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Article

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DEVELOPMENT ECONOMICS | RESEARCH ARTICLE

Public debt and economic growth in sub-Saharan Africa: Nonlinearity and threshold effects

Princewill U. Okwoche^{1*} and Christine S. Makanza¹

Abstract: Most studies on the effects of debt on growth, particularly following the global financial crisis, have focused mainly on the advanced and emerging countries. Our focus on sub-Saharan Africa (SSA) derives from the recent experience of slow growth at a time of rising debt in the sub-region. This approach allows us the opportunity to fit a model that accounts for some region-specific characteristics, such as the quality of institutions and policies, conflict, and adverse terms of trade shocks. Our dataset comprises 24 SSA countries spanning 39 years from 1980 to 2018. We employ a variety of panel estimation techniques suitable for addressing the problems of endogeneity and cross-section dependence. The fixed effects instrumental variable technique is used as the baseline technique, while the bias corrected least-squares dummy variable and the limited information maximum likelihood are used for robustness. In agreement with recent literature, we find compelling evidence in support of a nonlinear relationship between debt and growth, which suggests that public debt may become harmful to growth if it rises beyond a certain level. Further to that, the evidence presents a threshold estimate

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PUBLIC INTEREST STATEMENT

Sub-Saharan Africa's (SSA) public debt problem has been persistent for several decades, with many countries struggling to manage their debt burdens. In recent years, this problem has only become more pressing as debt levels have risen to unsustainable levels, threatening economic growth and sustainability in many countries in the region. This study examines the economic growth effect of debt in SSA focusing on the nonlinear and threshold effects. It employs a panel dataset that comprises 24 countries over 1980–2018. Empirical evidence from the study points to a nonlinear relationship between debt and growth, which shows that increases in public debt could have adverse growth effects if accumulated beyond a certain threshold. Further to that, the evidence presents a threshold estimate of 78–85% in most cases, beyond which debt becomes a drag on economic growth. The use of different empirical estimation techniques led to variations in threshold estimates, indicating the importance of conducting debt–growth studies specific to each country for more nuanced findings.

of 78–85% in most cases. Some variations in threshold estimates based on differences in empirical estimation techniques were observed, which point to the need to localize debt–growth studies to country-specific cases for more applicable results. Policy implications based on these findings are discussed.

Subjects: Research Methods in Development Studies; Economics and Development; Economics

Keywords: Growth; gross government debt; nonlinearity; endogeneity; cross-section dependence

Jel Classification: E62; H63

1. Introduction

Africa's poor economic performance in comparison with other developing countries in the 1980s and 1990s set off a heated debate in the growth literature where much attempt was made to explain the variability in growth (see, for example, Barro & Lee, 1994; Collier & Gunning, 1999; Easterly & Levine, 1997; Sachs & Warner, 1995). It was common among these growth studies to employ a large near-global sample and use regional dummies to capture the difference between sub-Saharan Africa (SSA) and other regions. The lack of statistical significance of the African regional dummy was used to evaluate the difference between the Africa and other regions in the standard explanatory variables. Several studies, however, found a significant African dummy (Barro & Lee, 1994; Collier & Gunning, 1999; Easterly & Levine, 1997) which meant that Africa's slow growth was attributable, even if partly so, to a set of variables that were globally important to the growth process, but that were less effective in African economies. It, therefore, seemed clear to researchers that certain factors specific to the region were responsible for the slow growth problem. Collier and Gunning (1999), for example, argued that SSA's poor economic performance was the result of the lack of social capital typically reflected by the high incidence of corruption. Similar arguments have been made from the related viewpoints of poor institutions and policies, economic mismanagement, and ethnic fractionalization (e.g., Cohen, 1997; Easterly & Levine, 1997).

