

Threshold effect of financial development on sectoral efficiency in Africa

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Abstract

Purpose – This paper aims to examine the threshold effect of financial development on sectoral efficiency using 42 African countries from 2000 to 2020.

Design/methodology/approach – The paper used the panel threshold regression estimation. To measure financial development, the paper used domestic credit to private sector and bank deposits to GDP.

Findings – The findings showed that the effect of financial development on sectoral efficiency depends on the measure of financial development. Domestic credit and bank deposits have a positive linear effect on the efficiency of the manufacturing sector. Domestic credit has a U-shaped relationship with agriculture technical efficiency, but its relationship with the service sector is inverted U-shaped. This study makes some significant contributions. Bank deposits drive efficiency but beyond a certain level, the effect is not significant.

Practical implications – It is recommended that domestic credit to the private sector beyond 8.0976% is good for agriculture technical efficiency, while domestic credit below 11.1906% is needed for service sector efficiency. Also, threshold values below 25.9713% and 14.8981% are recommended to see a significant positive effect of bank deposits on efficiency (agriculture and service sectors, respectively).

Originality/value – To the best of the authors' knowledge, this paper is the first to consider the threshold effect of financial development on sectoral efficiency.

Keywords Data envelopment analysis, Financial development, Panel threshold regression, Sectoral efficiency, Technical efficiency

Paper type Research paper



1. Introduction

Financial development plays a pivotal role in shaping the economic landscape of nations and industries. As a key element for growth, it facilitates risk reduction, ensures efficient and

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effective allocation of resources and also promotes capital formation (Aluko and Ibrahim, 2020; Zubair and Hayat, 2020). Pertaining to nations, robust financial systems can skyrocket economic success, whereas for industries, they can serve as a catalyst for innovation, unmask potential and promote competitiveness (Hynes *et al.*, 2020). Furthermore, a developed financial system directs funds more efficiently through risk management, information creation and reduction of transaction costs (Chen *et al.*, 2021). This can enhance the total factor productivity and efficiency of the firms and industries (sectors) by enhancing capital mobilisation and enabling innovative resources. Between the late 1980s and the late 1990s, the majority of African nations liberalised their financial sectors to increase the financial sector's capacity for economic development in response to the structural adjustment programmes by the World Bank and IMF. Credit ceilings were lifted, interest rates were liberalised, state-owned banks were restructured and privatised and various policies were implemented to encourage the growth of private banking and financial markets (Otchere *et al.*, 2017). These actions were accompanied by regulatory and supervisory programmes for banks, such as the implementation of deposit insurance in some nations (Cull *et al.*, 2005). However, the financial systems in Africa are underdeveloped compared to the other global regions, and this is attributed to factors such as sparse population density, informality, poor governance, political and economic instability and a lack of institutional quality (Allen *et al.*, 2014; Beck and Honohan, 2007; Singh *et al.*, 2009). Therefore, understanding the effect of financial development on Africa's growth is necessary.

There is still an inconclusive finding on the relationship between financial development and economic growth in the theoretical and empirical literature. There were two main schools of thought at first. Some early theorists in the first school of thought argued that finance is good for growth (Beck and Levine, 2004; Levine, 1997; Levine and Zervos, 1998; McKinnon, 1973; Schumpeter, 1911) through saving, investments and technological advancements. Some recent empirical studies have also found support for the positive effect of financial development on growth (Mensah *et al.*, 2025; Arestis *et al.*, 2015; Durusu-Ciftci *et al.*, 2017; Ibrahim and Alagidede, 2018a 2018b; Puatwoe and Piabuo, 2017).

However, the second school of thought, mainly supported by the neoclassical theorists, argued that finance is not the main driver of growth (Lucas, 1988). Linked to this, some empirical studies found that financial development reduces growth (Ayadi *et al.*, 2015; Ductor and Grechyna, 2015; Ho and Iyke, 2020). Although both theory and empirical studies have nearly established the significance of financial development on a nation's economic growth, the precise form of the effect is unclear. Evolving theoretical studies have argued that there might be thresholds in the relationship between finance and growth (Adeniyi *et al.*, 2015; Arcand *et al.*, 2012; Benczúr *et al.*, 2019; Cecchetti and Kharroubi, 2012; Ibrahim and Alagidede, 2018a 2018b). Nevertheless, most finance-growth nexus studies focused mostly on aggregate output with less attention on sectoral output, but the impact of financial development may not be uniform across different sectors of the economy. Also, empirical evidence on sectoral efficiency is still lacking. There is a need to examine the effect of financial development on sectoral efficiency because economic efficiency helps to capture resource utilisation for output maximisation which aggregate economic output fails to do.

According to Rajan and Zingales (2004), "growth is not the only metric by which to measure the effects of finance". For instance, rapid expansion does not always indicate that the most efficient production method is being used. Not all microeconomic or macroeconomic units necessarily function at or near their efficiency levels, even though the theory is predicated on the idea that behaviour should be optimised (Arestis *et al.*, 2006). Therefore, in addition to productivity, a nation's resource utilisation performance can also be described using the idea of efficiency. Few empirical studies have examined the effect of

financial development on production efficiency (Arestis *et al.*, 2006; Jeanneney *et al.*, 2006; Nourzad, 2002), but there are some identified gaps. Firstly, these studies focused on aggregate economic efficiency without considering efficiency in the various sectors since manufacturing, agriculture and services sectors may respond differently to financial development depending on their structural characteristics and dependency on external financing. Secondly, Jeanneney *et al.* (2006) and Nourzad (2002) assumed constant returns to scale in estimating efficiency, but constant returns to scale fail to capture the existing imperfect market systems and regulatory changes in the real world. Lastly, the thresholds in the relationship between financial development efficiency were not examined. There is a need to examine the threshold effect of financial development on sectoral efficiency to know the precise form of effect while considering the VRS assumption in efficiency estimation to reflect the changing economic environment.

Similarly, the closest empirical studies, Tekilu *et al.* (2018) and Ustarz and Fanta (2021) investigated the elements of finance and sectoral performance. However, they mainly examined the responses of sectoral output and growth. They did not directly quantify sectoral efficiency, or test whether there are financial development thresholds between sector within a multi-country African setting. The unique feature of this paper is that it focuses on sectoral efficiency, uses data envelopment analysis (DEA) with VRS and threshold dynamics to provide more comprehensive and policy-relevant evidence at the continental level.

The rationale behind this study is that there is an urgent need to have solid sector-specific empirical findings on the ways and at what levels financial development improves efficiency in African economies. In an area where weak financial systems co-exist with the ongoing misallocation of resources and productivity discrepancies, threshold-grounded insights should be credible to inform target reforms that will lead to efficient use of resources, competitiveness and sustainable structural change.

The paper, therefore, examines the threshold effect of financial development of sectoral efficiency using the fixed-effects panel threshold regression, for panel data of 42 African countries from 2000 to 2020 and showed that the effect of financial development on sectoral efficiency depends on the measure of financial development. Domestic credit and bank deposits have a positive linear effect on the efficiency of the manufacturing sector. Domestic credit has a U-shaped relationship with agriculture technical efficiency, but its relationship with the service sector is inverted U-shaped. Bank deposits drive efficiency, but beyond a certain level, the effect is not significant. This study makes some significant contributions:

Firstly, this study provides the first empirical evidence on financial development and sectoral efficiency while assuming a variable return to scale (VRS) production function under DEA. Secondly, the analysis treats sectors independently, recognising that financial development is uneven across the various sectors. Lastly, the study has significant policy implications since it emphasises the need to customise financial development plans to the unique requirements and circumstances of every industry rather than using a one-size-fits-all strategy.

