EFFICIENCY OF COMMERCIAL BANKS IN KENYA

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DECLARATION

STUDENT'S DECLARATION

This research paper is entirely my work and has never been submitted for a degree at any university.

Signed   Dated 23rd November 2022

Fredrick Namagwa Onyango

X50/34838/2019

SUPERVISOR'S DECLARATION

This paper has been submitted with my approval as the university supervisor.

Signed…………………………………… Dated 25/11/2022…………………………………………

Dr. Owen Nyang'oro

DEDICATION

This study is dedicated to Patience and Leo, for creating a supportive environment to carry out this project.

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ABSTRACT

We looked into Kenyan banks' efficiency and their determinants since 2014 to 2019. To find the efficiency of these banks, we employed Data Envelopment Analysis. In the following stage, a probit model was employed to assess the relationship of commercial banks' efficiency scores with interest rate, bank size, credit risk and liquidity ratio. The study's empirical findings show that interest rate, bank size and liquidity ratio have a positive relationship with banks being efficient or on the efficiency frontier. Larger banks, those charging a higher interest rate and those with high liquidity ratios are likely to be the most efficient in their peer group.

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LIST OF ACRONYMS AND ABBREVIATIONS

CBK	Central Bank of Kenya
CRS	Constant Returns to Scale
DEA	Data Envelopment Analysis
DMU	Decision-Making Units
DTMs	Deposit Taking Microfinance Institutions
EU	European Union
GDP	Gross Domestic Product
LDR	Loan-to-deposit ratio
OECD	Organization for Economic Cooperation and Development
SFA	Stochastic Frontier Analysis
TOC	Theory of Constraints
OTE	Overall Technical Efficiency
PTE	Pure Technical Efficiency
SE	Scale Efficiency
NPL	Non-performing loans

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Financial system is essential to a nation's economic growth and progress (World Bank, 1989). The debate over finance and growth can be traced back to Joseph Schumpeter's days in 1911 (Beck, Levine & Loayza, 1999). According to Schumpeter, the primary function of financial institutions in economic development is determining firms that should employ a society's limited resources.

According to the World Bank (1989), financial institutions are vital in an economy because they provide services such as payment mechanisms, savings mobilisation, credit allocation and trading as a result of the saving mobilisation together with credit allocation processes. If the commercial banks involved are efficient, they can help an economy expand by making the trade of goods and services more affordable and the loan and borrowing process more transparent. The banking system enables an economy to flourish by facilitating commerce, savings and resource efficiency. To increase the willingness of individuals and corporations to invest in long-term assets, banks offer attractive rates for their deposits, lending, and products (Heffernan, 2005).

The capacity of a bank to make the most out of the available resources is called efficiency. Efficiency is attained by maximising output and profitability, and the elimination of waste, i.e. implying the gap between service costs and profits, must be as high as possible. Dmitry (2018) opines that bank performance may be measured by operational performance; this relates to how successfully banks follow legal and national guidelines. Financial institutions work well when their operations are compatible with the legal requirements of the economy in which they operate.

For a country's economy to thrive, its financial industry must operate successfully since the banking industry significantly impacts economic development (Ngunyu, 2013). One of the pillars of a developing economy is the efficient utilisation of resources and commercial banks' competitive viability. Consequently, the extent to which commercial banks contribute to overall efficiency in an economy is linked to their operational efficiency. Efficiency means higher profits, more income for financial institutions, fair prices, and better client service (Berger et al., 1993).

1.1.1 Efficiency concepts

In his early publications, Pareto (1897) proposed the concept of efficiency as a broad performance metric for all enterprises. Since then, the idea of efficiency has attracted more attention in economic literature. It is understood as the state of optimal performance; that is, in product creation, an efficient firm has highest possible proportion of outputs to inputs. The highest possible ratio illustrates the most effective utilisation of scarce resources to generate maximum output (Alomari, Bashayreh, & Abdelhadi, 2020).

The financial system's efficiency level can be measured to help classify the performance of measuring units and determine whether there is potential for further development. These measures may give managers and regulators useful information for decision-making. According to Oluitan (2014), banking efficiency is essential for the financial sector to fulfil its objectives. A healthy financial sector tremendously impacts the economy at all levels facilitating free resource flow between surplus and deficit sectors. Cost reduction and profit maximisation are two aspects of efficiency, suggesting that a technically efficient firm achieves the desired output by properly utilising the inputs. In contrast, a cost-efficient one keeps the cost of output or service delivery as low as possible. A technically efficient firm cannot produce more without creating less of another (Koopmans, 1951). Allocative efficiency, however, involves determining the best combination of inputs at a given price to maximise outputs and profit. In order to attain business success, firms will aim for economic efficiency, including cost, technical, and allocative efficiency.

According to research, the efficient banks enjoy significant cost reduction benefits and competitive edge over others (Spong, Sullivan, & DeYoung., 1995). The cost of financial intermediation in a macro environment is affected by efficiency of the institutes of finance since banks act as a spinal cord in the financial markets. Inefficient business operations have several ramifications. These firms affect their production and ability to survive in a competitive market. Inefficiencies also contribute to waste because they hinder effective resource allocation within the country.

This research deals with technical efficiency, it assesses a bank's capacity to obtain the maximum feasible return from certain inputs or utilise minimal inputs for allowed output production. Technical efficiency is attained when extra output cannot be produced without reducing the production of another or increasing the production of at least one input. Scale efficiency (SE) and pure technical efficiency (PTE) are the two types of technical efficiency. PTE assesses how well banks allocate resources to maximise performance at a given size, while SE denotes the bank's proximity to its most profitable scale size. Other efficiency concepts include profit, cost and revenue efficiency. These concepts have an economic foundation since they have economical optimisation in response to market prices.

The gap between a firm's fluctuating earnings and the predicted profit necessary to create an optimal output bundle as economically as the best-practice firm is defined as profit efficiency (Berger & Mester, 1997). Profit efficiency contains the cost and revenue functions from variable inputs and outputs to depict the goal of profit maximisation. The standard profit measure is essential when firms deliver higher quality or additional services, which may increase earnings more than costs. Berger and Mester (1997) argue examining efficiency from a cost-cutting or revenue-maximizing position overlooks the point of firms, which is to raise profits while decreasing costs. It relates efficiency improvements to organisational efforts, environmental variables, and best practices.

The revenue efficiency technique compares the difference in a firm's earnings after a random error has been corrected to the estimated earnings that would be obtained by generating output as effectively as the firm with the best practice in the industry (Berger & Mester, 1997). Revenue efficiency is inferred from an output distance function that assesses output efficiencies since it cannot be directly assessed. If businesses have enough market power to extract the corresponding consumer surplus, revenue efficiency happens when they charge higher prices for higher quality services.

Any institution's cost efficiency is determined by its performance compared to the best firm’s performance with the lowest costs (Berger & Mester, 1997). Cost efficiency evaluates how closely a firm's expenses resemble those of the firm with the best practice when making similar outputs in the same environment. The utilisation of an excessive or inappropriate combination of input and output quantities, which leads to cost inefficiency, is a common consequence of technical inefficiency. Cost-efficiency may also be influenced by scale and scope efficiencies. The issue of whether the institution has the proper size in terms of production costs and the volume of output is addressed by scale efficiency. When an institution's cost of production declines per unit as production increases, it is said to be taking advantage of economies of scale. Jensen and Meckling (1976) consider diseconomies of scale to emerge when production costs per unit rise above a specific threshold. This suggests diseconomies of scale at higher output levels while economies of scale at lower output levels, resulting in a U-shaped average cost curve.

1.1.2 Overview of the Banking Sector in Kenya

Zeleza (1991) opines that Kenya's financial industry has developed substantially since the country’s independence in 1963. Only seven commercial banks existed when the country gained independence; by 1972, only one more had been added. The banking sector had considerable growth in the 1980s and 1990s.

By 31st December 2012, the banking industry had forty-four banking institutions (CBK, 2012). In the period ending 31st December 2015, seven major banks controlled more than 58% of the market (CBK, 2015). Banks in Kenya have been classified by the Central Bank of Kenya (CBK) into three tiers based on their market share, assets, and quantity of client deposits. Big banks' weighted composite index is at least 5%. Medium banks’ weighted composite index lies between 1 and 5%, whereas a weighted composite index of less than 1% defines small banks. Large banks make up Tier 1, which controls a large portion of the market, 49.9%. Medium-sized banks are categorised in tier 2. Medium banks have 41.7% of the total market share, while tier 3 banks have 8.4% of the market (CBK, 2015). Kenyan banks have different ownership structures. These structures can be classified as public and private, where we have foreign and local banks under private. Regarding ownership, the foreign-owned banks were 12, banks with government participation 6, and locally owned banks 15.

Since Kenya's independence, the banking sector has seen some important structural changes, some of which were intended to make banks leaner but more effective. These modifications include employee layoffs, branch rationalisation, and computerisation. The most important reforms implemented in the 1990s was liberalisation of interest rates and the introduction of open markets in favour of direct lending regulations (Cihak & Podpiera, 2005). However, given the ongoing distortions in other parts of the economy, it is unclear whether liberalisation has improved credit allocation efficacy. Large, ineffective government-owned institutions have hampered the Kenyan banking sector's efforts to improve intermediation efficiency. They accounted for the vast bulk of bad loans in the banking system.

Banks in Kenya continue to embrace technological breakthroughs in data processing and communication. These improvements give the institutions chances to raise their efficiency. The hope of increasing efficiency spurs the merging movement in Kenya. Banks consider acquisitions as a strategy to redistribute the expense of developing new products and back office operations over a broad base. By removing duplicate offices, employees, and other resources and services, acquisitions can enable the construction of more effective branch delivery systems (Spong et al., 1995). These trends imply that bankers' main priorities should be greater productivity and that successful resource management is essential for development of the banks.

