EFFICIENCY OF COMMERCIAL BANKS IN RWANDA

By

Bruno Mwenese

Reg no. X50/64341/2011

A Research Paper Submitted in Partial Fulfillment of the Requirements for the Award of the Degree of Master of Arts in Economics, of the University of Nairobi.

AUGUST 2012

DECLARATION

I hereby declare that this is my original work and that to the best of my knowledge it has not been presented for the award of a degree at any other university.

Signed .... Date: ....23/08/2012.

Bruno Mwenese

X50/64341/2011

Approval

This research paper has been submitted for examination with our approval as university supervisors.

Signed: .... Date: 23/08/2012

Dr Joy Kiiru

Signed .... Date: 23/08/2012

Dr Seth Gor

DEDICATION

To my late brother Jean Paul Muhirwa, I still do not understand your early departure.

To my mom, dad, brothers and sisters, for your love and support, I always have you in my heart, *May God guide you all*

ACKNOWLEDGEMENT

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

DEA Data Envelopment Analysis

DMU Decision Making Unit

GDP Gross Domestic Product

IMF International Monetary Fund

NBR National Bank of Rwanda

RWF Rwandan Franc

SFA Stochastic Frontier Analysis

WAEMU West African Economic and Monetary Union

ABSTRACT

Banking sector reforms and policies in developing economies have had limited effect on financial development. It is argued that knowledge about banks' efficiency helps to inform government policy by providing an assessment of the effects of their policies on banks' performance and development. This study examines the technical and cost efficiency of commercial banks in Rwanda and identifies the factors that influence such efficiencies. The study uses panel data collected on five commercial banks in Rwanda for a period of six years. It employs Data Envelopment Analysis and Stochastic Frontier Analysis and makes use of tobit regression model to identify the determining factors Consistent with some other studies on African economies, efficiency is found to be around 70% Factor like net income is found to have positive effects on technical efficiency whereas bank size and loans have negative effects on cost inefficiency. Technology was also found to have contributed immensely in increased efficiency in Rwandan commercial banks. Arising from these findings, we suggest that integration and expansion of technologies should be enhanced throughout the country. Loans should also be directed to more productive investments.

CHAPTER ONE

INTRODUCTION

1.1 Background

Economists have been theorizing the role of financial sector in economic growth since the time of Bagehot and later on Schumpeter. In Schumpeter's view as quoted in Sinha(2001): "The banker stands between those who wish to form new combinations and the possessors of productive means. He is essentially a phenomenon of development, though only when no central authority directs the social process. He makes possible the carrying out of new combinations, authorizes people, in the name of the society as it were, to form them. He is the ephor of the exchange economy".

This role remained, though, ignored till early 1980's, the time the financial crisis in Latin America exploded. Later on, Levine (1997) corroborated a strong and positive link between a well developed financial sector and economic growth. Financial factors were found to be an integral part of the growth process.

There seemed to be a consensus amongst economists on the role of financial sector in economic growth built on the notion of transaction costs and information asymmetry. It was completed by the notion of value creation driven by the notion of risk management. Levine (1997) and Schaltens and van Wensveen (2003) have grouped the ways financial sector contribute to economic growth into five: facilitation of risk management, allocation of resources, monitoring of managers and control of corporate governance, saving mobilization and easing of the exchange of goods and services.

Conventionally, the financial sector is composed of capital markets, banks, and insurance companies among others. In developing economies like Rwanda however, the banking sector constitutes the cornerstone of the financial sector. Performance is the key if banks are to play the role that is theirs in economic growth, more so in Africa; and efficiency analysis is essential in the assessment of banks' performance.

1

In the 1980s and before, developing countries were characterized by financial repression. Governments heavily controlled exchange rates, interest rates, volume and allocation of loans. In this context, financial sectors in such countries remained shallow and failed to contribute efficiently to the economic growth process (Rusagara, 2008, EAGER, 2001). In the late 1980s and 1990s most of the least developed countries embarked on economic liberalization programs and reforms of the financial sector in order to increase efficiency. Most of these reforms focused on seven factors.

The first one related to the creation of appropriate initial conditions for successful financial sector reform, by creating macroeconomic stability, institutional development, and putting an effective regulatory and monitoring mechanism in place. The second involved initiating complementary real and external sector reforms in the appropriate sequence to ensure removal of structural bottlenecks and destabilizing external sector pressures that could threaten the success and continuance of financial reforms. The third step was to ensure competition in the financial sector, by allowing entry, reducing fragmentation of financial markets, and ending predominance of government ownership in the financial sector. The fourth referred to building capacity and revitalizing sick financial institutions, through recapitalization and mergers, or liquidation where appropriate. The fifth involved banking sector reforms aimed at ending repressive policies like interest rate controls, directed credit, and unreasonable liquidity and reserve ratios. The sixth was the development of capital markets to widen the range of assets available to savers. The seventh was to ensure Central Bank autonomy (United Nations, 2008; Camen, Ncube and Senbet, 2008). These efforts should logically have led to the development of fully functional financial sectors.

Developing countries had followed religiously these reforms but well functioning financial sectors still eluded most of them. Past application of reforms has therefore only had limited success. A number of empirical studies tried to contribute to the knowledge by investigating banks' efficiency in developing countries but no study examined the case of banks in Rwanda with all its peculiarities.

1 2 An Overview of the Financial Sector in Rwanda

Currently, the Rwandan financial sector is made up of 9 commercial banks; a development bank; a housing bank, a micro-finance bank; a discount house and two hundred and thirteen micro-finance institutions, out of which two hundred are cooperatives while twelve are public limited companies and one private limited company. Among other financial institutions operating in Rwanda, there is a unit account of the Post Office, five insurance companies and the Social Security Fund of Rwanda (SSFR).

The banking regulation and supervision are in the hands of National Bank of Rwanda (NBR) whose main objectives are to control inflation, stabilize the financial sector, and modernize and secure the payment system. The mandate of the Bank includes: to ensure and maintain price stability; to enhance and maintain a stable and competitive financial system without any exclusion and to support Government's general economic policies, without prejudice to the first two missions.

Commercial banks represent over 70% of banks' total assets. The population access strand is as follows: 14% are formally banked, 7% formally served by non-banking institutions, 27% informally served and 52% are financially excluded (NBR, 2010).

Since 1994/1995 the Rwandan financial sector has undergone many reforms within the framework of structural adjustments programs and other support programs initiated by IMF and World Bank. The aim was to move the economy into a liberalized management. Before then, the economy was strongly managed. For instance, in banking sector the central bank decided on the total volume of credit to be given in the economy and on how it was shared out among banks and sectors (Musoni, 2010). Many reforms carried out from that period throughout, concerned privatization, bank supervision, licensing new banks and branches and prudential management.

Following NBR reports (2008, 2009a, 2010), this reform process emphasized the introduction of legal reforms. Flexible exchange rate regime was adopted and the autonomy and power of the central bank, in the field of its missions and particularly the bank supervision, reinforced. Other

3

legal reforms concerned the promulgation of the law regulating direct tax code on various and professional incomes, the implementation of the order on risk coverage and loan monitoring and the implementation of the Law regulating the organization and functioning of the money market. Since 1999, the Central Bank has issued several prudential regulations including: regulation on the solvency ratio that increased the ratio from 8% to 10%; regulation on risk coverage and loan monitoring and regulation on the liquidity ratio that has decreased the ratio from 100% to 80% of the demand deposits, in order to take into account a permanent portion of deposits.

The minimum share capital required for commercial banks has been increased from 300 million Rwf to 1.5 billion Rwf in 1999. Thereafter, in December 2006, this minimum capital has again been increased to 5 billion Rwf, in order to reinforce the financial system and adapt it to the prevailing economic context. In 1999 and 2000 regulations concerning internal control of banks and micro finance institutions were passed. The central bank was thereafter entitled to approve the management personnel of banks even at branch level.

Licensing of New Banks

After 1994 five new commercial banks were licensed. These banks and the existing ones opened new branches in different areas of the country. After issuing regulations on micro finance institutions and saving and credit cooperatives, respectively, several micro finance institutions were licensed. The licensing has since been carried out concomitantly with privatization of existing commercial banks. Following NBR report (2010), at the end of 2009 three banks were foreign owned above 80% of total shares, for one bank the total shares for foreigners was 40%. The Rwandan government bought 52% of one bank that were foreign controlled and restructured one cooperative bank that was controlled by the government into a commercial bank in which 35% of total shares are foreign owned

Performance of Banks in Rwanda

Since 2005 the consolidated assets of commercial banks in Rwanda have been increasing. They show an increase of 31% from 2006 to 2007 due to an increase in loans' disbursement. They registered an increase of 32.8% in 2008 and 13.2% in 2009 that was driven by an integration of a

4

new bank in the system. In 2010 the assets grew 25.9% due to an increase in deposits (NBR Annual reports, 2008, 2009a, 2010).

