

## Non-linear finance-growth nexus for African countries: A panel smooth transition regression approach

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**Abstract.** *The economic growth effects of financial development have been the focus of much research in empirical growth literature. Recent literature has focus on the nonlinear effects of financial development on economic growth using advances in econometric techniques. Using a novel data set, we examine the conditioning role of the overall level of financial development, financial institutions development and financial markets development in finance-growth nexus for African countries using panel smooth transition regression approach (PSTR). Our results show that a sufficient level of the overall financial development is needed for finance to be growth enhancing in African countries, while a robust non-linear finance-growth nexus cannot be established when we conditioned finance-growth nexus on financial institutions development or financial markets development.*

**Keywords:** financial development, non-linearities, growth, Africa.

**JEL Classification:** E44, G21, O47.

## 1. Introduction

The role of finance in economic growth literature has received great attention, especially with the proliferation of endogenous growth models (Beck et al., 2000; King and Levine, 1993b; Levine, 1997c, 2005; Levine et al., 2000). However, the debate on the role of finance in growth is subject to divergent views. Theoretical models show that financial development promote growth through the rate of saving, the amount of savings channeled to investment, and the social marginal productivity of investment, implying the need for lower transaction cost (Murinde, 2012; Pagan, 1993). Similarly by increasing the proportion of saving channeled to investment financial development promotes growth (Bencivenga and Smith, 1991; Greenwood and Jovanovic, 1990). In addition, financial systems that evaluate promising entrepreneurs, mobilize savings to productivity-enhancing projects, diversify risks, and reveal expected profits from these innovative activities are growth enhancing (King and Levine, 1993b). Moreover, empirical evidences show that financial systems that are able to produce information about possible investments and allocate capital; monitor investments and exert corporate governance; facilitate trade, diversify and manage risk; mobilize and pool savings; and ease the exchange of goods and services are able to promote economic growth (King and Levine, 1993b, 1993a; Levine, 2005).

These evidences however have been found on the backdrop of a linear finance-growth nexus, which have been call to question (Aghion et al., 2005; Berthelemy, 1996; Deidda and Fattouh, 2002; Deidda, 2006). Theoretical models that explain non-linear financial development and growth show that financial development and growth relationship exhibits multiple equilibria. These multiple equilibria in finance-growth nexus are explained in terms of reciprocal externalities between the real and financial sectors (Aghion et al., 2005; Berthelemy, 1996). In a simple overlapping generation model with risk averse agents and costly financial transaction, financial development impact growth ambiguously at low levels of development, but as development continues finance impacts growth positively (Deidda and Fattouh, 2002). The impact of the banking sector on economic growth depends on the level of financial markets development, so that countries with developed financial markets reap more from financial systems impact on growth (Deidda and Fattouh, 2008).

Moreover, (Beck et al., 2014) finds evidence for non-linearity in finance-growth nexus. Using a panel smooth transition regression model to account for non-linearity in finance-growth nexus for a sample of 45 advanced and developing countries during 1975-2009 (Doumbia, 2010) finds evidence of finance-growth nexus exhibiting an inverted U-shaped relation. Non-linearity stems from the level of income, so that in low income and lower middle income countries financial development enhances growth through boosting savings and investment, while its effect is nil or negative in more advanced economies. In a panel mean group (PMG) estimation method for middle income countries (Samargandi et al., 2013) show that financial development has a long run non-linear relationship with growth, however the short run effect is not significant.

Generally, the African evidence show a long run relationship between finance and growth as espoused in (Bangake and Eggoh, 2011; Hassan et al., 2011; Murinde, 2012). (Allen et al., 2000) finds that finance positively impacts long run investment, implying that financial

development's effect on growth through capital accumulation is positive. Moreover, (Rousseau and D'Onofrio, 2013) in a sample of 22 sub-Saharan African countries from 1960-2009 finds that financial development causes real activity (capital accumulation and economic growth) in two-third of the countries studied. However, the measure of financial development that appear to be growth-promoting is monetization, lending evidence to the role of money rather than finance.

Despite these efforts, the literature on non-linear finance-growth nexus with focus on Africa has not been given much attention. Using (Hansen, 1999, 2000) panel threshold regression technique, (Ibrahim and Alagidede, 2017) finds that the level of financial development, economic development and human capital stock mediate financial development's effect on economic growth in sub-Saharan countries during 1980-2014. However this technique (Hansen, 1999, 2000) panel threshold method- assumes an immediate shift from one regime to another, hence cannot model transition from one regime to another.

We differ with the extant literature on finance-growth nexus in Africa from a methodological aspect, as well as from exploring a new data set. We used panel smooth transition regression approach which is an improvement on the (Hansen, 1999, 2000) technique in that it allows the researcher to model the transition from one regime to another. Knowledge of how long it takes to move from one regime to the other is especially important for policy implementation when financial development is within the neighborhood of the threshold value. Another novelty of this study is the use of a broad based measure of financial development allowing us to better capture the concept of financial development as defined from the function approach (Levine 2005). To the best of our knowledge is the first time this data is used in the analysis of finance-growth nexus for African countries.