However, collapse of some banks in 1980s and 1990s forced the authorities to critically scrutinise the institutional framework of Kenya's financial system (Cihak & Podpiera, 2005). Because of this, the Central Bank's bank Supervision Department was reinforced, allowing it to undertake inspections of financial institutions. Also, it is mandated: to conduct on-site inspections of each financial institution at least once a year, determine capital adequacy and assess the quality of institutions, evaluate management competence, examine trends in institutions' earnings and liquidity and foreign exchange operations, and general soundness of these institutions.

1.2 Statement of the Problem

Efficiency is vital for boosting revenues, productivity, and customer satisfaction. Efficiency improves a bank's strategic position in the industry. Due to the financial sector's fragility and inefficiency, there is a limit to how efficiently resources can be accumulated and distributed, resulting in waste. Financial performance may be improved by supporting aggressive cost-cutting efforts and creating sustainable efficiency programmes. Executives at commercial banks must foresee short and long-term impacts of cost-cutting.

Efficiency measures have also failed to recognize the need for modification to keep up with economic trends and government regulations like interest cap laws. Regulatory measures frequently impose direct and indirect costs on the financial sector, resulting in higher interest spreads or fees on fee-based transactions (Hanson & Rocha, 1986). A decrease in the interest spread is a crucial advantage of increased efficiency (Vittas, 1991). Kamau (2011) opines that market forces determine bank rates in an efficient banking system. However, in an inefficient banking system, rates are not even with fundamentals of the market such as demand and supply, stretching the spread between the deposit and lending rates.

Wide interest rate spreads characterize Kenya's financial system. These challenges, along with inherent flaws and limited private-sector credit, are impeding economic growth. In 2016, the government established an interest cap to improve the financial system's efficiency. The interest cap was designed to protect borrowers from high credit interest rates, make loans more affordable, and improve financial intermediation by increasing credit access. However, following interest rate capping, banks avoided smaller borrowers and increased their holdings of government securities leading to a decline in private sector lending. Banks also boosted their revenue through commissions and fees instead of interest income. Small banks were severely impacted, with significant capital reductions (CBK, 2018).

The primary goal of any bank is to use resources effectively and efficiently. Although this objective has always been significant in banking, current circumstances have elevated banking efficiency to the limelight. Though Kenyan mainstream banks have been reporting huge profits recently, as seen from their financial reports, the banking sector has its fair share of challenges. Growing rivalry for financial services and technological advancement, for example, emphasizes cost control and efficient delivery of banking products and services.

Because of these challenges, it is becoming clear that banks' management must get the best from all the resources at their disposal. Efficiency is undoubtedly vital for staying competitive. Prudently, concentrating on cost-cutting is not a recipe for commercial bank efficiency and long-term success. However, increasing a bank's efficiency is a more balanced approach to increasing its capacity to adapt to market needs and change current and future trends to boost its success and assure long-term profitability. Since it is expected that when financial institutions operate more efficiently, their profits increase and a more significant amount of funds is intermediated; as a result, this study will focus on a recent time in order to estimate efficiency levels and their determinants.

1.3 Research questions

The following questions were addressed during this study:

i. What are the efficiency scores of Kenya's commercial banks?

ii. What are the determinants of banks' efficiency in Kenya?

1.4 Objectives of the study

The primary goal was to analyse efficiency and examine the determinants of the efficiency of banks in Kenya. Specific objectives included:

i. Analysing how bank-specific characteristics influence bank efficiency.

ii. Examining the determinants of banks' efficiency.

iii. Providing policy implications.

1.5 Justification of the Study

In contemporary business, assessing efficiency has become an essential component. It gives a quantitative and qualitative outline of banks' performance. The findings of this study facilitate the designing of banking reforms and policies. Technical efficiency results may help estimate how banks can enhance output without spending more on inputs. It also leads to better compliance with the legal requirements imposed by Kenya's central bank. Efficiency measures provide a basis for an excellent competitive structure and improvement of institutions' management and performance. It also offers information about the economy's financial health. As a result, this study examines commercial banks' management efficiency levels and also evaluates their operational scale. Because of the challenges banks face, it is becoming clear that bank management must get the best from all resources. Companies implementing efficiency initiatives are more likely to improve their financial performance by encouraging aggressive cost-cutting activities; creating and maintaining long-term efficiency programmes (Ngunyu, 2013). Therefore, monitoring the effectiveness of the banking system is vital as a critical indicator of a nation's economic performance. Analysis of the banks' efficiency determinants was essential to this study since it gives detailed information on some factors that management can incorporate to improve their performance and efficiency.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Efficiency largely determines commercial banks' long-term viability. This study evaluated banks' efficiency by looking at their operating features in terms of efficiency metrics. Several industries, notably banking, have highlighted efficiency as an essential success metric. This chapter includes an empirical review of bank efficiency and fundamental theories.

2.2 Theoretical Review

The vast majority of research concentrate on bank profitability and how they perform in a competitive environment in terms of efficiency. The primary reason is that banks are unique in their essential role in providing business loans. Theoretical literature dealt with main theories around efficiency. The ideas discussed in this section included agency theory and the theory of constraints.

2.2.1 Agency Theory

This theory explains how efficiency and ownership structure are related. This theory addresses the interaction of principals and agents. Managers, being the agents in firms, will try to enhance and fulfil their interests where there is incomplete information on labour and capital markets. Principals depend on the hired agents to carry out specific tasks, notably financial transactions on their behalf, which often leads to a disparity in priorities and practices. In most cases, unlike the agent, the principal has little knowledge of the project at hand. This means that having chosen the agent they believe is competent, the principal relies on the agent to carry out the given transaction or activity efficiently. This theory is also mired by the principal-agent problem, which is a concept that includes moral hazard and asymmetry of information (Shapiro, 2005).

The ability of a bank to receive accurate information about its customers' financial prospects, establish effective contracts, and enforce them depends on the property rights, laws, regulations, and contractual contexts in which it operates. Sometimes managers would raise factor costs deliberately over the optimal levels necessary for efficient operations and ignore ideal risk positions, which would otherwise enhance shareholder wealth prospects.

The agency theory is put in place to solve two main problems. One is the common occurrence that principals and agents always have different goals. Secondly, determining agents' activities are costly and challenging for principals (Rose, 1992).

Positivist agency scholars have been concentrating on identifying circumstances in which the principal and the agent's goals are likely to clash and explaining ways to limit agents' agendas. Furthermore, the principal-agent relationship between the proprietors and administrators of large, publicly traded enterprises has also received attention. In contrast, principal-agent scholars are interested in a general theory showing their relationships and scenarios it may be applied in, such as that of an employer and employee in a firm (Harris & Raviv, 1978). Because the banking sector works as an agent for investors and borrowers, the agency theory was found relevant in this study.

Like any principal-agent interaction, the banking sector may face moral hazards and information asymmetry issues. The efficiency of financial markets can be undermined by a lack of monitoring, uncertainty about the value of money tomorrow, enforcement measures, and any lack of information about the counterparty. As a result, regulatory bodies are crucial in helping to reduce inconsistencies in financial markets, allowing them to function more efficiently. Another component is transparency, which improves financial market efficiency by reducing monitoring and information costs for borrowers and banks. Transparency has been enhanced through market discipline and accounting disclosure rules.

2.2.2 Theory of Constraints

The primary agent framework highlights the influence of ownership and the importance of the amount management is restrained by the discipline of the capital market. Theoretically, the authority of owners over management is reduced when there is a lack of capital market discipline since managers are free to follow their own objectives because there are few incentives for them to be efficient.

The goal of any corporate organization or business setup is to improve its operational performance using a variety of methods continuously. The constraint theory concentrates on organizational restrictions and bottlenecks that slow down output; its fundamental concept is to increase an organization's throughput by increasing the output rate.

The theory of constraint focuses on organizational constraints that hinder efficient production processes. The firm's primary goal is to increase output as quickly as possible. Therefore, it necessitates a thorough examination of bottlenecks and restrictions. Therefore, this theory requires the management of organizations to reconsider their beliefs on how to accomplish their objectives, what constitutes productive behaviour, and what the actual purpose of cost management is. When demand for a resource exceeds availability, a company experiences a bottleneck (Flint, 2000). Situational circumstances, on the other hand, shortage of skilled staff, make accomplishing definite goals more complex than they would otherwise be.

The sales theory of constraints emphasizes the need to optimize objectives and revenues earned, aiming to overcome the identified barriers that stand in the way of an organization's success (Beverley, 1996). Financial experts utilize management accounting to identify and deliver a report on analysed opportunities impacting the business, playing a significant part in the implementation of the theory of constraint. Management accounting provides the foundation for integrating the various data sources available to decision-makers (King, 2008).

The theory of constraints relates to this research because banks use the cash generated from depositors to invest in ventures with varying degrees of risk, such as loans. Banks are under pressure to reduce operating expenses to boost earnings because non-traditional banking entities such as Safaricom are putting the traditional banking model to the test. On the other hand, the imposition of an interest cap reduced interest spreads, interfering with bank earnings.

2.3 Empirical Literature Review

Several studies have been conducted on banking efficiency. For example, Chortareas, Girardone, and Ventouri (2012) examined how regulations and oversight policies influenced the banks' efficiency from 2000 to 2008 using Data Envelopment Analysis (DEA) in 22 countries in European Union. Using the quasi-likelihood estimation method, the second stage of the study looked at DEA efficiency scores, intermediation costs, and cost-to-income ratios. Chortareas et al. (2012) found that tightening capital limits in collaboration with regulatory agencies improve private sector monitoring. Therefore, regulation of bank operations can increase the efficiency of banks.

