Financial development and income inequality: a nonlinear econometric analysis of 21 African countries, 1994-2015

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Abstract

A panel data analysis of financial inequality was conducted using the PSTR model to determine the threshold level at which excessive financial development worsens inequality. The results reveal evidence of a nonlinear effect between financial development and income inequality where the optimal level of financial development is found to be 19% as a share of GDP above which financial development increases inequality in African countries. The findings combine into a U-shape relationship, in line with other research in African studies. In this particular case, policy-makers are challenged to come up with policies that enforce the distributive effects of financial development with a view to share wealth equitably.

Keywords words: Financial development; income inequality; PSTR model

JEL Classifications: O16; O11; E44; C33

1 INTRODUCTION

Over the past decade the financial system in some African countries has experienced massive reforms in a bid to transform the sector from a state-owned

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system to a market-oriented financial one, in order to allow the financial sector to achieve its core mandate of financial intermediation efficiently. The main aim of these reforms was to branch financial development to mobilise more funds, projects and resources, with the best chance of maximisation, thereby supporting economic growth, which in turn would then lead to a reduce in income inequality and poverty. However, in the case of African countries, these financial transformations lead to a high level of inequality.

According to the African Development Bank (AfDB, 2015), African countries experience a massive problem of high inequality. The AfDB (2015) revealed that the richest people in Africa capture the largest stake of income, while the poor are suffering. In addition to a huge gap between the rich and the poor, this also has an adverse impact on the political representatives. For instance, the rich use their wealth to influence the government's policy-making, ensuring that policies are formulated in their favour at the expense of everyone else. Kumar (2014) pointed out that this can lead to an erosion of democratic governance, which could increase social unrest.

The biggest challenge that African countries experience is the problem of rising levels of poverty and income inequality. Demirgüç-Kunt and Klapper (2012) found that an increase in the level of financial development causes the level of income of the poor to reduce, because it accelerates growth and per capita income, which in turn has an adverse effect on income inequality.

There are five working and peer review papers that have investigated the financial-inequality relationship using African data (Batuo *et al.,* 2010; Kai & Hamori, 2009; Asongu, 2011; Tita & Aziakpono, 2016; Jobarteh & Kaya, 2019). These studies focused on testing the hypothesis made by Greenwood and Jovanovic (1990), known as the GJ inverted U-curve. Conversely, these studies partially did not provide empirical evidence of the threshold level between financial development and income inequality. Again, among these African studies, there is the paradox whether the GJ inverted U-shape (Batuo *et al.*, 2010) or the U-shape (Tita & Aziakpono, 2016) explains the financial-inequality relationship in African countries, while some believe in inequality-widening (Jobarteh & Kaya, 2019). The reasons behind these conflicting findings are implausible. Empirically, the feasible explanation for the divergent results in the existing African literature lies in the different model specifications, data sets, estimation techniques or countries that are including in the model in examining the relationship between financial development and income inequality.

This study extends existing African literature on financial development and income inequality following the work of Tita & Aziakpono (2016), investigating the relationship between financial development and income inequality by employing panel of 15 African countries over the period 1985-

2007, using the Augmented Mean Group estimator to determine if there is a threshold level of financial development or income inequality is related to the sectoral structure of the economy. Their findings suggest that the financial-inequality relationship in the sample of African countries studied is non-linear and ranges from an inverted U-shape to a U-shape depending on the measure of financial deployment. In their analysis income inequality was proxied using the Gini coefficient, while financial development was proxied using domestic credit to private sector (% of GDP). The author included trade openness, inflation, GDP per capita as control variables. However, major macroeconomic variable, such as Investment, that directly or indirectly impact the level of income inequality, was not captured in Tita & Aziakpono (2016) model. Furthermore, their study did not provide the threshold point above which financial development increases inequality in African countries. Finding the threshold will be helpful for policy formulation. Besides that, their analysis was based on a small group of African countries.

This paper aims to contribute to the existing sparse literature, due to data constraints, that has focused on African countries, by investigating the financial-inequality relationship in these countries over the period 1994-2015. This is done by testing the GJ inverted U-shape and determining above which level of financial development income inequality is stifled in African countries. As in the existing African literature, no study has managed to provide the threshold level. To investigate the existence of a threshold, the study makes use of the Panel Smooth Transition Regression (PSTR) model developed by Gonzalez *et al.* (2005). However, we will first consider machine learning (ML) using the random forest (RF) method, aiming to find the variable of importance.

The inspiration for this study came not only from a lack of studies examining the non-linear effect of financial development on income inequality, but more generally from the fact that this relationship may differ from the one that exists in the literature, or in advanced countries, due to differences in the smoothness of the economic development and the macro-economic policies that are being practiced. It was found that a nonlinear effect exists between financial development and income inequality, where the optimal levels of financial development are found to be 19% and 19.82% as a share of GDP, above which financial development increases inequality in African countries. Moreover, the data revealed a U-shaped relationship between the two variables, which contradicts the known theories on financial-inequality relationships.

2 REVIEW OF THE LITERARURE

The theoretical foundation of the current study is the G-J hypothesis, developed by Greenwood and Jovanovic (1990). Which postulate that there is an inverted U-shape between financial development and income inequality.

2.1 Theoretical Review

The theoretical perspective of the relationship between financial development and income inequality is categorized into three broad strands of hypotheses. The first strand believes in the GJ inverted U-shape, while the second strand is those who believe in an inequality-widening hypothesis. The last strand believes in an inequality-narrowing hypothesis.

The first strand is the theoretical foundation of an inverted U-curve between financial development and income inequality, that is well- known as the G-J hypothesis, developed by Greenwood and Jovanovic (1990). The G-J inverted U-shape model argues about the two agents in the economy, pointing out that there are investment opportunities for each of these agents. The first agent offers a safe but low return, while the second agent yields high returns, but accompanied by high risks. Both these agents have access to the financial sector. Therefore, the economy experiences a reversal trend of the income gap. Then the financial development may increase income inequality during the early stages of development while, as the average income increases, it tends to reduce the level of income inequality after a certain threshold point.

The second strand is drawn from an inequality-widening hypothesis, based on the theory developed by De-Gregorio (1996). The increase in inequality entertains the view that only the well-connected and the rich benefit from the development of the financial sector, due to the fact that they have connections and collaterals, especially when the development sector is becoming weaker. A similar hypothesis is shown in the Marxist theory, which expounds the fact that financiers are greedy middlemen who serve only the interests of the wealthy upper class and those who are well-connected financially and politically. The life-cycle model, with endogenous growth, assumes that people have to decide during their youth how much time needs to be devoted to education, due to the borrowing restrictions faced by individuals. Thus, financial development increases the level of income inequality, because those with more endowments for learning have a better opportunity to become wealthy professionals and entrepreneurs, due to the fact that financial development allows individuals with financial resources to develop their human capital optimally.

The last strand focuses on the inequality-narrowing theory developed by Galor and Zeira (1993), using a two-sector model, that only agents invest in invisible human-capital works in the skills-intensive sectors. The inequality-narrowing theory states that the more financial development improves, the more it narrows the differences in levels of income, since the poor will get opportunities for financial services. According to this point of view, development does not exclude poor households, since it increases opportunities for the poor to finance their education and entrepreneurship. To be more precise, financial development facilitating easier access to financial support and relaxing financial constraints is more beneficial to the poor than the rich.