The remaining sections of the study are structured as follows: Section 2 examines the literature review related to financial development and economic efficiency, and Section 3 presents the methodology. Statistical analyses are presented in Section 4, and Section 5 presents the empirical analysis. Section 6 concludes the study and offers some policy implications.

2. Literature review

The theories and empirical studies related to this paper are reviewed in this section. Due to the limited empirical evidence on financial development and production efficiency, studies

on financial development and economic growth will also be reviewed in the empirical section.

2.1 Theoretical review

2.1.1 Supply-leading hypothesis. The supply-leading hypothesis by [Patrick \(1966\)](#) suggests that financial development drives economic growth by providing the necessary infrastructure to mobilise savings, allocate capital ([Schumpeter, 1911](#)) and facilitate investments. This theory states that a strong financial system promotes economic activity by offering necessary services including risk management, credit allocation and effective financial intermediation, all of which increase sectoral efficiency and boost overall economic growth.

2.1.2 The three-sector theory of development. The three-sector theory of development ([Clark, 1967](#); [Fisher, 1935](#)) offers a framework of development, which can be traced both to financial development and sectoral efficiency ([Cyrek and Fura, 2019](#)). As economies develop from a primary to a secondary and then to a tertiary sector, the financial systems tend to get more complex, which in turn may impact the efficiency of different sectors ([Thierry and Emmanuel, 2023](#)). This implies that once financial development reaches a certain level, it may significantly boost efficiency across sectors by improving resource allocation and risk management.

With these theories, a solid conceptual foundation can be made to associate financial development with sectoral efficiency as opposed to macroeconomic growth. Although the supply-leading hypothesis can be used to clarify how financial systems can mobilise resources to promote productive activity, the three-sector theory implies that sectoral patterns of responding to finance can vary in agriculture, manufacturing and services. Thus, there is theoretical evidence that financial development can potentially have a heterogeneous and non-linear effect on sectoral efficiency, and this should be the focus of empirical research.

2.2 Empirical review and hypothesis development

Some previous empirical studies have found support for a linear and positive relationship between financial development and growth ([Durusu-Ciftci et al., 2017](#); [Jedidia et al., 2014](#)). [Yang \(2019\)](#) used models and techniques from earlier studies ([Levine and Zervos, 1998](#); [Rousseau and Wachtel, 2000, 2002](#)) to investigate how financial development affect economic development positively. [Yang \(2019\)](#) discovered that through the channels of physical capital stock and total factor productivity, financial development makes a substantial contribution to economic growth. Granger causation also exists between economic growth and the development of the equities market for all three kinds of economies, but with some being greater than others. Additionally, high-income economies exhibit a reverse causal relationship between economic growth and the development of the equity market that is not observed in other economies. Lastly, only trapped middle-income economies exhibit strong evidence of granger causality and feedback between the development of the banking system and inflation.

Using panel unit root, panel cointegration analysis, completely modified and dynamic OLS approaches, [Bist \(2018\)](#) examined the long-run link between financial development and economic growth in 16 low-income countries from 1995 to 2014 and concluded that financial development significantly stimulated economic growth in the long run. Furthermore, using time-series data from Cameroon *et al.* examined the relationship between financial development and economic growth. The study findings showed that the effect of financial development on economic growth in the short run depends on the measure of financial development. While there is a short-term negative effect of bank deposits and private investment on economic growth, monetary mass has a significant positive effect on

economic growth. [Puatwoe and Piabuo \(2017\)](#) also argued that in the long run, financial development drives growth. Despite the positive effect of financial development on economic growth, another strand of literature found a negative effect of financial development on economic growth ([Ayadi *et al.*, 2015](#); [Ductor and Grechyna, 2015](#); [Ho and Iyke, 2020](#)).

Evolving studies have also argued that the link between financial development and economic growth is a non-linear one. For instance, using the threshold regression model to [King and Levine \(1993\)](#) data, [Deidda and Fattouh \(2002\)](#) discovered evidence of a non-linear link between finance and growth. Some studies concluded that there is an inverted U-shaped relationship between financial development and economic growth where financial development is beneficial only until a certain point, after which it becomes harmful to growth ([Cecchetti and Kharroubi, 2012](#); [Law and Singh, 2014](#)). [Favara \(2003\)](#) concluded an S-shaped effect on economic growth. However, a study conducted in sub-Saharan Africa by [Ibrahim and Alagidede \(2018a; 2018b\)](#) using the panel threshold regression concluded that, although financial development has a positive and significant impact on economic growth, it is largely insignificant to growth below a certain estimated threshold.

While empirical studies have looked at the link between financial development and aggregate economic growth, some examined the relationship at the sector levels. [Tekilu *et al.* \(2018\)](#) used the autoregressive distributive lag (ARDL) bound testing approach to examine the relationship between financial development and sectoral production growth in Ethiopia, focusing on the country's agriculture, industry and service sectors. The study's empirical findings demonstrated that while financial development had a negligible short-term effect on the growth of output in the agriculture and service sectors, it had no significant long-term positive impact. In the short and long runs, however, financial development significantly promotes the growth of the industry's total output. Additionally, [Ustarz and Fanta \(2021\)](#) used the generalised method of moments (GMM) to examine the impact of financial development across sub-Saharan Africa's sectors from 1990 to 2018. The results demonstrated that the relationship between financial development and output growth for the service and agriculture sectors is inverted U-shaped but financial development has a U-shaped effect on output growth of the industry sector.

Since efficiency is inherently connected to the contribution of finance to productive capacity, empirical studies of financial development have historically been concerned with the role of finance in economic growth, increases in productivity and sectoral performance. Nevertheless, the evidence shows that there are conflicting results, which implies that the relationship can vary not only among sectors but also can have non-linear behaviour.

Using DEA to estimate production efficiency, [Arestis *et al.* \(2006\)](#) argued that financial development stimulates production efficiency, but the positive effect of financial deepening on economic efficiency depends on the level of production efficiency. [Jeanneney *et al.* \(2006\)](#) also confirmed that financial development drives technical efficiency using panel data of Chinese provinces from 1993 to 2001 and the GMM system estimation. [Nourzad \(2002\)](#) used the stochastic frontier analysis (SFA) to examine the effect of financial development on technical efficiency and also concluded that financial development drives technical efficiency.

Despite confirming that financial development can increase productive or technical efficiency, their studies are mainly at the aggregate national levels and fail to make distinctions between different sectors. More significantly, they do so under the assumption of linear effects, despite the fact that the current finance-growth literature continues to demonstrate that finance can always have threshold and non-linear effects. This leaves us yet to find out whether there is a difference in the efficiency boosts of financial development in

the agriculture, manufacturing and service sectors or whether these are dependent on the degree of financial development.

Based on the literature reviewed, there is a gap that is evident. Firstly, past research has looked upon financial development and output of the sectors; however, they have neglected the aspect of sectoral technical efficiency despite the fact that efficiency is a better measure of how effectively the resources are used. Secondly, though non-linear or threshold effect of the financial development on the economic growth has been observed, the existing literature has not applied the same knowledge on the efficiency of the sector. Thirdly, the limited literature on the subject on finance-efficiency has primarily been country-specific or aggregate and does not reflect the heterogeneity of sectors within African economies. To fill these gaps, this paper discusses whether financial development has threshold effects on sectoral efficiency in Africa based on DEA-based efficiency measures and panel threshold regression. Thus, this paper hypothesises that:

H1. Financial development has a significant non-linear effect on sectoral efficiency.