## 2. Data and methodology

### 2.1. Data

The dataset use in this study comprise thirty-three African countries during the period 1980-2014, where countries are included base on availability of data. The data set is derived from different sources such as from World Bank Development Indicators (WDI), Penn World Tables (PWT), International Country Risk Guide (ICRG) and IMF. Table 1 illustrates breakdown of the data and its sources. Economic growth, human capital, openness, inflation and per capita income are all taken from the World Development Indicators database, while data on financial development is source from IMF based on (Svirydzenka, 2016). Investment data and institutional quality data are source from PWT and International Country Risk Guide (ICRG) respectively. Growth refers to GDP growth rate, initial income is per capita GDP measured at 2011 international dollar, human capital is measured by gross tertiary school enrolment ratio, while trade openness is taken as the ratio of imports and exports to GDP. Government expenditure is given by the general government consumption expenditure as percentage of GDP, and institutional quality is measured by the ICRG's polity2 index.

**Table 1.** Data and sources

Variable	Measure	Source
Overall Financial Development	Financial development index	IMF
Financial Institutions Development	Financial institutions index	IMF
Financial Markets Development	Financial markets index	IMF
Growth	GDP per capita growth	WDI
Income	Per capita GDP (at 2011 Int'l \$)	WDI
Human Capital	Tertiary school enrollment ratio	WDI
Investment	Share of gross capital formation	PWT
Institutional Quality	Polity2	ICRG
Trade Openness	Export+ Import / GDP	WDI
Government expenditure	General government consumption expenditure/ GDP	WDI

In line with growth empirics and to purge out business cycle effects, 5-year averages are taken for each variable, with the initial income referring to the first period values in each 5-year average.

## 2.2. Panel smooth transition regression approach

Following (Deidda and Fattouh, 2002) we first examine a linear regression:

$$Growth_{it} = \mu_i + \beta_0 FD_{it-1} + \beta_1 X_{it-1} + \varepsilon_{it} \quad (1)$$

Where  $Growth_{it}$ ,  $findev_{it-1}$  and  $X_{it-1}$  refer to GDP growth, financial development, and the vector of controls respectively for the  $i^{th}$  country in period  $t$ . The terms  $\mu_i$  and  $\varepsilon_{it}$  represent country fixed effects and the residual error terms respectively, where the error term is assumed to be *i. i. d*  $(0, \sigma_\varepsilon^2)$ . Financial development impact growth positively if  $\beta_0 > 0$  and impacts negatively if  $\beta_0 < 0$ . However, recent literature has questioned the linear relationship between financial development and economic growth, hence we employ a panel smooth transition regression approach proposed by (Fok et al., 2005; Gonzalez et al., 2005) to capture the nonlinearity between financial development and economic growth as well as control for cross country heterogeneity in finance-growth nexus (Jude, 2010). For the purpose of simplicity, we specify a two-regime PSTR model given by the following expression.

$$Growth_{it} = \mu_i + \beta_0 FD_{it-1}(q_{it-1} < \gamma, c) + \beta_1 FD_{it-1}\Gamma(q_{it-1} > \gamma, c) + \varphi_0 X_{it-1}(q_{it-1} < \gamma, c) + \varphi_1 X_{it-1}\Gamma(q_{it-1} > \gamma, c) + \varepsilon_{it} \quad (2)$$

where the transition function  $\Gamma(q_{it}; \gamma, c)$  is a continuous bounded function, taking values between 0 and 1 depending on the threshold variable  $q_{it}$ , the threshold value  $c$  and  $\gamma$  the slope of the transition function. The transition variable in this study is the level of financial development. Based on the time series smooth transition autoregressive (STAR) model, (Fok et al., 2005; Gonzalez et al., 2005) specified a logistic function for the transition function as follows:

$$\Gamma(q_{it}; c) = \frac{1}{1 + \exp[-\gamma(q_{it} - c)]} \quad (3)$$

Depending on the values that the slope parameter assumes the PSTR model lies between the panel fixed effect model and the panel threshold regression (PTR) model of (Hansen 1999, 2000). Theoretically, PSTR offers the advantage that both time-varying and cross-country heterogeneity in finance-growth coefficient is captured, and allows the parameters

to change smoothly depending on the threshold variable. The finance-growth coefficient when the transition variable is financial development is defined as:

$$e_{it} = \frac{\partial Growth}{\partial FD_{i,t-1}} = \beta_0 + \beta_1 \Gamma(FD_{i,t-1}; \gamma, c) + \beta_1 \frac{\partial \Gamma(FD_{i,t-1}; \gamma, c)}{\partial FD_{i,t-1}} FD_{i,t-1} \quad (4)$$

Depending on the sign of  $\beta_1$ , the finance-growth elasticity ( $e_{it}$ ) takes a weighted average of the parameters  $\beta_0$  and  $\beta_1$  as follows: if  $\beta_1 > 0$ , then  $\beta_0 \leq e_{it} \leq \beta_0 + \beta_1$ ; and if  $\beta_1 < 0$ , then  $\beta_0 + \beta_1 \leq e_{it} \leq \beta_0$  because  $0 \leq \Gamma(q_{it}; \gamma, c) \leq 1$ . As can be notice from above, the true effect of financial development on economic growth can be different from the extreme parameters  $\beta_0$  and  $\beta_1$ . Precisely, the direct effect of finance on growth is fully captured by  $\beta_0$  when the transition function tends to 0; and the direct effect of finance on growth is directly captured by  $\beta_0 + \beta_1$  when the transition function tends to 1. The intermediate state comprise of an infinite weighted average of these two extremes for finance-growth coefficient. This is why, like Probit and Logit model, it is difficult to directly interpret the values of finance-growth coefficient. Hence, researchers concentrate on the sign of the parameters. The sign will show whether financial development increases or decreases with growth as the transition variable varies.