2.2 Empirical Review

After scrutinizing the empirical literature on the financial-inequality relationship, we find that a strong paradox emerges among the schools of thought, on which of the three theories, the G-J hypothesis, inequality-narrowing and inequality-broadening, explain the nature of the relationship between the two variables. Furthermore, even among schools of thought investigating the financial-inequality relationship in African countries, two different findings emerge. Some support the nonlinearity hypothesis, while others claim that there is linearity between the two variables. In this section both African and global literature is reviewed.

The first group of studies supports the nonlinear relationship between financial development and income inequality (Matsuyama, 2000; Rehman *et al.,* 2008; Roine *et al.,* 2009; Ang, 2010; Batuo *et al.,* 2010; Kim & Lin, 2011; Tan & Law, 2012; Tita & Aziakpono, 2016; Jobarteh & Kaya, 2019; Destek *et al.*, 2020). After scrutinizing the literature further, we found only five working papers and peer-reviewed papers that focused on the African countries (Batuo *et al.,* 2010; Kai & Hamori, 2009; Asongu, 2013; Tita & Aziakpono, 2016; Jobarteh & Kaya, 2019). Concerning the first group of studies, the study conducted by Matsuyama (2000) investigated the effect of credit-market development - wealth ? distribution on income inequality by looking at the trickle-down effect over time. The model confirmed the nonlinearity between financial development and income inequality and supported the G-J hypothesis. Thus, a conflict emerged when the study by Ang (2010) tested the G-J model using a time series over the period 1951-2014 in India. In order to realise this objective, the author used the ARDL, controlling for trade openness, per capita GDP growth and inflation. Financial development was found to have a good influence on income inequality, and there was no evidence of nonlinearity between the two variables.

A study by Roine *et al.* (2009) examined the relationship between financial development and income inequality using a generalized least squares (GLS) in a panel of 16 OECD countries over the period from 1900 to 2000. The main aim of their study was to examine how changes in the top shares are related to changes in financial development in the long run. Their study focused on three different groups of income earners: the wealthy group (P99-100), the upper middle-class group (P90-99) and the rest of the population which was coded as P0-90, To achieve their main objectives, the authors used capitalisation as the sum of the bank deposits and market-cap to measure financial development, while the following were used as control variables: bank deposits - which are a share of commercial and savings bank deposits in GDP - trade openness, stock market capitalization - which is the market value - and government spending measured by central government expenditure divided by GDP. The authors illustrated that the effects of financial development reduce the level of income inequality by reducing the wages of low-skilled or unskilled labour, while increasing the level of income inequality by increasing the wages of highly skilled labour. Roine *et al.* (2009) and Ang (2010) believe in inequality narrowing.

Looking at the African literature, the study by Batuo *et al.* (2010) tested the existence of the Inverted U-shaped hypothesis, using a panel of data from 22 African countries, from 1990 to 2004, applying the GMM technique. In their study they regressed M2 as a percentage of GDP, domestic private credit to bank sector as a percentage of GDP and liquid liabilities as a percentage of GDP as a proxy for financial development, while primary school enrolment rate as proxy of human capital development, inflation and per capita GDP level were used as control variables. Their main objective was to test whether the relationship between the two variables is linear or nonlinear. The results confirmed the existence of a nonlinear relationship between financial development and income inequality, thus supporting the G-J hypothesis. Tan and Law (2012) studied the nonlinear dynamics of the finance-inequality nexus in developing countries using dynamic panel GMM estimation. The author regressed two measures of financial development: the banking sector development indicator, which contains the liquid liabilities and private sector credit, where private credit is defined as the value of financial intermediary credit to the private sector. The other measure of financial development comprises stock-market development indicators, total share value traded and stock market capitalization. The income inequality was measured using the Gini coefficients, while the author controlled for inflation, real GDP and corruption. The finding further supports the argument of the nonlinear relationship between the variables, where a U-shape relationship was found to narrow down the income-inequality gap during the early stage of financial development of the countries. The financial inequality was further investigated by Tita and Aziakpono (2016) using the panel data of 15 African countries and the Augmented Mean Group (AMG) estimator, for the period 1985 to 2007. In examining the financial-inequality relationship, they regressed the Gini coefficient sourced from the SWIID to proxy income inequality, while bank deposits to GDP and domestic credit to GDP were used as a proxy for financial development. They also used GDP per capita to proxy economic development in order to find out whether financial inequality depends on the level of economic development. Government spending to GDP, primary enrolment as a proxy of HDI, inflation and trade openness were regressed as control variables. Their main objective was to examine whether financial development reduces or improves income inequality and to find out whether the relationship between the two variables depends on the level of financial development or the level of economic development. The empirical finding contradicts the existence of the inverted U-shape in African countries. As a result, the data yielded a U-shape relationship between the two variables.

Moreover, the latest empirical evidence was drawn from the study by Jobarteh and Kaya (2019) in the case of 23 African countries over the 1990-2014 period, using the GMM system. In their study the Gini coefficient as a measure of income inequality was used as a dependent variable, while they used overall financial development to measure financial development. They further regressed GDP per capita, human capital, inflation and agriculture as control variables. Their main objective was to test the existence of the nonlinearity between finance development and income inequality. The findings reveal the rejection of the nonlinearity between financial-inequality relationships, by supporting inequality widening. The more recent paper by Destek *et al.* (2020) studied the relationship between financial development and income inequality in Turkey using the autoregressive distributed lag (ARDL) approach over the period 1990-2015. In their studies they regressed Gini coefficient income as a proxy of inequality. They used principal component analysis in constructing the financial development index, using three sets of financial measures: liquid liabilities to GDP and private credit by deposit money banks to GDP, stock market capitalization to GDP and stock market turnover ratio and financial system deposit to GDP, while real GDP per capita, CPI and government expenditure were regressed as control variables. The results indicated an inverted U-shape with regard to financial inequality in the case of Turkey.

The second group supported the inequality-narrowing hypothesis (Galor & Zeira, 1993; Banerjee & Newman, 1993; Mookherjee & Ray, 2003; Beck *et al.,* 2007). The second study relied on the inequality-narrowing hypothesis as was first imitated by Galor and Zeira (1993), and then by Banerjee and Newman (1993) who constructed a three-sector model, which allows two sets of technology-indivisible investments. These indivisible, high-return technologies could not be run by the poor because of capital market imperfections. These capital market imperfections resulted in a long-run impact on income inequality, driven by wealth distribution.

Similar work is drawn from Jauch and Watzka (2016) who investigated the financial-inequality relationship using a panel-data approach in unbalanced data for 138 emerging and advanced countries over the period 1960-2008. The author used credit to GDP as a measure of financial development, while the Gini coefficient was used as a proxy for income inequality. Inflation rates, agriculture, government expenditure and GDP per capita were regressed as control variables. The result confirmed that financial development is positively related to income inequality. The recent study by Jung and Cha (2020) emerged with a strong contradiction according to which they believe that financial deepening plays no role in reducing inequality. Jung and Cha (2020) investigated the financial-inequality relationship in China using a GMM system over a time span from1998-2014. Their main argument was to test whether financial deepening reduces inequality in the long run at a provincial level. The author regressed financial intermediation/GDP as a measure of financial development, while the Gini coefficient was used as a proxy for income inequality. Moreover, deposit/GDP, loan/GDP, education attainment and trade openness were regressed as control variables. The findings revealed that financial deepening cannot reduces inequality. Instead, it makes the inequality worse.

