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Nonlinear Dynamics of the Financial–Growth Nexus in African Emerging Economies: The Case of a Macroprudential Policy Regime

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Abstract: A panel data analysis of nonlinear financial growth dynamics in a macroprudential policy regime was conducted in a panel of 10 African emerging countries from 1983–2020, where it had been a non-prudential regime from 1983–1999 and a prudential regime from 2000–2020. The paper explored the validity of invented U-shape hypothesis in the prudential policy regime as well as the threshold level at which excessive finance boosts growth using the panel smooth transition regression (PSTR) model. The PSTR model was adopted due to its ability to address the problems of endogeneity and heterogeneity in a nonlinear framework. The results reveal evidence of a nonlinear effect between financial development and economic growth, where the minimum level of financial development is found to be 60.5% of GDP, above which financial development increases growth in African emerging countries. The findings confirmed a U-shaped relationship, contradicting the invented U-curve hypothesis. The focal policy recommendation is that the financial sector should be given adequate consideration and recognition by, for example, implementing appropriate financial reforms, developing a suitable investment portfolio, and keeping spending on technological investment in Africa's emerging countries below the threshold. Again, caution is needed when introducing macroprudential policies at a low level of the financial system.

Keywords: African emerging markets; economic growth; financial development; macroprudential policy; PSTR

1. Introduction

Over the past decade, numerous African countries' financial systems have experienced substantial changes in an attempt to transition the sector from a state-owned to a market-oriented financial one, allowing the financial sector to efficiently carry out its fundamental mandate of financial intermediation. The primary goal of these changes was to broaden financial development in order to mobilize more funds, projects and resources with the highest probability of maximization, thereby boosting economic growth and alleviating income inequality and poverty. In the case of African countries, however, these financial developments result in sluggish growth as well as a high degree of poverty and inequality. To date, there have been controversies about both theoretical predictions and the empirical literature in identifying the role played by financial development in economic growth. Theories such as the invented U-curve hypothesis that was later proposed by Levine (2003) as the 'more finance, more growth hypothesis,' postulate the importance of financial institutions in supporting productive investments and stimulating innovation, which would subsequently lead to growth. On the other hand, Robinson (1952) developed the "demand-following" theory, which contends that finance is led by, rather than leads economic growth, and finance plays a minor role in economic growth. According to this non-monotonic relationship, endogenously emerging financial institutions generally have a positive effect on growth, though the magnitude varies with the type of financial

development, and as the level of finance increases, growth may increase as well before the threshold point (Greenwood and Jovanovic 1990).

The present literature contradicts whether financial development has a direct or indirect impact on growth, and the extant literature is vast and has capitulated extensive conflicting results, where some found the Schumpeter hypothesis acceptable (Goldsmith 1969; King and Levine 1993; Arcand et al. 2012; Puatwoe and Piabuo 2017; Bist 2018; Oro and Alagidede 2018; Jobarteh and Kaya 2019; Elijah and Hamza 2019; Abeka et al. 2021), while others leaned more towards non-monotonic association (Greenwood and Jovanovic 1990; Acemoglu and Zilibotti 1997; Rioja and Valev 2004; Arcand et al. 2012; Samargandi et al. 2015; Doumbia 2015; Ibrahim and Alagidede 2018; Swamy and Dharani 2019; Machado et al. 2021; Abu-Lila et al. 2021). A further contradiction emerged even among these studies on non-monotonic relationships, as some authors found an inverted U-shape (Samargandi et al. 2015; Oro and Alagidede 2018; Swamy and Dharani 2019; Abu-Lila et al. 2021; Machado et al. 2021), and others the U-shape (Ibrahim and Alagidede 2018; Oro and Alagidede 2019).

On the other hand, there is a strand of studies contending that financial development triggers growth through a variety of factors, rather than by itself. These include trade openness, income per capita, government size, inflation (Yilmazkuday 2011), institutional quality (Law and Azman-Saini 2012) and financial sector policies (Ang 2008). As a result of these factors, the impact of financial development is determined by the dominant economic conditions. The contradiction in these results may be due, but not limited to, the feasible explanation of the divergent results in the existing literature lying in the different model specifications, data sets, estimation techniques or level of economy being studied. The recent global financial crisis has led to a reassessment of both policymakers' and academics' prior conclusions (Law and Singh 2014). As a result, central banks are now pursuing a robust expansionary monetary policy with new unconventional tools, necessitating the implementation of macroprudential policies to mitigate the systemic risk. These policies are formulated and executed with a strong emphasis on the financial system and the economy as a whole. Emerging economies are second to advanced countries in implementing macroprudential policies, with a 3.5 index on average, according to the World Bank. The analysis and formulation of these new policy programmes are still evolving, with very limited research. Considering the high level of average adoption of macroprudential policies in emerging economies' responses to numerous systemic risks (e.g., financial crises), and the contradiction emerging in the literature, there is a pressing need for this subject matter to be investigated in African emerging countries.

This study extends the existing literature on the financial–growth relationship, following the seminal work of Ouedraogo and Sawadogo (2020) who employed the panel smooth transition regression (PSTR) in a panel of sub-Saharan African countries over the period 1980–2017. In their model, real GDP was utilized to measure economic growth, while the ratio of bank credit to the private sector to GDP was used to capture financial development, controlling for inflation and government expenditure. Their findings supported the literature on the "more finance, more growth" hypothesis.

The current study seeks to extend the existing debate on this subject matter, with roots back to the seminal work of the Greenwood and Jovanovic (1990) known as the invented U-curve hypothesis and many others on the so-called inverted U-shaped relationship, and then to add a twist by introducing a distinction between a macroprudential and a non-macroprudential policy regime, referring to the periods 1983–1999 and 2000–2020. This would allow the researcher to distinguish whether these policies triggered the financial–growth relationship in African emerging economies. Furthermore, the author seeks to include major monetary policy variables, known as macroprudential monetary policy instruments (i.e., financial-institution-targeted instruments) that were adopted by federal banks in various countries during the 2007 crisis. According to the existing literature on the monetary policy point of view, the macroprudential policy has been argued to have a direct and indirect effect on economic growth, which was not captured in the Ouedraogo

and Sawadogo (2020) model. Furthermore, their study did not provide the threshold point above which states that financial development improves economic growth. The current study supports the view that, as countries switch from a non-macroprudential policy regime to a macroprudential policy regime, the correlation between financial development and economic growth might differ.

