International Journal of
Financial Studies

MDPI

Article

Basel III Capital Regulations and Bank Efficiency: Evidence from Selected African Countries

Ayodeji Michael Obadire [1,2,*], Vusani Moyo [2] and Ntungufhadzeni Freddy Munzhelele [2]

1 School of Finance and Professional Studies, Botswana Accountancy College, Gaborone 00319, Botswana
2 School of Management Sciences, University of Venda, Thohoyandou 0950, South Africa; vusani.moyo@univen.ac.za (V.M.); freddy.munzhelele@univen.ac.za (N.F.M.)
* Correspondence: ayodejio@bac.ac.bw

Abstract: The core function of a commercial bank is the provision of credit facilities to its customers and to keep the flow and cycle of economic and financial resources balanced. Banks can only perform these functions if they are well regulated and efficient. The main focus of this study is to analyse the efficiency of African banks, most importantly after the 2008 global financial crisis when the Basel III regulations were popularly adopted by banks globally. The research focus was examined in two ways, the first part focused on investigating the impact of the Basel III capital regulations on the operational and investment efficiency of African banks by using the random effects and pooled ordinary least square panel data regression models. The second part examined if the African banks are indeed efficient by analysing their level of efficiency using the input-oriented DEA approach. The study used audited bank-level data from 45 listed banks operating in six African nations, namely, South Africa, Nigeria, Kenya, Tanzania, Uganda and Malawi, that have adopted the Basel III Accord for the period from 2010 to 2019. The bank-level data were obtained from the IRESS database. The findings revealed that capital buffer premiums significantly affect the operating and investment efficiency of African banks positively. This relationship implies that the capital buffer premium does not only serve as cushion capital against financial, market and economic shocks but also improves the banks' efficiency by influencing the banks' decisions and perspective on cost containment strategies. Another key finding is the positive influence the liquidity coverage ratio has on banks' operational efficiency. The implication of this relationship may simply mean that African banks with well-performing liquidity ratios are efficient in their operations with the ability to meet their short-term obligations such as meeting customers' credit needs, unannounced depositors' withdrawals and creditors' repayments, amongst others. This result could well be interpreted that adopting stricter liquidity requirements creates a liquidity buffer for African banks, giving them cushion confidence to undertake profitable and high-yielding projects, which invariably lead to increased profitability and operational efficiency. Furthermore, the DEA results showed that the sampled banks are operationally efficient with an aggregate of 84.8%, and for their investment efficiency, an aggregate of 94.9%. These findings suggest that African banks are largely efficient and can survive any possible financial or economic crisis. It can be put forward that it is probable that banks that are yet to adopt the Basel III Accord or strengthen their capital and liquidity base, are less efficient and might fail during a global crisis. The current work suggests some appropriate policy-based recommendations.

Keywords: African bank efficiency; capital adequacy ratios; capital buffer premiums; DEA; liquidity requirements; static panel data

check for updates

Citation: Obadire, Ayodeji Michael, Vusani Moyo, and Ntungufhadzeni Freddy Munzhelele. 2022. Basel III Capital Regulations and Bank Efficiency: Evidence from Selected African Countries. *International Journal of Financial Studies* 10: 57. https://doi.org/10.3390/ijfs10030057

Academic Editor: Sabri Boubaker

Received: 25 February 2022
Accepted: 16 June 2022
Published: 18 July 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Copyright: © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

The survival and success of any economy and its financial systems are dependent on the efficiency and resilience of its banking sector. The major role of any commercial bank is the intermediation function between the owners of surplus financial resources and the borrowers of funds who are in deficit (Bank for International Settlements (BIS) 2013). This core role can only be accomplished when banking operations and investment activities are performed efficiently.

The global financial crisis of 2008 exposed the inherent weaknesses in the Basel II capital regulations. The effect of the GFC was a massive blow for all businesses including the banking sectors globally due to business interconnectedness. This led to the proposition of the Basel III Accord with the main aim of addressing the pertinent issue of the minimum capital requirements and the excessive leverage of banks, amongst others (BCBS 2010). According to Abbas and Younas (2021), to promote an efficient and resilient banking system, regulations regarding holding a sufficient amount of capital to cushion against losses and economic shocks are paramount and must be instituted.

In light of the necessity to regulate bank capital and prevent excessive leverage, Basel III brought major changes to the existing Accords. First, the minimum capital requirement as highlighted in Basel II was amended and increased for banks to maintain a buffer of capital that could be used to absorb losses during periods of financial and economic stress. Second, the leverage requirements were improved to include a non-risk-based leverage ratio for the banks to prevent a financial crisis that could cause a lowered leverage, which could result in a downward trend of asset prices and bank capital. Finally, the liquidity requirement was amended to include two new liquidity ratios: the liquidity coverage ratio (LCR) and the net stable funding ratio (NSFR). The LCR requires banks to hold sufficient high-liquid assets that can withstand a 30-day stressed funding scenario as specified by the bank supervisor, and the NSFR requires banks to maintain stable funding above the required amount for one year of extended stress. The NSFR is primarily designed to address a liquidity mismatch in banks and to reduce liquidity crises in cases of shocks.

Although these Basel regulations may not be forcefully and legally binding in any country as such, they serve an advisory purpose and form the baseline for individual countries to formulate their bank capital regulations. The majority of the countries ultimately adopted the Basel regulations, whilst other countries made a few adjustments or improvements to the Accord to suit their specific needs (Bilal and Salim 2016). Moreover, Bilal and Salim (2016) argue that the decision on how to phase in, adopt and implement the Basel regulatory guidelines rests on each country's central bank and legislative arm.

Moudud-Ul-Huq (2019) defines bank efficiency as the ability to operate at a lower cost to maximise its returns. The measure of bank efficiency shows how effectively a bank has been operated and how proficient the bank is utilising its overhead expenses in generating profits. Bank efficiency is measured in various ways that include operational efficiency, investment efficiency and technical efficiency. Fiordelisi and Mare (2014) argue that the cost-containment strategy is the best way to keep a bank efficient, which includes, but is not limited to, the ability to design and develop an innovative digital platform for easy banking and renting out office spaces whilst non-human interacting staff work from home. In addition, merging branches, reducing the number of physical offices and strengthening corporate governance to enhance financial stability and operational transparency in the banking system, improve public confidence and faith in banks. Furthermore, banks are said to be operationally efficient when they issue credit and loans to well-vetted and highly creditworthy customers and through proper monitoring of the borrowers to reduce the possibility of bad debt and default (Gadanecz and Jayaram 2015); hence, the importance of bank investment and operational efficiency cannot be overemphasised.

A major argument for banking efficiency developing into bank resilience became a core concern after the 2008 GFC where the economy lost a vast majority of its gross domestic product, as inflation, interest rate and unemployment were on the rise, burdening the entire global community (Cerrone 2018). Based on the notion of a well-regulated bank leading to an efficient bank, some studies (Nguyen 2020; Lotto 2018) found that an efficient and well-regulated banking system is linked to economic development and financial stability. Lotto (2018) added that the Tanzanian commercial banks with more stringent capital regulations were more operationally efficient compared to their counterparts, which has led to stable growth in the economy. Similarly, Mashamba (2018) and Ahmed et al. (2015)

argued that the new capital adequacy requirements enhanced the operational efficiency and the profitability of the commercial banks in Bangladesh and other emerging markets. However, Chiaramonte and Casu (2017) reported a contrasting view and asserted that banks from the developed nations performed negatively upon the adoption of the higher capital requirements proposed by the Basel III Accord. They argued that adopting a higher capital requirement reduces the funds available for investment and operational lending purposes, which invariably impedes their efficiency. Furthermore, Gavalas and Syriopoulos (2018) and Banerjee and Mio (2018) reported that an inverse relationship exists between European banks' efficiency and higher regulatory capital. These results imply that inefficient European banks held more capital with a lower appetite for risk whilst the efficient banks held less capital with higher responsiveness in their risk behaviours, resulting in better financial performance. These studies, however, document contradicting and inconclusive findings. Despite the studies conducted on the relationship between bank regulatory capital and its efficiency, the majority of these studies used data from developed nations. Beck and Rojas-Suarez (2019) and Chiaramonte and Casu (2017) argued that the findings as regards the impact of Basel III in the developed countries may not apply to African countries because of the differences in the unique country fundamentals such as the political influence in the banking regulations and supervision, central bank legislation and independence, country size, GDP and risk rating, economic factors and local institutional factors such as bank size and operational jurisdiction, amongst others in the African countries. Moreover, whilst a limited number of studies have examined the effect of Basel III on banks' efficiency in Africa, the majority of these studies used financial performance indicators as a measure of efficiency, whilst others used the capital adequacy ratio as the main measure of the Basel III capital regulations (Lotto 2018; Kombo 2014). This study has identified this gap and aims to fill it by using extensive Basel III Accord measures such as the minimum capital requirements, capital buffer premium and liquidity coverage ratio. Thus, the main aim of this study was to analyse the efficiency of African banks, most importantly after the 2008 global financial crisis when the Basel III regulations were popularly adopted by banks globally. The research aim was examined in two ways, the first part focused on investigating the impact of the Basel III capital regulations on the operational and investment efficiency of African banks by using the popular random effects and pooled ordinary least square panel data regression models. The second part examined if the African banks are indeed efficient by analysing their level of efficiency using the input-oriented DEA approach. The DEA approach has been around for a while since it was first proposed by Charnes et al. (1978). It has been adopted across several disciplines, one of which is business and finance research. Boubaker et al. (2022) and Vidal-García et al. (2018) adopted the DEA approach in their studies and found it suitable for examining efficiency.