While the last group is drawn from the study by Mookherjee and Ray (2003) and Hamori and Hashiguchi (2012) who believe in the inequality-broadening hypothesis, the study was taken further by Hamori and Hashiguchi (2012), who examined the effect of deepening on inequality in an unbalanced panel of 126 countries over the period 1963-2020. In their studies they regressed income inequality as dependent variable, while they used M2-to-GDP ratio measured by money and quasi money (M2) as percentage of GDP, and credit-to-GDP measured by domestic credit to private sector as a percentage of GDP to account for financial development. In addition, they used trade openness, GDP per capita and inflation rate as control variables. Their findings support the argument that financial deepening reduces inequality. The studies by Mookherjee and Ray (2003) and Hamori and Hashiguchi (2012) further the argument by stating that human capital accumulation produces pecuniary externalities across the professions, while capital markets are imperfect. Then, persistence in consumption and inequality in utility is unavoidable at the steady state level and therefore, low inequality in equilibrium income will be driven by low inequality in initial wealth distribution.

What can be noted across these studies is that no empirical evidence has provided the threshold level beyond which financial development stifles income inequality in African countries. Therefore, this study aims to contribute to the body of knowledge by empirically providing the threshold level of financial development.

3 RESEARCH METHODS

This study aims to examine the nonlinear effect of financial development on income inequality in African countries over the 1994-2015 period, with an aim to finding the threshold below which the relationship is positive and above which it is negative. These aims were accomplished by using the PSTR model, because of its advantage in addressing the nonlinear problems.

3.1 Panel Smooth Transition Regression (PSTR) Model

To evaluate the nonlinear relationship between financial development and income inequality, the PSTR model developed by González *et al.* (2005) was used. The simplest case of the PSTR model, with two extreme regimes in single transition, functions in illustrating the threshold effect of financial development (FD_{it},) on income inequality ($INEQ_{it}$):

$$y_{it} = \mu_i + \lambda_t + \beta_0^{'} x_{it} + \beta_1^{'} x_{it} g(FD_{it}, \gamma, C) + \epsilon_{it} \quad (1)$$

where y_{it} is a dependent variable which is scalar, then $i = 1, \ldots, N$,and $t = 1, \ldots, T$ indicating a cross-section and the time dimensions of the panel, respectively, where λ_t and μ_i signify the time-effect and fixed individual effect, respectively, and ϵ_{it}denotes the errors term. Hence, a k-dimensional vector of time-varying exogenous-variables FD is denoted by x_{it} and thus the transition function $g(FD_{it}; \gamma, c)$ is a continuous function and depends on the threshold variable FD_{it}, normalized to be bounded between 0 and 1. These extreme values are associated with regression coefficients $\beta 0$ and $\beta 0 + \beta 1$.

More generally, the value of the transition variable FD_{it} determines the value of $g(FD_{it}; \gamma, c)$ and thus the effective regression coefficients $g(FD_{it}; \gamma, c)$ for individual i at time t, as in Teräsvirta (1994) and Teräsvirta *et al.* (2010), by using the logistic specification:

$$\begin{aligned} (FD_{ti}; \gamma, c) &= (1 + exp?(-\gamma \prod_{j=1}^{m} (FD_{it} - cj)))^{-1} \quad (2) \\ \text{with } \gamma &> 0 \; and \; c_1 \leq c_2 \leq \ldots c_m \end{aligned}$$

In (2), $c_j = (c_1, \ldots, c_m)$', which is an m dimensional vector of parameters location, 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, $m = 1 orm = 2$ is usually considered to be values that allow the commonly-encountered types of variation in the parameters. The model suggests that both extreme regimes are related, with high and low values of FD_{it} for $m = 1$, from $\beta_0 + \beta_0 + \beta_1$ as a monotonic transition of the coefficient, when FD_{it} is increasing, where the alteration is fixed around c_1.

When $g(FD_{it}; \gamma, c)$ becomes a pointer function $I[FD_{it} > c_1]$, $\gamma \to \infty$, as demarcated by $I[A] = 1$, then A takes place and 0 otherwise. In this case, the STAR proposed by Hansen (1999) is reduced in the PSTR model by the two regime panel thresholds in (1). The model falls into a homogenous or linear panel-regression model with fixed effects. The PSTR model will then be generalized in order to allow more than two different regimes in the additive model:

$$y_{it} = \mu_i + \lambda_t + \beta 0 x_{it} + \sum_{j=1}^{r} \beta_j' x_{it} g_j(FD_{it}^{(j)}; \gamma_j, c_j) + \epsilon_{it} \tag{3}$$

The transformation $g_j(FD_{it}^{(j)}; \gamma_j, c_j), j = 1, \ldots r$ simply defined by (2) with polynomial degrees m_j. When $m_j = 1, FD_{it}^{(j)} = FD_{pit}$ and $\gamma_j \to \infty$, when $j = 1, \ldots r$ then (3) falls to the PSTR model with $r + 1$ regimes. This becomes helpful for the test of no remaining nonlinearity (NRN) and time varying.

3.2 Model Specification Test: Testing Homogeneity

In the PSTR model, the specification stage in the modelling cycle consists of testing the homogeneity against the PSTR. The homogeneity test is helpful in identifying the appropriate transition variable FD_{it} in a set of candidate's transition variables that strongly reject the H_0 of the linearity. The sequence for selecting the order m of the transition function under $H_0^* : \beta_3^* = \beta_2^* = \beta_1^* = 0$ for selecting $m = 3$, if it is rejected, 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).

Testing homogeneity against the PSTR is important for two reasons. Firstly, if there is a statistical issue, specifically, the PSTR model does not identify whether the data-generating process is homogeneous and, to evade the estimation of unidentified models, homogeneity has to be tested in the first stage. Secondly, a homogeneity test may be useful for testing propositions from economic theory. By imposing either $H_0 : \gamma = 0$ or $H_0^{'} : \beta_1 = 0$, the PSTR model in (1) and (2) is reduced to a homogenous model. In testing the homogeneity, $H_0 : \gamma = 0$ is used, where $g(FD_{it}; \gamma, c)$ is imposed in avoiding the identification problem in (1) by its first-order Taylor development around$\gamma = 0$. After reparameterisation, this leads to the auxiliary regression:

$$y_{it} = \mu_i + \beta_0^{'} x_{it} + \beta_1^{'} x_{it} FD_{it} + \ldots + \beta_m^{'} x_{it} FD_{it}^m + u_{it}^* \quad (4)$$

where $(\beta_1^*, \ldots, \beta_m^*)$ are the parameter vectors that are multiples of γ and $u_{it}^* = u_{it}^* + R_m \beta_1^{'} x_{it}$, where R_m is the remainder of Taylor-expansions. Thus, testing the $H_0^* : \beta_1^* = \ldots, = \beta_m^* = 0$ in (3) is equivalent to testing H_0 in (1). The H_0 will be tested using the Lagrange Multiplier-Wald test and the Lagrange Multiplier-Fischer test, since both are for testing the linearity within the PSTR model. Hence, the Taylor series estimate does not touch the asymptotic-distribution theory when the H_0 is verified by an LM-test, due to that under the $H_0 \{u_{it}^*\} = u_{it}^*\}$. The LM-type statistic can be defined by writing (3) in a matrix-notation as follows:

$$y = D_\mu \mu + X\beta + W\beta^* + u^* \quad (5)$$

where $y = (y_1^{'}, .., y_N^{'})$ with $y_i = (y_{i1}^{'}, .., y_{iT}^{'})$, $i = 1, \ldots, N, D_\mu = (I_N \otimes i_T)$ where I_N is the $(N \times N)$ identity-matrix, i_T a $(T \times 1)$ vector of ones, and $\mu = (\mu_1, \ldots, \mu_N)$. Besides $X = (X_1^{'}, \ldots, X_N^{'})$, where $X_i = (x_{i1}, \ldots, x_{iT})$, where $W = (W_1^{'}, \ldots, W_N^{'})$ with $W_i = (w_{i1}, \ldots, w_{iT})$, and $w_{it}(x_{it}^{'} FD_{i1}, \ldots, x_{it}^{'} FD_{it}^m)$, $\beta = \beta_0^* \; and \; \beta^* = (\beta_1^{'}, \ldots, \beta_m^{'})$. Lastly $u^* = (u_1^{'}, \ldots, u_N^{'})$.