Figure 1: Evolution of Credit to Private Sector (in RWF million)

Evolution of Credit to Private Sector(In RWF million)

390,877.60
335,870.60
317,887.10
262,681.90
234,893.30
182,890.40

1   2   3   4   5   6

2005   2006   2007   2008   2009   2010

—◆—Year   —■—Credit to private sector
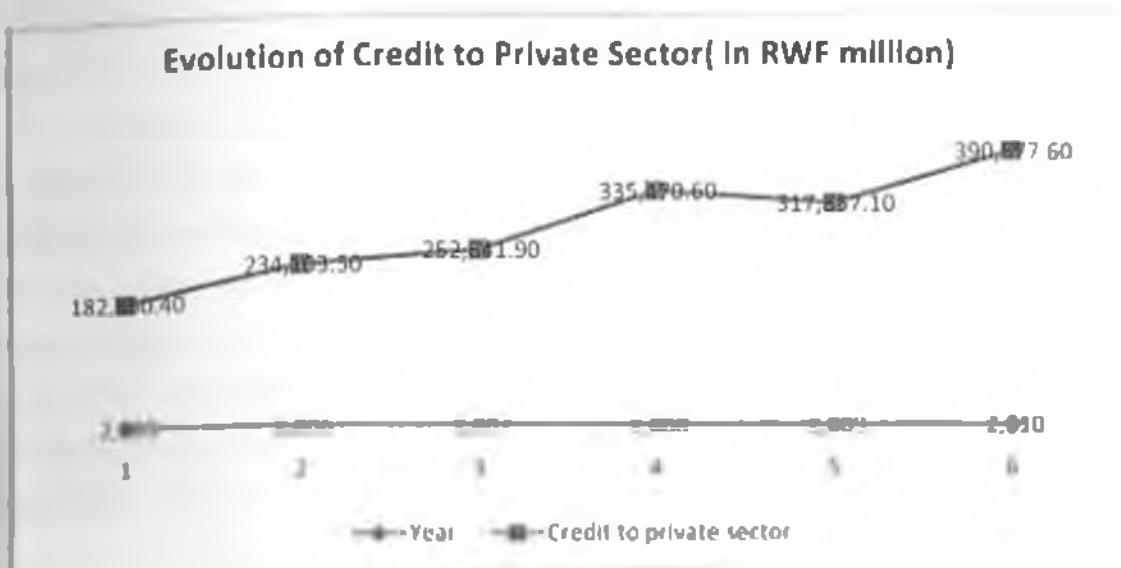
Source: NBR, (2008, 2009b, 2011)

Figure 1 shows that deposits grew continuously but at a decreasing rate. Loan advances to private sector increased throughout but a decrease of 5.2% was registered in 2009 with a recovery of 27% in 2010. The monetary authority monitors consistently the evolution of key financial soundness indicators. These are capital adequacy ratios, liquidity risk ratios and profitability ratios. These indicators have registered progress as reported in Table 1.

Table 1: Key Financial Indicators of Rwandan Banking Sector

	2006	2007	2008	2009	2010
Capital Adequacy Ratio	13.7%	16.2%	15.9%	19%	19.4%
Return on Assets	2.4%	1.7%	2.4%	0.7%	1.9%
Return on Equity	27.0%	17.5%	18.5%	5.0%	13.7%
Liquid Assets/Total Deposits	64.5%	76.4%	59.6%	65.3	55.6%

Source: NBR, (2008, 2009b, 2011)

5

The increase of the capital adequacy ratio from 2006 to 2008 was mainly explained by the integration of a new bank into the banking system. It continued to grow in 2009 and 2010 registering 19% and 19.4% which was above the minimum requirement of 15%.

The banking sector recorded a significant increase in asset quality from a ratio of non-performing loans of 25.01% in 2006, to 18.14% in 2007, and to 12.6% in 2008 However, the volume of non- performing loans grew by 17.1%. The level of non-performing loans worsened in 2009 with a ratio of 13.1% but improved to 11.3% in 2010. While assessing the quality of assets it is critical to observe that a large concentration of aggregate credit in a specific economic sector of activities makes banks vulnerable to adverse developments in that sector. For instance, the aggregate credit is still concentrated in mortgage industries as well as in trading (restaurants and hotels).The two sectors account for an average of 60.4% of the total loans to private sector during the period 2007-2010 and their shares are 29.3% and 31.1% respectively during the same period(NBR, 2008, 2009a, 2010).

With regard to profitability, records show a lot of fluctuations but downwards between 2005 and 2006. The return on equity never reached its level of 2006 of 27%. It drastically reduced in 2009 to 5% but exhibited a good recovery in 2010 at 13.7%.

Despite the progress registered all through, there still are deficiencies in the banking sector. Most of the challenges pertain to lack of or insufficiency of strategic definition and of positioning facing market and competition; a lack or insufficiency of policies and procedures of credit granting, an insufficiency of internal audit, a lack of managers' understanding and corporate governance standards, poor credit monitoring, deficiency in credit application analysis; lack of adequate and credible system frame of developers, gathering of files and the incompleteness of the legal system. Other challenges refer to a limited number of people with access to financial services, the oligopolistic nature of the banking industry in Rwanda and a high volume of non-performing loans (NBR, 2010).

6

1.3 Problem Statement

Enhanced bank efficiency entails greater mobilization of financial savings and more production of loans for industrial investment. This contributes to financial development which, in turn, strengthens economic growth. Rwanda, in the framework of structural adjustments programs, adopted banking sector reforms which, together with subsequent policies have had limited effect on financial development. These policies were not evidence based and authorities have been applying them by trial and error which has highly compromised effectiveness. In fact, knowledge about banks' efficiency helps to inform government policy by providing an assessment of the effects of deregulation, mergers, market structure and other policies on banks' performance and development. As it is, policies for improving efficiency of Rwandan banking sector lack this empirical foundation. Therefore, the purpose of this study is to contribute to filling this knowledge gap by carrying out a study on levels and determinants of efficiency of commercial banks in Rwanda

1.4 Objectives of the Study

The main objective of this study was to examine efficiency of commercial banks in Rwanda.

The specific objectives were to:
1. Determine the level of technical efficiency of commercial banks in Rwanda;
2. Determine the level of cost efficiency of commercial banks in Rwanda;
3. Identify determinants of commercial banks' efficiency in Rwanda;
4. Use (1), (2) and (3) above to suggest policy measures to be adopted for enhanced role of banking sector in economic growth.

1.5 Motivation of the Study

Self sustainable economic growth should be the goal of any developing economy. Rwanda can achieve it by building from within a sound and solid financial sector. Understanding the factors that influence efficiency will no doubt enhance performance of banks and their function in economic growth. Efficient banks allow for more mobilization of savings and improved allocation of resources. Subsequently, more profitable loans are advanced to businesses which accelerate the growth of financial institutions and of the economy in general.

7

The evaluation of commercial banks' efficiency in Rwanda is relevant to bank decision makers towards their understanding of controllable sources of performance on which to focus. It is also relevant to monetary authorities in their role to guide and control the banking system in its function of promoting growth.

CHAPTER TWO

LITERATURE REVIEW

This chapter has two sections. Section one focuses on theoretical basis of efficiency of a production unit. The second section deals with the empirical literature review with much focus on banks in Africa. An overview of the literature is provided at the end of the chapter.

2.1 Review of Theoretical Literature

The standard microeconomic theory assumes a production unit (a bank in our case) to be a profit maximizer. The ultimate objective of a firm therefore is to reach the maximum possible profit given resources available (Bikker and Bos, 2008). The literature tries to explain factors that drive changes in profit. There exist quantity effects and price effects. The quantity effect shows the impact on profit of an expansion or contraction of the business, holding prices fixed whereas the price effect shows the impact on profit of changes in the price structure of the business, holding quantities fixed. The theory of production posits that variations in quantities produced by a firm can be explained by changes in activities (which may involve scale and/or scope economies) or changes in productivity. Variations in productivity mainly result from technological effects or efficiency effects. This study focuses on the efficiency component.

To analyze the behavior of the firm, the theory of production starts by specifying a production set. A production set Y is a set of all output vectors Q that constitute feasible production plans for the firm. The output is produced using input vectors X limited by technological constraints. In a single output technology, this output-input relationship is commonly described by a production function $f(x)$ that gives the maximum amount of Q that can be produced using input amounts X. The resulting production set is described as:

$$Y = \{(x_1, \dots, x_{L-1}) : q, -f(x_1, \dots, x_{L-1}) \leq 0 \text{ and } (x_1, \dots, x_{L-1}) \geq 0\}$$

The effect of changes in inputs on output $\left(\frac{\partial q}{\partial x}\right)$ is called marginal productivity. In other words, the output growth corresponding to a shift of the production function is generated by the increase in productivity $\left(\frac{q}{x}\right)$. It involves a change in output/input relation.

