ADDIS ABABA UNIVERSITY
COLLEGE OF BUSINESS AND ECONOMICS
DEPARTMENT OF ACCOUNTING AND FINANCE

Cost Efficiency, Credit Risk-Taking and Capital Adequacy: an empirical study on Ethiopian commercial banks

By

Heruy Zeray Gebre

A Thesis Submitted to the Department of Accounting and Finance of Addis Ababa University in Partial Fulfillment of the Requirements for the Degree of Master of Science in Accounting and Finance

June 2015

Addis Ababa

Declaration

I, the undersigned, hereby declare that this thesis work entitled "*Cost Efficiency, Credit Risk-Taking and Capital Adequacy: an empirical study on Ethiopian commercial banks*" submitted by me for the award of the degree of Master of Accounting and Finance of Addis Ababa University at Addis Ababa Ethiopia, is original work and it hasn"t been presented for the award of any other Degree, Diploma, Fellowship or other similar titles of any other university or institution and that all source of material used for the thesis have been duly acknowledged.

Declared by:

Heruy Zeray Gebre		
Name	***Signature***	***Date***

Confirmed by advisor:

Habitamu Berhanu (Asst. Prof.)		
Name	***Signature***	***Date***

Statement of Certification

This is to certify that the thesis prepared by Heruy Zeray, entitled: *Cost Efficiency, Credit Risk-Taking and Capital Adequacy: an empirical study on Ethiopian commercial banks* and submitted in partial fulfillment of the requirements for the degree of Master of Science in Accounting and Finance complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

Approved by Board of Examiners:

Internal examiner:	Degefa Duressa (Asst. Prof.)		
	Name	***Signature***	***Date***
External examiner:	Alem Hagos (Asst. Prof.)		
	Name	***Signature***	***Date***
Advisor:	Habitamu Berhanu (Asst. Prof.)		
	Name	***Signature***	***Date***

Acknowledgments

The assistance from many individuals has made this study possible. First of all, I would like to acknowledge my thesis advisor Dr. Habitamu Berhanu for his professional guidance, constructive ideas, and comments. My grateful thanks also go to Bank Supervision Directorate employees of the National Bank of Ethiopia for their positive cooperation in giving the relevant financial data for the study.

I would also like to thank my wife Tamir Alemu for her valuable support during my education and all the rest of my life.

Finally, my indebtedness goes to my employer, National Bank of Ethiopia, for paying the tuition fee of the study.

Table of Contents

List of Tables

List of Figures

List of Annexes

Acronyms/Abbreviation

ASEAN	Association of Southeast Asian Nations
BCAD	Bank Capital Adequacy
BCBS	Basel Committee on Bank Supervision
CDs	Certificate of Deposits
CEFF	Cost Efficiency
CRAs	Credit Rating Agencies
CRISK	Credit Risk-Taking
DEA	Data Envelopment Analysis
DIC	Deposit Insurance Corporations
DMU	Decision Making Unit
FDH	Free Disposal Hull
GMM	Generalized method of Moments
MLE	Maximum Likelihood Estimation
NBE	National Bank of Ethiopia
NCA	Nordic Competition Authorities
NPLs	Non Performing Loans
OLS	Ordinary Least Squares
SFA	Stochastic Frontier Analysis
3SLS	Three-stage least square
SSA	Sub Saharan Africa
TC	Total Cost
TFA	Thick Frontier Approach
Translog	Transcendental logarithm

Abstract

The purpose of this study is twofold, first to investigate the cost efficiency level of Ethiopian commercial banks; and second, to analyze the relationship between cost efficiency, credit risk-taking and capital adequacy based on the notion of causality. Balanced panel data from samples of eight banks which have data for the period 2000 to 2014 have been used. The study applied Stochastic Frontier Analysis (SFA) techniques provided by Battese and Coelli (1995) to investigate the banks" cost efficiency level and Granger causality techniques to analyze causal relationship among cost efficiency, credit risk-taking and capital adequacy. The findings of the study highlight that the average cost efficiency level of the studied commercial banks is 89 percent. At individual bank level, Ethiopian Commercial Bank (CBE) is the most cost efficient while Construction and Business Bank (CBB) is the least cost efficient. State ownership has negative impact on cost efficiency due to the averaging effect of the two studied state owned commercial banks. Bank size has positive impact on cost efficiency indicating that large banks on average tended to be more cost efficient than small banks. With regard to the causal relationship, the results of the Granger model show that negative and bidirectional causality exists between cost efficiency and credit risk-taking supporting both the "luck" and "bad management" hypotheses. The study also shows that improvement in cost efficiency Granger cause increase in capital adequacy level. Capital adequacy and credit risk-taking also have bidirectional causality supporting both "luck" and "moral hazard" hypothesis. Overall, the results of the Granger model indicate that the severity of one of the three variables may increase unless the other is carefully managed.

***Key words**: Cost efficiency; Credit risk-taking; Capital adequacy; Granger causality; Stochastic Frontier Analysis; System GMM.*

Chapter One: Introduction

This section provides the basic ground for conducting the study including the nature and the linkage of cost efficiency, credit risk-taking and capital adequacy. It presents the background, statement of the problem, objectives, significance, and the data type and sources of the study. The organization of the thesis also described at the end of this chapter.

1.1 Background

Banks play a key role in improving economic efficiency by channeling funds from resource surplus unit to those with better productive investment opportunities. Banks also play key role in trade and payment system by significantly reducing transaction costs and increasing convenience (NCA, 2006). In less monetized countries, like Ethiopia, where banks are the most important element of the financial system as other financial structures are underdeveloped or almost nonexistence, effective and efficient functioning of the banking systems have significant role in accelerating economic growth (Northcott, 2004).

Banks‟ important role in a country‟s economy and most importantly economy wide impact of banking crisis has increased global concerns regarding the stability of the banking systems. Although systemic banking crises are usually triggered by a macroeconomic shock, studies revealed it is usually due to problems accumulated by the banking industry themselves specifically due to excessive risk-taking by the banks themselves (Malyutina and Parilova, 2001).

As a result, understanding the determinants of risk-taking behaviour of banks has recently become a subject of rigorous theoretical and empirical research. Available literature on this front tends to suggest that risk-taking by banks tends to be affected by a number of factors, including, among others, agency problems between bank management and shareholders. Second, managers‟ and shareholders‟ underestimate of the business cycle or the procyclicality of capital which my lead to excessive lending by banks, the emergence of bubbles and a financial accelerator effect (Dewatripont and Freixas, 2012). Third, banks excessive risk-taking is due to moral hazard as a consequence of shareholder limited liability and implicit or explicit safety net for bank depositors (like: deposit insurance, bailout, etc). Fourth, recent studies focused on the level of franchise value as a determinant of the excessive risk taking behaviour of banks. Franchise value can help

reduce excessive risk taking because banks with high franchise value have much to lose if a risky business strategy leads to insolvency (Dewatripont and Freixas, 2012).

Regulators, therefore, have tried to counterbalance the possible incentives of banks excessive risk-taking mainly by giving capital adequacy a more prominent role in the prudential regulatory process. Specially, the introduction of the 1988 Basel Accord on international bank capital standards and subsequent amendments reignited interest on the effectiveness of bank capital regulations. For instance, Demsetz et al., (1996) and Salas and Daurina (2003) found that banks with lower capital tended to operate with higher levels of credit risk in line with the moral hazard hypothesis. On the other hand, theoretical literature offers contradictory results as to the effects of capital requirements on bank risk-taking incentives (e.g. Berger et al., 1995; Freixas and Rochet, 2008; Santos, 1996; Boot et al., 1998). Overall then, the issue of whether higher capital ratios reduce overall banking risk has remained largely unresolved.

A major contribution on the relationship of bank capital and risk-taking debate came from Hughes and Mester (1998, 2009) who argued for the need to consider bank efficiency when analyzing the relationship between capital and risk. According to Hughes and Mester (1998, 2009) both capital and risk are likely to be determined by the level of bank efficiency. For instance, supervisory authorities may allow efficient banks (with high quality management) a greater flexibility in terms of their capital leverage or overall risk profile, ceteris paribus. On the other hand, a less efficient bank with low capital may be tempted to take on higher risk to compensate for lost returns due to moral hazard considerations. Hence, the capital regulation and its impact on risk-taking behaviour may either increase or decrease efficiency.

In this regard, Berger and DeYoung (1997) and Kwan and Eisenbeis (1997) also posit that it is crucial to recognize explicitly the concept of bank efficiency in empirical models analyzing the determinants of bank‟ risk-taking behaviour. Therefore, the objectives of this study are twofold, first to investigate the cost efficiency level and its determinants and next to analyze its underlying relation with capital and risk-taking behaviour in Ethiopian commercial banks.

1.2 Statement of the problem

Since 1991 Ethiopia has been taking various liberalization measures which are intended to enhance the performance of banking sector. Some of the measures include lifting of lending rate

cap, allowing private owners to invest in banks, introducing new financial instruments like introducing treasury bills, inter-bank foreign exchange market and others. As a result, the number of commercial banks has rapidly increased from one bank in 1991 (Commercial Bank of Ethiopia) to 18 banks in 2014 (NBE Quarterly Bulletin, 2014). Moreover, the competitions among commercial banks have increased especially in terms of service quality, efficiency (including use of technological advances), branch network expansions, advertising and prices paid on fixed deposit (Zerayehu, Kagnew and Teshome, 2013). This process has increased the emphasis on the importance of improved efficiency in Ethiopian banking sector. At the same time, this increase in the involvement of private owners and consequently increase in competition leads to greater (possibly excessive) risk-taking.

Regulators have tried to counterbalance these possible incentives by giving capital adequacy a more prominent role in the prudential regulatory process (Fiordelisi, Marques-lbanez and Molynex, 2010). Therefore, promoting bank safety and soundness rests on identifying the underlying bank efficiency level and its relationship with banks‟ risk-taking behaviour and capital adequacy is utmost important. However, studies in this regard in Ethiopian commercial banking sector are scanty.

1.3 Objectives of the study

The main objectives of this study is twofold: first to identify the cost efficiency level of Ethiopian commercial banks, the variation level among state and private ownership and provide justifications for the variations in cost efficiency among the two ownership groups. Second, the objective of the study is to assess the relationship between cost efficiency, credit risk-taking and capital based on the notion of causality. The study also has the following specific objectives:

- To assess the overall cost efficiency level of Ethiopian commercial banks;
- To investigate the impact of state ownership on commercial banks‟ cost efficiency;
- To identify the factors that determinants of cost efficiency level of commercial banks;
- To analyze the impact of cost efficiency on commercial banks‟ credit risk-taking; and
- To assess the impact of commercial banks‟ capital on credit risk-taking and cost efficiency trade-offs.

1.4 Scope of the study

The scope of the study was limited to see the interrelationship between cost efficiency, capital and risk-taking behaviour of banks focusing on commercial banks operating in Ethiopia between 2002 and 2014. Determinants of commercial banks‟ risk-taking behaviour, determinants of commercial banks‟ capital level and other bank efficiency measurements (like revenue and profit efficiency) are not in included in the scope of this study.

1.5 Significance of the study

The study has great contribution to the existing knowledge in the area of commercial banks‟ capital, risk-taking behaviour and cost efficiency relationship. This in turn contributes to the well being of the financial sector of the economy and the society as a whole. Therefore, the major beneficiaries from this study are each commercial bank, regulatory bodies, the academic staff of the country and the society as a whole in the country.

1.6 Organization of the study

This research report is organized in five chapters. Chapter one provides the general introduction about the whole report. Chapter two describes the review of related literatures. Chapter three provide detail description of the methodology employed by the research. Chapter four contains data presentation, analysis and interpretation. Finally, the last chapter concludes the total work of the research and shows the implication for policy makers and further research.

Chapter two: Literature review

The aim of this chapter is to briefly and critically review the pertinent theoretical and empirical literatures by categorizing the study area into four major categories. First, it reviews the determinants of banks‟ excessive risk-taking behaviour. Second, the impact of capital regulation on banks‟ excessive risk-taking behaviour has been reviewed. Then, bank efficiency and its measurement issues have been assessed. Finally, the interrelationship between bank excessive risk-taking behaviour, bank efficiency and capital adequacy level has been reviewed.

2.1 Determinants of Bank risk-taking behaviour

Bank risk-taking behavior has long been an important concern both of bank regulators and in the banking literature. The extent of risk-taking by banks influences the probability of bank failure on the micro-level, and on the macro-level it affects the viability of the banking system (Mitchell, 1986).

The successive banking crises that have occurred around the world reveal that banks often take excessive risks and these continuous crises have adverse snow-ball effects on the financial system and the real economy as well (Deelchand and Padgett, 2009).

To begin with, it is necessary to give a more precise definition of „excessive risk-taking‟ before trying to explore the reasons why banks choose to implement such a strategy. Excessive risk-taking defined as a level of risk such that, had it been known and taken into account ex ante by banks‟ stakeholders, it would have made the net present value of the bank‟s investment project negative (Dewatripont and Freixas, 2012). This view of „excessive risk-taking‟ has the advantage of preserving the option for banks to invest in high risk ventures provided they result in a corresponding high return and do not jeopardize the continuity of the bank as a going concern.

According to Dewatripont and Freixas (2012), five key issues are crucial to be examined to deeply understand the root causes of financial institutions‟ excessive risk-taking behaviour. First of all, excessive risk-taking is directly related to corporate governance. The decisions a bank takes regarding risk levels are ultimately the responsibility of managers and boards of directors. Whether in their strategic decisions managers consider their own bonuses, short-term stock price movements, shareholders‟ short-run interests (rather than stakeholders‟ long-run ones) or simply

the financial institution‟s culture of risk, these are all decisions that are substantiated by the board and therefore result from the structure of financial institutions‟ corporate governance (Dewatripont and Freixas, 2012).

Mehran, Morrison and Shapiro (2011) explore the impact of corporate governance on excessive risk-taking in financial institutions. The authors identify the multiplicity of stakeholders (insured and uninsured depositors, the deposit insurance company, bond holders, subordinate debt holders and hybrid securities holders), and the complexity of banks‟ operations results the possibility of a lower level of control by stakeholders over decisions by managers and boards of directors.

Second, the issue of excessive risk-taking may also be related to managers‟ and shareholders‟ understatement of the business cycle risk of downturn, as the procyclicality of capital may lead to excessive lending, the emergence of bubbles and a financial accelerator effect (Dewatripont and Freixas, 2012). The fact that banks did not have enough capital once the crisis unraveled is not only a failure of the Basel II regulatory framework and the models it is based on, but also evidence of how critical the issue of procyclicality is for financial stability. The regulatory proposal of Basel III on countercyclical buffers is intended to solve this issue. Still, rigorous analysis of the procyclicality of banks‟ capital may indicate that the issue is more complicated than it seems.

Basel III requires national authorities „to monitor credit growth and other indicators that may signal a buildup of system-wide risk‟. Based on this assessment they will put in place a countercyclical capital buffer which will extend the capital conservation buffer (described in section III of BCBS, 2010a), so banks will be subject to restrictions on capital distributions (dividends, share repurchases and discretionary bonus payments to staff) if they do not meet the additional capital requirement.

Third, it may be argued that the curtailing of excessive risk-taking was the joint responsibility of supervision and market discipline, and that neither did a proper job. Theoretically both firms and gatekeepers are supposed to provide accurate information to the market and to supervisory agencies. During the recent global financial crisis we have observed how very liquid, highly rated financial assets all of a sudden became „toxic assets‟, how ratings for structured products had to

be continuously downgraded, how several markets, such as the interbank market, broke down, and how banks faced severe liquidity and funding problems.

The role of credit rating agencies (CRAs) in providing information to the market has been increasing, in particular in the process of securitization and rating of structured products. With the development of the market for these products, the CRAs‟ role has become more dominant, with record high levels of activity and profits. Thus, Moody‟s profits, for example, tripled between 2002 and 2006 (Lowenstein, 2008).

This information transmission issue has been a key one in the analysis of financial crisis, as it has been argued that it was the opacity of some of the structured products, asset-backed securities, collateralized debt obligations and so on, that was in part responsible for the first stages of financial crisis. It has also been stated that the use of fair value accounting by banks aggravated the crisis. So it is clearly important to assess to what extent these claims are valid.

Fourth, banks excessive risk-taking is due to moral hazard as a consequence of shareholder limited liability and implicit or explicit safety net for bank depositors (like: deposit insurance, bailout, etc), bank shareholders gain from upside risk and protected from downside risk (Milne and Whalley, 2001). According to Davies (1996), if the state guarantees the existence of individual banks that can create incentives which encourage irresponsible behaviour. The prize for taking excess risk may – if things go well – be excess returns while, if things turn out badly, the state steps in and picks up the tab.

Fifth, recent studies focused on the level of franchise value as a determinant of the excessive risk taking behaviour of banks. Franchise value is the present value of the stream of profits that a bank is expected to earn as a going concern (Demsetz, Saidenberg and Stranhan, 1999). According to them, in banking, sources of franchise value include efficiency, access to markets protected from competition, and valuable lending relationships. Franchise value can help reduce excessive risk taking because banks with high franchise value have much to lose if a risky business strategy leads to insolvency (Dewatripont and Freixas, 2012).

Empirical studies investigate the relationship between franchise value and risk has noted some interesting patterns over time. Most notably, Keeley (1990) documents declines in bank franchise

value during the 1950s, 1960s, and 1970s, when the banking industry was experiencing deregulation and increased competition from nonbank financial institutions.

Regulators have tried to counterbalance the possible incentives of banks excessive risk taking mainly by giving capital adequacy a more prominent role in the prudential regulatory process. We analyze, in the next section, the role capital regulation plays in influencing banks‟ excessive risk-taking incentives.

2.2 Capital regulation and risk-taking behaviour

The recurrence of banking crises that has taken place over the last two decades has increased global concerns regarding the stability of the financial system. For instance, Vives (2000) notes that the general trends of regulation is to introduce competition in banking and to check risk-taking with capital requirements and appropriate supervision. Under this process, several authors have focused on the negative effects that a generous safety net may have in terms of incentives for bank risk-taking and hence, on the need for more stringent prudential regulation. Among the different tools used by regulators for prudential purposes, capital adequacy regulations have played an increasingly prominent role. For example, Milne and Whalley (1998) state that capital regulation and supervision of the banking system is one of the principal public policy interventions in the workings of the economy.

Bank capital represents the claim of the bank‟s owners on the net assets of the firm and acts as a buffer to absorb fluctuations in the value of assets (such as due to loan defaults or variations in securities prices) and liabilities. According to Davis (2010), it is this characteristic which gives rise to its role in prudential regulation, with minimum capital requirements being seen as a way of protecting other stakeholders – particularly depositors (or a deposit insurance fund standing in their stead).

Prudential regulation often imposes regulatory capital requirements [1] in order to create the necessary cushion to protect banks against unexpected losses and ultimately failure (Dewatripont and Tirole, 1994; Goodhart et al., 2003; Pennacchi, 2005; Goodhart, 2008; amongst others). One

[1] A bank's regulatory capital is divided into three tiers: tier 1 capital, also referred to as 'core capital'; tier 2 capital, or 'supplementary capital'; and tier 3 capital, eligible only to meet part of the capital requirements for market risks. The minimum total capital (Tier I + Tier II + Tier III) and core capital (Tier1) ratios set by the Basel Committee are 8 % and 4% of the risk-weighted assets, respectively.

of the principles in the design of capital requirements is to make them risk sensitive, obliging banks to put aside more capital when they enter into more risky positions. Therefore, the efficiency of regulatory capital requirements is intrinsically linked to their capacity to make "low" capital buffers banks rebuilt their buffers by simultaneously raising capital and lowering risk.

Theoretically, a higher level of capital offsets the moral hazard, which results as a consequence of shareholders limited liability and implicit and explicit safety net, by exposing shareholders to more downside risks (Milne and Whalley, 2001). Thus, it conventionally argued, provided that regulatory capital requirements are a binding constraint on bank excessive risk-taking behaviour , they will reduce both incentives for risk-taking and the frequency of bank failure.

The theoretical literature offers contradictory results as to the optimal design of capital adequacy regulation and to the effects of capital requirements on bank risk-taking incentives (Berger et al., 1995; Freixas and Rochet, 1997; Santos, 1999; Boot et al., 1999; Rime, 2001) so that the theoretical issue of how higher capital ratios reduces overall banking risk has largely been unresolved in the literature. On the other hand, there is almost a consensus that capital adequacy regulations should be set up in conjunction with other prudential regulatory and market instruments in order to create an optimal set of incentives (Freixas and Gabillon, 1999). With regard to the latter various researchers (e.g. Flannery, 1998, 2001; Benink and Wihlborg, 2003; Sironi, 2003; Gropp et al., 2004) note the importance that market discipline can have on bank risk-taking and capital strength. The argument goes that holders of bank liabilities such as deposits or/and unsubordinated debt have an incentive to penalize banks by asking for higher returns if they take on more risk. Banks in turn will respond by holding more capital to reduce insolvency risk. However, banks that take on more risk may not necessarily hold more capital if they believe all depositors are insured or if they underestimate the adverse systemic implications of bank failure. Nevertheless, bearing these factors in mind, the market discipline argument does suggest that holders of bank liabilities will restrict bank risk-taking by making such activity more costly.