Although it was widely agreed that the relatively poor growth of SSA countries was due to region-specific factors, the debt overhang problem¹ was at the same time one of the topmost sources of macroeconomic concerns in the sub-region (Elbadawi et al., 1997). Quite unsurprisingly, it was considered the main macroeconomic determinant of the slow and negative economic performance that was witnessed during the period (Battaile et al., 2015; Elbadawi et al., 1997). In response to the problem, two debt relief packages were launched, namely, the heavily indebted poor countries (HIPC) initiative in 1996, and the multilateral debt relief initiative (MDRI) in 1999. The centrality of the debt overhang problem and its effects on economic performance at the time made it a major topic of academic and policy dialogue in the sub-region (Ajayi, 1991; Elbadawi et al., 1997; Fosu, 1999).

It turns out that for about two decades beginning in the mid-1990s, that is, following the era of slow growth, the majority of SSA countries have experienced significant growth and development. It is noted, for example, that the period between 1990 and 2015 was marked by improvements in human development outcomes in SSA (Selassie, 2018). Typical examples of these outcomes are the increases in life expectancy, declines in mortality rates, and the narrowing of the infrastructure gap. Although these have been attributed to improved policies and institutions (IMF, 2019), they have also been credited to the debt relief packages offered to heavily indebted poor countries the majority of which are in SSA (Battaile et al., 2015; IMF, 2017; Selassie, 2018). Considering that debt may only be beneficial at reasonably low levels (Pattillo et al., 2002), one can imply that the era of increasing growth in SSA was a result of debt relief which increased the fiscal space and freed up

the much-needed resources in the beneficiary countries of SSA. A troubling reality in recent years, however, is that the episode of increasing growth appears to have been replaced by a slow growth episode beginning in 2015.

It is concerning that the outset of the recent episode of declining growth rates in parts of SSA coincides with the new episode of growing debt in the sub-region which began in the wake of the global financial crisis. Many economically fragile states are already behind on their debt service responsibilities and thus require debt restructuring.² Moreover, even in countries where the public debt burden is manageable, debt service obligations have taken a growing percentage of government revenues (IMF, 2019). Analysts worry that if left unchecked, this new wave of rising debt could bring back the experience of debt crisis that was witnessed in previous decades (Atingi-Ego et al., 2021; Coulibaly et al., 2019). The question of how debt affects growth continues to be relevant in African economies. Much of the previous studies, particularly since the outset of the global financial crisis, have focused on the advanced and emerging market economies. This study examines the debt-growth nexus for the case of SSA countries. It aims to investigate the presence or otherwise of a nonlinear relationship and to present threshold estimates that are unique to SSA. Our focus on the case of SSA is motivated by the opportunity to account for key region-specific determinants of economic performances such as institutional quality, conflict, and the terms of trade.

This study makes the following contributions to the debt-growth literature on SSA. First, it focuses on the issue of nonlinearity and threshold effect and tested this using the SLM test. Apart from the studies that employ specialised panel threshold techniques, we are not aware of any debt-growth study focusing on SSA that employs the SLM method to evaluate the evidence of nonlinearity. Second, this study is localized to SSA countries as it accounts for region-specific variables (terms of trade, conflict, and institutional quality). A similar study by Megersa (2015) accounted for terms of trade and foreign aid and employed pooled OLS and a non-parametric approach to nonlinearity. Third, this study also contributes by attempting to address potential issues of endogeneity and cross-section dependence. Again, while these have been addressed in the larger literature, there is a limited attempt at addressing them in studies focusing on Africa

The rest of the paper is organized as follows: Section 2 outlines a review of the current body of literature. In Section 3, we specify the model based on the underlying theoretical framework. Then, Section 4 presents and discusses the results. Lastly, Section 5 concludes and offers some policy suggestions.