The LM test statistic takes the following form:

$$LM_\chi = u^{0'} W \Sigma^{-1} \check{W} u^0 \quad (6)$$

Estimating the model under the H_0, where $\hat{u}^0 = (\hat{u}_1^{0'}, \ldots, \hat{u}_N^{0'})$, it yields the vector of residuals and the standard within the transformation matrix becomes $M_\mu = I_{NT} - D_\mu (D_\mu D_\mu)^{-1} D_\mu$ where$\bar{W} = M_\mu W$. In addition, $\hat{\Sigma}$ is a reliable estimator of the covariance matrix $\Sigma = (\hat{\beta}^* - \beta^*)(\hat{\beta}^* - \beta^*)$, where the errors are identically distributed across time-individuals and are homoscedastic, the standard covariance-matrix estimator takes this form:

$$\Sigma^{HAC} = [-\tilde{W}' \check{X} (\check{X}' \check{X}')^{-1} : I_{km}] \hat{\Delta} [-\tilde{W}' \check{X} (\check{X}' \check{X})^{-1} : I_{km}]^{'} \quad (7)$$

where I_{km} is $(km \times km)$ identity-matrix, and $\hat{\Delta} = \sum_{i=1}^{N} \tilde{Z}_i' \hat{u}_1^{0'} \hat{u}_N^{0'} Z_i$, with $\tilde{Z}_i = I_T - i_T (i_T^{'} i_T)^{-1} i_T^{'}) Z_i$, where $Z_i = [W_i, W_i], i = 1, \ldots, N$ the estimator in

(8) becomes consistent for a fixed T as $N \to \infty$, as it is clarified in Arellano (1987) and Hansen (2007). For an analysis of the remaining cases in which T is $N, T \to \infty$, with a fixed N. LM_χ becomes asymptotically distributed as $\chi^2(mk)$, under the H_0, where the F-version $LM_F = LM_\chi(TN - N - l - mk)/(TNmk)$ has an estimated $F(mk, TN - N - k - mk)$ distribution.

3.3 Model Evaluation

Model evaluation in the PSTR is an important part of the model-building procedure. In this paper, two misspecification tests were considered. The first one is that of the parameter of constancy (PC) over time and of NRH in the model, as developed by Eitrheim and Teräsvirta (1996), for univariate STAR models to fit the present panel framework.

3.3.1 *Testing Parameter Constancy*

In equation (1) is set for PC in the sense that variables change smoothly over time. Therefore, the alternative model may be called a time-varying panel smooth transition regression (TV-PSTR) model as follows:

$$\begin{aligned} y_{it} &= \mu_i + (\beta_{10}^{'} x_{it} + \beta_{11}^{'} x_{it} g(FD_{it}; \gamma_1, c_1)) + f(\frac{t}{T}; \gamma_2, c_2) \\ &\quad (\beta_{20}^{'} x_{it} + \beta_{21}^{'} x_{it} g(FD_{it}; \gamma_1, c_1)) + u_{it} \end{aligned} \tag{8}$$

The TV-PSTR model accommodates various alternatives to PC, depending on the definition of $f(\frac{t}{T}; \gamma_2, c_2)$. This function is assumed to have the form:

$$f(\frac{t}{T}; \gamma_2, c_2) = (1 + exp(-\gamma_2 \coprod_{j=1}^{h} (\frac{t}{T} - c_{2j}))^{-1}) \tag{9}$$

where $c_2 = (c_{21}, \ldots, c_{2h})'$ is an $h-$dimensional vector of location parameters, with $c_{21} < c_{22} < \ldots < c_{2h}, \, and \, \gamma_2 > 0$ being the slope parameters. This collapse to (10) is in order to be able to use an LM-type test for parameter constancy,

$$\begin{aligned} y_{it} = \mu_i + \beta_{10}^{*'} x_{it} + \beta_1^{*'} x_{it} (\frac{t}{T})' + \beta_2^{*'} x_{it} (\frac{t}{T})^2 \\ + \ldots + \beta_h^{*'} x_{it} (\frac{t}{T})^h + (\beta_{11}^{*'} x_{it} + \beta_{h+1}^{*'} x_{it} (\frac{t}{T})^2 \\ + \ldots + \beta_{2h}^{*} x_{it} (\frac{t}{T})^h) g(FD_{it}; \gamma_1, c_1) + u_{it} \end{aligned} \tag{10}$$

where $u_{it}^{*}=u_{it}+R_h(\frac{t}{T};\gamma_2,c_2)$ and $R_h(\frac{t}{T};\gamma_2,c_2)$ is the remainder term. In (15), the parameter vectors β_j^{*} for $j=1.2,\ldots,h,h+1,\ldots 2h$ are multiples of γ_2, such that the H_0 in (12) can be reformulated as $H_0^{*}:\beta_j^{*}=0$ for $j=1.2,\ldots,h,h{+}1,\ldots 2h$ in the auxiliary regression. Under $H_0^{*}\{u_{it}^{*}\}=\{u_{it}\}$, the Taylor series approximation does not affect the asymptotic distribution theory. The χ^2- and F-versions of the LM-type test can be computed as in (6) in defining $w_{it}^{'}=(x_{it}^{'}x_{it}^{'}g(FD_{it};\gamma_1,c_1))\otimes s_t^{\prime}\ with\ s_t=((\frac{t}{T}),\ldots,(\frac{t}{T}))^{h})^{\prime}$ and replacing $\bar{X}$ in (7) and (8) by$\bar{V}=M_\mu V$,where $V=V_1^{'},\ldots,V_N^{'}$ where $u_{it}=(x_{it}^{'}x_{it}^{'}g(FD_{it};\gamma_1,c_1),\left(\partial\frac{\hat{g}}{\partial\gamma_1}\right)x_{it}^{'}\hat{\beta}_2,\left(\partial\frac{\hat{g}c_1}{\partial}\right)x_{it}^{'}\hat{\beta}_2)^{\prime},$. Under the H_0,LM_χ is asymptotically distributed as $\chi^2(2hk,)$ and $\frac{LM_F=LM_\chi}{2hk}$ is approximately distributed as $F(2hk,TN-N-2K(h+1)-(m+1))$.