The estimation process involves three steps (Fouquau et al., 2008): a linearity test, test of no remaining linearity and PSTR parameter estimation. The linearity test in our context involve testing if finance-growth nexus is adequately modelled by a homogenous linear panel model or by a PSTR with at least two regimes. The null hypothesis ( $H_0$ ) is therefore constructed under linearity and the alternative ( $H_1$ ) hypothesis is a PSTR with atleast one threshold. The test is conducted using three statistics: The Fisher LM test, Wald test and the likelihood ratio test specified as:

$$LM_F = \frac{(SSR_0 - SSR_1)/K}{SSR_0/(TN - N - K)} \sim F(K, TN - N - K)$$

$$LM_w = \frac{NT(SSR_0 - SSR_1)}{SSR_0}$$

$$LR = -2[\log(SSR_1) - \log(SSR_0)]$$

Where  $SSR_0$  denote the sum of squares residual under  $H_0$  of linear panel model and  $SSR_1$  is the sum of squares residual under ( $H_1$ ) PSTR with atleast one threshold. The  $LM_F$  follows an  $F(K, TN - N - K)$  distribution, and  $LM_w$  and  $LR$  statistics follow a  $\chi^2(K)$ . The  $K$  degree of freedom refers to the number of explanatory variables, while  $T$  and  $N$  are the number of periods and number of countries. If the null hypothesis cannot be rejected, then the finance-growth nexus is adequately captured by a linear homogeneous panel model. However, we the null is rejected then the appropriate model is a PSTR with at least one threshold. Upon rejection of the null hypothesis, the second step involves testing the appropriate number regimes to capture the nonlinearity in the PSTR model, and this is called the test of no remaining nonlinearity. The null hypothesis  $H_0$  is constructed under a PSTR model with atleast one threshold or two regimes, while the alternative hypothesis  $H_1$  is constructed under a PSTR with at least two threshold or three regimes. If the null hypothesis cannot be rejected the test ends and a PSTR model of one threshold is

estimated in the third stage using non-linear least squares estimation techniques. However, if the null in the second stage is rejected the test is reconstructed with a null of at least two thresholds against an alternative of at least three thresholds. This procedure is followed until the null cannot be rejected, i.e. until all nonlinearities in the finance-growth nexus is captured. The test of no remaining nonlinearity is conducted using the Fischer, Wald and Likelihood Ratio test statistics.

According to (Fouquau et al., 2008) *the use a PSTR limits the potential endogeneity bias since for each level of the threshold variable there is a "particular" value of the estimated FH regression parameter.*" PP-20. Despite this we rely on one period lag of financial development ( $FD_{i,t-1}$ ) to correct for any remaining endogeneity.

### 3. Multidimensional measure and financial development in Africa

Financial development has come to be defined based on what the financial system does (Levine, 1997, 2005). Accordingly, financial development is defined as an improvement in the quality of the following five key functions of the financial system: 1. producing and processing information about possible investments and allocating capital based on these assessments; 2. monitoring individuals and firms and exerting corporate governance after allocating capital; 3. facilitating the trading, diversification, and management of risk; 4. mobilizing and pooling savings; and 5. easing the exchange of goods, services, and financial instruments.

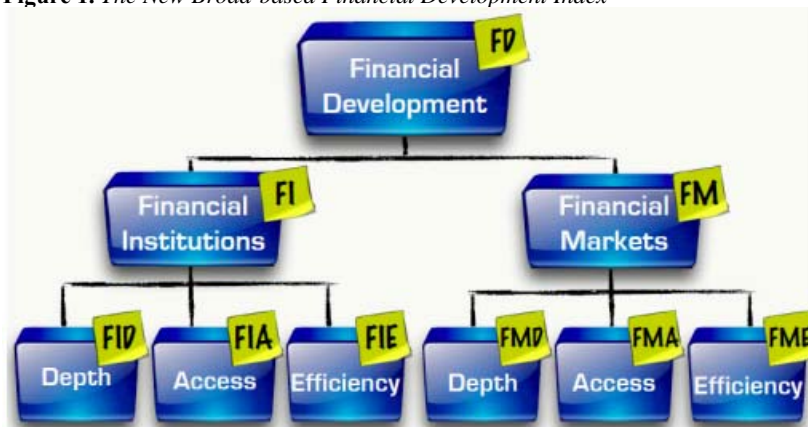
Base on this functional definition of financial development, it would be ideal to have a direct measure of how well the financial sectors performs: 1. information production and processing about possible investments and allocation of capital base on this information, 2. individuals and firms monitoring to exert corporate governance after capital is allocated, 3. facilitation of trading, diversification and management of risk, 4. mobilizing and pooling risk, and 5. easing exchange of goods and services. Without the challenge of measurement, one would like to be able to say, for example, in terms of information acquisition and processing, country X scores, say 50 out of 1000, and Y scores 79 out of 100, and so on.