A production plan q in Y is (technologically) efficient if there is no q' in Y such that $q' \geq q$ and $q' \neq q$. That is, a production plan is efficient if there is no way to produce more output with the same inputs or to produce the same output with less input. It is often assumed that the set of technologically efficient production plans can be described by a transformation function T where $T(q) - 0$ if and only if q is efficient. Therefore, efficiency affects productivity by improving the way inputs are used and transformed into outputs within a firm. Efficiency here refers to the difference between observed and optimal input-output mixes. It means producing at the production possibility frontier. This is a maximization point and inefficiencies represent movements away from it (Leibenstein, 1966, Stigler, 1976).

It is, therefore, theoretically important to measure efficiency. Measurements of efficiency were pioneered by Farell(1957) who defined efficiency as the largest possible production of output given a set of inputs. Efficiency is divided into technical efficiency and price efficiency (normally known as allocative efficiency). The former means achieving the highest attainable output given set of inputs and the latter refers to the optimal combination of inputs in view of their prices. Technical efficiency can be measured from an input conserving angle where the objective is to maximize the reduction of inputs to use given the technology and the output to produce. It can also be measured from an output expanding angle with a goal of maximizing the output given the technology and inputs.

Following Farell(1957) two measurement approaches have been mostly used in banking industry: Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA). Both SFA and DEA methods are efficiency frontier analysis, and are similar in that they determine a frontier and inefficiency based on that frontier. But, there exist vital differences between stochastic frontier analysis as an econometric approach and Data envelopment analysis as a mathematical programming method. Differences pertain as to how they construct a production frontier and calculate efficiency relative to the frontier. DEA is suited to measuring efficiencies of deterministic industry for multiple inputs/outputs information. On the other hand, SFA is suited to measuring efficiencies of stochastic industry for input/output information. Basically, the differences between the two approaches can be narrowed down to two essential features. First, the econometric approach is stochastic. It allows for distinguishing the effects of statistical noise from that of inefficiency. Second, the programming approach is nonparametric. It helps to avoid

10

issues of misspecification of the functional form with those of inefficiency (Fried, Lovell and Schmidt, 1976).

2.2 Review of Empirical Literature

Literature is replete with studies on banks' efficiency but most of them have been done on US and European banks. Developing countries count few studies in this field with the Sub-Saharan Africa coming last. The studies have covered many aspects of efficiency ranging from size to types of efficiency, ownership effects, regional effects, methods used, framework of analysis, cross-country studies, bank types and branches among others. Each study has examined only one or at most a combination of two or three aspects; none has covered all aspects in a single study.

In the last decade, studies on bank efficiency focused on specific countries or regional economic blocks in Africa. In a study on intermediation efficiency and productivity of banking sector in Kenya in the post liberalization period, Kamau (2011) used Data Envelopment Analysis in variable and constant returns to scale form. Variables were chosen following the intermediation approach. The study estimated scale efficiency, pure technical efficiency and the overall efficiency of 40 retail banks. The efficiency level was found not to be less than 40% with large banks being more efficient than small banks and foreign owned banks being more efficient than local banks. The main cause of inefficiency was found to be inefficient use of deposits.

Similar results on scale efficiency have been documented by Olaosebikan(2009) who surveyed efficiencies of Nigerian banks using similar methods and framework as Kamau(2011). The study found that bank size and bad loans are significant in explaining inefficiencies. This study also found that staff compensation is not significant. However, these findings are in contrast to Aikaeli(2008) results. Aikaeli(2008) studied x-inefficiency in commercial banks in Tanzania. Among other results, the study suggested that bank size is positively related to x-inefficiency. The reason being that as the firm grows, the separation of ownership and management increases, agency problem heightens, and the management self interests easily entrench firm objectives. Contrary to Olaosebikan(2009), Aikaeli also found that staff compensation is significant, indicating that when incentive to work increases x-inefficiency in banks decreases.

11

Some of Kamau(2011) results are in contrast to the findings of Frimpong(2010) and Ncube(2009). Frimpong(2010) when investigating efficiency of Ghanian banks found that domestic private banks were the most efficient group of banks in Ghana with their average efficiency level being 87%. They were followed by foreign banks (average of 72%) and lastly, the state-owned banks with an average score of only 51%. Ncube (2009) in a study of efficiency of the banking sector in South Africa found a negative correlation between cost efficiency and bank size. Cost efficiency fell systematically as bank size was increased.

Ikhide(2008) examined the scale efficiency of Namibian banks given the small size of the population. Stochastic frontier approach was used. Findings are that there were still economies that could be exploited by increasing the size of larger banks. Factor usage explained differences that appeared among banks

Onour and Abdalla (2010) examined the efficiency of 12 Sudanese commercial banks using Data Envelopment Analysis. Government owned bank was found to be economically efficient and small banks to be only technical efficient but scale inefficient. They conclude that size matters for scale efficiency but public ownership is not a constraint to performance. However, these findings on ownership effects on efficiency are not in accord with those of poshakwale and Qian(2009) in their study on competitiveness and efficiency of banking sector in Egypt, a country with islamic banks like Sudan. Their findings show that state owned banks are generally less efficient than private banks and foreign banks are less efficient than domestic banks. The average x-inefficiency of Egyptian banks is around 30%.

Mugume(2008) investigated the interaction between banking efficiency and market concentration/competition in Uganda. The study used stochastic frontier analysis in structure-conduct performance framework. The results were inconclusive

On regional economic blocks, Kablan (2009) studied technical and cost efficiency of West African Economic and Monetary Union using both parametric (SFA) to evaluate cost efficiency and non-parametric approach (DEA) to estimate technical efficiency. Local banks with private capital were found to be most efficient. The efficiency scores evolved over 70% and inefficiency

was mainly caused by low bank penetration or financial depth. The study did not make any comparison in results provided by the two methods used.

Effects of macroeconomic factors on banks' efficiency in developing countries were studied by Chan and Karim (2010) using parametric stochastic frontier approach. Among other results found, openness in terms of foreign direct investments had positive effects on cost and profit efficiency on banks in African region while trade openness had negative effects. These findings on trade openness are not in agreement with Asongu (2010) who applied a binary multivariate dummy model to study openness and bank efficiency in Africa. Among other results, trade openness and financial openness were found to decrease bank efficiency in low income countries.

Bader et al (2008) compared conventional and Islamic banks in 21 countries including seven African countries. They evaluated three components; revenue, cost and profit efficiency based on three grounds, size, age and region. They used data envelopment analysis and their results indicate that for the Africa region conventional banks outperform Islamic banks in cost, revenue, and profit efficiency. In Asia, conventional banks had better cost and revenue efficiencies but Islamic banks had scores for profit efficiency. In the Middle East and Turkey, the results indicate that Islamic banks outperform the conventional banks in cost, revenue and profit efficiency. On average, banks were found to be more efficient using their resources compared to their ability to generate revenues and profits. On average too, big banks are relatively more cost, revenue and profit efficient than small banks. But there were no significant difference between efficiency scores of small and big banks in conventional versus Islamic banks.

Kirkpatrick, Murinde and Tefula (2008) investigated determinants of x-inefficiency in nine sub Saharan African countries. The study used translog stochastic cost and profit approach. It explored bank specific as well as macroeconomic factors. Profit x-inefficiency was found to be higher than cost x-inefficiency. Average level of cost efficiency is 80% while that of profit efficiency is 67%. There was evidence of increasing agency costs. Factors that were found to positively influence x-inefficiency are bad loans and high capital ratios. Bank size and foreign bank ownership have negative effects on x-inefficiency. Findings of Kirkpatrick, Murinde and Tefula (2008) on effects of ownership on banks' efficiency are consistent with Kiyota(2009)

13

findings. Kablan(2010) confirmed some of these results in a study on banking efficiency and financial development in 29 Sub Saharan African countries. Bad loans negatively affect efficiency; however, foreign ownership is negatively associated with efficiency. In this study banks are estimated to be efficient at 76% on average

From the foregoing review, effects of ownership on banks' efficiency seem Inconclusive. This was first found by Figueira, Nellis and Parker (2006). They carried out a study on performance of state-owned versus privately-owned and domestically-owned versus foreign owned banks across 40 African countries (involving 340 banks) using cross-sectional data for 2001/2. The overall conclusion was that there is little evidence that privately-owned banks in Africa perform better than their state-owned counterparts. There is some evidence however, that foreign-owned banks are more efficient than domestically-owned banks. Moreover, there is a suggestion that differences in performance may not only be related to banks' ownership (Figueira, Nellis and Parker, 2006).