It has been established in Kenya that banks with low productivity find it costly to examine and supervise microfinance services (Blattman et al., 2004). The legal system's flaws make it difficult to enforce contracts and lead to comparatively high-value collateral requirements that smallest businesses find challenging to meet. Small businesses are less likely to have valuable security and are consequently subjected to significantly higher borrowing rates than their larger counterparts, making them less productive. Generally speaking, smaller businesses report using fewer credit instruments. Due to the expense and risk of rejection, these businesses are less inclined to ask for loans, making them credit-constrained (Blattman et al., 2004).

Ngugi (2001) investigated the variables that influence the interest rate spread within Kenya's banking industry. To reflect efficiency benefits and lower transaction costs as a result of the elimination of anti-competitive measures and the strengthening of the institutional framework, spreads in interest rates in the industry were predicted to contract over the post-liberalisation period (mid-1991). However, due to high intermediation costs and yet-to-be-acquired efficiency, evidence suggests that the spread expanded in the post-liberalisation period (Ngugi, 2001). The bank's efforts to protect vulnerable profit margins explain variations in the interest spread. As the percentage of non-performing loans increased, banks that faced increasing credit risk added a high premium to the lending rate.

The relative efficiency of 201 large banks in the United States of America was analysed by Miller and Noulas (1996). The study of the banks from 1984 to 1990 was carried out using data envelopment analysis. Interest paid, non-interest payments and deposits were among the inputs, whereas outputs included loans, interest revenue, non-interest income, and investments. The study found that technical efficiency was better in more extensive and profitable banks.

Adjei-Frimpong, Gan, and Hu (2014) used data envelopment analysis on Ghanaian banks' data between 2001 and 2010 to evaluate effect of banks' characteristics on efficiency. The study assessed the effect of the size of assets and capitalisation of a bank on efficiency using panel models. The findings reveal that the efficiency of banks was negatively influenced by capital adequacy, whereas bank size had little impact. Leong and Dollery (2004) also examined Singaporean banks between 1993 and 1999 to estimate influence of commercial banks' features on the efficiency. The study found that larger banks had more inefficiencies in their operations because of their size and complexity. Data shows that small banks have higher profit efficiency than large banks. In Ghana, small-sized banks were more scale efficient than large-sized banks because big banks have high average expenditures, implying that bank mergers would not enhance efficiency (Akoena, Aboagye, Antwi-Asare, & Gockel, 2009).

Drake and Hall (2003) studied the scale and the technical efficiency of Japanese banks to find reasons for bank mergers. The study revealed significant levels of inefficiency among Japanese banks. The analysis of Japanese banks suggests significant size-efficiency, that is, technical and scale efficiency, which explains the rationale for large-scale mergers in Japan's financial industry

(Drake & Hall, 2003). Fukuyama (1996) found that in comparison to scale inefficiency, pure technical inefficiency is the most significant contributor to total technical inefficiency in Japan's banks. As a result, efficiency was unaffected by the number of assets.

Ongore and Kusa (2012) analysed financial capabilities of banks in Kenya from 2001 to 2010. Panel data were analysed using multiple linear regression and generalised least squares. Except for the liquidity variable, the results indicated that bank-specific factors influenced commercial banks' performance. Accordingly, Musundi's (2008) examination of the relationship between commercial banks' profitability and size in Kenya between 1998 and 2007 demonstrates that liquidity positively affects profitability, whereas size has a negative effect.

Mutanu (2002) examined the performance characteristics of highly and lowly capitalised Kenyan banks using efficient cost frontier approach. In a study of eight publicly traded commercial banks, (Mutanu, 2002) reported that lowly-capitalised institutions were more efficient than the well capitalised banks. Mutanu (2002) reported that lowly-capitalised institutions were more efficient than the well capitalised banks.

Sakina (2006) investigated the X-efficiency of 33 commercial banks in Kenya. The stochastic econometric cost frontier analysis was used and concluded that the level of X-efficiency was 18%. The small banks were more inefficient than the average big banks, according to the evidence. The findings supported the forecast of a positive relationship between a bank's growth, profitability, and technical efficiency. Mutanu's (2002) study was confirmed by Sakina's (2006) findings that small banks are less efficient than large banks. Also, the findings contradicted Mutanu (2002), which indicated that Kenyan banks with high capitalisation levels were less efficient than those with low capitalisation levels. The development of the banks' capital structures over the course of the study may be the cause of the positive association between capitalisation and technical efficiency found in Mutanu's (2002) research. Long-term borrowing has been eschewed by commercial banks in favour of less expensive equity capital. This is demonstrated by the rise in the use of stock offerings by banks, such as share splits and bonus issues. It has been shown that banks would operate more efficiently if the long-term debt were increasingly preferred to equity because shareholders would have more control over the management of the institutions (Limam, 2001).

Taylor, Thompson, Thrall, and Dharmapal (1997) used Data Envelopment Analysis to examine the Mexican rural banks' technical efficiency from 1989 to 1991. The mean efficiency score was 0.72. The results also show that bank characteristics instead of customer profiles were significant efficiency drivers. By shifting their input mix over time, the findings suggest that banks could improve their efficiency in comparison to their rivals.

Sathye (2001) examined X-efficiency in Australian banks using DEA. The sampled Australian banks ranked low in efficiency scores compared to European and U.S. banks. In comparison to the American and European banks, the sampled banks were found to have low overall efficiency levels. According to the findings, technical efficiency was a bigger contributor to total inefficiency than allocative efficiency. Sathye (2001) attributed Australian bank inefficiency to waste inputs, that is, technical inefficiency, rather than inappropriate input combinations – allocative inefficiency. The study highlighted one of the advantages of the DEA approach. DEA identified the area of inefficiency, and this benefit would aid banks in making strategic planning decisions. Sathye (2001) found domestic banks with better efficiency levels than banks owned by foreigners. In Botswana, foreign-owned banks had better efficiency scores than domestic banks because they brought in better technology that helped to improve efficiency.

Kamau (2011) used the DEA to estimate the efficiency of Kenya's banking system. The study's important conclusions show that a good number of commercial banks performed averagely, with potential for improvement; the anticipated efficiency scores throughout the study were higher than 40%. The data also showed that banks under foreign owners were more efficient than domestic ones. Additionally, local private banks had better performance than public banks. According, to size, the findings revealed that large banks tend to have high efficiency levels.

Berger et al. (1999) investigated American banks' profit and cost efficiency and discovered that variation in operational efficiency scores is related to foreignness liability. As a result of the home-field advantage, foreign banks may encounter problems such as huge expenses during the provision of similar services or lower revenues when providing a service of the matching value and range as domestic institutions. Furthermore, while operating in other countries, banks may have enhanced operational efficiency since they can transfer better skills, practice policies and technology to local resources, cutting costs.

Havrylchyk (2006) assessed the technical efficiency, scale efficiency and cost efficiency of local and international banks in Poland between 1997 and 2001. In general, high levels of inefficiency were observed in domestic banks compared to international banks. Efficiency and credit risk were found to have a negative relationship (Havrylchyk, 2006). In analysing bank efficiency in transitioning economies, Weill (2003) found that banks under foreign ownership were more efficient than banks owned by locals. This efficiency was not attributable to variations in bank size or activity structure. However, it was also consistent with Hasan and Marton's (2003) research of Hungary from 1993 to 1997, which found locally owned banks in the initial stages of a transition much less efficient.

Barros, Ferreira, and Williams (2007) used a mixed logit model to analyse parameters explaining the likelihood of banks performing well or not. Efficiency scores were used as a performance indicator, and these scores were then transformed into binary responses of best and worst performance. According to this study, smaller banks with a higher lending intensity had a higher likelihood of achieving the best outcome. In contrast, foreign banks from countries with similar legal practices were likelier to be the best performers.

Staub, De Souza and Tabak (2010) used DEA and panel data regression to determine determinants of efficiency in the Brazilian financial system. They evaluated the bank's ownership, size, and activity. Staub et al. (2010) concluded that public banks were more cost-efficient than both private and foreign banks. Though, the type of activity and the size of the bank had no effect on efficiency. Some research found that greater asset size is connected with increased productivity and efficiency improvements (Miller & Noulas, 1996), but others argue in favour of smaller banks (Barros et al., 2007). Due to differences in management style and legal processes used by different ownership groups, ownership concerns impact the efficiency levels in the banking sector. Some studies show that public banks were superior to private and foreign-owned banks (Staub et al., 2010), whilst others argue in favour of foreign banks over public and private banks (Barros et al., 2007).

Ben, Mohamed, and Chenguel (2009) assessed the effects of liberalisation on the banking sector using a set of DEA models on panel data from Tunisian banks. The study revealed that private banks had better efficiency scores than public banks. The private banks attribute this performance as a result of their lower problem loan burden, higher foreign ownership participation, and typical smaller size. Additionally, the analysis showed that reforms had a lesser effect in bridging the gap of efficiency between foreign-owned private banks and domestically owned public banks.

Košak and Zajc (2006) established an inverse relationship between demand density and intermediation ratio in studying efficiency drivers in new members of the European Union (E.U.). Stochastic Frontier Analysis (SFA) approach was employed in the study. The cost efficiency was positively related to the deposit per capita and population.

2.4 Overview of the Literature

In contrast to Kamau's (2011) findings that domestic banks were less efficient than foreign banks, Berger et al. (1999) examination of American banks' profit and cost efficiency revealed that foreign banks were less efficient than local banks due to the home-field advantage. In the Brazilian banking system, Staub et al. (2010) concluded that state-owned banks are more cost-effective than private and foreign banks, while Ben et al. (2009) argued that private banks were more efficient than public sector banks in Tunisia.