It is because of these inconclusive and sometimes conflicting views that this study seeks to fill the gap in the literature by incorporating and examining the impact of financial development and these monetary policy variables and their effects on economic growth in African emerging economies, which most of the existing studies have not given attention to, and also by providing the threshold level of financial development that adversely affects growth. This will contribute to the body of evidence in African literature. The researcher constructed a balanced panel of 10 African emerging markets covering the period 1983–2020. The period from 1983–1999 is the non-macroprudential policy regime, while the period from 2000–2020 is the macroprudential policy regime. The 10 African emerging countries are South Africa, Namibia, Botswana, Mali, Mozambique, Eswatini, Burkina Faso, Nigeria, Tanzania and Uganda.

This study proposes to clarify the ongoing debate by analyzing the nonlinear effects of financial development on economic growth and employing the panel smooth transition regression (PSTR) model, as well as random or fixed effect estimators, as the baseline models. The PSTR is not a new model in the African context. However, in this study, the researcher aims to extend Ouedraogo and Sawadogo's (2020) African finance–growth model by introducing the lag to all variables, following González et al. (2017), and including macroprudential variables. Furthermore, this model allows for an examination of the impact of the financial development, as shown by its various phases. The originality of the PSTR model consists of the fact that individuals can shift between groups and over time, as based on changes in the threshold variable. Because parameters fluctuate smoothly as a function of a threshold variable, the PSTR model also gives a parametric solution to the cross-country variability and time instability of the finance–growth coefficients. These features cannot be accounted for by dynamic or static panel techniques, nor by interaction effects. The PSTR model could provide new insights, since this model endogenously identifies different regimes that correspond with distinct equations as well as the optimal degree of financial development, i.e., the threshold value, with respect to which the sign of the relationship could be different. Lastly, the inspiration for this study emanated not from a lack of studies examining the nonlinear effect of financial development on growth in African countries, but more generally from the fact that this relationship may differ from the one that exists in the literature due to the difference in the smoothness and the adopted financial and macroeconomic policies. Actually, the findings contradict Greenwood and Jovanovic's invention of the U-curve in both macroprudential and non-macroprudential policy regimes. However, what is interesting is that, during the adoption of these policies, they triggered the finance–growth relationship in these countries. Moreover, during the non-macroprudential policy regime, the impact seems to be positive in the high regime, however, statistically insignificant.

The remainder of the paper is organized in the following manner: the literature on the subject is briefly reviewed in Section 2, while Section 3 gives an overview of the model. The result of the PSTR and FE are discussed in Section 4, while Section 5 provides concluding remarks and discusses policy implications.

2. Literature Review

2.1. Theoretical Debate on Financial Growth

The financial–growth relationship has spawned a slew of channels. The central theoretical debate continues with four hypotheses: The Schumpeter hypothesis (Schumpeter 1934), the "supply-leading" and "demand-following" hypothesis (Patrick 1966), the endogenous growth theory of Romer (1986) and the non-monotonic finance–growth relationship of Greenwood and Jovanovic (1990). The current study builds on the non-monotonic rela-

tionship developed by Greenwood and Jovanovic (1990) as theoretical basis, going far back to the hypothesis developed by Schumpeter (1934), emphasizing the importance of financial institutions in supporting productive investments and stimulating innovation, which was subsequently renamed the "more finance, more growth" theory by Levine (2003). Building from the Schumpeter hypothesis (Schumpeter 1934; Robinson 1952) developed the "demand-following" theory, which contends that finance is led by, rather than leads economic growth, and finance plays a minor role in economic growth. Following this line of reasoning, finance is merely a by-product or an outcome of growth. The "supply-leading" theory, which was later developed by King and Levine (1993), contends that financial development is an essential precondition for economic growth; as a result, finance leads to economic growth and causation flows from financial development to economic growth. The number and composition of financial development factors, according to its proponents, cause economic growth by directly increasing savings in the form of financial assets, resulting in capital creation and hence economic growth. The quantity and composition of financial development variables, according to their proponents, affect economic growth by directly increasing savings in the form of financial assets, resulting in capital creation and hence economic expansion. The theoretical works of Romer (1986) contributed to the emergence of the endogenous growth theory by arguing that the financial sector plays an important role in boosting growth, particularly by mobilizing savings, allocating resources efficiently, monitoring costs, diversifying risks and facilitating the exchange of goods and services. The non-monotonic relationship between financial development and growth, built on the monotonic relationship hypothesized by Greenwood and Jovanovic (1990), posits that endogenously emerging financial institutions generally have a positive effect on growth, although the magnitude varies with the level of economic development; that is, as financial development increases, economic growth may increase too before a certain level of financial development is reached.

2.2. Empirical Review

After scrutinizing the empirical literature on this subject, the researcher found that existing studies build on the three strands, the Schumpeter hypothesis (Schumpeter 1934) which was later proposed by Levine (2003) as the 'more finance, more growth' hypothesis (Goldsmith 1969; King and Levine 1993; Arcand et al. 2012; Bist 2018; Jobarteh and Kaya 2019; Elijah and Hamza 2019; Abeka et al. 2021), the hypothesis that financial development leads to low growth (Gouider and Trabelsi 2006; Menyah et al. 2014; Elijah and Hamza 2019; Ho and Iyke 2020) and the non-monotonic relationship (Greenwood and Jovanovic 1990; Acemoglu and Zilibotti 1997; Rioja and Valev 2004; Arcand et al. 2012; Samargandi et al. 2015; Doumbia 2015; Ibrahim and Alagidede 2018; Oro and Alagidede 2018; Opoku et al. 2019; Swamy and Dharani 2019; Machado et al. 2021; Abu-Lila et al. 2021). There is inconsistency among these strands, as the Schumpeter hypothesis (Schumpeter 1934) posits the 'more finance, more growth' hypothesis, while the Greenwood and Jovanivic hypothesis claims that there is a nonlinearity relationship between financial development and economic growth.

Even in the African literature, a strong paradox has emerged among the studies, as two different findings have been reported. Some support the nonlinearity hypothesis (Ibrahim and Alagidede 2018; Ouedraogo and Sawadogo 2020; Machado et al. 2021), while others claim that there is linearity between the two variables (Assefa and Mollick 2017; Bist 2018; Jobarteh and Kaya 2019; Elijah and Hamza 2019; Chen et al. 2020). In this section, both the global and African literature is reviewed.

Going as far back as the study by King and Levine (1993) that tested the Schumpeter hypotheses (Schumpeter 1934) over the period 1960–1989 using a two-stage least squares (2SLS) model in a panel of 57 countries, their findings confirmed the Schumpeter hypothesis (Schumpeter 1934). These findings contradict the results reported by Gouider and Trabelsi (2006) in a panel of 66 countries covering the period 1960–1999, using the traditional cross-sectional simple panel and dynamic panel techniques. They used the standard deviation

of per capita real GDP as a proxy for economic growth, while the large money stock (M3) was used as a proxy for financial development. Their findings confirmed a negative relationship in developed countries, while in developing countries it was insignificant. Arcand et al. (2012) documented that finance starts having a negative effect on output growth when credit to the private sector reaches 100% of GDP in the period 1960–1990 including 16 country periods.