2.3 Overview of Literature

The reviewed literature shows that most of the studies on Africa focused on scale and cost efficiency. The levels of efficiency were found to be evolving between 70% and 80% in both country specific and cross-country studies. The most examined determinants of efficiency across economies are bank size, ownership (foreign versus domestic or private versus public), bad loans and staff compensation. Apart from bad loans that most studies found to be negatively related to x-efficiency, these studies are far from reaching a consensus on the effects of bank size and ownership. Most studies used Data Envelopment Analysis or Stochastic Frontier Analysis but very few used both methods DEA and SFA. The reviewed studies assumed that the intermediation approach prevails in African countries.

The reviewed literature stresses that factors and environment that affect efficiency of banks are not uniform across economies. Thus, this study proposes to follow intermediation approach and apply both DEA and SFA to identify determinants of efficiency of commercial banks in Rwanda.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

In this study, we applied two recognized methods in estimating efficiency in banking industry. Data Envelopment Analysis was used to evaluate production (technical) efficiency of commercial banks in Rwanda and Stochastic Frontier Analysis was used to compute cost efficiency. We then employed a tobit model to identify the determinants of efficiency of the commercial banks in Rwanda.

3.2 Data Envelopment Analysis

DEA emerged as a good method of measuring performance from the original work of Charnes, Cooper and Rhodes (CCR) (1978) inspired by the article of Farell (1957). It evaluates the efficiency of a decision making unit relative to other (similar) decision making units with the aim of estimating the benchmark for best practice frontier.

Charnes, Cooper and Rhodes (1978) assume that there are n decision making units (DMU) to be evaluated. Each DMU consumes varying amounts of m different inputs to produce s different outputs; i.e DMU consumes amount x_{ij} of input i and produces amount y of output r. Input(s) and output(s) are positive quantities.

Efficiency is given by the ratio multiple-output /multiple-input situation for each DMU. It can also be reduced to that of a single 'virtual' output and 'virtual' input. This ratio has to be maximized using the following objective function:

$$\max h_o\,(u, v) = \sum_r u_r y_{ro} / \sum_i v_i\, x_{io} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Subject to:

$$\frac{\sum_r u_r y_{ro}}{\sum_i v_i x_{io}} \leq 1, for\ j = 1, \dots, n$$

$u_r, v_i \geq 0$ for all i and r

Where:

u's and the v's are variables or weights that are attached to each producer's inputs and outputs so as to solve the problem;

y_{ra}'s and x_{io}'s are the observed output and input values, respectively, of the DMU to be evaluated.

This model is termed constant returns to scale and it assumes that all DMUs operate at an optimal scale. Since it aims at maximizing output it is also called output-oriented. The same model development is found in Al-Jarrah(2007)

Equation (1) can be turned into a minimization problem by duality principle:

$$\theta = \min \theta \ \dots\dots\dots (2)$$

Subject to

$\sum_{j=1}^{n} x_{ij}\lambda_j \leq \theta x_{io}, \quad i = 1, 2, \dots, n$

$\sum_{j=1}^{n} y_{rj}\lambda_j > y_{ra} \quad r = 1, 2, \dots, n$

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

Where θ is a scalar and λ is a vector of constant.

A DMU will be technical efficient if $\theta = 1$ and inefficient if $\theta < 1$.

Efficient points are located on the frontier. However, some points on the frontier may represent weak efficiency if inefficient points have been scaled and still contain non zero slacks. Taking care of non zero slacks, we estimated the following model:

$$\min \theta - \varepsilon\left(\sum_{i=1}^{m} S_i^- + \sum_{i=1}^{m} S_i^+\right) \ \dots\dots\dots (3)$$

Subject to

$\sum_{j=1}^{n} x_{ij}\lambda_j + S_i^- = \theta x_{io}, i = 1, 2, \dots, m$

$\sum_{j=1}^{n} y_{rj}\lambda_j - S_i^+ = y_{ra}, r = 1, 2, \dots, S$

$\lambda_j, S_i^-, S_r^+ \geq 0 \ \forall \ i, j, r$

Where, S_i^-, and S_i^+ are slack variables used to convert the inequalities in equation (3) into equalities and they do not affect the optimal θ which is obtained by solving equation (3).

Technical efficiency is concerned with how many and which inputs and outputs to consider. In the banking literature, two approaches have been advanced. The intermediation approach introduced by Sealey and Lindley (1977) that assumes bank deposits are inputs in the operational cycle. The second is the value-added approach proposed by Berger and Humphrey (1992). This approach assumes that banks engage in the intermediation of loan, payment, liquidity and safekeeping services. Hence, deposit is treated simultaneously as input and output of the banks. Clark and Siems(2002) investigated the impact of off-balance-sheet (OBS) activities on the measurement of X-efficiency in the banking industry. Their results provided strong support for including OBS activities in X-efficiency studies. In this study we applied intermediation approach.

Therefore, we estimated the following empirical model:

$(Loans,\ investments\ assets) = f(Labor, physical\ capital, financial\ capital)$ .... (4).

Where:

- Loans are used as net loans and advances to customers

- Investment assets are calculated as the total of investment in treasury bills and bonds, placements with other financial institutions and other financial investments

- Labor is given by total personnel expenses.

- Physical capital is Net of property and equipment

- Financial capital is the total of deposits by customers and non interest expenses.

The malmquist index is used to enable us to decompose improvements in bank performance stemming from technological change and that from efficiency change.

$$M_o^{t+1}(y_t, x_t, y_{t+1}, x_{t+1}) = \left[\frac{D_o^t(y_{t+1}, x_{t+1})}{D_o^t(y_t, x_t)} \times \frac{D_o^{t+1}(y_{t+1}, x_{t+1})}{D_o^{t+1}(y_t, x_t)} \right]^{1/2} \quad \cdots \cdots (5)$$

Where M denotes Malmquist productivity index of the most recent production point (x_{t+1}, y_{t+1}), using period $(t+1)$ technology relative to the earlier production point (x_t, y_t), using period t technology. Subscript o indicates output orientation; D is output distance function, while y and x are outputs and inputs, respectively. A value higher than one means a positive growth of total factors productivity between the period t and period t+1.

The decomposition of the above equation is obtained following Fare et al(1992) by extracting the term $\frac{D_0^{t+1}(y_{t+1}, x_{t+1})}{D_0^t(y_t, x_t)}$ from the right hand side of equation(5):

$$M_o^{t+1}(y_t, x_t, y_{t+1}, x_{t+1}) = \frac{D_0^{t+1}(y_{t+1}, x_{t+1})}{D_0^t(y_t, x_t)}\left[\frac{D_0^t(y_t, x_t)}{D_0^{t+1}(y_t, x_t)} \times \frac{D_0^t(y_{t+1}, x_{t+1})}{D_0^{t+1}(y_{t+1}, x_{t+1})}\right]^{1/2} \quad\ldots\ldots\ldots\ldots (6)$$

$$M_o^{t+1}(y_t, x_t, y_{t+1}, x_{t+1}) = TEA(y_t, x_t, y_{t+1}, x_{t+1}) \times TA(y_t, x_t, y_{t+1}, x_{t+1}) \quad\ldots\ldots\ldots\ldots (7).$$

The first term on the right hand side measures the contribution of the efficiency change to productivity change and the second term on the right hand side measures the contribution of the technological change to productivity change.

3.3 Stochastic Frontier Analysis

Measuring efficiency of a production unit refers to looking for a maximum point of production attainable or the minimum cost. It can be done by estimating a frontier function using stochastic frontier analysis. The general model was developed by Aigner, lovell and Schmidt (1977) in their pioneering work with a production function of the form:

$$y_i = f(x_i; \beta) + \varepsilon_i \; ; i = 1, \ldots, N \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Where $\varepsilon_i \leq 0$ and is a one sided disturbance term.

They proposed a composite error term of the form;

$$\varepsilon_i = v_i + u_i; i = 1, \ldots, N$$

$\{v_i\}$ reflects a statistical noise and is assumed to be independently and identically distributed as $N(0, \sigma_v^2)$.

18

$u_i \leq 0$ reflects inefficiency term and is a non-positive disturbance which implies that a firm's output must be less than or equal to $f(x_i; \beta) + v_i$. Deviations reflect inefficiency and the technical efficiency can then be measured by the ratio $y_i / f(x_i; \beta) + v_i$(Waldman, 1984).

Normally, u_i can be assumed to have an exponential distribution, a truncated distribution, a half-normal distribution or a gamma distribution. However, in many empirical studies it has been assumed to follow a half-normal or an exponential distribution. In this study, the truncated normal distribution proved to represent well our data

Analysis of efficiency by stochastic frontier is popular in evaluating production, cost efficiency or x-efficiency It is done by specifying a production (or cost) function which is estimated using maximum likelihood techniques. Usually, Cobb-Douglas production function or translogarithmic function are used but in banking sector the latter has been widely chosen because of its flexibility.