Turning to the empirical literature, there is an early line of research that examines the effects of bank capital regulations on bank behaviour (e.g. Peltzman, 1970 or Mayne, 1972) most of these studies build on Friedman"s (1962) capital adjustment model. The main concern of these early

studies was to analyze the effectiveness of financial regulation and, especially, to consider whether the existence of a flat-rate deposit insurance scheme (i.e. not linked to banks‟ risk) created incentives for excessive risk-taking by bankers at the expense of the Deposit Insurance Corporations (DIC). In order to avoid the transfer of value to the DIC, financial regulation was expected to force financial institutions to hold an amount of capital adequate to the amount of risk that individual institutions were taking. Overall, results from these earlier studies were skeptical about the effectiveness of banking capital regulation influencing banks‟ managers‟ target capital ratios and emphasized the need to control for other factors to limit risk-taking such as the influence of a deposit insurance flat fee rate or the effect of high nominal interest rates (Marcus, 1983).

The introduction of the 1988 Basel Accord on international bank capital standards (Basel I) reignited interest on the effectiveness of bank capital regulations. A new wave of studies tend to find that regulatory capital constraints were buttressing banks‟ capital (e.g. Wall and Peterson, 1988; Shrieves and Dahl, 1990; and Barrios and Blaco, 2003). The results from these studies suggest that regulatory minimum capital constraints are important in influencing the financing decisions made by a significant subset of banks. In the aftermath of the Basel I application and subsequent amendments, the interest on the effects of capital adequacy regulations on banks‟ risk persisted. For instance, Ediz et al., (1997) found that bank capital regulation had been effective in increasing capital ratios without substantially shifting bank portfolios and off-balance-sheet exposures towards riskier assets in the US and UK. In this direction also, Demsetz et al., (1996) and Salas and Saurina (2003) found that banks with lower capital tended to operate with higher levels of credit risk in line with the moral hazard hypothesis. Interestingly, these studies express concerns as to whether these results would still hold in more recent years given that financial innovation has made the Basel 1988 risk weights less meaningful. Also, it could be argued that increased competition and more expensive cost of capital are likely to encourage risk-taking – in order to make up for the lost returns needed to increase capital ratios.

Edizt, Micheal and Perraudin (1998) assess the effect of the Basel Capital Accord adequacy requirement on capital ratios of UK banks. By using confidential supervisory data, they discover that when the capital ratio of the UK banks approaches its minimum value required by the authorities, bank increase the capital ratio in the following quarter. They observe that the increase

in capital ratio of banks is likely come from an increase in narrow capital and there is no evidence that UK banks increase risk-taking in order to achieve and exceed the minimum target ratio. The results also indicate that the capital requirements significantly affect the capital ratio.

On the other hand, capital regulation may influence the bank‟ lending behaviors, in turn affect the banks‟ portfolio risk. Kentaro (2007) finds that capital regulations do not prevent risk taking behaviours as undercapitalized banks may issues more subordinated debts to meet the capital requirements. However, the Kentaro doubt that, the issues of recapitalized using subordinated debts may allow Japanese banks to swift their loan portfolio towards more risky investments in real estate sector and worsened the non performing loans problems.

Government guarantees provide incentives to the banks‟ management to take unnecessary risk because to some extent they are not bound to repay their depositors. In this respect, Berger et al. (1995) argue that government safety net guarantees reduce the incentive to issue equity shares, causing market capital levels to be artificially reduced. Hence, banks face a number of agency problems and associated moral hazard risks that impose on the capital decision without and with capital regulation.

Charter Value can also defined as the value of a bank being able to continue to do business in the future, reflected as part of its share price. Demsetz et al. (1996) suggest that franchise value plays an important role in banking because it helps mitigate the moral hazard problem. In order to maintain the franchise value, this will give the banks‟ management additional incentive to avoid excessively involved in risky businesses besides meeting the minimum level required by the regulator. Their empirical analysis supports the negative relationship of franchise value and risk. That banks having a lower franchise value (alternative term for charter value) behave more aggressively.

Additionally, Saunders and Wilson (2001) suggest that the relationship between charter value and capital structure decisions is procyclical. Their regression results show that during economic booms situation, high charter value banks posses a higher capital ratio. Nevertheless, during economic recessions, higher charter value banks uphold higher losses of charter value. The most important finding of this paper is that charter value may not able to lessen the amount of risky activities that banks involved.

A new perspective that contributes to the risk and capital debate came from Hughes and Mester (1998 and 2009). They argued for the need to consider bank efficiency when analyzing the relationship between capital and risk. Hence, in the next section, the theoretical and empirical literature on bank efficiency will be reviewed.

2.3 Bank efficiency and its measurement

Efficiency has been defined differently by scholars. As per Wikipedia efficiency is the ability to avoid wasting materials, energy, efforts, money, and time in doing something or in producing a desired result. Or in a more general sense the term efficiency is related to the ability to produce a result with minimum effort or resources. It measures how close a production unit gets to its production possibility frontier, which is composed of sets of points that optimally combine inputs in order to produce one unit of output. It is one of the key concepts for financial institutions. It has been extensively studied due to its importance. Mainly, the studies making typical comparisons of bank performance can be divided into two categories: (1) those which use simple aggregate bank ratios relating cost to revenues or assets, and (2) frontier technique which measures a bank‟s efficiency by its distance to the efficient frontier (Laeven 1999).

The measurement of relative efficiency where there are multiple possibly incommensurate inputs and outputs was addressed by Farrell (1957). He laid the foundation to measure efficiency and productivity studies at the micro level.

Farell proposed efficiency consists of two components: technical efficiency and allocative efficiency. The former reflects the ability of a Decision Making Unit (DMU) to minimize input use as to produce a given amount of output. The latter reflects the ability of a DMU to use inputs in optimal proportions, given their respective prices and the production technology together; these two measures represent a total efficiency measure (Coelli et al., 1997).

The other efficiency type having similar context with the concept of Farell is X-efficiency. It is an intra-firm inefficiency or the deviation from the production efficient frontier, which depicts the maximum attainable output for a given level of input. This inefficiency can arise from the differences in managerial ability to control cost and/or maximize profits Harvey Leibenstin (1966). Berger et al (1993) describe X-inefficiency, as a variance from the efficient frontiers set by the best practice or benchmark firm. It incorporates two components, those technical and

allocative inefficiencies. According to Farrell (1957) technical inefficiency occurs due to sub optimal usage of input leading to waste, while allocative inefficiencies arise from inappropriate mix or composition of inputs using inefficient business process. Both inefficiencies are attributed to employee, management or environment factors.

Scale Efficiency often arises from the ability of large firms to allocate fixed costs such as advertising expenses or cost of technology across a greater volume of output. It also shows whether the decision-making units (e.g. banks) operate at the minimum of their long run average cost curve. It focuses on technical efficiency, which is the ability of a bank to produce maximal output from a given set of inputs over a certain time period (Adongo et al, 2005).

The efficiency studies conducted in many developed and developing countries" commercial banks yield contradicting results regarding the efficiency of large and small banks, some studies indicating that large banks efficiency level is higher than that of small banks while other studies indicating different results. Also some studies of efficiency were aimed at evaluating the efficiency status of domestic and foreign banks similarly contradicting results were also indicated in level of performance of the two groups, some indicating higher efficiency level in domestic banks while others indicates the opposite. For example, countries in emerging economies for example Supachet C (2008) used DEA to analyze Relative efficiency of commercial banks in Thailand, using production approach and the empirical findings of the study revealed that the efficiency of Thai commercial banks via functional approach or operational Approach was very high and stable while using different approach i.e. intermediation approach the performance was moderately high and volatile. When referring to size, large, medium and small banks were efficient via operational approach with average efficiency of 100%. The similar study was used to compare the efficiency status of Foreign and Domestic banks in Malaysia, the study by Ong Tze San Lim Yee Theng and The Boon Heng (2011) applied DEA to compare the efficiency of Domestic and foreign banks in Malaysia, using the intermediation approach to determine inputs and outputs. The empirical findings indicate that Domestic banks have higher efficiency level than foreign banks. On another hand Izah,M.T, Nor,M.A and Sudin, H (2009) using DEA obtain similar results that Domestic banks were more efficient than foreign banks, more over it was found that the domestic bank inefficiency was attributed by pure technical inefficiency rather than scale inefficiency.

Few studies were conducted in Sub Saharan Africa (SSA) countries in which Ethiopia is one of those countries. The study of commercial banks‟ efficiency in SSA countries is very important because most of these countries have similar regulatory conditions with Ethiopia. The following are some of the key studies on bank efficiency in SSA counties whose main focuses were on assessing the cost and profit efficiency of banks, comparison of foreign banks and domestic banks efficiency level, foreign banks penetration and the economies of scale etc.

Kiyota (2009) provide a comprehensive banking sector efficiency analysis on sub SSA. He employed two stage analyses: first, he applied the stochastic frontier technique to assess the profit and cost efficiency of commercial banks; second, he employed Tobit regression to provide cross country evidence of the influence of environmental factors on efficiency of Sub Saharan African commercial banks, in similar vein the study intended to examine whether foreign banks are more efficient than domestic banks. The empirical results of the study indicated that foreign banks outperform domestic banks, which are consistent with the agency theory postulates; banks with higher leverage or lower equity are associated with higher profit efficiency. In terms of bank size, smaller banks were more profit efficiency where as medium size and larger banks are cost efficient. On another hand, the findings of the study suggested that non SSA Foreign banks are more cost efficient than Sub Saharan foreign as well as domestic banks for the period of 2000-2003.

Musonda (2008) investigated cost efficiency of Zambian banking sector since the baking crisis of the mid 1990s. Using a single stage stochastic frontier analysis method, the author has identified that Zambian banks are on average inefficient in the order of 11.4 %. Furthermore, foreign banks are more efficient than domestic banks, especially the state bank. However, domestic private banks have been closing the efficiency gap over the past few years. Contrary to popular thinking in the Zambian banking circles, regulatory intensity does not exacerbate inefficiency. Instead, bank specific factors and macroeconomic uncertainty have contributed significantly to the relatively low efficiency bank performance. Based on the finding, the author require banks to give more attention on improving risk management techniques and reducing credit to government in order to unlock the potential in the domestic banking sector.

Kamau, A,W (2011), using non parametric DEA method, investigated intermediation efficiency and productivity in the banking sector in the post liberalization period in Kenyan Commercial

banks. The results show that though the banks were not fully efficient in all aspect, they performed fairy well during the period under study. More over the commercial banks efficiency score was not less than 40% at any point. In terms of ownership and size, foreign banks were found to be more efficient than local banks, and in local category local private were more efficient than local public, large sized banks were more efficient than medium and small sized banks.

Olugbenga, S.O., and Olakunle, A. P., (1998) investigated the effect of gradual deregulation in a developing economy on the efficiency of banks and the banking sector in Nigeria. It assesses whether the policy package results in an improvement in the technical efficiency of the industry. The author applied the data envelopment analysis (approach) that has been used to assess inter-temporal changes in efficiency as well as the relative inefficiency of government controlled banks compared with private (new generation) banks. The author found that banking industry efficiency declined significantly during the years immediately following the adoption of deregulation, with slight improvements noticed only in recent times. The study concludes that this may be the effect of inconsistent policies to which the sector was subjected during this period.

.

With regard to studies conducted in Ethiopian commercial banks, the researcher found two works which assessed the efficiency level and factors affecting the efficiency level of commercial banks in Ethiopia (i.e. Tesfaye, 2014 and Rao and Tekeste, 2012).

Tesfaye (2014) investigates the efficiency level of Ethiopian banks for the period 2008 to 2012 using DEA. The result of the study has shown that the banking sector efficiency level is at modest level but it is characterized by both inter and intra group variations across different ownership structure and size. According to him, the efficiency of the government banks is the highest and specifically the CBE‟s efficiency score persistently is at the frontier and overall relatively newly opened commercial banks were less efficient than the older once except few banks in this group appears efficient as equivalent as the most efficient bank in the industry. Tesfaye (2014) concludes that the efficiency variation among public and private banks is explained by public banks favorable support from the government in creating easy market for deposit, loans and

foreign currency which has contributed a lot in reducing the cost of fund and boosting both interest and non-interest income.

Rao and Tekeste (2012) examine the relationship between cost efficiency and ownership structure of commercial banks in Ethiopia using DEA. Moreover, they attempted to explore the key factors that affect the cost efficiency of the commercial banks using Tobit model. In contrary to Tesfaye (2014), they found that the average cost efficiency level of state-owned commercial banks over the period 2000 to 2009 were 0.69 while that of the private commercial banks average cost efficiency were 0.74. The aggregate cost efficiency level of Ethiopian commercial banks was found to be 0.73. The study also indicates that the difference between the cost efficiency of the state-owned and private-owned commercial banks was statistically insignificant. Means, the study found little statistical evidence to conclude that the stat-owned commercial banks are less cost efficient than the private commercial banks. Thus, ownership structure has no significant influence on the cost efficiency of commercial banks in Ethiopia. In addition, the study had identified bank size, loan loss reserve to total assets, market share, market concentration, capital adequacy, and return on average assets as the key factors that influence the cost efficiency level of commercial banks in Ethiopia.

2.4 Interrelationship between bank efficiency, risk-taking and capital

A new perspective that contributes to the risk and capital debate came from Hughes and Mester (1998 and 2009). They argued for the need to consider bank efficiency when analyzing the relationship between capital and risk. According to them, both capital and risk are likely to be determined by the level of bank efficiency. For instance, supervisory authorities may allow efficient banks (with high quality management) a greater flexibility in terms of their capital leverage or overall risk profile, ceteris paribus. On the other hand, a less efficient bank with low capital may be tempted to take on higher risk to compensate for lost returns due to moral hazard considerations.

In this line Berger and De Young (1997) and Kwan and Eisenbeis (1997) posit that it is crucial to recognize explicitly the concept of bank efficiency in empirical model analyzing the determinants of banks‟ risk. Berger and De Young (1997) employ Granger-causality methods to assess the relationship among problem loans, cost efficiency, and bank capital for a sample of US banks from 1985 to 1994. The result suggests that problem loans precede reductions in measured cost

efficiency; that measured cost efficiency precedes reduction in problem loans; and the reductions in capital at thinly capitalized banks precede increases in problem loans. Hence, they concluded that cost efficiency may be an important indicator of future problem loans and problem banks.

Kwan and Eisenbeis (1997) use a simultaneous equation framework to test hypotheses about the interrelationships between bank risk, capitalization, and operating efficiency. A positive effect of inefficiency on risk-taking was found and supports the moral hazard hypothesis that poor performers are more vulnerable to risk-taking than high performance banking organizations. A positive effect of inefficiency on the level of capital is attributable to regulatory pressure on underperforming institutions. At the same time, firms with more capital are found to operate more efficiently than less well-capitalized banking organizations. They identified a U-shaped relationship between inefficiency and loan growth, indicating that operating efficiency improves at a decreasing rate as loan growth rate increases which support the hypothesis that entrenched managers who pursue a growth objective to enhance their own wealth tend to operate inefficiently.

Williams (2004) and Altunbas et al., (2007) have replicated both papers in a European banking setting. Similar to Berger and De Young (1997), Williams (2004) uses Granger-causality techniques to assess the inter-temporal relationships among problem loans, cost efficiency, and financial capital. His sample includes European savings banks over the period 1990 – 1998 and finds that poorly managed banks tend to make more poor quality loans. Altunbas et al., (2007) follow an approach similar to Kwan and Eisenbeis (1997) and use a static simultaneous equation framework to investigate the relationship between capital, loan provisions and cost efficiency for a sample of European banks over the period 1992 – 2000. In stark contrast to Williams (2004), Altunbase et al., (2007) do not find a positive relationship between inefficiency and bank risk-taking. Inefficient European banks appear to hold more capital and take on less risk.

All of the studies discussed above have been from a developed country viewpoint. However, from a developed country perspective, the interplay among efficiency, risk and capital may not be similar to the developed country. Hence, the following studies have been reviewed from the developing country perspective. For example, Abhiman Das and Saibal Ghosh (2004) have examined the interrelationships among risk, capital and operating efficiency of India‟s public sector banks from 1993 to 2000. The result shows that efficiency was found to have a positive

effect on credit risk in most cases, it was also has a positive effect on bank capitalization. This supports the fact that poor performers are more prone to risk-taking than high performing banking organizations. The positive effect of efficiency on capital is attributable to regulatory pressure, especially for banks which fall short of the prescribed minimum capital adequacy standards.

Izah Mohd Tahir and Abdul Mongid (2013) have investigated the interrelationship between bank cost efficiency, capital and risk-taking in six countries in the Association of Southeast Asian Nations (ASEAN) banking that is Indonesia, Malaysia, Singapore, Thailand, the Philippines and Vietnam for the period 2003 to 2008. The study applied the SFA to estimate bank cost efficiency and a three-stage least square (3SLS) method to estimate the interrelationship between bank cost efficiency, capital and risk-taking. The result for ASEAN banks‟ mean cost efficiency was 87.4 percent. On the interrelationship between bank‟s cost efficiency, capital and risk-taking, the study found that bank cost efficiency determines the capital position and risk-taking while banks‟ capital position and risk-taking determine bank cost efficiency. The study indicated that, bank cost efficiency is the foundation for banks‟ capital position and risk-taking.

To the best of knowledge of the researcher, no study has been made that investigate the interrelationship between cost efficiency, risk-taking and capital in Ethiopian commercial banks.

Chapter three: Methodological framework

The purpose of this chapter is to present the research problem, objectives, hypotheses and methodology adopted by the study. The chapter is outlined as follow: section 3.1 presents research problem and broad objectives of the study. This is followed by research hypotheses on capital-risk-efficiency interrelationship as presented under section 3.2. Next, capital-risk-efficiency interrelationship measurement model is explained in section 3.3. Then, variables description, data source and sample selected have been explained in section 3.4. Finally, cost efficiency measurement concept, measurement model and input/output determination and variable description have been explained in section 3.5.

3.1 Research problems and broad objectives

Since the downfall of the Derg regime, Ethiopia has been taking various financial sector liberalization measures as a result the number of private commercial banks have rapidly increased, the state owned commercial banks conducted various reforms and the competitions among banks especially in mobilizing deposits and in providing efficient service have increased from time to time. This process has increased the emphasis on the importance of cost efficiency in the banking sector. At the same time, this increase in the involvement of private owners and consequently increase in competition may lead to greater risk-taking.

The regulator has tried to counterbalance these possible incentives by giving capital adequacy a more prominent role in the prudential regulatory process. Therefore, promoting bank safety and soundness rests on identifying the underlying relationship between bank efficiency, risk-taking behaviour and capital adequacy is utmost important.

Hence, the main objectives of this study, as mentioned in chapter one, are twofold: The first objective is to identify the cost efficiency level of Ethiopian commercial banks, the variation level among state and private ownership and provide justifications for the variations in cost efficiency among the two ownership groups. Then, the second objective is to assess the relationship between cost efficiency, credit risk-taking and capital based on the notion of causality.

3.2 Cost efficiency measurement

3.2.1 Cost efficiency measurement concept

The proxy for credit risk and capital adequacy ratio is directly constructed from the annual financial statements of commercial banks and the regulatory data obtained from National Bank of Ethiopia. However, the cost efficiency ratio is separately estimated using stochastic frontier analysis.

The concepts of economic efficiency correspond to two specific micro-economic objectives: minimization of costs and maximization of profits. The indicator of efficiency aims to measure the degree of achievement of these objectives by comparing the observed costs and profits of each firm with the optimum figures (potential minimum costs or potential maximum profits) that it could have obtained.

The efficiency analysis has traditionally been approached by means of simple accounting ratios. Currently, however, the use of accounting ratios is being replaced by another type of efficiency indicators which, unlike accounting ratios, insulate from the effects of different factors like sector, size, specialization and economic environment on efficiency (Pastor and Serrano, 2000). The measurement of relative efficiency where there are multiple possibly incommensurate inputs and outputs was addressed by Farrell (1957). He laid the foundation to measure efficiency and productivity studies at the micro level.

Farell proposed efficiency consists of two components: technical efficiency and allocative efficiency. The former reflects the ability of a Decision Making Unit (DMU) to minimize input use as to produce a given amount of output. The latter reflects the ability of a DMU to use inputs in optimal proportions, given their respective prices and the production technology together; these two measures represent a total efficiency measure (Coelli et al., 1997).

The other efficiency type having similar context with the concept of Farell is X-efficiency. It is an intra-firm inefficiency or the deviation from the production efficient frontier, which depicts the maximum attainable output for a given level of input. This inefficiency can arise from the differences in managerial ability to control cost and/or maximize profits Harvey Leibenstin (1966). Berger et al (1993) describe X-inefficiency, as a variance from the efficient frontiers set by the best practice or benchmark firm. It incorporates two components, those technical and

allocative inefficiencies. According to Farrell (1957) technical inefficiency occurs due to sub optimal usage of input leading to waste, while allocative inefficiencies arise from inappropriate mix or composition of inputs using inefficient business process. Both inefficiencies are attributed to employee, management or environment factors.