3. Methodology

This section presents the data source, efficiency model, empirical model and estimation procedure of the paper.

3.1 Data

This paper uses annual data from 42 African countries from 2000 to 2020 to examine the threshold effect of financial development on sectoral efficiency, focusing on agriculture, manufacturing and service sectors. Data is sourced from the World Development Indicator (WDI) and World Governance Indicator (WGI).

3.2 Data envelopment analysis model

Following [Bampatsou and Halkos \(2019\)](#), the DEA under the VRS is used to measure efficiency in this study. The study assumed a VRS because of the changes in regulations and imperfect market conditions. Given that the agriculture, manufacturing and service sectors seek to maximise their output instead of minimising inputs, we also assume an output-oriented approach under the VRS. The study uses DEA because it allows multiple inputs and outputs and is less demanding than the SFA ([Kader et al., 2014](#)).

DEA has also been adopted since its methodological stance is appropriate in assessing the technical efficiency of the sector in the heterogeneous African economies. DEA is non-parametric frontier approach that does not assume a defined functional structure of production, which is indispensable due to structural distinctions between the agriculture, manufacturing and service sectors. It also enables simultaneous measurement of numerous inputs and outputs that capture the multi-dimensional feature of sectoral performance in a better manner than single-output measures. Notably, the use of DEA in the framework of VRS is indicative of capacity limitations, imperfect markets and regulatory distortions found in African economies. In contrast to SFA, DEA is not based on distributional assumptions of inefficiency and is especially suitable when there is a scarcity of sectoral price and cost information. Hence, DEA is selected due to the fact that it offers a theoretically justifiable, flexible and empirically sound model used to estimate the technical efficiency of the sector in this regard.

To formalise Farrell's (1957) technical efficiency, suppose that given n decision-making units (DMUs) ($j = 1, \dots, n$) that use a vector of x_i ($i = 1, \dots, m$) inputs given weight λ is to

produce a vector of y_r ($r = 1, \dots, s$) outputs, the technical efficiency under VRS and output-oriented approach for DMU_0 (i.e. one of the n DMUs) can be expressed as a linear programming problem as:

$$\max_y \left(\sum_{r=1}^s \lambda_j y_{ro} \right)$$

Subject to:

$$\sum_{i=1}^m \lambda_j x_{ij} \leq x_{i0}$$

$$\sum_{r=1}^s \lambda_j y_{rj} \geq y_{ro}$$

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

$$r = 1, 2, \dots, s; \quad i = 1, 2, \dots, m; j = 1, 2, \dots, n \quad (1)$$

$$\lambda_j \geq 0; \quad y_{ro}$$

The DEA linear programming model is subject to the following constraints; the sum of the weighted inputs of all the DMUs under observation is less than all equal to the inputs used by DMU_0 $\sum_{i=1}^m \lambda_j x_{ij} \leq x_{i0}$; the weighted outputs of DMU_0 is less the sum of the weighted outputs of all the DMUs under observation and the sum of all the constraints is one, given that the weights are non-negative integers ($\lambda_j \geq 0$). The inputs used for the agriculture sector are employment in agriculture as a percentage of total employment and agriculture raw material imports as a percentage of merchandise imports. Inputs for the manufacturing sector are employment in manufacturing as a percentage of total employment and manufacturing raw material imports as a percentage of merchandise imports. Employment in service as a percentage of total employment and service raw material imports as a percentage of merchandise import are inputs for the service sector. For outputs, agriculture, forestry and fishing, value added as a percentage of gross domestic growth (GDP), manufacturing value added as a percentage of GDP and service value added as a percentage of GDP are used for the agriculture, manufacturing and service sectors, respectively.

3.3 Empirical model

Similar to some existing empirical studies (Dell *et al.*, 2012; Duan *et al.*, 2022), the empirical model for this study is developed from a reduced production function.

Considering the literature that has associated financial development with the outcomes of productivity and efficiency, this study takes a reduced form of the production framework in developing the empirical model. Despite the fact that researchers, including Dell *et al.* (2012), Duan *et al.* (2022) and others, also paid attention to output, their theoretical framework is based on the production factor, out of which efficiency is created. The outcome of the production process is efficiency, the degree to which inputs are converted to outputs

and it is consistent to conceptually and empirically adapt the reduced-form specification to represent efficiency.

In addition, empirical and methodological evidence suggests the application of production-based models in the study of efficiency outcomes, as efficiency is essentially the difference between the production frontier and a behavioural construct (Farrell, 1957). In line with this reasoning, studies have used financial development variables under the productivity and efficiency paradigms (Arestis *et al.*, 2006). Therefore, the reduced-form specification is appropriate for modelling sectoral efficiency. Based on this framework, the empirical model is expressed as follows:

$$Y_{it} = A_{it}H_{it}^{\alpha}C_{it}^{\theta} \quad 0 < \alpha < 1 \quad 0 < \theta < 1 \quad (2)$$

where Y is efficiency, A is productivity, H is human capital, C is capital, i is country, t is year, $0 < \alpha < 1$ and $0 < \theta < 1$ denote decreasing return to scale in human capital and physical capital input, respectively. Natural logarithm is taken in both sides of the equation to linearise equation (1), and it becomes:

$$\ln(Y_{it}) = \ln(A_{it}) + \alpha \ln(H_{it}) + \theta \ln(C_{it}) \quad (3)$$

According to Ductor and Grechyna (2013), A is often used to represent financial development, technical progress or the quality of institutions in research. Following Duan *et al.* (2022) and Taiwo (2021), this paper assumes that financial development, GDP, institutions and inflation are other factors affecting efficiency, which are summarized in A .

Therefore, we can rewrite $\ln(A_{it})$ as:

$$\ln(A_{it}) = \beta_1 \ln(\text{FinD}_{it}) + \beta_2 \ln(\text{GDP}_{it}) + \beta_3 \ln(\text{Inst}_{it}) + \beta_4 \ln(\text{Inflation}_{it}) \quad (4)$$

Putting equation (4) into equation (3), the following equation is obtained:

$$\begin{aligned} \ln(Y_{it}) = & \beta_1 \ln(\text{FinD}_{it}) + \beta_2 \ln(\text{GDP}_{it}) + \beta_3 \ln(\text{Inst}_{it}) + \beta_4 \ln(\text{Inflation}_{it}) \\ & + \alpha \ln(H_{it}) + \theta \ln(C_{it}) \end{aligned} \quad (5)$$

We also add error terms to generate an econometrics form for equation (5). This is expressed as:

$$\begin{aligned} \ln(Y_{it}) = & \beta_1 \ln(\text{FinD}_{it}) + \beta_2 \ln(\text{GDP}_{it}) + \beta_3 \ln(\text{Inst}_{it}) + \beta_4 \ln(\text{Inflation}_{it}) + \alpha \ln(H_{it}) \\ & + \theta \ln(C_{it}) + \delta_i + \vartheta_t + \mu_{it} \end{aligned} \quad (6)$$

Equation (6) can be rewritten as:

$$Y_{it} = \beta_1 \text{FinD}_{it} + \beta_2 \text{GDP}_{it} + \beta_3 \text{Inst}_{it} + \beta_4 \text{Inflation}_{it} + \alpha \text{HC}_{it} + \theta \text{C}_{it} + \delta_i + \vartheta_t + \mu_{it} \quad (7)$$

From equation (7), Y_{it} is the sector efficiency for country i at year t proxied with agriculture, manufacturing and service technical efficiencies; FinD_{it} is financial development for country i at year t proxied with domestic credit to private sector and bank deposits to GDP; GDP_{it} is economic growth for country i at year t proxied with GDP per capita growth rate; Inst_{it} is institution for country i at year t proxied with principal component analysis (PCA) of governance indicators; Inflation_{it} is inflation rate for country i at year t ; HC_{it} is human

capital for country i at year t proxied with primary school enrolment; C_{it} is physical capital for country i at year t proxied with foreign direct investment inflows as a percentage of GDP; δ_i is country specific effects; ϑ_t is time-specific effect and μ_{it} is the error term. A summary of the regression variables is presented in [Table 1](#).