Kamau (2011) and Sakina (2006) found that big banks had better efficiency scores than both medium and small banks. On the other hand, Barros et al. (2007) study indicated that smaller banks with more loan intensity had a higher probability of having the best performance, while Adjei-Frimpong et al. (2014) showed that bank size had little impact.

From the empirical literature, previous studies have been inconclusive about the ownership and bank size's effect on efficiency. By assessing bank's overall technical efficiency and breaking it down into SE and PTE, this study expands the frontier of knowledge on the subject. Additionally, this study looks at how technical efficiency relates to bank size, credit risk, liquidity risk, and interest rate. This research will also contribute to policy discussions about the privatisation of state-owned banks to increase efficiency.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the methodology that was employed in the study. This includes the conceptual framework, measurement and definition of the variables, data analysis techniques and the diagnostic tests that were applied.

3.2 Conceptual Framework

The conceptual framework shows two stages: estimating DEA-based efficiency and analysing determinants of DEA-based efficiency. In stage one, we used non-parametric techniques to calculate efficiency. Several bank efficiency studies have focused on the intermediation and production approaches. These two techniques were employed to explain the input-output relationship in the behaviour of financial institutions (Leong et al., 2002). The production approach regards financial institutions as creators of deposit and loan accounts, with the quantity of such transactions and accounts as the output (Ferrier & Lovell, 1990; Leong et al., 2002). On the contrary, commercial banks operate as financial intermediaries in an economy under the intermediation approach and leverage resources like labour, capital, deposits, and other borrowed resources to create assets that can generate income (Limam, 2001). This approach presupposes that banks' primary goal is to convert liabilities into loans (Millas & Noulas, 1996).

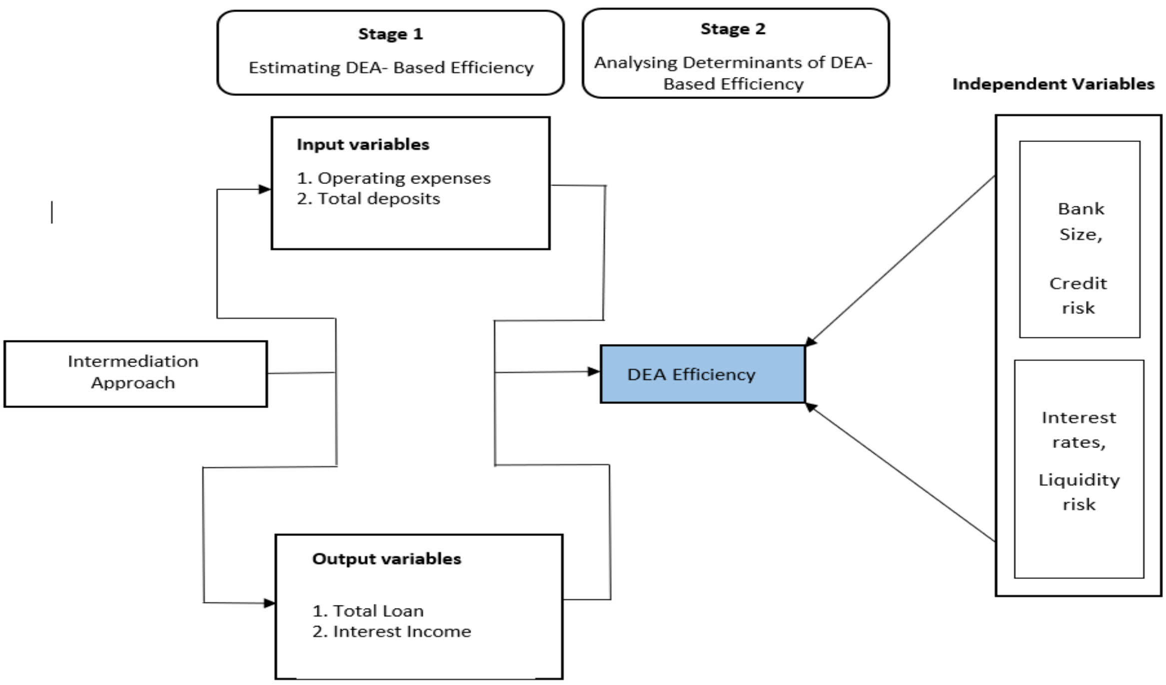
The main criticism of the production approach, according to (Leong et al., 2002), is that it overemphasises the importance of personnel expenses associated with staff and rental costs in defining inputs while excluding interest costs. The absence of these costs ignores the banking industry's conventional role as a distributor. Perhaps the intermediation technique has dominated this field's empirical study (Leong et al., 2002). Since it also includes interest payments on liabilities such as deposits and other obligations, the intermediation approach is inclusive of general costs of banking. Additionally, this method generally classifies deposits as inputs and outperforms other definitions in terms of data quality considerations (Limam, 2001).

According to this technique, we suppose that banks acquire deposits in order to transform them, incurring labour costs and other operating costs into loans that generate income. Therefore, earning assets and loans are perceived as output variables, whereas labour and deposits as input variables. We applied two inputs (deposits and operation costs) and two outputs (interest income and loans). We assessed total deposits by adding all demand and time deposits from clients, as well as interbank deposits, and we calculated operating expenses by adding up all personnel costs, including salaries, benefits, and interest costs. Using operating expenses as a DEA input is considered appropriate for measuring a commercial bank's efficiency for the following reasons: first, commercial banks often conduct business throughout the nation; they need numerous physical branches and cash offices. Second, rather than utilising technology tools and platforms like mobile banking, commercial bank clients typically prefer to speak face-to-face with bank staff.

The net value of loans measures advances to financial institutions and customers, whereas interest income is the total interest earned on loans, deposits with other institutions and bills. Since the majority of commercial banks' revenue comes from loan disbursements, which have the potential to generate income, interest income and total loans are relevant metrics of output to gauge the technical efficiency of banks.

In stage two, we analysed determinants of the DEA-based efficiency; independent variables included interest rate, bank size, liquidity risk and credit risk. A bank's size has a major impact on its efficiency. The significance is mirrored in the total assets. The most important consideration when using bank size is evaluating whether or not the sampled banks represent economies of scale. The assumption is that growing a bank's assets will help it become more efficient (Pasiouras, 2008). The log of assets should be used as a proxy for bank size in order to capture any potential non-linear relationship between efficiency and size. This concept is supported by the assumption that large-sized banks gain from economies of scale.

Figure 3.1: Conceptual Framework



The liquidity ratio, also known as the loan to deposit ratio (LDR), can impact efficiency of banks from both ends, that is, on the outputs and the inputs. Banks' primary business is loan disbursements. Banks must always maintain adequate liquidity to meet obligations such as sudden withdrawals of deposits and other short-term funding. The larger the LDR, the more significant the proportion of money allocated as credit, resulting in more interest earned and better bank profitability (Gul, Irshad, & Zaman, 2011). Insufficient liquidity may also require banks to borrow funds at exorbitant interest rates. During volatile financial periods, financial institutions may decide to reduce credit to riskier individuals and enterprises while increasing their exposure to less profitable but more liquid assets such as government securities. LDR is a potential source of growth in the lending business. As a result, LDR positively influence the bank efficiency.

Credit risk also impacts the level of a bank's technical efficiency. Credit accounts for most bank assets; it indicates both credit quality and asset quality as a whole. Banks with higher loan disbursement volumes are vulnerable to credit risk despite enjoying higher interest margins. Implying banks with a high credit risk must devote significant time and resources to resolving this issue (Karim, Chan, & Hassan, 2010)). The bank's operational efficiency would decrease due to the increased expenses concerning poor loans. High credit risk can also reduce bank efficiency since banks must deploy greater capital to cover such risks, restricting their degree of credit extension and consequent interest income, which are DEA efficiency outputs.

The ratio of interest income to total loans disbursed was used to calculate interest rate. The interest rates majorly determine the expenses of running banks. The prevailing interest rates influence one's decision to borrow. Debtors will borrow more money when interest rates are comparatively low, and as rates rise, borrowing will decrease (Dmitry, 2018). A high-interest rate could mean that the bank charges its customers high borrowing fees, which could make it difficult for the bank to lend. The quantity of bad loans rises as a result of the poor creditworthiness of the debtors who are willing to borrow at such rates. Bad loans ultimately lower bank efficiency (Kamau, 2011).

3.3 The DEA Model

Studies have employed simple ratio comparisons or complex statistical approaches to assess efficiency. Decision-making units' (DMUs) efficiency can be measured in two ways: first, parametric analysis (econometric). Second, non-parametric analysis (mathematical). DEA is a widely used non-parametric method, while SFA is the most often utilised parametric method (Raphael, 2013).

Based on Farrell's (1957) study, Charnes, Cooper, Lewin, and Seiford (1995) established the term DEA. Efficiency of DMUs is assessed using DEA, particularly financial institutions, because it comprehensively examines relative efficiencies for individual inputs and outputs. DEA offers various advantages in the context of our investigation, although it does not assume random error. One of them is that the DEA excels at working with small sample sizes, which was more pertinent to this study. There are only a few banks in Kenya's financial sector. Therefore, a non-parametric, data envelopment analysis model was adopted in this research.