In this study, the stochastic frontier model was helpful in analyzing x-inefficiency. A Cobb-Douglas cost function model provided suitable and significant estimate compared to a translog function. The study applied to equation (9) the maximum likelihood method in order to estimate parameters. The Cobb-Douglas cost function was expressed as follows:

$$\ln TC = \alpha_0 + \sum_i \alpha_i \ln Q_i + \sum_j \beta_j \ln P_j + \varepsilon \dots \dots \dots (9)$$

With:

TC total costs vector

Q output value vector

P input prices vector

$\varepsilon = v_n + u_n$:

v_n a statistical noise with the independent normal distribution $N(0, \sigma_v^2)$.

u_n= inefficiency term assumed to be distributed independently of v_n.

The likelihood function is expressed as follows:

$$\ln L(\varepsilon/\lambda, \sigma^2) = n \ln\left(\frac{\sqrt{2}}{\sqrt{\pi}}\right) + n \ln\left(\frac{1}{\sigma}\right) - \frac{1}{2\sigma^2}\sum_{i=1}^{n}\varepsilon_i^2 + \sum_{i=1}^{n}\ln[1 - \phi(\varepsilon_i\lambda\sigma^{-1})] \quad \ldots\ldots\ldots (10)$$

Where:

$\lambda = \sigma_u/\sigma_v$ and $\sigma^2 = (\sigma_v^2 + \sigma_u^2)$.

The estimation of the Cobb-Douglas function gave us variance and standard deviations that we used to estimate cost efficiency scores which were calculated using the following equation:

$$E(u_i/\varepsilon) = [\sigma\lambda/(1 + \lambda^2)]\left[\frac{\varphi\left(\frac{\varepsilon_i\lambda}{\sigma}\right)}{\psi\left(\frac{\varepsilon_i\lambda}{\sigma}\right)} + \frac{\varepsilon_i\lambda}{\sigma}\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$

Where ψ is the standard normal cumulative distribution and φ is the standard normal density function.

3.4 Tobit Model for Estimation of Determinants of X-inefficiency

DEA and SFA provided us with efficiency scores which we used as dependent variable. The study adopted Kablan(2009) and Aikaeli(2008) tobit framework. The tobit model is appropriate as efficiency scores are restricted within 0-1 range, and cannot be modeled by a logit or probit model because these efficiency scores are not dichotomous.

The simple tobit model is expressed following Greene (2004) as follows:

$$y_i^* = x_i\beta + \varepsilon_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (12)$$

$y_i = 0$ if $y_i^* \leq 0$, and

$y_i = y_i^*, if\ y_i^* > 0$

y_i^* is a latent variable and is only observed if its value exceeds a threshold c_i.

In case of two limits (lower and upper), the model becomes a double truncated tobit model which is the model this study applied.

$y_i = c_1\ if\ y_i^* \leq c_1$

$y_i = y_i^*\ if\ c_i < y_i^* \leq c_2$

20

$$y_i = c_2 \ if \ y_i^* \geq c_2$$

Where $(c_1; c_2) \in R^2$ are boundaries of the censorship.

We estimated two empirical models which have the same explanatory variables:

$$(Technical\ efficiency) = a_0 + a_1 SEA + a_2 NIA + a_3 LA + a_4 DEPA + a_6 IPC + a_7 SEf + a_8 Badloan + banksize. \dots\dots (13).$$

$$(inefficiency) = a_0 + a_1 SEA + a_2 NIA + a_3 LA + a_4 DEPA + a_6 IPC + a_7 SEf + a_8 Badloan + banksize. \dots\dots (14).$$

Where,

SFA is the ratio of shareholder equity to total assets;

NIA is net income to total assets which is a ratio of profitability;

LA is the ratio of total loans to total assets;

DEPA is the share of deposits to total assets (for each bank);

SEf is the proportion of shareholder equity held by foreigners;

Badloans are individual bank non-performing loans.

Banksize is the ratio of bank assets to total assets of all banks taken into account in this study.

The above seven variables are taken to be bank specific factors that affect efficiency except for IPC which is a macroeconomic factor.

3.5 Definition of Variables
The Ratio of Shareholders Equity to Total Assets (SEA). It represents the share that comes from the owners of the company to finance the activities of the company. It is distinguished from the money that comes from lenders. Both owners' equity and total assets are gotten from company's balance sheet.

Total Assets: they include cash in hand, cash balances with the National Bank of Rwanda, due from banks, loans and advances to customers, financial investments held-to-maturity, financial investments available-for-sale, other assets, intangible assets and property and equipment.

Total equity includes share capital, revaluation surplus, reserves and retained earnings.

The Ratio of Loans to Total Assets (LA): Is a measure of credit risk. It captures the weight of output produced on bank's efficiency. A higher ratio signifies that a bank is running a risk of being less liquid and is exposed to higher defaults.

The Ratio of Deposits to Total Assets (DEPA): It is an indicator of capital adequacy. Deposits are a major source for credit granting. A bank mobilizes saving from customers and uses the same to offer loans to other customers in need of financial resources. This ratio represents the role of external finance on bank performance.

The Ratio of Net Income to Total Assets(NIA): It captures how important profitability is in financing company's activities. It shows the role played by profit earned in affecting performance. We found net income in profit and loss account and total assets is taken from the balance sheet. The higher the percentage the better, as it implies that the company Is doing well and creating profitable transactions from its assets.

Foreign Ownership of Equity(Sef): refers to the ownership/control of shares in a company in a country by individuals who are not citizens of that country, or by companies whose headquarters are not in that country. It captures the influence of foreign knowledge/management experience on bank efficiency.

Bad Loan is a non-performing loan. A loan is considered as such when the borrower has failed to meet its obligations in terms of periodic amount of reimbursement and/or in terms of time of reimbursement as provided for in the contract. In Rwanda, this time is established by monetary authorities.

Income per Capita Growth (IPC): This is a macroeconomic variable. Here it is used to measure the effects of variations in country's output level on bank's efficiency. We assume that when the

22

economy slows down, businesses financed by bank loans will not perform well which will increase defaults and thus result into reduced banks returns.

Non-interest Expenses: usually these expenses relate to activities that are not associated with targeting customers to deposit funds in the bank.

Investment Assets: are securities designed to generate profits. They are grouped in categories known as asset classes and can be divided into stocks, bonds, commodities and currencies. In our case they include treasury bills and bonds, placements with other financial institutions and other financial investments.

Financial Capital: or just capital in finance and accounting, refers to the funds provided by lenders (and investors) to businesses to purchase real capital equipment for producing goods/services.

Bank Size: relative to bank activities (such as deposits mobilization, credit granting, etc.) this variable is used as a sign of the weight of a single bank in the entire banking system

3.6 Data Type and Sources

This study used secondary data from individual banks' balance sheets and profit and loss accounts. The study used the same data in DEA and SFA. Data was computed as elaborated before. For the Tobit model, all the data was also obtained from balance sheets and profit and loss accounts of individual banks apart from IPC that was obtained from World Bank development indicators 2010.

EMPIRICAL RESULTS

4.1 Introduction

This chapter presents results and analysis. Section 4.3 and 4.4 analyze technical and cost efficiencies respectively. In section 4.5 the study identifies factors that determine such efficiencies. A presentation of descriptive statistics precedes each section.

4.2 Descriptive Statistics of Variables

From 2005 to 2010 output variables show great variability in terms of investment assets for all banks. Loans are shown to increase from 2005 to 2009 for all banks except for one particular bank which shows an outstanding growth throughout the period. For input variables, the Cost of Labor and Financial Capital have increased in the same period for all banks. Table 2 and Table 3 report the summary statistics of variables and the correlation matrix respectively. Inputs variables are in ratios.

Table 2: Summary Statistics

	Mean	St. dev.
Total cost/total assets	0.097667	0.12767
Loans	3.13E+07	2.08E+07
Investment assets	1.89E+07	1.43E+07
Unit cost of labor	8122950	3699939
Unit cost of physical capital	0.229	0.208977
Unit cost of financial capital	0.024667	0.0104166
No. of Observations: 30		

Source: Author's computations

Table 3: Correlation Matrix

	TCTA	loan.	Invest assets	UCL.	UCPK	UCFK
Total Cost/Total Assets	1					
Loans	-0.3025	1				
Investment Assets	-0.2121	0.6497	1			
Unit Cost of Labor	0.5899	0.2156	0.3597	1		
Unit Cost of Physical Capital	0.4267	-0.1522	0.1503	0.2779	1	
Unit Cost of Financial Capital	-0.0074	-0.0041	0.5282	-0.257	0.1384	1

Source Author's computations

The small values reported in the correlation matrix mean that the variables are not highly correlated among themselves except between loans and investment assets, unit cost of labor and the ratio of Total cost to Total assets and between unit cost of financial capital and investment assets.

