

Effect of external public debt on inclusive growth in sub-Saharan Africa

أثر الدين العام الخارجي على النمو الشامل في إفريقيا جنوب الصحراء

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Abstract: This paper aims to analyze the effects of external public debt on inclusive growth in twenty-seven Sub-Saharan African countries between 1996 and 2021. Using the smooth transition panel regression models developed by Gonzales and al.(2005), this study provides new evidence on the threshold value of the external public debt-to-GDP ratio. The results indicate that external public debt has a non-linear effect on inclusive growth in these countries. A threshold of 47.29% of GDP is estimated using smooth transition panel models. When external public debt exceeds this level, it exerts a negative and statistically significant impact on inclusive growth. This finding remains robust when applying the dynamic threshold panel model of Seo and Shin (2016), which estimates a threshold of 45.52% of GDP. Furthermore, our regression results reveal that external public debt exhibits a non-linear relationship with various dimensions of inclusive growth. However, the relationship between external public debt and the environmental perception index is linear. These findings underscore the need for Sub-Saharan African countries to reform taxation and strengthen external public debt management to foster more inclusive growth.

Keywords : External public debt, inclusive growth, Sub-Saharan Africa, smooth transition panel models, dynamic threshold panel model.

JEL classification : F34, O11, C23.

ملخص:

تهدف هذه الدراسة إلى تحليل آثار الدين العام الخارجي على النمو الشامل في سبعة وعشرين بلدًا من بلدان إفريقيا جنوب الصحراء خلال الفترة 1996–2021. وباستخدام نماذج الانحدار اللوحي ذات الانتقال السلس (Smooth Transition Panel Regression) تقدم هذه الدراسة أدلة جديدة حول قيمة العتبة لنسبة، (2005) التي طورها غونزاليس وآخرون (2005). وتشير النتائج إلى أن للدين العام الخارجي أثرًا غير خطي على النمو. الدين العام الخارجي إلى الناتج المحلي الإجمالي الشامل في هذه البلدان

وعندما يتجاوز الدين العام .من الناتج المحلي الإجمالي باستخدام نماذج الانتقال السلس اللوحية %47.29 وقد تم تقدير عتبة تبلغ وتظل هذه النتيجة متينة عند تطبيق نموذج .الخارجي هذا المستوى، فإنه يُحدث أثرًا سلبيًا ذا دلالة إحصائية على النمو الشامل علاوة على .من الناتج المحلي الإجمالي %45.52 الذي قدّر العتبة عند ،(2016) Shin و Seo العتبة اللوحي الديناميكي ل ذلك، تكشف نتائج الانحدار أن الدين العام الخارجي يرتبط بعلاقة غير خطية مع مختلف أبعاد النمو الشامل، في حين أن العلاقة وتبرز هذه النتائج الحاجة الملحة لبلدان إفريقيا جنوب الصحراء .بين الدين العام الخارجي ومؤشر الإدراك البيئي تتسم بالطابع الخطي إلى إصلاح الأنظمة الضريبية وتعزيز إدارة الدين العام الخارجي من أجل تحقيق نمو أكثر شمولاً

الكلمات المفتاحية :

الدين العام الخارجي، النمو الشامل، إفريقيا جنوب الصحراء، نماذج الانتقال السلس اللوحية، نموذج العتبة اللوحي الديناميكي

تصنيفات JEL: F34, O11, C23

1. Introduction

Inclusive growth is a central concept in current debates, particularly in the context of poverty reduction, inequality mitigation, and employment promotion in developing countries. The transition from the United Nations' Millennium Development Goals (MDGs) to the Sustainable Development Goals (SDGs) exemplifies this recent discourse and the growing emphasis on the concept of growth inclusiveness. The notion of inclusive growth emerged as a counterpoint to the Kuznets (1955) hypothesis, which posited that inequality initially rises during early stages of development before declining as per capita income increases implying that the benefits of growth would eventually trickle down to all social strata. However, the growth model observed in sub-Saharan Africa, characterized by rising inequality and persistent poverty (Bernard and Jean, 2020), challenges this theory. Asongu and Nwachukwu (2016) highlight the renewed policy interest in inclusive growth, while an ILO (2016) report examines how public policies can help eradicate poverty. According to this report, economic growth must benefit the majority, as public policies can foster job creation and poverty reduction through expanded fiscal revenues.

Achieving the Sustainable Development Goals requires substantial investments in various sectors, including infrastructure, education, and healthcare. The active role of governments in promoting inclusive growth is reflected in different public expenditures (Whajah and al., 2019). In developing countries, particularly in sub-Saharan Africa, governments face limited revenue mobilization options, making debt financing a critical tool for raising public funds (Chiu and Lee, 2017; Owusu-Nantwi and Erickson, 2016). Indeed, external debt in developing countries has surged in recent decades, making it a key policy concern and a highly relevant research topic (Guisse, 2016). The severity of debt issues in Africa, especially in sub-Saharan countries, has been exacerbated by recent financial crises. These nations have experienced severe fiscal deficits, reaching unsustainable debt levels and falling into debt traps (Deguenonvo and Maholisoa, 2020). According to the World Bank (2020), despite debt relief initiatives such as the Heavily Indebted Poor Countries (HIPC) Initiative and the Multilateral Debt Relief

Initiative (MDRI) by international institutions (IMF and World Bank) aimed at fostering growth, reducing poverty, and ensuring external sustainability many developing countries remain heavily indebted. Sub-Saharan Africa, in particular, accounts for 82% of the world's most indebted nations (World Bank, 2020)). Between 1996 and 2021, sub-Saharan African countries recorded an average external public debt-to-GDP ratio of 63.26%, peaking in 1998 at 125% of GDP, alongside a Gini index of 43.98% and a growth rate of 2.65%.