There appear numerous studies which aim to analyze the efficiency of Banks using various techniques. The most commonly used techniques are classified broadly into nonparametric and parametric frontier analysis techniques excluding the traditional financial ratio measures. The nonparametric frontier analysis approach mainly includes Data Envelopment Analysis (DEA) and Free Disposal Hull (FDH). According to Berger and Humphrey (1997), DEA is a deterministic technique, and therefore does not make the separation, assuming that any deviation of observed profits from the maximum is due exclusively to inefficiency. The FDH is a special case of the DEA model where the points on lines connecting the DEA vertices are not included in the frontier. Instead, the FDH production possibilities set is composed only of the DEA vertices and the FDH points interior to these vertices (Berger and Humphrey, 1997).

The parametric frontier analysis approach mainly includes the stochastic frontier analysis (SFA) and the thick frontier approach (TFA). According to Berger and Humphrey (1997), SFA - sometimes also referred to as the econometric frontier approach - posits a composed error model where inefficiencies are assumed to follow an asymmetric distribution, usually the half-normal, while random errors follow a symmetric distribution, usually the standard normal. The TFA specifies a functional form and assumes that deviations from predicted performance values within the highest and lowest performance quartiles of observation represent random error, while deviations in predicted performance between the highest and lowest quartiles represent inefficiencies (Berger and Humphrey, 1997).

This paper uses the SFA method which is widely used to estimate individual efficiency scores due to its ability to disentangle the random variability (noise) from the inefficiency score. SFA is based on the pioneering work of Aigner et al. (1977) and Meeusen and van de Broeck (1977). Kumbhakar and Lovell (2003) provide a comprehensive overview. The basic idea is the introduction of an additive error term consisting of a noise and an inefficiency term. For the error as well as the inefficiency term distributional assumptions are made. Most often the half normal assumption is applied, but the exponential, truncated normal and gamma cases are also discussed

in specific literature. While the two-parameter distributions – the truncated normal and the gamma – potentially increase the flexibility of the model, in practical applications problems of identification seem to outweigh the potential gains for either distribution (Greene, 1997; and Ritter and Simar, 1997).

3.2.2 Cost efficiency measurement model

In order to estimate the efficiency levels of Ethiopian commercial banks, we assume that the inefficiency term, U_{it}, which represent the departure from the efficient frontier follows a non-negative half-normal distribution (since inefficiency can only have positive value), while V_{it}, the random fluctuations are distributed as two-sided normal with a zero mean and constant variance. While this basic idea behind the stochastic frontier has been extended in a number of ways, we use the approach provided by Battese and Coelli (1995) which is easily amenable to panel data analysis. The primary reason for using this methodology is that the estimation of this model is simple because of its availability in the FRONTIER (Version 4.1) software developed by Coelli (1996).

The Battese and Coelli (1995) model assumes that V_{it} are random variables which are assumed to be iid N(0, σ_v^2) and independent of the U_i, which are non-negative random variables which are assumed to account for technical inefficiency in production and are assumed to be independently distributed as truncations at zero of the N(μ_{it}, σ_u^2) distribution; where μ_{it} is a function of factors representing the firm specific environment: $\mu_{it} = Z_{it}\delta$. While z_{it} is an lxp vector of variables which may influence the (in)efficiency of a firm, δ is a pxl vector of parameters to be estimated. The model is:

$$Ln\ TC_{it} = X_{it}\beta + (V_{it} + U_{it}) \quad \text{.......................} \quad (Eq.\ 1)$$

The parameterization from Battese and Corra (1977) is used replacing σ_v^2 and σ_u^2 with $\sigma_s^2 = \sigma_v^2 + \sigma_u^2$. The parameters are estimated by Maximum Likelihood approach. The log likelihood function of this model is given in Battese and Coelli (1995).

The study employs the translog (transcendental logarithm) functional form to estimate the cost efficiency of individual banks in the sample. The translog functional form, due originally to Christensen, Jorgenson and Lau (1971), has several advantages: 1) it accommodates multiple outputs without necessarily violating curvature conditions; 2) it is flexible, providing a second-

order approximation to any well-behaved underlying cost frontier at the mean of the data; and, 3) it forms the basis of much of the empirical estimation and decomposition of cost efficiency based on a system of equations. The cost frontier function is represented by the following quadratic equation:

$$lnTC_{it} = \alpha_0 + \sum_{i=1}^{3} \alpha_i \ln y_i + \sum_{j=1}^{3} \beta_j \ln w_j + \tau_i lnE + b_i t + \frac{1}{2}\left[\sum_{i=1}^{3}\sum_{j=1}^{3} \delta_{ij} \ln y_i \ln y_j + \sum_{i=1}^{3}\sum_{j=1}^{3} \gamma_{ij} \ln w_i \ln w_j + \tau_{ij} lnE^2 + b_{ij} t^2\right] + \sum_{i=1}^{3}\sum_{j=1}^{3} \rho_{ij} \ln y_i \ln w_j + \sum_{i=1}^{3} \varphi_{ij} ln\, y_i lnE + \sum_{i=1}^{3} \varphi_{ij} ln\, y_i t + \sum_{j=1}^{3} \theta_j ln\, w_j lnE + \sum_{j=1}^{3} \theta_j ln\, w_j t + u_{it} + v_{it} \quad \text{(Eq.2)}$$

Where ***TC*** is the logarithm of the cost of production, y_i ($i = 1, 2, 3$) are output quantities, w_j ($j = 1, 2, 3$) are input prices, ***lnE*** is the natural logarithm of total equity capital, ***t*** is the time trend, u_{it} are the cost inefficiency components. Standard restrictions have been imposed in order to guarantee symmetry and linear homogeneity in input prices in estimating the parameters of equation (5) as follows:

- To impose restriction on symmetry: $\delta_{ij} = \delta_{ji}$ and $\gamma_{ij} = \gamma_{ji}$;
- To impose linear homogeneity: $\sum_{j=1}^{3} \beta_j = 1, \sum_{i=1}^{3} \gamma_{ij} = 0, \sum_{j=1}^{3} \rho_{ij} = 0, \sum_{j=1}^{3} \theta_j = 0.$

Cost and input prices are normalized by the prices of capital before taking logarithms to impose linear input price homogeneity.

3.2.3 Input, output and variable description

A widely debated issue in banking literature is the definition of banking inputs and outputs, and more specifically the classification of deposits in this respect. More specifically, commercial banking is a very difficult service industry in which to measure output, technical change, or productivity growth. First, there is disagreement over which services banks produce and over how to measure them. In addition, banking services are often priced implicitly through below-market interest rates on deposit balances, making observed revenue flows inaccurate guides to choosing the important outputs to include in the analysis. Banking also remains a highly regulated industry in which substantial inefficiencies have been shown to exist. As a result, technical improvements

that increase the productivity of the most efficient firms may not be well reflected in the industry as a whole. A further complication is that the deposit side of banking underwent substantial deregulation, including the lifting of effective interest rate ceilings on certain deposits and the creation of new types of accounts. The deregulation directly raised banking costs and shifted the optimal mix between the provision of services and the payment of interest to depositors. Measurement of cost changes and productivity gains must take these factors into account, including the possibility of a period of significant disequilibrium as banks attempted to adjust to deposit deregulation.

There is long-standing disagreement over exactly what it is that banks produce. Three alternative methods of choosing bank outputs are analyzed here, the asset, user cost, and value-added approaches.

Under the asset approach, banks are considered only as financial intermediaries between liability holders and those who receive bank funds. Loans and other assets are considered to be bank outputs; deposits and other liabilities are inputs to the intermediation process (Sealey and Lindley 1977).

The user cost approach determines whether a financial product is an input or an output on the basis of its net contribution to bank revenue. If the financial returns on an asset exceed the opportunity cost of funds or if the financial costs of a liability are less than the opportunity cost, then the instrument is considered to be a financial output. Otherwise, it is considered to be a financial input (Hancock 1985).

The value-added approach differs from the asset and user cost approaches in that it considers all liability and asset categories to have some output characteristics rather than distinguishing inputs from outputs in a mutually exclusive way. The categories having substantial value added, as judged using an external source of operating cost allocations, are employed as the important outputs. Others are treated as representing mainly either unimportant outputs, intermediate products, or inputs, depending on the specifics of the category.

The value added approach is originally proposed by Berger and Humphrey (1992) and recently applied in various cost studies of the banking industry (e.g., Fiordelisi, Marques-Ibanez and Molyneux, 2010) which identifies the major categories of produced deposits (demand, time and

savings) and loans (real estate, commercial, installment) as important outputs, because they are responsible for the great majority of value added. Purchased funds (federal funds purchased, large CDs, foreign deposits, other liabilities for borrowed money) are treated as financial inputs to the intermediation process, because they require very small amounts of physical inputs (labor and capital). On the asset side, government securities and other nonloan investments are considered to be unimportant outputs, because their value added requirements are also very low.

In this study the value added approach is used to define inputs and outputs of commercial banks. We posit that labour, financial capital and physical capital are inputs, where as total loans and advances (y_1), total deposits (y_2), and other earning assets (y_3) are outputs. Input prices are obtained as total personnel expenses over total assets (w_1), total interest expenses over total funds (w_2), and total depreciation and other non-interest expenses (general expense) over fixed assets (w_3). Variables included in the Z vector of the inefficiency equation are time, dummy variable for ownership group, an indicator of size and GDP. This selection of inputs and outputs follows the studies by Sathye (2001) and Dietsch and Lonzano (2000), Aly et al. (1990) and Hancock (1986), wherein the author develops a methodology based on user costs to determine the outputs and inputs of a banking firm. Variables included in the z vector of the inefficiency equation are indicator of size (logarithm of total asset) and two group dummies for ownership (public and private). The data is taken from annual financial statements of commercial banks published on their website and National Bank of Ethiopia for the period 2002 to 2014.

Table 1: Summary and description of input, output and price variables

Variables	***Symbol***	***Description***	***Sources***
Total Cost	*TC*	Sum of cost of human resources (employees‟ salary and benefit), cost of funds (interest expense), and cost of physical capital (depreciation and other non-interest and non-personnel expenses – general expense)	Commercial banks‟ audited annual financial statement
Output Quantity			
• Loans and advances	Y_1	Total loans and advances	Commercial banks‟ audited annual financial statement

Variables	*Symbol*	*Description*	*Sources*
• Total deposit	Y_2	Sum of demand, saving and time deposit	Commercial banks‟ audited annual financial statement
• Other earning assets	Y_3	Sum of investments in securities, shares and foreign currency reserves/deposits	Commercial banks‟ audited annual financial statement
Input Price			
• Price of labor	W_1	Cost of human resources over total assets	Commercial banks‟ audited annual financial statement
• Price of fund	W_2	Interest expense over total funds on which interest has paid	Commercial banks‟ audited annual financial statement
• Price of physical capital	W_3	Depreciation and other non-interest and non-personnel expenses (general expenses) over total fixed assets	Commercial banks‟ audited annual financial statement
Determinants			
• Bank size	*BS*	Natural logarithm of total assets	Commercial banks‟ audited annual financial statement
• Bank ownership	*BO*	Dummy variable, if the bank is state owned one, otherwise zero	
• GDP	*GDP*	Real growth rate of gross domestic production	NBE annual bulletin
• Time	*t*	Time trend	

3.3 Capital, risk and efficiency interrelationship measurement Model

Granger-Causality techniques were applied to investigate the interrelationship between cost efficiency, credit risk-taking, and capital adequacy as this approach allows to test unique time-ordered and signed relationships among pairs of variables (Granger, 1969). Granger‟s notion of causality states that y_t is causing x_t if we are better able to predict x_t using all available information than if the information apart from y_t had been used. Granger‟s suggestion to regress x_t on its own lags and a set of lagged y_t has become a standard procedure. If lagged y_t provides a statistically significant explanation of x_t, y_t "Granger" causes x_t. While Granger-Causality tests

have a number of limitations (for example, Granger-testing does not prove economic causation between two variables but identifies gross statistical associations) this approach has been widely used to analyze inter-temporal relationships in the economic literature (e.g. Jaeger and Paserman 2008, Assenmacher-Wesche and Gerlach 2008, Amato and Swanson 2001 and Bajo-Rubio et al., 2001) as well as in banking studies (e.g. Fiordelisi and Molyneux 2010, Casu and Girardone 2009, Beccalli 2007, Williams, 2004, Levine et al., 2000, Berger and DeYoung, 1997).

In order to disentangle the inter-temporal relationships between bank capital, cost efficiency and credit risk-taking the study estimates the following equations which were used by Fiordelisi et al. (2010).

$$CEff_{i,t} = f_1 (CRisk_{i,lag}, CEff_{i,lag}, BCad_{i,lag}, Z_{i,t}) + \varepsilon_{i,t} \quad \text{..... (Eq. 3)}$$

$$CRisk_{i,t} = f_1 (CRisk_{i,lag}, CEff_{i,lag}, BCad_{i,lag}, Z_{i,t}) + \varepsilon_{i,t} \quad \text{..... (Eq. 4)}$$

$$BCad_{i,t} = f_1 (CRisk_{i,lag}, CEff_{i,lag}, BCad_{i,lag}, Z_{i,t}) + \varepsilon_{i,t} \quad \text{..... (Eq. 5)}$$

Where the *i* subscript denotes the cross-sectional dimension across banks, *t* denotes the time dimension, CEff is the cost efficiency score, and CRisk is the variable accounting for bank‟s credit risk. BCad is the capital adequacy ratio while Z (*j = 1,…,4*) are control variables including factors influencing the efficiency-capital-risk relationship and ε is the random error term. The variable definitions are summarized in Table-2.

Table-2*: Cost efficiency, credit risk and capital variables description*

Variables	***Symbol***	***Description***	***Sources***
Cost Efficiency	CEff	Estimated using Stochastic Frontier Analysis techniques.	Estimation result from the model specified in the previous section
Credit Risk-Taking	CRisk	Non-performing loans over the gross value of total bank loans.	Commercial banks‟ audited annual financial statement
Bank Capital Adequacy	BCad	Value of total equity divided by total assets. Equity capital is measured focusing on the Basel Committee definition of capital by	Commercial banks‟ audited annual financial statement

Variables	*Symbol*	*Description*	*Sources*
		summing total equity, retained earnings, general banking risk reserves, other equity reserves, hybrid capital instruments and subordinated debts.	
Income diversification	ID	Net non-interest income to net operating income	Commercial banks‟ audited annual financial statement
Bank Size	BS	Bank asset size is the logarithm of the Birr value of banks‟ total assets.	Commercial banks‟ audited annual financial statement
Bank Ownership	BO	Dummy variable, if the bank is state owned one, otherwise zero	
Return on Asset	ROA	Income before tax over total assets	Commercial banks‟ audited annual financial statement
Year	Year	Set of dummy variable for each period	

Equation (1) tests if cost efficiency changes temporally precede variations in bank credit risk. Equation (2) assess if changes in bank credit risk temporally precede variations in cost efficiency and equation (3) considers whether bank capital levels temporally precede changes in risk.

We use four lags and estimate an *AR(4)* process for the risk, capital and efficiency variables. Following Casu and Girardone (2009), Granger causality is assessed as the joint test of the null hypothesis that the four lags are equal to zero. With the *AR(4)* process, we analyze Granger causality as the joint test that the four lags of each of the determinants is distributed as a chi-quare (X^2) with two degrees of freedom. If the probability is less than 10%, then the null hypothesis that *x* does not Granger-cause y is rejected at the 10% significance level.

Various studies which use Granger causality test apply OLS regression (e.g. Berger and DeYoung, 1997; Williams, 2004). However, various problems arise in the estimation of such a model. Because of the introduction of a lagged dependant variable among the predictors creates complications in the estimation as the lagged dependant variable is correlated with the disturbance (even under the assumption that $\varepsilon_{i,t}$ is not itself correlated). More recently, to tackle

this problem dynamic panel estimators have been applied (e.g. Casu and Girardone, 2009). Therefore, we use the system Generalized Method of Moments (GMM) estimators developed for dynamic panel models by Arellano and Bover (1995) and Blundell and Bond (1998).

3.4 Variable description and data

The first dependant variable in our model is nonperforming loan (CRisk) as a proxy for credit risk level of commercial banks. As bank credit risk is a crucial measure in our analysis, we try to capture using the traditional nonperforming loans to total asset ratio. Nonperforming loan ratio is the most commonly agreed-upon definition of credit risks in both the research literature, regulators requirement and the trade press, and has the benefit of being subject to less managerial discretion than are other measures on loan quality, such as loan loss provisions and charge-offs. According to Berger and DeYoung (1997), nonperforming loan is difficult to manipulate by managers because loans must be reported as nonperforming if the borrower is past due at least 90 days. Nevertheless, manipulation of nonperforming could take place by lending the borrower additional funds to make payments so that the loan does not become past due 90 days. To the extent that banks delay reporting nonperforming loans, the effects may still be captured in our lagged coefficients.

The second dependant variable is cost efficiency (CEff) as a proxy for bank efficiency level. We estimate cost efficiency using the stochastic frontier approach and the value addition approach for the input and output determination (details of the methodology used to estimate the efficiency level of individual banks are outlined in the section 3.5 this report). Cost efficiency measures the short-term cost efficiency of banks relative to its peers, or how close the bank is to the estimated industry-wide best-practice cost frontier.

The third dependant variable is bank capital adequacy (BCad) which measured as the equity to total assets ratio, i.e. the value of total equity divided by the value of total assets. Equity capital is measured focusing on the Basel Committee definition of bank capital by summing the Tier-I (i.e. total equity, retained earnings and other disclosed equity reserves) and Tier-II (i.e. undisclosed equity reserves, general provisions, hybrid capital instruments, and subordinated debts) components of capital. By focusing on a wider definition of banks‟ equity, we aim to consider supplementary items that are commonly used by banks to increase their capital on top of

traditional equity. This measure is able to capture better the concept of bank capital dadequacy (and management) than the book value of equity (Santos, 1999, Diamond and Rajan, 2000).

The right-hand-side variables (the independent variables) in equations one to three includes lagged values of the dependent variables CRisk, BEff, and CAD, as is standard procedure for Granger-causality models. That is, we attempt to determine whether variable y_i Granger-causes variable y_j by testing whether the past history of y_i adds information in predicting y_j, after taking into account the past history of all the other y's.

A number of control variables are added to all three equations that may influence the relationship between capital, risk and efficiency. Specifically, we include the following variables: 1) bank income diversification (ID, i.e. the ratio between net non-interest income and net operating income ratio). According to Lepetit et. al. (2008), banks expanding into non-interest income activities present higher risk and higher insolvency risk than banks which mainly supply loans; 2) banks‟ asset size (i.e. natural logarithm of total asset); 3) Bank ownership dummy variable to control the impact on state ownership; 4) financial performance or return on assets; and 5) Year, a set of dummy variables for each year of the data (excluding a base year), which accounts for changes in the macro-economy, the regulatory treatment of banks over time as well as changes in technology.

Turning to our sample, we focused on commercial banks operating in Ethiopia between 2000 and 2014. We focus on commercial banks as their behaviour, incentives and competitive environment differ from other types of banks (e.g. Development Bank of Ethiopia). The data is obtained from individual bank‟s audited financial statements and from National Bank of Ethiopia. Our final sample comprises eight commercial banks and fifteen years with a total of 120 bank observations.

3.1 Research hypothesis on cost efficiency, credit risk and capital interrelationship

Before introducing the empirical model and building on previous studies, we posit the major research hypotheses about the inter-temporal relationship between bank risk-taking, capital and cost efficiency building on Berger and DeYoung (1997) and Kwan and Eisenbeis 1997.

Banks‟ cost efficiency levels may impact on future bank risk-taking. In what Berger and DeYoung (1997), and Williams (2004) labeled as the **"*bad management*"** hypothesis, banks operating with low levels of cost efficiency have higher costs largely due to inadequate credit

monitoring and inefficient control of operating expenses (which is reflected in lower cost efficiency almost immediately). Declines in cost efficiency will temporally precede increases in banks‟ risk due to credit, operational, market and reputational problems.

The ***"cost skimping"*** hypothesis assumes that there is a trade-off between short-term cost efficiency and future risk-taking due to moral hazard considerations. In such cases, banks appear to be more cost efficient as they devote fewer resources to credit screening and monitoring. As a result the stock of non-performing loans remains unaffected in the short run. In the medium term however, banks reach higher risk levels as they have to purchase the additional inputs necessary to administer future higher risks. This will also normally result in higher future risks. In other words, a bank may be tempted to increase revenues simply by taking on higher risks to compensate for lost returns.