However, measurement challenge is a key problem in the financial development literature. Traditional measures of financial development based on depth such a private credit, domestic credit or bank liquidity do not capture broadly these functions of the financial system. In fact Levine (2005) content that such proxies often do not adequately capture the concept of financial development put forward by theory. This defines the move away from the traditional one-dimensional measures towards a multifaceted measure of financial development (Demirguc-Kunt and Maksimovic, 1996; Martin Cihak et al., 2012; Svirydzenka, 2016) backing on the functional approach to the role of financial sector in the economy. The idea is to capture some characteristics of the financial system, such as depth, access, efficiency and stability. These characteristics do not necessarily measure the functions directly but of the services provided by the financial system (Martin Cihak et al., 2012). For example depth does not measure information acquisition and the allocation of capital; it is rather an imperfect ex-post proxy for the overall depth of the financial services.

It is against this backdrop that this study is based on a multifaceted measures of financial development introduced by (Svirydzenka, 2016).

(Svirydzenka, 2016) developed a comprehensive measure of financial development that covers both financial institutions development and financial markets development. This broad measure of financial development recognizes the fact that financial services are provided by a broad range of institutions and that the availability of different markets allow households and firms to acquire loans and raise capital from diverse sources. This measure, unlike the traditional measures, capture the real gap in the financial services for a country that has a dominant banking sector as it is the case in most African countries. It assesses financial institutions and markets on three main dimensions: depth, access and efficiency. The depth dimension looks at the size and liquidity of financial institutions and markets, which is what the ad hoc measures of financial development seeks to capture (private credit to GDP ratio and liquid money to GDP ratio). Access to financial institutions and markets are equally important in the measuring of financial development, hence the access dimension of this new measure captures the ease of access for households and businesses to financial services in the economy. The efficiency dimension measures the ability of financial institutions and markets to provide funds to agents at low cost while maintaining sustainable profits. The figure below displays the various components to the index.

**Figure 1.** *The New Broad-based Financial Development Index*



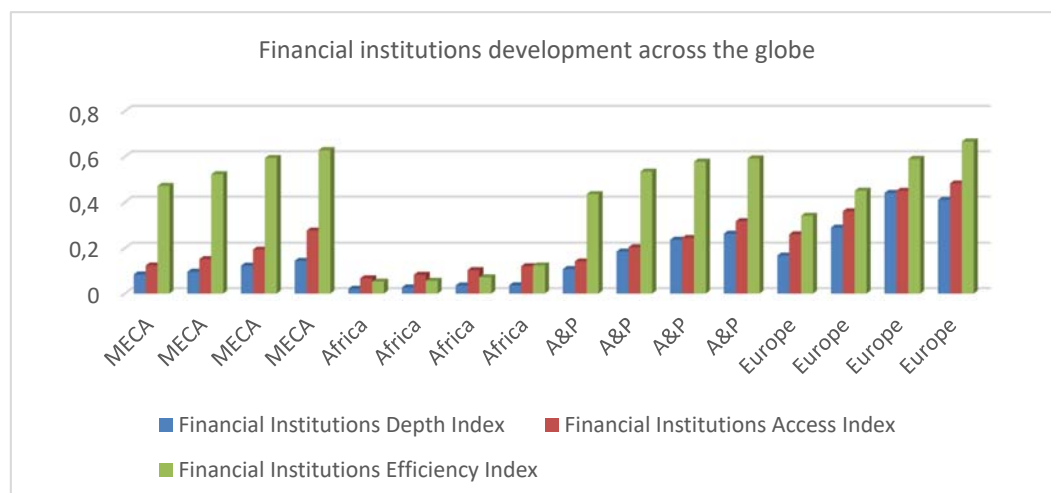
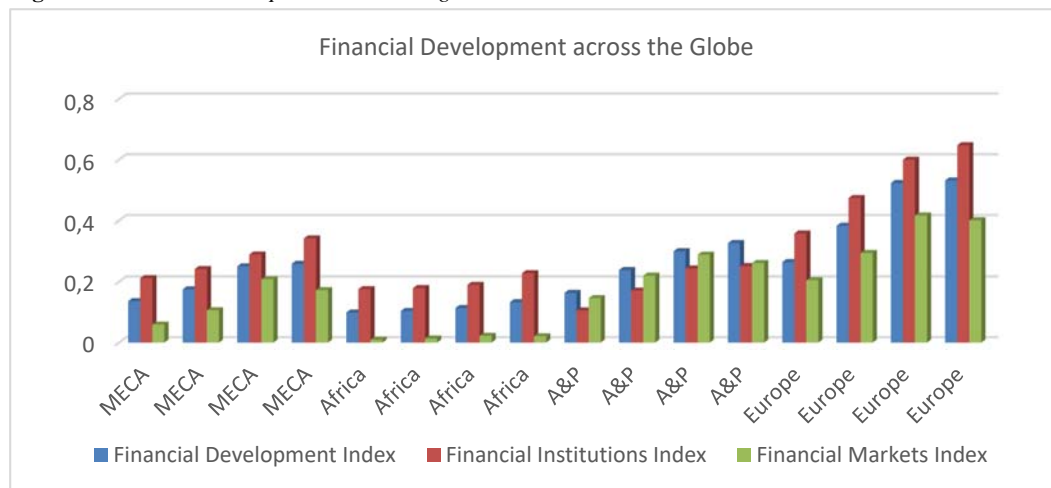
**Source:** Svirydzenka (2016).