However, between 2010 and 2014, despite country-specific variations, the region experienced remarkable growth rates alongside a significant decline in external public debt. Yet, debt stocks surged again from 2020 onward (from 28.71% of GDP in 2011 to 51.57% in 2020), while growth rates declined (-0.49% in 2020 vs. 4.59% in 2011 and 6.69% in 2010), with alarming levels of inequality and poverty. This raises a critical question : Has debt, which is supposed to stimulate growth and employment, instead become a drag on economic activity ?

Africa, despite massive aid inflows, debt cancellations, poverty eradication initiatives, and productive base restructuring, continues to grapple with widespread poverty and deepening inequality fundamental obstacles to development. Debt financing was envisioned as a pathway out of underdevelopment. Yet, rather than alleviating poverty, debt accumulation has persisted, becoming a major constraint to poverty eradication, productive efficiency, and sustainable development. According to the World Bank (2015), Africa hosts some of the world's most unequal countries, with the lowest poverty-growth elasticity globally (Fosu, 2011) and alarming debt levels. Public debt remains a central issue in economics. For centuries, one of the dominant questions in modern macroeconomics has been the impact of sovereign public debt on economic performance.

This study contributes to the literature in three key ways. First, we develop a synthetic index of inclusive growth using a two-step principal component analysis (PCA), minimizing the bias from weighting highly correlated indicators, as highlighted by (Mishra, 2007). This approach draws on the works of Avom and al.(2021), Cámara and Tuesta (2014). Initially, we estimate five sub-indices defining inclusive growth, then compute dimension weights and the overall inclusive growth index using these dimensions as explanatory factors.

Second, our study clarifies the debate on debt thresholds in developing countries, particularly in sub-Saharan Africa, by employing a dynamic panel threshold analysis to examine how external public debt affects inclusive growth. Third, we innovate by using an adjusted model where the relationship between external public debt and inclusive growth is linear, with debt indicator levels acting as regime-switching triggers, rather than modeling nonlinearity via a squared debt term.

The paper is structured as follows: Section 2 presents a literature review; Section 3 outlines the methodology and data; Section 4 discusses the empirical findings; and Section 5 concludes.

2. Literature Review

2.1 Theoretical Review

According to Erhel (2014), public policies play a crucial social role in improving labor market functioning and social inclusion, where access to employment constitutes a fundamental dimension. Indeed, Thomas (2000) identified a positive relationship between public education expenditures, economic growth, and unemployment reduction. Similarly, Ogbu (2012) demonstrated that public spending significantly impacts inclusive growth. Chiu and Lee (2017) argue that developing countries have limited means to finance their expenditures, leading them to rely heavily on external borrowing to raise revenue. Bentour (2022) shows that fiscal multipliers are sensitive to fiscal conditions, particularly changes in public debt, as well as the business cycle.

Arawatari and Ono (2015) found that countries with low inequality levels implement strict fiscal policies and maintain low public debt ratios, unlike high-inequality countries, which adopt more flexible fiscal policies accompanied by high public debt levels. Clements and al. (2003), Elbadawi (1997), however, argue that debt servicing does not directly affect economic growth rates but negatively influences growth and development through the crowding-out effect of debt servicing on public expenditures. Additionally, Cochrane (2011) highlights that debt can generate short-term adverse effects due to the uncertainty it creates about the future, particularly concerning interest rates. Chowdhury (2004) also finds that debt negatively affects investment and economic performance. Furthermore, Ngozi and Emeka (2013) established a strong correlation between debt and poverty, showing that debt accumulation adversely impacts poverty and inequality through economic growth and investment channels. Salti (2015) identifies two key findings in his analysis of inequality determinants and the role of public debt and its components. First, the level of public debt is significantly and positively linked to inequality. Second, the share of domestic debt in public debt is also significantly and positively associated with inequality. Similarly, Liu and Bai (2023) examine the relationship between public debt and household wealth inequality, along with potential transmission channels, and show that public debt expansion raises housing prices, leading to faster wealth growth for affluent households that own relatively more real estate, thereby widening the wealth gap.

Égert (2015) demonstrates that an increase in the debt-to-growth ratio may become a burden on economic activity. Likewise, Aghion and Kharroubi (2007) find that high debt leads fiscal policies to generate volatility and promote economic growth slowdowns, thereby hindering development. This view is supported by Kim and Kim (2017), De Vita and al. (2018), who show that high debt negatively affects economic growth. Amin and Audu (2006) also conclude that external debt has a negative effect on investment, a finding echoed by Ali and Mustafa (2012), Edo and al. (2020), Dey and Tareque, (2020), who highlight debt's adverse economic effects.

However, some authors, such as Haque and Montiel, (1989), Blinder and Solow (1976) examine the effects of fiscal policy and argue that introducing interest payments on public debt could lead to a larger long-term public spending multiplier. Specifically, interest payments increase private wealth or require higher output levels so that taxes can offset government interest

payments. Blinder and Solow (1976) even suggest that borrowing is a preferable long-term budget deficit financing method compared to money creation. Other scholars, including Aschauer (1989), incorporate investment into Blinder and Solow's model and demonstrate that the economy remains stable when the government controls the sum of public expenditures and debt interest payments. Finally, Diamond (1989) and Aschauer (1989) contend that debt can contribute to capital overaccumulation and that a positive relationship exists between debt-financed public spending, economic growth, and development. Stauvermann and Kumar (2017) show that small open economies can improve education subsidies financed by public debt. In a similar vein, Davin and al. (2023) study the impact of fiscal policies on the macroeconomic and health consequences of epidemics and conclude that public debt and spending can be used to mitigate epidemic effects. Fiscal policies can promote convergence toward a stable, epidemic-free state, and even when public policies fail to permanently eradicate an epidemic, public debt and income transfers can reduce infection rates while increasing per capita capital and income.