The ***"luck"*** hypothesis is related to the consequences of increases/decrease in bank risk on efficiency levels. It argues that external exogenous events (positive or negative economic environment or regulatory pressure) can precipitate increases/decrease in problem loans for the bank unrelated to managers‟ skills or their risk-taking appetite. These increases in risk-taking result in additional costs and managerial effort. Thus, under this hypothesis, we expect increases/decrease in bank risk-taking to precede decrease/increase in cost efficiency.

The ***"moral hazard"*** hypothesis suggests a negative causal relationship between capital and risk-taking pointing out that bank managers have incentives to take on more risk particularly when the level of bank capital is low (or banks are more inefficient). The moral hazard hypothesis could arise in the presence of informational frictions and the existence of relevant "agency problems" between bank managers and owners (Gorton and Rosen, 1995). A traditional moral hazard problem occurred when managers take-on risks that are borne entirely by the shareholders. Better capitalized banks, in contrast, have less moral hazard incentives (Jeitschko and Jeung, 2005) and are more prone to adopt careful practices to reduce costs (e.g. shareholders may be more active in controlling bank costs or capital allocation). Regulators can also force banks to increase the amount of capital commensurably with the amount of risk taken (Gropp and Heider, 2010). As indicated by Hellman, Murdock and Stiglitz (2000), banks could also respond to regulatory actions forcing them to hold more capital by increasing portfolio risk.

Chapter four: Analysis and Result

In this chapter, detailed analysis about the descriptive and econometric results starting with presentation of the data is made. Descriptive analysis, cost efficiency maximum likelihood results, and system GMM results are discussed. Causality and other diagnostic tests are also presented.

4.1 Data presentation and descriptive analysis

This section presents the summary of data used in the study and provides statistical description of cost efficiency estimation variables, and credit risk-taking and capital adequacy variables. The description is important in providing an insight about the distribution of the data by bank ownership category as well as their averages and graphical descriptions are included.

4.1.1 Descriptive analysis of cost efficiency estimation variables

The measurement of cost efficiency basically requires data on the input and output variables. As explained in chapter-three, the study applied value added approach to define the inputs and outputs of commercial banks following the studies by Sathye (2001) and Dietsch and Lonzano (2000).

The study consider that, human resource, physical capital and financial capital are inputs, where as deposit, loans and advances and other earning assets are output. Input prices are obtained as total personnel expense over total assets (as price of labor), total depreciation and other capital expenses over total fixed assets (as price of physical assets) and interest expenses (as price of financial capital).

The study also includes some environmental variable to use them for modeling the inefficiency in order to reduce the heterogeneity in the data set, these are: log of total assets as proxy for bank size, ownership dummy variable and time. Hence, in the next three sub-sections the descriptive statistics of input, output and control variables including their corresponding prices are presented.

4.1.1.1 Input variables

4.1.1.1.1 Human resources

Commercial banks make use of human resources in delivering various financial products and services to their clients. As a result, expenditures on human resources are one of the costs of inputs that are considered by the study in measuring the cost efficiency of the commercial banks. Table 4.1 presents the total expenditure of commercial banks on human resource over the study period.

Table 4.1: Cost of human resource (in Millions of Birr)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
All Banks	132	164	192	206	253	294	365	455	604	765	992	1,266	1,765	2,515	3,618
State Owned Banks	103	122	140	144	175	189	202	237	312	352	468	609	940	1,429	2,153
	78%	74%	73%	70%	69%	64%	55%	52%	52%	46%	47%	48%	53%	57%	60%
Private Banks	29	42	52	62	78	105	163	218	291	413	524	657	825	1,086	1,465
	22%	26%	27%	30%	31%	36%	45%	48%	48%	54%	53%	52%	47%	43%	40%

Source: Own computation

The expenditure on human resources basically includes salaries, benefits and incentives for bank employees. As it is shown in Table 4.1, the expenditure incurred by all commercial banks on human resource has shown a steady increment over the study period. The expenditure has gone up from132 million Birr in 2000 to 3,618 million Birr in 2014. The steady increment in expenditure on human resources attribute to the increase in the number of employees due to expansion of branch network and increasing in the salary and benefit scale due to intense competition among the commercial banks to attract high caliber employees.

As far as expenditure on human resource by ownership type is concerned, Table 4.1 indicates that the amount of expenditure on human resources incurred can be classified into three periods. In the First Period (2000 to 2008), the state owned commercial banks is much higher than the amount incurred by the six large size private commercial banks. This is because during these periods, the private commercial banks had smaller number of branches and were also confined to limited areas as they were in their infant stage (private commercial banks in Ethiopia came into existence only after the financial reform that was introduced in 1994). For example, as shown on Table 4.1, 78 percent of the total expenditure on human resources in the year 2000 is incurred by

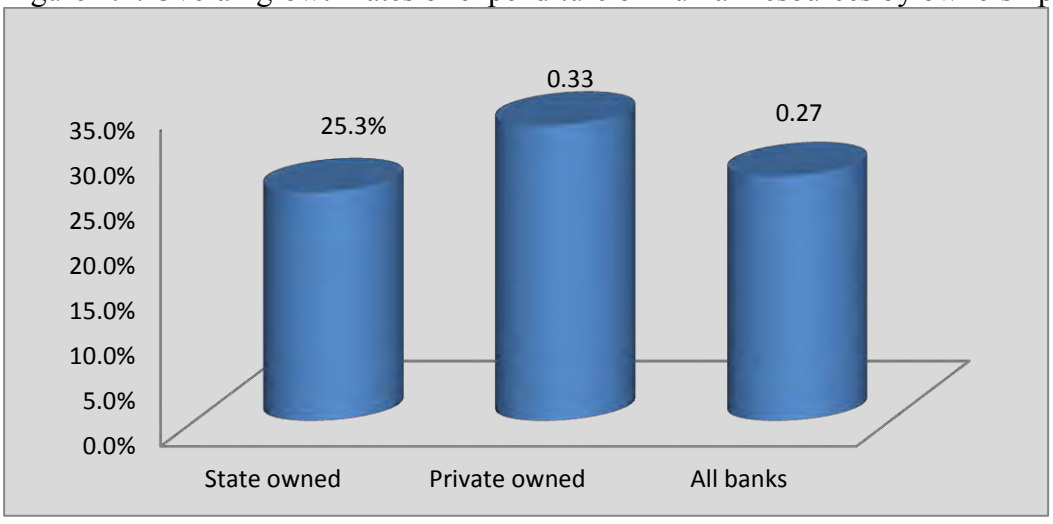
the state owned commercial banks while the 22 percent was incurred by the private commercial banks.

During the second period (2009 to 2011), expenditure on human resources by the private commercial banks precedes the amount incurred by the state owned commercial banks. For example, by the end of 2009, 54 percent of the total expenditure on labor is incurred by the six private commercial banks while 46 percent is incurred by the state owned commercial banks. This may be due to branch expansion of the private commercial banks and better pay rate than the state owned commercial banks during these periods.

During the late period of the study (2012 to 2014), the expenditure on human resources by state owned commercial banks once again precede the amount incurred by the six private commercial banks. This is because during these years, the state owned commercial banks especially Commercial Bank of Ethiopia"s aggressive branch expansion and improvements of employees" salary and benefit.

Figure 4.1 shows the overall average growth rates of expenditure on human resource over the period under study. On average the expenditure on human resource by the state owned commercial banks has grown at the rate 33 percent while the private commercial banks has grown at the rate 25 percent over the study period. Overall, expenditure on human resource by Ethiopian commercial banks has grown at the rate of 27 percent over the study period.

Figure 4.1: Overall growth rates of expenditure on human resources by ownership



Source: Own computation

4.1.1.1.2 Physical capital

Fixed assets of banks include buildings and their premises as well as various equipment and machinery, reported at the banks‟ year end book value, that the commercial banks make use of in providing financial services to their clients. The fixed assets of the commercial banks over the period under study are presented in Table 4.2.

Table 4.2: Cost of physical capital (Fixed assets) of the banks (in Millions of Birr)

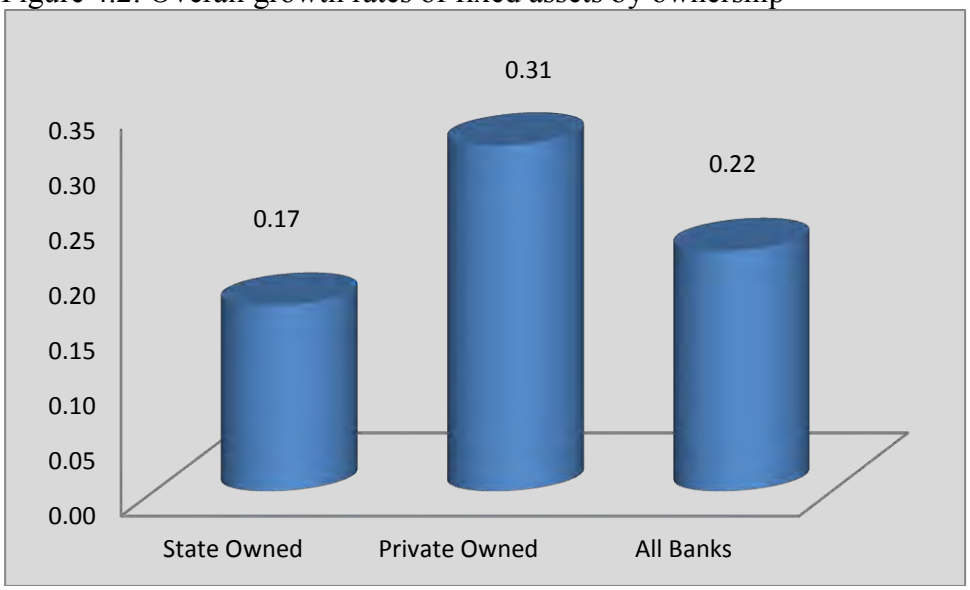
Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
All Banks	342	347	365	370	462	460	526	627	758	940	1,347	1,622	2,230	2,730	4,649
State Owned Banks	278	269	265	244	298	262	268	282	350	449	679	834	1,043	1,226	1,981
	81%	78%	73%	66%	65%	57%	51%	45%	46%	48%	50%	51%	47%	45%	43%
Private Banks	64	78	100	126	164	198	258	345	408	491	668	788	1,187	1,504	2,668
	19%	22%	27%	34%	35%	43%	49%	55%	54%	52%	50%	49%	53%	55%	57%

Source: Own computation

The fixed assets of the commercial banks have also witnessed an increment each year over the study period. In absolute terms, the book value of the fixed assets of the commercial banks has grown up from 342 million Birr in 2000 to about 4,649 million Birr. The increase in the fixed assets of the commercial banks has come from both the increase in fixed assets of the state owned and the private commercial banks. The fixed assets of the state owned commercial banks have increased from 278 million Birr in 2000 to 1,981 million Birr in 2014. And, the fixed assets of the private commercial banks have moved up from 64 million Birr in 2000 to 2,668 million Birr in 2014. The major reason for this increase in fixed assets may be the investment that banks have made to automate their business process and to expand their branch network.

Figure 4.2 shows the overall average growth rates of fixed assets of Ethiopian commercial banks over the study period. On average the fixed assets of the studied commercial banks have grown at the rate of 22 percent over the study period. On average the fixed assets of private commercial banks have grown at the rate of 31 percent while that of the state owned commercial banks have grown at the rate of 17 percent.

Figure 4.2: Overall growth rates of fixed assets by ownership



Source: Own computation

4.1.1.1.3 Financial capital

Financial assets are one of the inputs that are considered by the study in measuring the cost efficiency of the commercial banks. Commercial banks make use of customer deposits and other source of funds in delivering various financial products and services to their clients. Interest expenses are used as the cost of financial assets in the study.

Table 4.3: Cost of financial capital (Interest expenses) of the banks (in Millions of Birr)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
All Banks	498	582	566	391	432	495	607	730	1,155	1,340	1,605	2,259	3,177	4,168	5,685
State Owned Banks	424	468	431	274	288	313	354	378	578	662	805	1,197	1,783	2,503	3,581
	85%	80%	76%	70%	67%	63%	58%	52%	50%	49%	50%	53%	56%	60%	63%
Private Banks	74	114	135	117	144	182	253	352	576	678	800	1,063	1,394	1,666	2,103
	15%	20%	24%	30%	33%	37%	42%	48%	50%	51%	50%	47%	44%	40%	37%

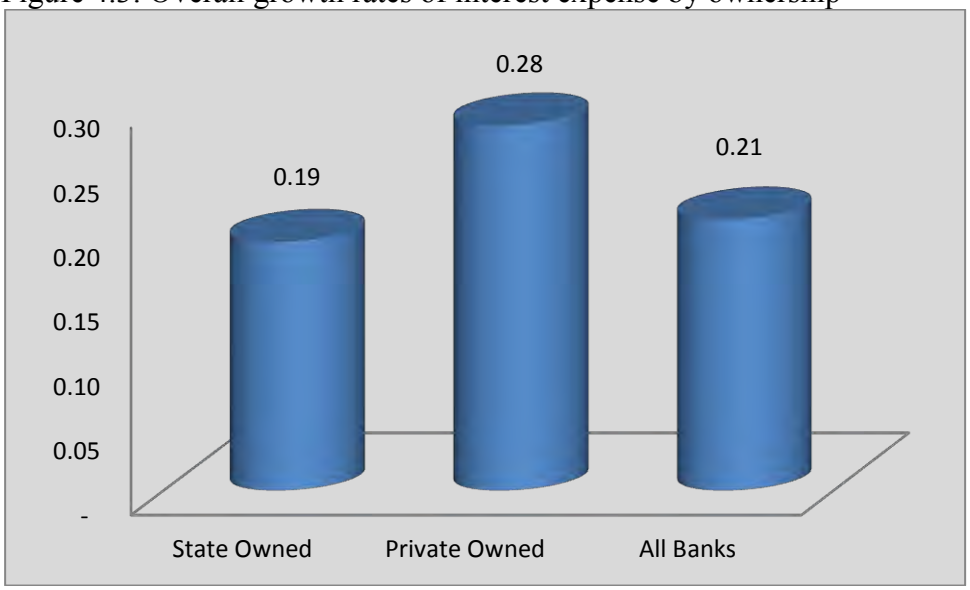
Source: Own computation

Table 4.3 contains information with regard to the total expenditure incurred by Ethiopian commercial banks on financial assets. The interest expenses (cost of financial capital) of commercial banks have witnessed an increment each year over the study period except some reduction in the period 2002 to 2003. In absolute term, the interest expenditures of commercial banks grow up from 498 million Birr in 2000 to about 5,685 million Birr in 2014. The increase in

the interest expenditures of commercial banks is due to increase in the volume of customers" deposit and nominal interest rate. The interest expenses of state owned commercial banks have increased from 424 million Birr in 2000 to 3,581 million Birr in 2014. Similarly, the interest expenses of private commercial banks have increased from 74 million Birr in 2000 to 2,103 million Birr in 2014.

Figure 4.3 presents the overall average growth rate of interest expenses of Ethiopian commercial banks over the study period. On average the interest expenses of all Ethiopian commercial banks have grown at the rate of 21 percent over the study period. On average the interest expenses of private commercial banks have grown at the rate of 28 percent while that of the state owned commercial banks have grown at the rate of 19 percent.

Figure 4.3: Overall growth rates of interest expense by ownership



Source: Own computation

4.1.1.2 Output variables

To measure the cost efficiency of the commercial banks, the study use three output variables in addition to the input variables described in the previous section. The output variables include net loans and advances, total deposit and other earning assets. The value of the outputs variables and their growth rates over the entire period of the study are discussed in the following subsections.

4.1.1.2.1 Loans and advances

Loans and advances are the primary sources of assets for commercial banks. Commercial banks in Ethiopia play an important role in supporting trade, investment, commerce and the overall development related works by providing loans and advances to the various sectors of the country‟s economy. The banking business proclamation No. 592/2008 of Ethiopia defines loans or advances as any financial assets of a bank that emanates from an obligation to advance funds by a bank to a person that is required to repay the funds and the interest accrued thereof either on a specified date or dates or on demand. Loans or advances of a bank also include any financial assets of a bank that arises from indirect advances such as unplanned overdrafts, participation in loan syndication and the purchase of loans from another lender.

Table 4.4 shows the total loans and advances extended by the Ethiopian commercial banking sector over the study period. The total amount of loans and advances extended by the commercial banks ranges between 13,074 million Birr in 2000 and 130,388 million Birr in 2014. The total amount of loans and advances extended by the commercial banks has steadily increased all over the study period except in 2002 and 2003. The decline in the amount of loans and advances in 2002 and 2003 may attribute to the poor performance of the country‟s economy during these periods. The country‟s economy recorded a slow growth of 1.6 in 2002 and negative growth of -2.1 in 2003 (NBE 4th Quarter Bulletin, 2013/14). Various studies also confirmed the existence of correlation between commercial bank credit and economic growth. For example, Avinash R. et al (2009) assess the causal relationship between commercial bank credit and economic growth in Trinidad and Tobago for the period 1970 to 2008 and found that overall, credit and growth demonstrate a „demand following‟ relationship. During the period 2000 to 2007, the share of the private commercial banks has increased though the state owned commercial banks are still having the higher share except in 2006 and 2007 in which the private commercial banks share have exceeded the share of the state owned commercial banks. However, during the period 2008 to 2014 the share of the state owned commercial banks have continued exceeding the share of the private commercial banks. For example, in 2014 the share of the state owned commercial banks have account 71 percent, while the share of the private owned commercial banks are 29 percent.

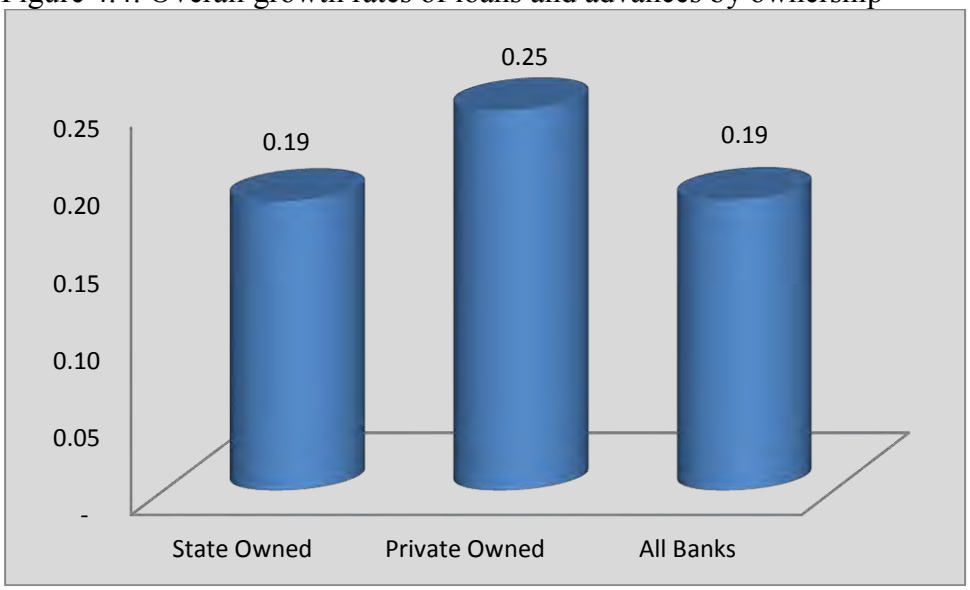
Table 4.4: Loans and advances extended by banks (in Millions of Birr)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
All Banks	13,074	14,119	13,543	13,547	14,564	17,897	21,546	25,275	34,983	38,837	44,747	60,181	93,003	107,960	130,388
State Owned Banks	11,163	11,469	10,472	9,260	9,058	10,413	10,475	11,088	18,726	22,479	25,766	37,708	64,118	73,337	91,998
	85%	81%	77%	68%	62%	58%	49%	44%	54%	58%	58%	63%	69%	68%	71%
Private Banks	1,911	2,650	3,071	4,287	5,506	7,484	11,071	14,187	16,257	16,358	18,981	22,473	28,886	34,623	38,390
	15%	19%	23%	32%	38%	42%	51%	56%	46%	42%	42%	37%	31%	32%	29%

Source: Own computation

Figure 4.4 indicates the overall average growth rates of loans and advances. The overall average growth rate of loans and advances by the Ethiopian commercial banks over the study period is 19 percent. The average growth rate of loans and advances extended by the private commercial banks is much higher than the state owned commercial banks. The loans and advances extended by the private commercial banks on average have grown at the rate of 25 percent over the entire period of study, while the corresponding figure for the state owned commercial banks is 19 percent.

Figure 4.4: Overall growth rates of loans and advances by ownership



Source: Own computation

4.1.1.2.2 Deposits

Basically commercial banks need funds to finance their intimidation operation. Banks could solicit funds from different sources to meet their operational requirements. In Ethiopia, deposits

are one of the main sources of funds for commercial banks. The deposits that Ethiopian commercial banks mobilize take three forms: Demand, saving and time deposits.