4.3 Technical Efficiency of Rwandan Commercial Banks

The technical efficiency scores in Table 4 were estimated using DEA with constant returns to scale assumption. DEAP 2.1 software was used. The estimated technical efficiency of commercial banks in Rwanda is found to be 71.8% on average.

Table 4: Commercial Banks Technical Efficiency Scores (estimated with DEA)

Year	ACCESS	Banque Commerciale du Rwanda	Bank of Kigali	ECOBANK	FINABANK	All banks
2005	1	0.634	1	0.428	0.61	0.734
2006	1	1	1	1	0.817	0.969
2007	0.751	0.578	1	0.257	0.452	0.608
2008	0.349	0.713	1	1	0.396	0.692
2009	0.335	0.613	1	0.702	0.747	0.68
2010	0.26	0.585	1	1	0.302	0.629
Average	0.615833	0.687167	1.00	0.731167	0.559	0.718667

Source Author's computations

From a total of five banks, three have been found to have an average productive efficiency below the overall average. In general, from 2005 to 2010 technical efficiency reduced by 16.7%. Access bank's mean efficiency registered a reduction of 84% in its technical efficiency whereas for Ecobank efficiency more than doubled. The bank with the highest technical efficiency was found to have registered the highest values in loans and the lowest variability in terms of unit cost of labor. To measure the change in technical efficiency we estimated Malmquist index. The results are reported in Table 5.

Table 5: Malmquist Index

BANK	Total Technical Efficiency Change	Technological Change	Pure Technical Efficiency Change	Scale Efficiency Change	Total Factor Productivity Change
ACCESS	0.764	1.096	1	0.764	0.837
Banque Commerciale du Rwanda(BCR)	0.984	1.111	0.949	1.037	1.093
Bank of Kigali (BK)	1	1.111	1	1	1.111
ECOBANK	1.185	1.179	1.179	1.005	1.397
FINABANK	0.869	1.296	1	0.869	1.126
Average	0.95	1.156	1.023	0.929	1.098

Source Author's computations

We found that total technical efficiency declined by 5% and this was caused by a decrease in scale efficiency of 7.1% since pure technical efficiency rose by 2.3%. Total factor productivity grew by 9.8% which was possibly driven by technological changes that amounted to 15.6%. This implies that for the period under review and before, commercial banks in Rwanda have been incorporating technological innovations in their operations.

4.4 Analysis of Cost Efficiency

Tables 6 and 7 respectively show the data (and its distribution) used in estimating cost efficiency using Stochastic Frontier Approach.

Table 6: Descriptive Statistics of Variables

	Mean	Std Dev.	Skewness	Kurtosis
Total Costs/Total Assets	-2.381075	0.3384999	0.964	0.022
Loans	17.06868	0.6454598	0.504	0.541
Investment assets	16.24627	1.197797	0.059	0.508
Unit Cost of Labor	15.79128	0.5270054	0.099	0.778
Unit Cost Of Physical Capital	-1.767295	0.7302372	0.068	0.957
Unit Cost of Financial Capital	-3.796461	0.457815	0.268	0.731

Source: Author's computations

Table 7: Correlation Matrix

	tcta	loan	invest assets	ucl	Upk	utk
Total Costs/Total Assets(tcta)	1					
Loans	0.2733	1				
Investment assets(invest assets)	0.0762	0.3702	1			
Unit Cost of Labor(ucl)	0.5707	0.3751	0.5074	1		
Unit Cost Of Physical Capital(upk)	0.5034	-0.0768	0.0746	0.4422	1	
Unit Cost of Financial Capital(utk)	0.0813	-0.0349	-0.5936	0.2759	-0.04	1

Source: Author's computations

Tables 6 and 7 show that the variables are positively skewed with Investment assets, Unit Cost of Labor and Unit Cost of Physical Capital being close to zero and the ratio of Total Costs to Total Assets, Loans and Unit Cost of Financial Capital being far from zero. This means that the distribution might not be normal. The values of kurtosis are all less than three. This indicates that variables are widely scattered from their mean but the probability of extreme values is less than that of a normal distribution. Except for four values that are above 0.5, the small values displayed in the correlation matrix show low correlation between the variables used in the estimation of the cost frontier.

To obtain cost efficiency of commercial banks in Rwanda we estimated a Cobb-Douglas cost function. The latter was preferred to a translog function because it was found to give more significant coefficients and was thus judged to fit more the data used in this study. This is

contrary to other studies done on African economies where translog cost functions were found to fit the data more than the Cobb-Douglas function.

The estimated parameters of the Cobb_Douglas cost function and the estimated cost efficiencies were obtained using FRONTIER4.1 software and are presented in Table 8 and 9 respectively (the variables are in logarithm). The null hypothesis is that gamma is equal to zero ($\gamma=0$) meaning that inefficiency does not exist.

Table 8: Estimated Parameters of the Cobb-Douglas Cost Function

Variable	coefficient	t-ratio
Constant	0.2111	0.1897
Loans	-0.2746	-3.4435
Investment assets	-0.1386	-2.7357
Unit Cost of Labor	0.4971	5.6966
Unit Cost Of Physical Capital	0.0427	0.8987
Unit Cost of Financial Capital	0.0730	1.3669
Sigma squared	0.0382	2.3672
Gamma	0.5080	1.9339
Mu	0.2787	1.9924
Eta	0.0000	
Number of observations	30	
Log likelihood function	12.6415	
LR test of the one-sided error	5.2416	

Source: Author's computations

Table 9: Commercial Banks Cost Efficiency Scores (estimated with SFA)

BANK	Average Efficiency
ACCESS Rwanda	0.747625
Banque Commerciale du Rwanda(BCR)	0.663006
Bank of Kigali (BK)	0.72215
ECOBANK Rwanda	0.681925
FINABANK Rwanda	0.925701
Mean efficiency for all banks	0.737756

Source: Author's computations

Tables 8 and 9 show that all the coefficients are significant except for the unit cost of physical capital. The existence of inefficiencies is confirmed by the significance of sigma squared and gamma. The likelihood ratio test is found to be greater than the critical value (5.138) from Kodde and Palm (1986) tables. We thus reject the null hypothesis. We can therefore conclude that 50.8% of variations are caused by inefficiency and 49.2% are due to idiosyncratic noise. A truncated normal distribution describes well the data used in this study more than a normal distribution and this is corroborated by the significance of Mu(μ). Our results also suggest that a time invariant model is more suitable compared to a time varying model as Eta (η) is not significant. The average cost efficiency of commercial banks in Rwanda is found to be 73.7% with the lowest efficiency score being 66.3% and the highest being 92.5%. These results resemble those of Poshakwale and Qian(2009) on Egyptian banks and are also close to those of Kablan(2009) on WAEMU banks.

4.5 Analysis of Determinants of Managerial Inefficiency

At this stage it is important to understand factors that cause inefficiencies. Literature on the banking sector has been using some bank specific and macro environmental factors. Due to lack of data this study uses one macroeconomic variable (Income per capita growth) and seven bank specific variables to estimate two equations. In equation 14 the dependent variable is the technical efficiency scores from DEA and in equation (13), the dependent variable is the cost inefficiency scores from SFA. The descriptive statistics of the data used are presented in Table 10 and 11 respectively.

Data used in estimating equation 13 and 14 are positively skewed and greater than zero. The measure of kurtosis shows that the values are spread wide around the mean, and the variables show no great correlation between them.

29

Table 10: Descriptive Statistics for Tobit Regression

Variables	Skewness	Kurtosis	Mean	Std. Dev.	Min	Max
cost inefficiency	0.009	0.823	0.2402551	0.087202	0.0741259	0.3280522
Shareholders equity/total assets	0.569	0.624	0.1075654	0.0241557	0.0612057	0.1612223
Net income/total assets	0.031	0.02	0.0162168	0.0234538	-0.0589529	0.0674289
Loans/total assets	0.795	0.172	0.4761522	0.1508999	0.1919577	0.7590792
Deposits/total assets	0.627	0.446	0.8293889	0.0427173	0.7324712	0.9170486
Foreign ownership/total equity	0.002	0.458	0.704	0.3605513	0	0.92
Bad loans	0	0	0.1616285	0.1906712	0.0172509	0.845
Income per capita growth	0.988	0	6.8	2.081114	4.2	9.2
Bank size	0.074	0.153	0.2	0.103313	0.0906268	0.418461

Source: Author's computations

Table 11: Descriptive Statistics for Tobit Regression

Variable	Skewness	Kurtosis	Mean	Std. Dev.	Min	Max
Technical efficiency	0.403	0.002	0.7186333	0.2749803	0.257	1
Shareholders equity total assets	0.569	0.624	0.1075654	0.0241557	0.0612057	0.1612223
Net income total assets	0.031	0.02	0.0162168	0.0234538	-0.0589529	0.0674289
Loans total assets	0.795	0.172	0.4761522	0.1508999	0.1919577	0.7590792
Deposits/total assets	0.627	0.446	0.8293889	0.0427173	0.7324712	0.9170486
Foreign ownership total equity	0.002	0.458	0.704	0.3605513	0	0.92
Bad loans	0	0	0.1616285	0.1906712	0.0172509	0.845
Income per capita growth	0.988	0	6.8	2.081114	4.2	9.2
Bank size	0.074	0.153	0.2	0.103313	0.0906268	0.418461

Source: Author's computations

Prior to estimation it is necessary to check the behavior of the error variance. In this case, null hypothesis is that the variance is constant (homoskedastic). Using the Breusch pagan/Cook Weisberg test (see Table 12) the null hypothesis has been rejected thereby confirming the presence of heteroskedasticity.