Seven years later, the study by Menyah et al. (2014) examined the causal relationship in a panel of 21 African economies over the period 1965–2008. Financial development was captured by applying a panel bootstrapped approach to Granger causality. The empirical results show limited support for finance-led growth. Samargandi et al. (2015) used the panel data of 52 middle-income countries over the period 1980–2008, applying pooled mean group estimations in a dynamic heterogeneous panel setting. A bank-based financial index was used to capture financial development. They found an inverted U-shaped relationship, which contradicts the studies by King and Levine (1993) and Gouider and Trabelsi (2006), while the study by Doumbia (2015) found the saving channel to be the main determinant of the financial–growth relationship in a panel of 43 advanced and developing economies over the period 1975–2009. These results further contradict the Nigerian study by Adeniyi et al. (2015), using time series data covering the period 1960–2010, using a nonlinear threshold model. Their findings supported the literature that believed in the U-shape relationship.

Recently, studies such as Assefa and Mollick (2017) employed the System Generalized Method of Moments (SGMM) in a panel of 15 African countries, over the period 1995–2010. In their model, economic growth was captured by real GDP, while international financial integration was used to proxy for financial development. The results were similar to those of the study by King and Levine (1993), but contradicted those of Samargandi et al. (2015). The results documented by Assefa and Mollick (2017) were further supported by Bist (2018) in a panel of 16 African and non-African low-income countries, using the fully modified and dynamic OLS technique. Financial development was captured using credit to the private sector, while the log of real GDP was used to capture economic growth. The results documented by Bist (2018) contradict those reported by Ibrahim and Alagidede (2018) in a panel of 29 sub-Saharan African (SSA) countries over the period 1981–2015, using the Hansen threshold model, as their findings support the non-monotonic hypothesis (U-shaped), which contradicts the findings documented by Samargandi et al. (2015) and Oro and Alagidede (2018). In their model, the ratio of private and domestic credit to GDP was used to capture financial development. The study by Oro and Alagidede (2018) utilized the panel GMM in panel data of 30 non-oil-producing and 30 oil-producing countries grouped by their quality of institutions over the period 2006 to 2015. Their findings confirmed the inverted U-shape.

Jobarteh and Kaya (2019) studied the same subject in African countries, using a PSTR model in a short run covering the period 1980–2014. The GDP per capita was used to capture economic growth, with the financial development index as a proxy for financial development. Their findings contradict the study by Ibrahim and Alagidede (2018), but support empirical literature that believes in the 'more finance, more growth' hypothesis. Their findings further reject the existence of nonlinearity in African economies. Elijah and Hamza (2019) used a vector error correction model (VECM) in Nigeria covering the period 1981–2015, using broad money supply as a proxy for financial development. Their finding contradicts the study by Samargandi et al. (2015), but supports that by Gouider and Trabelsi (2006). The study by Swamy and Dharani (2019) investigated the non-monotonic effect of finance on growth in a panel of 24 advanced economies over the period 1983–2013. In their model, economic growth was captured by GDP (annual %), while domestic credit to the private sector (% of GDP) was used to capture financial development. The results support the non-monotonic hypothesis (inverted U-shape), where the threshold was found to be 142% of GDP. These results contradict those reported by Ibrahim and Alagidede (2018), but support Samargandi et al. (2015). Asteriou and Spanos (2019) examined the finance growth during the financial crises from a panel of 26 EU countries, over the period 1990–2016.

Their main aim was to find the impact of financial development on growth before and after financial crises. The results show that before a crisis, financial development promotes economic growth, while after the crisis it hinders economic activity.

Chen et al. (2020) studied the asymmetric relationship of financial growth in Kenya using the Nonlinear Autoregressive Distributed Lag (NARDL), covering the period from 1972 to 2017. The financial development depth indicator was used to capture financial development. Their findings document the inflationary and government channels as the main determinants of the financial–growth relationship, claiming that no direct impact exists between the two variables in Kenya (Yilmazkuday 2011). However, the Ghanaian study by Ho and Iyke (2020) contradicts the Kenyan study, as it documents the existence of a negative direct effect between the two variables using the ARDL model over the period 1975–2014, which supports the studies by Elijah and Hamza (2019), Ibrahim and Alagidede (2020) and others.

Ouedraogo and Sawadogo (2020) used the PSTR estimates in SSA countries over the period 1980–2017, modelling the ratio of bank credit to the private sector to GDP as a proxy for financial development, with GDP per capita as a proxy for economic growth. Controlling for openness, inflation and government expenditure their finding contradicts the study by Ho and Iyke (2020). Aluko et al. (2020) studied the same subject in a panel of 33 SSA countries, using the panel causality test covering the period 1990–2015. Their findings document a bidirectional relationship between finance and growth, which then contradicts the study by Ouedraogo and Sawadogo (2020). Abu-Lila et al. (2021) tested the non-monotonic hypothesis in Jordan during the period 1990–2019, using the Johansen cointegration test. Their results document the evidence of a non-monotonic (inverted U-shaped) relationship, supporting the study by Swamy and Dharani (2019), which has lately been supported by Machado et al. (2021) in a panel of 36 SSA countries, covering the period 1980–2015 using the SGMM. In their model, economic growth is captured by a log of real GDP per capita, while financial development is captured by the natural logarithm of domestic credit to the private sector. However, different results were documented by Ustarz et al. (2021) in the same region as adopted by Machado et al. (2021), using the same model. However, Ustarz et al. (2021) used the financial development index, scaling from zero to 100 with an agricultural value as a proxy for financial development, covering the period 1990–2018. Their findings support Schumpeter's hypothesis. The study by Ustarz et al. (2021) is further supported by Abeka et al. (2021), where financial development is captured by telecommunication infrastructure.

3. Research Methods and Data Adopted for This Study

This study uses variables that were suggested by both the theories and the literature as the variables that explain the financial–growth relationship. However, the relationship was extended by adopting the concept of macroprudential policies in determining the nonlinear dynamics effect of financial growth in African emerging economies, as these policies were applied in these countries. It has been proposed that they may hamper economic activity (Caldera-Sánchez and Röhn 2016). Therefore, financial-institution-targeted instruments were included in the model to control for prudential policy effects, as they may affect growth explicitly or implicitly and were not captured in the Ouedraogo and Sawadogo (2020) model. According to the searchers knowledge of these policies, as well as their consequences for macroeconomic performance, remain a point of contention.