The total amount of deposits mobilized by the eight commercial banks over the study period is depicted in Table 4.5. The total amount of deposits mobilized by the sector has shown a sharp increment each year over the entire period under study. In absolute terms, the total amount of deposits mobilized by the commercial banks has increased from 18,423 million Birr in 2000 to 265,432 million Birr in 2014. The share of the private commercial banks in the total deposit has shown an annual increment each year until 2009, however after onwards the share of the private commercial banks have decreased. For example, from the period 2000 to 2009 the share of the private commercial banks has increased from 12 percent to 38 percent. However, from 2009 onwards their share has decreased and account 25 percent of the total deposit in 2014.

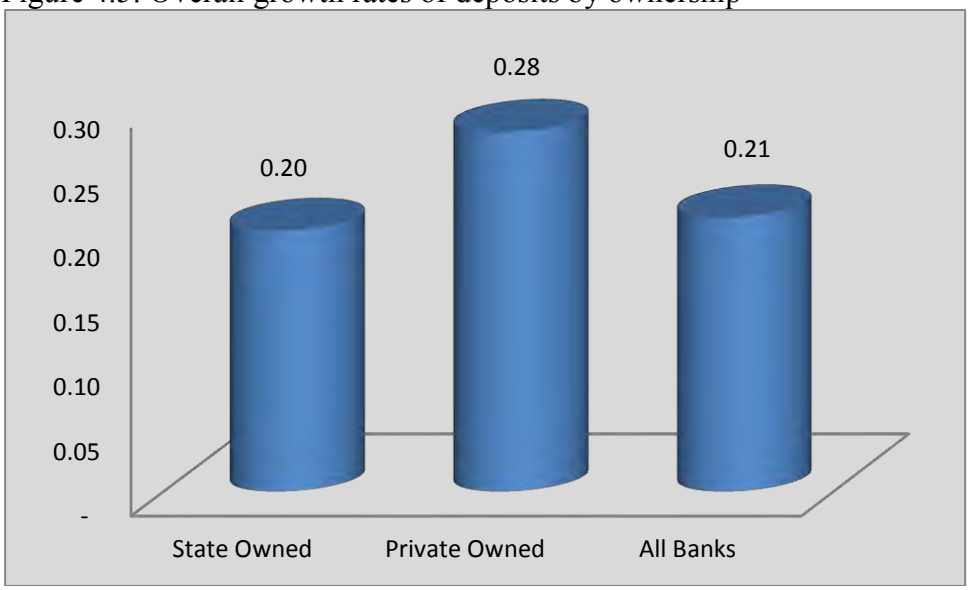
Table 4.5: Total deposit mobilized by banks (in Millions of Birr)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
All Banks	18,423	21,050	23,212	25,817	30,401	36,199	42,145	50,847	60,501	73,346	91,165	130,147	168,497	215,647	265,432
State Owned Banks	16,218	17,976	19,133	20,377	23,215	26,423	29,259	34,009	39,123	45,323	57,001	87,306	120,102	156,485	198,397
	88%	85%	82%	79%	76%	73%	69%	67%	65%	62%	63%	67%	71%	73%	75%
Private Banks	2,205	3,074	4,079	5,440	7,186	9,776	12,886	16,838	21,378	28,022	34,164	42,841	48,395	59,162	67,035
	12%	15%	18%	21%	24%	27%	31%	33%	35%	38%	37%	33%	29%	27%	25%

Source: Own computation

Figure 4.5 indicates the overall average growth rate of deposits mobilized by the banks. On average, the growth rate of the total deposits mobilized by the commercial banks over the study period is 21 percent. The overall average growth rate of deposits mobilized by the private commercial banks is far higher than the growth rate of the state owned commercial banks. On average deposits mobilized by the private banks has grown at the rate 28 percent while the corresponding figure for the state owned commercial banks is 20 percent.

Figure 4.5: Overall growth rates of deposits by ownership



Source: Own computation

4.1.1.2.3 Other earning assets

Commercial banks in Ethiopia employed their human resources, physical assets and financial assets not only to extend loans and advances and mobilize deposits; they also employed the inputs to invest in other earning assets. Other earning assets that Ethiopian commercial banks invest takes four forms: equity investment, investment in government securities, investment in corporate financial instruments and foreign exchange assets. Foreign exchange assets are included in other earning assets category due to its significant contribution in the financial performance of commercial banks by enabling them to get significant profit from international trade.

The total amount of other earning assets of commercial banks over the study period is shown in Table 4.6. The total amount of other earning assets has shown a sharp increment over the entire period under study except some fluctuation in year between 2003 and 2006. In absolute terms, the total amount of other earning assets has increased from 4,379 million Birr in 2000 to 156,404 million Birr in 2014. The sharp increase in total other earning assets shown in the recent years is due to increase in the investment on government securities including NBE Bills. The share of the private commercial banks in the other earning assets has also shown a yearly increment from 9 percent in 2000 to 20 percent in 2014. On the contrary, the share of state owned commercial banks has decreased from 90 percent in 2000 to 80 percent in 2014.

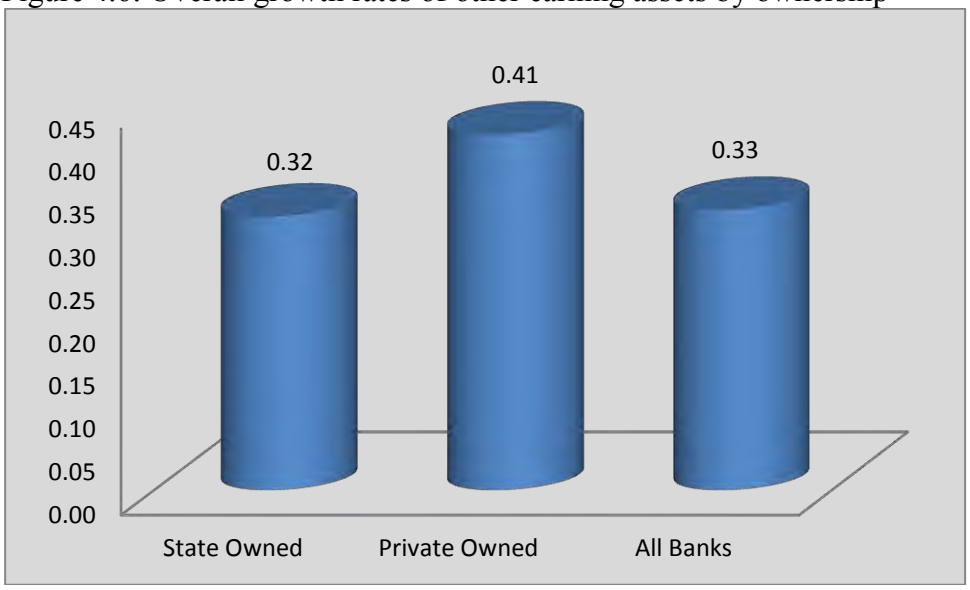
Table 4.6: Total other earning assets by banks (in Millions of Birr)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
All Banks	4,379	7,398	7,944	5,667	5,996	8,566	8,116	12,196	18,667	24,505	42,740	70,945	94,019	132,370	156,404
State Owned Banks	3,992	6,860	7,357	4,842	5,060	6,787	6,344	9,410	15,768	21,334	34,823	57,810	75,778	104,544	125,636
	91%	93%	93%	85%	84%	79%	78%	77%	84%	87%	81%	81%	81%	79%	80%
Private Banks	387	538	587	825	936	1,779	1,772	2,786	2,899	3,171	7,918	13,135	18,241	27,827	30,768
	9%	7%	7%	15%	16%	21%	22%	23%	16%	13%	19%	19%	19%	21%	20%

Source: Own computation

Figure 4.6 indicates the overall average growth rate of other earning assets invested by the commercial banks over the study period. On average the growth rate of the total other earning assets over the study period is 32 percent. The overall average growth rate of other earning assets by the private commercial banks is far higher than the growth rate of the state owned commercial banks. On average the total other earning assets of the private commercial banks has grown at the rate of 41 percent while the corresponding figure for the state owned commercial banks is 33 percent.

Figure 4.6: Overall growth rates of other earning assets by ownership



Source: Own computation

4.1.1.3 Price variables

As explained in the previous section, the input prices used for the estimation of commercial banks‟ cost efficiency is price of labor, price of physical capital and price of funds (deposits and other non-equity source of funds).

4.1.1.3.1 Price of labor

The first input price is the price of labor (*PL*), which defined as the ratio of personnel expenses scaled by total assets. Although scaling over total employees, instead of total assets, gives a better proxy of price of labor, the latter is chosen since for many observations the former is not available.

The average price of labor of commercial banks over the study period is shown in Table 4.7. The price of labor has witnessed an increment over the study period. In percentage terms, the price of labor has grown up from 0.9 percent in 2000 to 1.6 percent in 2014 with some reduction in years between 2003 and 2005 mainly due to increase in the total assets of private commercial banks relative to employees expenditures. The labor price of state owned commercial banks have showed a yearly increment from 0.7 percent in 2000 to 1.4 percent in 2014. And the price of state owned commercial banks also witnessed yearly increment except some reduction in year between 2002 and 2005. Throughout the studied periods, labor prices of private owned commercial banks are higher than that of the corresponding value of the state owned commercial banks.

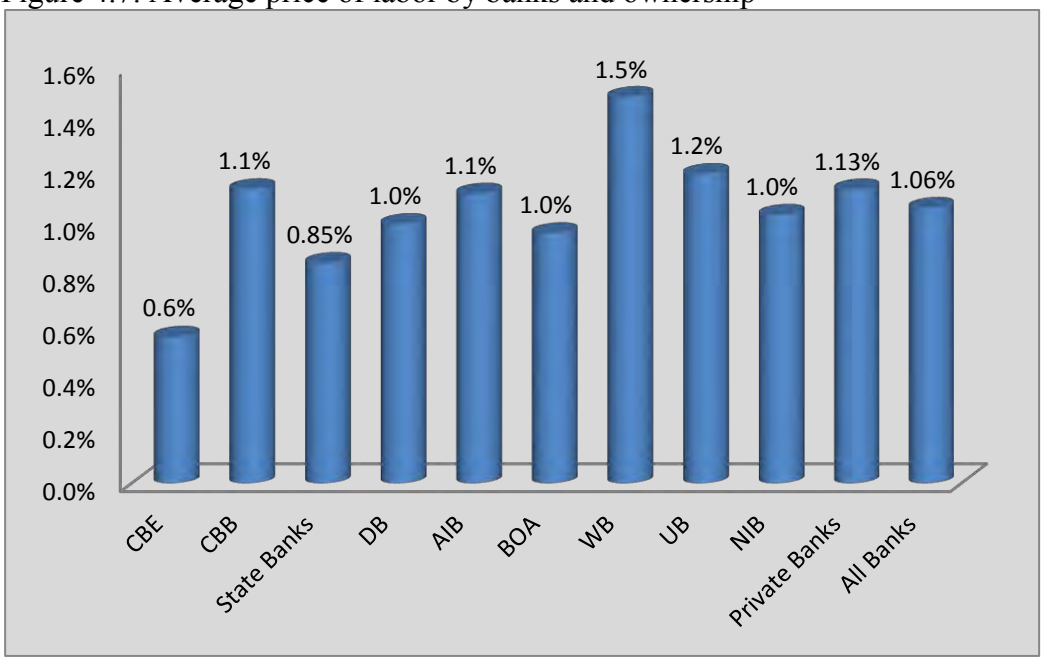
Table 4.7: Price of labor by ownership category

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
All Bank	0.9%	1.0%	1.0%	0.9%	0.9%	0.8%	0.9%	1.0%	1.0%	1.1%	1.1%	1.2%	1.2%	1.3%	1.6%
State Owned Banks	0.7%	0.7%	0.9%	0.9%	0.9%	0.6%	0.7%	0.8%	0.9%	0.8%	0.9%	0.9%	0.8%	0.9%	1.4%
Private Banks	1.0%	1.1%	1.0%	0.9%	0.9%	0.9%	1.0%	1.0%	1.1%	1.2%	1.2%	1.2%	1.4%	1.4%	1.7%

Source: Own computation

Figure 4.7 presents the average price of labor of the studied individual commercial banks and by ownership category. The overall average price of labor over the entire study period is 1.1 percent. The average labor price of private owned commercial banks is higher than the state owned commercial banks as the average labor price of the state owned commercial banks is 0.8 percent over the entire period of the study, while the corresponding figure of the private owned commercial banks is 1.1 percent.

Figure 4.7: Average price of labor by banks and ownership



Source: Own computation

4.1.1.3.2 Price of fund

The price of fund (financial capital) is defined as the ratio of a commercial bank‟s interest expenses scaled by the sum of deposits and other interest bearing funds. The average price of fund of commercial banks over the study period by ownership category is shown in Table 5.8. The average price of funds of the studied commercial banks has shown some decrement from 3.6 percent in 2000 to 2.9 percent in 2014. However, it has shown some fluctuation in between, that is, it consistently decreases from 3.6 percent in 2000 to the minimum of the whole studied period of 1.8 percent 2005. Then it consistently increases from 2 percent in 2006 to 2.9 percent in 2014. Table 4.8 also shows that the average price of fund of state owned commercial banks are higher than the private owned commercial banks from the 2000 to 2004 then after the private owned commercial banks‟ price of labor is higher than that of the state owned commercial banks.

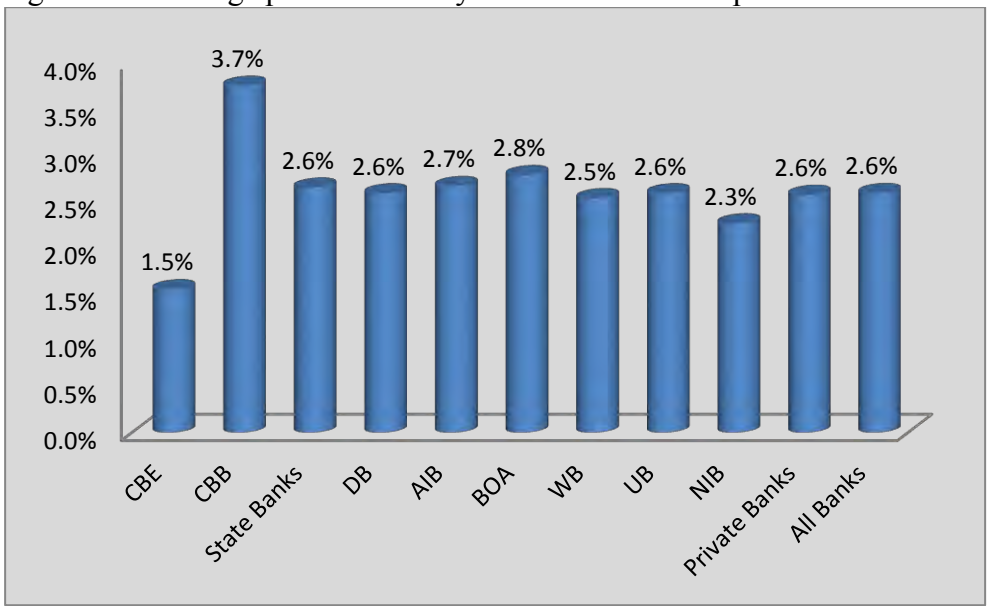
Table 4.8: Price of fund

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
All Bank	3.6%	3.9%	3.5%	2.2%	2.0%	1.8%	2.0%	2.1%	2.6%	2.3%	2.2%	2.4%	2.7%	2.7%	2.9%
State Owned Banks	5.4%	5.2%	4.1%	2.5%	2.1%	1.6%	1.8%	1.7%	2.2%	2.0%	2.0%	2.2%	2.2%	2.3%	2.3%
Private Banks	3.0%	3.5%	3.3%	2.2%	2.0%	1.9%	2.0%	2.2%	2.7%	2.4%	2.3%	2.4%	2.8%	2.8%	3.0%

Source: Own computation

Figure 4.8 indicates the average price of funds of each bank and by ownership category. The average price of funds has not shown variation among the state owned and private owned commercial banks as Figure 4.8 shows that the average price of fund for the two groups are 2.6 percent. At individual bank level, the average price of fund varies from the minimum of 1.5 percent of CBE to 3.7 percent of CBB. It can be conclude that CBE is paying the lowest cost for the funds among the studied banks, this is because CBE unlike other banks is enjoying with higher share of the low cost types of deposits (demand deposits). In other words, the high share of demand deposits enabled the CBE to reduce its cost of fund by large percentage points than other commercial banks in the sector from the minimum legal requirement of interest rate to be paid on saving and fixed time deposit of 5 percent.

Figure 4.8: Average price of fund by banks and ownership



Source: Own computation

4.1.1.3.3 Price of physical capital

Price of physical capital is constructed as depreciation and other non-interest expenses to fixed assets. The average price of physical capital of commercial banks over the study period by ownership category is presented in Table 4.9. As shown in Table 4.9, the price of physical capital decreased from 94 percent in 2000 to 78 percent in 2014 and shows ups and downs in between. The highest price of 95 percent has been observed on 2007 due to a leap in the price of CBE at the period. Table 4.9 also shows that the price of physical assets of state owned commercial banks is lower than the private banks during the year 2000 to 2010 with the exception of 2007.

However, during the recent period of the study (starting from 2011), the price of physical capital of state owned commercial banks are higher than the private commercial banks. This may be due the aggressive branch expansion of the commercial bank of Ethiopia that increases the general expense of the Bank.

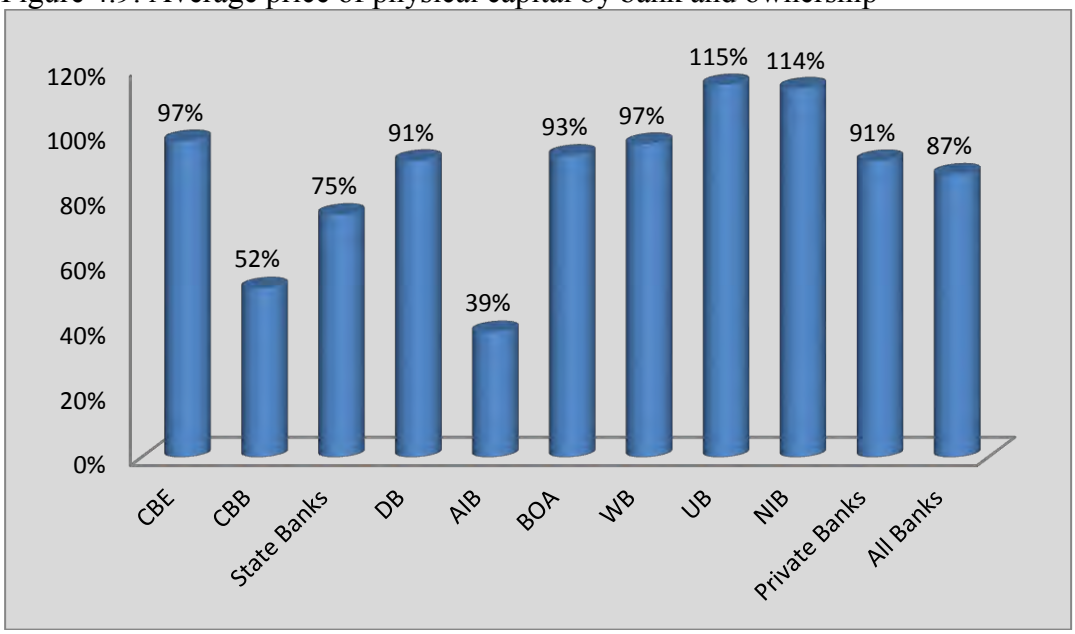
Table 4.9: Price of physical capital

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
All Bank	94%	94%	89%	85%	89%	94%	80%	95%	85%	80%	84%	93%	81%	88%	78%
State Owned Banks	40%	32%	91%	37%	44%	70%	60%	151%	73%	56%	71%	105%	91%	98%	102%
Private Banks	112%	114%	88%	102%	104%	102%	86%	76%	89%	88%	88%	89%	78%	84%	70%

Source: Own computation

Figure 4.9 shows the average price of funds of the studied banks and by ownership category. As shown from the table, the highest price of physical capital has observed on UB and NIB which is 115 percent and 114 percent, respectively. This may be due to the low level of fixed assets relative to the general expenses of the banks.

Figure 4.9: Average price of physical capital by bank and ownership



Source: Own computation

4.1.2 Descriptive analysis of credit risk-taking and capital adequacy

In order to analyze the interrelationship of credit risk, cost efficiency and capital adequacy, the study also use non performing loan ratio and capital adequacy ratio (i.e. the ratio of capital and

total assets) obtained from NBE and commercial banks‟ financial statement as a proxy for credit risk-taking and capital adequacy, respectively.

Moreover, the study uses control variables such as: bank income diversification (i.e. the ratio between net non-interest income and net-operating income), bank specialization (i.e. the proportion of loans over total assets) and bank size (i.e. logarithm of total assets). The value of the aforementioned variables and their growth rates over the entire period of the study are discussed in the following subsections.