Non-parametric frontier estimation procedures have the following characteristics: they do not require distributional efficiency assumptions and allow the production frontier estimation. This approach enables the simultaneous processing of numerous inputs and outputs. Outputs and inputs in the DEA model can be minimised or maximised. Inefficient DMUs are projected onto the efficient frontier using the input and output-oriented models. An output orientation strives to raise output levels while reducing input consumption, as opposed to an input orientation, which aims to decrease input amounts while maintaining current output levels. The capacity of a firm to make the most outputs with the fewest inputs is known as technical efficiency (Coelli et al., 2005). We adopted the input-oriented-based approach because decision-making units (banks) need to cut costs. The use of an input-oriented model indicates that banks do not just choose outputs but must also consider the degree of demand for their commodities.

DEA has been used in various bank efficiency studies, including those conducted by Miller and Noulas (1996), Leong and Dollery (2004), and Havrylchyk (2006). It can be used to assess individual banks' yearly scores, which would help analyse their performance over time. A DMU's efficiency is compared to that of other DMUs of a similar type by the DEA, with the limitation that no DMU may exceed the efficiency frontier.

DEA analyses the observed values for each DMU's outputs and inputs and then calculates each DMU's efficiency for all other DMUs (Charnes et al., 1995). Each firm's efficiency score will lie between 1 and 0 under the constraints. A value of one represents the most efficient "best practice" firm. When efficiency is less than one, some inefficiency is present. The greater the gap between the efficiency frontier and the measuring unit, the less efficient the measuring unit. For each unit under review, types and severity of inefficiency in both the input and output can be identified by utilising these efficiency scores as a yardstick (Bowlin, 1998). In addition, unlike other techniques, the structure of the underlying production relationships does not need to be defined explicitly in

DEA. Standard homogeneity and symmetry requirements ensure the computed frontier behaves well (Kumbhakar & Lovell, 2000).

A fractional programming formulation is used to start the DEA process. Assume there are n DMUs to be examined, with 33 commercial banks in Kenya in this scenario. DMUj consumes x1i input and generates y2r output, that is, different r outputs from a different number of i inputs. At least each DMU has a positive input and output value, with non-negative x1i and y2r inputs and outputs, respectively. DMU for an individual bank's efficiency may be expressed as:

$$g_j = \frac{\sum_{r=1}^{s} u_r y_{2r}}{\sum_{i=1}^{m} v_i x_{1i}} \quad (1)$$

u in the above equation denotes the weights for each output. Each input is denoted by v. DMUs are assigned weights using mathematical programming techniques, with the constraint that no other DMU with identical weights has efficiency score above 1, implying DMUs with a ratio of 1 as the most efficient. DMUj's objective function is: the proportion of weights of entire output divided by total input: where g0 is efficiency estimated for DMU0, weights optimized are v_i and u_r, for the jth DMU, the recorded quantity of output of the rth type is y_{2r} while the quantity of input recorded for the ith type is x_{1i}, i represents m different inputs, s different outputs are denoted by r, and the j denotes n different DMUs, i.e. different commercial banks.

$$\text{Max } g_0 = \frac{\sum_{r=1}^{s} u_r y_{0r}}{\sum_{i=1}^{m} v_i x_{0i}} \quad (2)$$

$$\text{Subject to } g_j = \frac{\sum_{r=1}^{s} u_r y_{jr}}{\sum_{i=1}^{m} v_j x_{ji}}\ , j = 0, 1, 2\ \dots\ n \quad (3)$$

$$u_r\ \geq\ 0,\ r\ -\ 1, 2, 3\ \dots.s \quad (4)$$

$$v_i = 1,2,3\ \dots.m \quad (5)$$

This study used two different DEA method specifications to analyse bank efficiency: one, it assumed constant returns to scale (CRS), and second, it used variable returns to scale (VRS). The CRS model is suitable for estimating technical efficiency in entities that are operating optimally. Because VRS incorporates a convexity restriction Σ λj=1, the model does not assume that all DMUs perform optimally. This constraint creates a convex hull that more compactly envelops the data points. As a result, the resulting efficiency scores are either higher or equal to those obtained in the CRS model.

Pure technical efficiency (PTE) refers to technical efficiencies calculated under VRS that are free of scale effects. They can be used to explain a measurement for management efficiency, that is, management's ability to convert inputs into outputs. At various scale sizes, the VRS model supports constant, increasing, and decreasing returns to scale. If a radial expansion in inputs causes a more proportionate radial growth in output levels, a firm will show increasing returns to scale. Conversely, if a radial increase in output level is less than proportional to an increase in input level, then decreasing returns to scale are observed. Technical efficiencies assessed under the CRS, on the other hand, are known as overall technical efficiency (OTE). They measure how much output can be increased without increasing inputs. The ratio of overall technical efficiency to pure technical efficiency is known as scale efficiency (SE).

SE determines whether a firm operates on an optimal or suboptimal scale. The bank involved may be operating at a too small scale, which falls under the increasing returns to scale on the production function. Similarly, due to its size, a firm may be operating in the decreasing returns to scale area of the production function. In both circumstances, altering the scale of operation can improve a firm's efficiency. The firm is scale efficient if the underlying operational technology has constant returns to scale. Using the CRS and VRS assumptions, the technical efficiency scores of each approach may be compared. The ratio depicts scale efficiency, which is the effect of scale size on DMU productivity. The scale efficiency measures the difference between a DMU's efficiency rating under CRS and VRS. The VRS score defines the DMU's scale size. Because pure technical efficiency is always larger than or equal to technical efficiency, scale efficiency is less than or equal to unity. If a DMU's technical efficiency and PTE are equal, then scale efficiency equals one. This means that scale size does not affect efficiency regardless of whether it is controlled (because it provides the same view of a DMU's technical efficiency). Scale efficiency will be less than one if CRS is less than VRS, indicating that the operation's scale affects the DMU's productivity.

3.4 How Data Envelopment Analysis works

An approach to valuing progress that is used to assess the relative efficiency of decision-making units (DMU) is called data envelopment analysis (DEA). A DMU is an autonomous organisational unit within an industry with discretion over some of its decisions. DMUs must perform a similar set of operations in order to be compared to one another. DEA may also be applied in the evaluation of non-profit organisations.

Ratios are a commonly used method to compare firms and measure their performance, i.e. the weighted sum of output measure is divided by the weighted sum of input measure in DEA. Weights are chosen to maximise the DMUs' efficiency when calculating the numerical values for their efficiency, thereby presenting each DMU in the best possible light (Charnes et al., 1995). The efficiencies must be between 0 and 1. Firms take inputs and convert them (with varying efficiency) into outputs. Then all other firms will be compared to the firm with the highest ratio between the outputs and inputs and calculate their relative efficiency concerning that firm. The ratio of other firms is divided by the firm's value with the highest ratio to find the relative efficiency.

The firms with low ratios do not compare well with the ones with the highest ratio, so they presumably do not perform well because they are less efficient in producing outputs from their input resources (Charnes et al., 1995). Therefore, comparing the firm with the highest ratio can be used to set targets for the other firms. The data's best practices are used to create the efficient frontier, which serves as a benchmark of performance for firms that aren't there. Firms identified as "best practice units" are rated one. In contrast, the Euclidian distance of the other firms' input-output ratios from the frontier is used to determine how technically inefficient they are.

3.5 Estimating Determinants of Efficiency

An observation that banks are technically efficient might not be helpful unless additional effort is made to identify the causes of such efficiency. Hence, the efficiency determinants are investigated in another analysis stage. The traditional two-stage approach has been primarily used in the literature to assess the determinants of efficiency, for example, Sathye (2001). The efficiency scores calculated in the first phase using DEA were regressed on a set of bank variables in this methodology.

The probit model was chosen from other comparable models like the logit and linear probability models. Linear Probability Model is affected by several problems, such as heteroscedasticity, the prospect that the endogenous variable is not within the 0-1 range and non-normality. The most crucial assumption is that the dependent variable's mean value is linearly related to the explanatory variable. It is unlikely that the explanatory variable's marginal effect will remain constant throughout (Gujarati, 1995). As a result, the probit regression model was the most appropriate for regression based on the distribution of explanatory variables and the nature of the dependent variable to assess the level to which bank characteristics explain the probability of bank efficiency.

The variables included in the panel probit model were: bank size, liquidity risk, interest rate and credit risk. The cumulative normal probability distribution serves as the base for probit model analysis. Assume that Y is a dichotomous variable. The dependent variable, Y, is binary and takes on zero values (efficiency scores less than one) and one (for efficiency scores equal to one). The general model:

$$Y_{it} = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + \beta_4 X_{4it} + \varepsilon_{it} \quad (6)$$

With,

$$P(Y = 1 | X_1, X_2, \ldots X_k) = \Phi(\beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + \beta_4 X_{4it}) \quad (7)$$

The cumulative standard normal distribution function is the population probit model has several regressors $X_1, X_2, \ldots, X_k$ and $\Phi(\cdot)$.

As a result, the chance that Y = 1 is predicted given $X_1, X_2, \ldots X_k$ can be estimated as follows:

$$\hat{y}_{it} = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + \beta_4 X_{4it} \quad (8)$$

Bj is the effect of a one-unit change in regressor Xj on Y when all other regressors are held constant. The specification of the panel probit model was as follows:

$$Y_{it} = \beta_0 + \beta_1 \text{Bank size}_{it} + \beta_2 \text{Liquidity risk}_{it} + \beta_3 \text{Interest rate}_{it} + \beta_4 \text{Credit risk}_{it} + \varepsilon_{it} \quad (9)$$

The probit model made the assumption that the data were drawn from a random sample of size N, represented by the notation i, I = 1,...,N. In order to rule out the serial correlation, the observations of Y must be statistically independent of one another. The Maximum Likelihood Estimation (MLE) approach was used to estimate the panel probit model parameters. MLE prioritised parameter estimations that offered the greatest likelihood of attaining the observed sample $\hat{y}$. The fundamental tenet of MLE was to select estimates of β that would maximise the probability of having observed this specific Y.