2.2 Empirical Review

Kumar and Woo (2010) conducted a panel analysis of 38 developed and emerging economies between 1970 and 2007 to examine the relationship between public debt and economic growth. They found that, *ceteris paribus*, a 10% increase in initial debt-to-GDP ratio would reduce annual growth by 0.2%. Similar results were obtained by Stephens (2001) in a study of 24 heavily indebted poor countries, where a \$1 increase in debt service was found to reduce education expenditures by \$0.33 and wage expenditures by \$0.14 to \$0.23. Other studies have also highlighted the adverse effects of debt on economic growth. Ferreira (2009) found that high debt ratios negatively impacted growth in a sample of 20 OECD countries between 1988 and 2001. Similarly, Pattillo and al. (2004) demonstrated that external debt's negative effect on economic growth stemmed from its adverse impact on capital accumulation and total factor productivity.

More recent research has corroborated these findings. Law and al. (2021) identified a threshold of 51.64% beyond which public debt exerts a negative effect on economic growth in a sample of 71 developing countries between 1984 and 2015. Sandow and al. (2022) found that external debt had a significant negative impact on economic growth in 31 sub-Saharan African countries from 2005 to 2017, with a threshold of 45%. Reinhart and Rogoff (2010) examined economic growth and inflation at various public debt levels in developed and emerging economies and found that economic growth declined by 1.2% when debt exceeded 90% of GDP. Checherita-Westphal and Rother (2012) identified a U-shaped relationship between public debt and growth in 12 Eurozone countries, with a negative marginal effect when the debt-to-GDP ratio reached 90–105%.

Other studies have further emphasized the nonlinear relationship between debt and economic growth. Pattillo and al. (2002), Boukhatem and Kaabi (2015) found that public debt stimulated economic growth up to a certain threshold before turning detrimental. Hassan and Meyer (2020) estimated a threshold of 44–53% for the external debt-to-GDP ratio in sub-Saharan African countries.

Finally, country-specific studies have reinforced these conclusions. Adeve (2016) found that external debt had a nonlinear effect on productive efficiency in Togo, while Drine and Nabi (2010) identified an 84% threshold for developing countries.

3. Data and Methodology

3.1 Data

This study employs a dynamic panel regression analysis of 27 sub-Saharan African countries spanning the period 1996-2021. The empirical framework incorporates inclusive growth as the dependent variable, constructed through a composite index derived from carefully selected indicators corresponding to the fundamental pillars of inclusive growth (ADB, 2013; UN, 2004), as detailed in the appendix. The explanatory variables include external public debt (our primary variable of interest) along with control variables comprising trade openness, labor productivity, gross fixed capital formation, inflation, and population growth. All data are sourced from the World Bank's World Development Indicators database for the studied sub-Saharan African countries. Our variable selection is grounded in the established literature on external public debt and growth, particularly drawing on the work of Law and al. (2021). External debt is operationalized as the ratio of total external debt stock to GDP. Control variables include trade openness measured as the sum of exports and imports of goods and services as a percentage of GDP, following Whajah and al. (2019), Law and al., 2021), which has been shown to stimulate growth (Musila and Yiheyis, 2015) ; labor productivity measured as GDP per employed person, following (Anand and al., 2013); gross fixed capital formation; inflation (which exhibits inverse effects on growth according to Law et al. (2021); and population growth (annual rates from World Bank indicators). The complete dataset, covering the period 1996-2021, was extracted from the World Bank database. Table 1 presents the descriptive statistics for all variables included in our estimations across the 27 sub-Saharan African countries under examination.

Table 1: Descriptive Statistics of Variables for the Period 1996-2021.

Variable	Obs	Mean	Std. dev.	Min	Max
Isci	702	0.458	0.25	0	1
Debt	702	63.259	56.384	9.426	506.037
Crxdem	702	2.715	0.969	-0.112	16.626
Pibcap	702	1346.339	1578.85	246.387	8963.205
Trade	702	56.665	23.89	4.128	156.862
Fbcf	702	14.949	7.192	0	73.64
Ifi	702	19.341	162.846	-8.975	4145.106

Note: isci: inclusive growth, debt: external public debt, crxdem: population growth, pibcap: labor productivity, trade: trade openness, fbcf: gross fixed capital formation, ifi: inflation.

Source : Authors's calculations

3.2 Methodology

Inclusive growth represents an abstract concept determined by the interaction of multiple variables with an underlying latent structure that can be identified through an information system, such as a composite inclusive growth index. To construct this index, we employ a two-step principal component analysis (PCA) approach, which offers the advantage of using non-uniform weights that account for data variability (Bernard and Jean, 2020). This method avoids biases toward highly correlated indicators, as highlighted by Mishra (2007). Following the strategy adopted by Avom and al.(2021), Cámara and Tuesta (2014), Nagar and Basu (2004). We first estimate sub-indices rather than directly computing the overall index, selecting all indicators simultaneously. Drawing on McKinley (2010), our analysis is structured around five pillars of inclusive growth (detailed in Appendix 1). Factor retention follows the Kaiser (1974) criterion, which recommends retaining principal components with eigenvalues exceeding the mean.

In the context of the debt-growth relationship, numerous studies, such as Kumar and Woo (2010), Pattillo and al. (2002), Greiner (2012), have explored this linkage. However, the most fruitful approach is the nonlinear one, given the debt stock of countries. With this in mind, we analyze the relationship between external public debt and inclusive growth using the Panel Smooth Transition Regression (PSTR) model developed by Gonzales and al. (2005). This framework provides an economic explanation for nonlinearity by identifying whether an economic series exhibits distinct dynamics across different regimes, facilitated by a smooth transition function and a transition variable that evolves simultaneously across both individual and temporal dimensions. The PSTR model is employed when the dependent variable may be influenced by a continuous and bounded function of the explanatory variable. Its advantage lies in its ability to form homogeneous subgroups of individuals. The model is defined by the process y_{it} , ($t \in \mathbb{Z}$ et $i \in \mathbb{Z}$) which satisfies a representation of PSTR models with two regimes if and only if $y_{it} = \mu_i + \beta_1 X_{it} + \beta_2 X_{it} G(q_{it}, \gamma, c) + \varepsilon_{it}$: Where μ_i is the vector of individual fixed effects, $G(q_{it}, \gamma, c)$ denotes the transition function associated with a transition variable q_{it} , a threshold value c , and a smoothing parameter γ . $X_{it} = (X_{it}^1, \dots, X_{it}^k)$ is the matrix of k explanatory variables excluding lagged endogenous variables, $\beta = (\beta_1, \dots, \beta_k)$ where ε_{it} is $iid(0; \sigma_\varepsilon^2)$. Here $i = 1, \dots, N$ represents the individual dimension, and $t = 1, \dots, T$ denotes the temporal dimension.