4.1.2.1 Non-performing loans

Directive number SBB/43/2008 issued by National Bank of Ethiopia defines non-performing loan as loans or advances whose credit quality has deteriorated such that full collection of principal and/or interest in accordance with the contractual repayment terms of the loan or advance is in question. For example, loans or advances with pre-established repayment programs are non-performing when principal and/or interest is due and uncollected for 90 consecutive days or more beyond the scheduled payment date or maturity.

Non-performing loan ratio has been computed by dividing total non-performing loan over total outstanding loans and advances. The non performing loan ratio of commercial banks over the study period is given in Table 4.10. The level of non-performing loan ratio has shown a sharp decrement each year over the entire period under study except some increment between the year 2002 and 2005. The increment of non-performing loan and advances during the period 2002 to 2005 is may be due to the slowdown of the country‟s economic growth. The non-performing loan ratio level has been reached its maximum of 26 percent and 24 percent during 2002 and 2003, respectively. During 2002 and 2003 the country‟s economic growth also reached its lowest level of 1.6 percent and -2.1 percent, respectively. The non-performing loan ratio of state owned commercial banks decreased from 21 percent in 2000 to 3 percent in 2014. Likewise, the level of non-performing loan ratio of private commercial banks has decreased from 13 percent in 2000 to 3 percent in 2014. The level non-performing loan ratio of state owned commercial banks are higher than the private commercial banks in each year over the study period. However, in 2014 the level of non-performing loan ratio of both private and state owned commercial banks have converged into 3 percent. The sharp decline of non-performing loan ratio after the period 2009

was mainly due to regulatory pressure as the National Bank of Ethiop obliged commercial banks to maintain the level of non-performing loan ratio below 5 percent.

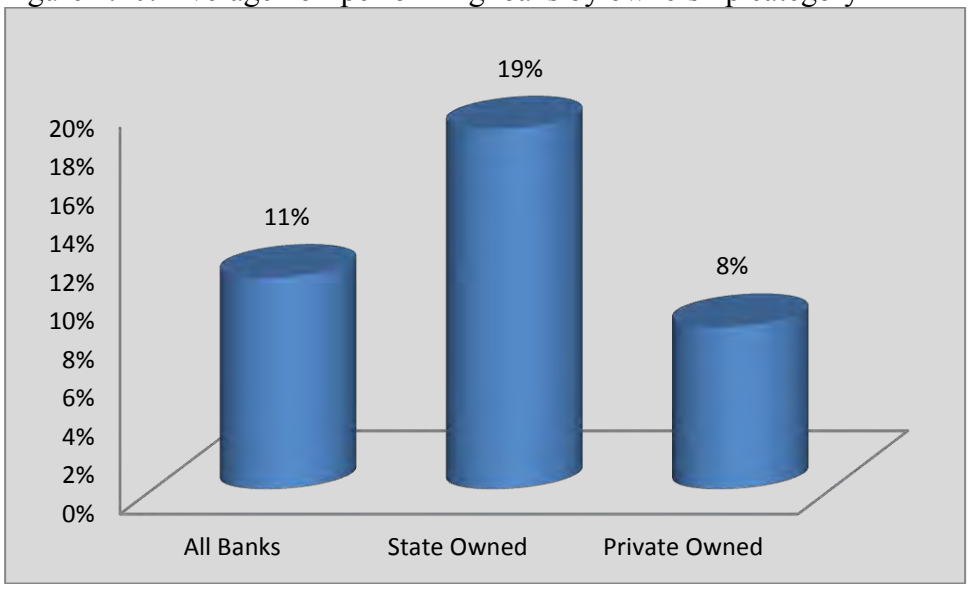
Table 4.10: Non-performing loan ratio by bank type

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
All Bank	15%	13%	26%	24%	18%	14%	10%	9%	8%	8%	5%	4%	3%	4%	3%
State Owned Banks	21%	24%	46%	47%	37%	28%	21%	16%	10%	8%	4%	4%	5%	6%	3%
Private Banks	13%	10%	19%	16%	12%	10%	6%	7%	8%	9%	5%	4%	3%	3%	3%

Source: Own computation

Figure 4.10 indicates the overall average non-performing loan ratios. The overall average non-performing loan ratio over the entire study period is 11 percent. The average non-performing loan ratio of state owned commercial banks is much higher than the private owned commercial banks. The average non-performing loan ratio of the state owned commercial banks is 19 percent over the entire period of the study, while the corresponding figure for the private owned commercial banks is 8 percent.

Figure 4.10: Average non-performing loans by ownership category



Source: Own computation

4.1.2.2 Capital adequacy

Commercial banks capital adequacy is measured as the equity to total assets ratio, i.e. the value of total equity divided by the value of total assets. Equity capital is measured focusing on the Basel Committee definition of bank capital by summing the Tier-I (i.e. total equity, retained earnings and other disclosed equity reserves) and Tier-II (i.e. undisclosed equity reserves, general provisions, hybrid capital instruments, and subordinated debts) components of bank capital. By focusing on a wider definition of banks‟ equity, the study aims to consider supplementary items that are commonly used by banks to increase their capital on top of traditional equity. However, the capital structure of Ethiopian banking sector is uniform and comprises only few traditional equity capital components such as: paid up capital, legal reserve and retained earnings. Therefore, the study uses the sum of paid-up capital, legal reserve and retained earnings as a proxy for capital adequacy.

The total value of commercial banks‟ capital over the study period is given in Table 4.11. The total amount of capital employed by the commercial banks has shown a sharp increment each year over the entire period under study. In absolute term, the total amount of bank capital employed by all banks has increased from 1,782 million Birr in 2000 to 21,817 million Birr in 2014. The share of the private commercial banks in the total capital has also shown an annual increment each year over the study period. The share of the private commercial banks in the total capital has increased from 424 million Birr in 2000 to 10,374 million Birr in 2014. Likewise, the amount of capital employed by the state owned commercial banks has increased from 1,358 million Birr in 2000 to 11,443 million Birr in 2014.

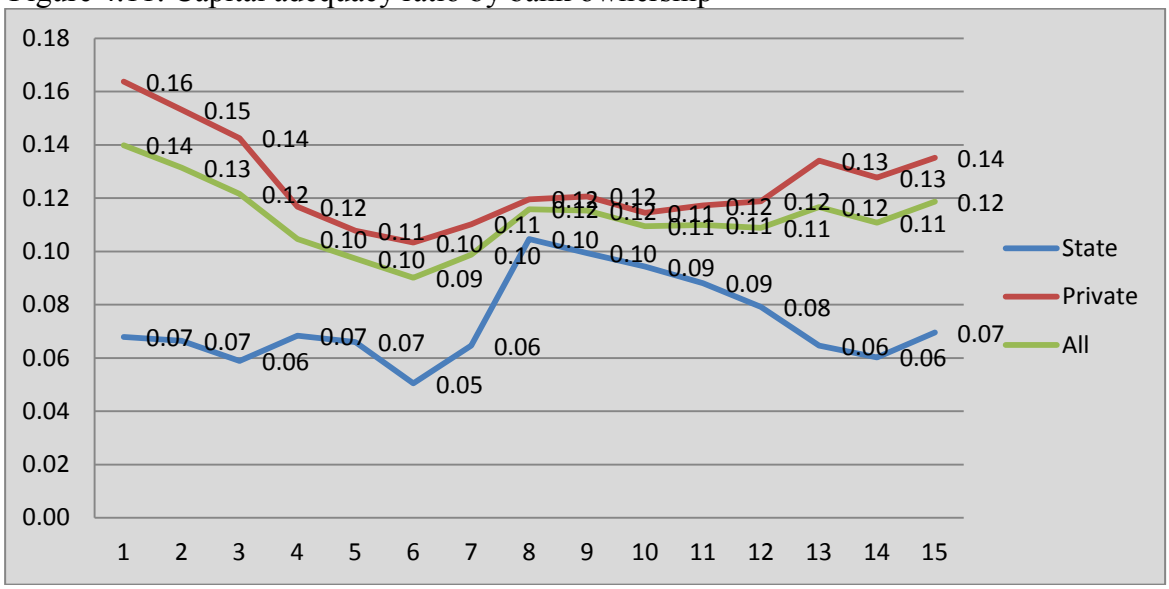
Table 4.11: Total capital by bank ownership (in Millions of Birr)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
All Banks	1,782	1,895	1,551	2,080	2,497	2,789	3,486	7,001	8,238	9,573	11,130	13,399	16,782	19,008	21,817
State Owned Banks	1,358	1,368	906	1,356	1,579	1,535	1,663	4,432	4,819	5,310	5,875	6,625	8,203	9,633	11,443
	76%	72%	58%	65%	63%	55%	48%	63%	59%	55%	53%	49%	49%	51%	52%
Private Banks	424	527	645	724	918	1,254	1,823	2,569	3,419	4,263	5,255	6,775	8,579	9,375	10,374
	24%	28%	42%	35%	37%	45%	52%	37%	41%	45%	47%	51%	51%	49%	48%

Source: Own computation

The capital adequacy ratio (i.e. total capital over total asset) of commercial banks over the study period by ownership type is given in Figure 4.11. Capital adequacy ratio of all commercial banks covered under study has shown downs and ups. During the period 2000 to 2005, capital adequacy ratio of commercial banks has shown some decrement from 14 percent to 9 percent, respectively. On the other hand, the capital adequacy ratio has shown some improvement from 10 percent in 2006 to 12 percent in 2014. This increment is mainly due to increase in the paid-up capital of state owned banks.

Figure 4.11: Capital adequacy ratio by bank ownership



Source: Own computation

4.2 Regression result and discussion

This section presents the results and discussions of regression results. The first sub-section of this section of the study presents and analyzes cost efficiency estimation regression results and the second sub-section presents and analyzes the regression result which estimates the causal relationship between cost efficiency, credit risk-taking and bank capital adequacy.

4.1.3 Cost efficiency estimation

The cost efficiency of Ethiopian commercial banks has been measured using stochastic frontier analysis (SFA) method provided by Battese and Coelli (1995) which is easily amenable to panel data analysis. The estimation of this model is made using FRONTIER (Version 4.1) software developed by Coelli (1996).

The study uses a common benchmark frontier by pooling the data set of both private and state owned commercial banks and estimating the cost efficiency equation provided in Chapter-three over the period 2000 to 2014. Although this is a common practice in bank efficiency studies, it may be argued in case of Ethiopia that it is unfair to compare a bank belonging to a particular ownership group with those of another group, especially in case there exists inter-group heterogeneity. To allow for such a situation, the study includes some environmental variables (control variables) without directly including these variables in the cost function in order to reduce the heterogeneity in the data set. The control variables include size of banks (log of total assets), ownership (dummy variable: 1 if the bank is government owned, 0 otherwise), time and real growth rate of domestic production (GDP).

Before discussing the estimates of cost efficiencies it is important to point out that likelihood ratio tests favored the frontier specification in all cases. The estimated maximum likelihood frontier function is not of immediate interest for the cost efficiency analysis; hence the estimate is reported in the Appendix-2. The estimate for the variance parameter ($\gamma = \frac{{\sigma_u}^2}{\sigma_v^2 + \sigma_u^2}$) is presented in the Appendix which is 99 percent is close to one, which indicates that the inefficiency determinants are likely to be highly significant in the analysis of the value of cost function. The value of likelihood-ratio test of null hypotheses that the inefficiency effects are absent or that they have simpler distributions is equal to 48.52 is significant. This indicates that the joint effect of these explanatory variables on the inefficiency is significant.

4.1.3.1 Cost efficiency of state and private owned commercial banks

Table 4.12 presents the results of individual banks‟ cost efficiency over each years of the study period, as well as the average cost efficiency of all commercial banks across period and across banks. According to the result, the yearly average cost efficiency of the banks ranges between 80 percent in 2000 to 92 percent in 2014 with some fluctuation in between. On average the cost efficiency of all banks over the study period is found to be 89 percent (see in Table 4.8). This implies that an average commercial bank has incurred 11 percent more costs than required to produce the given level of outputs over the study period. This, in other words, means that an average commercial bank could have cut its costs down by 11 percent while producing the same level of outputs over the study period.

The yearly average cost efficiency of the studied commercial banks is found to be 80 percent in 2000 which slightly went up to 87 percent in 2001 and to 91 percent in 2002. However, it declined over the period 2003 to 2007 except some improvement from 83 percent in 2005 to 89 percent in 2006 and 2007. It steadily increased from 91 percent in 2008 to 92 percent in 2014 with the highest efficiency level of 94 percent in 2013 due to mainly the improvement of the cost efficiency level of CBB.

At individual bank level, the average cost efficiency of each individual bank ranges from 97 percent of CBE to 81 percent of CBB. In other word, CBE is the most cost efficient commercial banks followed by WB, BOA, DB, AIB, NIB, UB and CBB, consecutively. Whereas, CBB is the least cost efficient bank among the studied commercial banks due to its weak performance in lending and deposit mobilization as compared to its investment in labor and physical capital relative to other commercial banks.

Table 4.12: Individual bank cost efficiency estimation result

Year	CBE	CBB	DB	AIB	BOA	WB	UB	NIB	Mean
2000	0.9682	0.7427	0.7441	0.8357	0.9194	0.8998	0.6318	0.6616	***0.80***
2001	0.9994	0.8406	0.8430	0.8700	0.7952	0.9990	0.7216	0.8965	***0.87***
2002	0.9926	0.7667	0.8918	0.9996	0.9509	0.9844	0.8056	0.8691	***0.91***
2003	0.9667	0.9995	0.9438	0.8098	0.8406	0.9138	0.6786	0.8065	***0.87***
2004	0.9960	0.6564	0.8742	0.7622	0.7905	0.9056	0.9679	0.8009	***0.84***
2005	0.9995	0.6555	0.8646	0.7635	0.7067	0.9000	0.9041	0.8711	***0.83***
2006	0.9993	0.7495	0.8837	0.7901	0.9908	0.9995	0.8581	0.8270	***0.89***
2007	0.9740	0.7960	0.8467	0.8317	0.9907	0.9995	0.8811	0.8348	***0.89***
2008	0.9634	0.8171	0.9354	0.7985	0.9959	0.9996	0.8772	0.8840	***0.91***
2009	0.9985	0.7933	0.9828	0.9369	0.9739	0.9781	0.8887	0.8680	***0.93***
2010	0.8659	0.8361	0.9660	0.9991	0.9362	0.8857	0.8374	0.8517	***0.90***
2011	0.8814	0.8261	0.9691	0.9996	0.9322	0.9121	0.9509	0.9905	***0.93***
2012	0.9889	0.7838	0.9487	0.8931	0.9987	0.8483	0.9864	0.9995	***0.93***
2013	0.9871	0.9061	0.9894	0.8880	0.9416	0.9514	0.9149	0.9476	***0.94***
2014	0.9999	0.9267	0.9472	0.8673	0.8748	0.9907	0.8188	0.9155	***0.92***
Mean	***0.97***	***0.81***	***0.91***	***0.87***	***0.91***	***0.94***	***0.85***	***0.87***	***0.89***
Rank	***1st***	***8th***	***4th***	***5th***	***3rd***	***2nd***	***7th***	***6th***	

Mean	Median	Maximum	Minimum	Std. Dev.
0.89088	0.89813	0.99987	0.63179	0.09158

Source: FRONTIER Version 4.1 estimation result and own computation

4.1.3.2 Determinants of cost efficiency

The maximum likelihood parameter estimate of the inefficiency equation has presented in Table 4.13. The table presents the effect of group-specific and bank-specific variables on the cost efficiency.

The bank size coefficient is negative and significant at 1% in the cost inefficiency model, which indicates that it has a positive effect on the cost efficiency. This variable implies that large banks on average tended to be more cost efficient than small banks. An explanation for this finding is that large banks may find it easier to engage in lending, deposit mobilization and international trade than small banks. Furthermore, large banks may undertake risky loan (with higher returns), in contrast to small banks, which usually avoid undertaking this type of loans.

State ownership, measured by the dummy variable „ownership" has a positive and significant coefficient at the 10% level, which indicates that it has a negative effect on the cost efficiency. That means on average state owned commercial banks are less efficient than private owned commercial banks. However, when we see the state owned commercial banks individually CBE is the most efficient bank among the studied banks, whereas CBB on the contrary is the less efficient bank in among the studied banks. Therefore, this is due to the net-off effect between CBE and CBB that forces the „ownership" coefficient to show negative impact on cost efficiency. As shown in Table 4.13, CBE persistently shows the highest cost efficiency level over the entire period under study, this may be due to: (1) the advantages related to holding the public enterprises market and the implicit guarantee of the depositor for CBE being a government owned bank; (2) CBE is the key and sole player in some of the national projects that support the urban poor like the housing/condominium projects which are designed to provide loans based on savings and account opening at the CBE is one of the mandatory requirements; (3) long time stay in the industry also have the advantage related to holding loyal customers; (4) all banks except the CBE are required to purchase NBE bill amounting 27% of every new loan disbursement. The main complains with regard to such requirement from banks is related to the lower yield (3%) from bill which is even lower than the minimum cost of fund required to be paid for deposits (5%); (4) in terms of foreign currency flow and level of foreign reserves of banks, the dominance of the CBE is observed. A convenient government policy framework for CBE in such regard is considered as the causes for CBE"s higher share (almost half) of the foreign market. For example,

the government policy that obliged every exports and imports with China to be channeled through the CBE and the central bank (NBE) avails foreign currency to CBE, unlike the private banks, with the intension of availing foreign currency for the government‟s mega projects.

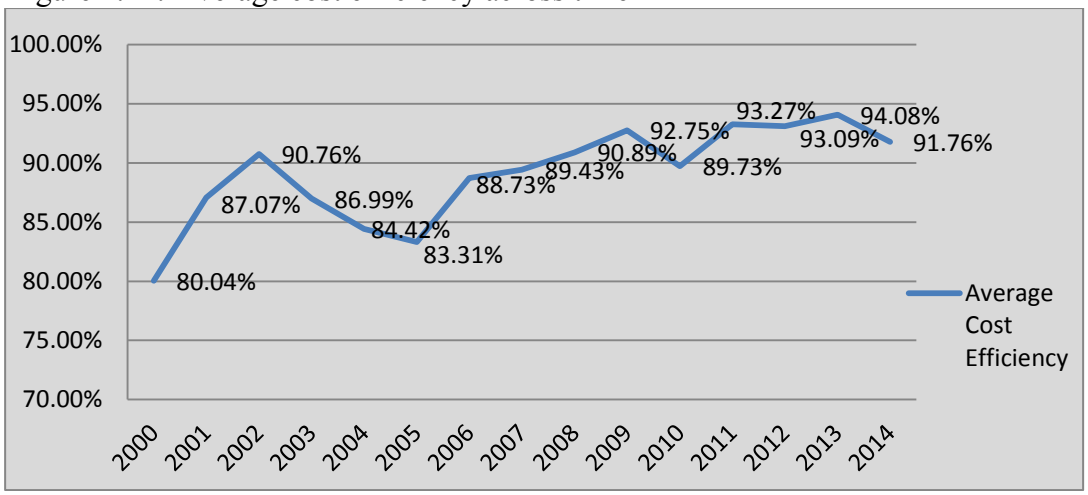
Table 4.13: Determinants of cost inefficiency

Coefficient	*Estimate*	*Standard -error*	*t-ratio*
Constant	1.01788	0.20722	4.91218***
Size	-0.14397	0.03239	-4.44447***
Ownership	0.12961	0.06816	1.90162*
Time	-0.01411	0.00866	-1.62850
GDP	0.62689	0.37666	1.66433

Source: FRONTIER Version 4.1 estimation result

The temporal behaviour of commercial banks‟ cost efficiency seems to be quiet stable and there does not appear to be any appreciable change over time. As shown from Table 4.13, the coefficient of time variable insignificant at 10% level due to stable nature of the cost efficiency across time. The sign of the time coefficient is negative means the inefficiency decrease across time which indicates that the cost efficiency is increased across time. For example, as shown in Figure 4.12, the average cost efficiency has increased from 80 percent in 2000 to 91 percent in 2014 with some variability in between. The general movement of the cost efficiency shows increasing trend.

Figure 4.12: Average cost efficiency across time



Source: Own computation

4.1.4 Causal relationship between Cost Efficiency, Credit Risk and Capital

As mentioned earlier the study employed Granger-Causality techniques to investigate the causal relationship between cost efficiency, credit risk-taking and capital as this approach allows to test time-ordered causal relationships among pairs of variables.

Grangers‟ (1969) notion of causality states that "*x* is causing *y* if we are better able to predict *y* using all available information than if the information apart from *x* had been used." Granger‟s suggestion to regress *y* on its own lags and a set of lagged *x* has become a standard procedure. If lagged *x* provides a statistically significant explanation of *y, „x* Granger causes *y*‟.

The study uses system-Generalized Method of Moments (GMM), estimation method developed for dynamic panel models to estimate the three models, which will help to alleviate the complication created as a result of the inclusion of a lagged dependant variable among the predictors in the Granger model.