The study drew its data specifically from listed banks of six African countries that have adopted the Basel III regulatory requirements, namely, South Africa, Nigeria, Kenya, Tanzania, Uganda and Malawi. Emphatically, the main purpose of the study was to examine whether the adoption of the Basel III regulatory requirements impacts the African banks' efficiency and also to assess if indeed the African banks are efficient.

The study contributes to the literature in several ways. Empirical studies on Basel III regulatory requirements within the African context that used the key measures of the Basel III Accord such as the minimum capital requirements, capital buffer premium and liquidity coverage ratio are scarce. Prior studies commonly only use the capital adequacy ratio as the measure of Basel III capital requirements to determine the efficiency of banks. The study contributes to the empirical literature by uniquely providing an exceptional perspective of the institutional differences between the developed and the developing countries, especially within the African context, by providing evidence that the liquidity requirements of the Basel III Accord have a significant effect on determining the efficiency of African banks, especially after the GFC. This suggests that the selected African banks are efficient because they adopt the Basel III liquidity requirements, which increased the confidence of bank investors and customers, making the banks safer and better able to survive and thrive under any financial stress. Additionally, the study contributes knowledge about the role of the capital buffer premium on bank efficiency. The capital buffer view has taken prominence since the GFC. The findings strongly validate the view that bank buffer premiums play a significant role in the operational efficiency of African banks. This is a significant revelation in the context of African banks as it fulfils the expectation of the Basel III regulatory requirements. It provides the knowledge that in times of unexpected financial crisis or shock, the selected African banks are well-cushioned with sufficient capital to fall back on.

Even more than this, the original findings of the study reveal that the Basel III capital buffer premiums have a significant positive relationship with both the operating and investment efficiency of African banks. This implies that the tighter the bank regulations are, the more efficient the sampled banks become. This positive relationship implies that the capital buffer premiums do not only provide cushions against financial, market and economic shocks but also improve the banking efficiency. Another important finding is the positive relationship between bank operating efficiency and the liquidity coverage ratio. Thus, African banks with well-performing liquidity ratios are efficient in their operations with the ability to meet their short-term obligations. By implication, adopting stricter liquidity requirements creates a liquidity buffer for banks, giving them cushion confidence to undertake profitable and high-yielding investments, which invariably lead to increased profitability and operational efficiency.

The rest of the paper is organised as follows. Section 2 provides a brief literature review regarding the interrelationship between the Basel III Accord and bank efficiency. Section 3 presents the research methodology used in the study. Section 4 discusses the empirical findings, whilst Section 5 concludes.

2. Literature Review

Following the occurrence of the GFC, the confidence of the public in banks and their ability to deliver their promised services reliably was shaken. The Basel III Accord focused on restoring the financial resilience and strength of the banks' reserve capital by limiting their exposure to credit, market, solvency and liquidity risk (Gropp and Heider 2010). This invariably cleared the doubts and questioning minds of the public and the economy regarding the banks' stability and efficiency in their deliverables and restored confidence. According to Berger and Bouwman (2013), banks are more susceptible to risk, shocks, insolvency and illiquidity that can increase depositors' run; thus, banks are expected to hold a stricter minimum regulatory capital to withstand such financial and economic shocks and absorb risks and bank runs. Lim (2016) added that it is important for private banks with a small capital base to hold more capital because they tend to face more negative shocks from the economy due to their restricted operation capped within their local domain as compared to internationally active banks that are medium and large capital based with access to financial markets in the event of need.

The literature has shown that (Romano 2014; Lyngen 2012) the Basel III Accord has promoted the financial reliability, resilience and efficiency of banking organisations, improved the risk coverage to comprise liquidity and counter-cyclical risks, and is forward-thinking as it addresses the bank-specific risk associated with portfolios and the macro-economic environment. The Accord has addressed the issue of banks' under capitalisation, over-leverage and heavy reliance on short-term funding.

The key elements of the Basel III Accord include, but are not limited to, the improved capital requirements, capital buffers, leverage and gearing ratio, and the new liquidity requirements. Basel III retained the 8% risk-weighted assets (RWA) stipulated in Basel II but significantly improved the quality of the capital or the numerator of the capital adequacy ratio by representing a stricter definition of capital and placing more emphasis on the Common Equity Tier (CET) 1 and Additional Tier 1 capital (Delimatsis 2012). On the one hand, the CET 1 now includes ordinary shares and retained earnings, which are viewed as a high-quality capital base, specifically required during financial crises, whilst the additional Tier 1 capital elements include instruments meeting the criteria for inclusion in additional

Tier 1 capital but not included in CET 1, such as the share premium from the issue of instruments included in additional Tier 1 capital; instruments issued by consolidated subsidiaries and held by third parties that meet the criteria for inclusion in additional Tier 1 capital but not included in CET 1; and regulatory adjustments applied in the calculation of additional Tier 1 Capital.

Furthermore, a capital conservation buffer that did not exist under Basel II has been introduced and is expected to be 2.5% of CET 1 capital. The capital conservation buffer is an additional reserve buffer to withstand the expected future periods of stress which is in place to strengthen the resilience of the banking sector and improve its efficiency (Bank for International Settlements (BIS) 2013).

With a view to correct the overly excessive leverage of banks, the Basel III Accord committee introduced a non-risk-based leverage ratio to supplement the capital minimum requirements and manage the build-up of excessive leverage in the banking system (BCBS 2013; Bank for International Settlements (BIS) 2013). The non-risk-based leverage ratio is the ratio of Tier 1 capital to total exposure. This addresses excessive leverage because the elements that constitute the total exposures are often the source of significant leverage. These elements include the on-balance sheet exposures, derivative exposures, securities finance transactions (SFTs), including repurchase agreements, reverse repurchase agreements and margin lending transactions, and off-balance sheet exposures, such as commitments, guarantees and standby letters of credit (Mateev et al. 2013).

One of the most important improvements made by the Basel III Accord is the introduction of liquidity measures that require banks to maintain liquidity buffers to reduce the chances of a future banking crisis and associated losses of economic output and improve their efficiency. The two major measures of liquidity are the Liquidity Coverage Ratio (LCR) and the Net Stable Funding Ratio (NSFR). The LCR aims to ensure that banks have enough liquid assets to withstand liquidity stress in the short term (30-days stressed funding), whilst the NSFR aims to encourage the banks to hold more stable and longer-term funding sources against their liquid assets to maintain operational efficiency (Jul-Larsen 2014; BCBS 2013).

In the past decade, the number of studies that have investigated the impact and relevance of the Basel regulations has increased. Some authors examined the effect of the capital adequacy ratio on bank performance and found a positive relationship (Nguyen 2020; Lee and Hsieh 2013), whilst others such as Lee and Chih (2013) and Onaolapo and Olufemi (2012) found a negative relationship. Other researchers such as Banerjee and Mio (2018), Chiaramonte and Casu (2017) and Bilal and Salim (2016) examined the impact of capital regulations on stability and efficiency and linked the tighter capital requirements to the operational and investment efficiencies of banks in several ways. They argued that a tighter capital requirement may affect the operational efficiency of banks through their lending functions. For instance, Chiaramonte and Casu (2017) argued that a tighter capital requirement impairs the financial performance of banks as they invest and lend less to meet the minimum capital requirements, which consequentially affects their efficiency. However, Bilal and Salim (2016) argued that, in the long run, with a stronger capital base, the confidence of the public and stakeholders is promoted, which attracts more lending businesses and provides sufficiency in their investments. This invariably impacts the banks' efficiency positively.

A recent study conducted by Moudud-Ul-Huq (2019) examined the relationship between the banks' Basel III regulatory capital buffers and the risk and efficiency adjustments with cyclical movements. The study used dynamic panel data from 461 banks of the BRICS countries for the period 2007–2015. The findings of this study showed that there was a positive and significant relationship between efficiency and the business cycle for four countries except for South Africa. This positive relationship suggests that the banks reported in the study were efficient, except for the ones in South Africa. Additionally, Banerjee and Mio (2018) in their study of British banks found a positive impact of the Basel III Accord on the efficiency of the banks.

Similarly, Lotto (2018) examined the impact of the Basel III capital requirements regulation on bank operating efficiency in Tanzania. The data for the study were collected from the annual accounts of large commercial banks operating in Tanzania between 2009 and 2015. The study used the OLS estimator as a technique to analyse the study variables. The findings of this study showed a positive and significant relationship between the Basel III capital ratio and bank operating efficiency. This suggested that the commercial banks in Tanzania with more stringent capital regulations were more operationally efficient. The relationship also showed that capital adequacy did not only strengthen financial stability by providing a larger capital cushion but also improved the bank's operating efficiency.

Applying the Basel III capital regulatory framework to examine the influence of capital requirements on commercial bank operating efficiency in 22 European Union countries, Chortareas et al. (2012) found that increasing capital requirements improved the operating efficiency of the banks. Similarly, in the global study of 72 countries on the influence of bank supervision, regulation and monitoring on operating efficiency, Barth et al. (2013) found that banks from countries with more strict capital requirements and adherence to Basel III were more operationally efficient compared to those banks from countries with flexible bank capital regulations.