On average financial institutions are more developed than financial markets in Africa, which springs from the fact that the Africa's financial sector is mainly dominated by deposit money banks, and other financial institutions like insurance companies. Furthermore, while deposit money banks, insurance companies and other financial institutions are present in all countries, financial market are absent in some African countries, resulting in a very low average financial markets index. On the other hand, where financial markets exist they seem to put up a relatively higher level of financial development compared to financial institutions. The maximum financial markets index is higher than that of financial institutions development.

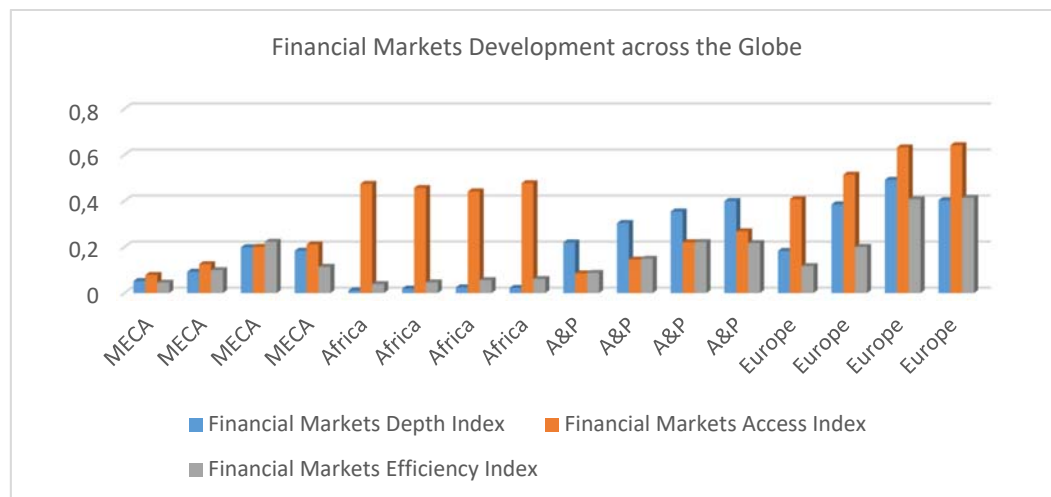
**Table 2.** Description of financial development based on (Svirydzenka, 2016)

Variable	Observation	Mean	Std. Dev.	Min	Max
Overall financial development	231	0.15027	0.1394	0	0.78668
Financial institutions development	231	0.22282	0.14389	0	0.77497
Financial markets development	231	0.06773	0.13545	0	0.80344

To make sense of these figures, we compare financial development and its various dimensions in Africa with other regions. Figure 2 shows the evolution of financial development, financial institutions development and financial markets development in Africa, Middle East and Central Europe (MECA), Asia and Pacific (A&P) and Europe during the 1980s, 1990s, 2000s, and 2010-2014 periods. For each region, the group of bars are listed chronologically.

**Figure 2.** Financial development across the globe





While Africa has the lowest level of overall financial development among all regions, until 2000s financial institutions development in Africa has been greater than in the Asia and Pacific region. The rapid development in Asia since the turn of the millennium means that today Africa is home to the shallowest financial sector among all regions by all dimensions. Strikingly, despite the enormous financial markets development in other regions-in some places exceeding financial institutions development- in Africa financial markets are almost non-existent. However, the trend in financial sector development has been increasing in Africa, just as in other regions, alluding to the enormous globalization since 1980. The 2008 Global financial crisis has led to the rewind in financial markets development significantly in other regions and just marginally in Africa (from 0.021 to 0.020 for 2000s and 2010-2014 periods, respectively).

Delving into the dynamics of financial institutions and markets development across regions, Africa's financial institutions development has been driven mainly by access to financial institutions. This story is corroborated by the homegrown innovative financial inclusion products in East Africa that leverage mobile technology. In the meanwhile, efficiency of financial institutions has driven their overall developing in other regions, especially in Asia and Pacific and Middle East and Central Europe. The advancements in information and communication technology has aided financial institution in their urge to efficiently serve their customers at low cost while making profit. An important observation is that though the most common traditional measures of financial development are those that capture financial institutions depth (Beck et al., 2000; Levine, 1997, 2005) data shows that financial institutions depth is the lowest contributor to overall financial institutions development in Africa since 1980.

Overall financial markets development is low in Africa, but were they exist access to markets are much more developed than elsewhere in MECA and A&P. In fact, it is as if financial markets development is one-dimensional, and focuses only on access. Financial markets depth and efficiency are moderate in the continent. This structure of financial markets development contrast other regions. In Europe for example financial markets

access, then depth and finally efficiency contributes the most to financial markets development. However, in the Asia and Pacific region, the structure is dominated by depth, then access and efficiency last; while markets development in MECA is balanced between all dimensions.