3.6 Data and selection of variables

This study used secondary data from 33 banks in Kenya from 2014 to 2019. Banks under mergers and acquisitions, new entrants and those that exited the market were excluded from the study to allow observation of the same unit in every period. The period chosen to examine commercial banks' efficiency was under a low-interest environment. Data sets were compiled from published balance sheets of individual banks and CBK's annual reports.

The balance sheet layout is one of the DEA model's most common techniques for selecting inputs and outputs. The resources connected with the balance sheet's passive section are called "inputs." In contrast, "outputs" refer to resources associated with the active part (assets). This approach to developing the DEA model specification uses money associated with the passive part to generate "output" which are subsequently noted to the active (asset) side of the balance sheet. The publication by Koshelyuk (2008) successfully implemented this method. As a result, it is feasible to compare the efficiency with which a bank employs its available resources to that of other similar banks in the sample.

Total deposits, including deposits from individuals, businesses, and banks, are considered inputs for DEA. This indicator is on the balance sheet's passive side, specifically in the liabilities section. Following the bank's intermediate function, it uses liabilities to create assets for example deposits are used as input and loans as output. According to Soba, Erem, and Ceylan (2016), deposits are often used as input in the technical efficiency study of banks.

Operating expenses are also considered an input because financial institutions are viewed as middlemen between depositors and borrowers under the intermediation method. Banks' middleman functions include accepting deposits and investing them in assets such as interest-bearing loans. Banks incur staff, property depreciation, and organizational and administrative costs during this process. To be viable, banks must adequately manage risks, invest deposits in income-generating investments, and keep operating expenses to a minimum.

Total loans and interest income are relevant output indicators to estimate commercial banks' technical efficiency since their income is generated from loan disbursement. Total Loans include loans to individuals, businesses, and banks. This component was chosen as an output of the bank's intermediary role, in which the bank makes loans using attracted funds (such as deposits). Bank's interest income is the second output. Interest income is typically result of banks' overall activities. The interest earned by banks on loans, deposits with other institutions, bonds, and promissory notes is referred to as interest income.

This study employed two inputs and two outputs because DEA's efficiency is highly dependent on the variable numbers. The capacity to distinguish between DMUs reduces as the number of variables increases. Inefficient units dominate the new dimension as variables increase, making inefficient units efficient (Shirouyehzad et al., 2014). Maintenance of DEA's discriminatory strength requires minimizing the quantity of outputs and inputs compared to the sample size.

Since the variables that could affect efficiency have no known theoretical explanations, we rely on the empirical literature to choose the pertinent bank-specific and market-related features to be used in the econometric model (Ariff & Can, 2008; Dietsch & Lozano, 2000). Table 3.1 shows the variables that were chosen and their descriptions.

Table 3.1: Variables of the regression model

Variables	Description	Remarks
Dependent variable		
Efficiency	1 for efficient and 0 otherwise	Technical efficiency scores 1 for banks on the efficiency frontier and 0 for banks lying below the frontier (i.e. technical efficiency score less than 1)
Independent variables		
Bank size	Natural logarithm for banks' assets	The bank's assets were used as a measure for its size.
Credit risk	The loan to total asset ratio	As a measurement of credit risk, the loan-to-total-asset ratio was used.
Liquidity risk	The loan-to-deposit ratio.	Loans to deposit ratio was utilised as a stand-in for bank liquidity
Interest rate	The interest income to total loan ratio	Interest rates were proxied by the interest income to total loan ratio.

3.7 Pre-Estimation Tests

3.7.1 The Hausman test

The choice between the random effect and the fixed effect model was evaluated using the Hausman test by identifying the endogeneity in independent variables. The null hypothesis stated that random effects were the preferred model while the alternate hypothesis was that the model is fixed effects. If Probability is greater than or equal to 0.05, the random effect model would be more suitable for use; otherwise, the fixed effect model would be appropriate.

3.8 Post-Estimation Tests

The following post-estimation tests were conducted after regression: multicollinearity test, the goodness of fit test, the heteroscedasticity test and the specification test.

3.8.1 Heteroscedasticity

When the standard errors of variables are inconsistent, heteroscedasticity develops. Heteroscedasticity causes biased estimates of standard errors, which may lead to overestimating the goodness of fit. Therefore, to check heteroscedasticity in our regression model, we conducted the Breusch-Pagan test. The null hypothesis was that all the error variances were equal whereas the alternate hypothesis was that the error variances were not equal. If the p-value of the test statistic is less than 0.05, heteroscedasticity is assumed and the null hypothesis of homoscedasticity is rejected.

3.8.2 Multicollinearity test

When a regression model has several independent variables that are correlated multicollinearity occurs. Multicollinearity makes statistical inferences less reliable. The null hypothesis was that independent variables were not linearly related to the target, while the alternate hypothesis of this statistical test was that the independent variables were linearly related to the target. Multicollinearity was tested using the Variance Inflation Factor (VIF). A VIF of one implies that two variables are uncorrelated, a VIF between one and five suggests a moderate correlation, and a VIF greater than five shows a strong correlation.

3.8.3 The goodness of fit test

To determine how well our data fit the model, we conducted a goodness-of-fit test using Hosmer-Lemeshow (H-L). The null hypothesis was lack of fit, while the alternate hypothesis was a good fit. If P-value is less than 0.05 it indicates that this model does not fit.

3.8.4 The specification test

The link test was utilised to examine whether the model was properly specified and if the probit was appropriate as a link function. The null hypothesis was that the coefficient equals zero, while the alternate hypothesis was that the coefficient is not equal to zero. For the probit model to be correctly specified, the prediction variable (hat) p-value < 0.05, while hatsq's p-value ≥ 0.05.

CHAPTER FOUR: DATA ANALYSIS AND DISCUSSION

4.1 Introduction

In this chapter, part 4.2 the descriptive statistics of the variables used in the analysis are presented, 4.3 presents pre-estimation test results, 4.4 presents the empirical results from the probit model and 4.5 presents post-estimation test results.

4.2 Descriptive statistics of data on variables used in DEA

Table 4.1 displays a descriptive statistics overview of the means, standard deviation, minimum and maximum values of each variable. Means represent the average values of each variable, while standard deviation shows how each variable is far from the mean.

Table 4.1: DEA Summary Statistics

Variable	**Observations**	**Mean**	**Std. Dev.**	**Min**	**Max**
Deposits	198	72781.61	101958.80	1947.36	536830
Expenses	198	9553.69	30544.95	3.00	411000
Loans	198	57408.59	86966.55	734.06	468258
Interest Income	198	9803.87	18561.10	0.6	182000

We can make various inferences from table 4.1 for 2014-2019. The average deposits for the banks are 72,781.61 million, with a standard deviation of 101,958.80, implying that the banks' deposits deviate significantly from the mean. The deposits range between 1,947.36 million and 536,830.00 million. Total expenses for the banks have a mean of 9,553.69 million, and the highest expenses are 411,000.00 million. The average loans and advances banks provide are 57,408.59 million, with the minimum loans being 734.06 million; on the other hand, the maximum loans being 468,258.00 million. The banks' mean for interest income is 9,803.87, with a standard deviation of 18,561.10 and a max of 182,000.00.

Table 4.2 presents the average annual findings attained in the first stage of efficiency estimation. The constant returns to scale (CRS), variable returns to scale (VRS) and scale efficiency (SE) results have been categorized yearly.

Table 4.2: Overall summary of the efficiency estimates

Year	CRS	VRS	SE
2014	0.822	0.873	0.945
2015	0.745	0.838	0.892
2016	0.810	0.853	0.951
2017	0.772	0.848	0.912
2018	0.775	0.841	0.923
2019	0.800	0.874	0.920
Mean	0.787	0.854	0.924

From 2014 to 2019, average efficiency using CRS model ranged between 74.5 per cent and 82.2 per cent, while average efficiency using VRS model ranged between 83.8 and 87.4%. Following the introduction of the interest cap in 2016, the average efficiency (CRS) reduced from 81% to 77.2% in 2017. The efficiency increased in 2018, then to 80 per cent in 2019 when the cap was lifted.

During this period (2014 – 2019), banks in Kenya had an average technical efficiency (CRS) of 78.7 per cent, meaning that they could create outputs with 21.3 per cent fewer inputs on average. Banks were 14.6% inefficient under variable returns to scale and 7.6% scale inefficient.

These findings from commercial banks' data indicate that the primary source of inefficiency is purely technical, as evidenced by measures of 21.3 per cent and not scale inefficiency which had 7.6 per cent. Commercial banks could benefit from improving their pure technical efficiency by enhancing management skills, adopting technology to deploy resources to their best optimal use, collecting deposits efficiently and boosting their operations scales.

Table 4.3 has a presentation of the average scores of efficiency of banks depending on ownership. There were three categories of ownership based on: those under direct or indirect control of the government (GOV), private and locally owned (PVTL), and private and foreign-owned (PVTF). A list of the banks included in each grouping is in Appendix 1.