In cost efficiency model, the current level of cost efficiency is the dependant variable while lags of cost efficiency, credit risk-taking and capital adequacy variables are among the independent variables. In credit risk-taking model, the current level of credit risk-taking is the dependant variable while lags of cost efficiency, credit risk-taking and capital adequacy variables are among the independent variables. In capital adequacy model, on the other hand, the current level of capital adequacy is the dependant variable while lags of cost efficiency, credit risk-taking and capital adequacy are among the independent variables. Income diversification, bank size, ownership type and return on assets are additional explanatory variables in the models.

Causality tests are conducted to identify whether unidirectional or bidirectional causality exists among cost efficiency, credit risk and capital. The test of whether on variable Granger-causes another variable consists of a test of the hypothesis that the coefficients of current and lagged values of the former variable are jointly equal to zero (Wald test) after controlling for the latter variable‟s own lags and the influence of additional controls.

Multicollinearity test is made prior to estimation of the results. The result from the test (appendix-3) shows that there is no multicollinearity problem observed in all of the models. The system-GMM regression estimation results for model one to three are presented in appendix-4. For this

estimation, a net of 88 observations from a total of 120 observations are used, the reduction is due to the introduction of four lags of cost efficiency, credit risk-taking and capital variables in the model.

Before discussing the estimation result of model it is important to point out that the over-identifying restrictions are valid. The Sergan statistics is used to test the null hypothesis of "the over-identifying restrictions are valid". The Sargan statistic is distributed as a $X^2(p - k)$, where k is the number of estimated coefficients and p is the instrument rank. The p-value is computed using the code "scalar pval=@chisq(J-statistic, (p-k))". Hence, the null-hypothesis of "the over-identifying restrictions are valid" is not rejected in all models.

4.1.4.1 Cost efficiency model result

The results of cost efficiency model (Model-1), as depicted in Table 4.14, show that the sum of all lagged cost efficiency coefficient (Ceff) has positive and statistically significant impact at 5 percent confidence level. This means that the increase in cost efficiency level of past years have caused increment on the current level of cost efficiency.

The sum of all lagged credit risk (Npl) coefficients has negative and significant impact on cost efficiency. This result supports the "luck" hypothesis which posits that an exogenous increase or decrease in bank risk-taking temporally precedes a cost efficiency increase. It is also consistent with the descriptive statistics presented on section 4.2.1, that is, the average level of non-performing loan ratio of the studied commercial banks have shown a sharp decrement from 15 percent in 2000 to 3 percent in 2014 mainly due to favorable macroeconomic condition and regulators target. As a result of the exogenous factors, the level of NPL decreased while the cost efficiency level has increased from 80 percent in 2000 to 93 percent in 2014. Therefore, it can be concluded that the decrease/increase in credit-risk level as a result of exogenous factors leads to increment/decrement in the cost efficiency level of Ethiopian commercial banks.

The sum of all lagged bank capital adequacy level (Bcad) coefficients has shown statistically insignificant impact on cost efficiency level of commercial banks. The regression result presented on Table 4.14 also shows that statistically significant relationship with two control variables. The first control variable is bank size (log of total asset) which has positive and significant impact on cost efficiency at 5 percent confidence level. This implies that, as explained in section 4.3.1.1,

large banks on average tended to be more cost efficient than small banks. An explanation for this finding is that large banks may find it easier to engage in lending, deposit mobilization and international trade than small banks.

The second control variable is state ownership variable which shows negative and significant impact on commercial banks cost efficiency level at 5 percent significance level. This result seems contradicting with the previous result of Commercial Bank of Ethiopia (state owned bank) is the most efficient bank among the studied banks. However, it is due to the net-off effect of Construction and Business Bank (it is also a state owned bank) which is the least efficient bank among the studied commercial banks. The overall result shows that state ownership has negative and statistically significant impact on cost efficiency. The possible reason that Construction and Business Bank is not as efficient as Commercial Bank of Ethiopia is my be due to it has not got equal attention from the government in obtaining adequate capital, in getting deposits from public enterprises, in getting foreign exchanges, in providing loans in government priority sectors, etc.

The other control variables, that is, income diversification (i.e. the level of net non-interest income from the total operating income), and return on asset (i.e. total operating income divided by total assets) have insignificant impact on cost efficiency model.

Table 4.14: Results of cost efficiency model (Model-1)

Parameter	***Dependant Variable: Cost Efficiency***			
	Coefficient	***Std. Error***	***t-stat.***	***Prob.***
Constant	0.21487	0.11178	1.92228	0.05920*
Ceff(-1)	0.39852	0.11436	3.48475	0.00090***
Ceff(-2)	-0.10428	0.10142	-1.02824	0.30790
Ceff(-3)	-0.01757	0.07286	-0.24110	0.81030
Ceff(-4)	0.04357	0.07953	0.54783	0.58580
$Ceff_{total}$				**0.00780*** **
Npl(-1)	-0.225295	0.122110	-1.845017	0.0627*
Npl(-2)	0.115979	0.226314	0.512469	0.6089
Npl(-3)	-0.055180	0.022924	-2.407084	0.0254**
Npl(-4)	-0.249330	0.102340	-2.436291	0.0189**
NPL_{total}				**0.0550** **
Bcad(-1)	-0.01988	0.48850	-0.04069	0.96770
Bcad(-2)	0.43484	0.68111	0.63843	0.52560
Bcad(-3)	0.18978	0.49736	0.38157	0.70410
Bcad(-4)	-0.00066	0.31978	-0.00206	0.99840
$Bcad_{total}$				**0.22830**
Income diversification	0.00722	0.01033	0.69944	0.48690
Size	0.04424	0.01275	3.47121	0.00100***
State ownership	-0.06155	0.02949	-2.08737	0.04100**

ROA	-1.28198	0.77644	-1.65109	0.10390
Year (2005)	-0.01935	0.04601	-0.42061	0.67550
Year (2006)	0.02830	0.04441	0.63721	0.52640
Year (2007)	0.00427	0.04029	0.10601	0.91590
Year (2008)	0.01918	0.04662	0.41134	0.68230
Year (2009)	0.01209	0.03916	0.30863	0.75870
Year (2010)	-0.02803	0.03974	-0.70520	0.48340
Year (2011)	0.01479	0.04196	0.35246	0.72570
Year (2012)	-0.01097	0.04662	-0.23526	0.81480
Year (2013)	-0.02051	0.04646	-0.44146	0.66040
Year (2014)	-0.04305	0.04388	-0.98119	0.33040
$Year_{total}$				**0.19870**

Source: EViews estimation result

Note: The variable $Ceff_{total}$, NPL_{total}, $Bcad_{total}$ $Year_{total}$ are the estimated coefficients (Wald test p-value) for the test that the sum of the four lagged terms and all the time dummies are equal to zero. The symbol *, **, *** represent significance levels of 10%, 5% and 1% respectively.

4.1.4.2 Credit risk-taking model result

The credit risk-taking model (Model-2) estimation results have been presented in Table 4.15. The result shows that credit risk-taking is significantly affected at 1% confidence level by the sum of its own four lags. This shows the persistent nature of the credit risk-taking behavior of the studied commercial banks.

The lagged cost efficiency variables have negative and statistically significant impact at 5% confidence level on commercial banks credit risk-taking behaviour. This result confirms the "bad management" hypothesis which states that banks operating with low levels of efficiency have higher costs largely due to inadequate credit monitoring and inefficient control of operating expenses. Decline in cost efficiency will temporally precede increase in banks" risk due to credit, operational, market and reputational problems. This result is in-line with the earlier findings of Berger and De Young (1997), Kwan and Eisenbeis (1997) and Williams (2004).

Table 4.15 also shows that the sum of the lagged capital ratio have a negative and significant impact on the credit risk-taking behaviour of the studied commercial banks at 1% confidence level. In other word, the result shows that an increase in the sum of the lagged capital ratio coefficients temporally precedes the decline in credit risks of the studied commercial banks. This confirms the "moral hazard" hypothesis which states that a negative causal relationship between capital and risk pointing out that bank managers have incentives to take on more risk particularly when the level of bank capital is low.

Table 4.15 also shows that the control variable of income diversification, bank size, state ownership and return on assets have insignificant impact on credit risk-taking behaviour of the studied commercial banks.

Table 4.15: Results of credit risk-taking model (Model-2)

Parameter	*Dependant Variable: NPL*			
	Coefficient	*Std. Error*	*t-stat.*	*Prob.*
Constant	0.08810	0.03735	2.35908	0.02150**
Ceff(-1)	-0.08560	0.03104	-2.75759	0.00770***
Ceff(-2)	-0.05595	0.02998	-1.86664	0.06680*
Ceff(-3)	-0.00646	0.02595	-0.24913	0.80410
Ceff(-4)	-0.02129	0.02815	-0.75621	0.45240
$Ceff_{total}$				**0.04250****
Npl(-1)	0.74793	0.06428	11.63616	0.00000***
Npl(-2)	-0.11935	0.07104	-1.67994	0.09810*
Npl(-3)	0.10730	0.05993	1.79030	0.07840*
Npl(-4)	-0.08866	0.03637	-2.43800	0.01770**
NPL_{total}				**0.00000*****
Bcad(-1)	-0.20695	0.16872	-1.22661	0.22470
Bcad(-2)	0.34374	0.19301	1.78096	0.07990*
Bcad(-3)	0.14560	0.15416	0.94445	0.34870
Bcad(-4)	-0.35123	0.08154	-4.30767	0.00010***
$Bcad_{total}$				**0.00020*****
Income diversification	-0.00272	0.00230	-1.18446	0.24080
Size	-0.00555	0.00373	-1.48607	0.14240
State ownership	0.00774	0.00776	0.99756	0.32240
ROA	-0.15147	0.27431	-0.55218	0.58280
Year (2005)	-0.01003	0.01345	-0.74571	0.45870
Year (2006)	-0.01260	0.01298	-0.97116	0.33530
Year (2007)	0.00154	0.01275	0.12055	0.90440
Year (2008)	0.00048	0.01391	0.03444	0.97260
Year (2009)	-0.00447	0.01394	-0.32045	0.74970
Year (2010)	-0.04009	0.01110	-3.61079	0.00060***
Year (2011)	-0.01063	0.01133	-0.93794	0.35200
Year (2012)	-0.01773	0.01350	-1.31277	0.19420
Year (2013)	-0.00379	0.01202	-0.31550	0.75350
Year (2014)	-0.02256	0.01459	-1.54627	0.12720
$Year_{total}$				**0.00000*****

Source: EViews estimation result

Note: The variable $Ceff_{total}$, NPL_{total}, $Bcad_{total}$ $Year_{total}$ are the estimated coefficients (Wald test p-value) for the test that the sum of the four lagged terms and all the time dummies are equal to zero. The symbol *, **, *** represent significance levels of 10%, 5% and 1% respectively.

4.1.4.3 Capital adequacy model result

The capital adequacy model result (Model-3), as depicted in table 4.16, shows that the sum of all lagged cost efficiency coefficients have positive and significant (at 5% confidence level) impact on bank capital adequacy ratio. Increase in the sum of the lagged cost efficiency coefficients temporally precedes capital adequacy ratio increases. This finding is consistent with Berger and

De Young (1997) and Williams (2004) where short-term cost efficiency gains as a result of reducing loan underwriting, monitoring and control costs would feed through into higher capital. This is probably because more efficient banks have higher earnings which Granger-cause increase in capital. The result is consistent with the "moral hazard" hypothesis which states that better capitalized banks have less moral hazard incentives (Jeitschko and Jeung, 2005) and are more prone to adopt careful practices to reduce costs.

The sum of all lagged non-performing loan ratios has positive and significant impact (at 5% confidence level) on bank capital adequacy ratios of the studied commercial banks. This result is also consistent with the "luck" hypothesis which states that regulators force banks to increase the amount of capital commensurably with the amount of risk taken.

As shown from Table 4.16, bank capital adequacy ratio is also significantly affected at 1% confidence level by the sum of its own lags. This shows the persistence nature of the capital adequacy level of the studied commercial banks.

Among the control variables bank size has negative and significant impact at 1% confidence level and return on asset have positive and significant impact at 5% confidence level on banks" capital adequacy level. This result implies that large banks have low level of capital adequacy ratio due to they have better capacity of mobilizing deposits than small banks.

Table 4.16: Results of capital adequacy model (Model-3)

Parameter	***Dependant Variable: BCAD***			
	Coefficient	***Std. Error***	***t-stat.***	***Prob.***
Constant	-0.02387	0.02554	-0.93464	0.35370
Ceff(-1)	0.01683	0.01803	0.93318	0.35440
Ceff(-2)	0.01469	0.01842	0.79737	0.42830
Ceff(-3)	0.04586	0.01621	2.82876	0.00630***
Ceff(-4)	0.00180	0.01871	0.09617	0.92370
$Ceff_{total}$				**0.03830****
Npl(-1)	0.02323	0.03795	0.61206	0.54280
Npl(-2)	0.04466	0.03695	1.20870	0.23140
Npl(-3)	-0.04522	0.02852	-1.58566	0.11800
Npl(-4)	-0.04103	0.02854	-1.43740	0.15570
NPL_{total}				**0.04170****
Bcad(-1)	0.81889	0.12318	6.64816	0.00000***
Bcad(-2)	-0.11462	0.13349	-0.85867	0.39390
Bcad(-3)	-0.04301	0.08706	-0.49397	0.62310
Bcad(-4)	0.11208	0.05796	1.93378	0.05780*
$Bcad_{total}$				**0.00000*****
Income diversification	-0.00014	0.00201	-0.06875	0.94540

Size	-0.00788	0.00212	-3.72051	0.00040***
State ownership	-0.00521	0.00396	-1.31446	0.19360
ROA	0.54673	0.25621	2.13397	0.03690**
Year (2005)	0.00457	0.00539	0.84775	0.39990
Year (2006)	0.01551	0.00468	3.31328	0.00160***
Year (2007)	0.02856	0.00819	3.48869	0.00090***
Year (2008)	0.02187	0.00775	2.82015	0.00650***
Year (2009)	0.01870	0.00609	3.06882	0.00320***
Year (2010)	0.02389	0.00625	3.82364	0.00030***
Year (2011)	0.02137	0.00608	3.51613	0.00080***
Year (2012)	0.03137	0.00719	4.36484	0.00010***
Year (2013)	0.02666	0.00654	4.07361	0.00010***
Year (2014)	0.03633	0.00745	4.87977	0.00000***
$Year_{total}$				**0.00000*** **

Source: EViews estimation result

Note: The variable $Ceff_{total}$, NPL_{total}, $Bcad_{total}$ $Year_{total}$ are the estimated coefficients (Wald test p-value) for the test that the sum of the four lagged terms and all the time dummies are equal to zero. The symbol *, **, *** represent significance levels of 10%, 5% and 1% respectively.

Chapter five: Conclusion and Implications

In this section, the conclusions followed from the results of the study and the possible implications are presented.

5.1 Conclusion

This paper studies cost efficiency and its causal relationship with credit risk-taking and capital adequacy of commercial banks in Ethiopia. In order to achieve this objective, sample of eight commercial banks which have data over the year 2000 to 2014 are used. The cost efficiency of the studied commercial banks have been measured using the stochastic frontier analysis method provided by Battese and Coelli (1995) which is easily amenable to panel data analysis. In order to assess the causal relationship among cost efficiency, credit risk and capital, the study applies the Granger-causality methods as proposed by Berger and De Young (1997) and Williams (2004).

The result of the cost efficiency study indicates that the aggregate cost efficiency level of the studied commercial banks is 89 percent indicating that an average commercial bank could have reduced its costs by 11 percent (or 11 percent opportunity for improvement) while producing the same level of output had it operated efficiently. At individual bank level, the average cost efficiency of the studied banks ranges from 97 percent of CBE to 81 percent of CBB. In other word, CBE is the most cost efficient while CBB is the least cost efficient among the studied commercial banks.

The analysis of ownership structure and bank efficiency indicated that state ownership has a negative impact on cost efficiency. That means, on average state owned commercial banks are less efficient than private owned commercial banks. This is due to the averaging effect of CBB as it is the least efficient bank among the studied commercial banks though CBE is the most efficient bank among the studied commercial banks. The significant efficiency gaps shown between the two state owned banks are may be due to the CBB has not obtained equal attention as the CBE obtained from the government.

The analysis of the impact of bank size on cost efficiency indicated that it has positive impact on the cost efficiency level of the studied commercial banks. This implies that large banks on

average tended to be more cost efficient than small banks. An explanation for this finding is that large banks may find it easier to engage in lending, deposit mobilization and international trade than small banks. Furthermore, large banks may undertake risky loan (with higher returns), in contrast to small banks, which usually avoid undertaking this type of loans.

The temporal behaviour of the studied commercial banks‟ cost efficiency shows positive change overtime though it is not significant at 10 percent confidence level. The general trend of the cost efficiency of the studied commercial banks is increasing, for example, the average cost efficiency has increased from 80 percent in 2000 to 92 percent in 2014 with some variability in between.

With regard to causal relationship that exists among cost efficiency, credit risk and capital, the study results show that credit risk Granger-causes cost efficiency supporting the "luck" hypothesis which posits that an exogenous increase or decrease in bank credit risk-taking temporally precedes a cost efficiency increase or decrease. The study also shows that cost efficiency Granger-causes credit risk-taking supporting the "bad management" hypothesis which states that banks operating with low levels of cost efficiency have higher costs largely due to inadequate credit monitoring and inefficient control of operating expenses. Hence, the causality test results show that bidirectional causality exists between cost efficiency and credit risk-taking, that is, credit risk-taking Granger-cause cost efficiency, and cost efficiency Granger-cause credit risk-taking. This indicates that the severity of one may increase unless the other is carefully managed.

Credit risk-taking Granger-causes bank capital adequacy supporting the "luck" hypothesis which posits that exogenous factors (regulators) force banks to increase the amount of capital commensurable with the amount of risk taken. Capital adequacy also Granger-causes credit risk-taking consistent with the "moral hazard" hypothesis which states that better capitalized banks have less moral hazard incentives to take more credit risk.

The study also shows that cost efficiency Granger-cause capital adequacy, which means that cost efficiency improvement precedes capital adequacy ratio increases. The result is consistent with the efficiency version of the "moral hazard" hypothesis which states that better capitalized banks have less moral hazard incentives and are more prone to adopt careful practices to reduce costs.

5.2 Implications

The implication of this study underlines the importance of efficiency measures. It is clear that the economic efficiency indicator can provide a better understanding of the banking sector economic condition. That makes it important to include economic efficiency as a component for a bank soundness indicator. Efficiency is significant for both risk-taking and capital underlining the capabilities of efficiency indicators for financial regulation and supervision. Overall, the study results believed to be particularly interesting from bank‟s management and a prudential supervisory perspective.

Despite the variation in policy framework for state owned and private banks, the variation in cost efficiency among private commercial banks are purely related to variations in management‟s capacity to efficiently handle the intermediation activities. Hence, banks need to work more towards improving their cost efficiency level so as to ensure their competitiveness at international level which will be helpful in times when foreign banks are allowed to operate in the country.

As it can be understood from the study, bank size has significant impact on the improvement of cost efficiency; hence, the government should not only protect private banks from external competition but also should support them to enhance their size and capacity. Moreover, the government should support the private banks by creating a level playing field and enhancing the supervisory capacity in a way to support the technical efficiency of the management.

The significant and the bidirectional relationship existed between cost efficiency and credit risk-taking and their impact on capital adequacy level necessitates the need to provide attention to the cost efficiency level of banks while regulating and supervising their credit risk-taking behaviour and capital adequacy level of commercial banks.

In addition to the above implications, the study suggest further study in bank efficiency using other bank efficiency indicators like revenue efficiency and profit efficiency and using other than the stochastic frontier analysis method. Moreover, it will better reflect causal relationship of efficiency, risk and capital if future studies use other future oriented broad measures of risk other than NPL which is post measure of credit risk.

Reference

Abhiman Das and Saibal Ghosh, 2004. Risk, capital and operating efficiency: Evidence from Indian public sector banks. Munich Personal RePEc Archive paper no. 17399.

Admassu B. and Asayehgn D. 2014. Banking Sector Reform in Ethiopia. International Journal of Business and Commerce Vol. 3, No. 8, 25-38.

Aigner DJ, Lovell CAK, Schmidt P (1977) Formulation and estimation of stochastic frontier production function models. Journal of Econometrics 6:21-37

Altunbas, Y., Carbo, S., Gardener, E. P.M., Molyneux, Philip., 2007. Examining the relationships between capital, risk and efficiency in European Banking. European Financial Management 13, 49-70.

Aly, H.Y., Grabowski, R., Pasurka, C., Rangan, N., 1990. Technical, scale and allocative effciencies in US banking: an empirical investigation, Review of Economics and Statistics 72, 211-218.

Arellano, M., 1989. A note on the Anderson-Hsiao estimator for panel data. Economic Letters 31, 337-341.

Arellano, M., Bond, S.R., 1991. Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. Review of Economic Studies 58, 277- 297.

Arellano, M., Bover, O., 1995. Another look at the instrumental variable estimation of error components models. Journal of Econometrics 68, 29-51.

