for 12 months and HSBC experienced full technical efficiency for two months, while AB and CB did not reach full technical efficiency even once during the 168-month period considered.

These results also correlate with the average technical efficiencies reported in Table 5.7 and Figure 5.12, namely that DB and IB generally exhibited the highest technical efficiencies of total equity as input. However, the other medium-sized banks need to make substantial adjustments in their use of total equity as input to improve their technical efficiencies in going forward from Phase 4.

5.3.1.2.4. SA group and finance

The average technical efficiency estimates of SA group and finance as input for the medium-sized banks are reported in Table 5.8 for each of the four phases defined in Table 5.2, and are also shown graphically in Figure 5.14. As is clear from Table 5.8 and Figure 5.14, except for IB, all the other medium-sized banks did not make efficient use of SA group and finance as input, with many experiencing technical inefficiency in one or more phases. This would seem to indicate that all these banks lack the appropriate internal systems and strategies to efficiently make use of this input (Cronje, 2003:32). Nonetheless, IB's average technical efficiency dropped steeply in Phase 4 to 23% after peaking at 76% in Phase 3. IB can improve its average technical efficiency of SA group and finance by 77% in the subsequent phase by adjusting its use of this input to achieve the same level of outputs. The other medium-sized banks can achieve even larger improvements of between 89% and 100% in their average technical efficiencies of SA group and finance. This is particularly important for AB, CB, and DB, since SA group and finance constituted between 9% and 25% of the total inputs of these banks, except for DB in Phase 4 (see Figure 5.5).

Table 5.8: Average technical efficiency estimates of SA group and finance across all four phases. Source: compiled by author.

Bank	Phase 1	Phase 2	Phase 3	Phase 4
African Bank Ltd. (AB)	0.00	0.03	0.33	0.02
Capitec Bank (CB)	0.00	0.00	0.05	0.00
Deutsche Bank AG (DB)	0.00	0.08	0.14	0.11
Investec South Africa. (IB)	0.60	0.73	0.76	0.23
JP Morgan Chase bank (JPM)	0.20	0.28	0.18	0.08
The Hongkong and Shanghai Corporation Limited-Johannesburg Branch (HSBC)	0.00	0.04	0.13	0.04

*AB - African Bank Ltd.; CB - Capitec Bank; DB - Deutsche Bank AG; IB -Investec South Africa; JPM - JP Morgan Chase bank; HSBC - The Hongkong and Shanghai Corporation Limited-Johannesburg Branch.

Despite the sharp decline in IBs technical efficiency in Phase 4, its relative efficient use of this input is notable given that SA group and finance contributed a maximum of 11% (see Figure 5.5) to its total inputs. It is also worth noting that IB generally also exhibited the highest technical efficiency scores with respect to the other inputs and technical efficiency overall, as discussed in the preceding sections. IB was the largest of the medium-sized banks considered in this study. While frequently considered as one of the major banks in South Africa, it was included in this study for the reasons explained in Section 5.2. Its size could contribute to its overall good performance, since larger banks generally have higher levels of technical efficiency (Miller & Noulas, 1996:507).

It is further apparent from Figure 5.14 that the second upward business cycle phase, Phase 3, seems to have facilitated an increase in the average technical efficiency relative to that of Phase 2 for AB, CB, DB, IB, and HSBC. On the other hand, IB and JPM demonstrate significant increases in average technical efficiency scores during Phase 2 relative to Phase 1, of which the former coincided with the global financial crisis period. Other than that, no clearly discernible pattern in the average technical efficiency scores presented in Figure 5.14 arise that would indicate a direct correlation with the four business cycle phases.

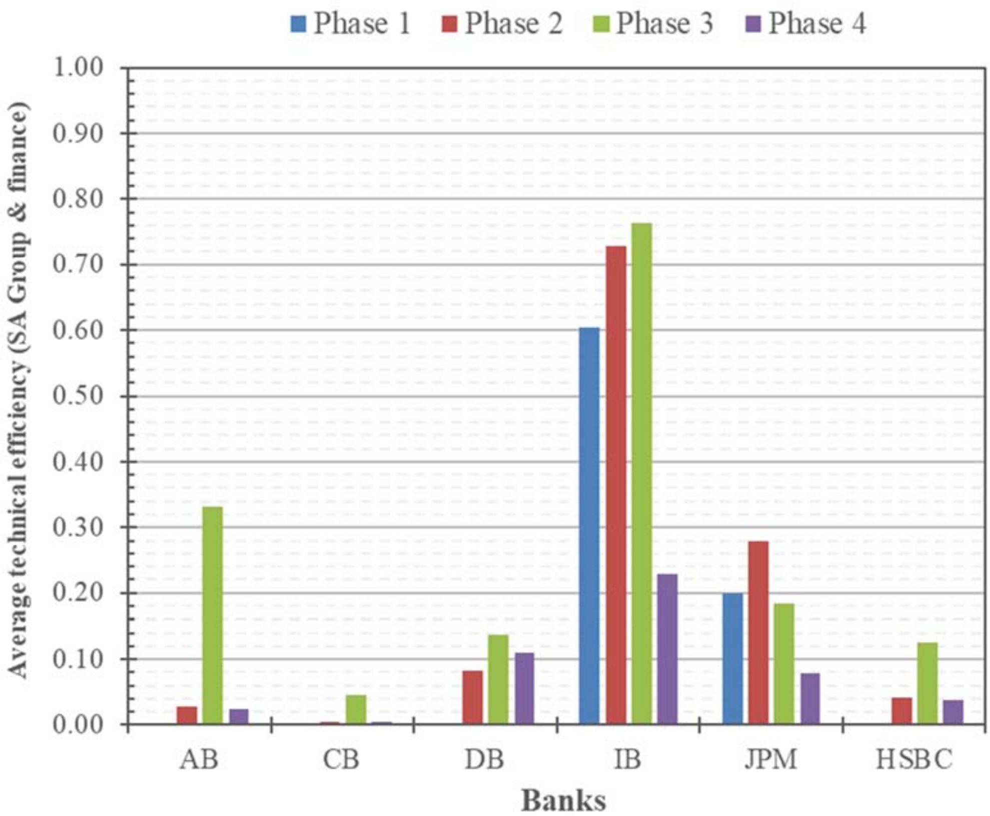

Figure 5.14: Average technical efficiency estimates with respect to SA group and finance of the medium-sized banks for Phase 1 – 4. Source: compiled by author.

The corresponding standard deviations of the average technical efficiency estimates (SA group & finance) are reported in Figure 5.15. Although IB generally had the highest average technical efficiency scores, these were characterised by large standard deviations, indicating large fluctuations in its use of the input during each phase. Compared with Figure 5.14, the improved average technical efficiency scores in going from Phase 2 (downward cycle) to Phase 3 (upward cycle) were also accompanied by increased volatility of the technical efficiency scores for AB, CB, DB and HSBC. The opposite was true for IB and JPM, i.e. that the technical efficiency volatility decreased from Phase 2 (downward phase) to Phase 3 (upward phase).

In addition to improving their average technical efficiency in the subsequent phases, IB along with the other medium-sized banks should also aim to consistently operate at their target efficiencies. Although the standard deviations of the average technical efficiencies of AB and CB were distinctly small (except for AB in Phase 3), these banks also demonstrated notably low technical efficiency scores. In other words, their technical efficiency scores were consistently low during each phase. Of all the banks, JPM exhibited the greatest technical efficiency fluctuations as is clear from Figure 5.15, which indicate that it was able to achieve high technical efficiencies for short periods but could not sustain such increased technical efficiency levels.

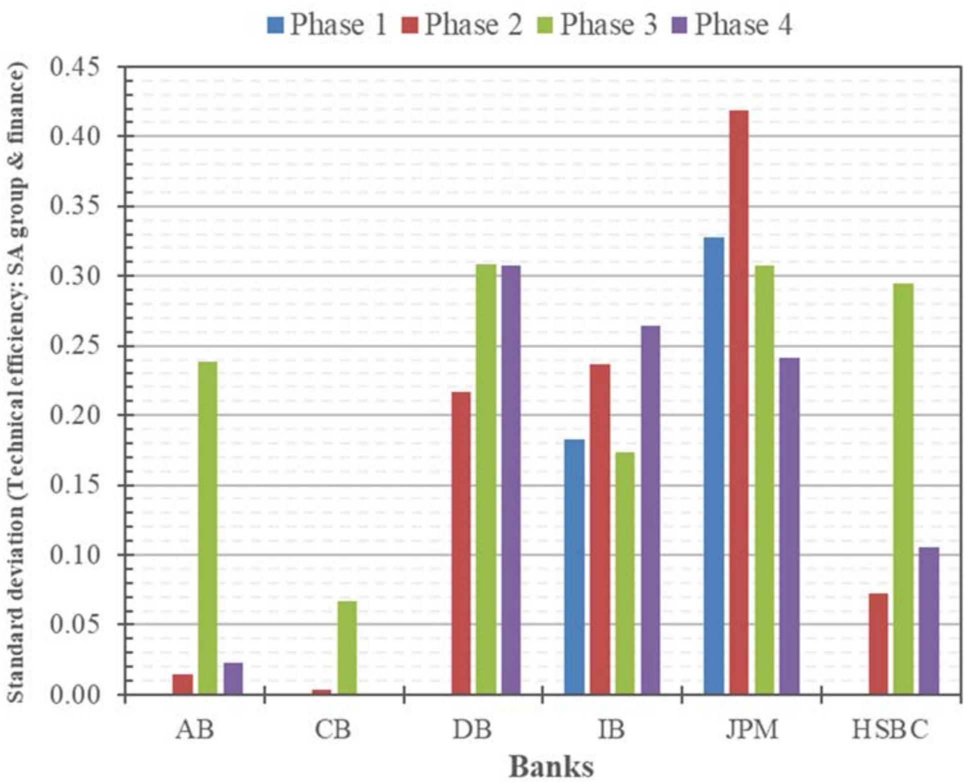

Figure 5.15: Standard deviation of technical efficiency estimates (SA group & finance). Source: compiled by author.

This notion is supported by the fact that JPM reached full technical efficiency of SA group and finance for 16 months out of the 168-month study period, compared with IB, which reached full technical efficiency for 28 months. The same conclusions can be drawn for DB, which succeeded in reaching full technical efficiency for 11 months out of the total 168 months, indicating that it is also capable of operating at much higher average technical efficiencies. DB and JPM can therefore focus on sustaining higher technical efficiency levels while also aiming to improve their average technical efficiencies in the subsequent phases. HSBC was able to operate at full technical efficiency during only four months whereas AB and CB failed to reach full technical efficiency during the 168-month period.

5.3.2. Scale efficiency estimates

As is the case with the technical efficiency estimates (Section 5.3.1), the scale efficiency scores of the medium-sized banks were estimated using the constant returns to scale (CRS) and variable returns to scale (VRS) model specifications while following an input-oriented approach. Similar to the previous sections on the technical efficiency results, the scale efficiency results will be discussed in the following sections with respect to the overall (Section 5.3.2.1) scale efficiency (taking all inputs into consideration) and the input-specific scale efficiency scores (Section 5.3.2.2). Scale efficiency scores have been obtained by performing the DEA analysis with respect to each of the four individual inputs considered, namely: total deposits, central bank and money, total equity, and South Africa (SA) group and finance.

5.3.2.1. Overall scale efficiency estimates

The average overall scale efficiency estimates obtained for the medium-sized banks are summarised in Table 5.9 for each of the four phases defined in Table 5.2. Increasing returns to scale, that is, when an increase in the inputs results in a larger than proportionate increase in the outputs, indicate that a bank has been operating at a scale that is too small and should increase the scale of its operations to reduce the relative cost of production (Mester, 1994:4). Decreasing returns to scale, i.e. when an increase in the inputs results in a less than proportionate increase in the outputs, indicate that a bank has been functioning at a scale that is too large and can therefore decrease the scale of its operations to reduce the relative costs of production (Mester, 1994:4). Constant returns to scale imply that a bank has been operating at an optimal capacity, that is, a change in its input levels would result in a proportionate change in its outputs, thereby reducing production costs.

The average overall scale efficiency results reported in Table 5.9 are also represented visually in Figure 5.16, from which it is evident that AB and JPM consistently performed at an average over all scale efficiency of 90% and upwards over the four phases. In contrast, CB, IB and HSBC were all able to gradually improve their respective scale efficiencies from Phase 1 to Phase 4 to 95% and upwards. DB achieved its highest scale efficiency in Phase 3, though it was not able to sustain the upwards trend given that it experienced a decrease in its average overall scale efficiency to 85% in Phase 4.

Table 5.9: Average overall **s**cale efficiency estimates for Phase 1 – 4. Source: compiled by author.

Phase #	Efficiency		Banks*					
			AB	CB	DB	IB	JPM	HSBC
Phase 1	Scale		0.99	0.53	0.66	0.48	0.91	0.73
	Returns to scale	Increasing	14	46	47	0	33	47
		Decreasing	27	0	0	47	0	0
		Constant	6	1	0	0	14	0
Phase 2	Scale		0.92	0.57	0.91	0.60	0.93	0.80
	Returns to scale	Increasing	7	21	15	0	10	20
		Decreasing	13	0	0	21	0	1
		Constant	1	0	6	0	11	0
Phase 3	Scale		0.95	0.82	0.96	0.63	0.98	0.83
	Returns to scale	Increasing	13	51	25	0	26	39
		Decreasing	35	0	0	51	9	10
		Constant	3	0	26	0	16	2
Phase 4	Scale		0.99	0.99	0.85	0.95	0.95	0.98
	Returns to scale	Increasing	10	49	38	0	32	9
		Decreasing	12	0	0	45	3	40
		Constant	27	0	11	4	14	0

*AB - African Bank Ltd.; CB - Capitec Bank; DB - Deutsche Bank AG; IB -Investec South Africa; JPM - JP Morgan Chase bank; HSBC - The Hongkong and Shanghai Corporation Limited-Johannesburg Branch.

On average, these results also indicate that in going forward from Phase 4, AB and CB need to improve their average overall scale efficiency by 1% each, while HSBC can achieve a further increase of 2% on average to operate at optimal scale. IB and JPM can further improve their respective scale efficiencies by 5%, while DB needs to improve its average overall scale efficiency significantly by 15% to operate at an optimal scale. Relative to the different business cycle phases, the same general observation can be made as with the technical efficiency scores, namely that the average overall scale efficiency scores do not seem to directly correlate with the upward and downward business cycle phases. That is, in some instances the efficiency scores increase or decrease in tandem with the business cycle phases, while in other instances this is not the case. For most banks (AB, IB, JPM, and HSBC), the scale efficiency did not change significantly from Phase 2 (the downward crisis phase) to Phase 3 (an upward business cycle phase). However, it is clear from Figure 5.16 that the downward business cycle phase of Phase 4 could be generally associated with higher averages over all of scale efficiency scores, especially for AB, CB, IB, and HSBC. This indicates that these banks implemented appropriate internal procedures and possibly benefitted from the various regulatory requirements during the latter phase (Cronjé, 2007:11).

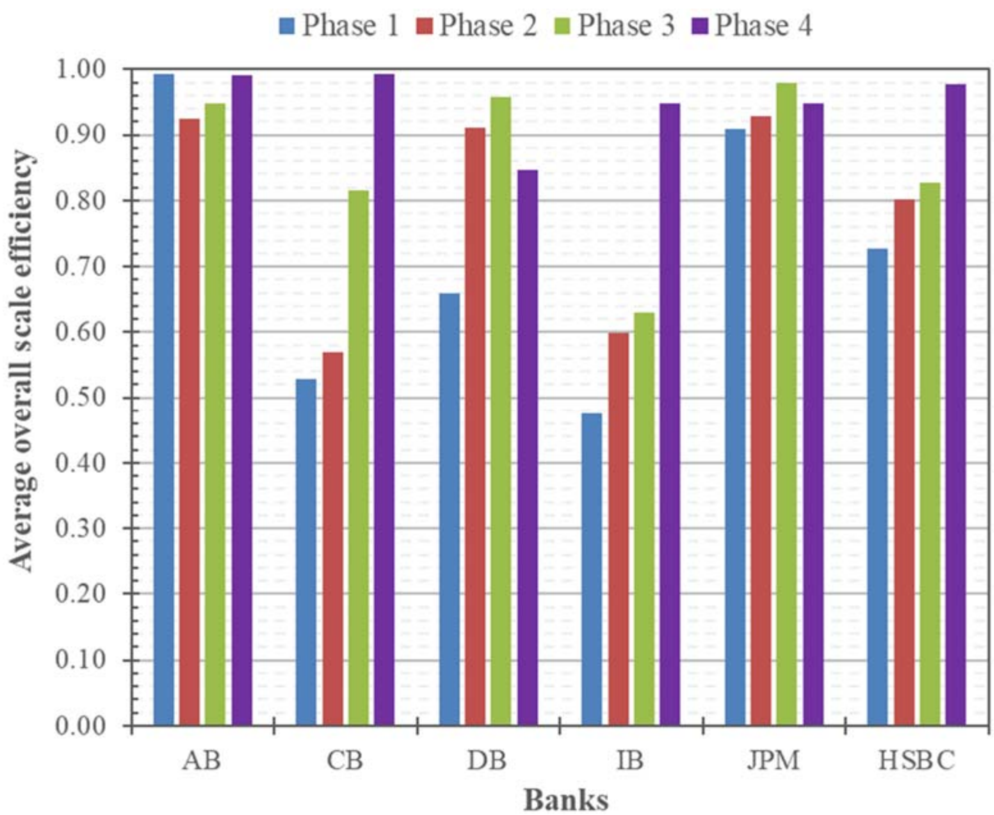

Figure 5.16: Average overall scale efficiency estimates of all the medium-sized banks included in this study for Phase 1 – 4. Source: compiled by author.

It is apparent from Figure 5.17 that CB, DB, and HSBC experienced high volatility in their overall scale efficiency scores during the first upward phase (Phase 1). CB and HSBC also experienced increased volatility during the second upward phase (Phase 3), while DB experienced the same during the downward phase of Phase 4. In contrast, AB, CB, IB, and HSBC experienced less volatility in their overall scale efficiency scores during the downward phase of Phase 4, because the standard deviations were below 4% in Phase 4 for all banks except DB and JPM. In other words, all the medium-sized banks except DB and JPM were able to maintain relatively little variation in their respective scale efficiencies, indicating that these banks had maintained operation at a consistent scale. The large standard deviation obtained for the average overall scale efficiency of DB in Phase 4 compared with the other banks indicate that, in addition to improving its scale efficiency by 15%, it also needs to focus on operating consistently at optimal scale.

The lack of consistent performance of DB in terms of scale efficiency is also reflected in Table 5.9 in that it operated at increasing returns to scale for a total of 125 months out of the total 168 months. This means that it operated at a less than optimal scale for 125 months and at constant returns to scale during only 43 out of the total 168 months (Table 5.9), during which full scale efficiency was also experienced. The results given in Table 5.9 further show that although IB saw an increase in its average overall scale efficiency, it operated at constant returns to scale for only four months during Phase 4, during which time it also experienced full scale efficiency, and it constantly operated at decreasing returns to scale throughout the other three phases. In other words, IB operated at higher than optimal scale during the majority of the four phases. Although AB and JPM had consistently high average overall scale efficiencies, these two banks experienced full scale efficiency during 36 and 55 months respectively and operated at constant returns to scale during a total of respectively 37 and 55 months out of the total of 168 months

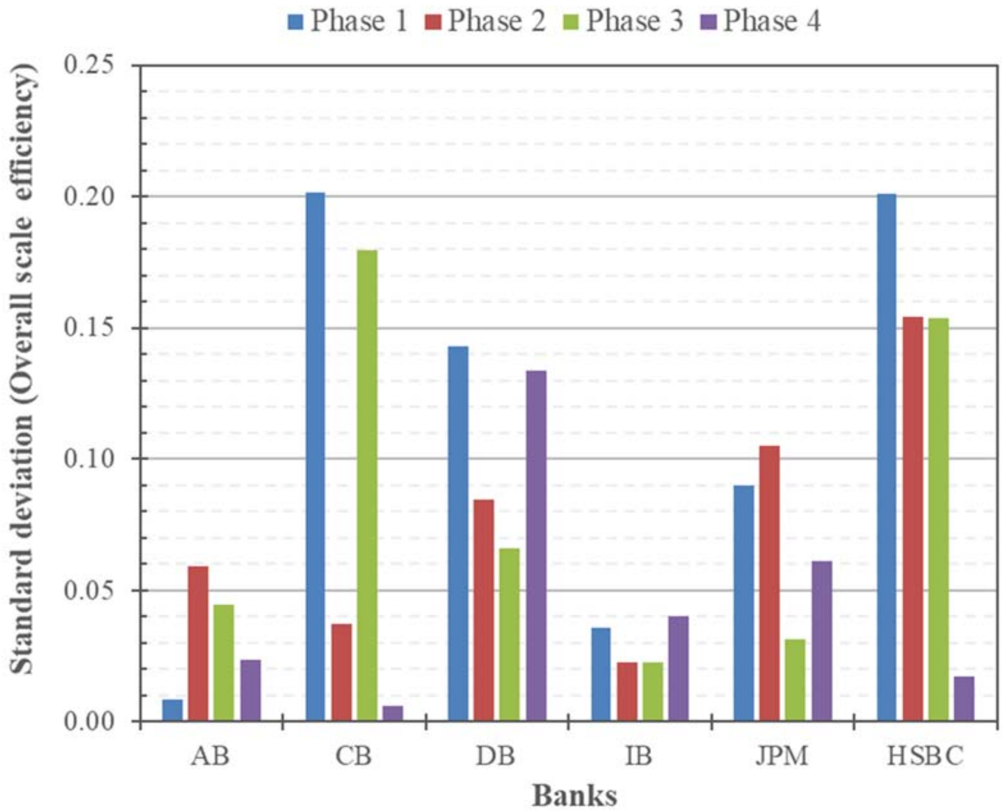

Figure 5.17: Standard deviation of the overall scale efficiency estimates. Source: compiled by author.

(Table 5.9). AB operated at increasing returns to scale (less than optimum scale) during a total of 44 months and at decreasing returns to scale (larger than optimum scale) during a total of 87 months. JPM operated at increasing returns to scale during a total of 101 months and at decreasing returns to scale during a total of only 12 months.

CB and HSBC achieved full scale efficiency the least amount of times, namely for a total of respectively one and two months during which each bank also operated at constant returns to scale (Table 5.9). CB operated at decreasing returns to scale for the rest of the 168 months, while HSBC experienced increasing returns to scale during a total of 115 months and decreasing returns to scale for a total of 51 months out of the total 168 months.

Lastly, it should be noted that while DB, IB and JPM attained consistently high technical efficiency scores over the four different business cycle phases (90% or higher), only JPM achieved scale efficiency scores of higher than 90% in each of the four business cycle phases. This result correlates with that of Miller and Noulas (1996:503-504), whose study found that some of the banks that experienced scale inefficiency did not experience technical inefficiency. Therefore, scale and technical efficiency are not necessarily related.

The input-specific scale efficiency of each bank for each phase will be further analysed in the subsequent sections, through which the aspects that should be addressed to improve each bank's overall scale efficiency will be identified.

5.3.2.2. Input specific scale efficiency estimates

5.3.2.2.1. Total deposits

The average scale efficiency estimates of total deposits for the four medium-sized banks are summarised in Table 5.10 and reported in Figure 5.18 for each of the four phases defined in Table 5.2. The average scale efficiency estimates (Table 5.10 and Figure 5.18) indicate that JPM saw an increase in its average scale efficiency of 70% in Phase 1 and subsequently operated consistently at an average scale efficiency of between 90% and 93% in the other three phases. In contrast, all the other medium-sized banks experienced a sharp decline in their respective average scale efficiencies in Phase 4 following improved efficiencies in Phases 2 and 3, except for CB which had a maximum scale efficiency in Phase 1. The improved scale efficiencies of all the medium-sized banks except for CB in Phase 2, which coincided with the onset of the global financial crisis, indicate the presence of effective internal systems and managerial strategies to operate close to optimal scale (Cronje, 2003:32). IB had the lowest average scale efficiencies throughout the four phases, reaching a maximum of only 45% in Phase 2 despite having the highest average technical efficiency scores for total deposits as input (Figure 5.8). From Phase 4 onwards, each bank can make improvements to its internal strategies and systems to operate at optimal scale.

Table 5.10: Average scale efficiency estimates of total deposits for Phase 1 – 4. Source: compiled by author.

Phase #	Efficiency		Banks*					
			AB	CB	DB	IB	JPM	HSBC
Phase 1	Scale		0.66	0.95	0.43	0.21	0.77	0.61
	Returns to scale	Increasing	0	15	0	0	4	1
		Decreasing	47	31	47	47	41	46
		Constant	0	1	0	0	2	0
Phase 2	Scale		0.83	0.72	0.87	0.45	0.90	0.94
	Returns to scale	Increasing	0	21	3	0	10	12
		Decreasing	20	0	18	21	9	9
		Constant	1	0	0	0	2	0
Phase 3	Scale		0.98	0.88	0.91	0.43	0.92	0.91
	Returns to scale	Increasing	41	51	51	0	43	51
		Decreasing	9	0	0	51	6	0
		Constant	1	0	0	0	2	0
Phase 4	Scale		0.68	0.54	0.55	0.20	0.93	0.69
	Returns to scale	Increasing	8	0	49	0	44	0
		Decreasing	38	49	0	49	4	49
		Constant	3	0	0	0	1	0

*AB - African Bank Ltd.; CB - Capitec Bank; DB - Deutsche Bank AG; IB -Investec South Africa; JPM - JP Morgan Chase bank; HSBC - The Hongkong and Shanghai Corporation Limited-Johannesburg Branch.

While JPM (the best performing bank in Phase 4) can improve its average scale efficiency of total deposits by 7%, IB (the bank with the weakest performance in Phase 4) can improve its scale efficiency by 80%. Relative to the four business cycle phase, it is further clear from Figure 5.18 that all the medium-sized banks experienced relatively high scale efficiency during the first downward phase (Phase 2 and crisis period) and during the second upward phase (Phase

3). Except for JPM, the medium-sized banks experienced reduced scale efficiency during the second downward phase of Phase 4. In other words, the medium-sized banks need to adjust the scale of their operations to improve their profitability through cost minimisation, while JPM needs to make only relatively small adjustments in this regard going forward from Phase 4.

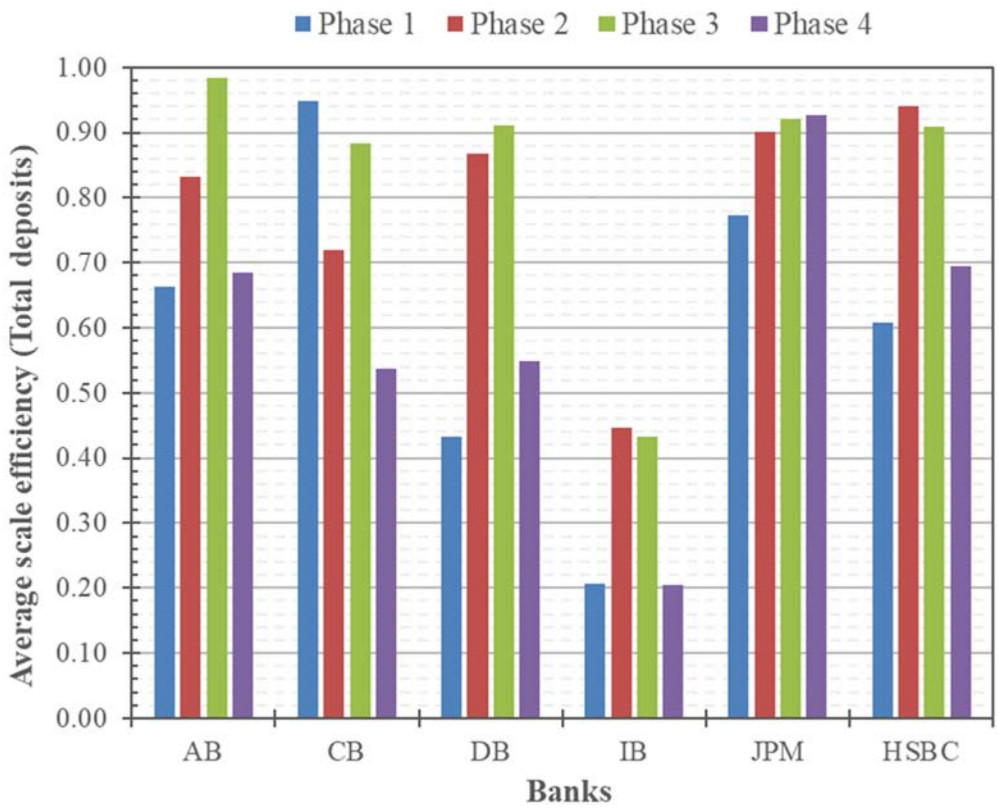

Figure 5.18: Average scale efficiency estimates of total deposits for the medium-sized banks for Phase 1 – 4. Source: compiled by author.

The standard deviations in the average scale efficiency estimates of total deposits for each bank during each phase are shown in Figure 5.19, from which it is evident that the scale efficiencies of CB and IB varied the least (small standard deviations) during each phase, except during Phase 3 when CB exhibited more pronounced variation in its scale efficiency. The small standard deviations in the average scale efficiency of IB therefore indicate that it consistently operated at low scale efficiency during each phase.

Although JPM generally operated at the highest scale efficiency, it did experience significant scale efficiency variations during each phase (standard deviations of between 9% and 17%). Limiting the degree of variation in its scale efficiency can therefore assist JPM in further improving its scale efficiency of total deposits. It is further clear from Figure 5.19 that AB experienced rapid scale efficiency fluctuations during Phase 1 and Phase 4, resulting in a standard deviation of nearly 25% (Phase 4), and they can therefore aim at operating at a more consistent scale to reduce the costs associated with the use of total deposits as input. With respect to the four business cycle phases, AB, DB, JPM and HSBC clearly experienced higher volatility in scale efficiency during the first upward phase (Phase 1), while AB, and to some degree DB, experienced increased volatility during the second upward phase (Phase 4). Additionally, all the medium-sized banks generally experienced relatively high volatility with respect to their scale efficiency scores during the crisis Phase (Phase 2).