**Figure 3.** *Financial development across Africa*  
Year: 1990-1999 and 2000-2009

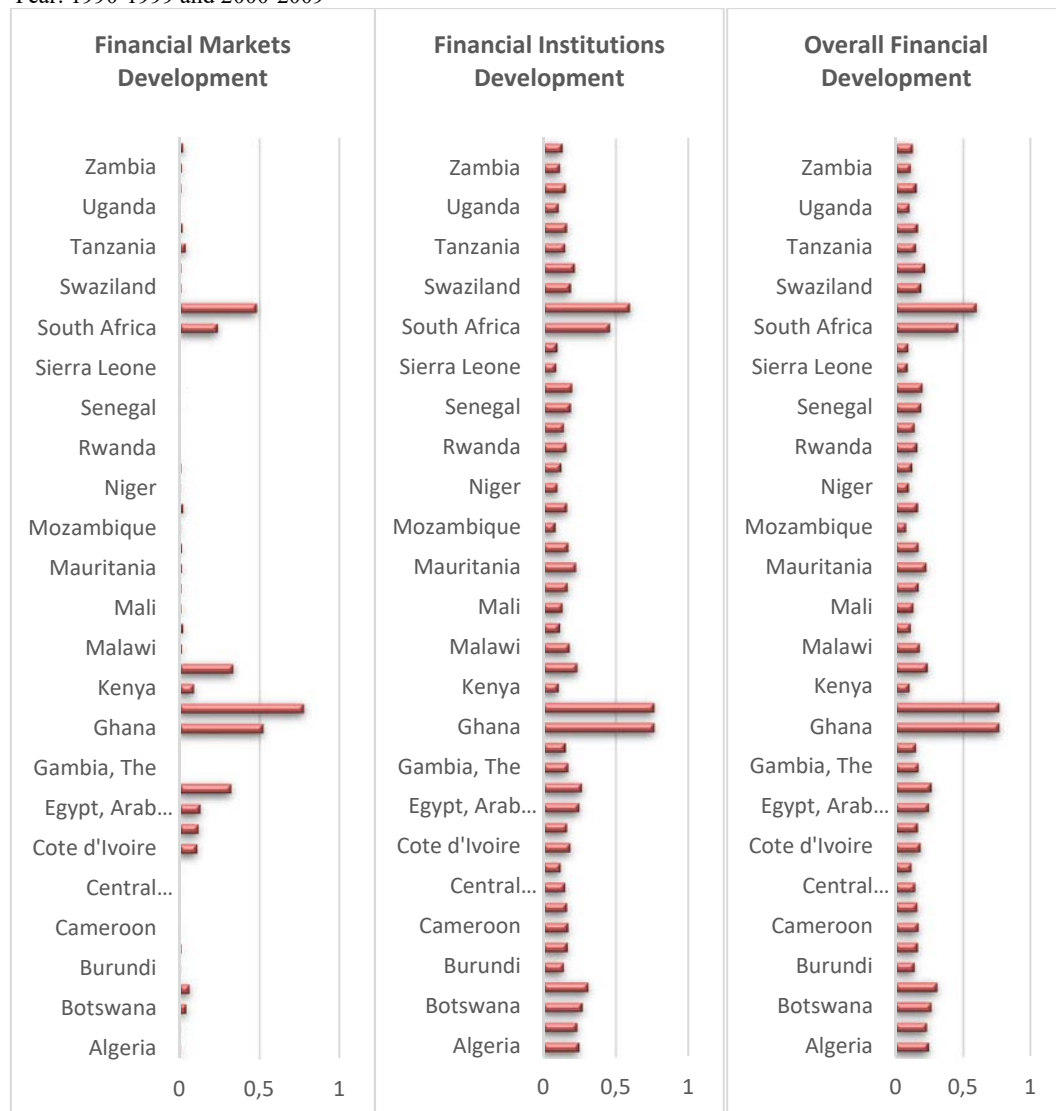


Figure 3 focuses on financial development within the sample African countries during the three decades since 1980 and 2010-2014 period. The two bars for each country show the average financial development in 1990-1999 and 2000-2009 periods. Among the sample countries, Ghana, South Africa, Kenya, Egypt and Botswana have the greatest financial sector development, institutions and markets. Several countries have zero financial markets

development because of their little or non-existence. Unsurprisingly, countries that have no financial markets tend to have the lowest financial institutions development and overall financial development. For example in countries such as Sierra Leone, Niger, Rwanda and Central African Republic, financial markets are non-existent until 2009. Rwanda's stock exchange was later launched on 31<sup>st</sup> January 2011.

## 4. Results and finding

### 4.1. Descriptive statistics

Table 3 shows the summary statistics and the correlation matrix for the data. The average GDP growth in the sample is moderate at 3.5% with wide range and high dispersion (CV is a normalized measure of dispersion of a probability distribution, and it is calculated as the ratio of standard error to the mean) of 4.48. This alludes to the heterogeneous nature of sample, a case further showed by the range in the per capita GDP. The mean per capita GDP is less than \$ 2000, with as low as a per capita income of \$ 115 and a maximum beyond \$10,000.