In contrast to the positive results obtained and reported by Moudud-Ul-Huq (2019), Banerjee and Mio (2018), Lotto (2018), Barth et al. (2013) and Chortareas et al. (2012), authors such as Chiaramonte and Casu (2017) and Berger and Di Patti (2006) reported otherwise. Chiaramonte and Casu (2017) argued that a tighter capital requirement harms the operational efficiency of banks. Berger and Di Patti (2006) studied the effect of bank regulations on profitability and efficiency and found that lower capital ratios increased the operating efficiency of banks. This suggested that a negative relationship existed between the higher capital regulatory requirements and the banks' efficiency. Based on this negative effect, they argued that banks holding higher capital in reserve had little capital left to explore future unseen investment opportunities, and that reduced their level of revenue and profits and invariably caused a reduced operating and investment efficiency. Furthermore, Altunbas et al. (2007) examined the cross-section of European banks and found a negative relationship between bank capital requirements and bank operating efficiency.

Additionally, the study of Mashamba (2018) on the effect of the Basel III liquidity regulation on banks' profitability in emerging economics showed a similar result. The study used data from 40 banks operating in 11 developing nations for the period 2011 to 2016. The result of the study showed that capital and liquidity regulatory pressures arising from the LCR requirements weakened the financial performance of banks in developing nations, which consequentially affects the operational efficiency of the banks.

In sum, previous studies have concluded with controversial and inconclusive results about the impact of the Basel III Accord on bank operational and investment efficiency. It is evident from the literature reviewed that no significant work has been conducted on the impact of the Basel III Accord on the banks' efficiency, and we have not come across any research that collectively investigates the impact of the Basel III Accord on the African countries that have adopted it to date.

Based on the empirical pieces of evidence aforementioned, the study hypothesised that the elements of the Basel III Accord, namely, minimum capital requirement (MCR), capital adequacy ratio (CAR) and capital buffer premium (CBP), would be significantly positively associated with African banks' efficiency. The study also postulated that the Basel III liquidity requirements would have a significant positive relationship with the banks' operational and investment efficiency.

3. Methodology and Data

This section presents the data used in the study along with the regression models and DEA techniques developed to achieve the research aim.

3.1. Data and Variable Definition

The first focus of this research was to examine the effect of the Basel III regulations on the operational and investment efficiency of selected African banks. The data for this study were collected from 45 listed banks from six African countries for the period from 2010 to 2019. The African countries investigated in this study are those that have adopted the Basel III accord. South Africa, Nigeria, Kenya, Tanzania, Uganda and Malawi are the six African countries under study. The study used the standardised audited financial statements of the 45 listed banks, which were obtained from the IRESS database.

The summarised definitions of variables are shown in Table 1. Gadanecz and Jayaram (2015) define bank efficiency as the ability of a bank to operate at a lower cost in order to maximise its returns. Miah and Sharmeen (2015), Dietrich and Wanzenried (2011), and Gungoraydinoglu and Öztekin (2011) measured bank efficiency in two popular ways. Firstly, they measured the ratio of overhead operating expenses to the total assets of the bank (OETA), and secondly, they used the net interest margin ratios (NIMRs), which are the ratios of the difference between interest revenue and interest expenses to the total earning asset.

Table 1. Definition of the dependent and independent variables.

S/N	Variables	Acronym	Variable Measurement
Dependent Variables			
1	Efficiency	EFF	OETA = ratio of operating expenses to total assets. NIMR = ratio of net interest revenue to total earnings
Basel III regulatory requirements: Independent Variables			
2	Minimum Capital Requirement	MCR	Minimum ratio of Tier 1 + Tier 2
3	Capital Adequacy Ratio	CAR	Tier 1 + Tier 2/Risk-Weighted Asset
4	Capital Buffer Premium	CBP	Actual capital (core capital plus supplementary capital) less minimum regulatory capital.
5	Liquidity Requirements	LCR	HQLA/ENCO

Note: Table 1 contains the definitions of the variables used in the study. The Table captures all the Basel III Accord variables and how they were measured. The variables include the efficiency (EFF), minimum capital requirement (MCR), capital adequacy ratio (CAR), capital buffer premium (CBP) and the liquidity requirement (LCR).

On the one hand, a higher OETA ratio means the bank is losing a larger percentage of its income to expenses. Thus, a lower OETA ratio is good for the bank and its shareholders because it indicates a good cost containment strategy (Miah and Sharmeen 2015). On the other hand, the NIMR, which is the difference between the interest income generated by the bank and the amount of interest paid out to the lender, shows the bank's ability to pay out interest to its depositors in relation to the amount of interest they earned on their assets. By implication, a positive net interest margin indicates that the bank is efficiently investing, whereas a negative net interest margin implies inefficient investing. The interest revenue is generated through interest payments the bank receives on outstanding loans and its other investments appearing on the face of its balance sheet. The interest expenses on the one hand are the price the lender charges the borrower in a financial transaction. It is the cost of borrowing money and the interest that accumulates on outstanding liabilities. This appears in a bank's balance sheet as customer deposits and wholesale financing amongst others. The total earning assets, on the other hand, are investments that produce income without significant effort on the bank's part, which includes stocks, bonds and certificates of deposits amongst others. Hence, a positive net interest margin indicates that a bank is earning more money from receiving interest on its investments than from paying interest. This indicates that the bank's capital is invested efficiently, whilst a negative NIM indicates that the bank is losing more money than it is making on its investments, and the bank is inefficient (Corporate Finance Institute (CFI) 2022; Gadanecz and Jayaram 2015). Thus, this study adopts the ratio of operating expenses to total assets and the net interest margin ratio as measures of a bank's operating and investment efficiency, respectively.

Following the Basel III regulatory requirements (BCBS 2010, 2013), this study used the elements of the Basel III Accord, namely, the minimum capital requirement (MCR), capital adequacy ratio (CAR), capital buffer premium (CBP) and liquidity requirements (LCR), as the main predictors of African bank efficiency.

3.2. Regression Model Specification

With an appropriate model specification, predictor variables can explain satisfactorily to a large extent what distinguishes each variable and observation in the pool of data. Nonetheless, there are still some intrinsic unnoticed heterogeneities that form part of the error term. One important way to reduce and manage the heterogeneities is dependent on the method used to model a dataset (Malik and Rafique 2013).

This research adopted the panel data method. According to Nigist (2015) and Shumet (2016), panel data methodology pools observations on a cross-section of subjects over a particular period, which makes each variable studied repeat over some time. This methodology allows for an increase in the amount of data because it combines the data between the cross-sectional and time-series data. This increases the degrees of freedom and decreases the collinearity between explanatory variables, which leads to the superior efficiency of the econometric estimation. This methodology also allows the researcher to analyse different econometric issues that cannot be accurately studied using only longitudinal or time series methodology.

The main advantage of this methodology is that it improves the estimation efficiency of the data set and widens the scope of concluding, it is more informative than pure time series or cross-sectional data analysis, making it well suited to detect the dynamics of change, and also allows for usage of diverse suitable estimators, which can be categorised under the static and dynamic data estimators. The study applied the static panel data model to test the effect of the Basel III Accord on banks' efficiency. The static panel data model is suitable over the dynamic panel data model in this instance because the present value of bank efficiency is not affected by its previous year's values. As aforementioned, the model is not without its limitation, the major drawbacks of the panel data model are heterogeneity, sample selectivity biases and short time series dimension problems (Malik and Rafique 2013). The researcher, therefore, conducted various tests to verify the presence or absence of multicollinearity, heteroscedasticity, unit root and cross-sectional independence. The nature of the data used in this study warrants the examination for the existence of non-stationarity in the data series. Non-stationary data generate the problem of spurious regression between unrelated variables; hence, both the left-hand side and right-hand side variables of the regression model must be made stationary to avoid the problem of spurious regression (Olweny and Omondi 2011). To address the issue of non-stationarity, the unit root test was carried out. There are numerous unit root tests and one of the most popular amongst them is the Augmented Dickey-Fuller (ADF) test that was used for this study. The decision criteria involve comparing the computed ADF test statistics with the critical value for the identification of a unit root. Generally, if the ADF test statistics are higher than the critical value tested at 1%, 5% and 10% significant levels, it denotes that the time series data are non-stationary and must be differenced until they become stationary (Sigauke 2014). In the presence of any of the panel data model errors, it is necessary to introduce corrective measures such as differencing the data set in order to not compromise the reliability of the results.

There are some estimators used in fitting the static panel data model such as the pooled ordinary least square (OLS), fixed effect (FE) and the random effect (RE) (Francis and Osborne 2012; Lee and Hsieh 2013). The pooled OLS estimator, on the one hand, uses a constant intercept across all cross-sectional units and assumes equal slope and intercepts for all observations (Torres-Reyna 2007). Thus, the estimator suffers from the problem of unobserved heterogeneity amongst the unit of analysis. However, this problem can be easily resolved by differencing the data set. The FE estimator, on the other hand, assumes that the sample is non-random, the variables have constant slopes but different cross-sectional intercepts and can handle unbalanced panel data. The major challenge with the FE estimator is the problem of time-constant heterogeneity, which can be overcome by introducing dummy variables that are usually referred to as the least square dummy variable (LSDV) estimators (Arellano and Bover 1995). The RE estimator is used to address the assumption that the error term follows the classical assumptions, thus the individual differences in the variable intercepts are captured by the error term. The main advantage of the RE estimator is that it retains both the observed individual heterogeneity and the n-degree of freedom in the regression model, whilst the FE estimators drop and lose the individual heterogeneity and the n-degree of freedom (Dougherty 2006).