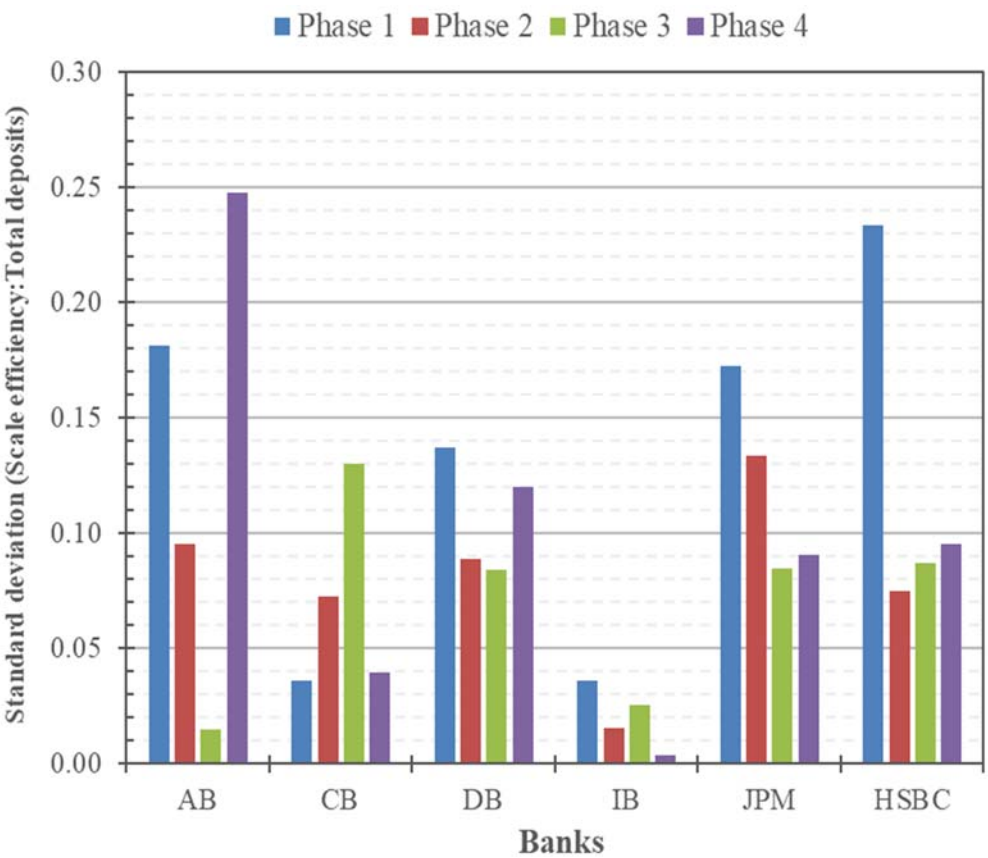

Figure 5.19: Standard deviation of scale efficiency estimates (total deposits). Source: compiled by author.

IB's low average scale efficiency, as reported in Table 5.10, is a result of it operating at decreasing returns to scale, i.e. at a scale that was too large, for the entire 168-month period without once operating at optimal scale. AB and HSBC also operated at decreasing returns to scale during the majority of the 168-month study period – AB during 114 months and HSBC during 104 months. AB operated at increasing returns to scale, i.e. at a scale that was too small, during 49 months and at constant returns to scale (Table 5.10) with full scale efficiency during five months, while HSBC operated at increasing returns to scale during 64 months and did not operate at optimal scale at any point during the study period. DB operated at increasing returns to scale, i.e. at a scale that was too small, during the majority of entire 168-month period, namely during 103 months and operated at decreasing returns to scale during the remaining 65 months. JPM operated at increasing returns to scale (a scale that was too small) during a total of 101 months, at decreasing returns to scale (a scale that was too large) during 60 months, and at constant returns to scale (Table 5.10) with full scale efficiency during seven months. CB operated at increasing returns to scale during 87 months, at decreasing returns to scale during 80 months, and reached full scale efficiency during only one month (Table 5.10) while also operating at constant returns to scale.

5.3.2.2.2. Central bank and money

The average scale efficiency estimates of central bank and money for the four medium-sized banks are summarised in Table 5.11 and reported in Figure 5.20 for each of the four phases defined in Table 5.2. The average scale efficiency estimates of central bank and money (Table 5.11 and Figure 5.20) indicate that all the medium-sized banks struggled to achieve sustainable average scale efficiencies over the four phases included in this study. DB was the only medium-size bank able to exhibit average scale efficiencies of more than 40% during more than two of the four phases. Further, DB and JPM were the only medium-sized bank that could sustain its average scale efficiencies above 50% during Phases 1 and 2. AB and IB were scale inefficient during Phase 3, while IB was also scale inefficient during Phase 1. This indicates a complete mismanagement of the scale of these bank’s operations.

The poor scale efficiency of IB stands in stark contrast to that of the other banks and to its relatively high technical efficiency (see Figure 5.10), although central bank and money contributed only about 2% of its total inputs (see Figure 5.3). On the other hand, CB’s poor scale efficiency with respect to central bank and money coincides with its poor technical efficiency scores (see Figure 5.10) despite having this input contribute the most to CB’s total inputs compared with the other medium-sized banks (see Figure 5.3).

Table 5.11: Average scale efficiency estimates of central bank and money for Phase 1 – 4. Source: compiled by author.

Phase #	Efficiency		Banks*					
			AB	CB	DB	IB	JPM	HSBC
Phase 1	Scale		0.26	0.03	0.55	0.00	0.56	0.26
	Returns to scale	Increasing	20	12	43	0	8	46
		Decreasing	0	0	0	47	17	0
		Constant	27	35	4	0	22	1
Phase 2	Scale		0.61	0.30	0.67	0.03	0.73	0.82
	Returns to scale	Increasing	0	21	3	0	14	13
		Decreasing	21	0	18	21	5	8
		Constant	0	0	0	0	2	0
Phase 3	Scale		0.00	0.14	0.13	0.00	0.02	0.09
	Returns to scale	Increasing	0	1	6	0	0	0
		Decreasing	51	42	44	51	50	46
		Constant	0	8	1	0	1	5
Phase 4	Scale		0.02	0.02	0.47	0.01	0.07	0.03
	Returns to scale	Increasing	0	0	15	0	0	0
		Decreasing	49	49	33	49	49	49
		Constant	0	0	1	0	0	0

*AB - African Bank Ltd.; CB - Capitec Bank; DB - Deutsche Bank AG; IB -Investec South Africa; JPM - JP Morgan Chase bank; HSBC - The Hongkong and Shanghai Corporation Limited-Johannesburg Branch.

All the medium-sized banks, except for CB and IB reached higher average scale efficiencies of between 61% and 82% in Phase 2, with HSBC obtaining the highest average scale efficiency (82%) during this phase. However, all the banks showed a sharp decrease in their respective scale efficiencies in Phase 3. Except for DB, who managed to operate at an average scale efficiency of 47% in Phase 4, the other medium-sized banks displayed very low scale efficiency scores of between 1% and 7% during this phase. Going forward from Phase 4, substantial improvements therefore should be made by AB, CB, JPM and HSBC (between 93% and 99%) to increase their respective scale efficiencies and to operate closer to optimum scale. On average, DB can increase its scale efficiency by 53% by adjusting the scale of its operations relative to central bank and money as input.

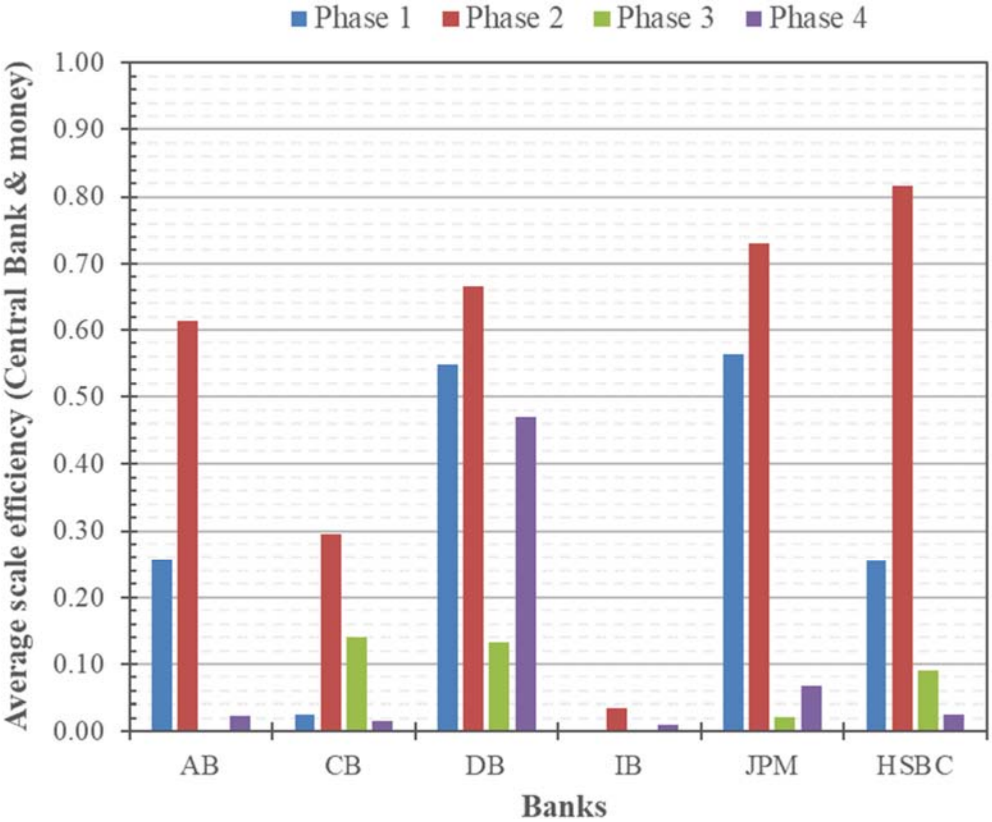

Figure 5.20: Average scale efficiency estimates of central bank and money for the medium-sized banks for Phase 1 – 4. Source: compiled by author.

With respect to the business cycle phases, it is further clear from Figure 5.20 that all banks except IB experienced increased scale efficiency during the downward phase of Phase 2 (crisis phase), and all of these banks, except for CB, also had relatively high average scale efficiency scores in the upward constituent of Phase 1. Again, it is apparent that the crisis phase does not seem to have negatively influenced the scale efficiency of the banks with respect to central bank and money as input (Erasmus & Makina, 2014:315). In all cases in Figure 5.20 there was, however, a sharp decline in the efficiency scores of the banks in the phases following the crisis phase with only DB being able to recover partially in Phase 4 (downward phase).

The standard deviations with respect to the average scale efficiency estimates (central bank & money) are presented in Figure 5.21, from which the very low standard deviation values of IB are apparent. These small standard deviation values coincide with the bank's very low average scale efficiency scores (indicating that IB was scale inefficient). The same was true for the other medium-sized banks in Phase 4, namely that they consistently operated at low scale efficiency during each phase, except for DB that displayed a standard deviation of 34% relative to its scale efficiency of 47% in Phase 4. The average scale efficiency scores of DB for the other phases were also accompanied by high standard deviations, that is, operating at an inconsistent scale and indicating a lack of consistent performance of the central bank and money as input. In summary, it is therefore apparent that all the medium-sized banks can make significant adjustments in the scale of their operation with respect to central bank and money as input while also aiming to sustain a consistent scale of operation.

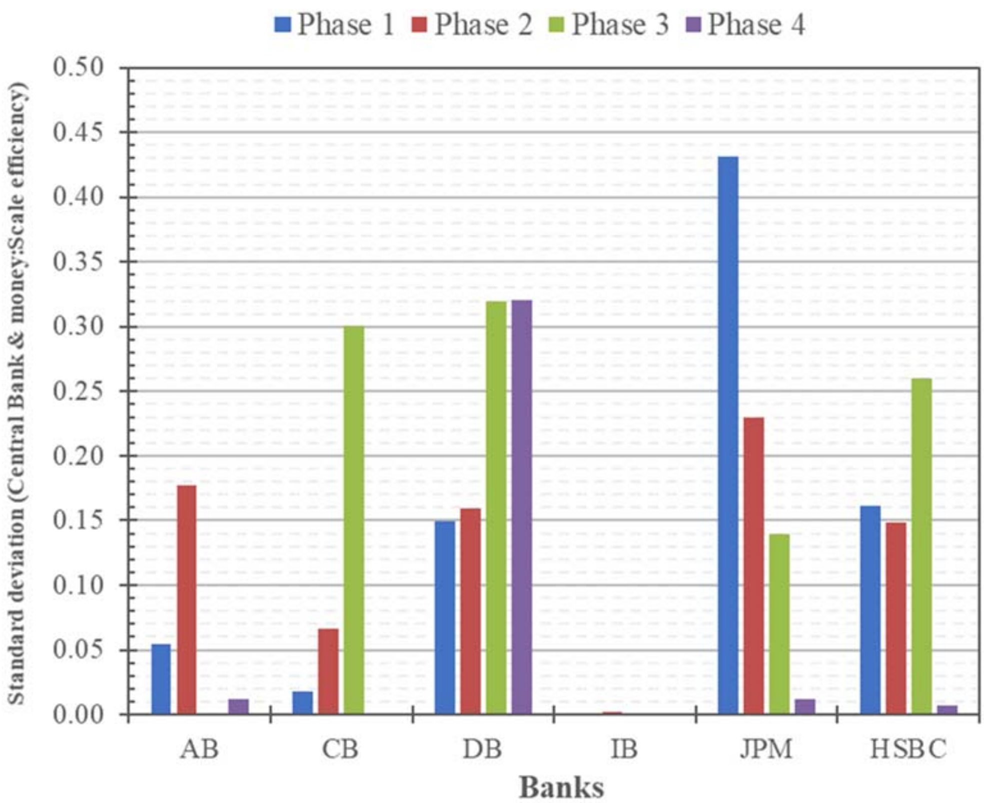

Figure 5.21: Standard deviation of scale efficiency estimates (central bank & money). Source: compiled by author.

Relative to the four business cycle phases, high to extremely high volatility was evident under the scale efficiency scores of DB, JPM, and HSBC. All the medium-sized banks except IB, which had the poorest scale efficiency score, also experienced relatively high volatility in Phase 2, i.e. the crisis phase. All the medium-sized banks with non-zero average scale efficiencies of central bank and money as input in Phase 3 (upward phase) experienced high levels of volatility (Figure 5.21). This is despite the average scale efficiency scores being very low, i.e. the maximum average score was 14% for CB. Further, although CB did not exhibit high average scale efficiencies (Figure 5.20) during the four phases, it operated at constant returns to scale during 43 months but did not once experience full scale efficiency. In comparison, AB and JPM operated at constant returns to scale during respectively 27 and 25 months but achieved full scale efficiency during only zero and five months respectively. DB and HSBC each operated at constant returns to scale during only six months out of the total 168 months (Table 5.11) and although DB experienced full scale efficiency during one month, HSBC could not reach full scale efficiency at all.

It is also clear from Table 5.11 that IB operated at decreasing returns to scale for the entire 168-month period, as was the case with total deposits. Therefore, IB again operated at a higher than optimal scale during all the four phases. The other medium-sized banks all also operated mostly at decreasing returns to scale (at a scale that was too large) for most of the 168 months, namely during 121 (AB and JPM), 91 (CB), 95 (DB), and 103 months (HSBC) respectively. DB and HSBC operated at increasing returns to scale (Table 5.11), i.e. at a scale that was too small, during 67 and 59 months respectively, while AB, CB and JPM operated at increasing returns to scale during respectively 20, 34, and 22 months out of the 168 months. It is therefore clear that all the medium-sized banks need to make substantial changes to the scale of their respective operations and should revise their internal systems and strategies to achieve the appropriate scale of operation.

5.3.2.2.3. Total equity

The average scale efficiency estimates of total equity for the four medium-sized banks are summarised in Table 5.12 and reported in Figure 5.22 for each of the four phases defined in Table 5.2. It is clear from the average scale efficiency estimates of total equity (Table 5.12 and Figure 5.22) that all the medium-sized banks had relatively high efficiencies that improved significantly from Phase 1 to Phase 4. JPM experienced a comparatively smaller increase in its average scale efficiency from Phase 1 to Phase 4 but was also the most consistent over the four phases, with its scale efficiency score in Phase 4 only being surpassed by HSBC. DB was the only bank to experience a decrease in its average scale efficiency to 71% in Phase 4 compared with Phase 3. CB and IB had especially low average scale efficiencies in Phase 1 but managed to improve their scale efficiencies the most between Phase 1 and Phase 4, i.e. from 3% to 94% (CB) and from 16% to 94% (IB). AB and HSBC had similar average scale efficiencies in Phase 1 of 32% and 31% respectively and succeeded in raising efficiency scores to 92% and 98% respectively. Going forward from Phase 4, DB is the only medium-sized bank that can substantially improve its average scale efficiency (by 29%), while the other banks only require between 2% and 8% improvement in their respective average scale efficiencies to reach optimal scale.

Table 5.12: Average scale efficiency estimates of total equity for Phase 1 – 4. Source: compiled by author.

Phase #	Efficiency		Banks*					
			AB	CB	DB	IB	JPM	HSBC
Phase 1	Scale		0.32	0.03	0.64	0.16	0.80	0.31
	Returns to scale	Increasing	47	47	47	0	44	47
		Decreasing	0	0	0	47	1	0
		Constant	0	0	0	0	2	0
Phase 2	Scale		0.87	0.19	0.83	0.51	0.91	0.69
	Returns to scale	Increasing	15	21	18	0	20	20
		Decreasing	6	0	1	21	0	1
		Constant	0	0	2	0	1	0
Phase 3	Scale		0.78	0.75	0.93	0.45	0.87	0.79
	Returns to scale	Increasing	14	39	44	0	3	51
		Decreasing	37	12	4	51	48	0
		Constant	0	0	3	0	0	0
Phase 4	Scale		0.92	0.94	0.71	0.94	0.94	0.98
	Returns to scale	Increasing	49	49	48	5	45	0
		Decreasing	0	0	0	43	1	49
		Constant	0	0	1	1	3	0

*AB - African Bank Ltd.; CB - Capitec Bank; DB - Deutsche Bank AG; IB -Investec South Africa; JPM - JP Morgan Chase bank; HSBC - The Hongkong and Shanghai Corporation Limited-Johannesburg Branch.

In comparing the average scale efficiency scores of the banks for the upward and downward phases, it is apparent from Figure 5.22 that AB, DB and JPM experienced relatively high scale efficiencies with respect to total equity during the downward phase of Phase 2, that is, the crisis phase. All the banks, except IB, also experienced relatively high average scale efficiencies during the subsequent upward phase (Phase 3), while every bank reached its highest scale efficiency score in the downward phase of Phase 4. Again, the downward phases did not correlate with reduced scale efficiency score, and the first upward phase correlated with suppressed scale efficiencies for all banks, but especially for CB and IB.

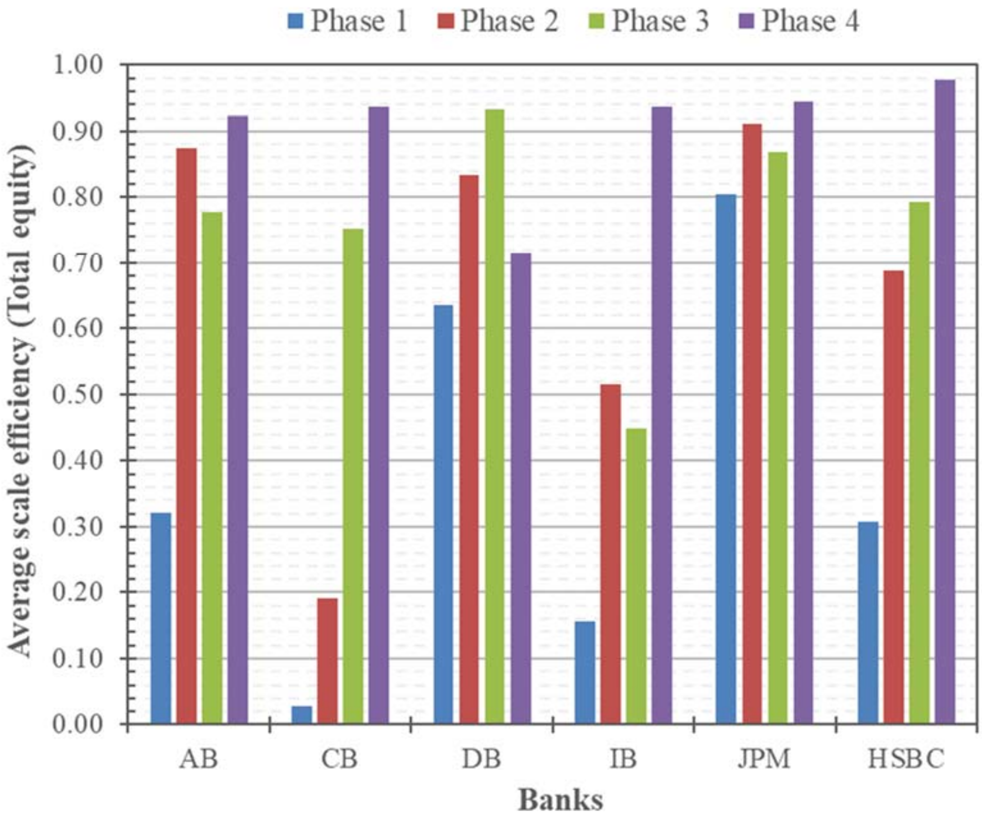

Figure 5.22: Average scale efficiency estimates of total equity for the medium-sized banks for Phase 1 – 4. Source: compiled by author.

Increased efficiency was observed in some instances where a downward phase followed an upward phase, especially for AB and JPM. As with the technical efficiency scores of total equity, this could have been due to reduced available capital in the business cycle phases following the crisis phase (Phase 2). Thus, while the prescribed Basel I (BIS, 1988), Basel II (BIS, 2004), and Basel III (BIS, 2011) guidelines could possibly have been effective in ensuring that the banks had access to enough capital reserves during Phase 2, the banks would have had an inherent incentive to apply these reserves in an efficient manner, and in this case would be incentivised to operate closer to optimal scale in Phase 2 than Phase 3 to reduce expenditure. In the subsequent business cycle phases (Phases 3 and 4) these banks would focus on replenishing their capital buffers.

The standard deviations of the average scale efficiency estimates of total equity (Table 5.12 and Figure 5.22) are shown in Figure 5.23. From Figure 5.23, it is deduced that IB displayed little variation in its scale efficiency during each phase due to the small standard deviations (between 2% and 6%) in the average scale efficiency of each phase. This is significant as it indicates that not only was IB able to improve its average scale efficiency (total equity) from Phase 1 to 4, but they it was also able to maintain the improved efficiency during each phase at a relatively constant level. The same can be concluded for JPM, for which the increase in its average scale efficiency from Phase 1 to 4 coincided with a decrease in the accompanying standard deviations. In contrast, all the other banks were less successful at maintaining improved scale efficiencies within a narrow range when going from one phase to the next, as is evidenced by the large spikes in the standard deviations of these banks (Figure 5.23). In this regard, the improved average scale efficiency of CB in Phase 3 was accompanied by a large standard deviation of 25%.

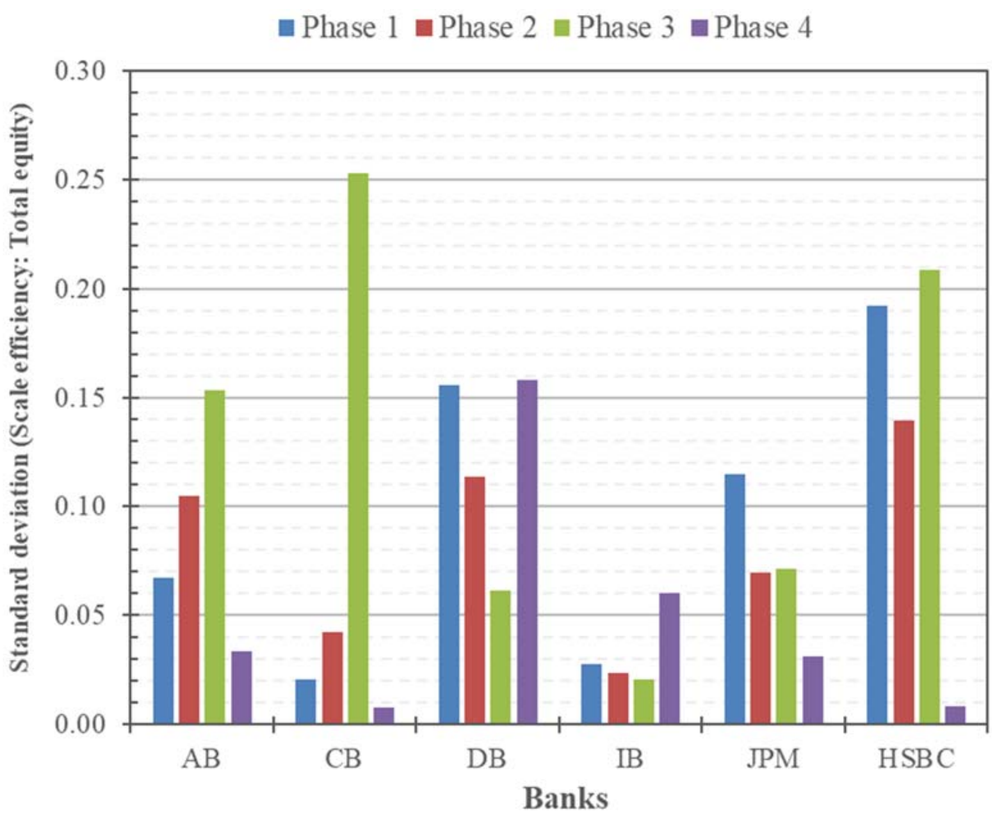

Figure 5.23: Standard deviation of efficiency estimates (total equity). Source: compiled by author.

Nonetheless, all the banks except for DB were able to reach their respective maximum average scale efficiencies in Phase 4 (Figure 5.22) while displaying very little variation in their respective scale efficiencies during this phase (small standard deviations as can be seen in Figure 5.23). The reason for all the banks except DB having experienced a maximum average scale efficiency during Phase 4 would need to be determined through detailed analysis of bank records (Cronjé, 2007:11).

The increased standard deviation in the scale efficiency (total equity) of DB in Phase 4 was accompanied by a decrease in its average scale efficiency. In other words, DB should aim at improving its scale efficiency in the subsequent phase while also improving its consistency. Comparing the degree of fluctuation (Figure 5.23) between the different banks relative to the four business cycle phases reveals that the upward constituent of Phase 1 was accompanied by significant volatility in scale efficiency of for DB, JPM and HSBC. The same can be said for AB, CB and HSBC for the last downward phase (Phase 4). AB, DB; HSBC also experienced relatively high volatility during the crisis phase (downward phase) of Phase 2, and again, no clear trend is observed relative to the upward and downward phases.

5.3.2.2.4. SA group and finance

The average scale efficiency estimates of SA group and finance for the four medium-sized banks are summarised in Table 5.13 and reported in Figure 5.24 for each of the four phases defined in Table 5.2. The average scale efficiency results (Table 5.13 and Figure 5.24) indicate that in general all the medium-sized banks operated at low scale efficiencies although AB, CB, DB and JPM each experienced a relatively high average scale efficiency during one of the four phases. DB was, however, the only bank to experience a steady growth in its average scale efficiency (SA group & finance) from Phase 1 (1%) to Phase 4 (66%). In contrast, AB, CB and JPM each experienced a sharp decrease in their respective average scale efficiencies after showing high average scale efficiencies during one of the four phases. These generally poor scale efficiency scores also indicate that the medium-sized banks did not operate at an appropriate scale in respect of this input (compare Figure 5.5), except for DB, which attained an increase in its average scale efficiency scores despite a decrease in the contribution of SA group and finance to its total inputs.

Table 5.13: Average scale efficiency estimates of SA group and finance for Phase 1 – 4. Source: compiled by author.

<table>
<tr><th rowspan="2">Phase #</th><th rowspan="2" colspan="2">Efficiency</th><th colspan="6">Banks*</th></tr>
<tr><th>AB</th><th>CB</th><th>DB</th><th>IB</th><th>JPM</th><th>HSBC</th></tr>
<tr><td rowspan="4">Phase 1</td><td colspan="2">Scale</td><td>0.61</td><td>0.08</td><td>0.01</td><td>0.00</td><td>0.06</td><td>0.30</td></tr>
<tr><td rowspan="3">Returns to scale</td><td>Increasing</td><td>0</td><td>9</td><td>0</td><td>0</td><td>0</td><td>8</td></tr>
<tr><td>Decreasing</td><td>12</td><td>0</td><td>47</td><td>47</td><td>44</td><td>17</td></tr>
<tr><td>Constant</td><td>35</td><td>38</td><td>0</td><td>0</td><td>3</td><td>22</td></tr>
<tr><td rowspan="4">Phase 2</td><td colspan="2">Scale</td><td>0.06</td><td>0.38</td><td>0.16</td><td>0.00</td><td>0.61</td><td>0.26</td></tr>
<tr><td rowspan="3">Returns to scale</td><td>Increasing</td><td>0</td><td>21</td><td>1</td><td>0</td><td>8</td><td>1</td></tr>
<tr><td>Decreasing</td><td>21</td><td>0</td><td>20</td><td>21</td><td>9</td><td>20</td></tr>
<tr><td>Constant</td><td>0</td><td>0</td><td>0</td><td>0</td><td>4</td><td>0</td></tr>
<tr><td rowspan="4">Phase 3</td><td colspan="2">Scale</td><td>0.00</td><td>0.14</td><td>0.18</td><td>0.00</td><td>0.00</td><td>0.09</td></tr>
<tr><td rowspan="3">Returns to scale</td><td>Increasing</td><td>0</td><td>0</td><td>3</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Decreasing</td><td>51</td><td>42</td><td>41</td><td>51</td><td>51</td><td>46</td></tr>
<tr><td>Constant</td><td>0</td><td>9</td><td>7</td><td>0</td><td>0</td><td>5</td></tr>
<tr><td rowspan="4">Phase 4</td><td colspan="2">Scale</td><td>0.00</td><td>0.00</td><td>0.66</td><td>0.00</td><td>0.02</td><td>0.00</td></tr>
<tr><td rowspan="3">Returns to scale</td><td>Increasing</td><td>0</td><td>0</td><td>17</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Decreasing</td><td>49</td><td>49</td><td>7</td><td>49</td><td>49</td><td>49</td></tr>
<tr><td>Constant</td><td>0</td><td>0</td><td>25</td><td>0</td><td>0</td><td>0</td></tr>
</table>

*AB - African Bank Ltd.; CB - Capitec Bank; DB - Deutsche Bank AG; IB -Investec South Africa; JPM - JP Morgan Chase bank; HSBC - The Hongkong and Shanghai Corporation Limited-Johannesburg Branch.