3.4 Estimation procedure

Some empirical studies on the non-linear finance-growth nexus included a quadratic term ([Baloch et al., 2019](#); [Benczúr et al., 2019](#); [Law et al., 2018](#); [Luintel et al., 2024](#)). However, differentiation is used to compute the exact points of inflection and the confidence intervals within which such thresholds fall are mostly unknown. To control for this, the panel threshold effect model by [Hansen \(1999\)](#) is used to examine the potential non-linear effect of financial development on agriculture, manufacturing and service sector technical efficiency. In addition, due to the unobserved individual heterogeneity and omitted variable bias, this study, specifically, uses the fixed-effect panel threshold model by [Hansen \(1999\)](#). [Hansen \(1999\)](#) threshold regression technique has the advantage of estimating thresholds through asymptotic theory. Also, non-linearities estimated by the threshold regression is not imposed and the confidence intervals of all the thresholds identified can empirically be verified. Furthermore, the technique allows to test for whether there is a threshold or there is no threshold. In this paper, if at least one threshold exists, it indicates that there is a non-linear relationship between the financial development and efficiency.

Following [Hansen \(1999\)](#), [Shen and He \(2022\)](#) and [Wang \(2015\)](#), the fixed-effect panel threshold model under a single threshold can be expressed as:

$$Y_{it} = \beta_0 + \beta_1 FinD_{it} + \delta' X_{it} + \varepsilon_{it}, \quad \text{if } q_{it} \leq \gamma$$

$$Y_{it} = \beta_0 + \beta_2 FinD_{it} + \delta' X_{it} + \varepsilon_{it}, \quad \text{if } q_{it} > \gamma \quad (8)$$

[Equation \(7\)](#) can be rewritten as:

$$Y_{it} = \beta_0 + \beta_1 FinD_{it} I(q_{it} \leq \gamma) + \beta_2 FinD_{it} I(q_{it} > \gamma) + \delta' X_{it} + \varepsilon_{it} \quad (9)$$

$$\varepsilon_{it} = \varnothing_i + \vartheta_t + \epsilon_{it}$$

The indicative function $I(\cdot)$ is:

$$I(q_{it} \leq \gamma) = \begin{cases} 1, & \text{if } q_{it} \leq \gamma \\ 0, & \text{if } q_{it} > \gamma \end{cases}$$

$$I(q_{it} > \gamma) = \begin{cases} 1, & \text{if } q_{it} \leq \gamma \\ 0, & \text{if } q_{it} > \gamma \end{cases} \quad (10)$$

Similarly, a double threshold can be expressed as:

$$Y_{it} = \beta_0 + \beta_1 FinD_{it} + \delta' X_{it} + \varepsilon_{it}, \quad \text{if } q_{it} \leq \gamma_1$$

Table 1. Summary of regression variables

Variable	Description	Measure	Source	Author(s)
<i>Y</i>	Agriculture technical efficiency, manufacturing technical efficiency and sector technical efficiency	Data envelopment analysis	Authors' own computation	Bampatsou and Halkos (2019)
<i>FinD</i>	Financial development	Domestic credit to private sector and bank deposit to GDP	World Development Indicator (WDI) and global financial development (GFD)	Acheampong (2019), Acheampong et al. (2023), Ayadi et al. (2015), Taiwo (2021), Wang et al. (2023)
<i>GDP</i>	Economic growth	GDP per capita growth rate	WDI	King and Levine (1993), Sahu (2021), Yang (2019)
<i>Inst</i>	Institution	Principal component analysis from control of corruption, government effectiveness, and regulatory quality	Authors' own computation from the World Governance Indicator (WGI)	Aluko and Ibrahim (2020), Khan et al. (2019)
<i>Inflation</i>	Inflation	Inflation rate	WDI	Sequeira (2021)
<i>H</i>	Human capital	Primary school enrolment	WDI	Popoola et al. (2019)
<i>C</i>	Physical capital (investment stock)	Foreign direct investment as a percentage of GDP	WDI	Bandaya, Murugan and Maryam (2021), Sahu (2021)
Source(s): Authors' own computation				

$$Y_{it} = \beta_0 + \beta_2 \text{FinD}_{it} + \delta' X_{it} + \varepsilon_{it}, \quad \text{if } \gamma_1 < q_{it} \leq \gamma_2$$

$$Y_{it} = \beta_0 + \beta_3 \text{FinD}_{it} + \delta' X_{it} + \varepsilon_{it}, \quad \text{if } q_{it} > \gamma_2 \quad (11)$$

The following can be obtained from [equation \(10\)](#):

$$Y_{it} = \beta_0 + \beta_1 \text{FinD}_{it} I(q_{it} \leq \gamma_1) + \beta_2 \text{FinD}_{it} I(\gamma_1 < q_{it} \leq \gamma_2) + \beta_3 \text{FinD}_{it} I(q_{it} > \gamma_2) + \delta' X_{it} + \varepsilon_{it} \quad (12)$$

$$\varepsilon_{it} = \varnothing_i + \vartheta_t + \epsilon_{it}$$

The indicative function $I(\cdot)$ is:

$$\begin{aligned} I(q_{it} \leq \gamma_1) &= \begin{cases} 1, & \text{if } q_{it} \leq \gamma_1 \\ 0, & \text{if } q_{it} > \gamma_1 \end{cases} \\ I(\gamma_1 < q_{it} \leq \gamma_2) &= \begin{cases} 1, & \text{if } \gamma_1 < q_{it} \leq \gamma_2 \\ 0, & \text{if } \gamma_1 \geq q_{it} > \gamma_2 \end{cases} \\ I(q_{it} > \gamma_2) &= \begin{cases} 1, & \text{if } q_{it} > \gamma_2 \\ 0, & \text{if } q_{it} \leq \gamma_2 \end{cases} \end{aligned} \quad (13)$$

From [equation \(7\)](#) (8), (9), (10), (11) and (12) Y_{it} represents the dependent variables, namely, agriculture technical efficiency, manufacturing technical efficiency, sector technical efficiency; FinD_{it} represents financial development; $\delta' X_{it}$ represents a vector of control variables, namely, GDP per capita, institutions, inflation, human capital and FDI; q_{it} is the threshold variable in this study (FinD), thus, financial development; γ , γ_1 and γ_2 are the thresholds.