Economic growth (measured by a log of GDP per capita at constant prices) (growth) was used, as Beck et al. (2007) argue that financial development affects growth through income levels (with financial development measured by domestic credit to the private sector as a share of GDP) (DCPS). While private credit (DCPS1) was used as a robustness check, the control variables were macroprudential policies (i.e., financial-institution-targeted instruments) (MPIF), inflation (INFL), investment (measured by gross fixed-capital formation) (INV), trade openness (TR) and government expenditure (measured by government final consumption expenditure as a share of GDP) (G). For the sensitivity analysis, the

researcher added tourism development (TOD) captured by proxy by the number of arrivals of international tourists.

The related measures of financial institutions are aimed at the balance sheets of banks, which influence the provision of credit to the economy. The buildup of extra capital may limit overly rapid credit expansion by raising the cost of providing new loans. These resources can be released in times of financial stress to avert credit constraint and absorb bank losses. Banks with larger credit provisions and higher capitalization reduce the likelihood of a financial crisis and improve the real economy's net benefits.

All the control variables were expected to be positively related to economic growth. The variables were extracted from WDI (2021), and Cerutti data (Cerutti et al. 2017). The unit-root test was not appropriate for this study as it deals with monotonic data and does not require integration or cointegration.

Panel Smooth Transition Regression Model

Following González et al. (2005), the study builds a PSTR model for the African emerging economies, to evaluate the nonlinear dynamics effect of the financial–growth relationship. The simplest case of the PSTR model, with a single transition function in two regimes illustrating the threshold effect of financial development on economic growth, is as follows:

$$Growth_{it} = \mu_i + \lambda_t + \beta'_0 DCPS_{it} + \beta'_1 DCPS_{it} \times g(q_{it}; \gamma, c) + \beta_2 K_{it} + e_{it} \tag{1}$$

where $Growth_{it}$ is a dependent variable captured by the log of GDP per capita at constant prices, then $i = 1, \ldots, N$, and $t = 1, \ldots, T$ indicate a cross-section and the time dimensions of the panel, respectively, whereas λ_t and μ_i denote the time and fixed individual effect, correspondingly, K_{it} is the vector of control variables (MPIF, INFL, INV, TR and G) and the error term is denoted by e_{it}. Succeeding to the work documented by Granger and Terasvirta (1993) and González et al. (2017), the transition function in the logistic form $g(q_{it}; \gamma, c)$ is a continuous function of the transition variable q_{it} bounded between 0 and 1 and defined as:

$$(q_{it}; \gamma, c) = \left(1 + \exp\left(-\gamma \prod_{j=1}^{m}(q_{it} - c_j)\right)\right)^{-1} \text{ with } \gamma > 0 \text{ and } c_1 \leq c_2 \leq \ldots c_m \tag{2}$$

In (2), $c_j = (c_1, \ldots, c_m)'$, which is an m dimensional vector of threshold parameters, where the slope parameter denoted by γ controls the smoothness of the transitions. Moreover, $\gamma > 0$ and $c_1 < \ldots < c_m$ are restrictions imposed for identification purposes. In practice, for $m = 1$ or $m = 2$, respectively, one or two thresholds of financial development occur, around which the impact of economic growth is nonlinear[1]. This nonlinear impact is represented by a continuum of parameters between the extreme regimes. For $m = 2$ the transition function has a minimum of $(c_1 - c_2)/2$ and reaches a value of 1 for both the low and high values of q_{it}. Therefore, if γ tends to infinity, the model becomes a three-regime threshold model. However, it is reduced to a homogenous or linear fixed effects panel regression, when the transition function becomes constant, i.e., when γ tends to 0.

As noted in González et al. (2017), before estimating Equation (1), there are three crucial tests that need to be undertaken, which are (1) testing for the appropriate transition variable among the set of variables included as candidates (DCPS, MPIF, INFL, INV, TR, and GE), (2) testing for the monotonic hypothesis and (3) testing for the sequence for selecting the order m of the transition function, using the LM-type test. The LM-type test contains two groups of misspecification tests, where group 1 is the Lagrange multiplier wild (LM_χ) and Lagrange multiplier Fischer (LM_f), group 2 is the wild bootstrap (WB) and wild-cluster bootstrap (WCB), while their F-statistic, corresponding with their p-values, will be used in the three tests mentioned in the first line of this paragraph. The theoretical reasoning behind the LM-type test is that, for all these tests, the p-value should be small.

Note that the WB and WCB will be utilized as robustness checks for linearity against the PSTR.

To be precise, amongst the appropriate transition variables, the variable to be used for testing for nonlinearity should have the smallest *p*-value compared to all the variables included as candidates. On the other hand, for the monotonic hypothesis between financial development and economic growth, the *p*-value of both LM_χ and LM_f should be zero or less than zero, which would signify the rejection of the H_0 of linearity between financial development and economic growth. Then, the WB and WCB will hold the argument that a nonlinearity still exists amongst the variables. Lastly, for the sequence for selecting the order *m* of the transition function, following González et al. (2017), the study will test up to order $m = 3$. The sequence for selecting the order *m* of the transition function under the $H_0^* : \beta_3^* = \beta_2^* = \beta_1^* = 0$ is selection $m = 3$. If it is rejected, it will continue to test $H_{03}^* : \beta_3^* = 0, H_{02}^* : \beta_2^* = 0 | \beta_3^* = 0$ and $H_{01}^* : \beta_1^* = 0 | \beta_3^* = \beta_2^* = 0$, in selection $m = 2$. If it still fails, $m = 1$ will be selected as default (Teräsvirta 1994; Teräsvirta et al. 2010).

Finally, the author evaluated the correlation between financial development and economic growth using the fixed effect (FE) and random effect models. In these models, the author generated the squared term of domestic credit to the private sector as a share of GDP (financial development) to capture the nonlinear form of financial growth in the African emerging markets. The author estimates Equation (3), which in order to account for nonlinearity includes interaction terms:

$$Growth_{it} = \alpha_i + \beta_0 DCPS_{it} + \beta_1 DCPS_{i,t-1}^2 + \beta_2 K_{it} + u_{it} \tag{3}$$

Equation (3) incorporates an interaction with a quadratic component to evaluate the nonlinear influence of the transition variable, which is financial development. With the addition of an interaction term, it is possible to see if the marginal effect of financial development differs at greater levels of this variable. The other variables of Equation (3) are defined as in Equation (1). The Hausman test will be used in order to decide between FE and random effects (RE) estimates, under the full set of random effects assumptions.

4. Empirical Analysis of the Study

The descriptive statistics of the different variables are reported in the Appendix A (Table A1). As described previously, the PSTR contains three stages, which include finding the appropriate transition variable among all the candidate variables, testing the linearity and finding the sequence for selecting the order *m* of the transition function using the LM-type test, with the proposed WCB and WB serving as robustness checks, before estimating the PSTR model. The results of the three stages are presented separately in the sections that follow.