IB displayed complete scale inefficiency (for all practical purposes) during each of the four phases. As is the case with central bank and money, this is particularly concerning, seeing that it attained relatively high technical efficiency scores compared to that of the other banks (see Figure 5.10), although SA group and finance contributed a maximum of 10% to its total inputs (see Figure 5.5). HSBC experienced a systematic decline in its average scale efficiency from Phase 1 (30%). From Phase 4 onwards, all the medium-sized banks can make substantial changes in their operations to increase their respective average scale efficiencies of SA group and finance. DB can improve its average scale efficiency by 34% while the other medium-sized banks need to make vast improvements. Each of the other banks can improve their average scale efficiency by 100% except for JPM, which can improve by 98%. Further comparison of the scale efficiency scores in Figure 5.24 for the business cycle phases does not reveal any specific correlation, except perhaps that AB and HSBC experienced their respective maximum scale efficiency scores in the upward phase of Phase 1. Also, CB, JPM, and HSBC experienced relatively high (CB and HSBC) to high (JPM) scale efficiencies during the crisis phase of Phase 2 (downward phase).

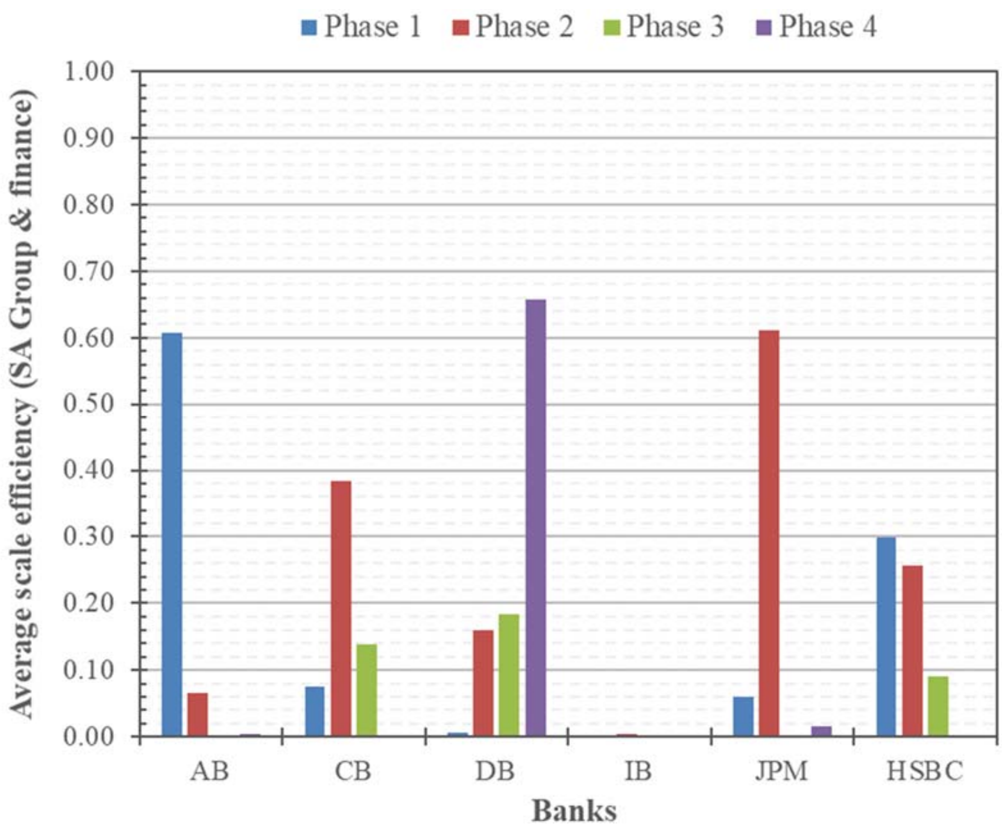

Figure 5.24: Average scale efficiency estimates of SA group and finance for the medium-sized banks for Phase 1 – 4. Source: compiled by author.

The standard deviations for the average scale efficiencies of the medium-sized banks (Table 5.13 and Figure 5.24) under SA group and finance as input are illustrated in Figure 5.25. Concerning the business cycle phases, it is apparent from Figure 5.25 that AB, JPM and HSBC experienced significant volatility in their respective scale efficiency scores during the upward constituent of Phase 1. DB, JPM, and HSBC also experienced high levels of volatility in scale efficiencies during the crisis phase (Phase 2), while CB, DB and HSBC experienced the same conditions during the final downward phase (Phase 4).

In most cases, the standard deviations in the respective average scale efficiency scores were large, even when the average scale efficiency was in the order of 10% to 30%, such as those of CB, DB, and HSBC in Phase 3. Evidently the medium-sized banks lacked the appropriate internal systems and strategies to minimise the costs associated with the use of SA group and finance as input (Cronje, 2003, Cronjé, 2007). Furthermore, the banks also failed to achieve a stable scale of operation for this input and should therefore aim to improve on these two aspects going forward from Phase 4.

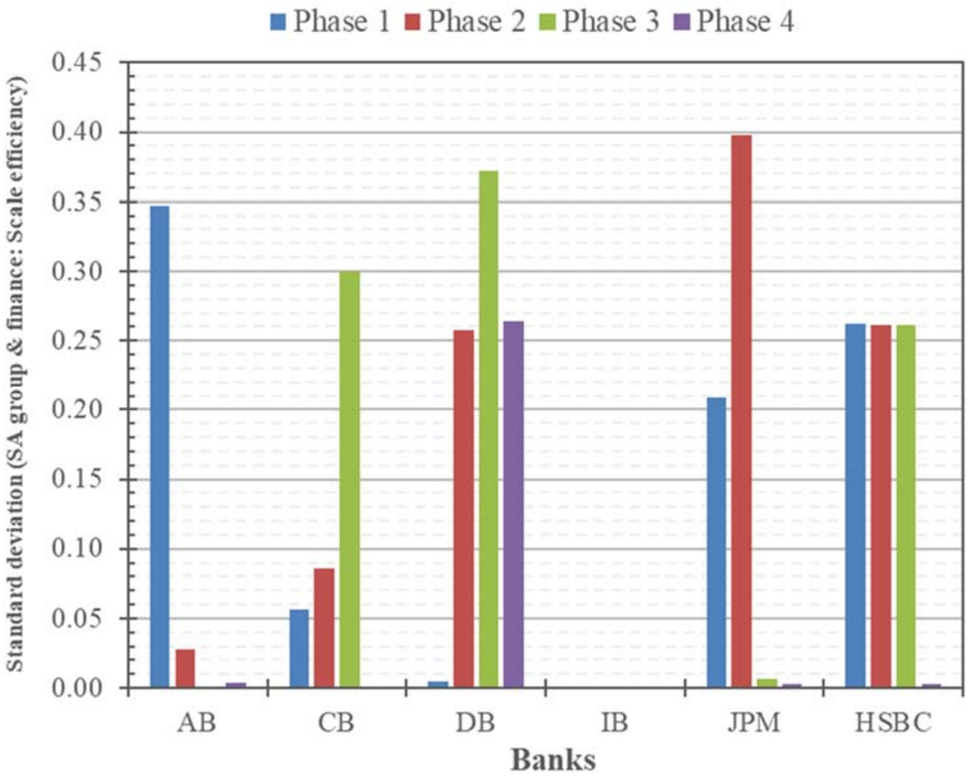

Figure 5.25: Standard deviation of scale efficiency estimates (SA group & finance). Source: compiled by author.

It is further evident from Table 5.13 that IB was the only medium-sized bank that operated at decreasing returns to scale (at a scale that was too large) during the entire study period of 168 months. AB, CB, DB, JPM and HSBC all operated at decreasing returns to scale during the majority of the 168-month period, i.e. during 133, 91, 115, 153 and 132 months respectively. CB and DB exhibited the most instances of operating at increasing returns to scale (a less than optimal scale), namely during 30 and 21 months respectively. JPM and HSBC operated at increasing returns to scale during only eight and nine months respectively. Except for IB, all the medium-sized banks experienced instances where operation proceeded at constant returns to scale. AB and CB exhibited the most instances as they operated at constant returns to scale during 35 and 47 months respectively, followed by DB and HSBC, who operated at constant returns to scale during 32 and 27 months respectively. JPM operated at constant returns to scale during the least number of months, namely during only seven out of the total of 168 months. DB and JPM were the only banks to reach full scale efficiency during the study period, albeit at a limited number of instances, namely that DB and JPM reached full scale efficiency during five and four months respectively.

The conclusions drawn from the technical and scale efficiency estimates of the medium-sized banks, as discussed above, will be summarised in the following section.

5.4. Conclusion

A hierarchal cluster analysis using the nearest neighbourhood method showed that Deutsche Bank AG (DB), the Hongkong and Shanghai Banking Corporation Ltd - Johannesburg branch (HSBC), Capitec Bank (CB), JP Morgan Chase bank (JPM), and African Bank Ltd. (AB) can be classified as the medium-sized banks in South Africa. Investec South Africa (IB), which is normally regarded as one of the top five banks, was found to have a significantly smaller average value of total asset (for the study period) compared with the other top four banks and for this reason was included in this study. IB was therefore regarded as the largest medium-sized bank in terms of total assets in this study.

The input distribution of each of the medium-sized banks across the four phases that were considered showed that the total inputs of the respective banks were generally dominated by total deposits. However, the inputs of AB, CB, DB, and JPM also included a significant portion of total equity. Central bank and money contributed the least to the total inputs of the medium-sized banks, with the input distribution of only CB across all four phases and that of DB in Phase 3 consisting of a sizeable proportion of more than roughly 5% of this input. Except in some instances for AB, CB, and DB, SA group and finance contributed between 15% and 25% to the total inputs of these medium-sized banks. In all other instances SA group and finance contributed only roughly 10% of the total inputs of all the medium-sized banks. In addition to contributing a relatively small proportion of the collective inputs of the medium-sized banks as considered in this study, the poor technical and scale efficiency results with respect to central bank and money and SA group finance indicated that the banks did not effectively apply these two inputs (low technical efficiency scores) in addition to applying them at an inappropriate scale (low scale efficiency scores). Therefore, the medium-sized banks should revise their internal systems and strategies and make adjustments to the scale of their operations to improve their technical and scale efficiency results for these two inputs (Cronje, 2003:32; Cronjé, 2007:11).

In terms of the overall technical efficiency, DB, IB, and JPM displayed the highest average overall scores that ranged between 90% and 99%. However, analysis of the input-specific technical efficiency scores showed that IB attained the highest average technical efficiency scores with respect to each individual input that was considered. The only exceptions occurred with in Phase 1 and Phase 4 when DB had higher average technical efficiency scores than IB for total equity. IB was the largest medium-sized bank included in this study (Table 5.1), and its size could help explain this behaviour since Miller & Noulas (1996:507) found in their study of 201 banks between 1984 and 1990 that larger, that more profitable banks tended to be characterised by higher levels of technical efficiency. A specific example of its advantage as a relatively large medium-sized bank is that IB was the only bank to achieve reasonable average technical efficiency scores in terms of central bank and money and SA group and finance.

However, the scale efficiency results indicated that IB operated at decreasing returns to scale for all but 10 of the 168 months considered and exhibited the highest level of scale inefficiency of all the medium-sized banks. Therefore, although IB's internal systems and strategies facilitated relatively high technical efficiency scores, it constantly operated at a scale that was too large and should reduce its scale to improve its cost-effectiveness. The scale inefficiency of IB stands in stark contrast to its generally high technical efficiency scores, but this correlates with the observation of Miller & Noulas (1996:507), namely that banks that experience scale inefficiency do not experience technical inefficiency. Nonetheless, all the other medium-sized banks also displayed a higher degree of scale inefficiency than technical inefficiency, and total equity was the only input for which respectable scale efficiencies had been attained by all the banks including IB, especially in the downward business cycle phase of Phase 4. Thus, all banks need to make adjustments to the scale of their operations to become more cost-effective.

With regards to the influence of the business cycle phases on the efficiency scores, it is concluded that both the technical and scale efficiency scores of the medium-sized banks (overall scores and input-specific scores) did not display a clear correlation with the upward and downward business cycle phases. Often, upward phases correlated with suppressed efficiency scores while increased efficiency scores were noted during the downward phases, especially during Phase 2 during which time the global financial crisis occurred. These counterintuitive results were also found by other authors (Erasmus & Makina, 2014:315), albeit for the major South African banks. One possible reason that was cited in such studies was that the South African banking industry is particularly resilient to external economic fluctuations due to its conservative banking practises that are supported by strict regulatory frameworks that limit foreign risk. It is therefore concluded that the medium-sized banks might also have benefited from such regulatory-driven practises that includes the National Credit Act (34 of 2005) and the Basel I (BIS, 1988), Basel II (BIS, 2004), and Basel III (BIS, 2011) frameworks. Another possible explanation for the anomalous results is that a time-lag effect could be at play. This is because instances were noted where efficiencies decreased in the upward business cycle phase that followed the downward crisis phase. In other instances, increased efficiencies were noted in a downward phase that followed directly on an upward phase. Therefore, it is possible for the effects of one business cycle phase to only present in the subsequent phase, which may influence results.

By examining the lower technical and scale efficiency scores for the total equity input often noted in Phase 3 (an upward phase) and following Phase 2 (a downward phase that also coincided with the crisis period), one possible reason found for this apparent time-lag effect might be related to reduced capital reserves following the downward phase of Phase 2. The Basel committee (BIS, 2011:6) prescribes minimum requirements to promote capital conservation to build sufficient buffers that can be used during downward business cycle phases. Although this might have been the case with the medium-sized banks, a downward business cycle phase such as Phase 2 (the financial crisis period) would partially drain any capital reserves. The banks would then revert to capital conservation in a subsequent upward business cycle phase to replenish the capital buffers as required by Basel and would be less focussed on using it to achieve higher output targets.

Another notable finding is the fact that, with the exception of SA group and finance, AB achieved its highest average technical efficiency scores with respect to the other three inputs during Phase 4, and this was also true for its average overall technical efficiencies between Phase 1 and Phase 4. This behaviour could have been brought on by the financial and managerial support that AB received from the SARB after defaulting in 2014 (Bonorchis, 2016), as this event fell in Phase 4. This evidently could have led to improved internal systems and strategies through which its efficiency was increased.

Finally, despite some instances of efficiency being observed with respect to technical and scale efficiency of the medium-sized banks of South Africa, significant improvements can still be made. This is especially true for technical and scale efficiency in terms of both central bank and money and SA group and finance as inputs. It would therefore be prudent for all the medium-sized banks to review their internal systems and strategies toward improving their technical efficiency while also aiming to make the appropriate adjustments to the scale of their operations to minimise costs.

Chapter 6

Conclusions & Recommendations

6.1. Introduction

A summary of the research conducted in this study will be presented in this chapter together with an evaluation of how the results obtained address the aim and objectives of the dissertation as formulated in Chapter 1.

The aim of this study (Section 1.3.1) has been to determine the efficiency of the medium-sized banks in South Africa over various phases of the business cycle, seeing that bank efficiency is of paramount importance to a country's economy and that there is not enough evidence on the efficiency of medium-sized banks in the country. As noted in Chapter 2, this is because the banking industry of a country contributes to its gross domestic product (GDP), and an efficient banking industry limits financial instability (Butterworth & Malherbe, 1999:5).

To assist in addressing the aim of this study, the following objectives have been formulated, namely (Section 1.3.2.):

- To review the South African financial sector with specific emphasis on the importance of banks.
- To explore the various efficiency measures available.
- To distinguish between performance measures and efficiency measures of banks.
- To analyse the efficiency of South-African medium-sized banks using a data envelopment analysis (DEA) model.
- To compare the efficiency levels of the medium-sized banks over various phases of the business cycle.
- To interpret the results obtained on technical and scale efficiency measurements of South Africa's medium-sized banks and make appropriate recommendations.

6.2. Summary and conclusions

This section will firstly reiterate the relevance and importance of bank efficiency, specifically within the South African context, and how the first two objectives have been addressed (Section 6.2.1). Secondly, a summary of how the last three objectives have been addressed in this study will be presented (Section 6.2.2).

6.2.1. The importance of bank efficiency and efficiency measures

To address the first objective, namely to review the South African financial sector with specific emphasis on the importance of banks, a literature review, as presented in Chapter 2, has been conducted. From this review it has been surmised that the South African financial sector, especially the banking industry, is one of the most advanced and developed in Africa (Okeahalam, 2001:15). The fact that well-developed risk-management systems have been implemented (Hughes & Mester, 2008:2) strengthens the fact that South African banks are well managed. This is important considering that banks play a paramount role in the success of the South African financial sector and failing to perform their principal roles will result in economic crises. In this regard, bank efficiency is an important concept because it provides an indication of the financial strength of a bank, where banks with high levels of performance are found to be highly efficient and vice versa. Inefficient banks, however, are more likely to experience higher levels of exposure to risks. Although the efficiency of the major South African banks has been well-studied (Van der Westhuizen, 2014; Okeahalam, 2001; Van Heerden & Heymans, 2013; Van der Westhuizen, 2008; Maredza & Ikhide, 2013), the question remains whether the medium-sized banks in South Africa are efficient and whether their efficiency is influenced by business cycle movements.

The results of this study indicated that the technical and scale efficiency of the medium-sized banks were indeed influenced by the business cycle phases, although the opposite of the expected behaviour was often noted. The results obtained in this study further showed that some of the medium-sized banks did exhibit signs of being efficient, although only a few banks achieved efficiency scores close to 100% in some instances. However, none of the banks showed simultaneous technical and scale efficiency. In other words, in most instances the medium-sized banks exhibited some degree of technical efficiency, while failing to achieve respectable scale efficiency scores, or vice versa. In respect to the role of the medium-sized banks in the South African financial sector, it can therefore be concluded that the technical and scale efficiency of the medium-sized banks can be improved to contribute further to the growth of the sector. Increased technical and scale efficiency would also contribute to a higher degree of resilience of these banks towards financial crises, which will be very beneficial during periods of significant economic downturn.

The second objective, namely, to distinguish between performance measures and efficiency measures of banks and to explore the various efficiency measures available, has been addressed in Chapter 3. In this chapter, performance and efficiency measures were distinguished and the various methods of estimating performance and efficiency were reviewed. Traditional performance measures, which form part of fundamental analyses, include financial ratios and relying on accounting data to estimate companies' financial positions. In addition to financial ratios, other performance measures include the DuPont analysis model and the economic value-added model (EVA). However, performance measures were also characterised in Chapter 3 by disadvantages, of which the most notable is that performance measures are inadequate for fully characterising operational performance due to the tendency of these measures to only focus on the short term. Furthermore, the lack of available data negatively affects the accuracy of performance measures since each performance benchmark only uses a subsection of applicable data. As noted above, efficiency and performance, although two distinctly different concepts, correlate. Therefore, only efficiency measures, also known as non-financial performance measures, have been considered in this study to estimate the efficiency of the South African medium-sized banks. These non-financial performance measures include the data envelopment analysis (DEA) model (Section 4.3.3), the stochastic frontier analysis (SFA) (Anderson *et al.*, 1999; Battese & Coelli, 1995; Vitaliano & Toren, 1994), the thick frontier analysis (TFA) (Berger & Humphrey, 1991; Berger & Humphrey, 1997), and the balance scorecard (BSC) method (Kaplan & Norton, 1992; Kaplan & Norton, 2001a).

Only the DEA method was used in this study, thereby addressing the third objective. The use of the DEA method was motivated by the advantages it offers, including it being a flexible method that is compatible with qualitative and quantitative data as well as non-discretionary and discretionary inputs. The DEA model is further advantageous since it can be used to identify the best-practices in complex circumstances and to distinguish between failing and non-failing banks. In essence, the DEA method entails solving a set of linear programming problems that yields a non-parametric, linearly piecewise, convex frontier, i.e. an efficiency frontier that envelops the input and output data. This efficiency frontier represents the optimal operating conditions under which production costs are minimised. Specifically, the intermediation approach with an input-oriented measure was identified to be the most appropriate tool for this study, which is consistent with previous studies on the efficiency of the major South African banks (Cronjé, 2007; Van der Westhuizen, 2014; Okeahalam, 2001).

The DEAFrontier software, which is an add-in for Microsoft Excel® developed by Zhu (2016), was used to estimate the technical and scale efficiency of the medium-sized banks with the intermediation approach and the input-oriented measure under the constant returns to scale and variable returns to scale model specifications. The inputs used for the DEA analysis were total deposits, central bank and money, total equity, and South Africa (SA) group and finance. The outputs of the efficiency estimates that were measured included other liabilities, deposits, loans and advances, investments, and bills, following the work of Yue (1992:36), Van Heerden and Heymans (2013:747), Grmanová and Ivanová (2018:260), Muhammad (2008:11), Jayamaha (2012:567), Mlambo and Ncube (2011:10), Kao and Liu (2004:2355), Kamau (2011:15), Wheelock and Wilson (1995:692-693), Elyasiani and Mehdian (1990:163-164) and Kaparakis *et al*. (1994:887). The input and output data obtained from the BA900 reports (SARB, 2018), and the average input distribution for each bank were analysed across the four phases, which indicated that total deposits were the dominant input for all the medium-sized banks. This input was followed by total equity, SA group and finance, and lastly, central bank and money, to which the banks had the least access as input.

The results of the DEA will be summarised in the following section together with the hierarchal cluster analysis results that were used to identify the medium-sized banks, thereby addressing the fourth and fifth objectives.

6.2.2. Efficiency measurement results

The results of the hierarchal single-linkage cluster analysis revealed the medium-sized banks of South Africa to be African Bank Ltd. (AB), Capitec Bank (CB), Deutsche Bank AG (DB), Investec South Africa (IB), JP Morgan Chase bank (JPM), and The Hongkong and Shanghai Banking Corporation Limited- Johannesburg Branch (HSBC). Although Investec South Africa is normally categorised as being one of the top five banks in South Africa, it was assigned to its own cluster in the cluster analysis results, and for this reason was also included as a medium-sized bank in this study.

DEA of the medium-sized banks were subsequently conducted to estimate the technical and scale efficiency scores of these medium-sized banks. The study period considered in this study spanned 13 years between January 2004 and December 2017, and consisted of four business cycle phases, i.e. upward and downward cycle phases. The four business cycle phases also included the different phases of the global financial crisis, and were namely an upward phase that spanned 47 months between January 2004 and November 2007 (pre-crisis phase), a downward phase that spanned 21 months between December 2007 and August 2009 (crisis phase), another upward phase that spanned 51 months between September 2009 and November 2013 (post crisis phase), followed by another downward phase that spanned 49 months between December 2013 and December 2017 (post crisis phase). During the latter phase, African Bank Ltd. caused major upsets throughout the financial system when it became exposed to credit risk. Efficient banks with high performance levels are of cardinal importance in stimulating and maintaining economic growth (Okeahalam, 2006; Spong *et al*., 1995; Levine, 1997), and this is especially true for the banking industry of a country that comprises large, medium, and small-sized banks (Ongore & Kusa, 2013:238). Had the SARB not taken control of African Bank Ltd. in 2014 before it defaulted, the South African economy could have been exposed to systemic risk. This has raised concerns regarding the efficiency of the medium-sized banks of South Africa, and forms part of the motivation for this study (Section 1.1). The results of the DEA will be summarised in the following paragraphs.

A summary of the technical efficiency results is given in Table 6.1 in which the banks are ranked from most efficient in Column 1 to least efficient in Column 6 over the four business cycle phases. This is done for the overall technical efficiency and the four input-specific technical efficiencies. The efficiency scores are also given.

The information in Table 6.1 was subsequently used to count the number of times that each bank was ranked in each category (first to sixth) in any of the technical efficiency measures. This number was then multiplied by a ranking factor, which equalled 1 for Column 1, ½ for Column 2, ¼ for Column 3, etc., to generate a ranking score. The total score for each bank was then computed so that the banks could be ranked holistically from most efficient to least efficient in terms of technical efficiency. Through this procedure, IB was identified as the most technically efficient bank, followed by JPM and DB as the second and third most technically efficient banks. AB was ranked fourth, followed by HSBC and CB at fifth and sixth respectively.

Table 6.1: Technical efficiency ranking table. Source: compiled by author.

Technical Efficiency	Phase #	Ranking											
		1		2		3		4		5		6	
Overall technical efficiency	1	JPM	0.95	IB	0.92	DB	0.91	AB	0.87	HSBC	0.77	CB	0.64
	2	IB	0.97	DB	0.95	JPM	0.94	CB	0.83	HSBC	0.74	AB	0.59
	3	DB	0.98	IB	0.97	JPM	0.91	HSBC	0.90	AB	0.81	CB	0.71
	4	DB	0.99	IB	0.97	AB	0.96	JPM	0.90	HSBC	0.71	CB	0.45
Total Deposits	1	IB	0.9	AB	0.79	JPM	0.75	DB	0.35	CB	0.29	HSBC	0.25
	2	IB	0.96	JPM	0.75	CB	0.66	DB	0.64	AB	0.57	HSBC	0.43
	3	IB	0.94	AB	0.71	JPM	0.68	CB	0.58	DB	0.44	HSBC	0.35
	4	IB	0.97	AB	0.88	JPM	0.70	DB	0.56	CB	0.32	HSBC	0.24
Central Bank & money	1	IB	0.63	JPM	0.21	HSBC	0.04	DB	0.00	AB	0.00	CB	0.00
	2	IB	0.92	JPM	0.41	DB	0.36	HSBC	0.08	AB	0.06	CB	0.02
	3	IB	0.73	JPM	0.27	DB	0.25	AB	0.21	CB	0.02	HSBC	0.00
	4	IB	0.95	AB	0.50	JPM	0.31	DB	0.29	HSBC	0.28	CB	0.17
Total Equity	1	DB	0.9	JPM	0.83	IB	0.76	HSBC	0.70	CB	0.56	AB	0.12
	2	IB	0.95	DB	0.91	JPM	0.74	HSBC	0.70	CB	0.55	AB	0.30
	3	IB	0.95	DB	0.79	JPM	0.65	HSBC	0.61	CB	0.30	AB	0.30
	4	DB	0.96	IB	0.90	HSBC	0.70	JPM	0.66	AB	0.39	CB	0.27
SA Group & finance	1	IB	0.60	JPM	0.20	DB	0.00	HSBC	0.00	AB	0.00	CB	0.00
	2	IB	0.73	JPM	0.28	DB	0.08	HSBC	0.04	AB	0.03	CB	0.00
	3	IB	0.76	AB	0..33	JPM	0.18	DB	0.14	HSBC	0.13	CB	0.05
	4	IB	0.23	DB	0.11	JPM	0.08	HSBC	0.04	AB	0.02	CB	0.00

*AB - African Bank Ltd.; CB - Capitec Bank; DB - Deutsche Bank AG; IB -Investec South Africa; JPM - JP Morgan Chase Bank; HSBC - The Hongkong and Shanghai Corporation Limited-Johannesburg Branch.

As noted in Chapter 5, the fact that IB was identified as the most technically efficient bank correlates with the observation by Miller and Noulas (1996:507) in that larger banks tend to be characterised by higher levels of technical efficiency. As also noted previously, IB had the highest average total assets of all the banks considered and was assigned to its own cluster in the cluster analysis when all the South African banks had been included in the analysis (Section

5.2). Although IB's total assets were significantly greater than that of the other medium-sized banks, it was also less than half that of Nedbank Ltd., which was the smallest of the four major banks according to total average assets. For this reason, IB was included in this study as one of the medium-sized banks. However, its larger size compared with the other medium-sized banks afforded it a slight competitive advantage. As also noted in Chapter 5, DB and JPM mostly showed consistently high technical efficiency scores, as was the case with IB. These two banks are, however, local branches of foreign banks, and as noted by Claessens *et al*. (2001:908), foreign banks tend to have higher levels of profitability and interest margins than domestic banks in developing economies. This would have contributed to the higher technical efficiencies of DB and JPM compared to the other domestic banks.

AB was found to be the second least technically efficient and was also the only bank to experience a marked decrease in its average overall technical efficiency from Phase 1 to Phase 2. In hindsight, this might have been an early warning signal that the bank's practices were not completely sound. However, AB frequently experienced sudden increases in its technical efficiency scores in Phase 4, which coincided with the SARB taking over curatorship of the bank when it defaulted in 2014 (Bonorchis, 2016). Despite HSBC also being a local branch of a foreign bank, it frequently displayed average to poor technical efficiencies. While the same was true for CB, it was the only bank to experience a significant increase in its average overall technical efficiency during the downward business cycle phase of Phase 2. This coincided with the strong growth that CB experienced from 2008 in contrast with other banks in the low-income market. Nonetheless, the relatively poor overall performance of CB in its technical efficiency scores indicates that there is still much room for improvement in the bank's internal systems and strategies.

A summary of the scale efficiency results is given in Table 6.2, in which the banks are ranked from most efficient to least efficient as explained for Table 6.1. In using the same scoring system as explained above for the technical efficiency results, JPM was identified as the medium-sized bank that generally exhibited the highest scale efficiency, followed by DB as the second most scale efficient, and AB and HSBC collectively as third. CB was ranked fourth, followed by IB, who exhibited the highest level of inefficiency. Although the comparably higher scale efficiencies of JPM and DB against the other medium-sized banks correlated with the same in terms of their technical efficiencies, IB showed the opposite behaviour. This result corresponds with the conclusions of Miller and Noulas (1996:503) from their study on 201 banks, namely that banks that experience technical efficiency can experience scale inefficiency. IB was also the only bank to operate at decreasing returns to scale throughout almost the entire study period and therefore needs to decrease the scale of its operations to increase its cost effectiveness.

Table 6.2: Scale efficiency ranking table. Source: compiled by author.