According to the panel threshold theory, the threshold value is the value that minimises the residual sum of squares ([Nguyen and To, 2017](#)). Thus, $\hat{\gamma} = \arg_{\gamma} \min S_1(\gamma)$. “Due to the fact that nuisance parameter problem makes the distribution of threshold estimate non-standard, test for the hypothesis $\gamma = \gamma_0$ (in which, γ_0 is the true value of γ) is necessary. [Hansen \(1999\)](#) also suggested that using the “no-reject region” method with a likelihood ratio (LR) statistic to construct the confidence interval is the best approach” ([Nguyen and To, 2017](#), p. 35). LR is expressed as:

$$LR_1(\gamma_0) = \frac{S(\gamma_0) - S(\hat{\gamma})}{\hat{\sigma}^2} \quad (14)$$

Following from [equation \(13\)](#) the F-statistics to test for threshold effect under the null hypothesis of no threshold effect following [Taiwo \(2021\)](#) is expressed as:

$$F_1 = \frac{S_0 - S_1(\hat{\gamma})}{\hat{\sigma}^2} \quad (15)$$

Since F_1 does not follow a standard distribution, [Hansen \(2000\)](#) suggested the bootstrap approach to calculate the p -values.

4. Data analysis

This section presents the statistical description of the regression variables, unit root test and the Pearson correlation matrix with the variance inflation factor.

4.1 Descriptive statistics

Table 2 presents the statistical description of the regression variables used in this paper.

From Table 2, the average technical efficiencies for the agriculture, manufacturing and service sectors are about 35.9%, 33.2% and 32.1%, respectively. This indicates that the agriculture, manufacturing and service sectors need to improve their technical efficiencies by 64.1%, 66.7% and 67.9%, respectively. Ranging between 0 (minimum financial development index) and 0.59 (maximum financial development index), the average financial development index in Africa is about 0.15. Furthermore, average domestic credit to private sectors in Africa is about 20.35% of GDP on the average, while the average bank deposits share to GDP is about 30.7% for the study period. On average, FDI inflows to Africa are about 4.30% of GDP ranging between -17.29% and 69.18% for the study period. The negative minimum value for the net FDI inflows indicates that foreign investors' disinvestment was greater than the capital invested in the receiving economy. The average GDP per capita growth rate for Africa for the study period is about 1.3%. Africa's institutional index ranges from -1.97251 to 0.9200, with an average of -0.58185. Lastly, the average percentage of Africans with a primary education is 78.07%. The majority of African nations require elementary education, which may account for the continent's high primary education rate.

4.2 Panel unit root test

Panel unit root test is performed to determine the stationarity of the series at levels or first difference. The results are presented in Table 3. The Levin-Lin-Chu, Fisher-type and Im-Pesaran-Shin test are used for the stationarity test.

Using the Levin-Lin-Chu test, all the variables are stationary at levels except domestic credit and bank deposits at 1% significance level. For the first difference, all the variables are stationary. With the Fisher-type test for stationarity, all the variables are stationary at first difference, but service technical efficiency and domestic credit are not stationary at levels. Lastly, results for the Im-Pesaran-Shin test for stationarity indicates that all the all the

Table 2. Descriptive statistics

Variable	Obs	Mean	Std.	Min	Max
Technical efficiency (agriculture)	882	0.359414	0.236709	0.000397	1
Technical efficiency (manufacturing)	882	0.332991	0.256811	0.001392	1
Technical efficiency (service)	882	0.320893	0.280838	5.59E-06	1
Domestic credit to private sector (%)	882	20.34515	18.49543	-6.376709	104.8486
Bank deposits to GDP (%)	882	30.66353	30.26576	-61.9866	276.1006
Foreign direct investment (FDI) (%)	882	4.203522	7.251474	-17.2922	69.18494
GDP per capita growth (%)	882	1.302636	6.580148	-75.77694	55.59033
Inflation (%)	882	8.094013	22.04088	-78.5622	379.9996
Institution	882	-0.58185	0.575514	-1.97251	0.920007
Primary school enrolment (%)	882	78.06596	17.55949	24.98238	122.3433

Source(s): Authors' own computation

Table 3. Panel unit root test

Variables	Levin–Lin–Chu		Fisher-type		Im–Pesaran–Shin	
	Level	First difference	Level	First difference	Level	First difference
AgricTE	–2.58***	–13.6663***	–0.9911	3.8984***	–1.2447	–14.1852***
ManufTE	–2.8654***	–10.0639***	3.7092***	4.0133***	–1.7564**	–14.1644***
ServiceTE	–2.8975***	–15.4404***	–1.0018	5.6666***	0.1304	–14.3531***
Domestic credit	–0.9303	–6.8605***	–1.4434	4.9776***	1.4883	–12.4969***
Bank deposits	–0.7891	–7.4571***	1.3892*	8.7451***	0.2129	–11.8473***
FDI	–4.9052***	–10.8862***	6.1669***	12.8596***	–6.4251***	–17.1635***
GDP per capita	–3.5807***	–17.8487***	3.3162***	17.2958***	–8.9473***	–17.7944***
Inflation	–4.1745***	–18.7093***	3.7332***	12.9591***	–9.8135***	–16.4138***
Institution	–2.7081***	–13.0248***	3.4393***	6.7913***	–1.3073*	–14.1339***
Primary	–6.2131***	–6.7757***	1.6519**	2.1638**	2.0511	–8.2643***

Note(s): *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; AgricTE = agriculture technical efficiency; ManufTE = manufacturing technical efficiency; ServiceTE = service technical efficiency; FinDI = financial development index; FDI = foreign direct investment; GDP per capita = gross domestic product per capita; Primary = primary school enrolment

Source(s): Authors' own computation

variables are stationary at first difference, but service technical efficiency, domestic credit, bank deposits and primary school enrolment are not stationary at levels.

4.3 Correlation matrix and variance inflation factor

The correlation matrix and variance inflation factor result to check are presented in [Tables 4](#) and [5](#).

From [Tables 4](#) and [5](#), multicollinearity does not exist in the regression variables because the correlation coefficients are less than 0.8, and the variance inflation factor for the variables are less than 10.

5. Empirical results

Possible non-linear effect of financial development on sectors' technical efficiency using the fixed-effects panel threshold regression technique by [Hansen \(1999\)](#) are presented in this section. The sectors considered are the agriculture, manufacturing and service sectors. The paper used the different financial development variables, namely, domestic credit to private sectors and bank deposits to GDP.

Before the panel threshold regression, the single-threshold model is first set for the various sectors to test the significance of threshold effect. The null hypothesis under the single-threshold model is that there is no threshold; thus, the model is linear. When the null hypothesis is rejected, it means that financial development has a non-linear effect on the sector's technical efficiency. Secondly, when the null hypothesis of "no threshold" is rejected, the threshold model with different number of thresholds is set to determine the number of thresholds for the regression model. For the double threshold, the null hypothesis is that there is a single threshold. Therefore, when the null hypothesis under the double threshold is rejected, it means there is a double-threshold effect of financial development on the sector's efficiency. The triple-threshold model corresponds to the null hypothesis of two thresholds and the alternative of three thresholds. This process of determining the number of thresholds continues until the null hypothesis is accepted.