4.1. The Results of the Transition Variable, Homogeneity Test and Selection of the Order m of the PSTR

Following González et al. (2017), the author includes all variables (DCPS, MPIF, INFL, INV, TR and GE) as candidates in identifying the appropriate transition variable. Table 1 presents the results of all the stages of the PSTR. The first section of Table 1 shows the results of the appropriate transition in the panel regression of financial development and economic growth. The results show that both the *p*-values of the LM_F-test (0.00009) and LM_X-test (4.556×10^{-10}) signify DCPS as the most suitable choice of transition variable for this study, as the *p*-values are smaller compared to other included variables as candidates.

Table 1. Results of selecting the transition variable.

		Transition Variable $DCPS_{it-1}$			Results of the H_0		Selecting Order m		
		$m = 1$	$m = 2$	$m = 3$	$m = 1$	$m = 1$; H_{01}	$m = 2$; H_{02}	$m = 3$; H_{03}	
LM_F	Fs	3.51	3.10	2.17	14.28	3.69	9.84	8.50	
	p-v	0.00009	0.01604	0.00020	2.984×10^{-16}	0.59	7.302×10^{-5}	1.226×10^{-5}	
LM_χ	Fs	15.06	13.58	12.04	9.20	7.40	54.86	48.01	
	p-v	4.556×10^{-10}	3.192×10^{-5}	2.062×10^{-6}	0.00	0.43	1.394×10^{-6}	3.533×10^{-8}	
WB	*p*-v	-	-	-	0.00	-	-	-	
WCB	*p*-v	-	-	-	0.00	-	-	-	

Note: The dependent variable is the growth. All variables (DCPS, MPIF, INFL, INV, TR and GE) were included as candidates for identifying the appropriate transition variable using the LM-type test. The *p*-v are the *p*-values, and the Fs denotes the F-statistic. Source: Author's calculation based on WDI (2021) and Cerutti (Cerutti et al. 2017) data.

The results of the homogeneity test are then reported in the second section of Table 1. The author generates the F-statistics and *p*-values of both LM_F (0.00) and LM_x (2.984×10^{-16}) to test the null hypothesis of linearity, while the proposed WCB (0.00) and WB (0.00) are robustness checks. Both the *p*-values of LM_χ and LM_F indicate the rejection of the null hypothesis of linearity, confirming that there is indeed nonlinearity between financial development and economic growth in selected African emerging countries. This was further supported by WB and WCB, signifying that nonlinearity remains between the two variables. The homogeneity results support studies documented by Assefa and Mollick (2017), Ibrahim and Alagidede (2018) and Machado et al. (2021).

Lastly, the third section of Table 1 reports the results of the sequence for choosing order *m* in PSTR[2]. The results reject H_0 as the *p*-value of both the $LM_F (0.59)$ and LM_X (0.43) when $m = 1$ signifying that, when $DCPS_{it-1}$ was selected as best transition variable, the model had one regime which separated the low level from the high level of financial development. This concludes that the model has two regimes with one transition and reject $m = 2$; H_{01} and $m = 3$; H_{02}. Conversely, the results of the LM_F and LM_x were evaluated using the WCB and WB, in the following section following Teräsvirta (1994).

4.2. Model Evaluation and the Estimated Threshold of the PSTR Model

This section reports the results of the model evaluation and the estimated threshold of the PSTR. After estimating the baseline model, following Eitrheim and Terasvirta (1996), the author first evaluated the reliability of selecting the order $m = 1$ as the best transition variable for this model, using two classes of the misspecification tests: Parameter Constancy (PC) and No Remaining Nonlinearity (NRN) (González et al. 2017). Table 2 presents the results of the PC, NRN and the estimated threshold. The first section of Table 2 reports the results of the PC. The *p*-values of the LM_F and LM_χ for parameter constancy show that the parameters are constant, while the second section of Table 2 shows the results of both the WB and WCB tests that take heteroskedasticity as well as possible within-cluster dependence into account, suggesting that the estimated model with one transition is adequate. Lastly, the third section of Table 2, contains the results of the estimated threshold for the baseline and robustness model.

Table 2. Results of the linearity test.

|	Parameter Constancy Test			
LM_F	6.384 (3.238×10^{-9})			
LM_χ	82.44 (4.973×10^{-13})			
	No Remaining Nonlinearity			
WB	1 (*p*-value)			
WCB	1 (*p*-value)			
	Results of the Estimated Threshold model			
	Model 1: Baseline	Model 2: Baseline	Model 3: Robustness	Model 4: Robustness
Threshold (c)	0.605 *** (0.02)	0.529 *** (0.05)	0.592 *** (0.01)	0.581 ** (0.10)
Slope (γ)	18.11 ** (4.20)	10.03 ** (5.04)	10.08 ** (4.10)	12.90 ** (5.01)

Note: The dependent variable is the growth. (***), while (**) reflects the 1%, 5% level of significance, respectively. Source: Author's calculation based on WDI (2021) and Cerutti (Cerutti et al. 2017) data.

The results show that the estimated financial development threshold is 60.5% of GDP in the macroprudential policy regime, while in the non-macroprudential policy regime it is 52.9% of GDP; while for the robustness model it is even beyond the baseline as it is 59.2% of GDP. Hence, the first regime, i.e., when the level of financial development is below the value of 60.5% as a share of GDP, reduces the level of growth. This can be justified as, in the low regime of finance, financial development may decrease economic growth through increased economic fragility. Financial innovation and financial liberalization, both of which are captured by financial development, have accumulated systemic risk (see Gambacorta et al. 2014). Higher systemic risk means more frequent and/or severe crises, which have a detrimental impact on economic growth rates. However, when financial development is above the threshold of between 52.9% and 60.5% as a share of GDP, it promotes growth by promoting capital accumulation, and technological advancement by accumulating savings, mobilizing and pooling savings, creating investment information, enabling and encouraging foreign capital inflows and optimizing capital allocation. Moreover, it will decrease inequality and poverty by broadening access to financing for the poor, facilitating risk management by lowering their vulnerability to stock, and increasing investment and productivity, which leads to increased revenue creation.

The mean of domestic credit to the private sector (DCPS) was calculated to obtain a clear picture of which countries are at the lower/higher end of the Greenwood and Jovanovic hypothesis of financial development and economic growth.

Figure 1 illustrates that the African emerging countries are at the lower end of financial development, with the exception of South Africa, which has a mean of DCPS (135.86%) (2000–2020).