The Panel Smooth Transition Regression (PSTR) model can be interpreted in two distinct ways. First, it can be viewed as a heterogeneous linear panel model with coefficients that vary across individuals and over time. The heterogeneity of regression coefficients is accounted for by assuming that these coefficients are continuous, bounded functions of an observable variable called the transition variable. This allows the coefficients to fluctuate between the bounds (often two) of extreme regimes. Second, the PSTR model can simply be regarded as a homogeneous nonlinear panel model. The latter interpretation is more common in the context of smooth transition autoregressive regression. The smooth transition mechanism between regimes can be

modeled using various transition functions, provided they are continuous and integrable over the interval $[0, 1]$. Gonzales and al. (2005) suggest a logistic function of order m :

$$G(q_{it}; y, c) = [1 + \exp(-\gamma \prod_{j=1}^m (q_{it} - c_j))]^{-1} \quad \text{where} \quad \gamma > 0, c_1 < c_2 < \dots < c_m \quad \text{with} \quad c = (c_1, \dots, c_m)'$$

being an m -dimensional vector and γ the smoothing parameter associated with the transition function. They recommend considering $m = 1$ or $m = 2$, as this allows sufficient flexibility in slope coefficients to capture most cases of nonlinearity arising from regime shifts. The smoothing parameter γ determines the speed of transition between regimes. Thus, if the smoothing parameter is large, the transition between two regimes becomes abrupt. Notably, the PSTR model reduces to the Panel Threshold Regression (PTR) model when the smoothing parameter approaches infinity. Conversely, when the smoothing parameter γ is very small, the PSTR model effectively behaves as a homogeneous linear model with individual fixed effects. The extension proceeds in two stages. The equation can be rewritten as follows:

$$y_{it} = \mu_i + \beta_1 X_{it} + \beta_2 X_{it} G(q_{it}, \gamma, c) + \varepsilon_{it}$$

The first step involves estimating and eliminating individual fixed effects, followed by estimating the regression coefficients using nonlinear least squares.

This initial step requires computing individual means for the equation while accounting for the influence of the threshold problem c and the smoothing parameter γ . Specifically, we center the dependent variable and residuals around their individual means. In other words, this step aims to remove fixed effects between individuals over time, which could otherwise bias the estimates. This is achieved by subtracting individual-specific means a procedure commonly referred to as the "within transformation." In threshold models, this transformation demands particular attention. Since individual effects depend on the thresholds, they must be recalculated

for each value. This yields the transformed model: $y_{it} = y_{it} - \bar{y}_{it}$ with $\bar{y}_{it} = \frac{1}{T} \sum_{t=1}^T y_{it}$ and:

$u_{it} = u_{it} - \bar{u}_{it}$ avec $\bar{u}_{it} = \frac{1}{T} \sum_{t=1}^T u_{it}$. To eliminate individual fixed effects from the independent

variables, we proceed in two parts. For explanatory variables independent of the transition function (first extreme regime), the mean is removed:

$x_{it} = x_{it} - \bar{x}_{it}$ with $\bar{x}_{it} = \frac{1}{T} \sum_{t=1}^T x_{it}$. For variables dependent on the transition function, we derive:

$$w_{it}(\gamma, c) = x_{it} G(q_{it}, \gamma, c) - \bar{w}_{it}(\gamma, c) \quad \text{with} \quad \bar{w}_{it}(\gamma, c) = \frac{1}{T} \sum_{t=1}^T x_{it} G(q_{it}, \gamma, c)$$

The equation can then be rewritten without individual effects as: $\tilde{y}_{it} = \beta'(\gamma, c) \bar{z}_{it}(\gamma, c_j) + \bar{u}_{it}$ where $\beta'(\gamma, c) = (\beta'_1(\gamma, c) \beta'_2(\gamma, c))$ and $\bar{z}_{it}(\gamma, c_j) = [\bar{x}_{it} : \bar{w}_{it}(\gamma, c)]$ are matrices of explanatory variables that depend on the transition function and must be recalculated for each pair of threshold c and smoothing parameter γ . After applying the within transformation, nonlinear least squares are used to estimate the model coefficients. Specifically, we minimize the residual

sum of squares of the PSTR model with respect to the slope coefficients, threshold, and smoothing parameters. For a given pair (c, γ) , the slope coefficients of the extreme regimes can be estimated using least squares;

$$\hat{\beta}(\gamma, c) = \left[\sum_{i=1}^N \sum_{t=1}^T \bar{z}_{it}''(y, c)' \bar{z}_{it}''(y, c) \right]^{-1} \left[\sum_{i=1}^N \sum_{t=1}^T \bar{z}_{it}''(y, c)' y_{it} \right]$$

Subsequently, the transition function parameters γ and c are estimated via nonlinear least squares using the following optimization program:

$$\text{ArgMin} = \sum_{i=1}^N \sum_{t=1}^T [\bar{y}_{it} - \hat{\beta}'(\gamma, c) \bar{z}_{it}''(y, c)]^2$$

Using the estimates of c and γ , the slope coefficients can be re-estimated via the least squares estimation equation. When residuals are assumed to be normally distributed, this estimation method is equivalent to a concentrated maximum likelihood procedure.