Table 4. Pearson correlation matrix

Variables	AgricTE	ManufTE	ServiceTE	DomesticC	BankD	FDI	GDP	Inflation	Institution	Primary
AgricTE	1									
ManufTE	0.2518	1								
ServiceTE	0.2168	0.3145	1							
DomesticC	-0.1222	-0.0763	-0.1252	1						
BankD	0.0390	-0.0089	-0.0387	0.6840	1					
FDI	-0.0307	-0.0341	-0.0174	-0.1256	-0.0998	1				
GDP	0.0603	-0.0057	0.083	0.0274	-0.0112	0.1711	1			
Inflation	-0.128	-0.0898	-0.056	-0.144	-0.0999	0.0949	-0.2411	1		
Institution	-0.066	-0.0185	0.0717	0.6692	0.5228	-0.039	0.1695	-0.1848	1	
Primary	0.1811	0.0748	0.0002	0.4178	0.3230	-0.0599	0.1878	-0.1336	0.4323	1

Note(s): AgricTE = agriculture technical efficiency; ManufTE = manufacturing technical efficiency; ServiceTE = service technical efficiency; DomesticC = domestic credit; BankD = bank deposits to GDP; FDI = foreign direct investment; GDP = gross domestic product per capita; Primary = primary school enrolment

Source(s): Authors' own computation

Table 5 Variance inflation factor

Variables	VIF	1/VIF	Variable	VIF	1/VIF
Institution	1.98	0.505878	Institution	1.59	0.62822
Domestic credit	1.94	0.51438	Bank deposits	1.43	0.69855
Primary	1.31	0.76222	Primary	1.28	0.77965
GDP per capita	1.17	0.85673	GDP per capita	1.17	0.85806
Inflation	1.11	0.90238	Inflation	1.11	0.90326
FDI	1.07	0.93523	FDI	1.06	0.94066
Mean VIF	1.43		Mean VIF	1.27	

Source(s): Authors' own computation

When the number of thresholds is determined, the threshold values corresponding to the number of thresholds are estimated. Lastly, the significance of the threshold values is further determined with the panel threshold regression. Table 6 presents the threshold test to determine the number of thresholds using the significance of the threshold effect.

From Table 6, the significance of the threshold effect of financial development on agriculture, manufacturing and service sectors are presented. This is to determine whether non-linearity exists between financial development and each sector's technical efficiency, and also, the number of thresholds for the non-linearity. The financial development variables used are the domestic credit to the private sector and the financial development index.

The threshold effect test of domestic credit on agriculture sector's technical efficiency shows that the null hypothesis of no threshold is rejected with a bootstrapped p -value of 0.0467 ($F_1 = 33.85 > \text{critical value} = 32.8561$) at 5% significance level, but null hypothesis of one threshold is accepted with a bootstrapped p -value of 0.42 ($F_2 = 10.59 < \text{critical value} = 22.9333$). This implies that domestic credit has a non-linear effect on agriculture technical efficiency and the threshold point is single. Furthermore, we fail to reject the null hypothesis of no threshold for the effect of domestic credit on manufacturing sector's technical efficiency with a bootstrapped p -value of 0.3867 ($F_1 = 26.23 < \text{critical value} = 49.9116$). This implies that there is no non-linear relationship between domestic credit and manufacturing technical efficiency. Thus, domestic credit only has a linear effect on manufacturing technical efficiency. Therefore, there is no need to fit the other number of thresholds for the relationship between domestic credit and manufacturing technical efficiency. The null hypothesis of no threshold for the effect of domestic credit on service sector's technical efficiency is rejected at 5% significance level with a bootstrapped p -value of 0.0467 ($F_1 = 16.98 > \text{critical value} = 16.1653$), but null hypothesis of one threshold is accepted ($F_2 = 2.56 < \text{critical value} = 11.4263$). This means that domestic credit has a non-linear effect on service sector's technical efficiency, but the number of thresholds is one.

The null hypothesis of no threshold for the relationship between bank deposits and agriculture technical efficiency is rejected at a 5% significance level ($F_1 = 51.44 > \text{critical value} = 35.256$), but we fail to reject the null hypothesis of one threshold ($F_2 = 8.3 < \text{critical value} = 21.164$). Therefore, bank deposits and agriculture technical efficiency have a non-linear relationship with a single threshold point. The test of the significance of the threshold effect between bank deposits and the manufacturing sector's technical efficiency fails to reject the null hypothesis of no threshold with a bootstrapped p -value of 0.6267. Hence, the relationship between bank deposits and manufacturing efficiency is linear. Furthermore, the null hypothesis of no threshold for the relationship between bank

Table 6. Threshold effect test

Threshold variable	Threshold hypothesis	RSS	MSE	Fstat	Prob	Crit10	Crit5	Crit1
Domestic credit (agriculture efficiency)	Null of no threshold	10.1793	0.0118	33.85**	0.0467	26.6461	32.8561	45.6127
	Null of one threshold	10.0557	0.0117	10.59	0.42	22.9333	27.8619	45.0311
	Null of no threshold	23.7046	0.0275	26.23	0.3867	49.9116	59.4071	85.6858
Domestic credit (manufacturing efficiency)	Null of no threshold	40.4225	0.0469	16.98**	0.0467	13.8719	16.1653	22.9887
	Null of one threshold	40.3025	0.0468	2.56	0.9167	11.4263	13.8806	20.8628
Bank deposits (agriculture efficiency)	Null of no threshold	10.483	0.0122	51.44**	0.0233	30.6567	35.256	59.0507
	Null of one threshold	10.3829	0.0121	8.3	0.55	21.164	26.7045	39.7732
	Null of no threshold	24.071	0.028	16.19	0.6267	45.6503	55.7723	69.7162
Bank deposits (manufacturing efficiency)	Null of no threshold	38.4553	0.0447	69.38***	0.0000	36.0245	41.4767	48.9147
	Null of one threshold	37.9708	0.0441	10.99	0.6467	23.2573	28.4168	38.3945
Source(s): Authors' own computation								

deposits and service technical efficiency is rejected at 1% significance level with a bootstrapped p -value of 0.0000 ($F_1 = 69.38 > \text{critical value} = 48.9147$), but null hypothesis of one threshold is accepted with a bootstrapped p -value of 0.42 ($F_2 = 10.99 < \text{critical value} = 23.2573$). This implies that a non-linear relationship exists between bank deposits and the service sector with a single threshold.

In summary, domestic credit has a significant non-linear effect on agriculture and service sectors' technical efficiency and the number of thresholds is one. Domestic credit has no non-linear effect on the manufacturing sector's technical efficiency.

From Table 6, the threshold values are further estimated for only the significant threshold number, and the results are presented in Table 7.

Table 7 presents the threshold values for the established non-linear relationships between financial development (domestic credit, bank deposits and financial development index) and the sector's technical efficiency as indicated in the results in Table 6. In Table 7, the threshold value for the non-linear effect of domestic credit on the agriculture sector's technical efficiency is 8.0976%, while the threshold value for the non-linear link between domestic credit and the technical efficiency of the service sector is 11.9424%. The threshold values for bank deposits in the agriculture and service sectors are 25.9713% and 14.8981%, respectively.

5.1 Effect of financial development on sectoral efficiency

The regression results for the effect of financial development on sectoral efficiency are shown in Tables 8 and 9. Table 8 shows the effect of domestic credit on sectoral efficiency, while Table 9 shows the effect of bank deposits on sectoral efficiency. For regression models where we failed to reject the null hypothesis of no threshold (see Table 6), we only estimate a linear model using the fixed effects with Driscoll–Kraay standard errors. However, in regression models where we reject the null hypothesis of no threshold (see Table 6), which indicates the existence of a non-linear relationship, the fixed-effects panel threshold regression technique is used for the non-linear model.