Scale Efficiency	Phase #	Ranking											
		1		2		3		4		5		6	
Overall scale efficiency	1	AB	0.99	JPM	0.91	HSBC	0.73	DB	0.66	CB	0.53	IB	0.48
	2	JPM	0.93	AB	0.92	DB	0.91	HSBC	0.80	IB	0.60	CB	0.57
	3	JPM	0.98	DB	0.96	AB	0.95	HSBC	0.83	CB	0.82	IB	0.63
	4	CB	0.99	AB	0.99	HSBC	0.98	JPM	0.95	IB	0.95	DB	0.85
Total Deposits	1	CB	0.95	JPM	0.77	AB	0.66	HSBC	0.61	DB	0.43	IB	0.21
	2	HSBC	0.94	JPM	0.90	DB	0.87	AB	0.83	CB	0.72	IB	0.45
	3	AB	0.98	JPM	0.92	DB	0.91	HSBC	0.91	CB	0.88	IB	0.43
	4	JPM	0.93	HSBC	0.69	AB	0.68	DB	0.55	CB	0.54	IB	0.20
Central Bank & money	1	JPM	0.56	DB	0.55	AB	0.26	HSBC	0.26	CB	0.03	IB	0.00
	2	HSBC	0.82	JPM	0.73	DB	0.67	AB	0.61	CB	0.30	IB	0.03
	3	CB	0.14	DB	0.13	HSBC	0.09	JPM	0.02	AB	0.00	IB	0.00
	4	DB	0.47	JPM	0.07	HSBC	0.03	AB	0.02	CB	0.02	IB	0.01
Total Equity	1	JPM	0.80	DB	0.64	AB	0.32	HSBC	0.31	IB	0.16	CB	0.03
	2	JPM	0.91	AB	0.87	DB	0.83	HSBC	0.69	IB	0.51	CB	0.19
	3	DB	0.93	JPM	0.87	HSBC	0.79	AB	0.78	CB	0.75	IB	0.45
	4	HSBC	0.98	JPM	0.94	IB	0.94	CB	0.94	AB	0.92	DB	0.71
SA Group & finance	1	AB	0.61	HSBC	0.30	CB	0.08	JPM	0.06	DB	0.01	IB	0.00
	2	JPM	0.61	CB	0.38	HSBC	0.26	DB	0.16	AB	0.06	IB	0.00
	3	DB	0.18	CB	0.14	HSBC	0.09	JPM	0.00	AB	0.00	IB	0.00
	4	DB	0.66	JPM	0.02	AB	0.00	HSBC	0.00	CB	0.00	IB	0.00

*AB - African Bank Ltd.; CB - Capitec Bank; DB - Deutsche Bank AG; IB -Investec South Africa; JPM - JP Morgan Chase Bank; HSBC - The Hongkong and Shanghai Corporation Limited-Johannesburg Branch.

In general, lower scale efficiency scores were observed for the medium-sized banks compared to their technical efficiency scores. It is therefore concluded that all the medium-sized banks can make substantial adjustments to the scale of their operations to become more efficient and reduce their production costs. In this regard, improving their respective scale efficiencies for central banks and money and SA group and finance requires special attention. Overall, JPM generally exhibited relatively high scale efficiency, and did so more consistently than the other medium-sized banks. In general, significant improvements in the overall and input-oriented technical and scale efficiencies of the medium-sized banks in South Africa can still be achieved.

Considering the different inputs, SA group and finance and central bank and money accounted for a comparatively small portion of the input distribution of the medium-sized banks. Generally, the medium-sized banks also displayed the lowest technical and scale efficiency scores with respect to these two inputs. IB, however, was the exception as it was the only bank to obtain reasonable technical efficiency scores while fairing the worst in terms of scale efficiency. IB and AB can mainly focus on addressing their poor scale efficiencies, while the other medium-sized banks, especially AB, CB and HSBC should aim at improving their technical efficiencies by increasing the utilisation of their inputs.

In respect of the different business cycle phases considered in this study, some anomalous behaviour was noted although similar observations have been made in previous studies (Shirvani *et al*., 2011:7-9; Erasmus & Makina, 2014:315). These include that a clear dependence of the average efficiency scores on the upward and downward cycle phases could not be deduced. Two possible explanations are proposed in this regard. One is that it is possible that the medium-sized banks indeed also benefited from the highly developed banking industry in South Africa (Erasmus & Makina, 2014:315; Okeahalam, 2001:15) that was characterised by strict regulations and conservative banking practices (Basel I, (BIS, 1988); Basel II, (BIS, 2004); & Basel III,(BIS, 2011); the National Credit Act, (34 of 2005)). Another explanation, based on observing the results, is that in many instances it would seem that the negative or positive effects of a downward or upward business cycle phase only reflect in the subsequent phase. In terms of total equity as an input, it was noted in Chapter 5 that this could be associated with reduced capital, which is an outcome of the Basel requirements for capital adequacy. A downward business cycle phase, such as Phase 2 (the financial crisis period), would partially drain any capital buffers. The banks would then revert to capital conservation to replenish the capital buffers as required by Basel and would be less focussed on using it to achieve higher output targets in subsequent upward business cycle phases.

Finally, the medium-sized banks show some signs of technical and scale inefficiency in respect of (i) specific inputs, especially central bank and money and SA group and finance, and (ii) inconsistency, since instances of high volatility were found to negatively affect the average efficiency scores.

6.3. Recommendations

Two sets of recommendations are made, namely recommendations based on the results of this study and, secondly, recommendations for future study.

Firstly, to address the two points mentioned in the conclusions, that is, (i) improving input-specific efficiency, and (ii) reducing volatility, the following recommendations are made that may be considered by the medium-sized banks. By focussing on improving their respective operations according to these recommendations, the medium-sized banks can significantly improve their overall technical and scale efficiency scores, which in turn will make a positive contribution to the banking industry and thus the South African economy.

- Since all banks plays a pivotal role in an economy (Chapter 2), improved technical and scale efficiency is also highly desired to limit the economy's risk exposure and to help prevent financial crises during periods of global economic downturn or political uncertainty.
- In light of the previous point, it istherefore recommended that all banks should aim at improving the consistency with which the various inputs are used and the scales at which they operate to prevent periods of technical and scale inefficiency from reducing their overall efficiency scores.
- AB, HSBC and CB should focus on improving their input utilisation to achieve improved technical efficiency, especially with respect to central bank and money and SA group and finance. This could be achieved by revising their internal systems and strategies and possibly also their managerial systems.
- DB, IB and JPM do not need to make major adjustments in their use of total deposits and total equity, but like AB, HSBC and CB can make significant improvements to the utilisation of central bank and money and SA group and finance as inputs.
- In terms of scale efficiency IB, as the most scale inefficient medium-sized bank, should aim at adjusting the scale of its operations to improve its cost-effectiveness with respect

to central bank and money and SA group and finance. Specifically, it should decrease the scale of its operations to increase its cost effectiveness.

- DB and JPM achieved relatively good scale efficiency scores and require minor adjustments to the scale of their operations with respect to total deposits and total equity to further improve in this regard. However, like all the other medium-sized banks, it should entail substantial improvements for central bank and money and SA group and finance as inputs.
- AB, HSBC, and CB need to focus on making the same adjustments as DB and JPM, although to a larger extent. Additionally, these banks also require substantial improvements in total deposits and total equity as inputs.

Secondly, the following recommendations are further made with respect to this study:

- Limitations were encountered in this study concerning the unavailability of financial data to perform fundamental analysis, which could have been used to compliment the efficiency analysis. This aspect can be further investigated in subsequent studies as data becomes available to confirm the conclusions reached in this study.
- Confirmation of the time-lag effect on the efficiency scores can be done by analysing the efficiency of the medium-sized banks over extended study periods in which more upward and downward business cycle phases can be included. In so doing, other major economic events can be included, which can help confirm whether negative external economic factors take time to manifest, for which lags and persistence tests could be useful.
- Determine the reasons for the observed volatility with respect to the technical and scale efficiency scores across the various phases to make more concrete recommendations as to how the medium-sized banks can improve their operations to limit fluctuations in their efficiency scores. This entails an internal evaluation of each bank.
- Estimate the extent to which improvements in the technical and scale efficiency of the medium-sized banks can contribute to the strength of the financial sector and thus the national economy.
- The contributions of central bank and money and SA group and finance to the total inputs of the medium-sized banks that were considered in this study were few. It was also noted that the medium-sized banks displayed poor efficiency with respect to these

two inputs. Therefore, a different input composition could be considered which would yield a more even distribution.

- Finally, other efficiency measurement methods can also be considered to compare the results obtained from the DEA method used in this study. Such efficiency methods include the stochastic frontier analysis (SFA) and the thick frontier analysis (TFA) methods.

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Appendix A

Table A.1: Overall technical efficiency estimates for all the medium-sized banks for Phase 1 (Jan 2004 - Nov 2007).

Date	***Phase 1: Overall Technical Efficiency***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Jan-04	1.00	1.00	1.00	1.00	0.95	1.00
Feb-04	0.98	0.94	1.00	0.93	1.00	1.00
Mar-04	0.95	1.00	1.00	0.93	1.00	1.00
Apr-04	0.93	0.92	1.00	0.93	0.75	0.999
May-04	0.90	0.97	0.98	1.00	0.79	1.00
Jun-04	0.90	0.98	0.93	1.00	0.79	0.999
Jul-04	0.93	0.97	0.93	0.86	0.90	0.99
Aug-04	0.92	0.89	0.95	0.85	0.76	1.00
Sep-04	1.00	0.90	0.96	0.88	0.77	0.98
Oct-04	0.94	0.86	0.94	0.88	0.93	0.98
Nov-04	0.96	0.81	0.91	0.88	1.00	0.98
Dec-04	1.00	0.81	0.91	0.83	1.00	0.98
Jan-05	0.99	0.76	0.93	0.80	1.00	0.96
Feb-05	1.00	0.74	0.93	0.81	1.00	0.97
Mar-05	0.79	0.69	0.92	0.87	1.00	0.95
Apr-05	0.80	0.72	0.90	0.85	0.87	0.95
May-05	0.83	0.67	0.87	0.85	0.88	0.94
Jun-05	0.91	0.77	0.87	0.81	1.00	0.95
Jul-05	0.96	0.78	0.91	0.88	1.00	0.95
Aug-05	1.00	0.75	0.97	0.84	1.00	0.94
Sep-05	0.99	0.72	0.93	0.86	1.00	0.94
Oct-05	0.96	0.67	0.92	0.88	1.00	0.94
Nov-05	0.95	0.63	0.93	0.92	0.98	0.90
Dec-05	1.00	0.64	0.96	0.91	0.99	0.56
Jan-06	0.95	0.63	0.96	0.90	1.00	0.86

Date	*Phase 1: Overall Technical Efficiency*					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Feb-06	0.88	0.60	0.94	0.90	0.98	0.67
Mar-06	0.87	0.58	0.97	0.93	0.99	0.55
Apr-06	0.86	0.58	0.91	0.92	1.00	0.57
May-06	0.79	0.56	0.94	0.89	0.98	0.60
Jun-06	0.84	0.59	1.00	1.00	0.96	0.60
Jul-06	0.83	0.57	0.93	0.90	1.00	0.59
Aug-06	0.84	0.42	0.90	0.94	0.97	0.58
Sep-06	0.90	0.41	0.91	1.00	1.00	0.54
Oct-06	0.84	0.37	0.79	0.98	1.00	0.56
Nov-06	0.78	0.37	0.82	0.88	1.00	0.55
Dec-06	0.92	0.40	0.88	0.96	1.00	0.57
Jan-07	0.82	0.40	0.89	0.98	1.00	0.56
Feb-07	0.75	0.34	0.97	0.96	1.00	0.57
Mar-07	0.72	0.35	1.00	1.00	0.98	0.54
Apr-07	0.68	0.37	0.89	0.90	0.88	0.56
May-07	0.66	0.36	0.82	0.91	0.86	0.54
Jun-07	0.72	0.39	0.77	1.00	0.88	0.55
Jul-07	0.71	0.40	0.75	0.99	0.90	0.59
Aug-07	0.68	0.41	0.79	0.98	0.91	0.55
Sep-07	0.69	0.45	0.77	1.00	0.95	0.54
Oct-07	0.70	0.48	0.71	1.00	1.00	0.50
Nov-07	0.72	0.41	0.80	0.88	1.00	0.48
Fully Technical Efficient	6	2	6	9	23	5
Min	0.66	0.34	0.71	0.80	0.75	0.48
Mean	0.87	0.64	0.91	0.92	0.95	0.77
Max	1.00	1.00	1.00	1.00	1.00	1.00
Standard Deviation	0.11	0.21	0.07	0.06	0.07	0.21

Table A.2: Overall scale efficiency estimates for all the medium-sized banks for Phase 1 (Jan 2004 - Nov 2007).

Date	***Phase 1: Overall Scale Efficiency***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Jan-04	1.00	1.00	0.54	0.50	1.00	0.69
Feb-04	0.999	0.49	0.52	0.50	1.00	0.72
Mar-04	0.998	0.74	0.51	0.51	1.00	0.50
Apr-04	0.995	0.47	0.54	0.51	0.97	0.53
May-04	0.99	0.54	0.51	0.48	0.99	0.50
Jun-04	0.99	0.46	0.53	0.46	0.99	0.48
Jul-04	0.999	0.46	0.47	0.52	0.91	0.48
Aug-04	0.997	0.37	0.61	0.52	0.97	0.52
Sep-04	1.00	0.48	0.57	0.52	0.94	0.51
Oct-04	0.998	0.45	0.52	0.51	0.89	0.51
Nov-04	0.998	0.40	0.48	0.51	1.00	0.49
Dec-04	1.00	0.41	0.54	0.53	1.00	0.49
Jan-05	0.99	0.35	0.62	0.53	0.94	0.52
Feb-05	1.00	0.36	0.58	0.53	1.00	0.53
Mar-05	0.99	0.25	0.62	0.52	1.00	0.51
Apr-05	0.99	0.40	0.60	0.52	0.83	0.49
May-05	0.995	0.37	0.51	0.52	0.99	0.59
Jun-05	0.998	0.34	0.51	0.52	0.82	0.55
Jul-05	0.998	0.33	0.55	0.49	0.79	0.59
Aug-05	1.00	0.31	0.79	0.49	1.00	0.55
Sep-05	0.999	0.35	0.60	0.49	0.76	0.50
Oct-05	0.999	0.38	0.65	0.49	0.78	0.49
Nov-05	0.997	0.38	0.62	0.48	0.78	0.54
Dec-05	1.00	0.43	0.57	0.47	0.74	0.85
Jan-06	0.98	0.43	0.51	0.46	0.90	0.70
Feb-06	0.99	0.40	0.66	0.47	0.78	0.93
Mar-06	0.99	0.38	0.87	0.46	0.77	0.89
Apr-06	0.998	0.38	0.62	0.45	0.86	0.91

Date	*Phase 1: Overall Scale Efficiency*					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
May-06	0.998	0.38	0.77	0.46	0.82	0.93
Jun-06	0.997	0.36	0.99	0.42	0.88	0.98
Jul-06	0.997	0.38	0.99	0.46	1.00	0.96
Aug-06	0.99	0.44	0.75	0.45	0.92	0.99
Sep-06	0.96	0.46	0.84	0.43	1.00	0.86
Oct-06	0.99	0.56	0.64	0.42	1.00	0.92
Nov-06	0.99	0.57	0.63	0.46	0.92	0.88
Dec-06	0.97	0.62	0.67	0.44	0.99	0.89
Jan-07	0.99	0.64	0.74	0.43	1.00	0.88
Feb-07	0.997	0.73	0.80	0.44	1.00	0.91
Mar-07	0.99	0.80	0.99	0.42	0.83	0.91
Apr-07	0.99	0.94	0.73	0.46	0.79	0.92
May-07	0.99	0.89	0.80	0.46	0.83	0.93
Jun-07	0.997	0.81	0.59	0.42	0.80	0.94
Jul-07	0.99	0.80	0.53	0.43	0.84	0.98
Aug-07	0.99	0.86	0.84	0.44	0.86	0.91
Sep-07	0.98	0.87	0.82	0.45	0.83	0.92
Oct-07	0.98	0.86	0.74	0.42	1.00	0.98
Nov-07	0.998	0.79	0.86	0.45	1.00	0.98
Fully Scale Efficient	6	1	0	0	14	0
Min	0.96	0.25	0.47	0.42	0.74	0.48
Mean	0.99	0.53	0.66	0.48	0.91	0.73
Max	1.00	1.00	0.99	0.53	1.00	0.99
Standard Deviation	0.01	0.20	0.14	0.04	0.09	0.20

Table A.3: Technical efficiency estimates with respect to total deposits for all the medium-sized banks in Phase 1 (Jan 2004 - Nov 2007).

Date	***Phase 1: Technical Efficiency -Total Deposits***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Jan-04	0.98	1.00	0.28	1.00	0.92	0.81
Feb-04	0.94	0.32	0.28	0.92	0.89	0.14
Mar-04	0.87	0.79	0.27	0.93	1.00	0.15
Apr-04	0.81	0.46	0.28	0.93	0.65	0.16
May-04	0.78	0.56	0.26	0.94	0.72	0.15
Jun-04	0.75	0.47	0.27	0.90	0.76	0.14
Jul-04	0.92	0.45	0.22	0.86	0.67	0.14
Aug-04	0.90	0.31	0.32	0.85	0.67	0.15
Sep-04	1.00	0.42	0.30	0.88	0.67	0.15
Oct-04	0.91	0.37	0.25	0.88	0.73	0.14
Nov-04	0.87	0.31	0.21	0.88	0.93	0.15
Dec-04	1.00	0.33	0.26	0.83	0.99	0.14
Jan-05	0.99	0.25	0.32	0.80	0.86	0.14
Feb-05	0.97	0.26	0.30	0.81	1.00	0.15
Mar-05	0.55	0.15	0.33	0.87	0.71	0.14
Apr-05	0.55	0.29	0.30	0.85	0.63	0.15
May-05	0.62	0.24	0.23	0.85	0.87	0.16
Jun-05	0.79	0.26	0.23	0.81	0.65	0.15
Jul-05	0.88	0.25	0.28	0.88	0.71	0.17
Aug-05	0.997	0.20	0.39	0.84	0.69	0.15
Sep-05	0.91	0.20	0.34	0.86	0.62	0.14
Oct-05	0.91	0.19	0.35	0.88	0.67	0.14
Nov-05	0.93	0.16	0.36	0.92	0.66	0.16
Dec-05	1.00	0.20	0.35	0.90	0.64	0.15
Jan-06	0.91	0.18	0.32	0.87	0.74	0.29
Feb-06	0.79	0.17	0.37	0.89	0.68	0.35

Date	*Phase 1: Technical Efficiency -Total Deposits*					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Mar-06	0.75	0.15	0.45	0.92	0.62	0.20
Apr-06	0.73	0.16	0.32	0.90	0.69	0.22
May-06	0.62	0.16	0.42	0.88	0.65	0.21
Jun-06	0.70	0.15	0.49	0.90	0.68	0.36
Jul-06	0.70	0.15	0.47	0.89	0.71	0.31
Aug-06	0.78	0.16	0.38	0.92	0.74	0.26
Sep-06	0.90	0.17	0.44	1.00	1.00	0.28
Oct-06	0.81	0.20	0.30	0.91	1.00	0.34
Nov-06	0.74	0.21	0.29	0.86	0.70	0.31
Dec-06	0.81	0.23	0.35	0.94	0.66	0.38
Jan-07	0.69	0.20	0.41	0.92	0.69	0.36
Feb-07	0.63	0.24	0.45	0.94	0.71	0.37
Mar-07	0.62	0.28	0.60	0.91	0.66	0.32
Apr-07	0.59	0.34	0.40	0.89	0.59	0.32
May-07	0.58	0.32	0.40	0.90	0.62	0.33
Jun-07	0.63	0.31	0.28	1.00	0.64	0.37
Jul-07	0.63	0.30	0.26	0.94	0.67	0.47
Aug-07	0.62	0.29	0.50	0.95	0.71	0.41
Sep-07	0.65	0.29	0.46	1.00	0.60	0.38
Oct-07	0.67	0.22	0.42	1.00	0.97	0.38
Nov-07	0.66	0.17	0.60	0.88	1.00	0.36
Fully Technical Efficient	3	1	0	5	5	0
Min	0.55	0.15	0.21	0.80	0.59	0.14
Mean	0.79	0.29	0.35	0.90	0.75	0.25
Max	1.00	1.00	0.60	1.00	1.00	0.81
Standard Deviation	0.14	0.16	0.09	0.05	0.13	0.13

Table A.4: Scale efficiency estimates with respect to total deposits for all the medium-sized banks in Phase 1 (Jan 2004 - Nov 2007).

Date	***Phase 1: Scale Efficiency -Total Deposits***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Jan-04	0.84	1.00	0.52	0.28	0.98	0.85
Feb-04	0.84	0.998	0.54	0.28	0.96	0.81
Mar-04	0.84	0.92	0.56	0.29	0.97	0.82
Apr-04	0.84	0.92	0.42	0.28	0.999	0.76
May-04	0.85	0.92	0.54	0.27	0.999	0.77
Jun-04	0.83	0.93	0.55	0.25	0.999	0.77
Jul-04	0.83	0.95	0.59	0.23	0.85	0.76
Aug-04	0.82	0.99	0.31	0.22	0.85	0.73
Sep-04	0.84	0.97	0.34	0.20	0.80	0.79
Oct-04	0.84	0.98	0.44	0.22	0.94	0.79
Nov-04	0.84	0.99	0.56	0.20	0.91	0.86
Dec-04	0.83	0.98	0.41	0.23	0.86	0.84
Jan-05	0.80	0.995	0.30	0.23	0.86	0.83
Feb-05	0.83	0.96	0.35	0.22	1.00	0.72
Mar-05	0.82	0.99	0.35	0.21	0.91	0.84
Apr-05	0.81	0.96	0.33	0.20	0.88	0.86
May-05	0.82	0.97	0.48	0.20	0.91	0.83
Jun-05	0.80	0.98	0.46	0.20	0.83	0.77
Jul-05	0.76	0.996	0.36	0.23	0.73	0.77
Aug-05	0.74	0.97	0.24	0.24	0.71	0.73
Sep-05	0.75	0.96	0.56	0.23	0.81	0.85
Oct-05	0.73	0.94	0.50	0.22	0.84	0.79
Nov-05	0.69	0.94	0.60	0.23	0.73	0.87
Dec-05	0.67	0.94	0.70	0.22	0.68	0.85
Jan-06	0.63	0.93	0.90	0.23	0.75	0.70
Feb-06	0.66	0.84	0.29	0.21	0.66	0.75
Mar-06	0.69	0.94	0.24	0.21	0.61	0.59
Apr-06	0.69	0.88	0.37	0.21	0.59	0.62
May-06	0.67	0.96	0.37	0.20	0.55	0.63

Date	***Phase 1: Scale Efficiency -Total Deposits***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Jun-06	0.64	0.93	0.36	0.20	0.63	0.59
Jul-06	0.60	0.95	0.25	0.20	0.58	0.55
Aug-06	0.56	0.92	0.40	0.20	0.58	0.42
Sep-06	0.73	0.97	0.35	0.20	0.67	0.36
Oct-06	0.70	0.97	0.49	0.20	0.46	0.32
Nov-06	0.67	0.96	0.38	0.20	0.61	0.35
Dec-06	0.51	0.95	0.38	0.19	0.53	0.28
Jan-07	0.50	0.91	0.31	0.18	0.47	0.31
Feb-07	0.47	0.95	0.29	0.17	0.40	0.28
Mar-07	0.41	0.96	0.24	0.16	0.55	0.31
Apr-07	0.39	0.97	0.42	0.16	0.58	0.32
May-07	0.37	0.96	0.35	0.16	0.78	0.29
Jun-07	0.38	0.95	0.55	0.16	0.70	0.27
Jul-07	0.36	0.94	0.65	0.16	0.84	0.23
Aug-07	0.33	0.93	0.35	0.15	0.85	0.24
Sep-07	0.33	0.92	0.39	0.15	0.99	0.29
Oct-07	0.31	0.88	0.62	0.15	0.999	0.31
Nov-07	0.30	0.85	0.37	0.15	1.00	0.27
Fully Scale Efficient	0	1	0	0	2	0
Min	0.30	0.84	0.24	0.15	0.40	0.23
Mean	0.66	0.95	0.43	0.21	0.77	0.61
Max	0.85	1.00	0.90	0.29	1.00	0.87
Standard Deviation	0.18	0.04	0.14	0.04	0.17	0.23

Table A.5: Technical efficiency estimates with respect to Central bank and money for all the medium-sized banks in Phase 1 (Jan 2004 - Nov 2007).

Date	*Phase 1: Technical Efficiency -Central bank and money*					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Jan-04	0.00	0.00	0.00	1.00	0.37	1.00
Feb-04	0.00	0.00	0.00	0.86	1.00	1.00
Mar-04	0.00	0.00	0.00	0.71	0.76	0.00
Apr-04	0.00	0.00	0.00	0.70	0.00	0.00
May-04	0.00	0.00	0.00	0.68	0.00	0.00
Jun-04	0.00	0.00	0.00	0.70	0.00	0.00
Jul-04	0.00	0.00	0.00	0.34	0.00	0.00
Aug-04	0.00	0.00	0.00	0.32	0.00	0.00
Sep-04	0.00	0.00	0.00	0.35	0.00	0.00
Oct-04	0.00	0.00	0.00	0.32	0.00	0.00
Nov-04	0.00	0.00	0.00	0.33	1.00	0.00
Dec-04	0.00	0.00	0.00	0.28	0.79	0.00
Jan-05	0.00	0.00	0.00	0.26	0.00	0.00
Feb-05	0.00	0.00	0.00	0.41	1.00	0.00
Mar-05	0.00	0.00	0.00	0.34	0.00	0.00
Apr-05	0.00	0.00	0.00	0.32	0.00	0.00
May-05	0.00	0.00	0.00	0.35	0.24	0.00
Jun-05	0.00	0.00	0.00	0.31	0.00	0.00
Jul-05	0.00	0.00	0.00	0.48	0.00	0.00
Aug-05	0.00	0.00	0.00	0.53	0.00	0.00
Sep-05	0.00	0.00	0.00	0.55	0.00	0.00
Oct-05	0.00	0.00	0.00	0.50	0.00	0.00
Nov-05	0.00	0.00	0.00	0.58	0.00	0.00
Dec-05	0.00	0.00	0.00	0.60	0.00	0.00
Jan-06	0.00	0.00	0.00	0.66	0.00	0.00
Feb-06	0.00	0.00	0.00	0.53	0.00	0.00
Mar-06	0.00	0.00	0.00	0.51	0.00	0.00
Apr-06	0.00	0.00	0.00	0.70	0.00	0.00
May-06	0.00	0.00	0.00	0.57	0.00	0.00

Date	*Phase 1: Technical Efficiency -Central bank and money*					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Jun-06	0.00	0.00	0.00	1.00	0.33	0.00
Jul-06	0.00	0.00	0.00	0.60	0.30	0.00
Aug-06	0.00	0.00	0.00	0.69	0.30	0.00
Sep-06	0.00	0.00	0.00	1.00	1.00	0.00
Oct-06	0.00	0.00	0.00	0.98	1.00	0.00
Nov-06	0.00	0.00	0.00	0.61	0.19	0.00
Dec-06	0.00	0.00	0.00	0.68	0.13	0.00
Jan-07	0.00	0.00	0.00	0.90	0.03	0.00
Feb-07	0.00	0.00	0.00	0.84	1.00	0.00
Mar-07	0.00	0.00	0.00	1.00	0.00	0.00
Apr-07	0.00	0.00	0.00	0.51	0.00	0.00
May-07	0.00	0.00	0.00	0.53	0.00	0.00
Jun-07	0.00	0.00	0.00	1.00	0.00	0.00
Jul-07	0.00	0.00	0.00	0.78	0.00	0.00
Aug-07	0.00	0.00	0.00	0.78	0.00	0.00
Sep-07	0.00	0.00	0.00	1.00	0.00	0.00
Oct-07	0.00	0.00	0.00	1.00	0.02	0.00
Nov-07	0.00	0.00	0.00	0.73	0.47	0.00
Fully Technical Efficient	0	0	0	7	6	2
Min	0.00	0.00	0.00	0.26	0.00	0.00
Mean	0.00	0.00	0.00	0.63	0.21	0.04
Max	0.00	0.00	0.00	1.00	1.00	1.00
Standard Deviation	0.00	0.00	0.00	0.24	0.36	0.20

Table A.6: Scale efficiency estimates with respect to Central bank and money for all the medium-sized banks in Phase 1 (Jan 2004 - Nov 2007).

Date	***Phase 1: Scale Efficiency -Central bank and money***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Jan-04	0.21	0.01	0.42	0.00	0.00	0.01
Feb-04	0.21	0.01	0.41	0.00	0.00	0.08
Mar-04	0.21	0.01	0.40	0.00	0.00	0.07
Apr-04	0.21	0.01	0.42	0.00	0.93	0.09
May-04	0.21	0.01	0.39	0.00	0.97	0.10
Jun-04	0.21	0.01	0.40	0.00	0.91	0.09
Jul-04	0.21	0.01	0.34	0.00	0.90	0.10
Aug-04	0.21	0.01	0.50	0.00	0.82	0.12
Sep-04	0.20	0.01	0.47	0.00	0.83	0.11
Oct-04	0.20	0.01	0.41	0.00	0.98	0.10
Nov-04	0.20	0.01	0.34	0.00	0.00	0.10
Dec-04	0.21	0.01	0.41	0.00	0.00	0.10
Jan-05	0.21	0.01	0.52	0.00	0.03	0.13
Feb-05	0.21	0.01	0.48	0.00	1.00	0.17
Mar-05	0.21	0.01	0.50	0.00	0.81	0.14
Apr-05	0.21	0.01	0.48	0.00	0.81	0.16
May-05	0.21	0.01	0.35	0.00	0.00	0.18
Jun-05	0.22	0.01	0.35	0.00	0.97	0.19
Jul-05	0.22	0.02	0.41	0.00	0.99	0.19
Aug-05	0.22	0.02	0.69	0.00	0.94	0.18
Sep-05	0.23	0.02	0.53	0.00	0.83	0.13
Oct-05	0.23	0.02	0.54	0.00	0.82	0.13
Nov-05	0.24	0.02	0.60	0.00	0.78	0.14
Dec-05	0.26	0.02	0.61	0.00	0.81	0.15
Jan-06	0.26	0.02	0.52	0.00	0.91	0.18
Feb-06	0.26	0.02	0.54	0.00	0.87	0.31
Mar-06	0.25	0.02	0.76	0.00	0.83	0.18
Apr-06	0.25	0.02	0.50	0.00	0.92	0.24
May-06	0.25	0.02	0.67	0.00	0.86	0.21

Date	*Phase 1: Scale Efficiency -Central bank and money*					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Jun-06	0.26	0.02	0.93	0.00	0.00	0.41
Jul-06	0.26	0.03	0.90	0.00	0.00	0.35
Aug-06	0.27	0.03	0.64	0.00	0.00	0.32
Sep-06	0.26	0.03	0.74	0.00	0.00	0.36
Oct-06	0.26	0.03	0.51	0.00	0.00	0.40
Nov-06	0.27	0.03	0.52	0.00	0.00	0.40
Dec-06	0.29	0.04	0.55	0.00	0.00	0.49
Jan-07	0.30	0.04	0.63	0.00	0.00	0.47
Feb-07	0.30	0.04	0.68	0.00	1.00	0.47
Mar-07	0.31	0.04	0.88	0.00	0.83	0.39
Apr-07	0.32	0.05	0.63	0.00	0.78	0.38
May-07	0.33	0.05	0.69	0.00	0.81	0.40
Jun-07	0.33	0.05	0.44	0.00	0.97	0.46
Jul-07	0.34	0.05	0.43	0.00	0.87	0.57
Aug-07	0.36	0.05	0.69	0.00	0.90	0.58
Sep-07	0.37	0.06	0.67	0.00	0.81	0.52
Oct-07	0.39	0.06	0.57	0.00	0.00	0.50
Nov-07	0.40	0.07	0.72	0.00	0.00	0.50
Fully Scale Efficient	0	0	0	0	2	0
Min	0.20	0.01	0.34	0.00	0.00	0.01
Mean	0.26	0.03	0.55	0.00	0.56	0.26
Max	0.40	0.07	0.93	0.00	1.00	0.58
Standard Deviation	0.05	0.02	0.15	0.00	0.43	0.16

Table A.7: Technical efficiency estimates with respect to total equity for all the medium-sized banks in Phase 1 (Jan 2004 - Nov 2007).