Since the domain of the smoothing parameter γ is no longer finite, and the distance between the threshold parameter and the transition variable influences the value of the transition function, it is no longer possible to solve the previous program by scanning over an interval as in PTR models. The use of a numerical optimization algorithm becomes necessary. However, the convergence of these coefficients is highly dependent on the choice of initial conditions for the parameters. The solution proposed by Colletaz and Hurlin (2006) is to create a parameter search grid by selecting multiple possible values for the smoothing parameter and the threshold (chosen from the transition values).

The next step is to select the pair that minimizes the sum of squared residuals (SSR) and use it as a starting value. Another solution, proposed by Gonzales and al. (2005), is the use of the simulated annealing algorithm. Following the methodology for threshold regime tests, the first step in PSTR models is to test linearity. If the null hypothesis is not rejected, the testing strategy stops, and a new alternative hypothesis must be formulated for example, by selecting a new transition variable. Conversely, if the linearity hypothesis is rejected, two misspecification tests, originally defined for univariate models by Eitrheim and Teräsvirta (1996) must be sequentially implemented. Specifically, for misspecification testing, two tests adapted by Gonzales et al. (2005) for panel data are considered : the parameter constancy test and the residual nonlinearity test. The latter is performed upon rejection of linearity to determine the number of transition functions to employ.

4. Empirical Results

4.1. Main Results

4.1.1. Linearity Test

The results of the linearity (or homogeneity) test (Table 2) reveal that the relationship between external public debt and inclusive growth is nonlinear in the Sub-Saharan African subregion, depending on the level of indebtedness in each member country. This nonlinearity arises from heterogeneity, as evidenced by the rejection of the null hypothesis of homogeneity (or linearity) in the panel structure. The PSTR model effectively accounts for this heterogeneity. The relationship between external public debt and inclusive growth is characterized by a regime transition, where the nature of the relationship (positive or negative) may differ across regimes.

Thus, depending on the regime, external debt may have either a positive or negative effect on inclusive growth. The linearity test results presented in Table 2 confirm this nonlinearity, with the following significance values: Wald test (p-value = 0.000), Fisher test (p-value = 0.000), and LRT test (p-value = 0.000). These results validate the use of the PSTR model to capture the complexity of the relationship between external public debt and inclusive growth in Sub-Saharan Africa.

Table 2: Homogeneity Test Results

Tests	Inclusive Growth Index (IGI)	
	Statistic	P-value
Lagrange Multiplier - Wald (LM_W)	41.212	0.000
Lagrange Multiplier Fisher (LM_F)	6.954	0.000
Likelihood ratio (LR)	42.471	0.000

Notes : $H_0: r = 0$ (homogeneous panel with fixed effects) vs. $H_1: r = 1$ (PSTR with at least one transition function). Source : Authors's calculations

Source : Authors's calculations.

4.1.2. Test for No Remaining Heterogeneity

The test for no remaining heterogeneity (Table 3) supports the selection of $m = 1$, as a first-order transition function ($m = 1$) better captures the shift between regimes. Table 3 reports the significance values (p-values) of the tests conducted, including the Wald test (p-value = 0.113), Fisher test (p-value = 0.136), and LRT test (p-value = 0.110). These results indicate that the two-regime PSTR model is more statistically significant, thereby better accounting for the heterogeneity in the relationship between external public debt and inclusive growth in Sub-Saharan African countries. In other words, the nonlinearity between external public debt and inclusive growth is more accurately captured by a two-regime PSTR model. These specification tests confirm that Models 1 and 2 better explain the relationship between external debt and inclusive growth in Sub-Saharan countries, characterized by two distinct phases (two extreme regimes). First phase (first extreme regime): External debt has a positive effect on inclusive growth in Sub-Saharan African countries. Second phase (second extreme regime): External public debt has a negative effect on inclusive growth.

The transition between regimes occurs gradually. The parameter estimates of the model will provide further insights into the two external debt regimes. Given that the estimated PSTR model with one transition is appropriate, we proceed to the next step: interpreting the results of the estimated PSTR model (Table 4).

Tableau 3 : Test for No Remaining Heterogeneity

Tests	Inclusive Growth Index (IGI)	
	Statistic	P-value
Lagrange Multiplier - Wald (LM_W)	10.300	0.113
Lagrange Multiplier Fisher (LM_F)	1.630	0.136
Likelihood ratio (LR)	10.376	0.110

Notes : H_0 : $r = 1$ (PSTR with two regimes) vs. H_1 : $r = 2$ (PSTR with three regimes).

Source : Authors's calculations.

4.1.3. PSTR Estimation Results

The analysis of the model parameters reveals contrasting relationships between the studied variables and inclusive growth, depending on the regime. In the first regime, population growth is positively associated with inclusive growth, aligning with Simon's theory (1987, 1987) extended to inclusive growth. Conversely, in the second regime, this relationship turns negative, confirming the findings of Kremer and Chen (2002) who demonstrate that inequality is linked to larger fertility disparities within countries, leading to weaker growth. The latter relationship suggests that a large population hinders wealth redistribution and, consequently, inclusive growth.

The results also indicate a positive relationship between labor productivity and inclusive growth, consistent with the World Bank's definition, which incorporates labor productivity into the growth inclusion process. Furthermore, Table 4 reveals a negative relationship between trade openness and inclusive growth in the first regime, corroborating the conclusions of the ILO and WHO (2011). However, in the second regime, this relationship becomes positive, aligning with Stolper and Samuelson's (1941) analysis of trade liberalization's impact on inequalities, derived from the Heckscher-Ohlin trade model, which posits that trade liberalization reduces inequalities in developing countries.

Table 4 shows a positive relationship between gross fixed capital formation (investment) and inclusive growth, supporting Keynesian theories that investment positively affects economic growth, which in turn reduces unemployment and broadens participation in the growth process. In contrast, inflation and inclusive growth exhibit a negative relationship, consistent with Reinhart and Rogoff (2010) findings. Since inclusive growth encompasses all social strata, a rise in the general price level, including essential goods for the most vulnerable, significantly impacts inclusive growth.