To select the appropriate estimator amongst the pooled OLS, FE and RE to fit the static model equation, the F-test, Hausman–Wu and Breusch and Pagan test were carried out. These models, estimators and statistical tests were implemented in the STATA 15 econometric software.

To test the impact of Basel III regulatory requirements on the African banks' operational and investment efficiency, the following models were defined

$$OETAi,t = \beta_0 + \beta_1 MCR\ i,t + \beta_2 CAR\ i,t + \beta_3 CBP\ i,t + \beta_4 LCR\ i,t + \varepsilon\ i,t \quad (1)$$

$$NIMRi,t = \beta_0 + \beta_1 MCR\ i,t + \beta_2 CAR\ i,t + \beta_3 CBP\ i,t + \beta_4 LCR\ i,t + \varepsilon\ i,t \quad (2)$$

In the above models, Equations (1) and (2), β_0 represents the intercept/slope parameters, whilst $\beta_{1\text{–}4}$ represents the coefficient of the variables and ε_t represents the error term. Model Equation (1) tests the extent to which the operating efficiency of banks, which is represented by the ratio of operating expenses to total assets (OETA), was affected by the Basel III regulatory requirements, whilst model Equation (2) tests the extent to which the investment efficiency of banks, which is represented by the ratio of net interest revenue to total earnings (NIMR), was affected by the Basel III regulatory requirements.

3.3. Data Envelopment Analysis (DEA)

Data envelopment analysis (DEA) is a linear programming approach and a non-parametric methodology used in applied economics research, management sciences research, operations research, business and finance research and mathematics applied research, amongst others. DEA is used to measure the efficiency of the decision-making unit (DMU). One predominant benefit of the DEA approach is that it can contain numerous and different input and output variables in a single model (Horvat and Budimcevic 2018). The results of the DEA estimation show the ranks and efficiency scores of each DMU with reference sets for benchmarking. According to Ji and Lee (2010), DEA exhibits several beneficial attributable characteristics such as no assumptions about input-output function, no limits to the number of inputs and outputs, no required weight restrictions, provides reference sets for benchmarking and provides useful information for input-output mix decision. DEA can either be input-oriented or output-oriented. The input-oriented approach aims at minimising the input to improve performance, whilst the output-oriented approach focuses on increasing the output to improve performance. According to Milenković et al. (2022), the choice of the DEA model orientation depends largely on whether the decision-makers have more influence on improving the input or output levels; therefore, in this paper, the input-oriented DEA model with a variable return to scale (VRS) was adopted to analyse the level of efficiency of the 45 listed banks operating in the six sampled African countries. Charnes et al. (1981) originally proposed the efficiency measurement of the DMUs that allows only a constant return to scale (CRS). The CRS is based on the assumption that the input and output variables change proportionately and all DMUs operate at their optimal level. Later, Banker et al. (1984) introduced the variable returns to scale (VRS) efficiency measurement model, allowing the breakdown of efficiency into technical and scale efficiencies in DEA. The VRS of Banker et al. (1984) suggested that in reality, inputs and outputs change disproportionately. This is because it will be difficult for the DMUs to decide that a one per cent change in inputs will result in a proportionate one per cent change in outputs.

The application of DEA models under the CRS is appropriate only in cases where all entities operate under an optimal condition, which can influence a proportionate change in inputs and outputs. Therefore, this study used the DEA model with a variable return to scale and found it appropriate.

The sampled banks are the DMUs in the study. Similar to the study of Ngo and Le (2019), the study included the operating expenses and interest revenues as its input variables, whilst outputs consisted of the total assets and total earnings. Note that the use of two sets of input and outputs is consistent with the DEA literature (Ngo and Le 2019). The analysis was performed by solving the following models developed by Banker et al. (1984) of linear programming for each DMU and time period.

$$\max\left(\theta = \frac{\sum_{r=1}^{s} \lambda_r y_{r0}}{\sum_{r=1}^{m} \lambda_i x_{i0}}\right)$$

Subject to

$$\frac{\sum_{r=1}^{s} \lambda_r y_{rj}}{\sum_{r=1}^{m} \lambda_i x_{ij}} \leq 1; j = 1,\ 2, \ldots,\ n$$

where

$$\lambda_i\ \geq 0; i = 1, 2,\ \ldots,\ m$$

$\lambda_r\ \geq 0; r = 1, 2,\ \ldots, s$ and n is the number of entities (DMUs) in the sample (banks in every country in this study). s is the number of output variables, whilst m is the number of input variables. xij is the amount of input i utilised by jth DMU, whilst yrj is the amount of output r produced by the jth DMU. λi is the weight given to input i and λr is the weight given to output r. The efficiency score is θ, which represents the factor by which the current levels of input constraints are solved under the VRS assumption. This analysis was performed using the STATA 15 econometric software.

4. Discussion of Results

This section presents and discusses the descriptive statistics and normality test results as well as the static panel data regression and DEA results.

4.1. Descriptive Statistics

This section presents the descriptive statistics and normality test results of the variables used in this study.

The descriptive statistics results in Table 2 show that, on average, all sampled banks have operating (OETA) and investment (NIMR) efficiency of 0.82% and 430.03%, respectively. On the one hand, the interpretation of the bank operating efficiency of 0.82% is that, on average, the operating expenses of any bank in the sample of this study comprise only 0.82% of the total assets of the bank. Miah and Sharmeen (2015) suggested that a higher OETA ratio means the bank is losing a larger percentage of its revenue to expenses and a lower ratio is good for the bank and its shareholders because a smaller ratio indicates a more profitable bank. The OETA ratio is a clear indicator of how efficient the bank is operating.

On the other hand, the interpretation of the bank investment efficiency of 430.03% is that, on average, any bank in the study sample can pay out interest to its depositors 430 times as a result of its high earnings and investments. Investment efficiency measures the ability of a bank to pay out interest to its depositors in relation to the amount of interest they earned on their assets. A higher NIMR indicates cheaper funding and high margins, which shows how efficient a bank is. This suggests that, on average, the African banks in this study were highly efficient.

Table 2. Summary statistics, normality and stationarity test results of the variables.

Variables	Mean	Std Deviation	Minimum	Maximum	Skewness	Kurtosis	ADF Test-Statistics
OETA	0.0082	0.0065	0.0011	0.0855	0.0591	0.6061	−7.596 ***
NIMR	4.3030	22.8573	−26.8340	211.3770	−0.0360	0.7454	−12.467 ***
MCR	0.1359	0.0620	0.0628	0.2090	0.0054	0.0204	−10.309 ***
CAR	0.2937	0.1851	0.1056	0.4818	0.0156	0.0518	−16.112 ***
CBP	0.1578	0.1231	0.0428	0.2728	0.0950	6.0737	−0.552
LCR	1.8172	1.1984	0.7053	2.6991	0.0251	0.1170	−14.809 ***

Note: Table 2 presents the summary statistics for the dependent and independent panel data variables. The panel data variables were constructed from the data drawn from the annual financial statements, which were obtained from the IRESS database. To eliminate outlier observations and the most extremely misreported data, all variables were winsorized to the 99th percentile. The bank efficiency was measured by both the OETA and NIMR, which are the dependent variables. The independent Basel III Accord variables in the Table are defined as follows: MCR denotes the minimum capital requirement; CAR denotes the capital adequacy ratio; CBP denotes the capital buffer premium and LCR denotes the liquidity coverage ratio. The unit root test was performed using the Augmented Dickey-Fuller (ADF) test and tested at a 99% (***) confidence level. All the variables are well defined in Table 1 and full ADF test results are presented in Table A2. Source: Authors' computation (2022).

Minimum capital requirements and the capital adequacy ratio are crucial elements in protecting banks from financial stress and cushioning them from economic failures. This is because banks are the riskiest business in the financial sector due to the high level of loan defaults and bank runs. The banks' failure significantly affects the entire economy locally and globally; therefore, banks are obliged to have adequate capital to avoid the crashing of the financial system.

The Basel III Accord prescribed a total capital ratio of 8% and liquidity coverage ratio of 100%, which was adopted closely by all the banks in the study sample. Table 2 shows that, on average, every bank in the study sample holds a capital and liquidity requirement of about 13.59% (MCR), 29.37% (CAR), 15.78% (CBP) and 181.72% (LCR), levels well above the stipulated regulatory requirement in the Basel III Accord (BCBS 2013).

A higher CAR indicates that African banks keep their capital adequacy ratio far above the 8% of the CET 1 ratio and Tier 1 capital ratio prescribed by the Basel III Accord. Moreover, the higher CBP indicates that, on aggregate, the banks have an adequate capital buffer to cushion them in probable times of financial or economic crisis. Furthermore, the high LCR implies that for the period under study, the African banks held excess of the LCR threshold of liquid assets to withstand the liquidity crisis. This reduces the chances of a future banking crisis and associated losses of economic output in the short term.