3.3.2 *Test of the Hypothesis of No Remaining Heterogeneity and Time Varying*

The assumption that a two-regime PSTR model (1) with (2), adequately captures the heterogeneity in a panel data set, can be tested in various ways. In the PSTR framework, it is a natural idea to consider an additive PSTR model with two transitions ($r=2$) as an alternative. Thus,

$$\begin{aligned} y_{it} &= \mu_i+\beta_0^{\prime *}x_{it}+\beta_1^{\prime *}x_{it}g_1(FD_{it}^{(1)};\gamma_1,c_1) \\ &\quad +\beta_2^{\prime *}x_{it}g_2(FD_{it}^{(2)};\gamma_2,c_2)+u_{it}^{*} \end{aligned} \tag{11}$$

where the transition variables $FD_{it}^{(1)}$ and $FD_{itit}^{(2)}$ can be, but need not be, the same. Then H_0 of no remaining heterogeneity in an estimated two-regime PSTR model will be formulated as $H_0:\gamma_2=0$ in (7). This testing procedure has its own problems, due to the presence of unidentified nuisance parameters under H_0. The identification problem would be terminated by replacing $g_2(FD_{it}^{(2)};\gamma_2,c_2)$ by a Taylor expansion around $\gamma_2=2$. This leads to the auxiliary regression

$$\begin{aligned} y_{it} &= \mu_i+\beta_0^{*'}x_{it}+\beta_1^{*\prime}x_{it}g_1(FD_{it}^{(1)};\hat{y}_1,\hat{c}_1) \\ &+\beta_2^{\prime *}x_{it}FD_{it}^{(2)}+\ldots+\beta_{2m}^{*'}x_{it}FD_{it}^{(2)m}+u_{it}^{*} \end{aligned} \tag{12}$$

where $\hat{y}_1$and $\hat{c}$ are estimates under H_0. Thus, since $\beta_{21}^{*},\ldots,\beta_{2m}^{*}$ are multiples of γ_2 , the hypothesis of no remaining heterogeneity can be restated as $H_0^{*}:\beta_{21}^{*},\ldots,\beta_{2m}^{*}=0$, if $\beta_1\equiv 0$ in (17), and the resulting test collapses into the homogeneity test. In order to compute the LM-type test statistic defined in (7) and its F-version, by setting $w_{it}=x_{it}^{'}FD_{it}^{(2)}+$

$\ldots + x_{it}^{'}FD_{it}^{(2)m}\prime$ and by replacing $\bar{X}$ in (7) and (8) with $\bar{V}$, where in this case $u_{it} = (x_{it}^{'}x_{it}^{'}g, (FD_{it}^{(1)}; y_1, c_1)(\partial\frac{\hat{g}}{\partial\gamma})x_{it}^{'}\hat{\beta}_1, (\partial\frac{\hat{g}c_1}{\partial})x_{it}^{'}\beta_1)'$, when H_0^* holds, the LM_χ statistic has an asymptotic $\chi^2(mk,)$ distribution, whereas LMF has an approximate $F(2hk, TN - N - 2K(h+1) - (m+1))$ distribution.

3.4 Variables of the Study

The study adopted variables which were suggested in theory, as well as in the empirical literature, as the variables that explain the relationship between financial development and inequality. Income inequality (measured by the Gini coefficient) (INEQ) was used as dependent variable, with financial development (measured by private credit, which is a claim on the private sector by financial intermediaries) (FD) as a variable of interest and, for robustness, the credit sector as a share of GDP. Control variables were the consumer price index (CPI) as proxy of inflation, trade openness (OPEN) and real GDP per (GDPPC). The data source was SWIID (Solt, 2014 and WDI, 2018).

4 EMPIRICAL FINDINGS

4.1 Random Forest

The aim of the FR in this study is a prediction of the model specification that would allow the researcher to find out how the variables will be ordered in the PSTR model, by finding the variable that has a strong influence on inequality. Therefore, Figure 1 contains the results of variable importance. The FR shows that the total variables used in this study explain 80.55 per cent of the variation to income inequality.

The first graph denoted by [A] reveals the mean decrease accuracy ("%incMSE"), which tests how much worse the model performs without each variable. The second graph represented by [B] reveals the nodes (IncNodePurity) which aim to measure how pure the nodes are at the end of the tree without each variable. In graph [A], GGFCE and OPEN show that, if these are excluded while making the trees, the model would be inaccurate due to the high level of significance they contribute, which is 30.89 and 23.55 per cent, respectively. Thus, GDPPC becomes the third contributor, followed by DF1 with 20.09 and 18.08 percent accuracy, respectively. Lastly, Infl contributes about 2 per cent to the accuracy.

Graph [B] shows that, if GGFCE is removed, the mean decreases since this variable contributes 33 per cent to the dependent variable, followed by FD1, GDPPC, OPEN and Infl with 26, 17, 14 and 9 per cent, respectively.

Machine learning (ML) causes GGFCE to have a robust influence on income inequality, followed by OPEN, GDPPC, FD1 and Infl. This signifies that the PSTR will be estimated following this order, but will also rely on the variable selected as a transition variable.

4.2 Testing for the Appropriate Transition m Variable in the PSTR Model

The linearity test was used to identify the appropriate transition variable among the set of variables used as candidates in this study (González *et al.*, 2005). Table 2 presents LM-type tests of homogeneity, as well as the corresponding P-values (P-v) in the panel regression of growth inequality and other explanatory variables.

The LM-type test, based on the asymptotic χ^2distributions and their$F$ versions for both the LM_X-test and LM_F -test, signify FD as the most suitable choice of transition variable for this study, due to the P-v of 2.353e-15 and 1.515e-14, which is smaller than all other sets of variables included as candidates in this test. The results of the HAC version are quite informative. After identifying the right transition variable among a set of variables, we tested the H_0 of the linearity using the DF.

4.3 Linearity Result against the PSTR Model

One of the aims of this study was to find the nonlinearity between financial development and income inequality in African countries as it is hypothesised by the G-J theory. Moreover, the linearity test is important for two reasons, being statistical and economic reasons. The linearity was tested as explained in the methodology section 3.2.

We used the LM_W and LM_F-tests in (4) to test the H_0 of linearity between financial development and income inequality in African countries. In addition, we make use of the wild bootstrap (WB) and wild cluster bootstrap (WCB) proposed by Cameron *et al.* (2011) as robustness checks of the linearity. The WB aims to evaluate the $H_0$of no time-varying parameters (TVP), while the WCB was developed to test the H_0 of NRN in the model.

Table 2 shows that there is a nonlinearity between FD (financial development) and income inequality, due to the P-v of both being $LM_\chi$and LM_F . This signifies the rejection of the H_0 of linearity, since there are 2.353e-17 and 1.515e-14, respectively. Moreover, the WB and WCB signify that TVP and NRN exist. Thus, the LM-type test confirmed that nonlinearity does indeed exist between the two variables in African countries. Our findings confirmed what has been reported by other researchers (Aydin & Odabasioglu. 2017; Asghari & Heidari, 2016). The producer of the estimation proceeds to the test for selecting the order m of the transition variable.

4.4 Sequence for Selecting the Order m of the Transition Function

The homogeneity test was also used as a sequence for choosing order m amongst $m = 1 - 3$ as it was proposed by Granger and Teräsvirta (1993) and Teräsvirta (1994). For the testing procedure behind testing the order m, please refer to section 3.2 in the methodology. The results of the sequence of homogeneity tests are reported in table 3.

The results failed to reject the H_0 for all levels of m. Since the test failed to reject the H_0, we applied the simple rule as explained by Teräsvirta (1994) in selecting $m = 1$ as the best choice when FD is used as the transition variable. However, this rule will be evaluated using WB and WCB. The sequence of homogeneity test for selecting the order m shows that in Africa financial development and the income inequality relationship is explained by one transition, which separates the lower and high regime. Then, after passing all of the tests of the PSTR, we continue with the estimation of the PSTR model.