These results align with Friedman's (1970) theory, which advocates combating inflation as a threat to economic stability. Similarly, Dornbusch and Edwards (1995; 2007) argue that expansionary policies and inflationary spending yield short-term gains but ultimately lead to macroeconomic crises marked by high inflation, undermining growth and hindering sustainable redistribution and inequality reduction, as emphasized by Cardoso and Helwege (1991).

Table 4 : Regression Results of Parameters

Parameter s	Inclusive Growth (IGI)	
	Lower Regime (1)	Upper Regime (2)
Debt	0.0034** (0.0011)	-0.0049*** (0.0011)
Crxdem	0.0156*** (0.0203)	-0.0313 (0.0192)
Pibcap	-0.0041 (0.0031)	-0.0032 (0.0038)
Trade	-0.001 (0.0009)	0.0039*** (0.0008)
Fbcf	0.0134*** (0.0031)	-0.0107** (0.0034)
Ifi	-0.0052** (0.0017)	0.0052** (0.0017)

Notes : *, **, *** denote statistical significance at the 1%, 5%, and 10% levels, respectively; standard errors in parentheses. IGI: inclusive growth, debt: external public debt, crxdem: population growth, pibcap: labor productivity, trade: trade openness, fbcf: gross fixed capital formation, ifi: inflation.

Source : Author's calculations.

4.1.4. Transition Parameter Results

The tests corroborate the conclusions regarding the effect of external debt on inclusive growth. A threshold is estimated at 47.30%. The results confirm the significance of a single threshold, while a double threshold test proves insignificant, supporting the existence of a unique threshold in this relationship.

The estimation results in Tables 4 and 5 show a positive effect of external debt on inclusive growth initially, followed by a negative effect beyond the threshold. This highlights a non-linear relationship between external public debt and inclusive growth, with a threshold of 47.30% of the debt-to-GDP ratio. This finding aligns with the results of Pattillo and al. (2002), Reinhart and Rogoff (2010), Elbadawi and al. (1997), Guisse (2016). The inverse relationship in the second phase can be attributed to the substantial interest payments on external debt in Sub-Saharan African countries. As external debt rises, future interest payments increase, potentially undermining wealth redistribution and reducing welfare, consistent with Barro's (1974) Ricardian equivalence. Over the medium term, debt substitutes for taxes, necessitating higher tax burdens to service external debt. According to DiPeitro and Anoruo (2012), economies have surpassed the optimal debt threshold, leading to a negative relationship between external debt and inclusive growth in Sub-Saharan Africa beyond 47.30%.

Table 5 : Transition Parameters

Transition Parameters	Inclusive Growth (IGI)
Threshold (c)	47.2986
Slope	385.9047
Number of Countries	27

Source : Authors

4.2. Estimation Results of External Public Debt Effects on the Pillars of Inclusive Growth

A thorough examination of the effects of external public debt on the pillars of inclusive growth productive development, social inclusion, human capital, social protection, and governance reveals an intrinsically non-linear relationship marked by structural heterogeneity across Sub-Saharan African countries. Linearity and residual homogeneity tests (Tables 6 and 7) systematically reject the null hypothesis of a uniform relationship, with the notable exception of the environmental pillar. For this dimension, Wald (p-value = 0.149), Fisher (p-value = 0.168), and likelihood ratio (LRT p-value = 0.146) tests confirm statistically significant linearity. This divergence underscores the uniqueness of the environmental pillar, whose dynamics remain unaffected by debt thresholds, unlike other inclusive growth dimensions, where observed heterogeneity reflects regime-switching behavior. Specifically, the impact of external debt on these pillars varies discontinuously depending on debt levels (Table 9). This non-linearity implies that the debt-inclusive growth relationship is neither monotonic nor stable but heavily contingent on each country's debt regime. Models 1, 2, 3, and 5, validated by specification tests, support the hypothesis of a biphasic relationship characterized by two extreme regimes.

In the first phase (lower regime), external debt exerts a positive effect on all pillars productive development, inclusion, human capital, social protection, and governance in Sub-Saharan African countries. Conversely, in the second phase (upper regime), external public debt negatively impacts these same pillars. The transition between regimes occurs gradually. Furthermore, our regression results demonstrate that external public debt exhibits non-linear relationships with the various dimensions of inclusive growth, each associated with distinct thresholds :

- Productive development : A threshold of 161.13% of GDP was identified, below which public debt exerts positive effects.
- Inclusion : A threshold of 47.12% of GDP was identified, below which public debt exerts positive effects.
- Human capital : A threshold of 47.29% of GDP was identified, below which public debt exerts positive effects.
- Social protection and governance : A threshold of 71.47% of GDP was identified, below which public debt exerts positive effects.

In contrast, the relationship between debt and the environmental perception index is linear. The model's parameter estimates provide insights into the two external debt regimes.

Table 6 : Homogeneity Tests

	Productive Development		Inclusion		Human Capital		Environment		Social Protection & Governance	
Tests	Stat	P-value	Stat	P-value	Stat	P-value	Stat	P-value	Stat	P-value
Lagrange Multiplier - Wald (LM_W)	111.147	0.000	42.101	0.000	43.911	0.000	9.464	0.149	51.618	0.000
Lagrange Multiplier Fisher (LM_F)	20.975	0.000	7.114	0.000	7.440	0.000	1.524	0.168	8.849	0.000
Likelihood ratio (LR)	121.001	0.000	43.416	0.000	45.344	0.000	9.529	0.146	53.614	0.000