From Table 8, domestic credit has a significant positive linear effect on the manufacturing sector's technical efficiency. A percentage increase in domestic credit leads to a 0.281% increase in the manufacturing sector's technical efficiency at a 10% significance level. Below a threshold value of 8.0976%, a percentage increase in domestic credit leads to a 0.855% reduction in the technical efficiency of the agriculture sector but beyond a threshold of 8.0976% but beyond the threshold value of 8.0976%, a percentage increase in domestic credit leads to a 0.385% increase in the technical efficiency of agriculture sector at 1% significance level. Therefore, a U-shaped link between domestic

Table 7. Threshold estimation and confidence interval

Threshold variable	Threshold no.	Threshold estimation	95% confidence interval	
Domestic credit (agriculture efficiency)	1	8.0976	7.9209	8.0982
Domestic credit (service efficiency)	1	11.9424	11.6842	12.0012
Bank deposits (agriculture efficiency)	1	25.9713	25.8095	26.4976
Bank deposits (service efficiency)	1	14.8981	14.8268	14.9616

Source(s): Authors' own computation

Table 8. Effect of financial development (domestic credit) on sectoral efficiency

Variables	(Linear regression)	(Threshold regression)	(Threshold regression)
	Manufacturing	Agriculture	Service
Domestic credit	0.00281* (0.00148)		
<i>Domestic Credit</i> ≤ γ		−0.00855*** (0.00246)	0.00795** (0.00332)
<i>Domestic Credit</i> > γ		0.00385*** (0.00076)	−0.00290* (0.00150)
FDI	0.00045 (0.00147)	−0.00128* (0.00068)	−0.00251* (0.00134)
GDP per capita	−0.00302 (0.00180)	0.00049 (0.00071)	0.00406*** (0.00141)
Inflation	−0.00045*** (0.00014)	−0.00017 (0.00021)	−0.00073* (0.00041)
Institution	−0.20724*** (0.04984)	−0.08909*** (0.02656)	−0.02803 (0.05290)
Primary school enrolment	0.00230*** (0.00034)	0.00341*** (0.00041)	−0.00353*** (0.00080)
Constant	−0.01803 (0.08364)	−0.01840 (0.03677)	0.62302*** (0.07260)
<i>F</i> -statistics	94.42***	31.77***	10.35***
<i>R</i> -squared	0.0714	0.21071	0.08003
Observations	882	882	882
Number of id	42	42	42

Note(s): Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Source(s): Authors' own computation

Table 9. Effect of financial development (bank deposits) on sectoral efficiency

Variables	(Linear regression)	(Threshold regression)	(Threshold regression)
	Manufacturing	Agriculture	Service
Bank deposits	0.00065* (0.00036)		
<i>Bank deposits</i> ≤ γ		0.00464*** (0.00067)	0.01303*** (0.00161)
<i>Bank deposits</i> > γ		0.00040 (0.00026)	0.00017 (0.00049)
FDI	0.00060 (0.00164)	0.00023 (0.00072)	0.00165 (0.00141)
GDP per capita	−0.00338 (0.00179)	−0.00021 (0.00071)	0.00509*** (0.00135)
Inflation	−0.00054*** (0.00011)	−0.00069*** (0.00021)	−0.00097** (0.00040)
Institution	−0.20679*** (0.04904)	−0.06031** (0.02721)	0.03851 (0.05274)
Primary school enrolment	0.00264*** (0.00044)	0.00424*** (0.00040)	−0.00257*** (0.00079)
Constant	−0.00741 (0.07534)	−0.04792 (0.03601)	0.50065*** (0.07051)
<i>F</i> -statistics	91.86***	27.40***	16.97***
<i>R</i> -squared	0.0677	0.18717	0.12481
Observations	882	882	882
Number of id	42	42	42

Note(s): Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Source(s): Authors' own computation

credit and agriculture efficiency. Furthermore, domestic credit below 11.1906% has a significant positive effect on the service sector's technical efficiency at a 5% significance level, but the effect is negative at a 10% significance level when domestic credit beyond 11.1906%. This indicates an inverted U-shaped relationship between domestic credit and the service sector.

On the controls, FDI has no significant effect on the manufacturing sector, but there is a significant negative effect of FDI on agriculture and service sectors' technical efficiency at a 10% significance level. GDP per capita has a negative effect on the efficiency of the manufacturing sector, but it is not significant. GDP per capita showed a positive effect on the

technical efficiency of agriculture and service sectors, but the relationship is significant for the service sector at a 1% significance level. Inflation has a negative effect on sectoral technical efficiency, but it is not significant for agriculture. The institution also has a negative effect on sectoral efficiency, but it is only significant for the manufacturing and agriculture sectors at a 1% significance level. Primary school enrolment has a significant positive effect on the technical efficiency of the manufacturing and agriculture sectors, but it has a significant negative effect on the service sector.

In [Table 9](#), bank deposits are used as a measure for financial development to examine its impact on sectoral efficiency.

From [Table 9](#), bank deposits have a linear relationship with manufacturing efficiency, which is positive at a 10% significance level. A percentage increase in bank deposits to GDP leads to a 0.065% increase in manufacturing efficiency. Moreover, when bank deposits to GDP is below 25.9713%, a percentage increase in bank deposits to GDP leads to a 0.464% increase in agriculture efficiency at a 1% significance level, but beyond 25.9713%, a percentage increase in bank deposits to GDP has no significant on efficiency for agriculture. Therefore, a non-linear relationship exists between bank deposits and the agriculture sector. Furthermore, bank deposits below 14.8981% have a significant positive effect on service technical efficiency, but beyond 14.8981%, the positive effect is not significant.

For the controls, consistent with the results in [Table 8](#), GDP per capita has no significant impact on the manufacturing and agriculture sectors, but GDP per capita has a significant positive effect on the technical efficiency of the service sector at a 1% significance level. Inflation has a significant negative effect on sectoral efficiency at a 1% significance level. Similar to the results in [Table 9](#), institutions have a significant negative effect on the manufacturing and agriculture sectors.

5.2 Discussions

The effect of financial development on sectoral efficiency depends on the measure of financial development. Financial development has a linear relationship with the manufacturing sector where both bank deposits and domestic credit significantly drive the technical efficiency of the manufacturing sector. Domestic credit to private sector and bank deposits are very important in stimulating the efficiency of the manufacturing sector. This result is consistent with existing studies, which revealed a positive linear effect of domestic credit to the private sector and bank deposits on manufacturing sector growth ([Aiyedogbon and Anyanwu, 2016](#); [Perera, 2017](#)). This is also consistent with [Arestis et al. \(2006\)](#) who found a positive effect of financial development on technical efficiency. However, the positive linear relationship between bank deposits and the manufacturing sector contradicts [Majeed and Iftikhar \(2020\)](#) conclusions that bank deposits reduce manufacturing output. This implies that sector-specific structural circumstances, financial intermediation quality and institutional backing can affect the manner in which finance can be translated into efficiency outcomes, thus reaffirming the point that the impact of finance is context-specific and not universal across economies. More than merely reiterating these results, this discovery opines that production operations are poised in a better position to turn finance to efficiency benefits due to their increased integration with formal financial institutions, enhanced technological strength and more understood lines of investment. This confirms theoretical predictions that credit improves productivity in those industries with established financial and well-established capital utilisation structures.