There are various dynamics that might lead these countries to be at the lower end of the Greenwood and Jovanovic curve, which might, for example, be the high level of inequality in these countries, as is evident from Zungu and Greyling (2021a, 2021b). Another possible factor could be the adopted policies that do not benefit the people in improving their standards of living. It has been evident that per-capita income can be a good indicator of an institution's overall development and complexity. As a result, rapid financial development is correlated with high growth. Some countries below the threshold have an average GDP per capita below USD3000 (2000–2020), which further supports the argument that countries with a low level of development tend to be the ones that also have low levels of financial development.
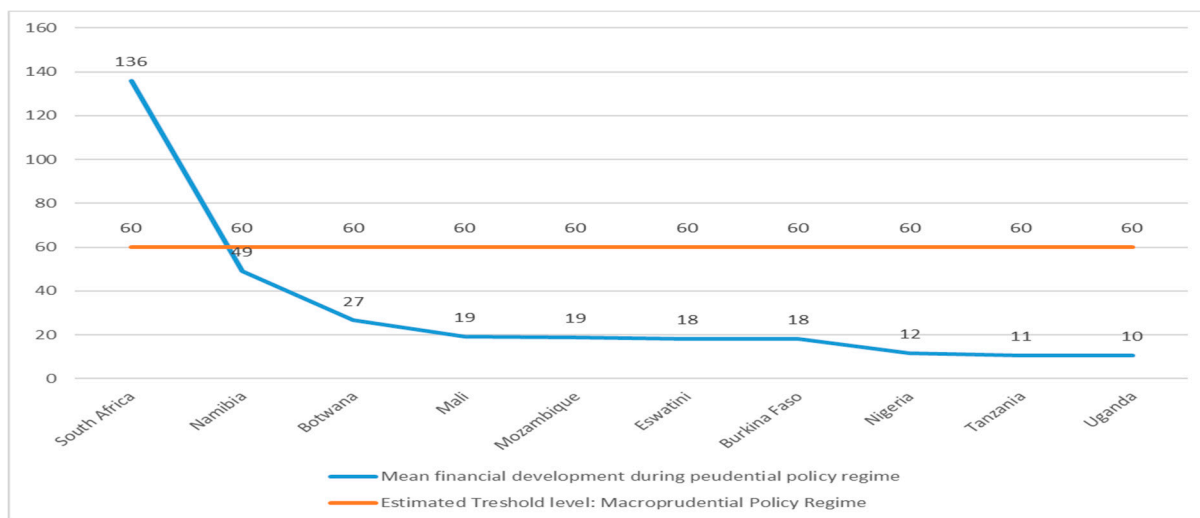
Figure 1. The mean GDPS per capita and the estimated thresholds. **Source:** Author's calculation based on WDI (2021) data.

4.3. Empirical Results of the PSTR and FE Models

The results of both the PSTR and the fixed effect are reported in Table 3 where the base-line model is the PSTR, which is a lag of a two-regime model, while the fixed effect model is utilized in supporting the results of the PSTR. First, in both Model I, the macroprudential policy, and Model II, the non-macroprudential policy regime, the results of the baseline model (PSTR) indicate that financial development reduces economic growth, measured by β_{0j}, and it is significant. Furthermore, this finding is supported by the results of the FE. A strong nonlinearity is reported between financial development and economic growth, as the results in Table 1 confirm the homogeneity between the variables by rejecting the hull hypothesis of linearity. Therefore, the results of the homogeneity test allow the estimation of the study to generate the coefficient (β_{1j}) that captures the nonlinear component, which is found to be positive and highly significant.

Subsequently, the impact of financial development on economic growth is conditional to the level of financial development. As a result, the study's findings imply that changes in economic growth in terms of financial development range from low to high. The shift between these extreme regimes occurs around the associated endogenous location parameter. When comparing the macroprudential policy regime with the non-macroprudential policy regime across all the estimation tools the authors find that, while the impact is similar, the magnitude coefficient of DCPS in the macroprudential policy regime, when the financial system starts to develop, has a massive impact compared to its impact on a non-macroprudential policy regime. On the other hand, when financial development is high above the threshold, the DCPS has a massive impact on the common man in the macroprudential policy regime, compared to the non-macroprudential policy regime period. Focusing on the baseline model, the magnitude below the threshold is 4.62 and 0.88, while it is 3.62 and 1.03 above the threshold, respectively. The findings of this study contribute significantly to the existing literature in understanding the nonlinear dynamics impact of financial development on economic growth in countries that have implemented macroprudential policies, as they show that integrating these policies at a low level of financial development may cause the level of economic growth to crumble. The argument for financial development being anti-growth might be that a lower level of financial system promotes risk and ineffective resource allocation, which may reduce the rate of savings and risk, resulting in lower economic growth. Higher systemic risk means more frequent and/or severe crises, which would have a detrimental effect on growth rates. The results are in line with findings documented by Puatwoe and Piabuo (2017) in the case of Cameroon.

Table 3. Panel smooth transition regression model estimation.

Variables: Growth	Model I: Financial Growth: Macroprudential Policy Regime (2000–2020)			Model II: Financial Growth: Non-Macroprudential Policy Regime (1983–1999)		
	PSTR		FE	PSTR		FE
	Low Regime $\beta_{0j} \times 100$	High Regime $(\beta_{0j} + \beta_{0j}) \times 100$		Low Regime $\beta_{0j} \times 100$	High Regime $(\beta_{0j} + \beta_{0j}) \times 100$	
$DCPS_{i,\,t-1}$	−4.62 ** (1.08)	3.62 ** (0.31)	3.50 ** (0.87)	−0.88 *** (0.04)	1.03 (1.33)	−1.40 ** (0.02)
$DCPS^2_{i,t-1}$		1.99 ** (0.09)				0.99 (2.09)
$MPIF_{i,\,t-1}$	−4.42 ** (1.18)	3.44 ** (1.48)	3.44 ** (1.48)			
$INFL_{i,\,t-1}$	−0.06 (0.21)	0.99 ** (0.35)	0.99 ** (0.35)	−0.76 ** (0.31)	0.05 (1.44)	0.76 ** (0.31)
$INV_{i,\,t-1}$	3.06 ** (0.91)	1.73 ** (0.73)	1.73 ** (0.73)	1.79 *** (0.18)	3.45 (4.60)	1.79 *** (0.18)
$TR_{i,\,t-1}$	4.63 *** (0.40)	1.50 ** (0.37)	1.50 ** (0.37)	1.80 ** (0.24)	0.3 ** (0.01)	1.80 ** (0.24)
$G_{i,\,t-1}$	2.88 ** (0.78)	−3.15 ** (1.03)	−3.15 ** (1.03)	1.56 ** (0.80)	−0.99 ** (0.02)	1.56 ** (0.80)
Dummy	Yes	No	No	Yes	No	No
Transition Parameters						
Threshold (c)	0.605 *** (0.02)			0.529 * (0.05)		
Slope (γ)	18.11 ** (4.20)			10.03 ** (5.04)		
ESD	0.045			0.024		
Hansen: *p*-value			0.679			0.702
R^2			0.62			0.58
# of obs.	210			170		
# of countries	**10**					

Note: The dependent variable is the growth. The numbers in brackets denote that the standard errors in brackets are obtained by using the cluster-robust and heteroskedasticity-consistent covariance estimator, allowing for error dependency within individual countries. The (***), (**) and (*) reflect the 1%, 5% and 10% levels of significance, respectively. ESD denotes the estimated standard deviation (residuals), while *p*-v are the *p*-values. **Source**: Author's calculation based on WDI (2021) and Cerutti (Cerutti et al. 2017) data.