Table 4.3: Efficiency estimates by ownership

Ownership	Type	2014	2015	2016	2017	2018	2019	Mean
GOV	CRS	0.869	0.793	0.846	0.785	0.827	0.894	0.836
	VRS	0.903	0.830	0.873	0.863	0.846	0.931	0.874
PVTF	CRS	0.780	0.748	0.807	0.698	0.700	0.707	0.740
	VRS	0.861	0.849	0.863	0.787	0.776	0.787	0.820
PVTL	CRS	0.832	0.722	0.798	0.826	0.814	0.849	0.807
	VRS	0.869	0.832	0.837	0.891	0.891	0.930	0.750

Table 4.3 shows that private foreign banks had the lowest technical efficiency (CRS) of 74 per cent. Government-owned institutions had the highest level of technical efficiency (CRS), at 83.6 per cent, while private locally owned banks had 80.7 per cent. The results concur with Berger et al. (1999) findings. Berger et al. (1999) found that domestic banks' efficiency levels were higher than those of foreign banks because of the home advantage. Foreign banks cannot also avoid implicit and explicit constraints such as management and monitoring challenges, cultural and language differences.

We classified banks into three tiers to find average efficiency scores by the size of the banks. Commercial banks in Kenya are categorized by CBK into three tiers based on their share of market, assets, and client deposits. Banks with a weighted composite index of at least five per cent are in tier one, those in tier two have a weighted composite index lying between one per cent and five per cent, whereas tier three banks have less than one per cent weighted composite index.

Table 4.4: Efficiency estimates by size

Tier		**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**Mean**
TIER 1	CRS	0.897	0.829	0.831	0.752	0.822	0.836	0.827
	VRS	0.935	0.906	0.915	0.892	0.902	0.902	0.908
TIER 2	CRS	0.769	0.790	0.864	0.815	0.790	0.739	0.794
	VRS	0.787	0.804	0.890	0.869	0.840	0.842	0.839
TIER 3	CRS	0.817	0.692	0.778	0.761	0.750	0.813	0.769
	VRS	0.888	0.826	0.813	0.822	0.817	0.877	0.841

Table 4.4 shows the distribution of different size groups' average efficiency scores (both CRS and VRS). Tier 1 banks have the highest average efficiency (CRS) of 82.7 per cent, tier 2 banks had 79.4% while tier 3 banks had an average of 76.9%.

Tier 1 banks have the highest efficiency levels. The outcomes infer that banks commanding a large share of the market and also with more assets are closer to the efficiency frontier than others. Also, public banks show high efficiency in the sample, leading private local and private foreign banks on the efficiency frontier. Our findings agree with the previous studies in the Kenyan banking sector. The studies described variation in efficiency scores in different years and high efficiency was primarily observed in public banks than in banks owned by foreigners, which also performed better than private banks owned by locals (Sathye, 2001).

4.3 Pre-test results

4.3.1. The Hausman Test

To examine if the statistical model conforms to the data, we evaluated the consistency of the estimators using the Hausman test. The probability value of chi2 was more than the significant level i.e. 0.3267; hence we accepted H0 and rejected H1. Random effects model was chosen due to higher efficiency.

Table 4.5: The Hausman Test

	Coefficients (b) Fe	(B) Re	(b-B) Difference	Sqrt(diag(v_b_B) S.E.
Natural log of Bank Size	-0.1209	0.0147	-0.1356	0.1219
Credit Risk	0.0546	-0.1503	0.2049	0.2983
Liquidity risk	0.2670	0.4802	-0.2133	0.1160
Interest rate	0.2160	0.1735	0.0425	0.0703

b = consistent under H0 and Ha; obtained from xtreg

B = inconsistent under Ha; efficient under H0; obtained from xtreg

Test: H0: difference n coefficients not systematic.

Prob > chi2 = 0.3267

4.4 Empirical results of probit regression

We used the probit model to establish the determinants of efficiency in banks, and the output is presented in Table 4.7. To determine the predictor of the likelihood of a bank on the efficiency frontier, we estimated the panel probit regression model described in equation (9). The input-oriented efficiency scores obtained from the DEA using the constant returns to scale model were used in a regression to relate bank efficiency to selected bank factors. The CRS model was chosen because banks in our sample operate under similar conditions, and the model has high accuracy and discriminating power. Table 4.6 displays the descriptive statistics of variables in the probit regression model.

Table 4.6**:** Descriptive statistics of variables

Variable	Mean	Min	Max	Std. Dev.
Efficiency	0.79	0	1	0.364
Natural log Bank Size	10.62	8.47	13.42	1.319
Credit Risk	0.60	0.03	1.25	0.165
Liquidity risk	0.84	0.04	2.36	0.336
Interest rate	0.18	0.0122	2.51	0.182

The average efficiency score is 79 per cent, with a standard deviation of 0.364 during the given period. The results in table 4.6 also show that the natural logarithm for bank size (total assets) lies between 8.47 and 13.42, with an average of 10.62. However, no significant difference was observed between the minimum value for credit risk and liquidity risk variables. On the other hand, the average interest rate was 18 per cent for the entire period. Table 4.7 exhibits the parameter estimates for the probability of bank efficiency.

Table 4.7**:** Estimation results of heteroscedastic probit regression model

Efficiency	Coef.	Robust Std. Err.	Z	P>|z|	[95% conf.	Interval]
LnBS	0.113	0.115	0.98	0.325	-0.112	0.388
IR	0.770	0.548	1.41	0.160	-0.303	1.844
LR	2.221	0.839	2.65	0.008	0.576	3.865
CR	-1.083	1.771	-0.61	0.041	-4.553	2.388
_cons	-3.807	1.493	-2.55	0.011	-6.735	0.879
/Insig2u	-1.165	0.770			-2.673	0.344
Sigma_u	0.559	0.215			0.263	1.188
Rho	0.238	0.140			0.065	0.585

Notes: (Number of observations 198, Prob > chi2 = 0.0022, Wald chi (4) = 16.75).

Table 4.7 shows that bank size, proxied by the total assets, positively impacts efficiency. The result is in agreement with the theory and supports Kamau (2011) findings since the relation between efficiency and bank size is positive. However, the result at 5% significance level is not significant. As a result, it does not significantly impact efficiency. This finding suggests that Kenyan commercial banks profited from economies of scale as a result of owning sizable assets, implying that the bigger the bank, the more efficient it is.

Liquidity risk is another critical determinant of the efficiency in Kenyan banks. It is proxied by total loans to total bank deposits. Liquidity risk positively and significantly impacted efficiency. The finding concurs with the hypothesis and Musundi (2008) results. The empirical finding indicated that efficiency rises when the ratio of loans to deposits rises. Therefore, to increase their levels of efficiency, commercial banks in Kenya should manage their liquidity by increasing loans.

Credit risk is the other important determinant of commercial banks' efficiency in Kenya. The ratio of loans to assets is proxied as credit risk. The study found a statistically significant negative relationship between this variable and efficiency, which is consistent with the hypothesis. This negative relationship means that the riskier loans included in the portfolios of Kenyan commercial banks, the higher the loan defaults and the lower the likelihood of efficiency. In this context, the negative coefficient means that bank management should focus on establishing credit risk management to effectively evaluate credit risk and minimise problems related to loan default risk.

Although there was a positive relationship between bank efficiency and interest rates, it was not statistically significant. The results contradict with the hypothesis claims regarding the relationship between the two variables. The main reason the efficiency and interest rate had a positive relationship is that when the interest rate is low due to capping, banks will find it difficult to recover costs. Therefore, they will likely reduce credit allocation to small borrowers and other costlier risky markets, decreasing non-performing loans and improving banks' efficiency.

Table 4.8 displays the heteroscedastic probit model estimation results and marginal effects calculation. The marginal effect explains the explanatory variable's influence on the likelihood that y = 1.

Table 4.8**:** Marginal effects

Efficiency	dy/dx	Delta-method Std. Err.	Z	P>|z|	[95% conf.	Interval]
LnBS	0.021	0.022	0.950	0.345	-0.022	0.638
IR	0.142	0.102	1.390	0.165	-0.058	0.341
LR	0.408	0.152	2.680	0.007	0.110	0.706
CR	-0.199	0.326	-0.610	0.041	-0.838	0.440
_cons	0.000	0.000	-2.900	0.000	0.000	0.120

Notes: (Number of observations 198, Prob > chi2 = 0.0000).

At a 5% significance level, the marginal effect of bank size was positive but not statistically significant. Keeping all other variables constant, an increase in a bank size by one per cent increased the probability of a bank being efficient by 0.021 percentage points. The outcome was consistent with prior research findings (Kamau, 2011; Miller & Noulas, 1996). Specifically, an increase in bank size increases the likelihood of efficiency. This finding contradicts the findings of Barros et al. (2007), as their findings showed that the smaller banks had a higher probability of being the best performers than large ones.

Concerning interest rate, at a 5% significance level, the marginal effect was positive though not statistically significant. There is a 0.142 likelihood that an efficient bank was more likely to offer high-interest rates than less efficient banks. These results do not concur with Dmitry's (2018)) findings that a positive change in rates of interest increases bad loans as those willing to borrow at those rates may have poor creditworthiness.

The marginal effect was positive and significant at 5% significance level regarding liquidity risk. Banks with high liquidity risk ratio had a probability of 0.408 percentage points of being more likely to be efficient than those that did not. The positive percentage points imply that liquidity risk positively influences a bank's efficiency. The study disagrees with Mutanu's (2002) and Adjei-Frimpong et al. (2014) results, who found that banks with high ratios of loans to deposits perform worse than those with low ratios but concurs with Musundi's (2008) findings.

Regarding a bank's credit risk, the marginal effect was negative and statistically significant at a 5% significance level. There is a probability of 0.199 that a bank with a high credit risk was inefficient compared to banks with low credit risk. The findings concur with Havrylchyk (2006), who also found a negative relation between efficiency and credit risk.

4.5 Post-test results

4.5.1 Multicollinearity test

The computed model's multicollinearity was evaluated using the Variance Inflation Factor (VIF). VIF detects the correlation between regressors and also the strength of that association. As a rule of thumb, multicollinearity is considered present if a variable has a VIF above 10. The results in Table 4.9 show that multicollinearity did not exist because the VIF for each variable was less than 10. A mean value of 2.02 VIF further confirmed the absence of multicollinearity in the model.