Financial institutions are on average more developed and less disperse among African countries than financial markets. The average is highest and dispersion lowest for financial institutions index than financial markets index, and the overall financial development index lies in between the two as expected. Openness on average is high while the average level of institutional quality is low and its dispersion high. On the correlation between GDP growth and its covariates, the signs are as per expectations. Initial income is negatively correlated with growth because of the 'catch-up' or convergence hypothesis. All financial development indicators, human capital, investment, openness and institutional quality, and government expenditure are all positively correlated with growth. The magnitudes are equally moderate except for the human capital measure.

**Table 3. Summary statistics**

Variable	Growth	Income	Human capital	investment	Overall financial development	Financial institutions development	Financial markets development	Institutional quality	Trade openness	Government expenditure
Mean	3.557328	1747.606	5.940065	20.05356	0.150273	0.222823	0.067733	-1.06061	70.6019	5.580453
Max	33.21688	12139.64	37.19728	46.77489	0.78668	0.774968	0.803444	10	229.6381	60.8852
Min	-31.0159	115.7941	0.08859	3.958171	0	0	0	-10	12.876	-68.2379
S.D	4.481586	2222.641	7.336863	7.309797	0.139395	0.14389	0.135446	5.933879	32.45534	10.40167
CV	1.259818	1.27182	1.235149	0.364514	0.927611	0.645761	1.999706	-5.5948	0.459695	1.863947
Correlation										
Growth	1									
Income	-0.1116	1								
Human capital	0.0123	0.4007	1							
Investment	0.2291	0.3265	0.2559	1						
Overall financial development	0.1043	0.3381	0.5049	0.265	1					
Financial institutions development	0.105	0.432	0.5077	0.3834	0.9313	1				
Financial markets development	0.0902	0.1915	0.4191	0.1018	0.9274	0.7462	1			
Institutional Quality	0.198	0.0578	0.111	0.0802	0.3099	0.2616	0.3034	1		
Trade openness	0.1701	0.2879	0.1539	0.419	0.1881	0.2677	0.0789	0.0897	1	
Government expenditure	0.4313	-0.0841	-0.0195	0.151	0.0055	0.0015	0.0228	0.1071	0.1885	1

## 4.2. Linear panel data result

In this section, we use systems GMM (Arellano and Bover, 1995; Blundell and Bond, 1998) to uncover the independent unbiased effect of finance on growth in Africa and the results are shown in Table 4. The first three columns present result for the basic specification with the three financial development indicators, one for each column.

**Table 4.** *Linear panel data result*

VARIABLES	I	II	III
Initial income	-0.000291*** (6.50E-05)	-0.000280*** (8.57E-05)	4.01E-05 (6.39E-05)
Human capital	0.0362*** (0.0107)	0.0283* (0.0139)	-0.00227 (0.0114)
Investment	0.0878*** (0.0217)	0.0631** (0.0267)	0.0338 (0.0244)
Overall financial development	5.505*** (0.895)		
Financial institutions development		6.941*** (1.074)	
Financial markets development			3.028*** (0.837)
Institutional quality	0.0231 (0.0257)	0.0263 (0.0288)	0.0471** (0.0226)
openness	0.0198*** (0.00526)	0.0182*** (0.00605)	0.0309*** (0.00571)
Government expenditure	0.00588 (0.0136)	-0.00547 (0.0123)	0.00497 (0.0108)
Constant	-2.386*** (0.335)	-2.395*** (0.362)	-1.648*** (0.376)
Observations	163	163	163
Number of ID	32	32	32
AR(2)	0.411	0.436	0.375
Hansen	0.614	0.734	0.923

Like the linear panel data result, Table 4 shows that financial development is highly significant by all three measures. In all cases financial development is positively and significantly related to growth, however the magnitude is higher for financial institutions than financial markets. This is not surprising given that financial institutions are more developed (mean of 0.22) than financial markets (mean of 0.06). Combined together, the overall financial sector development exerts an even more effect on growth. Other growth covariate are also examined and results show that initial income, human capital and investment are significant determinants of growth. Human capital and investment exert a significant positive impact on growth, while initial income is significantly negatively related to growth.

Serial correlation of the first degree are bound to be present in dynamic models however model diagnostics show that serial correlation of second degree is not a problem in all specifications in Table 4, (P-values > 0.05). Model over-identification restrictions tests of Hansen show that the validity of the over-identification restrictions cannot be rejected in all specifications.

## 5. Panel Smooth Transition Regression (PSTR) results

Recent advances in econometric techniques coupled with ease in numerical computation has served as a springboard for researchers' interest in heterogeneous economic relationships. Meanwhile, the recent financial crisis has questioned the belief that finance is monotonically good for growth, hence the recent surge in nonlinear finance-growth studies (Eggoh and Khan, 2014; Ibrahim and Alagidede, 2017; Jude, 2010; Law et al., 2013; Samargandi et al., 2013). The extant literature has tried to study the existence of non-linearity as well as study the conditional variables that moderate such nonlinearity. In this section, we estimate a panel smooth transition regression model of finance-growth nexus where finance-growth nexus is conditioned on the level of overall financial development, financial institutions development and financial markets development for African countries.