Even more than this, the skewness normality test of data integrity shows that all variables are evenly distributed with skewness coefficients close to zero. All variables are skewed rightward except for NIMR skewed to the left. This suggests that the variables are asymmetrically distributed where the mean, median and mode do not occur at a regular frequency or the same point (Joanes and Gill 1998). In addition, the kurtosis coefficients for most variables have values less than 3, which is suggestive of no positive surplus kurtosis following a light-tailed distribution known as a platykurtic distribution. The exception to this general light-tailed distribution is the capital buffer premium with a kurtosis coefficient of 6.0737, which follows a heavy-tailed distribution, by this means unveiling one of the important features of financial and economic panel data, viz. that of leptokurtosis (Sigauke 2014). Moreover, all variables are stationary with no unit root since the computed ADF test statistics are less than the critical values at 1%, except for the capital buffer premium, which exhibits the non-stationarity-containing unit root.

Hence, to remove the surplus positive kurtosis and eliminate the unit roots identified, the capital buffer premium variable was transformed by differencing it to its 1st order level to follow a normal stationary distribution, which is suitable to fit the static panel data regression model. This also curtails the forfeiture of information and removes the existence of multicollinearity in the right-hand independent variables, which could lead to higher standard errors for individual estimates and misrepresentation of the coefficient's statistical significance.

4.2. Regression Results

The study conducted several relevant tests such as the multicollinearity test, the F-test and Breusch and Pagan test and the Hausman specification test to fit the regression model appropriately.

The multicollinearity test was conducted to ascertain that there is no existence of multicollinearity in the predictor variables, which could lead to a wrong understanding of the coefficient's statistical significance. The test was performed by calculating the variance inflation factors (VIF) for the variables in the model equation. The VIF test results are reported in Table 3.

Table 3. Multicollinearity test results for the Z-score model.

Variables	OETA		NIMR	
	VIF	**1/VIF**	**VIF**	**1/VIF**
MCR	2.85	0.3507	2.85	0.3507
LCR	1.91	0.5222	1.91	0.5222
CAR	1.56	0.6393	1.56	0.6393
DCBP	1.03	0.9737	1.03	0.9737
Mean VIF	1.84		1.84	

Note: Table 3 presents the results of the multicollinearity test for the OETA and NIMR efficiency models. The test was performed by calculating the variance inflation factors for the variables in Model Equations (1) and (2). In Model Equation (1), the bank efficiency was measured by the ratio of operating expenses to total assets (OETA), and in Model Equation (2), the bank efficiency was measured by the ratio of net interest revenue to total earnings (NIMR). The variable definition follows the same as presented in Tables 1 and 2 for the exception of the DCBP, which denotes the capital buffer premium differenced on the 1st order level. The Table shows no multicollinearity. Source: Authors' computation (2022).

The VIF for the relationship between the independent and dependent variables as shown in Table 3 is less than 10 with a mean VIF of 1.84. This is evidence that there is no existence of multicollinearity in the independent variables associated with the regression models.

Furthermore, choosing a suitable estimator to fit the regression models, the F-test, Breusch and Pagan test and the Hausman specification tests were performed. The F-test is used to identify if there is an existence of fixed effects in a regression model. If the H_0 is rejected and the p-value is statistically significant, then the FE model is suitable. The Breusch and Pagan test is used to identify if there is an existence of random effects in a regression model. If the H_0 is rejected and the p-value is statistically significant, then the RE model is suitable. However, in a situation where there are no fixed or random effects in a regression model, that is, the p-value of both tests is statistically insignificant, the pooled OLS model is favoured.

In addition, peradventure where there are fixed and random effects in a regression model, that is, the p-value of both tests is statistically significant, the Hausman specification test is used to select the most suitable estimator between the FE and RE. A fixed effects model is chosen if the H_0 of the Hausman test is rejected, that is, the p-values of the Hausman tests are statistically significant and vice versa.

Based on the aforementioned selection criteria of the suitable estimator between the pooled OLS, FE and RE, the OETA model diagnostic test results for the F-test and Breusch and Pagan test were statistically significant. This suggests that there is an existence of fixed and random effects in the regression model. Hence, the pooled OLS estimator was dropped and the Hausman specification test was used to arrive at a suitable estimate between FE and RE. The p-values of the Hausman specification tests were statistically insignificant for the OETA regression model. Therefore the H_0 was not rejected in favour of the fixed effects. Hence, the random effects estimator was favoured and used to report the results for the OETA regression model. For the NIMR regression model, the F-test and Breusch and Pagan test were conducted, and the results show that there were no fixed or random effects in the model. This is because the p-value from both the F-test and Breusch and Pagan test were statistically insignificant, and therefore the H_0 is not rejected. Based on these results, the pooled OLS estimator was favoured and selected as a good fit to report the results for the NIMR regression model.

The regression results presented in Table 4 show that bank capital regulation positively impacts the operating and investment efficiency of the sampled African banks. The results show that, for every increase in one unit of bank buffer capital, the banks' operating and investment efficiency increases by 0.71 and 70.5, respectively. The results of the random effect and pooled OLS regression also show a statistically significant positive relationship at 10% and 5% significant levels, respectively.

Table 4. Random effects and pooled OLS regression results.

	Random Effects Results			Pooled OLS Results		
	OETA			NIMR		
Variables	**Coefficients**	**Z-Statistics**	***p*-Value**	**Coefficients**	**T-Statistics**	***p*-Value**
MCR	0.1081	1.30	0.221	21.1478	0.71	0.810
CAR	0.0450	1.31	0.430	7.4288	1.01	0.321
DCBP	0.1701	1.74	0.081 *	70.5403	2.35	0.030 **
LCR	0.2810	3.42	0.000 ***	−2.0525	−0.68	0.203
Obs.	450			450		
Adjusted R^2	0.6430			0.761		
BP L-M statistics	347.33		0.000			
Hausman Test:						
Chi^2-value	6.23					
Prob > chi^2	0.2843					

Note: Table 4 shows the regression results of the operating and investment efficiency model. The bank efficiency was measured by both the OETA and NIMR. The operating efficiency (OETA) model was fitted using the RE estimator, whilst the investment efficiency (NIMR) was fitted using the pooled OLS estimator. All the coefficients were estimated at a 99% confidence level. The variable definition follows the same as presented in Tables 1–3. The markings ***, ** and * indicate significance levels at 1%, 5% and 10%, respectively. The static panel data estimation test results are shown at the bottom of the Table. Source: Authors' computation (2022).

This implies that the increased regulations on capital requirements influence a bank's decisions and perspectives on cost containment strategies to improve operational efficiency. More than this, they change their risk behaviours in terms of considering only value-adding and positive net present value investments to improve their investment efficiency.

It is commonly argued that stricter and higher regulatory requirements and buffer premiums are expected to keep the banks stable and protected against market and economic shocks (Lotto 2018; Sutorova and Teplý 2013). This enables banks to be more financially stable and confident to explore various profitable investments at a well-reasoned risk level, expand their operations, consider value-adding innovative ways of conducting business and flourish in their core line of business, which is lending and credit creation.

Giordana and Schumacher (2017) argue that banks that are poorly capitalised with inadequate buffer capital avoid taking risks that could yield profitable returns because they do not have cushion capital to secure them against risk and probable losses. They further added that under capitalisation hinders the operational viability of banks and leads to inefficiencies in their operations.

This study has similar results to those of Capgemini (2014), who concluded that there is a positive relationship between capital buffer premiums and bank efficiencies. They argued that an increased and stricter capital requirement promotes the financial performance of the banks, which invariably improves the bank's efficiency. A recent study with similar results is that of Nguyen (2020), who argued that an increased capital gives the African banks some level of confidence, as the capital buffer serves as a cushion against economic and financial shocks. Hence, banks can carry out their lending operations smoothly and confidently undertake profitable and high-yielding investments, which invariably lead to an increase in operational and investment efficiency.

Similarly, Lee and Hsieh (2013) argued in their study of European banks that banks with more capital make stronger monitoring and supervisory efforts. They make better lending decisions than they would do if they were less well capitalised, and they can extract higher payments from the borrowers. This increases the profitability of a bank and its return to the shareholders. Hence, a bank increasing its capital ratio is consistent with the maximisation of the profits and efficiency enhancement as stipulated by the Basel III capital regulatory framework.

On the one hand, the results in Table 4 show that the liquidity coverage ratio positively impacts the operating efficiency of the sampled African banks. The results show that, for every increase in one unit of the liquidity coverage ratio, a bank's operating efficiency increases by 28.1 The results of the random effect also show a statistically significant positive relationship at a 1% significant level.

This suggests that African banks with well-performing liquidity ratios are efficient in their operations with the ability to meet their short-term obligations such as meeting customers' credit needs, unannounced depositors' withdrawals and creditors' repayments, amongst others.

Previous studies by Abbas and Younas (2021) and Ha and Quyen (2018) and the expectation of the Basel III Accord indicate that banks from countries with strict regulations and adherence to the Basel III liquidity requirements are more operationally efficient as compared to those banks from countries with flexible and unstructured capital regulations. This is mainly because stricter liquidity requirements create a liquidity buffer giving banks from countries with structured requirements not just cushion confidence but the ability to meet their operational obligations. This result is consistent with the findings of Sutorova and Teplý (2013), who found that there was a positive relationship between banks' technical and operational efficiency and liquidity requirements. Similarly, the study of Chortareas et al. (2012) on the influence of Basel III capital and liquidity requirements on commercial banks' operating efficiency in 22 European Union countries, found that increasing capital and liquidity requirements improves the operating efficiency of banks.