Battese, G.E., Coelli, T.J., 1995. A model for technical inefficiency effects in a stochastic frontier production function for panel data. Empirical Economics 20, 325-32.

Berger, A.N., De Young, R., 1997. Problem loans and cost efficiency in commercial banking. Journal of Banking and Finance 21, 849-70.

Berger, A.N., Humphrey, D. B., 1992. Measurement and efficiency issues in commercial banking, in Output Measurement in the Service Sectors, Zvi Grilicheseds. The University of Chicago Press, 245-279.

Berger, A.N., Mester, L.J., 1997. Inside the black box: What explains differences in the efficiency of financial institutions. Journal of Banking and Finance 21, 895-947.

Berger, A.N., Herring, R.J., Szego, G.P., 1995. The role of capital in financial institutions. Journal of Banking and Finance 19, 393-430.

Besanko, D., Kanatas, G., 1996. The regulation of bank capital: Do capital standards promote bank safety? Journal of Financial Intermediation 5, 160-183.

BIS (2010). Basel-III: International framework for liquidity risk measurement, standards and monitoring. Basel Committee on Banking Supervision December, Bank for International Settlements.

Blundell, R., Bond, S., 1998. Initial conditions and moment restrictions in dynamic panel data models. Journal of Econometrics 87, 115-143.

Blundell, R., Bond, S., Windmeijer, F., 2000. Estimation in dynamic panel data models: Improving on the performance of the standard GMM estimator. Advances in Econometrics 15, 53–91.

Bonin, John P. &Iftekhar Hasan and Paul Wachtel.2005. Privatization matters: Bank efficiency in transition countries. Journal of Banking and Finance, Elsevier, vol. 29(8): 2155-2178

Casu, B., Girardone, C., 2009. Testing the relationship between competition and efficiency in banking: A panel data analysis. Economics Letters 105, 134-137.

Coelli, T. (1996). A computer program for stochastic frontier production and cost function estimation. Centre for Efficiency and Productivity Analysis (CEPA), Working Paper 96/07.

Dietsch, M., Lozano-Vives, A., 2000. How the environment determines banking efficiency: A comparison between French and Spanish industries. Journal of Banking and Finance 24, 985-1004.

Dacanay, S. J. O. 2007. Profit and Cost Efficiency of Philippine Commercial Banks Under Periods Of Liberalization, Crisis And Consolidation. The Business Review, Cambridge, Vol.7 (2): 315-322.

Fadzlan Sufian, 2008. Risk and efficiency in Malaysian banking. Research Center on International Cooperation of the University of Bergamo. Vol. 32, No. 1, pp. 7-29.

Farrell, M. J. (1957). The measurement of productive efficiency. Journal of the Royal Statistical Society, Volume 120, pp. 253-81

Fiordelisi, F. & Marques-Ibanez, D. and Molyneux, P. 2011. Efficiency and risk in European banking. Journal of Banking and Finance, Elsevier, vol. 35(5):1315-1326

Fiordelisi, F., Molyneux, P., 2010. The determinants of shareholder value in European Banking. Journal of Banking and Finance 34, 1189-1200.

Frame, S.W., Coelli, T., 2001. U.S. Financial services consolidation: The case of corporate credit unions. Review of Industrial Organization 18, 229-242.

Freixas, X., Gabillon, E., 1998. Optimal regulation of a fully insured deposit banking system. Journal of Regulatory Economics 16, 111-34.

Granger, C.W.J., 1969. Investigating causal relations by econometric models and cross spectral methods. Econometrica 37, 424-438.

Ikhide, Sylvanus I., (2008). Measuring the operational efficiency of commercial banks in Namibia. South African Journal of Economics 76(4), 586-595.

Izah, M. T. and Abdul M., 2013. The interrelationship between bank cost efficiency, capital and risk-taking in ASEAN banking. International Journal of Economics and Management, Vol. 2, No. 12, PP. 01-15.

Jackson, P., 1999. Capital requirements and bank behaviour: The impact of the Basle accord. Basle Committee on Banking Supervision Working Papers 1.

Jondrow, J., Lovell, C. A., Materov, I. S. and Schmidt, P. (1982). On the estimation of technical inefficiency in the stochastic frontier production model. Journal of Econometrics, Volume 19, pp. 233-238.

Kamau, A, W. (2011). Intermediation efficiency and productivity of the banking sector in Kenya. Interdisciplinary Journal of Research in Business, Vol. 1, Issue 9, pp. 12 – 26.

Kiyota (2009). Efficiency of commercial banks in Sub-Saharan Africa: a comparative analysis of domestic and foreign banks. A paper prepared for presentation at the CSAE conference 2009 on "Economic Development in Africa" to be held at the University of Oxford from 22nd to 24th March 2009.

Kwan S. and Eisenbeis R.A., 1996. Bank risk, capitalization and inefficiency. The Wharton Financial Institutions Center. Working Paper.

Lin, Hong-Jen, Winston T. Lin & Sunil K. Mohanty. 2009. The Cost and Profit Efficiencies and Scope Economies of Commercial Banks: Evidence from Taiwan and China. International Journal of Finance, vol.21(2): 6097-123

Meeusen, W. and van den Broek, J. (1977). Efficiency estimation from Cobb-Douglas production functions with composite errors. International Economic Review, Volume 18, pp. 435-444.

Mohana k. Rao and Tekeste B., 2012. Cost efficiency and ownership structure of commercial banks in Ethiopia: an application of non-parametric approach. European Journal of Business and Management. Vol. 4, No. 10, pp. 36-47.

Molyneux, P., Altunbas, Y. & Gardener, E. 1996. Efficiency in European Banking, John Wiley and Sons, Sussex.

Musonda, Antony (2008). An investigation into the determinants of cost efficiency in the Zambian banking sector. Paper presented at the 13th annual African Econometrics Society (AES) conference, July 1 – 11, 2008, South Africa.

NCA (2006). Competition in Nordic Retail Banking. Nordic Competition Authorities, Report No. 1/2006.

Northcott C (2004). Competition in Banking: A review of Literature. Bank of Canada, Working paper 2004-24.

Olugbenga, S.O., and Olakunle, A. P., (1998). Bank performance and supervision in Nigeria: analyzing the transition to a deregulated economy. African Economic Research Consortium, research paper no. 71, archive 113309.

Santos J. 2007. Profit and cost efficiency of Philippine commercial banks under period of liberalization, crisis and consolidation. Business Review, Cambridge, vol. 7, No. 2, pp. 315-322.

Sealey, C. and Lindley, J. (1977), Inputs, outputs and a theory of production and cost at depository financial institutions. Journal of Finance, Volume 32, pp. 1251-1266.

Sensarma R. 2005. Cost and profit efficiency of Indian banks during 1986 – 2003: A Stochastic Frontier Analysis. Economic and Political Weekly p. 1198 – 1209.

Shen. Zhie ,Hailin Liao & Thomas Weyman-Jones, 2009. Cost efficiency analysis in banking industries often Asian countries and regions. Journal of Chinese Economic and Business Studies, Taylor and Francis Journals, vol. 7, No.2, p 199-218.

Tesfaye B. 2014. Efficiency in the Ethiopian banking system: an application of Data Envelopment Analysis. European Journal of Business and Management, Vol. 6, No. 23, p 129-138.

Tsionas, E. (2002). Stochastic frontier models with random coefficients. Journal of Applied Econometrics 17, 127-147.

Annexes

Annex – 1: List of Sample Banks

Ser. No.	Name of the Bank	Abbreviation	Ownership
1	Commercial Bank of Ethiopia	CBE	State owned bank
2	Construction and Business Bank	CBB	State owned bank
3	Dashen Bank	DB	Private owned bank
4	Awash International Bank	AIB	Private owned bank
5	Bank of Abyssinia	BOA	Private owned bank
6	Wegagen Bank	WB	Private owned bank
7	United Bank	UB	Private owned bank
8	Nib Bank	NIB	Private owned bank

Annex – 2: Maximum likelihood estimation result of cost efficiency

Parameter		Coefficient	Standard - error	t – statistics
β0	***Constant***	4.85973	0.73315	6.62852
β1	***ln LA***	-1.25879	0.39972	-3.14919
β2	***ln DEP***	1.74691	0.44371	3.93708
β3	***ln OEA***	0.19744	0.19590	1.00786
β4	***ln (PL/PPC)***	2.40729	0.45034	5.34554
β5	***ln (PF/PPC)***	-1.09070	0.47193	-2.31114
β6	***ln EQ***	-0.36167	0.45334	-0.79778
β7	***t***	0.08663	0.08122	1.06664
β8	***ln LA2***	1.06203	0.20932	5.07358
β9	***ln DEP2***	0.75801	0.18830	4.02562
β10	***ln OEA2***	0.05186	0.02445	2.12134
β11	***ln (PL/PPC)2***	0.27819	0.08219	3.38482
β12	***ln (PF/PPC)2***	0.06057	0.07510	0.80657
β13	***ln EQ2***	0.14156	0.15256	0.92793
β14	***t2***	-0.00257	0.00145	-1.77533
β15	***ln LA . Ln DEP***	-1.55808	0.33175	-4.69653
β16	***ln LA . Ln OEA***	0.03116	0.07425	0.41970
β17	***ln LA . Ln (PL/PPC)***	0.39982	0.15379	2.59985
β18	***ln LA . Ln (PF/PPC)***	-0.59561	0.12387	-4.80842
β19	***ln LA . Ln EQ***	-0.50910	0.18419	-2.76402
β20	***ln LA . T***	0.00676	0.03213	0.21026
β21	***ln DEP . Ln OEA***	-0.14695	0.08656	-1.69768
β22	***ln DEP . Ln (PL/PPC)***	-0.27860	0.16608	-1.67755
β23	***ln DEP . Ln (PF/PPC)***	0.68064	0.21511	3.16410
β24	***ln DEP . Ln EQ***	0.24724	0.27056	0.91380
β25	***ln DEP . T***	-0.04730	0.02694	-0.75541
β26	***ln OEA . Ln (PL/PPC)***	0.01814	0.06228	0.29135
β27	***ln OEA . Ln (PL/PPC)***	-0.11536	0.05296	-2.17816
β28	***ln OEA . Ln EQ***	-0.06395	0.05456	-1.17191
β29	***ln OEA . t***	0.01933	0.00796	2.42807
β30	***ln (PL/PPC) . Ln (PF/PPC)***	-0.31989	0.13467	-2.37530
β31	***ln (PL/PPC) . Ln EQ***	-0.25568	0.14235	-1.79616
β32	***ln (PL/PPC) . t***	0.00749	0.02481	0.30196
β33	***ln (PF/PPC) . Ln EQ***	0.10717	0.17560	0.61028
β34	***ln (PF/PPC) . t***	-0.00104	0.01865	-1.05581
β35	***ln EQ . t***	0.02903	0.02727	1.06418
δ0	***Constant***	1.01788	0.20722	4.91218
δ1	***size***	-0.14397	0.03239	-4.44447
δ2	***ownership***	0.12961	0.06816	1.90162
δ3	***time***	-0.01411	0.00866	-1.62850
δ4	***gdp***	0.62689	0.37666	1.66433
σ^2	***Sigma - squared***	0.013354	0.00135	9.89124
γ	***Gamma***	0.999997	0.00002	56618.51100
Log Likelihood		164.90		
LR test		48.52		

Source: FRONTIER program Version 4.1 maximum likelihood estimation result.
Note: LA = Loans and advances, DEP = Total deposit, OEA = other earning assets, PL = Price of labor, PF = Price of fund, PPC = Price of physical capital, EQ = Equity, t = time.

Annex 3: Correlation Result

	CEFF(-1)	CEFF(-2)	CEFF(-3)	CEFF(-4)	NPL(-1)	NPL(-2)	NPL(-3)	NPL(-4)	BCAD(-1)	BCAD(-2)	BCAD(-3)	BCAD(-4)	ID	SIZE	OWNERSHIP	ROA
CEFF(-1)					-0.20	-0.23	-0.24	-0.15	-0.05	-0.15	-0.19	-0.20	-0.06	0.50	-0.09	0.06
CEFF(-2)					-0.06	-0.10	-0.15	-0.15	-0.05	-0.12	-0.18	-0.20	-0.01	0.45	-0.11	-0.01
CEFF(-3)					-0.05	-0.02	-0.01	-0.07	-0.11	-0.18	-0.23	-0.24	0.28	0.45	-0.05	0.18
CEFF(-4)					-0.08	-0.02	0.07	0.07	-0.12	-0.29	-0.33	-0.36	0.19	0.51	0.03	0.19
NPL(-1)	-0.20	-0.06	-0.05	-0.08					-0.37	-0.32	-0.21	-0.17	-0.12	-0.23	0.44	-0.51
NPL(-2)	-0.23	-0.10	-0.02	-0.02					-0.37	-0.34	-0.24	-0.19	-0.04	-0.21	0.45	-0.44
NPL(-3)	-0.24	-0.15	-0.01	0.07					-0.40	-0.40	-0.35	-0.29	0.02	-0.09	0.49	-0.27
NPL(-4)	-0.15	-0.15	-0.07	0.07					-0.40	-0.43	-0.41	-0.39	-0.03	0.00	0.52	-0.22
BCAD(-1)	-0.05	-0.05	-0.11	-0.12	-0.37	-0.37	-0.40	-0.40					-0.08	-0.38	-0.54	0.25
BCAD(-2)	-0.15	-0.12	-0.18	-0.29	-0.32	-0.34	-0.40	-0.43					-0.15	-0.42	-0.49	0.10
BCAD(-3)	-0.19	-0.18	-0.23	-0.33	-0.21	-0.24	-0.35	-0.41					-0.09	-0.46	-0.45	0.02
BCAD(-4)	-0.20	-0.20	-0.24	-0.36	-0.17	-0.19	-0.29	-0.39					-0.07	-0.47	-0.44	0.01
ID	-0.06	-0.01	0.28	0.19	-0.12	-0.04	0.02	-0.03	-0.08	-0.15	-0.09	-0.07				
SIZE	0.50	0.45	0.45	0.51	-0.23	-0.21	-0.09	0.00	-0.38	-0.42	-0.46	-0.47	0.21			
OWNERSHIP	-0.09	-0.11	-0.05	0.03	0.44	0.45	0.49	0.52	-0.54	-0.49	-0.45	-0.44	0.06	0.38		
ROA	0.06	-0.01	0.18	0.19	-0.51	-0.44	-0.27	-0.22	0.25	0.10	0.02	0.01	0.48	0.17	-0.26	

Appendix – 4: GMM and Granger Causality Test Result

Parameter	Dependant Variable: Cost Efficiency				Dependant Variable: Credit Risk (Non-performing Loan)				Dependent Variable: Bank Capital Adequacy			
	Coefficient	Std. Error	t-Stat.	Prob.	Coefficient	Std. Error	t-Stat.	Prob.	Coefficient	Std. Error	t-Stat.	Prob.
Constant	0.21487	0.11178	1.92228	0.05920*	0.08810	0.03735	2.35908	0.02150**	-0.02387	0.02554	-0.93464	0.35370
Ceff(-1)	0.39852	0.11436	3.48475	0.00090***	-0.08560	0.03104	-2.75759	0.00770***	0.01683	0.01803	0.93318	0.35440
Ceff(-2)	-0.10428	0.10142	-1.02824	0.30790	-0.05595	0.02998	-1.86664	0.06680*	0.01469	0.01842	0.79737	0.42830
Ceff(-3)	-0.01757	0.07286	-0.24110	0.81030	-0.00646	0.02595	-0.24913	0.80410	0.04586	0.01621	2.82876	0.00630***
Ceff(-4)	0.04357	0.07953	0.54783	0.58580	-0.02129	0.02815	-0.75621	0.45240	0.00180	0.01871	0.09617	0.92370
Cost efficiency (total)				**0.00780*** **				**0.04250** **				**0.03830** **
Npl(-1)	-0.225295	0.122110	-1.845017	0.0627*	0.74793	0.06428	11.63616	0.00000***	0.02323	0.03795	0.61206	0.54280
Npl(-2)	0.115979	0.226314	0.512469	0.6089	-0.11935	0.07104	-1.67994	0.09810*	0.04466	0.03695	1.20870	0.23140
Npl(-3)	-0.055180	0.022924	-2.407084	0.0254**	0.10730	0.05993	1.79030	0.07840*	-0.04522	0.02852	-1.58566	0.11800
Npl(-4)	-0.249330	0.102340	-2.436291	0.0189**	-0.08866	0.03637	-2.43800	0.01770**	0.04103	0.02854	1.43740	0.15570
Credit risk (total)				**0.0550** **				**0.00000*** **				**0.04170** **
Bcad(-1)	-0.01988	0.48850	-0.04069	0.96770	-0.20695	0.16872	-1.22661	0.22470	0.81889	0.12318	6.64816	0.00000***
Bcad(-2)	0.43484	0.68111	0.63843	0.52560	0.34374	0.19301	1.78096	0.07990*	-0.11462	0.13349	-0.85867	0.39390
Bcad(-3)	0.18978	0.49736	0.38157	0.70410	0.14560	0.15416	0.94445	0.34870	-0.04301	0.08706	-0.49397	0.62310
Bcad(-4)	-0.00066	0.31978	-0.00206	0.99840	-0.35123	0.08154	-4.30767	0.00010***	0.11208	0.05796	1.93378	0.05780*
Bank capital adequacy (Total)				**0.22830**				**0.00020*** **				**0.00000*** **
Income diversification	0.00722	0.01033	0.69944	0.48690	-0.00272	0.00230	-1.18446	0.24080	-0.00014	0.00201	-0.06875	0.94540
Size	0.04424	0.01275	3.47121	0.00100***	-0.00555	0.00373	-1.48607	0.14240	-0.00788	0.00212	-3.72051	0.00040***
Ownership	-0.06155	0.02949	-2.08737	0.04100**	0.00774	0.00776	0.99756	0.32240	-0.00521	0.00396	-1.31446	0.19360
ROA	-1.28198	0.77644	-1.65109	0.10390	-0.15147	0.27431	-0.55218	0.58280	0.54673	0.25621	2.13397	0.03690**
Year (2005)	-0.01935	0.04601	-0.42061	0.67550	-0.01003	0.01345	-0.74571	0.45870	0.00457	0.00539	0.84775	0.39990
Year (2006)	0.02830	0.04441	0.63721	0.52640	-0.01260	0.01298	-0.97116	0.33530	0.01551	0.00468	3.31328	0.00160***
Year (2007)	0.00427	0.04029	0.10601	0.91590	0.00154	0.01275	0.12055	0.90440	0.02856	0.00819	3.48869	0.00090***
Year (2008)	0.01918	0.04662	0.41134	0.68230	0.00048	0.01391	0.03444	0.97260	0.02187	0.00775	2.82015	0.00650***
Year (2009)	0.01209	0.03916	0.30863	0.75870	-0.00447	0.01394	-0.32045	0.74970	0.01870	0.00609	3.06882	0.00320***
Year (2010)	-0.02803	0.03974	-0.70520	0.48340	-0.04009	0.01110	-3.61079	0.00060***	0.02389	0.00625	3.82364	0.00030***
Year (2011)	0.01479	0.04196	0.35246	0.72570	-0.01063	0.01133	-0.93794	0.35200	0.02137	0.00608	3.51613	0.00080***
Year (2012)	-0.01097	0.04662	-0.23526	0.81480	-0.01773	0.01350	-1.31277	0.19420	0.03137	0.00719	4.36484	0.00010***
Year (2013)	-0.02051	0.04646	-0.44146	0.66040	-0.00379	0.01202	-0.31550	0.75350	0.02666	0.00654	4.07361	0.00010***
Year (2014)	-0.04305	0.04388	-0.98119	0.33040	-0.02256	0.01459	-1.54627	0.12720	0.03633	0.00745	4.87977	0.00000***
Year (total)				**0.19870**				**0.00000*** **				**0.00000*** **
R-squared	0.56809				0.94660				0.90004			
Adjusted R-squared	0.38400				0.92384				0.85743			
S.E. of regression	0.06566				0.01952				0.01249			
Durbin-Watson stat.	1.44363				2.08118				2.10558			
Instrument rank	28				28				28			
Mean dependent var.	0.90133				0.07881				0.10835			
S.D. dependent var.	0.08366				0.07073				0.03309			

Sum squared resid	0.26300				0.02324				0.00952			
J-statistic	1.32057				0.05035				0.41111			
P-Value of J-statistics	**0.250491**				**0.82245**				**0.52140**			

Note: the study uses step system GMM estimator developed for dynamic panel model. The symbols *, **, *** represent significance levels of 10%, 5% and 1%, respectively. The variable Cost efficiency (total), credit risk (total) and bank capital adequacy (total) are the estimated coefficients for the test that the sum of lagged terms (for the cost efficiency, the bank risk-taking and the equity asset ration variables, respectively) is equal to zero. A significance level lower than 10% enables to reject the null hypothesis of no causality from the *x* to the *y*. A coefficient greater than zero show a positive causation from the x to the y; a coefficient smaller than zero show a negative causation from the x to the y.