The PSTR result is shown in Table 5 and comes in three sections: linearity test, test of no remaining heterogeneity, and final PSTR estimation. The first section indicates that finance-growth nexus is non-linear by all three statistics when we condition the nexus on the overall level of financial development, non-linear when conditioned on financial institutions development and financial markets developed by the Likelihood Ratio statistic. Going by the Fisher and Wald Statistics, we cannot reject linearity when we condition finance-growth nexus upon the level of financial institutions and financial markets development.

For probe further, we test for the appropriate number of thresholds in each model using the Fisher, Wald and LR test statistics. The results in the second section of Table 5 highlights that the null of only one threshold/two regimes cannot be rejected in all three models at 10% level of significance, alluding to the point that usually one threshold is sufficient to capture all non-linearities in economic relationships (Gonzalez et al., 2005). In the final section of Table 5, the PSTR estimation output for finance-growth nexus is shown.

**Table 5.** Linearity, no remaining non-linearity tests and PSTR estimation results

Linearity Test	Financial development		Financial Institution		Financial Market development	
	test stat	p-value	test stat	p-value	test stat	p-value
Likelihood Ratio	6.0134	0.00	12.0335	0.00	4.345	0.00
Wald	6.019	0.007	1.410	0.207	4.289	0.746
Fisher	0.706	0.005	11.59	0.115	0.497	0.835
Test of No Remaining Non-linearity	test stat	p-value	test stat	p-value	test stat	p-value
Likelihood Ratio	9.414	0.224	7.199	0.408	2.135	0.952
Wald	9.146	0.242	7.041	0.425	2.121	0.953
Fisher	0.974	0.453	0.740	0.639	0.216	0.981
PSTR Coefficient Estimates						
Gamma	198.89		5.3808		5.9918	
C	0.0193 [0.010-0.439]		-3.20 [0.0801-0.4049]		-3.4683 [0.000-0.1902]	
	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2
Coefficient	-2.2639*** (-11.67)	2.2644*** (11.66)	2.7516 (0.0597)	-2.7516 (-0.0063)	3.2203 (0.000)	-3.2203 (-0.000)

The result for estimating the PSTR show that a very small threshold value (0.0193) of the overall financial development index is significant (lies within the interval), such that below this level financial development harms economic growth and above it financial development imparts growth positively. The movement from regime 1 to regime 2 occurs at a slope of 198.98, which is considerably high. This therefore means that financial development and economic growth has a U-shaped relationship in African countries when the relationship is conditioned on the level of overall financial development. However, with just 10% of the observation below the threshold and the fact that the current value of financial development in all countries is above this threshold, greater overall financial development in the region is poised to enhance growth. This finding is similar to (Ibrahim and Alagidede, 2017) who find that below a threshold value of 8% and 13.5% of private credit and domestic credit GDP ratio financial development does not significantly impact economic growth and beyond these cut off points finance positively impact economic growth in sub-Saharan Africa.

When we disintegrate the financial system and focus attention on financial institutions and financial markets, our results are interesting. First, they consistently show that the threshold values reached at are both out of band and insignificant, while the conditioned finance-growth nexus is insignificant in both regimes of both models. Furthermore the transition from one regime to another is relatively faster compared to the overall financial development. Given the weak evidence for non-linearity in these two models (only LR statistics show non-linearity), and results of the final section, we conclude that a robust non-linear nexus cannot be established for finance-growth nexus when conditioned on financial institutions development or financial markets development separately. However, taken the evolution of the overall financial development, we show that finance-growth nexus is not linear such that beyond a threshold values of 0.019 index values financial development impacts growth significantly.

## 6. Conclusion and recommendations

In the light of a new broad-based measure of financial development based on (Svirydzenka, 2016), this paper attempts to investigate finance-growth nexus for a sample of thirty-three African countries for the period 1980-2014, taking five-year average of variables to smooth-out business cycle effects. The investigation was done in two stages, where the first stage studies linear finance-growth nexus as found in the earlier finance-growth literature. The findings from this analysis show that the overall financial development, financial institutions development and financial markets development significantly enhanced economic growth, even after controlling for other significant growth covariates in the set-up of a dynamic panel regression method.

In second stage of analysis we rely on endogenous threshold model of panel smooth transition regression (PSTR) introduced by (Fok et al., 2005; Gonzalez et al., 2005) to further investigate non-linearity in financial development and growth relationship. The findings from the PSTR show that (i) non-linear and (ii) such non-linearity depends on the overall level of financial development and (iii) The separate evolution of financial

institutions and financial markets does not seem to affect the non-linearities in finance-growth nexus. These results are in line with previous findings for developing countries in (Ibrahim and Alagidede, 2017; Jude, 2010; Law et al., 2013; Samargandi et al., 2013).

Based on the findings in this paper, policy makers in African countries should further pursue financial development from a broad perspective, focusing not just on financial institutions, which dominate the financial sector of African countries, or financial markets, which are nascent in some countries, but keeping an eye on the trajectory of the overall financial sector development to allow growth enhancing financial development. Moreover, given that financial development index is a multidimensional, our result call to policy makers to not just focus on financial deepening but also access and efficiency aspects of the African financial superstructure. This study is silent on the disaggregated effect of individual sub-dimension of financial institutions development and financial markets development. Given the rich nature of the (Svirydzhenka, 2016) data, we leave that to further research.

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