Table 12: Breusch-Pagan / Cook-Weisberg Test for Heteroskedasticity

Ho: Constant variance		Decision
chi2(8)	12.77	
Prob > chi2	0.12	Reject
Technical efficiency as a dependent variable		
chi2(8)	12.23	
Prob > chi2	0.1410	Reject

Source: Author's computations

In this situation, estimation is bound to lead to biasness. To correct this, we use robust standard errors. The results reported in Table 13 confirm that the model used fits the data more than an empty model as indicated by the probability value. For equation 13 the variable Nia(ratio of net income to total assets) is significant and has a positive effect on technical efficiency. Shareholders' equity held by foreigners and income per capita growth are also significant but the latter has an unexpected sign.

Table 13: Results from Tobit Regression

Dependent Variable: Technical Efficiency		Dependent Variable: Inefficiency
Variable	Coefficient	Coefficient
Shareholders equity/total assets	-3.00733	1.513027**
	(-1.12)	(2.16)
Net income/total assets	8.167049*	-0.0660786
	(4.21)	(-0.10)
Loans/total assets	-0.2507337	-0.2298111**
	(-0.68)	(-2.69)
Deposits/total assets	-1.714772	0.1522318
	(-0 13)	(0.57)
Foreign ownership/total equity	-0.4390308***	0.0643355
	(-1.92)	(1 46)
Bad loans	-0.343144	-0.1184486***
	(-1.55)	(-1.76)
Bank size	1.184881	3.1235*
	(-0 52)	(4.091)
Bank size squared	-4.542384	-5.654991*
	(0.01)	(4.44)
Income per capita growth	-0.037874***	-0.0041227
	(-1.80)	(-0.68)
The constant	1.784952	-0.2765237
	(1 35)	(-0.84)
Sigma	0.1827748	0.0417444
No. of observations: 30		
Prob > F = 0.0000		

Source: Author's computations

T-ratios in brackets

*, ** and *** represent 99%, 95% and 90% Significance level respectively.

In equation 14 the variable bad loans is significant but with a bad sign. The ratio of shareholders' equity to total assets (sea), ratio of loans to total assets (la), bank size and bank size squared are also significant. Increase in the ratio of loans to total assets reduces inefficiencies but the ratio of

shareholders' equity to total assets raises inefficiencies. Bank size is found to raise inefficiencies up to a certain level after which it starts affecting inefficiencies negatively. The other variables are found not to be significant.

4.6 Conclusion

This chapter presented empirical findings from data analysis. Technical efficiency results are obtained using DEA and they range from 55.9% to 100%. Cost efficiency results were extracted from SFA and they range from 66% to 92.5%. Banks with the highest technical efficiency score are found not to be the most cost efficient. The bank with the lowest technical efficiency score has been found to have the highest cost efficiency score. Determinants of efficiency are also identified from a tobit model. Net income is found to have positive effects on technical efficiency but foreign ownership and income per capita growth have negative effects. Bank size and loans have negative effects on X-inefficiency but shareholders' equity has positive effects on X-inefficiency.

CHAPTER FIVE

SUMMARY, POLICY RECOMMENDATIONS AND CONCLUSION

5.1 Introduction

Chapter five has three small sections. The first section traces all the work carried on and results. Section two draws on the empirical findings and formulates some policy suggestions. Drawbacks of the study and area for future research are also discussed in this section.

5.2 Summary

The literature ascertains that efficiency is crucial for banks to perform and put gears into financial development. The lack of knowledge about efficiency of banks in Rwanda is thus a problem that needs to be solved. This study sought therefore to examine efficiency of commercial banks in Rwanda. Specifically, it looked at levels of technical and cost efficiencies of commercial banks of Rwanda and it identified their determinants.

The literature reviewed in this study confirmed that it is theoretically important to measure efficiency as it affects productivity and thereafter increases profit. Nevertheless, empirical studies showed us that factors and environment that influence efficiency of banks are not uniform across economies. Factors like bank size, ownership, bad loans and labor could be found to be important by one study but not by another.

To achieve its objectives this study applied two recognized approaches in measuring efficiency. DEA was employed to get technical efficiency and SFA was used to obtain cost efficiency. The data is on 5 biggest commercial banks in Rwanda from 2005 to 2010. Tobit regression was thereafter used to identify determinant of x-inefficiency.

Similar to results we came across in most studies on African economies, technical and cost efficiencies were found to be 71.8% and 73.7% on average respectively. Bank size and loans advanced to economic agents were identified as reducing X-inefficiency. Integrating technological innovations was found to have a positive impact on productivity of commercial banks in Rwanda, and, growing net income relative to total assets was found to have a positive

effect on technical efficiency whereas foreign ownership was identified as a source of technical inefficiency.

5.3 Policy Recommendations

It is evident from this study that the integration of technological innovations played a tremendous role in improving factor productivity of commercial banks in Rwanda. This practice should be enhanced and extended to other kinds of innovations not limited to the use of ATMs. It is also necessary to expand the use of technologies which is concentrated in Kigali to other provinces of the country. The incorporation of improved technologies by micro financial institutions and other small cooperative banks can definitely have positive effects on the performance of the banking sector.

Increasing percentage of loans to total assets, which is synonymous with a growing volume of loans given out to economic agents has proved to bring about increased efficiency of commercial banks. However, financial statements of all commercial banks report increasing investment in treasury bills and sometimes more than loans. Therefore, monetary authorities should find a way to direct resources to more productive investments but this should move in tandem with improved mechanisms to curb bad loans.

5.4 Conclusion

This study ascertains that, across African countries, the levels of efficiency are averagely in the same range. However, there exist considerable differences among these economies that pertain to which type of efficiency and factors that are taken into consideration.

We underscore the fact that some variables are not significant whereas in other studies they were found to affect efficiency positively or negatively. The findings of this study on the role of bank size are in accord with those of Kirkpatrick, Murinde and Tefula(2008), Bader et al(2008), Kablan(2010), Onour and Abdalla(2010), Ikhide(2008) and Kamau(2011). However, these results are in contrast to those of Ncube (2009) and Aikaeli (2008)

This study prolongs the debate on the importance of uniqueness of each country in policy formulation as far as financial development is concerned. It also corroborates that more growth can be achieved by increasing the efficiency of commercial banks in Rwanda.

5.5 Limitations of the Study and Areas for Further Research

This study focused on efficiency of five commercial banks in Rwanda for a period of six years Thus, this scope does not include all facets of the entire banking sector in Rwanda. Availability and accessibility of data on all financial institutions in Rwanda could have helped to conduct a more comprehensive and informative study. Furthermore, only one variable (Income per Capita Growth) is used in identification of determinants of efficiency. It does not, however, capture the real macroeconomic environment in which financial institutions operate in Rwanda.

It was mentioned in chapter two that there exist two approaches in the choice of inputs and outputs to be included in investigating efficiency in the banking sector. These are the intermediation approach and the value added approach. This study followed the intermediation approach. A study that will apply the other approach and use more inputs and outputs can provide insights for comparison and better understanding of the behavior of efficiency of the Rwandan financial sector. Another interesting area may be a study on efficiency of rural bank branches and rural financial cooperatives and their effects on financial depth.

References

Aigner, D., K. Lovell and P. Schmidt (1977). "Formulation and Estimation of Stochastic Frontier Production Function Models", *Journal of Econometrics*, 6: 21-37

Aikaeli, J. (2008). "Commercial Banks Efficiency in Tanzania", a Paper Presented in a *CSAE Conference on Economic Development in Africa*, 16-18 March 2008, viewed 20 March 2012, http://www.ideasrepec.org.

Al-Jarrah, I.M. (2007). "The Use of DEA in Measuring Efficiency in Arabian Banking", *Banks and Bank Systems*, 2(4).