Source : Authors's calculations.**Table 7 : Residual Heterogeneity Tests**

	Productive Development		Inclusion		Human Capital		Environment		Social Protection & Governance	
Tests	Stat	P-value	Stat	P-value	Stat	P-value	Stat	P-value	Stat	P-value
Lagrange Multiplier - Wald (LM_W)	9.948	0.127	19.064	0.004	8.113	0.230	10.188	0.117	36.885	0.000
Lagrange Multiplier Fisher (LM_F)	1.574	0.152	3.057	0.006	1.280	0.264	1.613	0.141	6.073	0.000
Likelihood ratio (LR)	10.019	0.124	19.327	0.004	8.161	0.227	10.263	0.114	37.890	0.000

Source : Authors's calculations.**Table 8 : Regression Results of Parameters**

	Productive Development		inclusion		Human Capital		Environmen t	Social Protection & Governance	
parameters	Lower Regime (1)	Upper Regime (2)	Lower Regime (1)	Upper Regime (2)	Lower Regime (1)	Upper Regime (2)	(1)	Lower Regime (1)	Upper Regime (2)
Debt	-0.0028*** (0.0007)	0.0029*** (0.0006)	0.0035*** (0.0009)	-0.0045*** (0.0009)	0.0019* (0.0011)	-0.0035** (0.0011)	0.0025*** (0.0006)	0.0009** (0.0004)	-0.0004 (0.0004)
crxdem	0.0762*** (0.0175)	-0.1680* (0.0701)	-0.0290* (0.0155)	0.0220 (0.0140)	0.0322 * (0.0194)	-0.0416* (0.0180)	-0.0400*** (0.0119)	-0.0053 (0.0084)	0.0215* (0.0105)
pibcap	0.0048* (0.0027)	-0.0018 (0.0070)	0.0002 (0.0019)	-0.0027 (0.0025)	-0.0033 (0.0027)	-0.0033 (0.0029)	0.0028* (0.0012)	-0.0018 (0.0011)	-0.0000 (0.0024)
trade	-0.0101*** (0.0008)	-0.0139*** (0.0019)	0.0005 (0.0006)	0.0012 * (0.0006)	-0.0014 * (0.0008)	0.0027*** (0.0007)	0.0004 (0.0005)	0.0004 (0.0004)	-0.0028*** (0.0005)
fbcf	0.0125*** (0.0029)	-0.0265** (0.0096)	0.0079*** (0.0020)	-0.0058 * (0.0023)	0.0105 *** (0.0026)	-0.0075* (0.0030)	0.0042** (0.0015)	-0.0007 (0.0008)	0.0024 (0.0018)
ifl	0.0006 (0.0007)	-0.0012 (0.0011)	0.0001 (0.0015)	-0.0001 (0.0015)	-0.0034* (0.0014)	0.0034* (0.0014)	0.0000 (0.0010)	-0.0000 (0.0002)	-0.0000 (0.0002)

Notes : *, **, *** denote statistical significance at the 10%, 5%, and 1% levels, respectively ; standard errors in parentheses. IGI : inclusive growth, debt : external public debt, crxdem : population growth, pibcap : labor productivity, trade: trade openness, fbcf: gross fixed capital formation, ifl: inflation.

Table 9 : Transition Parameters

Transition Parameters	Productive Development	inclusion	Human Capital	Social Protection & Governance
Threshold (c)	161,13	47.12	47.29	71.4665
slope	0.0149	549.0377	417.8958	0.2100
Number of Countries	27	27	27	27

Source : Source : Authors's calculations**4.3. Robustness Tests**

To test the robustness of the regression results on the effects of external public debt on inclusive growth in Sub-Saharan Africa (SSA), we adopt the approach of Seo and Shin (2016). Their first-difference GMM estimator treats both the threshold variable and regressors as endogenous, thereby addressing potential endogeneity issues in the threshold variable.

Table 10: Results from the Seo and Shin (2016) Dynamic Threshold Regression

VARIABLES	(1) Lower Regime	(2) Upper Regime
IGI	0.752*** (0.276)	-0.126 (0.232)
Debt	0.0511 (0.0350)	-0.0520* (0.0284)
crxdem	1.071*** (0.371)	-0.869* (0.502)
pibcap	0.000319** (0.000159)	-0.000211*** (3.89e-05)
trade	-0.0219** (0.0104)	0.00436 (0.0138)
fbcf	0.0357* (0.0192)	-0.0235 (0.0241)
ifl	0.0305 (0.0243)	-0.0377 (0.0256)
Constant	6.084*** (1.629)	
Threshold	45.52*** (7.667)	
Confidence interval	[30.4896 ;60.5421]	
Observations	27	

Notes : Standard errors in parentheses. * p<0.01, ** p<0.05, *** p<0.1. All differences are first-differences.

Source : Authors's calculations.

The robustness results presented in Table 10, obtained through the dynamic panel model extension with a potentially endogenous threshold variable, reveal a debt threshold effect on the synthetic inclusive growth index estimated at 45.52% of GDP. This confirms the non-linear relationship between external public debt and inclusive growth previously observed with

smooth transition panel models. The external debt coefficient is positive in the first regime and negative in the second regime, above the threshold, characterizing the dual-phase evolution of external public debt effects on inclusive growth.

When external public debt is below the estimated 45.52% threshold, it has positive effects on inclusive growth. Conversely, when external debt exceeds this threshold, it exerts negative effects. These findings show similarities with the Panel Smooth Transition Regression results, particularly the close threshold estimate of 47.30% of GDP, demonstrating the robustness of the external debt-inclusive growth regressions.

5. Conclusion

This paper employed Panel Smooth Transition Regression (PSTR) models (Gonzales et al., 2005) and the dynamic threshold panel extension (Seo et al., 2019) to analyze the effects of external public debt on inclusive growth in 27 Sub-Saharan African countries between 1996 and 2021. Motivated by the existence of different debt thresholds, this study contributes to the literature on external public debt and inclusive growth in the subregion, using innovative panel estimation. The results reveal a non-linear effect of external public debt on inclusive growth.