Date	***Phase 1: Technical Efficiency -Total Equity***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Jan-04	0.15	0.84	1.00	1.00	0.69	0.99
Feb-04	0.15	0.83	0.99	0.92	0.70	1.00
Mar-04	0.15	0.81	1.00	0.85	0.70	0.99
Apr-04	0.14	0.80	1.00	0.68	0.65	0.97
May-04	0.14	0.80	0.98	0.65	0.65	1.00
Jun-04	0.14	0.83	0.93	0.48	0.64	0.99
Jul-04	0.13	0.80	0.93	0.49	0.62	0.99
Aug-04	0.13	0.78	0.95	0.49	0.61	0.99
Sep-04	0.13	0.75	0.94	0.48	0.62	0.97
Oct-04	0.13	0.73	0.93	0.50	0.65	0.98
Nov-04	0.12	0.74	0.91	0.50	0.67	0.98
Dec-04	0.14	0.73	0.90	0.47	0.68	0.98
Jan-05	0.13	0.71	0.92	0.45	0.63	0.96
Feb-05	0.13	0.70	0.91	0.46	0.66	0.96
Mar-05	0.13	0.67	0.90	0.50	0.61	0.95
Apr-05	0.12	0.66	0.90	0.50	0.60	0.95
May-05	0.12	0.65	0.86	0.52	0.63	0.93
Jun-05	0.11	0.73	0.86	0.51	1.00	0.94
Jul-05	0.11	0.72	0.89	0.63	1.00	0.94
Aug-05	0.11	0.71	0.95	0.68	0.997	0.94
Sep-05	0.12	0.68	0.93	0.68	0.96	0.94
Oct-05	0.12	0.64	0.92	0.68	0.96	0.94
Nov-05	0.11	0.62	0.93	0.80	0.95	0.90
Dec-05	0.12	0.61	0.96	0.82	0.97	0.49
Jan-06	0.12	0.62	0.96	0.84	0.98	0.49
Feb-06	0.12	0.60	0.94	0.84	0.95	0.48
Mar-06	0.12	0.57	0.97	0.86	0.96	0.48
Apr-06	0.12	0.57	0.90	0.88	0.96	0.48
May-06	0.12	0.55	0.94	0.85	0.94	0.48

Date	***Phase 1: Technical Efficiency -Total Equity***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Jun-06	0.12	0.59	1.00	0.90	0.96	0.49
Jul-06	0.12	0.56	0.93	0.86	0.94	0.48
Aug-06	0.11	0.41	0.90	0.90	0.96	0.47
Sep-06	0.11	0.41	0.91	1.00	1.00	0.47
Oct-06	0.11	0.34	0.79	0.89	1.00	0.46
Nov-06	0.11	0.34	0.82	0.84	0.99	0.46
Dec-06	0.13	0.35	0.88	0.96	1.00	0.47
Jan-07	0.13	0.34	0.89	0.92	0.99	0.47
Feb-07	0.12	0.24	0.97	0.96	1.00	0.46
Mar-07	0.12	0.24	1.00	0.91	0.90	0.45
Apr-07	0.11	0.23	0.89	0.90	0.85	0.44
May-07	0.11	0.23	0.82	0.91	0.84	0.44
Jun-07	0.12	0.24	0.77	1.00	0.88	0.43
Jul-07	0.12	0.24	0.75	0.99	0.84	0.45
Aug-07	0.11	0.23	0.75	0.98	0.81	0.44
Sep-07	0.11	0.23	0.74	1.00	0.83	0.43
Oct-07	0.11	0.23	0.68	1.00	0.88	0.33
Nov-07	0.13	0.23	0.69	0.83	0.93	0.33
Fully Technical Efficient	0	0	5	5	6	2
Min	0.11	0.23	0.68	0.45	0.60	0.33
Mean	0.12	0.56	0.90	0.76	0.83	0.70
Max	0.15	0.84	1.00	1.00	1.00	1.00
Standard Deviation	0.01	0.21	0.08	0.19	0.15	0.26

Table A.8: Scale efficiency estimates with respect to total equity for all the medium-sized banks in Phase 1 (Jan 2004 - Nov 2007).

Date	***Phase 1: Scale Efficiency -Total Equity***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Jan-04	0.26	0.01	0.51	0.11	0.95	0.01
Feb-04	0.26	0.01	0.50	0.12	0.96	0.10
Mar-04	0.26	0.01	0.49	0.11	0.99	0.09
Apr-04	0.26	0.01	0.52	0.14	0.85	0.11
May-04	0.26	0.01	0.48	0.15	0.87	0.12
Jun-04	0.26	0.01	0.49	0.19	0.83	0.11
Jul-04	0.26	0.01	0.42	0.20	0.75	0.12
Aug-04	0.27	0.01	0.61	0.20	0.68	0.15
Sep-04	0.25	0.01	0.57	0.20	0.65	0.13
Oct-04	0.25	0.01	0.50	0.19	0.86	0.13
Nov-04	0.25	0.01	0.42	0.20	0.92	0.13
Dec-04	0.26	0.01	0.51	0.20	0.94	0.13
Jan-05	0.27	0.01	0.63	0.21	0.80	0.17
Feb-05	0.26	0.01	0.59	0.21	0.89	0.21
Mar-05	0.27	0.01	0.61	0.20	0.65	0.18
Apr-05	0.27	0.01	0.59	0.20	0.70	0.20
May-05	0.27	0.01	0.44	0.19	0.86	0.22
Jun-05	0.27	0.01	0.44	0.19	0.78	0.24
Jul-05	0.27	0.02	0.51	0.16	0.71	0.24
Aug-05	0.28	0.02	0.81	0.15	0.69	0.22
Sep-05	0.29	0.02	0.59	0.15	0.67	0.16
Oct-05	0.29	0.02	0.63	0.16	0.64	0.17
Nov-05	0.30	0.02	0.62	0.14	0.63	0.18
Dec-05	0.32	0.03	0.56	0.14	0.68	0.18
Jan-06	0.33	0.03	0.43	0.14	0.70	0.19
Feb-06	0.32	0.02	0.66	0.15	0.72	0.29
Mar-06	0.31	0.02	0.87	0.14	0.74	0.22
Apr-06	0.31	0.02	0.61	0.14	0.79	0.27
May-06	0.32	0.02	0.77	0.14	0.78	0.25

Date	***Phase 1: Scale Efficiency -Total Equity***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Jun-06	0.32	0.03	0.99	0.14	0.82	0.39
Jul-06	0.33	0.03	0.99	0.14	0.86	0.36
Aug-06	0.34	0.03	0.75	0.14	0.91	0.39
Sep-06	0.32	0.03	0.84	0.12	1.00	0.45
Oct-06	0.33	0.03	0.61	0.13	0.84	0.50
Nov-06	0.34	0.03	0.63	0.14	0.90	0.49
Dec-06	0.36	0.04	0.66	0.13	0.99	0.59
Jan-07	0.37	0.04	0.74	0.14	0.99	0.57
Feb-07	0.38	0.04	0.80	0.14	1.00	0.56
Mar-07	0.39	0.05	0.99	0.15	0.80	0.49
Apr-07	0.40	0.05	0.73	0.15	0.72	0.47
May-07	0.41	0.05	0.80	0.15	0.65	0.50
Jun-07	0.41	0.06	0.54	0.14	0.73	0.57
Jul-07	0.42	0.06	0.45	0.15	0.71	0.68
Aug-07	0.44	0.07	0.79	0.15	0.70	0.69
Sep-07	0.46	0.07	0.77	0.14	0.70	0.62
Oct-07	0.48	0.08	0.58	0.14	0.85	0.61
Nov-07	0.50	0.09	0.82	0.14	0.95	0.60
Fully Scale efficient	0	0	0	0	2	0
Min	0.25	0.01	0.42	0.11	0.63	0.01
Mean	0.32	0.03	0.64	0.16	0.80	0.31
Max	0.50	0.09	0.99	0.21	1.00	0.69
Standard Deviation	0.07	0.02	0.16	0.03	0.11	0.19

Table A.9: Technical efficiency estimates with respect to SA group and finance for all the medium-sized banks in Phase 1 (Jan 2004 - Nov 2007).

Date	***Phase 1: Technical Efficiency -SA group and finance***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Jan-04	0.00	0.00	0.00	1.00	0.00	0.00
Feb-04	0.00	0.00	0.00	0.63	0.00	0.00
Mar-04	0.00	0.00	0.00	0.84	1.00	0.00
Apr-04	0.00	0.00	0.00	0.70	0.00	0.00
May-04	0.00	0.00	0.00	1.00	0.00	0.00
Jun-04	0.00	0.00	0.00	0.78	0.00	0.00
Jul-04	0.00	0.00	0.00	0.58	0.44	0.00
Aug-04	0.00	0.00	0.00	0.56	0.00	0.00
Sep-04	0.00	0.00	0.00	0.58	0.00	0.00
Oct-04	0.00	0.00	0.00	0.60	0.36	0.00
Nov-04	0.00	0.00	0.00	0.66	0.48	0.00
Dec-04	0.00	0.00	0.00	0.51	1.00	0.00
Jan-05	0.00	0.00	0.00	0.46	0.13	0.00
Feb-05	0.00	0.00	0.00	0.40	0.01	0.00
Mar-05	0.00	0.00	0.00	0.54	0.05	0.00
Apr-05	0.00	0.00	0.00	0.54	0.05	0.00
May-05	0.00	0.00	0.00	0.45	0.02	0.00
Jun-05	0.00	0.00	0.00	0.37	0.00	0.00
Jul-05	0.00	0.00	0.00	0.53	0.02	0.00
Aug-05	0.00	0.00	0.00	0.45	0.02	0.00
Sep-05	0.00	0.00	0.00	0.47	0.11	0.00
Oct-05	0.00	0.00	0.00	0.54	0.01	0.00
Nov-05	0.00	0.00	0.00	0.68	0.02	0.00
Dec-05	0.00	0.00	0.00	0.62	0.05	0.00
Jan-06	0.00	0.00	0.00	0.44	0.42	0.00
Feb-06	0.00	0.00	0.00	0.44	0.10	0.00
Mar-06	0.00	0.00	0.00	0.62	0.05	0.00
Apr-06	0.00	0.00	0.00	0.47	0.44	0.00
May-06	0.00	0.00	0.00	0.44	0.14	0.00

Date	***Phase 1: Technical Efficiency -SA group and finance***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Jun-06	0.00	0.00	0.00	0.47	0.00	0.00
Jul-06	0.00	0.00	0.00	0.46	0.10	0.00
Aug-06	0.00	0.00	0.00	0.59	0.06	0.00
Sep-06	0.00	0.00	0.00	1.00	1.00	0.00
Oct-06	0.00	0.00	0.00	0.58	1.00	0.00
Nov-06	0.00	0.00	0.00	0.43	0.25	0.00
Dec-06	0.00	0.00	0.00	0.74	0.01	0.00
Jan-07	0.00	0.00	0.00	0.53	1.00	0.00
Feb-07	0.00	0.00	0.00	0.56	0.01	0.00
Mar-07	0.00	0.00	0.00	0.49	0.13	0.00
Apr-07	0.00	0.00	0.00	0.46	0.01	0.00
May-07	0.00	0.00	0.00	0.52	0.00	0.00
Jun-07	0.00	0.00	0.00	1.00	0.00	0.00
Jul-07	0.00	0.00	0.00	0.60	0.03	0.00
Aug-07	0.00	0.00	0.00	0.67	0.02	0.00
Sep-07	0.00	0.00	0.00	1.00	0.00	0.00
Oct-07	0.00	0.00	0.00	1.00	0.00	0.00
Nov-07	0.00	0.00	0.00	0.42	0.85	0.00
Fully Technical Efficient	0	0	0	6	5	0
Min	0.00	0.00	0.00	0.37	0.00	0.00
Mean	0.00	0.00	0.00	0.60	0.20	0.00
Max	0.00	0.00	0.00	1.00	1.00	0.00
Standard Deviation	0.00	0.00	0.00	0.18	0.33	0.00

Table A.10: Scale efficiency estimates with respect to SA group and finance for all the medium-sized banks in Phase 1 (Jan 2004 - Nov 2007).

Date	***Phase 1: Scale Efficiency -SA group and finance***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Jan-04	0.73	0.02	0.01	0.00	0.01	0.01
Feb-04	0.74	0.02	0.01	0.00	0.02	0.28
Mar-04	0.73	0.02	0.01	0.00	1.00	0.25
Apr-04	0.73	0.02	0.01	0.00	0.03	0.30
May-04	0.73	0.02	0.01	0.00	0.13	0.33
Jun-04	0.74	0.03	0.01	0.00	0.99	0.31
Jul-04	0.74	0.03	0.02	0.00	0.01	0.34
Aug-04	0.74	0.03	0.01	0.00	0.01	0.41
Sep-04	0.70	0.03	0.01	0.00	0.01	0.37
Oct-04	0.69	0.03	0.01	0.00	0.01	0.37
Nov-04	0.70	0.03	0.02	0.00	0.01	0.36
Dec-04	0.73	0.03	0.01	0.00	0.01	0.36
Jan-05	0.74	0.03	0.00	0.00	0.01	0.47
Feb-05	0.74	0.03	0.01	0.00	0.01	0.59
Mar-05	0.74	0.03	0.01	0.00	0.01	0.50
Apr-05	0.75	0.03	0.01	0.00	0.01	0.55
May-05	0.74	0.03	0.01	0.00	0.01	0.63
Jun-05	0.76	0.04	0.01	0.00	0.01	0.68
Jul-05	0.77	0.04	0.01	0.00	0.00	0.67
Aug-05	0.78	0.05	0.00	0.00	0.00	0.62
Sep-05	0.80	0.06	0.01	0.00	0.01	0.46
Oct-05	0.82	0.06	0.00	0.00	0.01	0.47
Nov-05	0.85	0.06	0.01	0.00	0.01	0.51
Dec-05	0.90	0.07	0.01	0.00	0.00	0.51
Jan-06	0.91	0.07	0.02	0.00	0.00	0.51
Feb-06	0.91	0.07	0.00	0.00	0.00	0.78
Mar-06	0.87	0.07	0.00	0.00	0.00	0.60
Apr-06	0.88	0.07	0.01	0.00	0.00	0.76
May-06	0.89	0.07	0.00	0.00	0.00	0.71

Date	***Phase 1: Scale Efficiency -SA group and finance***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Jun-06	0.90	0.07	0.00	0.00	0.00	0.03
Jul-06	0.92	0.07	0.00	0.00	0.00	0.17
Aug-06	0.94	0.07	0.00	0.00	0.00	0.03
Sep-06	0.91	0.07	0.00	0.00	0.00	0.01
Oct-06	0.93	0.08	0.01	0.00	0.00	0.01
Nov-06	0.96	0.09	0.00	0.00	0.00	0.01
Dec-06	0.16	0.11	0.00	0.00	0.00	0.01
Jan-07	0.06	0.11	0.00	0.00	0.00	0.01
Feb-07	0.04	0.12	0.00	0.00	0.00	0.01
Mar-07	0.03	0.13	0.00	0.00	0.00	0.01
Apr-07	0.02	0.13	0.00	0.00	0.00	0.01
May-07	0.02	0.14	0.00	0.00	0.01	0.01
Jun-07	0.02	0.15	0.01	0.00	0.00	0.01
Jul-07	0.02	0.16	0.01	0.00	0.01	0.00
Aug-07	0.01	0.18	0.00	0.00	0.01	0.00
Sep-07	0.01	0.20	0.00	0.00	0.02	0.00
Oct-07	0.01	0.22	0.01	0.00	0.40	0.01
Nov-07	0.01	0.24	0.00	0.00	0.00	0.01
Fully Scale Efficient	0	0	0	0	1	0
Min	0.01	0.02	0.00	0.00	0.00	0.00
Mean	0.61	0.08	0.01	0.00	0.06	0.30
Max	0.96	0.24	0.02	0.00	1.00	0.78
Standard Deviation	0.35	0.06	0.00	0.00	0.21	0.26

Table A.11: Overall technical efficiency estimates for all the medium-sized banks for Phase 2 (Dec 2007 - Aug 2009).

Date	***Phase 2: Overall technical efficiency***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Dec-07	1.00	1.00	1.00	0.86	1.00	0.88
Jan-08	0.56	0.99	1.00	0.87	1.00	0.97
Feb-08	0.53	0.98	1.00	0.94	0.82	0.89
Mar-08	0.53	1.00	1.00	0.96	1.00	0.87
Apr-08	0.51	1.00	1.00	0.99	1.00	0.83
May-08	0.50	0.96	1.00	0.99	1.00	0.82
Jun-08	0.54	0.92	1.00	1.00	1.00	0.81
Jul-08	0.53	0.88	1.00	0.96	0.73	0.80
Aug-08	0.51	0.84	1.00	1.00	0.98	0.79
Sep-08	0.51	0.83	0.94	1.00	0.73	0.64
Oct-08	0.54	0.80	0.94	1.00	1.00	0.63
Nov-08	0.55	0.80	0.99	0.998	1.00	0.64
Dec-08	0.60	0.79	0.96	0.996	0.88	0.74
Jan-09	0.66	0.77	0.94	0.99	1.00	0.68
Feb-09	0.62	0.73	0.93	0.96	0.83	0.65
Mar-09	0.65	0.72	1.00	0.95	0.82	0.66
Apr-09	0.63	0.70	0.84	0.95	1.00	0.66
May-09	0.56	0.67	0.82	0.91	1.00	0.65
Jun-09	0.59	0.69	0.85	1.00	1.00	0.61
Jul-09	0.62	0.67	0.82	0.98	1.00	0.62
Aug-09	0.66	0.66	1.00	1.00	1.00	0.63
Fully Technical Efficient	1	3	11	6	14	0
Min	0.50	0.66	0.82	0.86	0.73	0.61
Mean	0.59	0.83	0.95	0.97	0.94	0.74
Max	1.00	1.00	1.00	1.00	1.00	0.97
Standard Deviation	0.11	0.12	0.06	0.04	0.10	0.11

Table A.12: Overall scale efficiency estimates for all the medium-sized banks for Phase 2 (Dec 2007 - Aug 2009).

Date	***Phase 2: Overall scale efficiency***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Dec-07	1.00	0.61	0.80	0.61	1.00	0.74
Jan-08	0.94	0.60	0.99	0.59	1.00	0.98
Feb-08	0.95	0.59	1.00	0.59	0.87	0.93
Mar-08	0.97	0.64	1.00	0.59	1.00	0.91
Apr-08	0.97	0.63	0.85	0.62	0.76	0.65
May-08	0.97	0.50	1.00	0.62	0.75	0.61
Jun-08	0.99	0.50	1.00	0.64	0.84	0.59
Jul-08	0.99	0.54	0.81	0.60	0.68	0.62
Aug-08	0.99	0.55	0.80	0.61	0.84	0.56
Sep-08	0.98	0.57	0.93	0.61	0.80	0.53
Oct-08	0.95	0.56	0.93	0.63	1.00	0.72
Nov-08	0.94	0.56	0.88	0.62	1.00	0.94
Dec-08	0.92	0.57	0.70	0.60	0.95	0.99
Jan-09	0.87	0.57	0.95	0.60	1.00	0.98
Feb-09	0.88	0.55	0.90	0.59	0.99	0.98
Mar-09	0.86	0.56	1.00	0.58	0.99	0.85
Apr-09	0.86	0.55	0.84	0.60	1.00	0.86
May-09	0.87	0.53	0.92	0.58	1.00	0.83
Jun-09	0.85	0.57	0.92	0.57	1.00	0.81
Jul-09	0.83	0.60	0.91	0.57	1.00	0.86
Aug-09	0.81	0.62	1.00	0.54	1.00	0.87
Fully Scale Efficient	1	0	6	0	11	0
Min	0.81	0.50	0.70	0.54	0.68	0.53
Mean	0.92	0.57	0.91	0.60	0.93	0.80
Max	1.00	0.64	1.00	0.64	1.00	0.99
Standard Deviation	0.06	0.04	0.08	0.02	0.10	0.15

Table A.13: Technical efficiency estimates with respect to total deposits for all the medium-sized banks in Phase 2 (Dec 2007 - Aug 2009).

Date	***Phase 2: Technical Efficiency -Total deposits***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Dec-07	1.00	1.00	0.53	0.85	1.00	0.38
Jan-08	0.48	0.95	0.66	0.87	0.57	0.61
Feb-08	0.46	0.93	0.80	0.94	0.62	0.59
Mar-08	0.48	0.97	0.76	0.96	0.95	0.63
Apr-08	0.47	0.94	0.64	0.99	0.60	0.36
May-08	0.46	0.72	1.00	0.99	0.90	0.32
Jun-08	0.51	0.68	0.75	1.00	0.84	0.28
Jul-08	0.52	0.68	0.63	0.94	0.57	0.28
Aug-08	0.51	0.65	0.45	1.00	0.82	0.31
Sep-08	0.51	0.66	0.78	1.00	0.59	0.26
Oct-08	0.54	0.61	0.72	1.00	1.00	0.33
Nov-08	0.55	0.59	0.68	0.99	1.00	0.46
Dec-08	0.60	0.59	0.50	0.99	0.53	0.61
Jan-09	0.65	0.57	0.60	0.98	1.00	0.52
Feb-09	0.62	0.53	0.56	0.95	0.81	0.50
Mar-09	0.65	0.52	0.73	0.94	0.76	0.46
Apr-09	0.63	0.49	0.47	0.95	0.62	0.47
May-09	0.56	0.44	0.54	0.91	0.76	0.45
Jun-09	0.59	0.46	0.50	0.97	0.71	0.41
Jul-09	0.62	0.45	0.46	0.98	0.61	0.43
Aug-09	0.66	0.45	0.60	1.00	0.57	0.44
Fully Technical Efficient	1	1	1	5	4	0
Min	0.46	0.44	0.45	0.85	0.53	0.26
Mean	0.57	0.66	0.64	0.96	0.75	0.43
Max	1.00	1.00	1.00	1.00	1.00	0.63
Standard Deviation	0.12	0.19	0.14	0.04	0.17	0.12

Table A.14: Scale efficiency estimates with respect to total deposits for all the medium-sized banks in Phase 2 (Dec 2007 - Aug 2009).

Date	***Phase 2: Scale Efficiency -Total deposits***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Dec-07	1.00	0.59	0.91	0.46	0.93	0.95
Jan-08	0.98	0.61	0.98	0.46	0.99	0.74
Feb-08	0.96	0.62	0.76	0.46	0.99	0.80
Mar-08	0.94	0.64	0.87	0.46	0.93	0.84
Apr-08	0.93	0.65	0.99	0.46	0.94	0.99
May-08	0.92	0.67	0.78	0.46	0.79	0.99
Jun-08	0.89	0.68	0.71	0.45	0.96	0.99
Jul-08	0.87	0.70	0.97	0.45	0.67	0.99
Aug-08	0.85	0.71	0.97	0.44	0.95	0.98
Sep-08	0.83	0.72	0.83	0.45	0.94	0.97
Oct-08	0.82	0.74	0.83	0.45	0.43	0.99
Nov-08	0.80	0.75	0.91	0.45	1.00	0.95
Dec-08	0.79	0.76	0.97	0.45	0.92	0.85
Jan-09	0.77	0.75	0.80	0.44	1.00	0.92
Feb-09	0.76	0.75	0.84	0.45	0.97	0.89
Mar-09	0.75	0.76	0.71	0.45	0.97	0.99
Apr-09	0.74	0.76	0.95	0.44	0.89	0.99
May-09	0.74	0.77	0.83	0.45	0.89	0.98
Jun-09	0.72	0.81	0.93	0.42	0.85	0.98
Jul-09	0.71	0.84	0.91	0.42	0.96	0.99
Aug-09	0.70	0.85	0.78	0.40	0.98	0.99
Fully Scale Efficient	1	0	0	0	2	0
Min	0.70	0.59	0.71	0.40	0.43	0.74
Mean	0.83	0.72	0.87	0.45	0.90	0.94
Max	1.00	0.85	0.99	0.46	1.00	0.99
Standard Deviation	0.10	0.07	0.09	0.02	0.13	0.07

Table A.15: Technical efficiency estimates with respect to Central bank and money for all the medium-sized banks in Phase 2 (Dec 2007 - Aug 2009).

Date	***Phase 2: Technical Efficiency - Central bank and money***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Dec-07	0.04	0.02	0.29	0.82	0.17	0.09
Jan-08	0.04	0.02	0.21	0.62	0.11	0.29
Feb-08	0.04	0.02	0.69	0.91	0.17	0.14
Mar-08	0.04	0.02	0.60	0.91	0.35	0.12
Apr-08	0.04	0.03	0.20	0.98	0.27	0.05
May-08	0.04	0.03	0.50	0.95	0.14	0.05
Jun-08	0.05	0.03	0.53	1.00	0.12	0.05
Jul-08	0.05	0.02	0.07	0.94	0.11	0.05
Aug-08	0.05	0.02	0.07	1.00	0.16	0.05
Sep-08	0.05	0.02	0.10	0.93	0.12	0.05
Oct-08	0.05	0.02	0.09	1.00	1.00	0.05
Nov-08	0.05	0.02	0.04	0.96	0.67	0.07
Dec-08	0.06	0.02	0.06	0.996	0.22	0.10
Jan-09	0.06	0.02	0.33	0.98	0.25	0.08
Feb-09	0.06	0.02	0.45	0.84	0.11	0.10
Mar-09	0.07	0.02	1.00	0.92	0.16	0.06
Apr-09	0.07	0.01	0.20	0.89	0.83	0.06
May-09	0.07	0.02	0.23	0.87	1.00	0.07
Jun-09	0.08	0.02	0.41	0.92	1.00	0.08
Jul-09	0.07	0.01	0.44	0.95	1.00	0.09
Aug-09	0.10	0.02	1.00	1.00	0.63	0.09
Fully Technical Efficient	0	0	2	4	4	0
Min	0.04	0.01	0.04	0.62	0.11	0.05
Mean	0.06	0.02	0.36	0.92	0.41	0.08
Max	0.10	0.03	1.00	1.00	1.00	0.29
Standard Deviation	0.02	0.00	0.29	0.09	0.36	0.05

Table A.16: Scale efficiency estimates with respect to Central bank and money for all the medium-sized banks in Phase 2 (Dec 2007 - Aug 2009).

Date	***Phase 2: Scale Efficiency - Central bank and money***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Dec-07	0.96	0.20	0.73	0.04	0.75	0.81
Jan-08	0.89	0.21	0.80	0.04	0.77	0.45
Feb-08	0.85	0.21	0.50	0.04	0.77	0.58
Mar-08	0.80	0.22	0.66	0.04	0.98	0.63
Apr-08	0.77	0.23	0.90	0.04	0.66	0.95
May-08	0.74	0.24	0.52	0.04	0.73	0.91
Jun-08	0.71	0.25	0.34	0.04	0.78	0.90
Jul-08	0.68	0.27	0.91	0.04	0.71	0.95
Aug-08	0.65	0.28	0.91	0.04	0.62	0.82
Sep-08	0.62	0.29	0.61	0.04	0.59	0.74
Oct-08	0.60	0.31	0.61	0.03	0.24	0.99
Nov-08	0.58	0.31	0.72	0.03	0.26	0.80
Dec-08	0.57	0.32	0.71	0.03	0.50	0.64
Jan-09	0.52	0.32	0.57	0.03	0.41	0.74
Feb-09	0.50	0.32	0.63	0.03	0.99	0.70
Mar-09	0.46	0.32	0.38	0.03	0.92	0.95
Apr-09	0.45	0.33	0.82	0.03	0.88	0.95
May-09	0.44	0.34	0.62	0.03	1.00	0.88
Jun-09	0.40	0.38	0.76	0.03	1.00	0.86
Jul-09	0.39	0.42	0.73	0.03	0.92	0.94
Aug-09	0.32	0.43	0.55	0.03	0.87	0.94
Fully Scale Efficient	0	0	0	0	2	0
Min	0.32	0.20	0.34	0.03	0.24	0.45
Mean	0.61	0.30	0.67	0.03	0.73	0.82
Max	0.96	0.43	0.91	0.04	1.00	0.99
Standard Deviation	0.18	0.07	0.16	0.00	0.23	0.15

Table A.17: Technical efficiency estimates with respect to total equity for all the medium-sized banks in Phase 2 (Dec 2007 - Aug 2009).