4.5 Empirical Results of the PSTR

Then, after finding the sequence order$m$, we estimated the PSTR model as follows:

$$\begin{gathered} INEQ_{it} = \mu_i + \lambda_t + \beta_{01} FD_{it} + \beta_{02} GGFCE_{it} + \beta_{03} OPEN_{it} \\ + \beta_{04} GDPPC_{it} + \beta_{05} Infl_{it} (\beta_{11} FD_{it} + \beta_{12} GGFCE_{it} \\ + + \beta_{13} OPEN_{it} + \beta_{14} GDPPC_{it} + \beta_{15} Infl_{it}) g(FD_{it}; \gamma, c) \\ + u_{it} \end{gathered} \tag{13}$$

where the time-fixed effect is denoted by λ_i

$$(FD_{it}; \gamma, c) = (1 + exp(-\gamma((FD_{it} - cj)))^{-1} \text{ with } \gamma > 0 \tag{14}$$

Before analysing the estimated results in detail, it was crucial to test the adequacy of a two-regime PSTR model by applying the misspecification test of the PC and of NRN in (13), to detect whether the estimated model with one transition is adequate or not. Moreover, this test again aims to validate whether the selected order m is the best choice for the study. The following section provides the result of the model evaluation.

4.5.1 *Model evaluation*

Evaluation of the estimated PSTR model is an essential part of the model building procedure. The author considered two different types of misspecification tests for different purposes. The tests were adopted specifically for PC over time and for NRH (Eitrheim & Teräsvirta, 1996). The test of NRH was also used as a misspecification test for determining whether the adequacy of the two-region is appropriate for the PSTR model. Table 4 presents the results of the PC and NRH.

The results of both WCB and WB take both the possible within cluster dependence and heteroskedasticity into account, signifying that the estimated model is adequate with two regimes or one transition.

4.5.2 *Interpretation results of the (PSTR) model*

Table 4 presents the estimated results of the PSTR model. In facilitating the interpretation, the estimates of β_{0j} and $\beta_{0j} + \beta_{1j}$, for $j = 1, \ldots 5$, correspond to a regression coefficient in the regimes associated with $g(FD_{it}; \gamma, c)$ bounded by zero and one respectively. Hence, the coefficients β_{0j} and $\beta_{0j} + \beta_{1j}$, simply represent the low and high regimes. The estimated slope parameter ? is projected to be 5,53, simply supporting the smoothness of FD from the low regime to the high regime. Moreover, the estimated threshold point C, where it distinguishes the low regime from the high regime, is projected to be 19% as a share of GDP.

Figure 2 graphically demonstrates those countries of which the values are below, close to and above the estimated threshold, compared to the countries' calculated mean private credit as a percentage of GDP. As depicted, out of all the selected African countries, South Africa is above the threshold with a mean of 165% as a share of GDP; while the rest are below, with some being really low at the lower tail of the GJ U-shape (Botswana). Mauritius is second, above the threshold point with a mean of 91% as a share of GDP. Moreover, South Africa is one of the selected African countries that has the highest level of financial development, yet suffers high levels of inequality and unemployment rates.

In contrast, Botswana has a negative mean of about 22% of financial development as a share of GDP, with high levels of inequality. Botswana needs to focus more on their policies that will improve the level of financial development in order to reduce the level of inequality. On the contrary, other

African countries' reviews (with the exception of Botswana, Mauritius and South Africa) confirm the narrowing inequality hypothesis - meaning that financial development reduces inequality.

Table 5 presents the estimated results of the two-regime PSTR model, where the standard errors in brackets are obtained by using the cluster-robust and heteroskedasticity-consistent covariance estimator, allowing for error dependency within individual countries.

Model 1 shows that financial development (FD) has a negative and statistically significant impact on income inequality when the level of financial development is low, while in the high regime above the threshold, it possesses a positive and statistically significant impact on income inequality. The negative impact of financial development on income inequality supports the inequality-narrowing hypothesis (Beck *et al.,* 2007, Clarke *et al.*, 2013; Jauch & Watzka, 2016), while the positive relationship supports the inequality-broadening hypothesis (Mookherjee & Ray, 2003; Hamori & Hashiguchi, 2012). Therefore, the findings of the study contradict the G-J inverted U-curve theory in supporting the empirical literature that believes in the U-shape relationship between financial development and income inequality (Jauch & Watzka, 2012; Tan & Law, 2012; Tita & Aziakpono, 2016; Park & Shin, 2017). These studies investigated the nonlinear relationship, using both the balance and unbalance data in emerging and advanced countries. In addition, the findings support the empirical findings reported by Tita and Aziakpono (2016), using African data.

The possible logic behind the negative relationships between financial development and income inequality in African countries could be financial market imperfections resulting in limited competition and restrictive access. The empirical finding shows that, the more financial development improves, the more it narrows the level of income, since inequality narrowing is believed to open doors for the poor to get access to financial services. Therefore, this results in an inequality-narrowing hypothesis. The inequality-narrowing hypothesis argues that the impact accrues in the presence of an imperfect credit-market, as well as indivisibilities in human capital (investment). Thus, an improvement in the credit market, due to an expansion in the number of agents of the economy, unlocks more sufficient funds to invest in human capital. Hence, an increase in capital investment automatically reduces the level of income inequality.

The possible logic behind a positive relationship between the two variables results in an inequality-widening hypothesis. This hypothesis is based on a viewpoint of De-Gregorio (1996). Financial development widens income discrepancies by benefiting the rich at the expense of the poor. This happens when institutions are feeble, and financial systems channel money to the upper class, as well as to those who are well-connected, who will be able to offer collateral and who will in all possibility repay the loan. Therefore, as the financial sector progresses, the poor will be neglected with regard to loans because they are unable to provide collateral, and then the upper class will continue to benefit from the financial sector. The development of the financial sector is also unable to stop the migration of the poor from rural to urban areas. Furthermore, it is unable to support the poor in starting new businesses and investing in education. The current propensity might be reinforced if the rich are able to prevent new firms from getting access to finance, and reduce the ability of the poor to improve their economic lot. Thus both inequality-narrowing and inequality-widening combine the U-shape relationship between financial development and income inequality.

GGFCE emerges with a positive impact on income inequality in both low regimes. However, in the high regime it becomes statistically insignificant. The findings support the argument made by Ryo *et al.* (2005) that a shift relies on capital-intensive technology, with the aim of increasing production due to an increase in the level of financial infrastructure, pushing up the level of income inequality. OPEN has a negative and statistically significant impact on income inequality in the low regime, while in the high regime above the threshold point OPEN, it has a positive and statistically significant impact on income inequality. Similar findings were reported by Fukuda (2017). Fundamentally, GDPPC has a negative and statistically significant impact on income inequality when the level of GDPPC is low, while it has a positive and statistically significant impact on income inequality when the level of GDPPC is high above the threshold point. The results of this study support the empirical findings reported by Wahiba and Weriemmi (2014) and Jauch and Watzka (2016). Inflation has a positive impact on income inequality in both regimes; however, in the low regime it statistically insignificant. The argument is that the upper-class households have more access to financial instruments that can hedge the exposure to inflation, while the poor have limited access to such instruments and instead hold more cash (Erosa & Ventura, 2002; Hamori &Hashiguchi, 2012). Similar conclusions were drawn by Chen and Kinkyo (2016).

In model 2, we adopted the Gini coefficient after personal taxes and transfer payments as a proxy of income inequality. The finding reveals that the relationship between financial development and income inequality does not vary with the variables used to measure income inequality. The findings confirmed a U-shape relationship between the two variables. OPEN becomes statistically insignificant in both regimes in model 2, while the rest of the variables remain unchanged.