On the other hand, the results in Table 4 show that the liquidity coverage ratio is negatively related to the investment efficiency of the sampled African banks. Though this result is statistically insignificant, the reasonable explanation for this inverse relationship might be that in the race for African banks to comply with the tighter Basel III liquidity requirements, funds are allocated to meet up with the requirements to the detriment of other viable investment decisions. Giordana and Schumacher (2017), who found a negative relationship between the Basel III liquidity requirements and the Luxembourg banks' efficiency, argued that Luxembourg banks became more vulnerable to failure and inefficiency. They explained that the tighter liquidity requirements restricted profitable banking activities and constrained profitable investment choices, which invariably severed their financial and investment efficiencies.

In order to assess the robustness of the regression model results discussed above, a model variation test was conducted by substituting the actual regulatory capital held by the selected listed African banks with the Basel III prescribed minimums as the control variables. This test was conducted to ascertain the impact of the Basel III prescribed minimums on the efficiency of the selected listed African banks. From the test results, the study deduced the most viable option between the Basel III prescribed minimums and the actual capital held by the selected African banks. Thus, the study used the Basel III prescribed minimums as the control variables. See Table A3 in the Appendix A for the robustness test results. Based on the aforementioned results and the robustness test results, the study therefore argues that the Basel III capital buffer premiums and liquidity coverage ratio have a significant positive impact on the operational and investment efficiencies of the sampled African banks.

4.3. DEA Efficiency Results

The DEA model was implemented using the STATA 15 software using the VRS DEA approach with input orientation. This implies that the study assessed the level of the banks' operational (OETA) and investment (NIMR) efficiency on a total aggregate and based on each sampled country. The results also show which banks from the sampled country need to increase their efficiency by reducing their input variables. The results of this analysis are presented in Table 5 and Appendix A Table A1.

Table 5. DEA Efficiency results.

		OETA		NIMR	
S/N	**Country**	**Average Efficiency Score**	**Ranking**	**Average Efficiency Score**	**Ranking**
1	Kenya	0.7304	6th	0.9021	6th
2	Nigeria	0.8653	3rd	0.9378	5th
3	South Africa	0.9587	1st	0.9912	1st
4	Tanzania	0.8421	4th	0.9582	3rd
5	Uganda	0.7877	5th	0.9596	2nd
6	Malawi	0.8891	2nd	0.9510	4th
Total		0.8480		0.9488	

Note: Table 5 shows the average efficiency score of the sampled banks from the individual countries as derived from the VRS DEA estimation. The ranking for each country is also presented in the Table. The table shows the results for both the operational efficiency measured by the (OETA) and the investment efficiency measured by the (NIMR). The South African banks have the highest ranking for the (OETA) and the (NIMR), whilst the Kenyan banks have the lowest ranking for the (OETA) and the (NIMR). Source: Authors' computation (2022).

The result presented in Table 5 shows that African banks operate at an impressive level of efficiency. This is because the aggregate score of both the operational and investment efficiency was above 80% for the period under study, though the African banks' investment efficiency appears to have a much higher score of 95% as compared to the operational efficiency of 85%.

South African banks, amongst other sampled African banks, had the highest operational and investment efficiency scores of 96% and 99%, respectively, over the ten year period under study. This indicates that amongst other sampled countries, South African banks are the most efficient. The Kenyan banks had the least operational and investment efficiency scores of 73% and 90%, respectively, over the ten years under study. As a result of this, Kenyan banks need to increase their efficiency performance by reducing their input operational and investment expenses. Banks in Nigeria, Tanzania, Uganda and Malawi appear to have average efficiency scores across their operational and investment efficiencies. The overall average efficiency of the sampled banks for the period under study were 85% operational efficiency and 95% investment efficiency

5. Conclusions

The study examined the impact of the Basel III regulations on the banking efficiencies in six African countries that have adopted the Basel III Accord from 2010 to 2019. The study further analysed the level of the banks' operational and investment efficiencies.

The study used the random effect estimator to fit the regression model to test the relationship between the Basel III regulations and the banks' operational efficiency, whilst the pooled OLS estimator was used to fit the regression model to test the relationship between the Basel III regulations and the banks' investment efficiency. The DEA approach was adopted to test the level of the banks' operational and investment efficiencies.

The study findings show a positive and significant relationship between the capital buffer premiums and the banks' operating and investment efficiency, implying that the tighter the bank regulations are, the more efficient the sampled banks become. This positive relationship implies that the capital buffer premiums do not only provide cushions against financial, market and economic shocks but also improve the banking efficiency by influencing the banks' decisions and perspectives on cost containment strategies such as adopting innovative digital banking systems. This study also shows that the increased capital regulations influence banks' risk-taking behaviours in terms of considering only value-adding and positive net present value investments, which invariably improves their investment efficiency.

Another important finding is the positive relationship between bank operating efficiency and the liquidity coverage ratio. By implication, this means that African banks with well-performing liquidity ratios are efficient in their operations, with the ability to meet their short-term obligations such as meeting customers' credit needs, unannounced depositors' withdrawals, and creditors repayments, amongst others. The study also shows that adopting stricter liquidity requirements creates a liquidity buffer for banks, giving them some cushion confidence to undertake profitable and high-yielding projects, which invariably leads to increased profitability and operational efficiency. The results of the regression models were validated by the DEA results, showing that the overall average efficiency of the sampled banks for the period under study were 85% operationally efficient and 95% investment efficient.

This research has important implications as it does not only address the issue of the scant Basel III literature within the African context but also fills the gap in examining the significant influence of the capital buffer premium and the new liquidity requirements on the operational and investment efficiency of African banks. The study validates the expectation of the Basel III capital and liquidity regulations on the efficiency of banks and provides evidence that the liquidity requirements of the Basel III Accord have a significant positive impact on determining the operational efficiency of the selected African banks, especially after the GFC. This suggests that the selected African banks are operationally efficient because they adopt tighter capital and liquidity requirements.

Based on the results explained above, the study suggests the following policy-based recommendations. Firstly, the sampled African banks are advised to continually maintain a reasonable level above the prescribed buffer premium and liquidity coverage ratio minimum to remain efficient. In order words, the central and reserve banks who implement the Basel III framework in each country should target having a well-established buffer capital as it significantly protects the banks from possible economic and financial shocks and also helps with various cost containment strategies as well as control the risk-taking behaviours of the bank managers and directors. Thus, the central/reserve banks of the African countries should monitor the levels of the buffer premium and liquidity coverage ratio kept by the banks and their compliance with this regulatory supervisory monitoring framework. Secondly, the governments, central banks and banks from other African nations who are considering the implementation of the Basel III framework can rely on this study's findings and methodology and test using their local bank-level data to ensure the suitability of the new Accord in their jurisdiction. Lastly, the result from this study reveals that implementing the Basel Accord and selecting the rightful mix of the Basel III Accord variables requires a careful assessment. Thus, African banks and central banks are advised to carefully choose which mix of the Basel III Accord suits their prioritised needs as the Basel III regulatory requirements appear to be a two-edged sword within the African context and have varying impacts on the banks' efficiency.

The study was conditioned by some limitations. Firstly, the study could only use a small sample, which consisted of 45 listed African banks obtainable from the IRESS database. This is because the study focused only on the African countries that have adopted the Basel III regulatory framework. Future research in similar areas may increase their sample size provided more and other African countries have adopted the Basel III Accord by then. In addition, the study only used the main components of the Basel III framework such as the minimum capital requirements, capital adequacy ratio, capital buffer premium and the liquidity coverage ratio in its regression model because these main components are largely adopted within the African context. Future studies can include other revised elements of the Basel III Accord such as the credit valuation adjustment framework, corporate supervision, counterparty credit risk and stress testing in their regression model when the relevant data are available. Lastly, the study used the NIMR as the measure of investment efficiency for the sampled banks as available from the IRESS database. This measure, like others, has its inherent limitation as the bank may over or underestimate its investment activities. The measure was used despite its limitation because the data were extracted from the audited financial statement extracts available on the IRESS database, which is a reliable source. Although this study is limited by data availability, it does not affect our results' reliability and robustness; future studies can consider using other measures of investment efficiency provided data availability to uncover other new dynamics.

Author Contributions: Conceptualization, A.M.O.; methodology, A.M.O.; software, A.M.O.; validation, V.M. and N.F.M.; formal analysis, A.M.O.; investigation, A.M.O.; resources, V.M.; data curation, A.M.O.; writing—original draft preparation, A.M.O.; writing—review and editing, A.M.O.; visualization, A.M.O.; supervision, V.M. and N.F.M.; project administration, V.M. and N.F.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data that support the findings of this study are available on the IRESS database with the support of the University of South Africa to access the University library database. The datasets can be accessed at www.iress.co.za (accessed on 15 March 2021).

Acknowledgments: Firstly, the authors acknowledge the intervention of Eugene Mwaba, the Director of the School of Finance and Professional Studies, Botswana Accountancy College, and the entire college for the support and the atmosphere provided to diligently complete this paper article to add value to the body of knowledge. The authors would like to thank the anonymous reviewers whose invaluable suggestions and comments improved the quality of this work. Lastly, special acknowledgement goes to my friend Emmanuel Olamijuwon for the invaluable guidance and motivation provided during the paper review.

Conflicts of Interest: The authors have declared no financial or personal relationships that may have inappropriately influenced the writing of this article, hence, no conflict of interest exists.