Date	***Phase 2: Technical Efficiency – Total equity***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Dec-07	0.34	0.63	1.00	0.85	0.78	0.88
Jan-08	0.34	0.61	0.98	0.81	0.77	0.97
Feb-08	0.33	0.60	1.00	0.90	0.72	0.88
Mar-08	0.31	0.59	1.00	0.91	0.85	0.86
Apr-08	0.31	0.58	0.98	0.96	0.77	0.83
May-08	0.31	0.60	0.97	0.96	0.84	0.81
Jun-08	0.32	0.59	1.00	1.00	0.88	0.81
Jul-08	0.31	0.59	0.97	0.94	0.59	0.80
Aug-08	0.30	0.57	0.99	1.00	0.52	0.79
Sep-08	0.29	0.56	0.92	0.97	0.51	0.63
Oct-08	0.28	0.55	0.92	1.00	1.00	0.63
Nov-08	0.29	0.55	0.93	0.94	0.96	0.60
Dec-08	0.29	0.55	0.83	0.99	0.82	0.60
Jan-09	0.28	0.53	0.90	0.99	0.85	0.59
Feb-09	0.27	0.51	0.85	0.96	0.77	0.59
Mar-09	0.28	0.50	0.89	0.95	0.69	0.59
Apr-09	0.27	0.49	0.81	0.93	0.69	0.58
May-09	0.27	0.48	0.82	0.91	0.77	0.58
Jun-09	0.28	0.51	0.80	0.95	0.66	0.57
Jul-09	0.28	0.50	0.74	0.98	0.58	0.57
Aug-09	0.28	0.49	0.88	1.00	0.57	0.56
Fully Technical Efficient	0	0	4	4	1	0
Min	0.27	0.48	0.74	0.81	0.51	0.56
Mean	0.30	0.55	0.91	0.95	0.74	0.70
Max	0.34	0.63	1.00	1.00	1.00	0.97
Standard Deviation	0.02	0.04	0.08	0.05	0.14	0.14

Table A.18: Scale efficiency estimates with respect to total equity for all the medium-sized banks in Phase 2 (Dec 2007 - Aug 2009).

Date	***Phase 2: Scale Efficiency – Total equity***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Dec-07	0.68	0.13	0.80	0.54	0.89	0.74
Jan-08	0.70	0.13	0.54	0.55	0.80	0.98
Feb-08	0.73	0.14	1.00	0.54	0.86	0.94
Mar-08	0.75	0.14	0.81	0.54	0.95	0.88
Apr-08	0.77	0.15	0.63	0.53	0.85	0.62
May-08	0.78	0.16	0.92	0.53	0.85	0.59
Jun-08	0.81	0.16	1.00	0.52	0.88	0.59
Jul-08	0.83	0.17	0.75	0.54	0.82	0.62
Aug-08	0.86	0.18	0.79	0.54	0.82	0.53
Sep-08	0.88	0.19	0.87	0.54	0.80	0.49
Oct-08	0.91	0.20	0.87	0.50	1.00	0.66
Nov-08	0.93	0.20	0.84	0.50	0.997	0.75
Dec-08	0.96	0.21	0.75	0.50	0.97	0.86
Jan-09	0.99	0.21	0.94	0.50	0.98	0.78
Feb-09	0.99	0.21	0.84	0.50	0.98	0.81
Mar-09	0.99	0.21	0.98	0.50	0.96	0.62
Apr-09	0.98	0.21	0.81	0.50	0.92	0.62
May-09	0.97	0.22	0.88	0.51	0.99	0.57
Jun-09	0.96	0.25	0.80	0.48	0.98	0.56
Jul-09	0.94	0.27	0.79	0.48	0.94	0.61
Aug-09	0.93	0.28	0.93	0.46	0.94	0.62
Fully Scale Efficient	0	0	2	0	1	0
Min	0.68	0.13	0.54	0.46	0.80	0.49
Mean	0.87	0.19	0.83	0.51	0.91	0.69
Max	0.99	0.28	1.00	0.55	1.00	0.98
Standard Deviation	0.10	0.04	0.11	0.02	0.07	0.14

Table A.19: Technical efficiency estimates with respect to SA group and finance for all the medium-sized banks in Phase 2 (Dec 2007 - Aug 2009).

Date	***Phase 2: Technical Efficiency – SA group and finance***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Dec-07	0.02	0.01	0.02	0.32	0.09	0.01
Jan-08	0.02	0.01	0.04	0.30	1.00	0.07
Feb-08	0.01	0.01	1.00	0.41	0.00	0.32
Mar-08	0.02	0.01	0.23	0.52	0.03	0.09
Apr-08	0.01	0.01	0.02	0.82	0.00	0.00
May-08	0.01	0.00	0.11	0.75	0.02	0.00
Jun-08	0.02	0.00	0.11	1.00	0.01	0.00
Jul-08	0.02	0.00	0.01	0.53	0.00	0.00
Aug-08	0.02	0.00	0.01	1.00	0.00	0.00
Sep-08	0.01	0.00	0.01	0.87	0.00	0.00
Oct-08	0.02	0.00	0.03	1.00	1.00	0.01
Nov-08	0.02	0.00	0.02	0.90	1.00	0.06
Dec-08	0.04	0.00	0.00	0.80	0.21	0.11
Jan-09	0.06	0.00	0.03	0.80	1.00	0.07
Feb-09	0.03	0.00	0.01	0.64	0.06	0.09
Mar-09	0.06	0.00	0.05	0.56	0.02	0.01
Apr-09	0.05	0.00	0.01	0.74	0.00	0.01
May-09	0.02	0.00	0.01	0.42	0.17	0.00
Jun-09	0.03	0.00	0.01	1.00	0.04	0.00
Jul-09	0.04	0.00	0.01	0.89	0.20	0.01
Aug-09	0.04	0.00	0.02	1.00	1.00	0.01
Fully Technical Efficient	0	0	1	5	5	0
Min	0.01	0.00	0.00	0.30	0.00	0.00
Mean	0.03	0.00	0.08	0.73	0.28	0.04
Max	0.06	0.01	1.00	1.00	1.00	0.32
Standard Deviation	0.01	0.00	0.22	0.24	0.42	0.07

Table A.20: Scale efficiency estimates with respect to SA group and finance for all the medium-sized banks in Phase 2 (Dec 2007 - Aug 2009).

Date	***Phase 2: Scale Efficiency – SA group and finance***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Dec-07	0.12	0.25	0.08	0.00	0.08	0.10
Jan-08	0.11	0.27	0.91	0.00	1.00	0.04
Feb-08	0.10	0.28	0.05	0.00	0.996	0.06
Mar-08	0.09	0.29	0.07	0.00	0.11	0.07
Apr-08	0.09	0.30	0.34	0.00	0.90	0.19
May-08	0.08	0.32	0.04	0.00	0.86	0.30
Jun-08	0.08	0.33	0.02	0.00	0.94	0.32
Jul-08	0.07	0.35	0.11	0.00	0.85	0.19
Aug-08	0.07	0.36	0.11	0.00	0.91	0.86
Sep-08	0.06	0.38	0.06	0.00	0.89	0.96
Oct-08	0.06	0.40	0.06	0.00	0.00	0.14
Nov-08	0.06	0.41	0.08	0.00	0.48	0.09
Dec-08	0.06	0.42	0.92	0.00	0.99	0.07
Jan-09	0.05	0.42	0.05	0.00	1.00	0.08
Feb-09	0.05	0.41	0.07	0.00	0.24	0.08
Mar-09	0.04	0.42	0.02	0.00	0.26	0.19
Apr-09	0.04	0.43	0.10	0.00	0.92	0.19
May-09	0.04	0.44	0.06	0.00	0.13	0.43
Jun-09	0.03	0.50	0.09	0.00	0.09	0.64
Jul-09	0.03	0.54	0.08	0.00	0.20	0.22
Aug-09	0.02	0.56	0.05	0.00	1.00	0.21
Fully Scale Efficient	0	0	0	0	3	0
Min	0.02	0.25	0.02	0.00	0.00	0.04
Mean	0.06	0.38	0.16	0.00	0.61	0.26
Max	0.12	0.56	0.92	0.00	1.00	0.96
Standard Deviation	0.03	0.09	0.26	0.00	0.40	0.26

Table A.21: Overall technical efficiency estimates for all the medium-sized banks for Phase 3 (Sep 2009 - Nov 2013)

Date	***Phase 3: Overall Technical Efficiency***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Sep-09	0.70	1.00	1.00	0.99	1.00	1.00
Oct-09	0.68	0.97	1.00	1.00	1.00	0.95
Nov-09	0.68	0.89	1.00	0.98	1.00	1.00
Dec-09	0.70	0.87	1.00	0.97	1.00	0.98
Jan-10	0.71	0.84	0.93	1.00	1.00	0.94
Feb-10	0.70	0.82	0.90	0.98	1.00	0.95
Mar-10	0.66	0.85	1.00	0.96	1.00	0.98
Apr-10	0.67	0.83	0.90	0.94	0.91	0.96
May-10	0.67	0.81	0.91	0.95	0.76	0.91
Jun-10	0.69	0.85	0.94	0.93	0.90	0.96
Jul-10	0.69	0.84	1.00	0.95	0.86	0.96
Aug-10	0.70	0.84	1.00	0.93	0.83	0.96
Sep-10	0.66	0.82	1.00	0.92	0.80	0.92
Oct-10	0.66	0.80	1.00	0.91	0.96	0.90
Nov-10	0.65	0.81	1.00	0.93	1.00	0.94
Dec-10	0.71	0.83	1.00	0.97	1.00	0.94
Jan-11	0.67	0.70	0.99	0.96	1.00	0.94
Feb-11	0.66	0.71	1.00	0.97	0.95	0.90
Mar-11	0.64	0.74	1.00	0.92	1.00	0.88
Apr-11	0.64	0.71	1.00	0.97	0.92	0.88
May-11	0.66	0.69	1.00	0.92	0.75	0.86
Jun-11	0.68	0.70	0.99	1.00	1.00	0.89
Jul-11	0.68	0.68	1.00	0.90	0.95	0.86
Aug-11	0.71	0.67	1.00	1.00	1.00	0.91
Sep-11	0.70	0.66	1.00	1.00	1.00	0.81
Oct-11	0.69	0.68	1.00	1.00	0.96	0.78
Nov-11	0.72	0.63	0.99	1.00	1.00	0.96
Dec-11	0.88	0.62	1.00	1.00	0.80	0.88
Jan-12	1.00	0.70	1.00	1.00	0.80	0.81

Date	***Phase 3: Overall Technical Efficiency***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Feb-12	0.93	0.67	1.00	0.98	0.70	0.91
Mar-12	0.91	0.67	0.99	0.93	0.69	0.98
Apr-12	0.93	0.67	0.80	0.92	0.70	0.81
May-12	0.92	0.67	0.87	0.94	0.91	0.96
Jun-12	0.91	0.67	0.90	0.94	0.77	1.00
Jul-12	0.94	0.71	1.00	0.98	0.96	0.88
Aug-12	0.93	0.66	1.00	0.97	1.00	0.92
Sep-12	0.96	0.67	0.98	0.99	0.91	0.92
Oct-12	0.95	0.70	1.00	0.98	1.00	0.84
Nov-12	0.92	0.60	1.00	0.996	1.00	0.71
Dec-12	0.95	0.63	1.00	1.00	1.00	0.88
Jan-13	0.99	0.64	1.00	1.00	0.89	0.93
Feb-13	1.00	0.63	1.00	1.00	0.94	1.00
Mar-13	0.91	0.62	0.99	0.98	0.77	0.83
Apr-13	0.96	0.63	1.00	1.00	0.83	1.00
May-13	0.94	0.61	1.00	1.00	0.92	0.80
Jun-13	0.96	0.60	1.00	1.00	0.90	0.71
Jul-13	1.00	0.59	1.00	1.00	0.81	0.70
Aug-13	0.94	0.58	1.00	1.00	1.00	0.72
Sep-13	1.00	0.57	0.95	1.00	0.88	0.68
Oct-13	1.00	0.56	0.98	1.00	0.74	1.00
Nov-13	0.998	0.54	1.00	1.00	0.82	1.00
Fully Technical Efficient	5	1	35	20	20	7
Min	0.64	0.54	0.80	0.90	0.69	0.68
Mean	0.81	0.71	0.98	0.97	0.91	0.90
Max	1.00	1.00	1.00	1.00	1.00	1.00
Standard Deviation	0.14	0.11	0.04	0.03	0.10	0.09

Table A.22: Overall scale efficiency estimates for all the medium-sized banks for Phase 3 (Sep 2009 - Nov 2013)

Date	***Phase 3: Overall Scale Efficiency***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Sep-09	0.90	0.43	0.97	0.65	1.00	0.68
Oct-09	0.89	0.44	0.95	0.66	1.00	0.64
Nov-09	0.89	0.44	1.00	0.66	1.00	0.66
Dec-09	0.90	0.48	0.98	0.65	1.00	0.54
Jan-10	0.90	0.50	0.85	0.65	1.00	0.53
Feb-10	0.90	0.51	0.77	0.66	1.00	0.64
Mar-10	0.91	0.54	1.00	0.66	1.00	0.62
Apr-10	0.92	0.55	0.90	0.66	0.98	0.66
May-10	0.92	0.55	0.95	0.65	0.96	0.58
Jun-10	0.92	0.65	0.96	0.65	0.92	0.65
Jul-10	0.93	0.66	1.00	0.65	0.95	0.73
Aug-10	0.93	0.64	1.00	0.63	0.93	0.73
Sep-10	0.95	0.65	1.00	0.65	0.997	0.71
Oct-10	0.95	0.65	1.00	0.64	0.99	0.61
Nov-10	0.94	0.80	1.00	0.65	1.00	0.63
Dec-10	0.91	0.85	1.00	0.64	0.95	0.62
Jan-11	0.95	0.72	0.87	0.64	1.00	0.64
Feb-11	0.95	0.86	0.997	0.63	0.998	0.68
Mar-11	0.95	0.97	1.00	0.65	1.00	0.71
Apr-11	0.95	0.94	1.00	0.63	0.97	0.73
May-11	0.94	0.88	0.90	0.64	0.93	0.80
Jun-11	0.95	0.92	0.96	0.60	0.98	0.84
Jul-11	0.95	0.88	0.75	0.64	0.87	0.84
Aug-11	0.95	0.87	0.995	0.61	1.00	0.86
Sep-11	0.94	0.83	1.00	0.56	1.00	0.91
Oct-11	0.94	0.89	1.00	0.58	0.99	0.95
Nov-11	0.91	0.92	0.97	0.59	0.88	0.94
Dec-11	0.75	0.88	0.76	0.61	0.99	0.88
Jan-12	0.93	0.94	1.00	0.60	0.998	0.90
Feb-12	0.99	0.89	0.97	0.60	0.998	0.90
Mar-12	0.996	0.85	0.90	0.62	0.96	0.95
Apr-12	0.98	0.85	0.85	0.63	0.99	0.92
May-12	0.98	0.86	0.91	0.63	0.98	0.97
Jun-12	0.99	0.88	0.95	0.62	0.97	1.00

Date	*Phase 3: Overall Scale Efficiency*					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Jul-12	0.98	0.89	1.00	0.62	0.99	0.98
Aug-12	0.99	0.90	1.00	0.63	1.00	0.99
Sep-12	0.97	0.92	0.97	0.64	0.99	0.99
Oct-12	0.98	0.93	1.00	0.63	1.00	0.96
Nov-12	0.99	0.98	1.00	0.64	1.00	0.99
Dec-12	0.98	0.99	1.00	0.65	1.00	0.98
Jan-13	0.95	0.98	1.00	0.63	0.98	0.96
Feb-13	0.94	0.98	1.00	0.64	0.98	0.94
Mar-13	0.998	0.98	0.89	0.64	0.95	0.98
Apr-13	0.98	0.98	1.00	0.64	0.99	0.89
May-13	0.997	0.98	1.00	0.64	0.99	0.996
Jun-13	0.99	0.98	1.00	0.63	0.99	0.95
Jul-13	1.00	0.98	1.00	0.62	0.99	0.95
Aug-13	0.99	0.98	1.00	0.63	0.91	0.97
Sep-13	1.00	0.98	0.88	0.60	0.99	0.98
Oct-13	1.00	0.98	0.97	0.58	0.99	1.00
Nov-13	0.99	0.98	1.00	0.59	0.99	0.95
Fully Scale Efficient	3	0	26	0	16	2
Min	0.75	0.43	0.75	0.56	0.87	0.53
Mean	0.95	0.82	0.96	0.63	0.98	0.83
Max	1.00	0.99	1.00	0.66	1.00	1.00
Standard Deviation	0.04	0.18	0.07	0.02	0.03	0.15

Table A.23: Technical efficiency estimates with respect to total deposits for all the medium-sized banks in Phase 3 (Sep 2009 - Nov 2013).

Date	***Phase 3: Technical Efficiency – Total Deposits***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Sep-09	0.52	0.78	0.47	0.92	0.75	0.56
Oct-09	0.50	0.72	0.52	0.93	0.69	0.50
Nov-09	0.50	0.57	0.37	0.90	0.80	0.51
Dec-09	0.51	0.58	0.43	0.87	0.76	0.49
Jan-10	0.51	0.56	0.44	0.90	0.61	0.46
Feb-10	0.50	0.54	0.36	0.89	0.67	0.48
Mar-10	0.48	0.55	0.45	0.90	0.69	0.54
Apr-10	0.48	0.54	0.29	0.87	0.61	0.48
May-10	0.49	0.53	0.38	0.88	0.52	0.41
Jun-10	0.51	0.54	0.38	0.85	0.71	0.41
Jul-10	0.51	0.54	0.30	0.88	0.70	0.42
Aug-10	0.52	0.55	0.36	0.85	0.69	0.41
Sep-10	0.56	0.54	0.35	0.87	0.56	0.42
Oct-10	0.56	0.51	0.37	0.88	0.73	0.36
Nov-10	0.54	0.52	0.38	0.88	0.87	0.34
Dec-10	0.58	0.54	0.50	0.93	0.68	0.31
Jan-11	0.56	0.55	0.52	0.91	0.67	0.32
Feb-11	0.56	0.58	0.63	0.92	0.64	0.25
Mar-11	0.53	0.61	0.62	0.89	0.73	0.24
Apr-11	0.54	0.60	0.64	0.94	0.65	0.23
May-11	0.54	0.57	0.53	0.89	0.55	0.26
Jun-11	0.57	0.56	0.55	0.92	1.00	0.27
Jul-11	0.57	0.56	0.39	0.88	0.90	0.29
Aug-11	0.60	0.54	0.36	0.99	0.89	0.32
Sep-11	0.59	0.52	0.36	1.00	1.00	0.27
Oct-11	0.58	0.54	0.29	1.00	0.79	0.27
Nov-11	0.57	0.54	0.30	1.00	0.55	0.33
Dec-11	0.59	0.54	0.32	1.00	0.52	0.25
Jan-12	0.88	0.67	0.32	0.98	0.50	0.27

Date	***Phase 3: Technical Efficiency – Total Deposits***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Feb-12	0.88	0.62	0.30	0.94	0.44	0.33
Mar-12	0.88	0.60	0.29	0.87	0.53	0.37
Apr-12	0.87	0.60	0.33	0.90	0.48	0.30
May-12	0.86	0.60	0.34	0.91	0.69	0.35
Jun-12	0.86	0.59	0.39	0.92	0.56	0.42
Jul-12	0.88	0.65	0.40	0.96	0.73	0.33
Aug-12	0.89	0.59	0.42	0.95	1.00	0.35
Sep-12	0.90	0.58	0.39	0.98	0.80	0.37
Oct-12	0.90	0.62	0.42	0.97	0.99	0.30
Nov-12	0.88	0.60	0.44	0.97	1.00	0.32
Dec-12	0.91	0.63	0.65	0.995	1.00	0.30
Jan-13	0.90	0.64	0.70	0.98	0.77	0.31
Feb-13	0.91	0.63	0.60	0.99	0.87	0.33
Mar-13	0.91	0.62	0.55	0.98	0.62	0.33
Apr-13	0.92	0.63	0.51	0.995	0.51	0.34
May-13	0.93	0.61	0.53	1.00	0.58	0.36
Jun-13	0.96	0.60	0.45	1.00	0.50	0.32
Jul-13	1.00	0.59	0.45	1.00	0.37	0.28
Aug-13	0.93	0.58	0.45	1.00	0.49	0.28
Sep-13	0.98	0.57	0.44	0.97	0.43	0.31
Oct-13	1.00	0.56	0.48	1.00	0.40	0.32
Nov-13	0.98	0.54	0.49	1.00	0.50	0.31
Fully Technical Efficient	2	0	0	10	5	0
Min	0.48	0.51	0.29	0.85	0.37	0.23
Mean	0.71	0.58	0.44	0.94	0.68	0.35
Max	1.00	0.78	0.70	1.00	1.00	0.56
Standard Deviation	0.19	0.05	0.11	0.05	0.17	0.08

Table A.24: Scale efficiency estimates with respect to total deposits for all the medium-sized banks in Phase 3 (Sep 2009 - Nov 2013).

Date	***Phase 3: Scale Efficiency – Total Deposits***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Sep-09	0.95	0.53	0.96	0.46	0.998	0.85
Oct-09	0.95	0.54	0.96	0.46	0.94	0.85
Nov-09	0.95	0.57	0.97	0.46	0.93	0.82
Dec-09	0.96	0.62	0.97	0.47	0.84	0.76
Jan-10	0.96	0.64	0.95	0.46	0.96	0.77
Feb-10	0.96	0.66	0.94	0.47	0.83	0.87
Mar-10	0.96	0.71	0.97	0.46	0.87	0.81
Apr-10	0.96	0.72	0.96	0.46	0.84	0.83
May-10	0.96	0.72	0.97	0.46	0.84	0.85
Jun-10	0.97	0.77	0.97	0.46	0.83	0.81
Jul-10	0.97	0.79	0.98	0.46	0.88	0.83
Aug-10	0.97	0.81	0.99	0.46	0.89	0.84
Sep-10	0.98	0.83	0.97	0.46	0.95	0.87
Oct-10	0.98	0.84	0.97	0.45	0.98	0.85
Nov-10	0.98	0.87	0.98	0.46	0.98	0.81
Dec-10	0.98	0.90	0.99	0.45	0.98	0.71
Jan-11	0.98	0.91	0.99	0.45	0.97	0.83
Feb-11	0.98	0.92	0.99	0.45	0.96	0.75
Mar-11	0.98	0.92	0.996	0.45	0.86	0.71
Apr-11	0.99	0.93	0.99	0.44	0.81	0.77
May-11	0.99	0.93	0.98	0.44	0.84	0.91
Jun-11	0.99	0.93	0.98	0.44	0.77	0.91
Jul-11	0.99	0.94	0.94	0.44	0.79	0.95
Aug-11	0.99	0.94	0.96	0.40	0.99	0.96
Sep-11	0.99	0.94	0.96	0.37	1.00	0.96
Oct-11	0.99	0.95	0.85	0.38	0.95	0.97
Nov-11	0.99	0.95	0.88	0.38	0.96	0.98
Dec-11	0.99	0.95	0.87	0.40	0.97	0.96
Jan-12	0.99	0.95	0.78	0.40	0.96	0.96

Date	*Phase 3: Scale Efficiency – Total Deposits*					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Feb-12	0.99	0.95	0.77	0.41	0.97	0.97
Mar-12	0.99	0.95	0.78	0.44	0.87	0.98
Apr-12	0.996	0.95	0.88	0.43	0.90	0.97
May-12	0.997	0.96	0.89	0.43	0.98	0.98
Jun-12	0.997	0.96	0.97	0.42	0.95	0.99
Jul-12	0.997	0.97	0.98	0.42	0.99	0.98
Aug-12	0.997	0.97	0.93	0.43	0.63	0.99
Sep-12	0.99	0.97	0.87	0.44	0.98	0.99
Oct-12	0.997	0.97	0.83	0.43	0.99	0.98
Nov-12	0.99	0.98	0.84	0.44	1.00	0.98
Dec-12	0.99	0.98	0.73	0.44	0.67	0.98
Jan-13	0.99	0.98	0.69	0.43	0.98	0.99
Feb-13	0.99	0.98	0.74	0.43	0.99	0.99
Mar-13	0.99	0.98	0.72	0.43	0.93	0.99
Apr-13	0.99	0.98	0.81	0.43	0.98	0.99
May-13	0.99	0.98	0.81	0.43	0.99	0.99
Jun-13	0.99	0.98	0.94	0.42	0.995	0.97
Jul-13	0.99	0.98	0.94	0.41	0.98	0.97
Aug-13	0.995	0.98	0.90	0.42	0.97	0.98
Sep-13	0.997	0.98	0.93	0.41	0.98	0.98
Oct-13	1.00	0.98	0.94	0.39	0.98	0.98
Nov-13	0.99	0.98	0.93	0.39	0.96	0.99
Fully Scale Efficient	1	0	0	0	2	0
Min	0.95	0.53	0.69	0.37	0.63	0.71
Mean	0.98	0.88	0.91	0.43	0.92	0.91
Max	1.00	0.98	0.996	0.47	1.00	0.99
Standard Deviation	0.01	0.13	0.08	0.03	0.09	0.09

Table A.25: Technical efficiency estimates with respect to Central bank and money for all the medium-sized banks in Phase 3 (Sep 2009 - Nov 2013).

Date	***Phase 3: Technical Efficiency – Central bank and money***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Sep-09	0.00	1.00	0.03	0.62	1.00	0.002
Oct-09	0.00	0.00	0.03	0.60	0.49	0.002
Nov-09	0.00	0.00	0.03	0.62	0.46	0.001
Dec-09	0.00	0.00	0.05	0.62	0.31	0.000
Jan-10	0.00	0.00	0.02	0.68	1.00	0.000
Feb-10	0.00	0.00	0.01	0.64	1.00	0.002
Mar-10	0.00	0.00	0.03	0.61	0.07	0.001
Apr-10	0.00	0.00	0.01	0.57	0.22	0.001
May-10	0.00	0.00	0.02	0.62	0.00	0.002
Jun-10	0.00	0.00	0.02	0.60	0.00	0.001
Jul-10	0.00	0.00	0.12	0.62	0.07	0.001
Aug-10	0.00	0.00	0.16	0.61	0.07	0.001
Sep-10	0.00	0.00	0.05	0.58	0.13	0.001
Oct-10	0.00	0.00	0.71	0.51	0.13	0.001
Nov-10	0.03	0.00	1.00	0.61	0.13	0.000
Dec-10	0.07	0.00	0.90	0.63	0.19	0.000
Jan-11	0.09	0.00	0.75	0.65	0.02	0.000
Feb-11	0.11	0.00	0.91	0.69	0.02	0.000
Mar-11	0.11	0.00	1.00	0.33	0.02	0.000
Apr-11	0.13	0.00	0.81	0.73	0.02	0.000
May-11	0.15	0.00	0.63	0.63	0.00	0.000
Jun-11	0.17	0.00	0.75	1.00	0.00	0.001
Jul-11	0.18	0.00	0.19	0.63	0.01	0.001
Aug-11	0.20	0.00	0.19	0.91	0.19	0.001
Sep-11	0.20	0.00	0.65	0.58	0.16	0.001
Oct-11	0.23	0.00	0.73	0.98	0.19	0.001
Nov-11	0.25	0.00	0.10	1.00	0.13	0.002
Dec-11	0.27	0.00	0.08	0.90	0.08	0.001
Jan-12	0.29	0.00	0.00	1.00	0.16	0.001

Date	*Phase 3: Technical Efficiency – Central bank and money*					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Feb-12	0.30	0.00	0.00	0.59	0.06	0.001
Mar-12	0.29	0.00	0.00	0.31	0.03	0.002
Apr-12	0.33	0.00	0.01	0.64	0.03	0.002
May-12	0.33	0.00	0.02	0.73	0.14	0.003
Jun-12	0.33	0.00	0.09	0.76	0.05	0.003
Jul-12	0.36	0.00	1.00	0.88	0.53	0.002
Aug-12	0.34	0.00	0.77	0.81	1.00	0.003
Sep-12	0.36	0.00	0.56	0.86	0.11	0.003
Oct-12	0.38	0.00	0.08	0.74	0.11	0.002
Nov-12	0.37	0.00	0.07	0.75	0.77	0.002
Dec-12	0.38	0.01	0.00	1.00	1.00	0.002
Jan-13	0.41	0.01	0.00	0.79	0.10	0.004
Feb-13	0.40	0.02	0.00	0.87	0.37	0.007
Mar-13	0.35	0.02	0.00	0.63	0.05	0.003
Apr-13	0.40	0.03	0.01	0.76	0.12	0.007
May-13	0.38	0.03	0.00	1.00	0.59	0.002
Jun-13	0.39	0.03	0.04	0.87	0.66	0.001
Jul-13	0.42	0.02	0.03	1.00	0.13	0.001
Aug-13	0.35	0.02	0.01	1.00	1.00	0.002
Sep-13	0.38	0.02	0.01	0.69	0.52	0.002
Oct-13	0.37	0.02	0.01	1.00	0.12	0.002
Nov-13	0.35	0.03	0.00	1.00	0.13	0.002
Fully Technical Efficient	0	1	3	9	6	0
Min	0.00	0.00	0.00	0.31	0.00	0.00
Mean	0.21	0.02	0.25	0.73	0.27	0.00
Max	0.42	1.00	1.00	1.00	1.00	0.01
Standard Deviation	0.16	0.14	0.35	0.18	0.32	0.00

Table A.26: Scale efficiency estimates with respect to Central bank and money for all the medium-sized banks in Phase 3 (Sep 2009 - Nov 2013).