4.6 Sensitivity Analysis

The study adopted domestic credit to private sector as a share of GDP to measure financial development, since this variable is probably the most important banking development measure, because it reflects the extent to which firms have the opportunity to obtain bank finance. According to Rajan and Zingales (2003b) private credit contains the information where entrepreneurs or companies with sound projects can obtain finance. The main aim in adopting this variable is to trace whether financial inequality depends on the variable used to measure financial development.

All the testing procedures of the PSTR were followed. The estimated threshold level, where it separate the lower level of FD associated with the higher level of FD, is projected to be 19.50% as a share of GDP. The threshold is similar to the one reported in models 1 and 2. Equation 15 provides the result whereby domestic credit to private sector as a share of GDP is adopted to measure financial development.

$$
\begin{gathered}
GINI_{it} = \mu_i + \lambda_i - 0.21FD2^{***} - 0.06GGFCE^{**} \\
+0.39OPEN^{**} - 0.41GDPPC - 0.001Infl^{**}(0.07FD2^{**} \\
+0.18GGFCE - 2.23OPEN^{**} + 0.19GDPPC^{**} \\
+0.09Infl^{**})g[FD2; 9.34^{***}_{\gamma}, 19.50^{***}_{C}]
\end{gathered}
$$

The results in equation 15 support the U-shape relationship between financial development and income inequality. The GDPPPC, GGFCE, OPEN and Infl seem to vary with the variable used to measure financial development.

5 CONCLUSION AND POLICY RECOMMENDATIONS

The study aimed to test three hypotheses related to financial inequality relationships in African countries: (i) Testing the existence of the nonlinearity between financial inequality and income inequality, (ii) finding the threshold level where excessive financial development worsens income inequality, and (iii) testing the validity of the GJ inverted U-curve in African countries. The objectives of the study followed the GJ inverted U-shape hypothesis developed by Greenwood and Jovanovic (1990). This was achieved by the use of the PSTR model.

The study reveals the negative effect on inequality in the low regime and positive effect in the high regime. Therefore, the study concludes that financial development has a U-shape effect on income inequality in African countries (Tan & Law, 2012; Jauch & Watzka, 2012; Tita & Aziakpono, 2016; Park & Shin, 2017). Consequently, the findings of this study arrive at the same findings as reported by these studies. The economic reason for the U-shape is based on inequality narrowing, believing that more financial access opens doors for the poor to get financial services to uplift their human capital and inequality widening, believing that more financial development lowers the level of income, which then allows certain individuals with different endowments to develop.

Secondly, based on the findings, the estimated threshold point that separates the low and high regimes is projected to be 19%, and 19.82% as a share of GDP. This shows that, once the level of financial development surpasses this level, financial development improves inequality. Moreover, the findings confirmed that the impact of financial development on inequality varies with countries. For example, some African countries such as South Africa and Mauritius show no causal link between financial development and inequality.

Policy implications are that the study suggests that countries below the threshold level need to expand their level of financial development by making their banking system accessible to the poor in order to reduce the level of inequality. In addition, more attention is needed in Botswana, due to the fact that their mean financial development is far less than zero (-22% as a share of GDP), while SA and Mauritius need to be cautious of excessive financial development, since that is no longer helpful in reducing inequality.

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Table 1: Result of Selecting the Transition Variable

m	Transition variable FDI1			
	LM_{χ}		LM_F	
	$test$	P-v	$test$	P-v
1	**70.02**	**2.353e-15**	**7.96**	**1.515e-14**
2	20.05	8.016e-10	5.73	2.082e-09
3	11.40	6.994e-05	6.14	9.903e-11

Source: Author's calculation based on SWIID data (Solt, 2014 and WDI, 2018).

Table 2: Results of the Linearity (homogeneity) Tests

Transition variable FDI1										
	LM_{χ}		LM_F		HAC_{χ}		HAC_F		WB	WCB
m	$test$	P-v	$test$	P-v	$test$	P-v	$test$	P-v	P-v	P-v
1	39.02	2.353e-17	7.96	1.515e-14	5.45	0.36	1.01	0.40	0	0

Source: Author's calculation based on SWIID data (Solt, 2014 and WDI, 2018).

Table 3: Sequence of Homogeneity Tests for Selecting Order m of the Transition Function

m	LM_{χ}		LM_F		WB	WCB
	$test$	P-v	$test$	P-v	P-v	P-v
Sequence of Homogeneity Tests for Selecting Order *m* of Transition						
H_{01}^{*}	**70.02**	2.353e-02	**7.96**	**1.515e-14**	**0.00**	**0.00**
H_{02}^{*}	20.05	8.016e-10	5.73	2.082e-09	0.00	0.00
H_{03}^{*}	11.40	6.994e-05	6.14	9.903e-11	0.00	0.00

Source: Author's calculation based on SWIID data (Solt, 2014 and WDI, 2018).

Table 4: Results of Parameter Constancy and No Remaining Non-Linearity

m	LM_χ		LM_F		HAC_χ		HAC_F	
	$test$	$p-v$	$test$	$p-v$	$test$	$p-v$	$test$	p$-v$
PC test								
1	81.59	2.452e-13	7.41	7.095e-11	6.03	0.81	0.54	0.85
NRH test								
1	57.7	9.827e-09	5.24	2.788e-07	9.26	0.50	0.84	0.58
	WB	WCB						
	WB and WCB NRH test							
1	1	1						

Source: Author's calculation based on (SWIID data (Solt, 2014 and WDI, 2018).

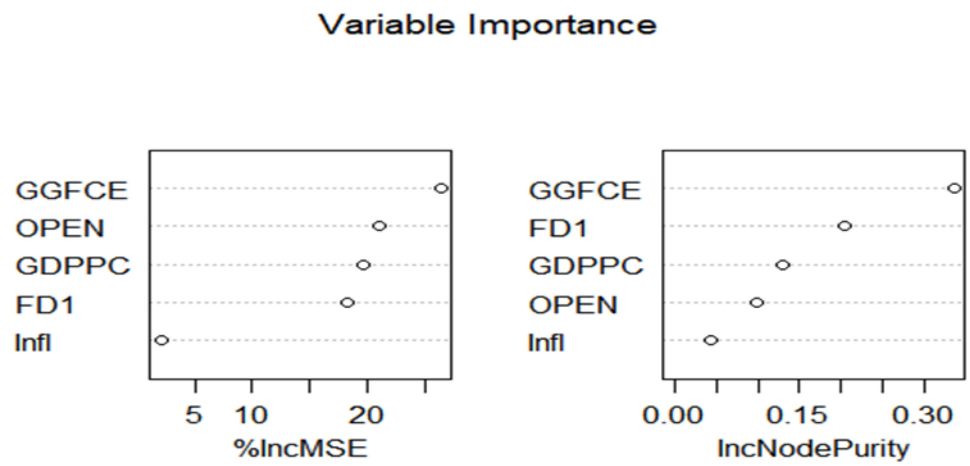
Table 5: Panel Smooth Transition Regression Model Estimation