Domestic credit has a significant U-shaped relationship with agriculture technical efficiency but an inverted U-shaped effect on the service sectors. Domestic credit initially

reduces the technical efficiency of the agriculture sector may be due to the domestic credit constraints to the agriculture sector, but domestic credit beyond 8.0976% may ensure efficient resource allocation, technological development and liquidity creation in the agriculture sector, which may stimulate production efficiency. This contradicts [Ustarz and Fanta \(2021\)](#) conclusions that showed there is an inverted U-shaped relationship between financial development and agriculture output. The present finding therefore extends their conclusion by demonstrating that the non-linear finance–sector nexus is not only evident in output responses but also in efficiency performance, highlighting the importance of sufficient and well-structured financing in agriculture. This means that the agricultural sectors might need a critical mass of funding before efficiency gains could be realised. Credit at low levels can deteriorate inefficiencies since the absorption capacity is weak and credit delivery structures are unsatisfactory, and it is not well mechanised. Nonetheless, beyond a significant level of financing, this becomes efficiency enhancing. This adds to the literature by emphasising that it is not just the presence of finance, but its magnitude, structure and timing that can be relevant in explaining efficiency responses.

In the service sector, domestic credit initially increases technical efficiency by stimulating technological advancement and investment in productive projects, but beyond 11.1906%, domestic credit reduces efficiency, possibly reflecting financial misallocation and structural constraints rather than productivity-enhancing use of credit. This is consistent with [Ustarz and Fanta \(2021\)](#) findings that showed there is an inverted U-shaped relationship between financial development and sector output. The current finding thus indicates that non-linear finance–sector nexus is not only observed in the responses of output but also efficiency performance, which emphasizes the significance of proper and well-designed financing in the service sector. This result augers well with the threshold-finance literature argument that a high level of financial deepening can result in less or even negative efficiency in the absence of proper management within productive and regulatory boundaries. It demonstrates that finance can bring efficiency at the beginning of its development by contributing to innovation and growth, and excessive credit can encourage speculation, inefficient growth or bad oversight, thus undermining efficiency. Therefore, the role of finance in the performance of service sectors is not automatic.

Moreover, bank deposits initially increase technical efficiencies in agriculture and service sectors, but after a certain threshold, the positive effect is not significant. Bank deposits below 25.9713% and 14.8981% are essential to significantly stimulate technical efficiencies of the agriculture and service sectors, respectively. This contradicts [Ibrahim and Alagidede \(2018a, 2018b\)](#) who found that financial development below a certain threshold has no significant effect on economic growth for sub-Saharan African countries, but beyond that threshold, the positive effect is significant. This reinforces emerging evidence in the threshold-finance literature, which suggests that excessive financial deepening may generate inefficiencies and resource misallocation when not accompanied by strong regulatory oversight and productive absorption capacity. This consequently expands on the current knowledge by showing that threshold behaviour is applicable not only to growth indicators but also efficiency outcomes. This means that financial development should be sustainable with efficiency-oriented financial policies, institutional reinforcement and sector-specific financial structures to convert liquidity into productive efficiency.

On the controls, GDP per capita stimulates the technical efficiency in the service sector because growth in GDP per capita may stimulate technological advancement and innovations in the service sectors, which may reduce inefficiencies. Furthermore, inflation reduces sectoral efficiency due to the high cost of production associated with inflation.

Hence, sectors are unable to maximise their production output. This is consistent with previous empirical studies on economic output (Acquah and Ibrahim, 2020; Aziz and Mishra, 2016), which concluded that inflation reduces economic output. Furthermore, institutions reducing technical efficiencies in the agriculture and manufacturing sectors may be explained by the bureaucratic bottlenecks associated with institutions. This reduces the quality and effectiveness of the institutions to drive efficiency. The negative link between efficiency and efficiency contradicts Ata *et al.* (2012) who found a significant positive effect of institutions on economic growth. Primary school enrolment has a significant positive effect on the manufacturing and agriculture sectors, but the effect on the service sector is negative. The service sector requires a very high-quality human resource with innovative thinking, which primary education cannot offer. This may explain the negative effect of primary school enrolment on the service technical efficiency. However, primary school enrolment in the manufacturing and agriculture sectors may stimulate productivity and output efficiency. Overall, the results point to the fact that financial development does not always promote efficiency; it actually depends on the aspects of the sector, financial heights and the quality of institutions, thus the necessity to implement various financial development policies by the sector. These control effects, when combined, demonstrate that macroeconomic stability, human capital quality and institutional capability are meaningful mediating variables in the financial development efficiency relationship, which supports the notion that financial development in its own right is not sufficient to drive structural development.

Generally, the results suggest that efficiency is not always encouraged by financial development. Rather, its impact relies on sectoral features, financial threshold, institutional environment and quality of financial intermediation. The analysis thus adds to the literature by making the change in discussion about finance-growth links to finance-efficiency motions and proving that the reactions of efficiency are non-linear and policy-sensitive.

5.3 Policy implications

The results have clear policy implications on financial sector regulators, governments and policymakers in the sector. To begin with, the positive linear correlation between financial development and manufacturing efficiency indicates that the effectiveness of the access to credit and mobilisation of deposits may help to boost the manufacturing productivity significantly. To maintain the gains in efficiency, policymakers are advised to focus more on specific financing schemes, conducive credit policy and bank-based innovation financing depending on the requirements of the manufacturing industry.

Secondly, the U-shaped effect of domestic credit on agriculture suggests that small and ill-constructed finance can enhance inefficiency, and that adequate and well-designed finance can help productivity. This requires carefully designed agricultural credit programmes, better credit delivery channels, risk-sharing plans and capacity support to enable the agriculture sector to be able to absorb and use credit in an efficient and productive manner.

Thirdly, the inverted U-shaped effect of the service sector puts emphasis on the fact that excessive credit without proper monitoring can create inefficiencies. To prevent such misallocation of funds, policymakers should thus balance financial deepening by effective regulation and better handling of credit risk and providing incentives on the productivity-enhancing investment.

Moreover, the threshold behaviour of bank deposits in agriculture and services also suggests that financial deepening has to be accompanied by its efficient intermediation and institutional enhancement instead of assuming that the increase in liquidity inevitably leads to efficiency. Lastly, the prominent positions of macroeconomic stability, institutional quality

and human capital point to the necessity of the complementary structural reforms, as well as the financial development policies.

On the whole, the research highlights that industry-oriented, properly designed and efficiency-focused financial policies are necessary so that financial development would be turned into the long-term efficiency uptake of the sector.

6. Summary, conclusion and recommendations

The paper examined the threshold effect of financial development on sectoral efficiency using a balanced panel of 42 African countries for the period 2000–2020. The sectors considered in this paper are the manufacturing, agriculture and service sectors. The findings of the study showed that the effect of financial development on sectoral efficiency depends on the measure of financial development. Domestic credit and bank deposits have a positive linear effect on the efficiency of the manufacturing sector. Domestic credit has a U-shaped relationship with agriculture technical efficiency, but its relationship with the service sector is inverted U-shaped. Also, domestic credit and bank deposits affect sectoral efficiency in diverse ways depending on the level of domestic credit and bank deposits. Therefore, it is recommended that domestic credits to the private sector beyond 8.0976% are good for agriculture technical efficiency, while domestic credit below 11.1906% is needed for service sector efficiency. Also, threshold values below 25.9713% and 14.8981% are recommended to see a significant positive effect of bank deposits on efficiency (agriculture and service sectors, respectively).

This study can be extended into a meta-analysis of high-income, low-income and middle-income economies globally.

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