Furthermore, the deployment of these policies beyond a certain threshold of financial development is found to be growth driven by the development of the financial system, while other determinants remain constant. The possible logic behind the positive relationship above the threshold could be that financial development improves growth through technological innovations meaning that, when the level of finance is high, it will be able to provide sufficient funds to the firms that make the most productive use of them. It was further documented in the study by Levine (2005) that financial institutions and markets may stimulate economic growth through a variety of channels, including (i) acquisition and processing, (ii) easing the exchange of goods and services through the provision of payment services and (iii) mobilizing and pooling savings from a large number of investors. This finding is consistent with the previous empirical studies that demonstrated a substantial positive and negative effect of financial development on economic growth; these are Ibrahim and Alagidede (2018) for SSA countries and Oro and Alagidede (2018) for Nigeria. Finally, the findings formulate a U-shaped relationship between the two variables of interest in African countries, which supports the findings reported by Ibrahim and Alagidede (2018). The theoretical justification for the U-shape relationship in African countries is formulated in the same way as that for the lower regime and the high regime.

The current study extended the existing debate in the literature by incorporating macroprudential policy instruments (i.e., financial-institution-targeted instruments) in exemplifying the finance–growth relationship. In the low regime of financial development, MPIF has a statistically negative impact on growth in the low regime, while in the high regime it has a positive impact. This shows that tightening the financially related measures is bad for growth in these countries during the low level of financial development while, as the financial sector develops beyond a minimum of 60.5% of GDP, these policies become obsolete in boosting economic activities, which then results in an increase in growth.

Many African economies are prone to macroeconomic instability, which can manifest as inflationary pressures. Therefore, the study controls for inflation in the model. Inflation

(INFL) has a positive and statistically significant impact on economic growth in the high regime of DCPS, while in the low regime it is negative and insignificant. In Model II, inflation has a negative impact on growth in the low regime. Even the estimates of the fixed effect model support the positive impact of inflation on growth. While it was discovered to be detrimental to growth during the non-prudential policy regime, the results show that in the period of the macroprudential policy regime, inflation promotes growth while in the non-policy regime, inflation reduces the level of growth. This is supported by the logic behind the positive relationship between inflation and output. It could be explained as follows: when the economy is not operating at full capacity, which means there is underutilized labor or resources, inflation can potentially assist in improving output. More money equals greater spending, which equals more aggregated demand. High demand, in turn, leads to more production in order to fulfill that need. Overall, this would lead to high growth.

In both the macroprudential policy regime and the non-macroprudential policy regime, INV has a positive and statistical impact on growth. However, during the non-macroprudential policy regime, above the threshold, investment becomes insignificant. Even the estimates of the FE model in the macroprudential policy regime show that investment improves growth, while in the non-macroprudential policy regime it is insignificant. In general, emerging countries invest a larger proportion of their GDP in investment to facilitate rapid growth, which boosts aggregate demand, which in turn boosts future productive capability. The results confirmed the findings reported in the study by Boamah et al. (2019) in a panel of 18 Asian countries. For both macroprudential and non-macroprudential policy regimes, TR has a statistically positive effect on growth in both the low and high regimes of DCPS. Furthermore, the magnitude coefficient of TR shows that, in the macroprudential policy regime, TR has a massive impact on growth compared to its impact in the non-prudential regime. The findings were further confirmed by the estimate of the FE model. The findings support the study by Keho (2017) in Cote d'Ivoire. The logic behind the positive impact could be that trade enables integration with global trade, with sources of innovation, and boosts FDI gains. Trade openness enables economies to grow output, improving returns to scale and specialization economies, which then leads to growth.

Finally, in both policy regimes, G has a statistically significant impact, showing that below the threshold of DCPS it increases growth, while in the high regime beyond the threshold it decreases economic growth. Even the estimates of the FE support the negative effect of government expenditure on economic growth. The results are consistent with the results reported by Zungu et al. (2020) in the SADC region and Zungu and Greyling (2021a, 2021b) in the African emerging countries. This may be due to a variety of factors, including an increase in government activity, which could impede economic activities such as transfer payments, which tend to discourage people from taking employment, thereby reducing the level of output. Additionally, it may appear when government expenditure is financed by tax revenues.

4.4. Robustness Checks and Sensitivity Analysis

Even when the author uses claims on private sectors by financial intermediaries to capture financial development, the results obtained prove that the effect of financial development on economic growth is indeed nonlinear in the African emerging economies, regardless of the variable used to capture financial development. The variables utilized in this section have the same definition as those defined in the baseline model. For the sensitivity analysis, the researcher added tourism development (TOD) captured by the number of arrivals of international tourists. The results of the robustness and sensitivity analysis are reported in Table 4 for both the PSTR and FE models in both the macroprudential and non-macroprudential policy regimes. Again, all the testing procedures for these models were followed.

Table 4. Development inequality: robustness checks model.

	Model III: Financial Growth: Macroprudential Policy Regime (2000–2020)	Model IV: Financial Growth: Non-Macroprudential Policy Regime (1983–1999)
PSTR	Growth = −5.34DCPS1 *** − 2.89MPIF *** − 0.99INFL ** + 2.88TOD ** + 2.01INV ** + 2.98TR ** + 3.01G ** $\left[\text{DCPS1}; 10.08^{**}_{\gamma}, 0.592^{***}_{C}\right]$ + 2.99DCPS1 ** + 1.29MPIF *** + 0.28INFL** + 3.40TOD *** + 2.99INV *** + 1.01TR ** + 2.31G ***	Growth = −0.99DCPS1 ** − 1.60INFL ** + 1.25TOD *** + 2.01INV ** + 1.56TR ** + 2.11G ** $\left[\text{DCPS1}; 12.90^{***}_{\gamma}, 0.581^{**}_{C}\right]$ + 1.22DCPS1 + 0.29INFL + 3.88TOD ** + 1.09INV ** + 3.21TR ** + 1.10G **
FE	Growth = −3.20DCPS1 ** + 2.67DCPS1^2 ** + 2.51MPIF *** + 1.03INFL ** + 3.76TOD *** + 1.89INV *** + 2.07TR ** + 2.00G *** Hansen: *p*-value 0.598 R^2: 0.61	Growth = −2.00DCPS1 ** + 1.56DCPS1^2 − 1.23INFL ** + 2.09TOD *** + 1.991INV ** + 1.82TR ** + 1.12G ** Hansen: *p*-value 0.709 R^2: 0.68

(**), (*) reflect the 1% and 5% level of significance, respectively. **Source:** Author's calculation results based on WDI (2021) and Cerutti (Cerutti et al. 2017) data.