Appendix A

Appendix A shows the efficiency scores of the DEA estimation result, the ADF test statistics and the robustness test results. The efficiency scores are shown for all sampled banks in the sampled countries for the period 2010 to 2019 in Table A1, the ADF test results in Table A2 and the robustness test result in Table A3. The summarised version of Table A1 is shown in Table 5.

Table A1. DEA Efficiency Scores.

			OETA	NIMR
S/N	**Country**	**DMU**	**Score**	**Score**
1	Tanzania	CRDB Bank	0.780167	0.96431
2	Tanzania	OCB Commercial Bank	0.781439	0.961874
3	Tanzania	KCB Group Plc	0.781046	0.962355
4	Tanzania	Maendeleo Bank Plc	0.78015	0.958146
5	Tanzania	Mkombozi Commercial Bank Plc	0.785724	0.955836
6	Tanzania	Mucoba Bank	0.99395	0.95133

Table A1. *Cont.*

			OETA	NIMR
S/N	**Country**	**DMU**	**Score**	**Score**
7	Tanzania	NMB Bank Plc	0.993561	0.953982
Average			0.842291	0.958262
8	South Africa	ABSA Bank Ltd.	0.992896	0.990131
9	South Africa	Capitec Bank Holdings	1	0.99554
10	South Africa	First National Bank	0.996209	1
11	South Africa	Nedbank Group Ltd.	0.91635	0.992974
12	South Africa	Sasfin Holdings Ltd.	0.923536	0.977752
13	South Africa	Standard Bank Group Ltd.	0.923981	0.990111
Average			0.958829	0.991078
14	Uganda	Bank of Baroda Uganda	0.929605	1
15	Uganda	DFCU Ltd.	0.934308	0.94597
16	Uganda	Equity Bank Ltd.	0.700412	0.930998
17	Uganda	KCB Group Plc	0.69636	0.922998
18	Uganda	Stanbic Bank Uganda Ltd.	0.679158	0.997799
Average			0.787969	0.959553
19	Malawi	National Bank of Malawi	0.879104	0.96835
20	Malawi	NBS Bank	0.869020	0.948934
21	Malawi	Standard Bank Malawi	0.919155	0.935912
Average			0.889093	0.951065
22	Kenya	Absa Bank	0.770312	0.93839
23	Kenya	BK Group Plc	0.746503	0.940617
24	Kenya	Co-operative Bank of Kenya Ltd.	0.700495	0.948219
25	Kenya	Diamond Trust Bank	0.602219	0.91532
26	Kenya	Equity Group Holdings Plc	0.665996	0.855576
27	Kenya	I&M Holdings	0.874659	0.843729
28	Kenya	KCB Group	0.873802	0.836308
29	Kenya	National Bank of Kenya	0.681904	0.91128
30	Kenya	NIC Group Plc	0.79172	0.883624
31	Kenya	Stanbic Holdings Plc	0.75155	0.935564
32	Kenya	Standard Chartered Bank	0.57514	0.9152
Average			0.730391	0.902166
33	Nigeria	Access Bank Plc	0.915479	0.919599
34	Nigeria	Eco Bank	0.917807	0.92884
35	Nigeria	FBN Holdings Plc	0.935185	0.932556
36	Nigeria	FCMB Group	0.822388	0.933497
37	Nigeria	Fidelity Bank	0.821355	0.941982
38	Nigeria	Stanbic IBTC Holding Plc	0.810171	0.942188
39	Nigeria	Sterling Bank	0.820942	0.953407
40	Nigeria	Union Bank of Nigeria	0.831225	0.957367

Table A1. *Cont.*

			OETA	NIMR
S/N	**Country**	**DMU**	**Score**	**Score**
41	Nigeria	United Bank for Africa	0.913026	0.932673
42	Nigeria	Unity Bank	0.927069	0.914649
43	Nigeria	Wema Bank	0.930412	0.922865
44	Nigeria	Zenith Bank	0.804117	0.938437
45	Nigeria	Guaranty Trust Bank	0.807749	0.973845
Average			0.865917	0.937839
TOTAL			0.848019	0.948891

Table A2. ADF Test Results.

OETA	ADF Test Statistic	1% Critical value	5% Critical value	10% Critical value
	−7.596 ***	−3.480	−2.884	−2.574
p-Value Inference No of obs.	(0.000) Stationary 450			
NIMR	ADF Test Statistic	1% Critical value	5% Critical value	10% Critical value
	−12.467 ***	−3.480	−2.884	−2.574
p-Value Inference No of obs.	(0.000) Stationary 450			
MCR	ADF Test Statistic	1% Critical value	5% Critical value	10% Critical value
	−10.309 ***	−3.480	−2.884	−2.574
p-Value Inference No of obs.	(0.000) Stationary 450			
CAR	ADF Test Statistic	1% Critical value	5% Critical value	10% Critical value
	−16.112 ***	−3.480	−2.884	−2.574
p-Value Inference No of obs.	(0.000) Stationary 450			
CBP	ADF Test Statistic	1% Critical value	5% Critical value	10% Critical value
	−0.552	−3.480	−2.884	−2.574
p-Value Inference No of obs.	(0.881) Non−stationary 450			
LCR	ADF Test Statistic	1% Critical value	5% Critical value	10% Critical value
	−14.809 ***	−3.480	−2.884	−2.574
p-Value Inference No of obs.	(0.000) Stationary 450			

The marking *** indicates significance levels at 1%.

Table A3. Robustness Test Results.

Variables	Pooled OLS Model	Random Effects Model
	NIMR	**OETA**
pMCR	−63.8682 (−0.45)	0.0438 (1.45)
pCAR	88.7360 (0.68)	−0.0336 (−1.21)
pDCBP	3.7912 (0.04)	0.0422 (2.25)
pLCR	−0.8018 (−0.04)	0.7538 ** (3.39)
Obs.	450	450
Adjusted R^2	0.7800	0.8500
BP L-M statistics		407.34 ***
Hausman Test:		
Chi^2-value	0.00	
Prob > chi^2	1.0000	

Table A3 shows the regression results of the Basel III prescribed minimums. The Table shows the estimation results for the relationship between the efficiency of African banks and the Basel III prescribed minimums. The regression model was fitted with the pooled OLS and RE estimator for the NIMR and the OETA model, respectively. All the coefficients were estimated at 99% confidence level. The independent variable pMCR denotes the prescribed minimum capital requirement; pCAR denotes the prescribed capital adequacy ratio; pDCBP denotes the prescribed capital buffer premium differenced on the 1st order level; and pLCR denotes the prescribed liquidity coverage ratio. The t-statistics for the pooled OLS as well as the z-statistics for the RE model are presented in parentheses. The markings *** and ** indicate significance levels at 1% and 5% respectively. The static panel data estimate test results are shown at the bottom of the Table.

References

Abbas, Faisal, and Zahid Irshad Younas. 2021. How Do Bank Capital and Capital Buffer Affect Risk: Empirical Evidence from Large US Commercial Banks. *Journal of Central Banking Theory and Practice* 2: 109–31. [CrossRef]

Ahmed, Sarwar Uddin, Samiul Ahmed, M. Nazmul Islam, and G. M. Ullah. 2015. Impact of Basel II implementation on the financial performance of private commercial banks of Bangladesh. *European Journal of Economics, Finance and Administrative Sciences* 77: 73–84.

Altunbas, Yener, Santiago Carbo, Edward P. M. Gardener, and Philip Molyneux. 2007. Examining the relationships between capital, risk and efficiency in European banking. *European Financial Management* 13: 49–70. [CrossRef]

Arellano, Manuel, and Olympia Bover. 1995. Another look at the instrumental variable estimation of error components models. *Journal of Econometrics* 68: 29–51. [CrossRef]

Banerjee, Ryan N., and Hitoshi Mio. 2018. The impact of liquidity regulation on banks. *Journal of Financial Intermediation* 11: 1–15. [CrossRef]

Bank for International Settlements (BIS). 2013. Basel III: The Liquidity Coverage Ratio and Liquidity Risk Monitoring Tools. Available online: http://www.bis.org/publ/bcbs238.htm (accessed on 15 March 2021).

Banker, Rajiv D., Abraham Charnes, and William Wager Cooper. 1984. Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science* 30: 1078–92. [CrossRef]

Barth, James R., Gerard Caprio, and Ross Levine. 2013. Bank regulation and supervision in 180 countries from 1999 to 2011. *Journal of Financial Economic Policy* 5: 111–219. [CrossRef]

Basel Committee on Banking Supervision (BCBS). 2010. *Basel III: International Framework for Liquidity Risk Measurements, Standards and Monitoring*. Basel: BIS.

Basel Committee on Banking Supervision (BCBS). 2013. *Basel III: The liquidity Coverage Ratio and Liquidity Risk Monitoring Tools*. Available online: http://www.bis.org/publ/bcbs238.pdf (accessed on 10 January 2022).

Beck, Thorsten, and Liliana Rojas-Suarez. 2019. *Making Basel III Work for Emerging Markets and Developing Economies: A CGD Task Force Report*. Washington: Center for Global Development.

Berger, Allen N., and Christa H. Bouwman. 2013. How does capital affect bank performance during financial crises? *Journal of Financial Economics* 109: 146–76. [CrossRef]

Berger, Allen N., and Emilia Bonaccorsi Di Patti. 2006. Capital structure and firm performance: A new approach to testing agency theory and an application to the banking industry. *Journal of Banking & Finance* 30: 1065–102.