Asongu, S.A. (2010). "Bank Efficiency and Openness in Africa: Do Income Levels matter?", *MPRA*, 27011, viewed February 2012, http://mpra.ub.uni-muenchen.de/27011.

Bader, M.K, S. Mohamad, M. Ariff and T. Hassan (2008). "Cost, Revenue and Profit Efficiency of Islamic Versus Conventional Banks: International Evidence using Data Envelopment Analysis", *Islamic Economic Studies*, 15(2).

Badunenko, O., M. Fritsch and A. Stephan (2006). "Allocative Efficiency Measurement Revisited: Do we Really Need Input Prices?", *Freiberg Working Papers*, 2006(4), http://www.bdl.handle.net.

Banker, R.D., A. Charnes and W.W. Cooper (1984). "Models for Estimating Technical and Scale Efficiencies", *Management Science*, 30 1078 – 1092.

Berger, A. N., and D. B. Humphrey (1992). "Efficiency of Financial Institutions: International Survey and Directions for Future Research", *Working Papers Wharton School, University of Pennsylvania*

Black, J.D. (1930). "The Definition of Efficiency", *Journal of Farm Economics*, 12(2):335-336.

Behr, A. and S. Tente (2008). "Stochastic Frontier Analysis by Means of Maximum Likelihood
and the Method of Moments". *Banking and Financial Studies*, Discussion Paper Series
2(19).

Bikker, J.A. and J.W.B. Bos (2008). *Bank Performance: A Theoretical and Empirical
Framework for the Analysis of Profitability, Competition and Efficiency*. Abingdon:
Routledge.

Camen, U., M. Ncube and L.M Senbet(2008). "The Role of the Financial System in the
Operation of Monetary Policy in Africa". In A. M. Ncube(Eds), *Financial Systems and
Monetary Policy in Africa* (pp.18-58). Nairobi: *AERC*.

Chan, S.G. and M.Z Karim (2010). "Bank Efficiency and Macroeconomic Factors: The Case of
Developing Countries". *Global Economic Review*, 39(3):269-289.

Charnes, A., W.W Cooper and E. Rhodes (1978)". Measuring the Efficiency of the Decision
Making Units". *European Journal of Operational Research*, 2:429-444.

Clark, A. and T F. Siems (2002). "X-efficiency in Banking: Looking Beyond the Balance Sheet".
Journal of Money, Credit and Banking, 34(4):987-1013.

EAGER (2001). "Impact of Policy Reforms on Bank Efficiency and Savings Mobilization in
Ghana" *Policy Brief*, 55, viewed 1 March 2012, http://www.ideasrepec.org.

Farell, M.J. (1957). "The Measurement of Productive Efficiency', *Journal of the Royal
Statistical Society*. series A 120(3):253-290.

Figueira, C., J. Nellis and D. Parker (2006). "Does Ownership Affect the Efficiency of African
Banks" *The Journal of Developing Areas*, 40(1):38-63.

Fried, H.O., C.A.K. Lovell and S.S. Schmidt (1976). *The measurement of Productive Efficiency*

Techniques and Applications. Oxford, Oxford University Press inc.

Frimpong, J.M. (2010). "Investigating Efficiency of Ghana Banks: A Non-parametric Approach". *American Journal of Scientific Research*, 7:64-76.

Green, W. (2004). *Econometric Analysis* New York, Prentice-Hall

Ikhide, S.I. (2008). "Measuring Operational Efficiency of Commercial Banks in Namibia". *South African Journal of Economics*, 76(4).

Kablan, S. (2009). "Measuring Bank Efficiency in Developing Countries: the Case of the West African Economic and Monetary Union". *AERC*, RP 192.

_____(2010). "Banking Efficiency and Financial Development in Sub Saharan Africa". *IMF Working Paper Series*, 10(136).

Kamau, A.W. (2011). "Intermediation Efficiency and Productivity of the Banking Sector in Kenya" *Interdisciplinary Journal of Research in Business*, 1(9):12- 26

Kiyota, H (2009). "Efficiency of Commercial Banks in Sub-Saharan Africa: A Comparative Analysis of Domestic and Foreign Banks', A Paper Presented at the CSAE Conference on *Economic Development in Africa* held at the University of Oxford from 22-24 March 2009.

Kirkpatrick, C., V. Murinde and M Tefula (2008). "The Measurement and Determinants of X-Inefficiency in Commercial Banks in Sub-Saharan Africa". *The European Journal of Finance*, 14(7):625-639.

Kokkinou, A. (2009). "Stochastic Frontier Analysis: Empirical Evidence on Greek Productivity". viewed 1 March 2012, http://www.ideasrepec.org.

Kumbhakar, S.C. and C.A.K. Lovell (2000). *Stochastic Frontier Analysis*. Cambridge, Cambridge University Press.

Leibenstein, H., (1966). "Allocative Efficiency vs. X-Efficiency". *American Economic Review*, 56(3):392-415.

Levine, R. (1996). "Financial Development and Economic Growth, Views and Agenda". World Bank working Paper Series WPS 1678.

Levine, R. and S. Zervos (n.d). *Stock Markets, Banks and Economic Growth'*, viewed February 2012, http://www.ideasrepec.org.

Lovell, K. (1992). "Production Frontiers and Productive Efficiency", in Fried, Lovell and Schmidt (eds). *The Measurement of Productive Efficiency: Techniques and Applications*. Oxford University Press.

Matthews, K. (2010). "Banking Efficiency in Emerging Market Economies". *Zahid Husain Memorial Lecture Series*, No. 17.

Mugume, A. (2008). "Efficiency in Ugandan Banking Industry". *Bank of Uganda Working Paper Series*, No. 12.

Musoni, J.R. (2010). "Economic Liberalization, Monetary Policy and Money Demand in Rwanda: 1980-2005", *AERC*, RP193.

Republic of Rwanda (2008), National Bank of Rwanda Annual Report 2007

_____(2009a), National Bank of Rwanda Financial Stability Report 2008.

_____(2009b), National Bank of Rwanda Annual Report 2008

_____(2011), National Bank of Rwanda Annual Report 2010.

Ncube, M. (2009). "Efficiency of the Banking Sector in South Africa□". A Paper Presented at African Economic Conference on *Fostering Development in an Era of Economic and Financial Crises*, held at Addis Ababa on 11-13 November 2009.

Olaosebikan, B. (2009). "Surveying Efficiencies of Nigerian Banks Before and After the Minimum Capital Requirement Increase". *Honors Projects*, No. 20.

Oluitan, R. (2010). "Bank Efficiency in Africa', viewed 24 March 2012, http://www.ideasrepec.org.

Onour, I. and A. Abdalla (2010). "Scale and Technical Efficiency of Islamic Banks in Sudan: Data Envelopment Analysis". *MPRA*, No. 29885.

Qian, B. and S. Poshakwale (2009). "Competitiveness and Efficiency of the Banking Sector and Economic Growth in Egypt". Paper Presented in the Workshop on *Competitiveness of the Financial Services Sector in Africa*, Johannesburg, June 2009.

Rusagara, C. (2008). "Financial Sector Development Program: Case of Rwanda". Paper Presented at *African Finance Seminar*, 4-5 March 2008, viewed 8 March 2012, http://www.bnr.rw.

Scholtens, B. and D. van Wensveen (2003). "The Theory of Financial Intermediation: An Essay on What it Does (not) Explain". *The European Money and Finance Forum, SUERF studies*, 2003/1.

Seiford, L.M. and R.M. Thrall(1990). "Recent Developments in DEA: The Mathematical Programming Approach to Frontier Analysis". *Journal of Econometrics*, 46:7-38.

Sinha, T. (2001). "The Role of Intermediation in Economic Growth: Schumpeter Revisited". In Dahiya, S. B. and V. Orati (eds.). *Economic Theory in the Light of Schumpeter's Scientific Heritage*, Rohtak India, Spellbound Publishers.

Somnez, D., J. Laws and J. Thompson (n.d). "Production Efficiency of Turkish Banks". Viewed
20 March 2012, http://www.ideasrepec.org.

Stigler, G., (1976). "The Existence of X-efficiency". *American Economic Review*, 66:213-
216.24.

United Nations (2008). "*Assessing Financial Sector Reforms in Eastern Africa*". viewed 11
March 2012, http://www.ideasrepec.org

Vittas, D. (1991). "Measuring Commercial Bank Efficiency". World Bank Working Paper
Series, WPS 806.

Waldman, D.M. (1984). "Properties of Technical Efficiency Estimators in the Stochastic Frontier
Model', *Journal of Econometrics*, 25:353-364.

Wang, W.S. and P. Schmidt (2009). "On the Distribution of Estimated Technical Efficiency in
Stochastic Frontier Models". *Journal of Econometrics*, 148:36-45.