The author checked the sensitivity of the findings in the baseline model by including an additional control variable. This would help strengthen the findings reported in the baseline models on whether they are sensitive to variables included in the system as control variables. Estimation results demonstrate that the nonlinear effect of financial development on economic growth is not sensitive to the variable included in the system as a control variable, or to the variable used to measure financial development. Indeed, the findings are very similar to those initially obtained. The new adopted variable is found to improve growth in all models and in both the macroprudential and non-macroprudential policy regimes.

5. Conclusions and Policy Recommendations

The relationship between financial development and economic growth is a source of contention in the theoretical and empirical literature. This paper aims to overcome these inconclusive results by examining the dynamics of financial growth by focusing on a macroprudential policy regime and comparing it to a non-macroprudential policy regime; in brief, by examining how the financial–growth relationship in African emerging countries was triggered by macroprudential policies implemented during the financial crisis. Using panel smooth transition regression and fixed effect models, this study examined the nonlinear dynamics implications of financial development on economic growth in African emerging markets. The study further sought to test the existence of non-monotonic hypotheses in African emerging economies, as well as to determine the threshold at which the level of finance promotes economic growth. The estimation results strongly support the presence of nonlinearities in the financial–growth relationship in African emerging economies. The study's findings reveal that, depending on the degree of the financial system, there are two extreme regimes that differentiate the impact of financial development on economic growth in the case of African emerging economies.

Firstly, below the threshold of 60.5% as a share of GDP, a lower level of the financial system promotes risk and ineffective resource allocation, which may reduce the rate of savings and risk, resulting in lower economic growth. In this case, more policies aimed at ensuring improvement/financial inclusion and increasing social mobility and investment are significant. Secondly, above the threshold, a high level of financial development is found to improve growth. More specifically, after passing the minimum threshold of 60.5% as a share of GDP, having more financial institutions/systems will ease the exchange of goods and services through the provision of payment services, and the mobilization and pooling of savings from a large number of investors, which then creates job opportunities, ultimately stimulating growth. The findings of this study were shown to be resistant to the technique and control variables applied, since the author achieved the same results utilizing

the fixed effect estimator methods, even when tourism development (TOD) was included in the system. Adopting macroprudential policies, such as financial-institution-targeted instruments aimed at the balance sheets of banks, which influence the provision of credit to the economy, was found to reduce growth in the lower regime, while improving it in the higher regime.

What is interesting in this study is that, when comparing the macroprudential with the non-macroprudential policy regime, the magnitude of financial development was found to have a profound impact on growth during the macroprudential policy. As the study found, in the lower regime the magnitude was 4.64% in the policy regime and 0.88% in the non-policy regime. Furthermore, at a high level of finance, the magnitude was found to be 3.63 and 1.03%. The impact on the non-prudential policy regime was found to be insignificant. It is evident that the adopted macroprudential policy triggered the financial–growth relationship in the African emerging countries.

The study further documents that a surge in investment and trade openness increases the level of economic growth in both macroprudential and non-macroprudential policy regimes. Government expenditure is found to improve the level of growth up to a certain threshold, but beyond that threshold it is found to have a detrimental effect on economic growth.

From a policy perspective, the findings of this study may derive various policy implications. Firstly, the presence of a financial development threshold challenges the effectiveness of policies aimed at improving the financial system to attract investment and technological innovation in African emerging countries.

Secondly, countries that are situated just below the threshold level are encouraged to give the financial sector adequate consideration and proper recognition, such as the provision of appropriate financial reform and also work towards formulating policies that aim to develop a suitable investment portfolio, as well as spending on technological investment in these countries. Improving these activities will create job opportunities, which will boost the well-being of the citizens and thus increase economic growth.

Thirdly, the findings may help policymakers in African emerging economies to be cautious when introducing macroprudential policies. In a nutshell, these policies are growth-driven when the level of the financial system is high beyond the minimum of 60.5% of domestic credit to the private sector as a share of GDP.

The author suggests that future research should focus on a comparative study, where African emerging countries are compared to European or other countries. Conducting a panel smooth transition vector error correction model (VECM) will be a measure contribution. However, this can only be conducted in a bivariate setting. The interesting feature of the latter methodology is a Granger causality test that is conducted in a non-linear framework. Again, because the current study provides the minimum level of financial development required for African countries to improve growth, future studies that aim to find the optimal point for financial growth will be important for understanding how much financial development is required for these countries.

Conflicts of Interest: The author declares no conflict of interest. Additionally, the funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

Appendix A

Table A1. Descriptive Statistics (Dependent and Independent Variables).

Variables	Mean	Std. Dev	Min	Max
Growth	7.448093	1.199798	5.086570	9.487033
DCPS	70.85394	7.92579	28.636358	80.91936
MPIF	0.672004	0.783259	0.000000	6.441176
INFL	7.835168	0.3430	6.04124	11.2325
INV	21.41213	8.053423	2.631579	52.93884
TR	52.13190	15.30813	2.774000	70.77984
TOD	52.13190	15.30813	2.774000	70.77984
G	26.33704	1.259438	24.32601	29.17810

Notes

[1] González et al. (2005) consider that it is sufficient to consider $m = 1$ or $m = 2$, as these values allow for commonly encountered types of variation in the parameters.

[2] The sequence for selecting the order m of the transition function under the $H_0^* : \beta_3^* = \beta_2^* = \beta_1^* = 0$ for selection $m = 3$. If it is rejected, it will continue to test $H_{03}^* : \beta_3^* = 0, H_{02}^* : \beta_2^* = 0 | \beta_3^* = 0$ and $H_{01}^* : \beta_1^* = 0 | \beta_3^* = \beta_2^* = 0$, in selection $m = 2$. If it still fails, $m = 1$ will be selected as default (Teräsvirta 1994; Teräsvirta et al. 2010).

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