Date	***Phase 3: Scale Efficiency – Central bank and money***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Sep-09	0.00	0.65	0.00	0.00	0.00	0.01
Oct-09	0.00	0.66	0.00	0.00	0.00	0.01
Nov-09	0.00	0.69	0.00	0.00	0.00	0.01
Dec-09	0.00	0.75	0.00	0.00	0.00	0.99
Jan-10	0.00	0.78	0.00	0.00	0.00	0.04
Feb-10	0.00	0.80	0.00	0.00	1.00	0.01
Mar-10	0.00	0.87	0.00	0.00	0.00	0.01
Apr-10	0.00	0.90	0.00	0.00	0.00	0.01
May-10	0.00	0.91	0.00	0.00	0.03	0.01
Jun-10	0.00	0.05	0.00	0.00	0.01	0.01
Jul-10	0.00	0.02	0.00	0.00	0.00	0.01
Aug-10	0.00	0.01	0.00	0.00	0.00	0.01
Sep-10	0.00	0.01	0.00	0.00	0.00	0.01
Oct-10	0.00	0.01	0.00	0.00	0.00	0.01
Nov-10	0.00	0.01	0.00	0.00	0.00	0.02
Dec-10	0.00	0.00	0.00	0.00	0.00	0.82
Jan-11	0.00	0.00	0.00	0.00	0.00	0.01
Feb-11	0.00	0.00	0.00	0.00	0.00	0.85
Mar-11	0.00	0.00	0.00	0.00	0.00	0.79
Apr-11	0.00	0.00	0.00	0.00	0.00	0.88
May-11	0.00	0.00	0.00	0.00	0.01	0.01
Jun-11	0.00	0.00	0.00	0.00	0.00	0.01
Jul-11	0.00	0.00	0.00	0.00	0.00	0.00
Aug-11	0.00	0.00	0.00	0.00	0.00	0.00
Sep-11	0.00	0.00	0.00	0.00	0.00	0.00
Oct-11	0.00	0.00	0.00	0.00	0.00	0.00
Nov-11	0.00	0.00	0.01	0.00	0.00	0.00
Dec-11	0.00	0.00	0.01	0.00	0.00	0.00
Jan-12	0.00	0.00	0.96	0.00	0.00	0.00

Date	***Phase 3: Scale Efficiency – Central bank and money***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Feb-12	0.00	0.00	0.93	0.00	0.00	0.00
Mar-12	0.00	0.00	0.90	0.00	0.00	0.00
Apr-12	0.00	0.00	0.01	0.00	0.00	0.00
May-12	0.00	0.00	0.00	0.00	0.00	0.00
Jun-12	0.00	0.00	0.00	0.00	0.00	0.00
Jul-12	0.00	0.00	0.00	0.00	0.00	0.00
Aug-12	0.00	0.00	0.00	0.00	0.00	0.00
Sep-12	0.00	0.00	0.00	0.00	0.00	0.00
Oct-12	0.00	0.00	0.00	0.00	0.00	0.00
Nov-12	0.00	0.00	0.00	0.00	0.00	0.00
Dec-12	0.00	0.00	0.99	0.00	0.00	0.00
Jan-13	0.00	0.00	0.94	0.00	0.00	0.00
Feb-13	0.00	0.00	0.92	0.00	0.00	0.00
Mar-13	0.00	0.00	0.80	0.00	0.00	0.00
Apr-13	0.00	0.00	0.01	0.00	0.00	0.00
May-13	0.00	0.00	0.18	0.00	0.00	0.00
Jun-13	0.00	0.00	0.00	0.00	0.00	0.00
Jul-13	0.00	0.00	0.00	0.00	0.00	0.00
Aug-13	0.00	0.00	0.01	0.00	0.00	0.00
Sep-13	0.00	0.00	0.01	0.00	0.00	0.00
Oct-13	0.00	0.00	0.00	0.00	0.00	0.00
Nov-13	0.00	0.00	0.00	0.00	0.00	0.00
Fully Scale Efficient	0	0	0	0	1	0
Min	0.00	0.00	0.00	0.00	0.00	0.00
Mean	0.00	0.14	0.13	0.00	0.02	0.09
Max	0.00	0.91	0.99	0.00	1.00	0.99
Standard Deviation	0.00	0.30	0.32	0.00	0.14	0.26

Table A.27: Technical efficiency estimates with respect to total equity for all the medium-sized banks in Phase 3 (Sep 2009 - Nov 2013).

Date	***Phase 3: Technical Efficiency – Total Equity***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Sep-09	0.29	0.56	1.00	0.98	0.90	0.66
Oct-09	0.29	0.57	1.00	1.00	0.71	0.67
Nov-09	0.29	0.56	1.00	0.97	0.62	0.67
Dec-09	0.32	0.54	1.00	0.96	0.49	0.66
Jan-10	0.33	0.52	0.89	1.00	0.45	0.66
Feb-10	0.32	0.51	0.86	0.97	0.37	0.65
Mar-10	0.31	0.50	0.998	0.94	0.41	0.65
Apr-10	0.31	0.49	0.88	0.93	0.42	0.65
May-10	0.31	0.47	0.89	0.94	0.37	0.64
Jun-10	0.32	0.51	0.91	0.92	0.38	0.63
Jul-10	0.33	0.47	1.00	0.94	0.49	0.63
Aug-10	0.32	0.46	1.00	0.93	0.52	0.62
Sep-10	0.14	0.44	1.00	0.89	0.65	0.62
Oct-10	0.15	0.43	0.75	0.88	0.61	0.61
Nov-10	0.16	0.42	0.67	0.92	0.62	0.62
Dec-10	0.18	0.41	0.84	0.94	0.63	0.62
Jan-11	0.19	0.27	0.82	0.94	0.44	0.62
Feb-11	0.19	0.25	0.95	0.94	0.42	0.63
Mar-11	0.18	0.25	1.00	0.87	0.43	0.64
Apr-11	0.19	0.24	0.86	0.91	0.42	0.63
May-11	0.20	0.24	0.75	0.88	0.38	0.62
Jun-11	0.21	0.25	0.82	0.86	0.42	0.61
Jul-11	0.22	0.23	0.59	0.85	0.46	0.60
Aug-11	0.23	0.22	0.70	0.94	0.74	0.57
Sep-11	0.22	0.23	0.71	1.00	0.75	0.60
Oct-11	0.23	0.23	0.69	0.99	0.75	0.61
Nov-11	0.24	0.20	0.67	1.00	0.66	0.63
Dec-11	0.26	0.19	0.64	1.00	0.54	0.61
Jan-12	0.27	0.19	0.67	1.00	0.70	0.60

Date	*Phase 3: Technical Efficiency – Total Equity*					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Feb-12	0.28	0.19	0.67	0.98	0.54	0.58
Mar-12	0.27	0.20	0.64	0.93	0.51	0.67
Apr-12	0.28	0.20	0.63	0.90	0.48	0.56
May-12	0.29	0.21	0.70	0.92	0.83	0.67
Jun-12	0.30	0.22	0.71	0.91	0.62	0.72
Jul-12	0.31	0.22	1.00	0.98	0.91	0.60
Aug-12	0.31	0.22	0.92	0.96	1.00	0.68
Sep-12	0.31	0.23	0.83	0.97	0.83	0.66
Oct-12	0.32	0.23	0.69	0.96	0.79	0.55
Nov-12	0.33	0.17	0.70	0.99	0.98	0.57
Dec-12	0.34	0.18	0.71	0.99	1.00	0.53
Jan-13	0.35	0.18	0.72	0.94	0.78	0.63
Feb-13	0.34	0.19	0.72	0.95	0.84	0.66
Mar-13	0.33	0.19	0.67	0.93	0.64	0.61
Apr-13	0.34	0.20	0.75	0.93	0.76	0.62
May-13	0.33	0.20	0.66	1.00	0.88	0.60
Jun-13	0.34	0.20	0.65	0.98	0.87	0.45
Jul-13	0.34	0.18	0.66	1.00	0.78	0.45
Aug-13	0.53	0.18	0.69	1.00	0.95	0.47
Sep-13	0.55	0.19	0.64	0.97	0.83	0.49
Oct-13	0.56	0.19	0.63	1.00	0.69	0.49
Nov-13	0.57	0.18	0.67	1.00	0.73	0.51
Fully Technical Efficient	0	0	9	11	2	0
Min	0.14	0.17	0.59	0.85	0.37	0.45
Mean	0.30	0.30	0.79	0.95	0.65	0.61
Max	0.57	0.57	1.00	1.00	1.00	0.72
Standard Deviation	0.09	0.14	0.14	0.04	0.19	0.06

Table A.28: Scale efficiency estimates with respect to total equity for all the medium-sized banks in Phase 3 (Sep 2009 - Nov 2013).

Date	***Phase 3: Scale Efficiency – Total Equity***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Sep-09	0.97	0.27	0.97	0.48	0.74	0.53
Oct-09	0.97	0.28	0.95	0.48	0.84	0.54
Nov-09	0.97	0.29	0.94	0.48	0.87	0.49
Dec-09	0.97	0.31	0.98	0.48	0.93	0.42
Jan-10	0.97	0.33	0.89	0.48	0.95	0.43
Feb-10	0.98	0.33	0.80	0.48	0.97	0.57
Mar-10	0.98	0.36	0.99	0.48	0.98	0.48
Apr-10	0.98	0.37	0.84	0.48	0.97	0.50
May-10	0.98	0.38	0.98	0.47	0.96	0.53
Jun-10	0.98	0.43	0.98	0.47	0.99	0.49
Jul-10	0.99	0.46	0.99	0.47	0.93	0.51
Aug-10	0.99	0.48	1.00	0.47	0.91	0.52
Sep-10	0.996	0.51	1.00	0.46	0.84	0.57
Oct-10	0.996	0.52	0.98	0.46	0.84	0.57
Nov-10	0.96	0.58	0.99	0.46	0.85	0.54
Dec-10	0.91	0.62	0.99	0.46	0.85	0.59
Jan-11	0.88	0.64	0.99	0.46	0.95	0.57
Feb-11	0.86	0.71	0.99	0.46	0.97	0.74
Mar-11	0.86	0.77	1.00	0.46	0.96	0.78
Apr-11	0.84	0.77	0.99	0.46	0.97	0.79
May-11	0.82	0.82	0.97	0.46	0.997	0.78
Jun-11	0.80	0.85	0.98	0.46	0.97	0.77
Jul-11	0.78	0.87	0.87	0.46	0.95	0.81
Aug-11	0.77	0.89	0.99	0.45	0.83	0.89
Sep-11	0.76	0.91	0.99	0.41	0.83	0.86
Oct-11	0.74	0.94	0.97	0.42	0.83	0.87
Nov-11	0.73	0.96	0.96	0.42	0.86	0.98
Dec-11	0.71	0.96	0.84	0.44	0.90	0.84
Jan-12	0.69	0.97	0.92	0.45	0.83	0.85

Date	*Phase 3: Scale Efficiency – Total Equity*					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Feb-12	0.69	0.97	0.90	0.45	0.89	0.97
Mar-12	0.68	0.97	0.86	0.45	0.91	0.99
Apr-12	0.67	0.97	0.85	0.45	0.89	0.97
May-12	0.66	0.97	0.96	0.45	0.81	0.99
Jun-12	0.65	0.98	0.97	0.45	0.85	0.99
Jul-12	0.65	0.99	0.86	0.44	0.79	0.99
Aug-12	0.64	0.99	0.89	0.44	0.79	0.99
Sep-12	0.64	0.99	0.93	0.44	0.81	0.99
Oct-12	0.63	0.997	0.97	0.44	0.82	0.99
Nov-12	0.62	0.998	0.97	0.44	0.75	0.99
Dec-12	0.61	0.98	0.97	0.44	0.76	0.99
Jan-13	0.61	0.96	0.93	0.44	0.82	0.99
Feb-13	0.61	0.94	0.92	0.44	0.80	0.99
Mar-13	0.61	0.92	0.84	0.44	0.86	0.99
Apr-13	0.60	0.91	0.99	0.44	0.83	0.99
May-13	0.60	0.90	0.85	0.42	0.80	0.99
Jun-13	0.60	0.89	0.86	0.43	0.79	0.93
Jul-13	0.60	0.91	0.86	0.43	0.82	0.88
Aug-13	0.61	0.90	0.86	0.43	0.75	0.99
Sep-13	0.61	0.91	0.84	0.42	0.81	0.99
Oct-13	0.61	0.90	0.83	0.40	0.83	0.99
Nov-13	0.61	0.89	0.86	0.41	0.84	0.99
Fully Scale Efficient	0	0	3	0	0	0
Min	0.60	0.27	0.80	0.40	0.74	0.42
Mean	0.78	0.75	0.93	0.45	0.87	0.79
Max	0.996	0.998	1.00	0.48	0.997	0.99
Standard Deviation	0.15	0.25	0.06	0.02	0.07	0.21

Table A.29: Technical efficiency estimates with respect to SA group and finance for all the medium-sized banks in Phase 3 (Sep 2009 - Nov 2013).

Date	*Phase 3: Technical Efficiency – SA group and finance*					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Sep-09	0.00	0.00	0.00	0.68	1.00	0.00
Oct-09	0.00	0.00	0.00	0.82	0.38	0.00
Nov-09	0.00	0.00	0.00	0.79	0.57	0.00
Dec-09	0.00	0.00	0.00	0.73	0.00	0.00
Jan-10	0.01	0.00	0.00	0.81	0.30	0.00
Feb-10	0.01	0.00	0.00	0.80	0.00	0.00
Mar-10	0.01	0.00	0.00	0.63	0.12	0.00
Apr-10	0.01	0.00	0.00	0.62	0.02	0.00
May-10	0.01	0.00	0.00	0.61	0.02	0.00
Jun-10	0.02	0.00	0.00	0.61	0.00	0.00
Jul-10	0.03	0.00	0.00	0.60	0.00	0.00
Aug-10	0.04	0.00	0.01	0.49	0.00	0.00
Sep-10	0.12	0.00	0.00	0.58	0.36	0.00
Oct-10	0.15	0.00	0.00	0.52	0.02	0.00
Nov-10	0.15	0.00	0.00	0.61	0.45	0.00
Dec-10	0.37	0.00	0.07	0.59	0.22	0.00
Jan-11	0.29	0.00	0.08	0.62	0.81	0.00
Feb-11	0.29	0.00	0.19	0.58	0.01	0.00
Mar-11	0.17	0.03	0.32	0.74	0.03	0.00
Apr-11	0.19	0.01	0.56	0.69	0.12	0.00
May-11	0.22	0.00	0.21	0.74	0.00	0.00
Jun-11	0.21	0.01	0.45	0.91	0.05	0.00
Jul-11	0.23	0.00	0.00	0.55	0.04	0.00
Aug-11	0.31	0.00	0.00	0.82	0.61	0.03
Sep-11	0.35	0.00	0.00	1.00	0.03	0.00
Oct-11	0.34	0.01	0.00	1.00	0.01	0.00
Nov-11	0.39	0.01	0.00	1.00	0.997	0.03
Dec-11	0.67	0.00	0.00	1.00	0.02	0.01
Jan-12	0.77	0.01	0.00	0.94	0.02	0.00

Date	*Phase 3: Technical Efficiency – SA group and finance*					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Feb-12	0.37	0.00	0.00	0.72	0.01	0.02
Mar-12	0.33	0.00	0.00	0.59	0.06	0.09
Apr-12	0.33	0.00	0.00	0.69	0.10	0.01
May-12	0.41	0.00	0.00	0.63	0.63	0.11
Jun-12	0.51	0.01	0.00	0.67	0.00	1.00
Jul-12	0.43	0.06	0.00	0.70	0.04	0.02
Aug-12	0.49	0.05	0.00	0.65	1.00	0.13
Sep-12	0.61	0.08	0.00	0.61	0.00	0.17
Oct-12	0.55	0.16	1.00	0.52	0.19	0.02
Nov-12	0.42	0.12	0.01	0.67	1.00	0.01
Dec-12	0.59	0.19	0.00	0.89	0.13	0.19
Jan-13	0.65	0.18	0.00	1.00	0.00	0.32
Feb-13	0.72	0.19	1.00	1.00	0.02	0.95
Mar-13	0.50	0.18	0.00	0.57	0.00	0.10
Apr-13	0.51	0.21	1.00	0.96	0.00	1.00
May-13	0.57	0.15	1.00	1.00	0.00	0.11
Jun-13	0.55	0.13	1.00	1.00	0.00	0.02
Jul-13	0.59	0.14	0.03	1.00	0.00	0.02
Aug-13	0.48	0.11	0.01	1.00	0.02	0.02
Sep-13	0.71	0.11	0.00	1.00	0.00	0.01
Oct-13	0.65	0.09	0.01	1.00	0.00	1.00
Nov-13	0.63	0.08	0.03	1.00	0.00	1.00
Fully Technical Efficient	0	0	5	13	3	4
Min	0.00	0.00	0.00	0.49	0.00	0.00
Mean	0.33	0.05	0.14	0.76	0.18	0.13
Max	0.77	0.21	1.00	1.00	1.00	1.00
Standard Deviation	0.24	0.07	0.31	0.17	0.31	0.29

Table A.30: Scale efficiency estimates with respect to SA group and finance for all the medium-sized banks in Phase 3 (Sep 2009 - Nov 2013).

Date	*Phase 3: Scale Efficiency – SA group and finance*					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Sep-09	0.00	0.65	0.00	0.00	0.00	0.01
Oct-09	0.00	0.66	0.00	0.00	0.00	0.01
Nov-09	0.00	0.69	0.00	0.00	0.00	0.01
Dec-09	0.00	0.74	0.00	0.00	0.00	0.99
Jan-10	0.00	0.78	0.00	0.00	0.00	0.06
Feb-10	0.00	0.79	0.00	0.00	0.04	0.01
Mar-10	0.00	0.86	0.00	0.00	0.00	0.01
Apr-10	0.00	0.89	0.00	0.00	0.00	0.01
May-10	0.00	0.91	0.00	0.00	0.02	0.01
Jun-10	0.00	0.07	0.00	0.00	0.01	0.02
Jul-10	0.00	0.02	0.00	0.00	0.00	0.01
Aug-10	0.00	0.01	0.00	0.00	0.00	0.01
Sep-10	0.00	0.01	0.00	0.00	0.00	0.01
Oct-10	0.00	0.01	0.00	0.00	0.00	0.01
Nov-10	0.00	0.01	0.00	0.00	0.00	0.03
Dec-10	0.00	0.01	0.00	0.00	0.00	0.81
Jan-11	0.00	0.01	0.00	0.00	0.00	0.02
Feb-11	0.00	0.00	0.00	0.00	0.00	0.86
Mar-11	0.00	0.00	0.00	0.00	0.00	0.80
Apr-11	0.00	0.00	0.00	0.00	0.01	0.88
May-11	0.00	0.00	0.00	0.00	0.01	0.01
Jun-11	0.00	0.00	0.00	0.00	0.00	0.01
Jul-11	0.00	0.00	0.00	0.00	0.00	0.00
Aug-11	0.00	0.00	0.00	0.00	0.00	0.00
Sep-11	0.00	0.00	0.00	0.00	0.00	0.00
Oct-11	0.00	0.00	0.01	0.00	0.00	0.00
Nov-11	0.00	0.00	0.00	0.00	0.00	0.00
Dec-11	0.00	0.00	0.01	0.00	0.00	0.00
Jan-12	0.00	0.00	0.93	0.00	0.00	0.00

Date	*Phase 3: Scale Efficiency – SA group and finance*					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Feb-12	0.00	0.00	0.91	0.00	0.00	0.00
Mar-12	0.00	0.00	0.91	0.00	0.00	0.00
Apr-12	0.00	0.00	0.01	0.00	0.00	0.00
May-12	0.00	0.00	0.00	0.00	0.00	0.00
Jun-12	0.00	0.00	0.00	0.00	0.00	0.00
Jul-12	0.00	0.00	0.00	0.00	0.00	0.00
Aug-12	0.00	0.00	0.00	0.00	0.00	0.00
Sep-12	0.00	0.00	0.00	0.00	0.00	0.00
Oct-12	0.00	0.00	1.00	0.00	0.00	0.00
Nov-12	0.00	0.00	0.01	0.00	0.00	0.00
Dec-12	0.00	0.00	0.95	0.00	0.00	0.00
Jan-13	0.00	0.00	0.89	0.00	0.00	0.00
Feb-13	0.00	0.00	0.89	0.00	0.00	0.00
Mar-13	0.00	0.00	0.81	0.00	0.00	0.00
Apr-13	0.00	0.00	1.00	0.00	0.00	0.00
May-13	0.00	0.00	1.00	0.00	0.00	0.00
Jun-13	0.00	0.00	0.01	0.00	0.00	0.00
Jul-13	0.00	0.00	0.00	0.00	0.00	0.00
Aug-13	0.00	0.00	0.01	0.00	0.00	0.00
Sep-13	0.00	0.00	0.01	0.00	0.00	0.00
Oct-13	0.00	0.00	0.01	0.00	0.00	0.00
Nov-13	0.00	0.00	0.01	0.00	0.00	0.00
Fully Scale Efficient	0	0	3	0	0	0
Min	0.00	0.00	0.00	0.00	0.00	0.00
Mean	0.00	0.14	0.18	0.00	0.00	0.09
Max	0.00	0.91	1.00	0.00	0.04	0.99
Standard Deviation	0.00	0.30	0.37	0.00	0.01	0.26

Table A.31: Overall technical efficiency estimates for all the medium-sized banks for Phase 4 (Dec 2013 - Dec 2017).

Date	***Phase 4: Overall Technical Efficiency***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Dec-13	0.97	0.54	0.99	0.95	0.69	0.92
Jan-14	0.97	0.53	1.00	1.00	1.00	1.00
Feb-14	1.00	0.51	0.97	0.97	0.72	0.80
Mar-14	0.98	0.53	1.00	0.95	0.76	0.88
Apr-14	0.97	0.52	1.00	0.97	0.78	0.90
May-14	0.99	0.51	1.00	0.96	0.78	0.79
Jun-14	1.00	0.51	0.99	0.99	0.81	0.80
Jul-14	1.00	0.51	1.00	0.96	0.72	0.75
Aug-14	1.00	0.49	1.00	0.94	0.74	0.91
Sep-14	1.00	0.50	0.99	0.91	0.80	0.89
Oct-14	1.00	0.50	1.00	0.91	0.76	0.74
Nov-14	1.00	0.49	0.99	0.91	0.84	0.80
Dec-14	1.00	0.48	1.00	0.94	0.90	0.68
Jan-15	1.00	0.49	0.99	0.95	0.94	0.85
Feb-15	1.00	0.47	1.00	0.96	0.95	0.82
Mar-15	1.00	0.49	1.00	0.99	0.79	0.84
Apr-15	1.00	0.48	1.00	0.97	1.00	0.81
May-15	1.00	0.47	1.00	0.99	1.00	0.75
Jun-15	1.00	0.47	0.99	1.00	1.00	0.77
Jul-15	1.00	0.46	0.98	1.00	0.86	0.77
Aug-15	1.00	0.46	0.99	0.98	0.91	0.73
Sep-15	1.00	0.46	0.99	0.99	1.00	0.70
Oct-15	1.00	0.46	0.99	0.97	1.00	0.72
Nov-15	1.00	0.45	1.00	0.97	0.97	0.70
Dec-15	1.00	0.44	1.00	1.00	1.00	0.69
Jan-16	1.00	0.44	0.96	1.00	1.00	0.78
Feb-16	1.00	0.44	1.00	1.00	1.00	0.79
Mar-16	1.00	0.45	0.99	0.98	1.00	0.73
Apr-16	0.66	0.44	0.96	0.97	0.85	0.79

Date	***Phase 4: Overall Technical Efficiency***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
May-16	0.71	0.44	1.00	0.95	1.00	0.70
Jun-16	0.75	0.43	0.99	0.97	0.82	0.73
Jul-16	0.79	0.42	1.00	0.98	0.89	0.62
Aug-16	0.87	0.43	1.00	1.00	0.96	0.63
Sep-16	0.87	0.42	1.00	0.97	1.00	0.60
Oct-16	0.88	0.43	1.00	1.00	1.00	0.59
Nov-16	0.92	0.42	0.98	1.00	0.89	0.57
Dec-16	0.93	0.41	1.00	0.99	1.00	0.52
Jan-17	0.92	0.42	0.99	0.97	1.00	0.56
Feb-17	1.00	0.41	0.99	0.98	1.00	0.48
Mar-17	1.00	0.41	0.98	0.96	0.97	0.61
Apr-17	0.99	0.40	1.00	1.00	1.00	0.46
May-17	0.99	0.41	0.99	1.00	0.76	0.49
Jun-17	0.99	0.41	1.00	1.00	1.00	0.63
Jul-17	1.00	0.40	1.00	0.96	0.78	0.59
Aug-17	0.94	0.38	0.95	1.00	0.78	0.66
Sep-17	0.95	0.40	0.99	0.96	0.87	0.57
Oct-17	0.96	0.38	1.00	0.97	0.84	0.57
Nov-17	0.98	0.40	0.96	0.98	1.00	0.66
Dec-17	1.00	0.40	0.95	1.00	1.00	0.63
Fully Technical Efficient	27	0	25	14	20	1
Min	0.66	0.38	0.95	0.91	0.69	0.46
Mean	0.96	0.45	0.99	0.97	0.90	0.71
Max	1.00	0.54	1.00	1.00	1.00	1.00
Standard Deviation	0.08	0.04	0.01	0.02	0.10	0.12

Table A.32: Overall scale efficiency estimates for all the medium-sized banks for Phase 4 (Dec 2013 - Dec 2017).

Date	***Phase 4: Overall Scale Efficiency***					
	AB	CB	DB	IB	JPM	HSBC
Dec-13	0.90	0.97	0.94	0.84	0.87	0.97
Jan-14	0.90	0.97	1.00	0.84	1.00	0.91
Feb-14	0.91	0.98	0.85	0.89	0.97	0.97
Mar-14	0.95	0.98	1.00	0.88	0.86	0.98
Apr-14	0.97	0.98	1.00	0.89	0.87	0.94
May-14	0.997	0.98	0.90	0.88	0.81	0.98
Jun-14	1.00	0.99	0.95	0.86	0.85	0.97
Jul-14	1.00	0.99	1.00	0.91	0.90	0.99
Aug-14	1.00	0.99	0.79	0.91	0.87	0.99
Sep-14	1.00	0.99	0.76	0.93	0.90	0.97
Oct-14	1.00	0.99	0.80	0.95	0.83	0.97
Nov-14	1.00	0.99	0.88	0.93	0.80	0.98
Dec-14	1.00	0.99	0.83	0.94	0.92	0.99
Jan-15	1.00	0.99	1.00	0.93	0.91	0.97
Feb-15	1.00	0.99	0.91	0.94	0.96	0.98
Mar-15	1.00	0.99	0.95	0.94	0.85	0.99
Apr-15	1.00	0.99	0.92	0.93	1.00	0.98
May-15	1.00	0.99	1.00	0.94	0.97	0.97
Jun-15	1.00	0.99	0.82	0.95	1.00	0.97
Jul-15	1.00	0.99	0.77	0.97	0.97	0.99
Aug-15	1.00	0.99	0.77	0.94	0.98	0.98
Sep-15	1.00	0.99	0.82	0.95	1.00	0.98
Oct-15	1.00	0.99	0.85	0.98	1.00	0.96
Nov-15	1.00	0.99	0.95	0.99	0.98	0.97
Dec-15	1.00	0.99	1.00	1.00	1.00	0.97
Jan-16	1.00	0.99	0.92	1.00	1.00	0.98
Feb-16	1.00	0.99	1.00	1.00	1.00	0.99
Mar-16	1.00	0.99	0.96	0.98	0.97	0.97
Apr-16	0.97	0.99	0.86	0.99	0.86	0.97

Date	*Phase 4: Overall Scale Efficiency*					
	AB	CB	DB	IB	JPM	HSBC
May-16	0.99	0.99	1.00	0.98	1.00	0.98
Jun-16	0.99	0.99	0.87	0.98	0.92	0.96
Jul-16	0.99	0.99	1.00	0.96	0.90	0.99
Aug-16	0.99	0.99	0.89	0.96	0.98	0.97
Sep-16	0.98	0.99	0.58	0.97	0.99	0.96
Oct-16	0.98	0.99	0.57	0.97	1.00	0.93
Nov-16	0.99	0.99	0.56	1.00	0.95	0.97
Dec-16	0.99	0.99	0.83	0.97	0.93	0.99
Jan-17	0.99	0.99	0.67	0.97	0.96	0.97
Feb-17	1.00	0.99	0.67	0.97	1.00	0.99
Mar-17	1.00	0.99	0.69	0.97	0.99	0.99
Apr-17	0.99	0.99	0.61	0.98	1.00	0.99
May-17	0.99	0.99	0.70	0.97	0.99	0.99
Jun-17	0.98	0.99	1.00	0.99	1.00	0.99
Jul-17	1.00	0.99	0.99	0.97	0.99	0.99
Aug-17	0.99	0.99	0.78	0.96	0.99	0.99
Sep-17	0.99	0.99	0.66	0.94	0.98	0.99
Oct-17	0.99	0.99	0.83	0.95	0.99	0.99
Nov-17	0.99	0.99	0.75	0.92	1.00	0.99
Dec-17	1.00	0.99	0.66	0.93	0.98	0.96
Fully Scale Efficient	26	0	11	4	14	0
Min	0.90	0.97	0.56	0.84	0.80	0.91
Mean	0.99	0.99	0.85	0.95	0.95	0.98
Max	1.00	0.99	1.00	1.00	1.00	0.99
Standard Deviation	0.02	0.01	0.13	0.04	0.06	0.02

Table A.33: Technical efficiency estimates with respect to total deposits for all the medium-sized banks in Phase 4 (Dec 2013 - Dec 2017).

Date	***Phase 4: Technical Efficiency –Total Deposits***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Dec-13	0.91	0.36	0.36	0.94	0.47	0.15
Jan-14	0.94	0.36	0.36	1.00	0.75	0.24
Feb-14	1.00	0.35	0.44	0.97	0.42	0.18
Mar-14	0.93	0.34	0.33	0.95	0.47	0.22
Apr-14	0.95	0.34	0.43	0.93	0.44	0.21
May-14	0.99	0.33	0.51	0.96	0.58	0.20
Jun-14	1.00	0.34	0.43	0.99	0.46	0.19
Jul-14	0.93	0.34	0.44	0.93	0.36	0.21
Aug-14	0.93	0.32	0.49	0.94	0.38	0.25
Sep-14	0.93	0.33	0.49	0.91	0.41	0.25
Oct-14	0.93	0.34	0.56	0.91	0.51	0.20
Nov-14	0.93	0.33	0.47	0.90	0.57	0.22
Dec-14	0.93	0.34	0.43	0.93	0.56	0.15
Jan-15	0.93	0.35	0.51	0.95	0.59	0.25
Feb-15	0.93	0.33	0.37	0.96	0.55	0.24
Mar-15	0.93	0.33	0.35	0.99	0.52	0.27
Apr-15	0.93	0.33	0.35	0.97	0.61	0.27
May-15	0.93	0.32	0.34	0.98	0.62	0.22
Jun-15	0.93	0.33	0.43	0.98	0.81	0.23
Jul-15	0.93	0.32	0.41	0.98	0.47	0.25
Aug-15	0.93	0.32	0.52	0.93	0.59	0.23
Sep-15	0.93	0.31	0.48	0.95	0.72	0.23
Oct-15	0.93	0.31	0.50	0.95	0.68	0.24
Nov-15	0.93	0.31	0.50	0.97	0.66	0.23
Dec-15	0.93	0.32	0.66	1.00	0.97	0.22
Jan-16	0.93	0.33	0.60	0.98	1.00	0.28
Feb-16	0.93	0.32	0.58	1.00	1.00	0.30
Mar-16	0.93	0.32	0.59	0.98	0.63	0.24
Apr-16	0.51	0.31	0.66	0.97	0.74	0.29

Date	*Phase 4: Technical Efficiency –Total Deposits*					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
May-16	0.52	0.31	0.71	0.95	1.00	0.25
Jun-16	0.51	0.31	0.67	0.97	0.55	0.30
Jul-16	0.67	0.30	0.71	0.98	0.80	0.25
Aug-16	0.63	0.31	0.54	1.00	0.77	0.25
Sep-16	0.67	0.29	0.70	0.97	1.00	0.23
Oct-16	0.73	0.31	0.80	0.99	1.00	0.23
Nov-16	0.74	0.30	0.72	0.99	0.73	0.23
Dec-16	0.71	0.30	0.82	0.99	1.00	0.21
Jan-17	0.72	0.32	0.73	0.96	0.98	0.23
Feb-17	1.00	0.31	0.66	0.98	0.96	0.20
Mar-17	1.00	0.28	0.64	0.96	0.81	0.28
Apr-17	0.99	0.29	0.76	1.00	0.71	0.19
May-17	0.98	0.29	0.70	1.00	0.74	0.19
Jun-17	0.99	0.30	0.75	1.00	0.90	0.29
Jul-17	1.00	0.29	0.56	0.96	0.72	0.27
Aug-17	0.93	0.28	0.57	0.97	0.70	0.31
Sep-17	0.91	0.29	0.75	0.96	0.71	0.26
Oct-17	0.91	0.28	0.65	0.96	0.68	0.26
Nov-17	0.92	0.31	0.58	0.96	0.93	0.31
Dec-17	0.96	0.34	0.63	1.00	1.00	0.27
Fully Technical Efficient	5	0	0	8	7	0
Min	0.51	0.28	0.33	0.90	0.36	0.15
Mean	0.88	0.32	0.56	0.97	0.70	0.24
Max	1.00	0.36	0.82	1.00	1.00	0.31
Standard Deviation	0.13	0.02	0.14	0.03	0.20	0.04

Table A.34: Scale efficiency estimates with respect to total deposits for all the medium-sized banks in Phase 4 (Dec 2013 - Dec 2017).