Applying smooth transition regression models to Sub-Saharan African data shows that: (1) the relationship between external public debt and inclusive growth is not linear in the medium term; (2) the relationship reveals a single threshold estimated at 47.30% of GDP, beyond which external public debt becomes negative and a significant determinant of inclusive growth. Additionally, the positive effects of gross fixed capital formation (investment) on inclusive growth, as well as the negative effects of external public debt and population growth beyond the 47.30% of GDP threshold, were highlighted.

The empirical results are robust in terms of significance, sign, and estimation methods. Dynamic threshold panel extension estimates show a threshold of 45.52% of GDP, confirming the dependence of the external public debt-inclusive growth relationship on the debt threshold. It is therefore crucial to know the debt ceiling. Given that Sub-Saharan African countries have a low external public debt threshold, economic policymakers must exercise caution regarding their external public debt levels. Furthermore, our more detailed regression results show that public debt has a non-linear relationship with different dimensions of inclusive growth, characterized by specific thresholds for each dimension :

- Productive development: a threshold of 161.13% of GDP was identified, below which public debt has positive effects on this dimension.
- Inclusion: a threshold of 47.12% of GDP was identified, below which public debt has positive effects on this dimension.
- Human capital: a threshold of 47.29% of GDP was identified, below which public debt has positive effects on this dimension.
- Social protection and governance: a threshold of 71.47% of GDP was identified, below which public debt has positive effects on this dimension.

In contrast, the relationship between external public debt and the environmental perception index is linear.

Policy recommendations from the analysis emphasize the need for Sub-Saharan African countries to make growth more inclusive by increasing available funds to create jobs that absorb more poor people into society. It is essential to direct public investments toward productive sectors, enabling mass participation in the growth process, and to strengthen debt policy coordination through prudent debt management ; productive investments ; inclusive fiscal policies ; monitoring and evaluation; and institutional capacity building.

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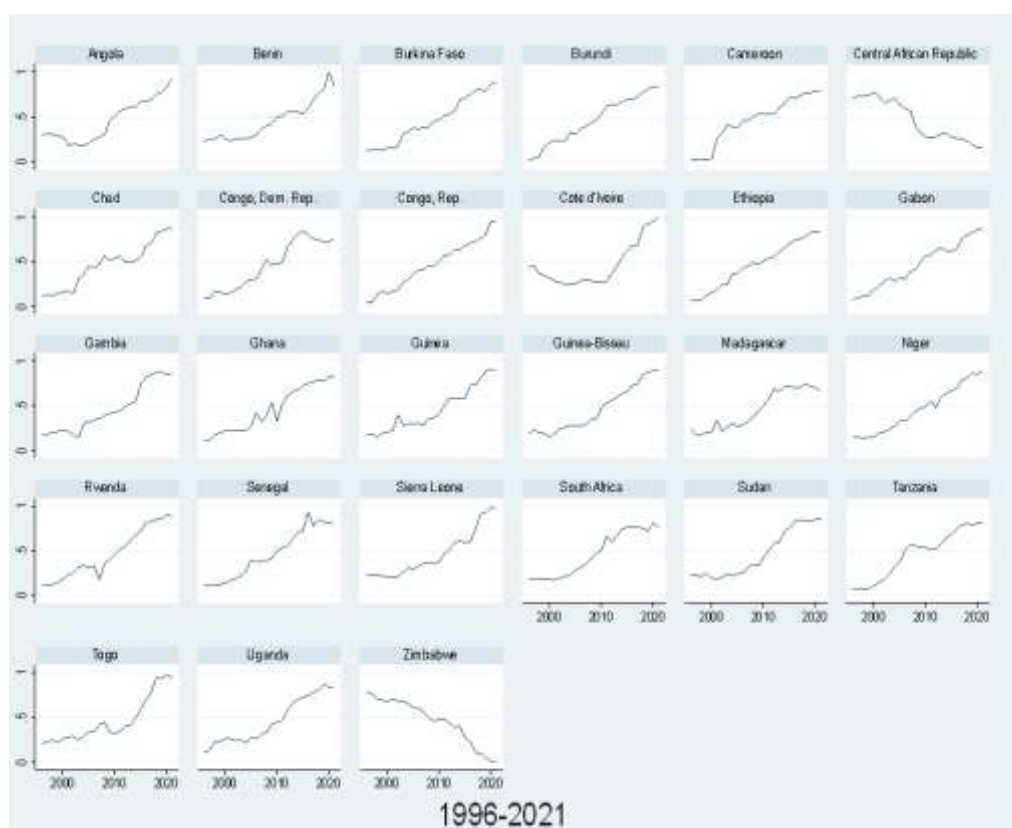
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Appendices: Supplementary data

Appendix 1.1: Inclusive growth indicators

First pillar: productive development,	- Economic growth Udah and Bassey (2013), Ali and Son (2007), IMF (2022)	GDP growth rate
	- Productive employment World Bank (2009), ADB (2016),	unemployment rate, employment/population ratio, share of paid employment, share of employment in industry, share of employment in agriculture
	- Economic infrastructure Khan and al (2016) , ADB (2016), Fernando (2008)	Mobile Internet subscription rate, electricity rate.
Second pillar: inclusion	- Poverty and inequality Lopez and Serven (2015), Ali and Son (2007)	poverty index, poverty gap, Gini index
	- Gender Hsieh and al. (2019),	The ratio of women to men at work.
Third pillar: human capital	- Health, demography and sanitation IMF (2022), Mckinley (2010)	Life expectancy at birth, mortality rate, proportion of population with access to drinking water, public spending on health
	- -Education Balakrishman and al. (2013)	Public expenditure on education.
Fifth pillar: social protection and governance	- Social protection Ali and Son (2007)	The vulnerable employment rate
	- Governance (ADB,2011).	corruption perception index
Fourth pillar: environment	- Environmental performance Ali (2007)	environmental performance index

Source: AuthorsAppendix 2: Evolution of the Composite Inclusive Growth Index



Source: Authors