Table 4.9**:** Multicollinearity test

Variable	**VIF**	**1/VIF**
Credit risk	3.04	0.3290
Liquidity risk	2.79	0.3590
Interest rate	1.23	0.8159
Natural log of bank size	1.04	0.9625
Mean VIF	2.02	

4.5.2 The goodness of fit test

This test was done to establish if the data fit well in the model. The Hosmer-Lemeshow (H-L) test results are displayed in Table 4.10. The tests determine whether observed binary responses are consistent with predictions, that is, if the outcomes in the regression indicates the outcomes observed in the data. From the results, the probability value of chi-square was 0.4170 for the test at 8 degrees of freedom and was statistically insignificant; hence the model fitted well with the data.

Table 4.10: Goodness of fit test

Number of observations	198
Number of groups	10
Hosmer-Lemeshow chi2(8)	8.17
Prob > chi2	0.4170

4.5.3 Heteroskedasticity test

After running the probit model, heteroscedasticity was checked using the Breusch-Pagan/Cook-Weisberg test. The Breusch-Pagan/Cook-Weisberg test statistic from Table 4.11 had a p-value of 0.0014, resulting in the rejection of the null hypothesis of homoscedasticity, thereby concluding that the data was heteroscedastic.

Table 4.11: Heteroskedasticity test

chi2(1)	10.18
Prob > chi2	0.0014

This problem was addressed using heteroskedastic probit (Alvarez & Brehm, 1997). The heteroscedastic model has been widely used to analyze heterogeneous choices and behaviours (Alvarez & Brehm, 1997; Busch & Reinhardt, 1999). This model specifies the probit model by extending a standard normal cumulative distribution function of a random variable to a normal cumulative distribution function with a variance not fixed at one but which varies as a function of explanatory variables (Obebo, Wawire, & Muniu, 2018). The model addresses the disparities in variances of binary outcomes by producing heteroskedastic-robust standard errors.

4.5.4 Test for specification of the probit model

A link test was conducted to establish whether the model was correctly specified. Model misspecification may occur if one or more variables are left out of the model or if the model contains irrelevant variables. Whenever relevant variables are erroneously omitted, the standard variance shared with the variables included may be incorrectly ascribed to those variables hence inflating the error term. Generally, model misspecification can substantially affect the estimates of regression coefficients. The results from the test are presented in Table 4.12 and shows that prediction variable (hat) was statistically significant since its p-value was 0.003, while hatsq was not since its p-value was 0.990. Therefore, the model was correctly specified.

Table 4.12: Link test

<table>
<tr><th></th><th>Coeff.</th><th>Std Err.</th><th>Z</th><th>P>|z|.</th><th colspan="2">[95% Conf. Interval]</th></tr>
<tr><td>_hat</td><td>1.018</td><td>0.338</td><td>3.01</td><td>0.003</td><td>.355</td><td>1.681</td></tr>
<tr><td>_hatsq</td><td>0.101</td><td>0.140</td><td>0.07</td><td>0.942</td><td>-.263</td><td>0.284</td></tr>
<tr><td>_cons</td><td>-.005</td><td>0.406</td><td>-0.01</td><td>0.990</td><td>-.800</td><td>0.790</td></tr>
</table>

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND POLICY IMPLICATIONS

5.1 Introduction

This chapter provides an overview of the findings in part 5.2. Part 5.3 gives conclusions from the results, while part 5.4 presents policy implications based on the study findings. Part 5.5 suggests areas of further studies that may be done to investigate the efficiency of commercial banks.

5.2 Summary

Despite structural reforms in the banking system to increase efficiency, commercial banks in Kenya remain inefficient. Mainly, wide interest spreads characterise the financial sector. The goal of this study was to investigate the effect of bank-specific factors on the efficiency of banks, estimate efficiency levels of banks in Kenya and provide policy implications. Banks were classified for analysis based on ownership and size. According to ownership, we had the following groups: government banks, private banks owned by locals, and private banks owned by foreigners, while according to size, we had tiers, namely tier 1 for large banks, tier 2 for medium banks and tier 3 for small banks.

This study used annual data from audited financial statements of various banks and annual reports of CBK covering the period from 2014 to 2019. Our research findings from the DEA model show that public banks in Kenya outperformed private banks owned by locals and banks owned by foreigners in terms of average yearly efficiency scores in the industry. A panel probit model was employed to examine contributing factors of efficiency in banks. The DEA model efficiency values were utilised as the panel probit model estimation dependent variables. In contrast, the explanatory variables were bank liquidity risk, size, credit risk and interest rate.

The empirical evidence explains roles of bank features in determining the probability of a bank's efficiency frontier. Small banks are at a competitive disadvantage in Kenyan banking industry; since large banks are likely to be efficient than them. Also, banks with high deposits and adequate total assets appear to be on Kenyan commercial banks' efficiency frontier. Interest rates are not significant to Kenyan banks though has a positive relationship with efficiency, while credit risk has negatively affected banks' efficiency.

5.3 Conclusions

This empirical study showed that liquidity and credit risk has a significant effect on the efficiency of banks in Kenya. Although the relationship between bank efficiency and liquidity risk was positive, the relationship was negative for credit risk. The negative relationship between credit risk and efficiency indicates that a high ratio of non-performing loans to total assets is related to low levels of banks' efficiency. Thus, it is possible to conclude that banks with few non-performing loans are the most efficient. Liquidity risk, represented by the ratio of loans to deposits, was found to have a positive relationship with bank efficiency. This result indicates that capital adequacy is required for banks to have high efficiency since banks can invest most of their liquid assets and generate more income boosting their efficiency and performance in the industry.

The results from the study also showed that both the interest rate and bank size's relationship with the efficiency of commercial banks were not significant. It was found that bank size and interest rate positively correlated with efficiency. The positive relation shows that an increase in bank size would increase the efficiency levels of banks. On the other hand, the interest cap reduced banks' interest rates on loans for 2016-2019, interfering with the industry's efficiency. This shows that the government interfering with the interest rates (capping) negatively affects the efficiency of banks. Therefore, market forces should be allowed to determine interest rates with less government interference.

In conclusion, we deduce from this empirical analysis that the most critical determinants of the efficiency of banks in Kenya are bank-specific characteristics, specifically liquidity risk and credit risk. The results are consistent with the efficiency structure theory, which holds that improved managerial efficiency results in increased efficiency.

5.4 Policy Implications

Apart from demand deposits, Kenyan commercial banks should consider increasing the collection of low-cost deposits such as savings from many individuals, which are mainly inelastic and can insulate the bank funding costs against economic shocks by maintaining the stability of interest expenses and withdrawal patterns. Banks should also pursue strategies for increased growth. These strategies include increasing the bank's products to attract and encourage customers to maintain sufficient balances in their accounts, and subsequently, stable funding enhances the bank's business and transaction volumes. The banks should therefore diversify their funding sources and investments in these funds to reduce the concentration risk.

These results show that the liquidity ratio affect banks' efficiency positively. Therefore, the commercial banks can increase the ratio of loans to deposits at their disposal to generate more revenues. Banks should hold a well-diversified portfolio of assets in various sectors to increase the propensity to tap more income through increased return on investment. In terms of managing credit risk, banks should invest in earning assets that are not all dependent on the same economic variables but are consistent with the return they seek. In order to minimise exposure to credit risk, banks should consider risk-free assets, mainly government securities. The bills and bonds have returns guaranteeing the bank's income and thus shield them from the possible effect of interest to be paid to the owners of the resources that have been transformed into assets. Policies must prioritise prudent credit risk control and a technology-based internal resource management strategy.

Commercial banks in Kenya should focus on loan growth and improving lending conditions rather than increasing provisions for bad loans. They should evaluate their fixed assets if owning lots of tangible assets is necessary and consider whether there is another way to use them. Also, because public banks outperformed private banks, the findings suggest that they should not be privatised.

5.5 Areas of further research

This study mostly looked at the internal components that affected banking efficiency in Kenya and calculated the probability of a bank being efficient or not. However, we did not consider any macroeconomic factors contributing to banking efficiency in Kenya. Similar studies can be conducted using macro parameters. The micro and macro elements that contribute to banks' efficiency can be identified and utilised to calculate the probability of banks being efficient.

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APPENDICES

APPENDIX 1: List of commercial banks under study

Tier 1 Banks	**Tier 2 Banks**	**Tier 3 Banks**
Co-operative Bank of Kenya	Family Bank Ltd	Spire Bank Ltd
Kenya Commercial Bank	HFC Ltd	Jamii Bora Bank Ltd
Equity Bank Kenya Ltd	Ecobank Kenya Ltd	Gulf African Bank Ltd
ABSA Bank Kenya Plc	Prime Bank Ltd	African Banking Corporation Ltd
Standard Chartered Bank	Bank of Baroda (K) Ltd	UBA Kenya Bank Ltd
Diamond Trust Bank Kenya Ltd	Citibank N.A. Kenya	Credit Bank Ltd
Stanbic Bank Kenya Ltd	National Bank of Kenya Ltd	Habib A.G Zurich Bank
	Bank of India	Consolidated Bank of Kenya Ltd
		Development Bank of Kenya Ltd
		Guaranty Trust Bank
		Victoria Commercial Bank
		Guardian Bank Ltd
		Middle East Bank K Ltd
		M Oriental Commercial Bank Ltd
		Paramount Universal Bank
		Trans-National (Access Bank)
		First Community Bank Ltd
		Sidian Bank Ltd

Source: (CBK, 2014)