Date	***Phase 4: Scale Efficiency –Total Deposits***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Dec-13	0.43	0.61	0.72	0.20	0.80	0.999
Jan-14	0.42	0.60	0.80	0.19	0.95	0.75
Feb-14	0.43	0.60	0.63	0.20	0.89	0.86
Mar-14	0.46	0.60	0.75	0.20	0.87	0.73
Apr-14	0.46	0.60	0.62	0.21	0.85	0.74
May-14	0.47	0.60	0.54	0.20	0.80	0.78
Jun-14	0.47	0.59	0.61	0.20	0.88	0.80
Jul-14	0.48	0.58	0.59	0.21	0.92	0.77
Aug-14	0.48	0.59	0.50	0.21	0.94	0.62
Sep-14	0.48	0.58	0.53	0.21	0.98	0.66
Oct-14	0.48	0.57	0.60	0.21	0.83	0.78
Nov-14	0.48	0.57	0.65	0.21	0.84	0.70
Dec-14	0.48	0.57	0.61	0.21	0.94	0.95
Jan-15	0.48	0.56	0.65	0.21	0.99	0.67
Feb-15	0.48	0.56	0.65	0.21	0.99	0.66
Mar-15	0.48	0.55	0.74	0.21	0.91	0.61
Apr-15	0.48	0.56	0.70	0.21	0.99	0.63
May-15	0.48	0.55	0.77	0.21	0.98	0.69
Jun-15	0.48	0.55	0.62	0.21	0.98	0.66
Jul-15	0.48	0.54	0.59	0.21	0.93	0.62
Aug-15	0.48	0.54	0.58	0.21	0.99	0.65
Sep-15	0.48	0.54	0.58	0.21	0.99	0.68
Oct-15	0.48	0.54	0.59	0.20	0.99	0.68
Nov-15	0.48	0.53	0.64	0.20	0.99	0.68
Dec-15	0.48	0.53	0.70	0.20	0.56	0.72
Jan-16	0.48	0.53	0.61	0.20	0.63	0.59
Feb-16	0.48	0.53	0.64	0.20	0.83	0.55
Mar-16	0.48	0.52	0.56	0.20	0.99	0.62
Apr-16	0.90	0.53	0.50	0.20	0.92	0.55

Date	***Phase 4: Scale Efficiency –Total Deposits***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
May-16	0.88	0.52	0.56	0.20	1.00	0.61
Jun-16	0.95	0.52	0.47	0.20	0.99	0.59
Jul-16	0.93	0.52	0.48	0.20	0.95	0.66
Aug-16	0.93	0.51	0.47	0.20	0.99	0.66
Sep-16	0.97	0.52	0.40	0.20	0.99	0.69
Oct-16	0.96	0.51	0.39	0.20	0.97	0.73
Nov-16	0.95	0.51	0.40	0.20	0.95	0.71
Dec-16	0.94	0.51	0.36	0.20	0.86	0.76
Jan-17	0.95	0.50	0.40	0.20	0.89	0.73
Feb-17	1.00	0.50	0.42	0.20	0.91	0.85
Mar-17	1.00	0.51	0.42	0.20	0.99	0.68
Apr-17	0.99	0.51	0.38	0.20	0.98	0.86
May-17	0.99	0.50	0.39	0.20	0.96	0.76
Jun-17	0.98	0.49	0.38	0.20	0.96	0.61
Jul-17	1.00	0.50	0.46	0.20	0.98	0.63
Aug-17	0.99	0.50	0.43	0.20	0.97	0.58
Sep-17	0.98	0.48	0.39	0.20	0.96	0.64
Oct-17	0.99	0.49	0.54	0.20	0.99	0.65
Nov-17	0.99	0.46	0.45	0.20	0.99	0.60
Dec-17	0.99	0.44	0.39	0.20	0.97	0.64
Fully Scale Efficient	3	0	0	0	1	0
Min	0.42	0.44	0.36	0.19	0.56	0.55
Mean	0.68	0.54	0.55	0.20	0.93	0.69
Max	1.00	0.61	0.80	0.21	1.00	0.999
Standard Deviation	0.25	0.04	0.12	0.00	0.09	0.10

Table A.35: Technical efficiency estimates with respect to Central bank and money for all the medium-sized banks in Phase 4 (Dec 2013 - Dec 2017).

Date	***Phase 4: Technical Efficiency -Central bank and money***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Dec-13	0.73	0.18	0.24	0.95	0.20	0.16
Jan-14	0.73	0.17	0.43	1.00	0.48	0.36
Feb-14	0.72	0.18	0.23	0.97	0.26	0.21
Mar-14	0.73	0.19	1.00	0.89	0.18	0.33
Apr-14	0.69	0.17	0.43	0.97	0.09	0.18
May-14	0.68	0.17	0.21	0.95	0.13	0.20
Jun-14	0.72	0.18	0.46	0.97	0.17	0.16
Jul-14	0.63	0.17	1.00	0.96	0.17	0.19
Aug-14	0.63	0.17	0.18	0.93	0.18	0.44
Sep-14	0.63	0.17	0.08	0.90	0.17	0.43
Oct-14	0.63	0.17	0.12	0.88	0.10	0.20
Nov-14	0.63	0.17	0.27	0.91	0.12	0.28
Dec-14	0.63	0.15	0.25	0.94	0.17	0.11
Jan-15	0.63	0.16	0.54	0.88	0.35	0.28
Feb-15	0.63	0.16	0.48	0.92	0.27	0.40
Mar-15	0.63	0.18	0.39	0.93	0.21	0.40
Apr-15	0.63	0.14	0.19	0.95	0.27	0.40
May-15	0.63	0.17	0.18	0.99	0.16	0.30
Jun-15	0.63	0.18	0.06	1.00	0.28	0.39
Jul-15	0.63	0.16	0.04	1.00	0.43	0.39
Aug-15	0.63	0.17	0.04	0.98	0.38	0.30
Sep-15	0.63	0.18	0.09	0.99	0.40	0.32
Oct-15	0.63	0.16	0.19	0.96	0.54	0.23
Nov-15	0.63	0.16	0.56	0.95	0.57	0.34
Dec-15	0.63	0.16	1.00	1.00	1.00	0.20
Jan-16	0.63	0.17	0.51	0.93	1.00	0.31
Feb-16	0.63	0.17	0.74	1.00	1.00	0.52
Mar-16	0.63	0.15	0.26	0.95	0.47	0.43
Apr-16	0.13	0.15	0.10	0.95	0.25	0.25

Date	*Phase 4: Technical Efficiency -Central bank and money*					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
May-16	0.32	0.17	1.00	0.56	0.37	0.36
Jun-16	0.33	0.17	0.99	0.94	0.29	0.45
Jul-16	0.32	0.17	1.00	0.95	0.26	0.25
Aug-16	0.38	0.19	0.47	0.95	0.31	0.27
Sep-16	0.28	0.17	0.05	0.93	0.25	0.23
Oct-16	0.15	0.19	0.03	0.99	0.23	0.18
Nov-16	0.37	0.18	0.03	0.99	0.28	0.18
Dec-16	0.38	0.14	0.03	0.99	0.18	0.13
Jan-17	0.37	0.17	0.03	0.97	0.21	0.14
Feb-17	0.36	0.18	0.03	0.96	0.39	0.11
Mar-17	0.35	0.14	0.03	0.96	0.38	0.23
Apr-17	0.31	0.16	0.03	1.00	0.23	0.17
May-17	0.33	0.16	0.03	0.99	0.16	0.17
Jun-17	0.31	0.16	0.03	0.99	0.24	0.25
Jul-17	0.31	0.18	0.11	0.95	0.23	0.36
Aug-17	0.30	0.14	0.07	0.98	0.22	0.47
Sep-17	0.27	0.16	0.02	0.87	0.22	0.24
Oct-17	0.29	0.14	0.06	0.96	0.31	0.33
Nov-17	0.30	0.15	0.04	0.98	0.30	0.35
Dec-17	0.30	0.19	0.02	1.00	0.21	0.26
Fully Technical Efficient	0	0	5	7	3	0
Min	0.13	0.14	0.02	0.56	0.09	0.11
Mean	0.50	0.17	0.29	0.95	0.31	0.28
Max	0.73	0.19	1.00	1.00	1.00	0.52
Standard Deviation	0.18	0.01	0.32	0.07	0.21	0.10

Table A.36: Scale efficiency estimates with respect to Central bank and money for all the medium-sized banks in Phase 4 (Dec 2013 - Dec 2017).

Date	***Phase 4: Scale Efficiency -Central bank and money***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Dec-13	0.01	0.02	0.12	0.01	0.10	0.04
Jan-14	0.01	0.02	0.09	0.01	0.07	0.03
Feb-14	0.01	0.02	0.19	0.01	0.07	0.04
Mar-14	0.01	0.02	0.12	0.01	0.08	0.03
Apr-14	0.01	0.02	0.19	0.01	0.08	0.03
May-14	0.01	0.02	0.33	0.01	0.10	0.03
Jun-14	0.01	0.02	0.22	0.01	0.07	0.04
Jul-14	0.01	0.02	0.25	0.01	0.06	0.03
Aug-14	0.01	0.02	0.48	0.01	0.07	0.02
Sep-14	0.01	0.02	0.55	0.01	0.06	0.02
Oct-14	0.01	0.02	0.27	0.01	0.09	0.03
Nov-14	0.01	0.02	0.17	0.01	0.09	0.03
Dec-14	0.01	0.02	0.22	0.01	0.06	0.05
Jan-15	0.01	0.02	0.16	0.01	0.06	0.02
Feb-15	0.01	0.02	0.17	0.01	0.06	0.02
Mar-15	0.01	0.02	0.11	0.01	0.08	0.02
Apr-15	0.01	0.02	0.14	0.01	0.05	0.02
May-15	0.01	0.02	0.11	0.01	0.07	0.02
Jun-15	0.01	0.02	0.20	0.01	0.07	0.02
Jul-15	0.01	0.02	0.31	0.01	0.04	0.02
Aug-15	0.01	0.02	0.31	0.01	0.06	0.02
Sep-15	0.01	0.02	0.35	0.01	0.06	0.02
Oct-15	0.01	0.02	0.29	0.01	0.06	0.02
Nov-15	0.01	0.02	0.17	0.01	0.06	0.02
Dec-15	0.01	0.02	0.17	0.01	0.04	0.03
Jan-16	0.01	0.02	0.26	0.01	0.05	0.02
Feb-16	0.01	0.02	0.16	0.01	0.05	0.02
Mar-16	0.01	0.02	0.43	0.01	0.06	0.02
Apr-16	0.04	0.02	0.97	0.01	0.07	0.02

Date	*Phase 4: Scale Efficiency -Central bank and money*					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
May-16	0.04	0.02	1.00	0.01	0.05	0.02
Jun-16	0.04	0.01	0.87	0.01	0.06	0.02
Jul-16	0.03	0.01	0.85	0.01	0.06	0.02
Aug-16	0.03	0.01	0.87	0.01	0.06	0.02
Sep-16	0.04	0.01	0.73	0.01	0.06	0.03
Oct-16	0.04	0.01	0.67	0.01	0.07	0.03
Nov-16	0.04	0.01	0.76	0.01	0.07	0.03
Dec-16	0.03	0.01	0.70	0.01	0.09	0.03
Jan-17	0.03	0.01	0.92	0.01	0.08	0.03
Feb-17	0.04	0.01	0.98	0.01	0.07	0.04
Mar-17	0.04	0.01	0.82	0.01	0.07	0.02
Apr-17	0.04	0.01	0.85	0.01	0.07	0.04
May-17	0.04	0.01	0.99	0.01	0.07	0.03
Jun-17	0.04	0.01	0.98	0.01	0.07	0.02
Jul-17	0.04	0.01	0.36	0.01	0.07	0.02
Aug-17	0.04	0.01	0.42	0.01	0.07	0.02
Sep-17	0.04	0.01	0.95	0.01	0.07	0.02
Oct-17	0.04	0.01	0.36	0.01	0.06	0.02
Nov-17	0.04	0.01	0.48	0.01	0.07	0.02
Dec-17	0.04	0.01	0.98	0.01	0.07	0.02
Fully Scale Efficient	0	0	1	0	0	0
Min	0.01	0.01	0.09	0.01	0.04	0.02
Mean	0.02	0.02	0.47	0.01	0.07	0.03
Max	0.04	0.02	1.00	0.01	0.10	0.05
Standard Deviation	0.01	0.00	0.32	0.00	0.01	0.01

Table A.37: Technical efficiency estimates with respect to total equity for all the medium-sized banks in Phase 4 (Dec 2013 - Dec 2017).

Date	***Phase 4: Technical Efficiency -Total Equity***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Dec-13	0.39	0.31	0.98	0.86	0.62	0.91
Jan-14	0.39	0.30	1.00	0.97	0.82	0.89
Feb-14	0.39	0.29	0.97	0.91	0.72	0.80
Mar-14	0.43	0.31	1.00	0.88	0.67	0.88
Apr-14	0.44	0.30	1.00	0.85	0.66	0.84
May-14	0.43	0.29	0.99	0.87	0.63	0.79
Jun-14	0.44	0.30	0.99	0.87	0.64	0.80
Jul-14	0.55	0.29	0.98	0.86	0.65	0.75
Aug-14	0.55	0.29	0.98	0.85	0.68	0.91
Sep-14	0.55	0.29	0.98	0.81	0.70	0.87
Oct-14	0.55	0.29	0.97	0.77	0.62	0.74
Nov-14	0.55	0.29	0.97	0.77	0.66	0.80
Dec-14	0.55	0.28	1.00	0.80	0.65	0.68
Jan-15	0.55	0.28	1.00	0.78	0.87	0.85
Feb-15	0.55	0.27	0.99	0.79	0.75	0.82
Mar-15	0.55	0.29	0.99	0.82	0.73	0.84
Apr-15	0.55	0.28	1.00	0.80	0.74	0.80
May-15	0.55	0.28	0.99	0.84	0.60	0.75
Jun-15	0.55	0.27	0.98	0.84	0.62	0.77
Jul-15	0.55	0.27	0.98	0.87	0.69	0.77
Aug-15	0.55	0.27	0.99	0.88	0.68	0.73
Sep-15	0.55	0.27	0.99	0.90	0.70	0.70
Oct-15	0.55	0.27	0.99	0.89	0.73	0.71
Nov-15	0.55	0.27	1.00	0.92	0.74	0.70
Dec-15	0.55	0.26	1.00	1.00	1.00	0.69
Jan-16	0.55	0.26	0.90	1.00	1.00	0.78
Feb-16	0.55	0.26	0.86	1.00	1.00	0.79
Mar-16	0.55	0.27	0.84	0.91	0.87	0.73
Apr-16	0.20	0.26	0.84	0.88	0.68	0.79

Date	*Phase 4: Technical Efficiency -Total Equity*					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
May-16	0.20	0.26	0.83	0.88	0.91	0.70
Jun-16	0.20	0.26	0.83	0.87	0.76	0.70
Jul-16	0.21	0.25	0.83	0.86	0.71	0.61
Aug-16	0.24	0.25	0.93	0.93	0.74	0.63
Sep-16	0.24	0.25	0.93	0.88	0.72	0.59
Oct-16	0.23	0.26	0.94	1.00	0.62	0.56
Nov-16	0.24	0.25	0.96	1.00	0.63	0.57
Dec-16	0.24	0.24	0.97	0.93	0.54	0.52
Jan-17	0.24	0.24	0.95	0.92	0.57	0.56
Feb-17	0.24	0.24	0.97	0.92	0.64	0.48
Mar-17	0.24	0.25	0.97	0.92	0.45	0.53
Apr-17	0.23	0.24	0.98	0.97	0.43	0.46
May-17	0.23	0.24	0.97	1.00	0.40	0.47
Jun-17	0.23	0.25	0.97	0.98	0.43	0.59
Jul-17	0.22	0.24	0.94	0.91	0.44	0.55
Aug-17	0.23	0.23	0.93	0.96	0.43	0.58
Sep-17	0.22	0.24	0.94	0.88	0.41	0.53
Oct-17	0.22	0.23	0.94	0.97	0.48	0.53
Nov-17	0.22	0.24	0.94	0.98	0.46	0.54
Dec-17	0.22	0.24	0.94	1.00	0.42	0.51
Fully Technical Efficient	0	0	8	7	3	0
Min	0.20	0.23	0.83	0.77	0.40	0.46
Mean	0.39	0.27	0.96	0.90	0.66	0.70
Max	0.55	0.31	1.00	1.00	1.00	0.91
Standard Deviation	0.15	0.02	0.05	0.07	0.15	0.13

Table A.38: Scale efficiency estimates with respect to total equity for all the medium-sized banks in Phase 4 (Dec 2013 - Dec 2017).

Date	***Phase 4: Scale Efficiency -Total Equity***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Dec-13	0.96	0.92	0.91	0.86	0.95	0.98
Jan-14	0.96	0.92	1.00	0.83	0.96	0.98
Feb-14	0.96	0.92	0.81	0.89	0.97	0.97
Mar-14	0.96	0.93	0.96	0.89	0.96	0.98
Apr-14	0.96	0.92	0.81	0.93	0.96	0.98
May-14	0.96	0.92	0.69	0.89	0.96	0.98
Jun-14	0.96	0.93	0.77	0.89	0.95	0.97
Jul-14	0.95	0.93	0.76	0.94	0.97	0.99
Aug-14	0.95	0.93	0.64	0.92	0.91	0.99
Sep-14	0.95	0.93	0.70	0.96	0.93	0.98
Oct-14	0.95	0.93	0.80	0.99	0.95	0.97
Nov-14	0.95	0.93	0.85	0.99	0.87	0.98
Dec-14	0.95	0.93	0.78	0.99	0.97	0.99
Jan-15	0.95	0.93	0.90	0.99	0.94	0.97
Feb-15	0.95	0.93	0.83	0.99	0.98	0.98
Mar-15	0.95	0.93	0.93	0.99	0.89	0.99
Apr-15	0.95	0.93	0.89	0.99	0.997	0.99
May-15	0.95	0.93	0.96	0.99	0.92	0.97
Jun-15	0.95	0.93	0.80	0.99	0.89	0.97
Jul-15	0.95	0.94	0.77	0.99	0.99	0.99
Aug-15	0.95	0.94	0.78	0.99	0.96	0.98
Sep-15	0.95	0.94	0.80	0.99	0.94	0.98
Oct-15	0.95	0.94	0.79	0.99	0.95	0.97
Nov-15	0.95	0.94	0.86	0.99	0.94	0.97
Dec-15	0.95	0.94	0.94	0.95	1.00	0.97
Jan-16	0.95	0.94	0.86	1.00	1.00	0.98
Feb-16	0.95	0.94	0.88	0.98	1.00	0.99
Mar-16	0.95	0.94	0.74	0.99	0.98	0.97
Apr-16	0.89	0.94	0.67	0.99	0.93	0.97

Date	*Phase 4: Scale Efficiency -Total Equity*					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
May-16	0.89	0.94	0.76	0.99	0.99	0.98
Jun-16	0.89	0.94	0.64	0.99	0.95	0.98
Jul-16	0.89	0.94	0.65	0.98	0.93	0.98
Aug-16	0.89	0.94	0.64	0.94	0.94	0.97
Sep-16	0.89	0.94	0.55	0.97	0.94	0.96
Oct-16	0.89	0.94	0.52	0.89	0.92	0.97
Nov-16	0.89	0.94	0.52	0.89	0.92	0.96
Dec-16	0.89	0.94	0.47	0.92	0.91	0.97
Jan-17	0.89	0.95	0.50	0.92	0.90	0.97
Feb-17	0.89	0.95	0.54	0.91	0.91	0.98
Mar-17	0.89	0.94	0.53	0.91	0.93	0.98
Apr-17	0.88	0.94	0.48	0.87	0.92	0.98
May-17	0.88	0.95	0.49	0.84	0.95	0.98
Jun-17	0.88	0.95	0.48	0.85	0.92	0.98
Jul-17	0.88	0.95	0.60	0.89	0.93	0.98
Aug-17	0.88	0.95	0.56	0.86	0.92	0.99
Sep-17	0.88	0.95	0.49	0.90	0.91	0.98
Oct-17	0.88	0.95	0.69	0.84	0.94	0.97
Nov-17	0.88	0.95	0.56	0.83	0.93	0.99
Dec-17	0.88	0.95	0.48	0.81	0.98	0.98
Fully Scale Efficient	0	0	1	1	3	0
Min	0.88	0.92	0.47	0.81	0.87	0.96
Mean	0.92	0.94	0.71	0.94	0.94	0.98
Max	0.96	0.95	1.00	1.00	1.00	0.99
Standard Deviation	0.03	0.01	0.16	0.06	0.03	0.01

Table A.39: Technical efficiency estimates with respect to SA group and finance for all the medium-sized banks in Phase 4 (Dec 2013 - Dec 2017).

Date	***Phase 4: Technical Efficiency – SA group and finance***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Dec-13	0.02	0.01	0.00	0.06	0.00	0.00
Jan-14	0.02	0.01	0.00	0.06	0.10	0.62
Feb-14	0.02	0.01	0.00	0.07	0.00	0.00
Mar-14	0.02	0.01	1.00	0.06	0.00	0.01
Apr-14	0.02	0.00	1.00	0.07	0.07	0.10
May-14	0.04	0.00	0.00	0.08	0.00	0.00
Jun-14	0.04	0.00	0.00	0.08	0.06	0.00
Jul-14	0.05	0.00	0.00	0.07	0.00	0.01
Aug-14	0.05	0.00	0.00	0.07	0.00	0.01
Sep-14	0.05	0.00	0.00	0.06	0.08	0.06
Oct-14	0.05	0.00	0.00	0.06	0.00	0.00
Nov-14	0.05	0.00	0.00	0.04	0.00	0.01
Dec-14	0.05	0.00	0.00	0.05	0.00	0.00
Jan-15	0.05	0.00	0.00	0.08	0.00	0.01
Feb-15	0.05	0.00	0.00	0.13	0.00	0.02
Mar-15	0.05	0.00	0.00	0.10	0.00	0.02
Apr-15	0.05	0.00	0.00	0.10	0.01	0.05
May-15	0.05	0.00	0.00	0.08	0.07	0.01
Jun-15	0.05	0.00	0.00	0.22	0.00	0.01
Jul-15	0.05	0.00	0.00	0.15	0.11	0.01
Aug-15	0.05	0.00	0.00	0.06	0.00	0.00
Sep-15	0.05	0.00	0.00	0.13	0.02	0.00
Oct-15	0.05	0.00	0.00	0.17	0.01	0.03
Nov-15	0.05	0.00	0.00	0.12	0.00	0.01
Dec-15	0.05	0.00	0.00	1.00	1.00	0.00
Jan-16	0.05	0.00	0.00	0.25	1.00	0.01
Feb-16	0.05	0.00	1.00	0.23	1.00	0.03
Mar-16	0.05	0.00	0.00	0.09	0.01	0.01
Apr-16	0.00	0.00	0.00	0.17	0.00	0.03

Date	*Phase 4: Technical Efficiency – SA group and finance*					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
May-16	0.00	0.00	0.00	0.15	0.00	0.01
Jun-16	0.00	0.00	0.00	0.18	0.00	0.09
Jul-16	0.00	0.00	0.00	0.19	0.00	0.02
Aug-16	0.00	0.00	0.00	0.19	0.00	0.01
Sep-16	0.00	0.00	0.00	0.06	0.00	0.02
Oct-16	0.00	0.00	0.00	0.12	0.01	0.07
Nov-16	0.00	0.00	0.00	0.63	0.00	0.01
Dec-16	0.00	0.00	1.00	0.15	0.00	0.00
Jan-17	0.00	0.00	0.00	0.10	0.00	0.01
Feb-17	0.00	0.00	0.00	0.21	0.00	0.00
Mar-17	0.00	0.00	0.00	0.11	0.00	0.02
Apr-17	0.00	0.00	0.00	0.42	0.22	0.00
May-17	0.00	0.00	0.00	0.48	0.00	0.00
Jun-17	0.00	0.00	0.33	1.00	0.02	0.02
Jul-17	0.00	0.00	1.00	0.22	0.00	0.00
Aug-17	0.00	0.00	0.00	1.00	0.00	0.04
Sep-17	0.00	0.00	0.00	0.25	0.01	0.01
Oct-17	0.00	0.00	0.00	0.52	0.00	0.01
Nov-17	0.00	0.00	0.00	0.27	0.00	0.02
Dec-17	0.00	0.00	0.00	1.00	0.00	0.42
Fully Technical Efficient	0	0	5	4	3	0
Min	0.00	0.00	0.00	0.04	0.00	0.00
Mean	0.02	0.00	0.11	0.23	0.08	0.04
Max	0.05	0.01	1.00	1.00	1.00	0.62
Standard Deviation	0.02	0.00	0.31	0.26	0.24	0.11

Table A.40: Scale efficiency estimates with respect to SA group and finance for all the medium-sized banks in Phase 4 (Dec 2013 - Dec 2017).

Date	***Phase 4: Scale Efficiency – SA group and finance***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
Dec-13	0.00	0.00	0.43	0.00	0.02	0.01
Jan-14	0.00	0.00	0.05	0.00	0.01	0.00
Feb-14	0.00	0.00	0.92	0.00	0.01	0.01
Mar-14	0.00	0.00	1.00	0.00	0.02	0.00
Apr-14	0.00	0.00	0.86	0.00	0.01	0.00
May-14	0.00	0.00	0.77	0.00	0.02	0.00
Jun-14	0.00	0.00	0.83	0.00	0.02	0.01
Jul-14	0.00	0.00	0.81	0.00	0.02	0.00
Aug-14	0.00	0.00	0.71	0.00	0.02	0.00
Sep-14	0.00	0.00	0.78	0.00	0.02	0.00
Oct-14	0.00	0.00	0.90	0.00	0.02	0.00
Nov-14	0.00	0.00	0.95	0.00	0.02	0.00
Dec-14	0.00	0.00	0.86	0.00	0.02	0.01
Jan-15	0.00	0.00	0.09	0.00	0.02	0.00
Feb-15	0.00	0.00	0.93	0.00	0.02	0.00
Mar-15	0.00	0.00	0.14	0.00	0.02	0.00
Apr-15	0.00	0.00	0.96	0.00	0.02	0.00
May-15	0.00	0.00	0.10	0.00	0.02	0.00
Jun-15	0.00	0.00	0.88	0.00	0.02	0.00
Jul-15	0.00	0.00	0.86	0.00	0.01	0.00
Aug-15	0.00	0.00	0.88	0.00	0.02	0.00
Sep-15	0.00	0.00	0.93	0.00	0.02	0.00
Oct-15	0.00	0.00	0.88	0.00	0.02	0.00
Nov-15	0.00	0.00	0.66	0.00	0.02	0.00
Dec-15	0.00	0.00	0.02	0.00	0.01	0.00
Jan-16	0.00	0.00	0.08	0.00	0.01	0.00
Feb-16	0.00	0.00	1.00	0.00	0.00	0.00
Mar-16	0.00	0.00	0.83	0.00	0.01	0.00
Apr-16	0.01	0.00	0.75	0.00	0.02	0.00

Date	***Phase 4: Scale Efficiency – SA group and finance***					
	AB	*CB*	*DB*	*IB*	*JPM*	*HSBC*
May-16	0.01	0.00	0.89	0.00	0.01	0.00
Jun-16	0.01	0.00	0.72	0.00	0.01	0.00
Jul-16	0.00	0.00	0.75	0.00	0.02	0.00
Aug-16	0.00	0.00	0.72	0.00	0.02	0.00
Sep-16	0.01	0.00	0.65	0.00	0.02	0.00
Oct-16	0.01	0.00	0.60	0.00	0.02	0.00
Nov-16	0.00	0.00	0.59	0.00	0.02	0.00
Dec-16	0.00	0.00	0.53	0.00	0.02	0.00
Jan-17	0.00	0.00	0.56	0.00	0.02	0.00
Feb-17	0.01	0.00	0.59	0.00	0.02	0.01
Mar-17	0.01	0.00	0.58	0.00	0.02	0.00
Apr-17	0.01	0.00	0.53	0.00	0.02	0.01
May-17	0.01	0.00	0.53	0.00	0.02	0.00
Jun-17	0.01	0.00	0.52	0.00	0.02	0.00
Jul-17	0.01	0.00	0.62	0.00	0.02	0.00
Aug-17	0.01	0.00	0.58	0.00	0.02	0.00
Sep-17	0.01	0.00	0.58	0.00	0.02	0.00
Oct-17	0.01	0.00	0.76	0.00	0.02	0.00
Nov-17	0.01	0.00	0.60	0.00	0.02	0.00
Dec-17	0.01	0.00	0.52	0.00	0.01	0.00
Fully Scale Efficient	0	0	2	0	0	0
Min	0.00	0.00	0.02	0.00	0.00	0.00
Mean	0.00	0.00	0.66	0.00	0.02	0.00
Max	0.01	0.00	1.00	0.00	0.02	0.01
Standard Deviation	0.00	0.00	0.26	0.00	0.00	0.00