Explanatory variables	**Model 1**: Gini coefficient before personal income taxes and transfer payment.		**Model 2**: Gini coefficient after personal income taxes and transfer payment	
	Low regime $\beta_{0j} \times 100$	High regime $(\beta_{0j} + \beta_{1j}) \times 100$	Low regime $\beta_{0j} \times 100$	High regime $(\beta_{0j} + \beta_{1j}) \times 100$
Financial development (***FD***)	**-0.04**** (0.02)	**0.07**** (0.03)	**-0.06**** (0.01)	**0.08**** (0.02)
Investment (**GGFCE**)	**0.17**** (0.08)	0.10 0.14	**0.12**** (0.04)	**0.11**** (0.02)
Trade openness (**OPEN**)	**-2.75**** (1.18)	1.12 (1.15)	0.13 (0.31)	-0.03 (0.20)
GDP per capita (***GDPPC***)	**-0.36**** (0.10)	**1.00*** (0.6)	**-0.53***** (0.10)	**1.10**** (0.31)
Inflation (***Infl***)	0.0012 0.0032	**0.05***** 0.03	0.02 (0.06)	**0.4***** (0.1)
Transition Parameters				
Threshold (c)		**19.00***** (0.70)	**19.82***** (3.69)	
Slope (γ)		**5.53*** (3.00)	**3.00**** (1.05)	
# of obs.		462		
# of countries		21		

*The ***/**/* denotes the level of significance at 1%, 5% and 10%, respectively.*
Source: Author's calculation results based on (SWIID data (Solt, 2014 and WDI, 2018).

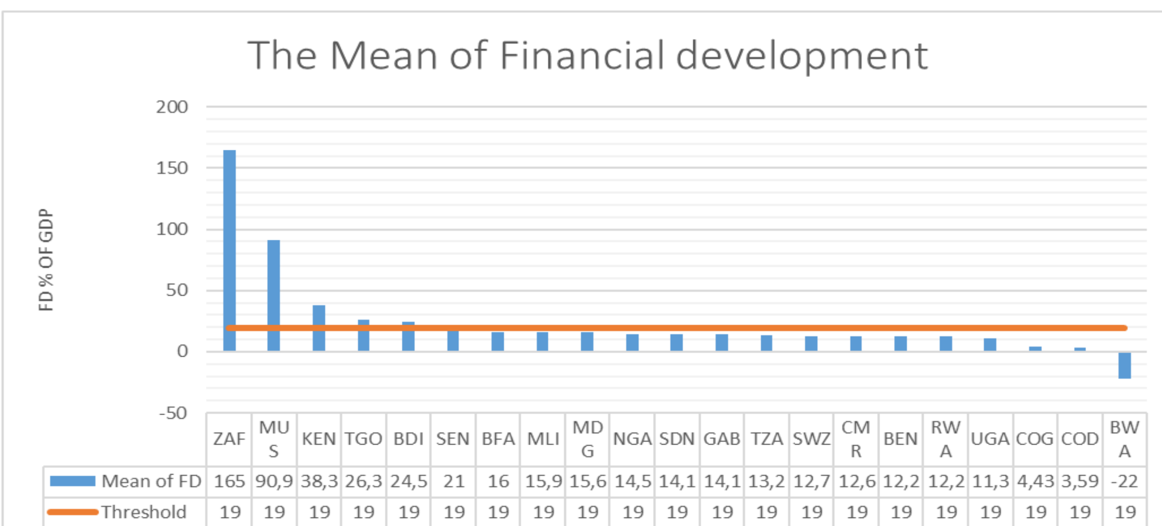
Figure 1: Variable Importance

A	B



Source: Author's illustration based on SWIID (Solt, 2014 and WDI, 2018).

Figure 2: The Mean of Financial Development and the Estimated Threshold



Source: Author's calculation based on SWIID data (Solt, 2014) and WDI, 2018).

Appendices

Appendix A: Results of both Homogeneity Test and Parameter constancy and No Remaining Nonlinearity respectively, when income was measured with Gini after tax.

Table A1: Results of the Linearity (Homogeneity) Tests

```
Results of the linearity (homogeneity) tests:
-------------------------------------------------------------------
LM tests based on transition variable 'FD2'
 m LM_X       PV LM_F       PV HAC_X    PV HAC_F    PV WB_PV WCB_PV
 1 43.67 2.703e-08 7.732 5.787e-07 3.576 0.612 0.6331 0.6746    0      0
*******************************************************************
Sequence of homogeneity tests for selecting number of switches 'm':
-------------------------------------------------------------------
LM tests based on transition variable 'FD2'
 m LM_X      PV LM_F       PV HAC_X    PV HAC_F     PV WB_PV WCB_PV
 1 43.67 2.703e-08 7.732 5.787e-07 3.576 0.612 0.6331 0.6746    0      0
```

H_0: Linear Model: H_1 PSTR Model with at least one threshold.
Source: Estimation results of the study (Rstudio software).

Table A2: Tests of Parameter Constancy and No Remaining Nonlinearity for Robustness Model

```
Results of the evaluation tests:
-------------------------------------------------------------------
Parameter constancy test
 m LM_X      PV LM_F      PV HAC_X     PV HAC_F     PV
 1 53.2 0.007836 1.404 0.07791 22.01 0.8828 0.5808 0.9662
---------------------------------------------------------------------
No remaining nonlinearity (heterogeneity) test
 m LM_X       PV LM_F        PV HAC_X     PV HAC_F     PV
 1 114.5 1.684e-11 3.021 3.459e-07 22.02 0.8825 0.5811 0.9661
-------------------------------------------------------------------
WB and WCB no remaining nonlinearity (heterogeneity) test
 m WB_PV WCB_PV
 1    1      1
```

*H0: Linear Model: H1 PSTR Model with at least one threshold***.**
Source: Estimation results.

Appendix B: Results of both Homogeneity Test and Parameter Constancy and No Remaining Nonlinearity Respectively, when financial development was measured by domestic credit to private sector as a share of GDP

Table B1: Results of the Linearity (Homogeneity) Tests for Robustness Model

```
LM tests based on transition variable 'FD1'
 m LM_X       PV LM_F       PV HAC_X    PV HAC_F     PV WB_PV WCB_PV
 1 42.53 4.607e-08 7.916 3.782e-07 4.869 0.432 0.9064 0.4767    0   0.25
*******************************************************************
Sequence of homogeneity tests for selecting number of switches 'm':
-----------------------------------------------------------------
LM tests based on transition variable 'FD1'
 m LM_X      PV LM_F       PV HAC_X    PV HAC_F     PV WB_PV WCB_PV
 1 42.53 4.607e-08 7.916 3.782e-07 4.869 0.432 0.9064 0.4767    0   0.25
```

*H_0: Linear Model: H_1 PSTR model with at least one threshold***.**
Source: Estimation results of the study (Rstudio software).

Table B2: Tests of Parameter Constancy and No Remaining Nonlinearity for Robustness Model

```
Results of the evaluation tests:
-----------------------------------------------------------------
Parameter constancy test
 m LM_X       PV LM_F       PV HAC_X     PV HAC_F     PV
 1 67.15 1.571e-10 6.104 1.06e-08 4.945 0.8948 0.4495 0.9212
-----------------------------------------------------------------
No remaining nonlinearity (heterogeneity) test
 m LM_X       PV LM_F        PV HAC_X     PV HAC_F    PV
 1 85.4 4.352e-14 7.764 1.897e-11 7.459 0.6815 0.6781 0.745
-----------------------------------------------------------------
WB and WCB no remaining nonlinearity (heterogeneity) test
 m WB_PV WCB_PV
 1    1      1
```

*$H0$: Linear Model: $H1$ PSTR Model with at least one threshold***.**
Source: Estimation results.