Bilal, Zaroug Osman, and Badreldin F. Salim. 2016. Does Basil III Implementation Impact on Financial Performance? Evidence from Omani's Commercial Banks. *International Journal of Economics and Financial Issues* 6: 963–70.

Boubaker, Sabri, Tu D. Q. Le, and Thanh Ngo. 2022. Managing bank performance under COVID-19: A novel inverse DEA efficiency approach. *International Transactions in Operational Research*. [CrossRef]

Capgemini, Merrill Lynch. 2014. World Wealth Report. Available online: https://www.worldwealthreport.com (accessed on 3 February 2021).

Cerrone, Rosaria. 2018. Deposit guarantee reform in Europe: Does European deposit insurance scheme increase banking stability? *Journal of Economic Policy Reform* 21: 224–39. [CrossRef]

Charnes, Abraham, William Wager Cooper, and Edwardo Rhodes. 1978. Measuring the efficiency of decision making units. *European Journal of Operational Research* 2: 429–44. [CrossRef]

Charnes, Abraham, William Wager Cooper, and Edwardo Rhodes. 1981. Evaluating program and managerial efficiency: An application of data envelopment analysis to program follow through. *Management Science* 27: 668–97. [CrossRef]

Chiaramonte, Laura, and Barbara Casu. 2017. Capital and liquidity ratios and financial distress. Evidence from the European banking industry. *The British Accounting Review* 49: 138–61. [CrossRef]

Chortareas, Georgios E., Claudia Girardone, and Alexia Ventouri. 2012. Bank supervision, regulation, and efficiency: Evidence from the European Union. *Journal of Financial Stability* 8: 292–302. [CrossRef]

Corporate Finance Institute (CFI). 2022. Net Interest Margin—Overview, Components, and Examples. Available online: corporatefinanceinstitute.com (accessed on 26 May 2022).

Delimatsis, Panagiotis. 2012. Financial innovation and prudential regulation: The new Basel III rules. *Journal of World Trade* 46: 1309–42. [CrossRef]

Dietrich, Andreas, and Gabrielle Wanzenried. 2011. Determinants of bank profitability before and during the crisis: Evidence from Switzerland. *Journal of International Financial Markets Institutions and Money* 21: 307–27. [CrossRef]

Dougherty, Christopher. 2006. The marriage earnings premium as a distributed fixed effect. *Journal of Human Resources* 41: 433–43. [CrossRef]

Fiordelisi, Franco, and Davide Salvatore Mare. 2014. Competition and financial stability in European cooperative banks. *Journal of International Money and Finance* 45: 1–16. [CrossRef]

Francis, William B., and Matthew Osborne. 2012. Capital requirements and bank behaviour in the UK: Are there lessons for international capital standards? *Journal of Banking & Finance* 36: 803–16.

Gadanecz, Blaise, and Kaushik Jayaram. 2015. Macroprudential Policy Frameworks, Instruments and Indicators: A Review. Режим доступу. Available online: https://www.bis.Org (accessed on 20 February 2022).

Gavalas, Dimitris, and Theodore Syriopoulos. 2018. Basel III and its effects on banking performance: Investigating lending rates and loan quantity. *Journal of Finance and Bank Management* 2: 17–52. [CrossRef]

Giordana, Gastón A., and Ingmar Schumacher. 2017. An empirical study on the impact of Basel III standards on banks' default risk: The case of Luxembourg. *Journal of Risk and Financial Management* 10: 8. [CrossRef]

Gropp, Reint, and Florian Heider. 2010. The determinants of bank capital structure. *Review of Finance* 14: 587–622. [CrossRef]

Gungoraydinoglu, Ali, and Özde Öztekin. 2011. Firm-and country-level determinants of corporate leverage: Some new international evidence. *Journal of Corporate Finance* 17: 1457–74. [CrossRef]

Ha, Nguyen Tran Thai, and Gia Quyen. 2018. The Impact of Funding Liquidity on Risk-taking Behaviour of Vietnamese Banks: Approaching by Z-Score Measure. *International Journal of Economics and Financial Issues* 8: 29.

Horvat, Aleksandra Marcikic, and Kristina Budimcevic. 2018. Efficiency Analysis of Airlines using DEA model. *Modern Management Tools and Economy of Tourism Sector in Present Era* 3: 221–30.

Ji, Yong-Bae, and Choonjoo Lee. 2010. Data envelopment analysis. *The Stata Journal* 10: 267–80. [CrossRef]

Joanes, Derrick N., and Christine A. Gill. 1998. Comparing measures of sample skewness and kurtosis. *Journal of the Royal Statistical Society Series D (The Statistician)* 47: 183–89. [CrossRef]

Jul-Larsen, Lene. 2014. Basel III-Financial Stability at the Expense of Innovation and Economic Growth? An Analysis of the Possible Effects Basel III Have on access to Funding for Small and Medium Sized Enterprises, Entrepreneurs and Economic Growth. Master's thesis, Norwegian School of Economics, Bergen, Norway.

Kombo, Kevin. 2014. Effects of Basel III Framework on Capital Adequacy of Commercial Banks in Kenya. Master's thesis, United State International University, School of Business, Nairobi, Kenya.

Lee, Chien-Chiang, and Meng-Fen Hsieh. 2013. The impact of bank capital on profitability and risk in Asian banking. *Journal of International Money and Finance* 32: 251–81. [CrossRef]

Lee, Tung-Hao, and Shu-Hwa Chih. 2013. Does financial regulation affect the profit efficiency and risk of banks? Evidence from China's commercial banks. *The North American Journal of Economics and Finance* 26: 705–24. [CrossRef]

Lim, Kwangsoo. 2016. The shift of a dividend policy and a leverage policy during the 2008 financial crisis. *International Journal of Finance & Banking Studies* 5: 9–14.

Lotto, Josephat. 2018. The empirical analysis of the impact of bank capital regulations on operating efficiency. *International Journal of Financial Studies* 6: 34. [CrossRef]

Lyngen, Narissa. 2012. Basel III: Dynamics of state implementation. *Harvard International Law Journal* 53: 519.

Malik, Muhammad Farhan, and Amir Rafique. 2013. Banks Liquidity in Pakistan: Firm Specific and Macroeconomic Factors. *Romanian Economic Journal* 16: 139–54.

Mashamba, Tafirei. 2018. The effects of Basel III liquidity regulations on banks' profitability. *Journal of Governance & Regulation* 7: 34–48. [CrossRef]

Mateev, Miroslav, Panikkos Poutziouris, and Konstantin Ivanov. 2013. On the determinants of SME capital structure in Central and Eastern Europe: A dynamic panel analysis. *Research in International Business and Finance* 27: 28–51. [CrossRef]

Miah, Md Dulal, and Kashfia Sharmeen. 2015. Relationship between capital, risk and efficiency. *International Journal of Islamic and Middle Eastern Finance and Management* 8: 203–21. [CrossRef]

Milenković, Nada, Boris Radovanov, Branimir Kalaš, and Aleksandra Marcikić Horvat. 2022. External Two Stage DEA Analysis of Bank Efficiency in West Balkan Countries. *Sustainability* 14: 978. [CrossRef]

Moudud-Ul-Huq, Syed. 2019. Banks' capital buffers, risk, and efficiency in emerging economies: Are they counter-cyclical? *Eurasian Economic Review* 9: 467–92. [CrossRef]

Ngo, Thanh, and Tu Le. 2019. Capital market development and bank efficiency: A cross-country analysis. *International Journal of Managerial Finance* 15: 478–91. [CrossRef]

Nguyen, Thi Hien. 2020. Impact of bank capital adequacy on bank profitability under Basel III Accord: Evidence from Vietnam. *Journal of Economic Development* 45: 31–46.

Nigist, Melese. 2015. Determinants of Banks Liquidity: Empirical Evidence on Ethiopian Banks. Ph.D. dissertation, Addis Ababa University, Addis Ababa, Ethiopia. *unpublished*.

Olweny, Tobias, and Kennedy Omondi. 2011. The Effect of Macro-Economic Factors on Stock Return Volatility in the Nairobi Stock. Exchange, Kenya. *Journal of Economics and Finance Review* 1: 34–48.

Onaolapo, A. A., and Adebayo E. Olufemi. 2012. Effect of capital adequacy on the profitability of the Nigerian banking sector. *Journal of Money, Investment and Banking* 24: 62–72.

Romano, Roberta. 2014. For diversity in the international regulation of financial institutions: Critiquing and recalibrating the Basel architecture. *Yale Journal on Regulation* 31: 1.

Shumet, Mekbib. 2016. Determinants of Liquidity in Banks of Ethiopia: The Case of Selected Private Banks. Ph.D. dissertation, Addis Ababa University, Addis Ababa, Ethopia.

Sigauke, Caston. 2014. Modelling Electricity Demand in South Africa. Ph.D. dissertation, University of the Free State, Free State, South Africa.

Sutorova, Barbora, and Petr Teplý. 2013. The impact of Basel III on lending rates of EU banks. *Finance a Uver* 63: 226.

Torres-Reyna, Oscar. 2007. Panel data analysis fixed and random effects using Stata (v. 4.2). *Data & Statistical Services Priceton University* 112: 1–41.

Vidal-García, Javier, Marta Vidal, Sabri Boubaker, and Majdi Hassan. 2018. The efficiency of mutual funds. *Annals of Operations Research* 267: 555–84. [CrossRef]