2. Review of related literature

2.1. The theoretical literature

The impact of debt on growth has been the topic of a well-known theoretical debate. Historically, researchers are easily classified as proponents or opponents of the theory of debt neutrality (Barro, 1974),³ which supposes *inter alia* that individuals have finite lives, live in overlapping generations, and adherent to the theory of rational expectations. Accordingly, given an increase in public debt, the expectation of a resultant future rise in taxes will elicit an immediate response from agents in the form of increased savings. The implication is that the interest rate will remain unchanged and public debt will have no effect on growth as there will be no crowding out of private capital (Barro, 1974; Bernheim, 1987; Buchanan, 1976). Over the decades, this argument has been severely weakened by the systemic growth of public debt across the globe, which researchers have associated with negative long-run growth effects (Diamond, 1965; Modigliani, 1961; Panizza & Presbitero, 2013). Researchers now tend to agree that public debt has important economic consequences and, therefore, focus on understanding the nature and variabilities of these effects (e.g., Cecchetti et al., 2011; Panizza & Presbitero, 2013; Saungweme & Odhiambo, 2018). The debt neutrality theory, nevertheless, continues to be an important starting point in the analysis of the

effects of debt since researchers often begin by assuming a state of the world where the theory does not hold.

The opponents of debt-neutrality are simply of the view that public debt has positive short-run and negative long-run effects on economic activity (Diamond, 1965; Elmendorf & Mankiw, 1999). This argument is popularly referred to as the conventional or traditional view. The short-run effects are linked to the Keynesian theory and the long-run effects, to the neoclassical theory (Bernheim, 1989). In the Keynesian view, individuals are short-sighted, liquidity-constrained, and have a high propensity to consume current disposable income (Bernheim, 1989). Given these suppositions and coupled with the notion of sticky wages and prices in the short-run, aggregate demand responds positively to a temporary reduction in taxes and the use of debt-finance. This Keynesian stimulation of aggregate demand leads to an overall increase in output in the short run.

In the long-run neoclassical view where agents are farsighted and have the ability for life-time consumption planning, the fall in public savings created by the rise in deficit is not matched by an increase in private savings since the Ricardian equivalence argument does not hold (Diamond, 1965). As a result, a chain of economic effects is set in motion which ultimately leads to the fall in future gross national output (Bernheim, 1987; Elmendorf & Mankiw, 1999). The neoclassical growth model has been the workhorse for the empirical analyses of the effects of debt on economic growth—both in developed and developing countries.

While the shortage of savings in developing countries makes external borrowing beneficial for growth, there are theoretical arguments that indicate that a large accumulation of public debt may harm growth. In view of SSA countries, these arguments are laid out in the debt overhang theory (Krugman, 1988; Sachs, 1989). Debt overhang refers to the loss of confidence on the part of creditors, in the ability of the debtor country to fully repay its debt (Krugman, 1988). The term is similarly associated with the notion of efficiency losses arising when “current debt far exceeds the present value of expected net debt service payments” (Sachs et al., 1987 pp592). This had been the experience in many developing countries in previous decades and accounts for the debt relief interventions that were provided to affected countries. An important point that the debt overhang theory raises is that of debt sustainability (Sachs, 1989; D’Erasmus & Mendoza, 2018). The debt-overhang hypothesis is developed in view of countries where the larger proportion of debt is held in a foreign currency, as typically obtainable in SSA (Panizza & Presbitero, 2013). It was thus the basis of early empirical studies such as those of Elbadawi et al. (1997)

The debt overhang hypothesis also conceptualizes the nonlinear link between debt and growth, since it gives the idea that a high and rising public debt is harmful to the growth process. Moreover, it questions the point at which the debt burden has become unsustainable (Panizza & Presbitero, 2013). This idea that debt may have a nonlinear growth effect is popularly depicted by the Debt Laffer curve, a derivative of the debt overhang theory. Elbadawi et al. (1997) and Megersa (2015) are two empirical studies focusing on SSA where the Debt Laffer curve was used to analyse the nonlinear effects of debt. Originally, however, the Debt Laffer curve is a concept used to explain the bell-shaped nexus between the nominal debt outstanding and its corresponding market value (Claessens, 1990). It was first introduced by Sachs (1989) through the debt overhang hypothesis. Overall, it is worth noting that there is still no unified theory that specifies a magnitude of debt-to-GDP ratio for all countries beyond which debt becomes unsustainable.

2.2. Empirical literature

Previous research on the debt–growth nexus can be categorized into two phases. The first phase is characterized by its predominant focus on developing countries due to the heavy indebtedness of these countries during the 1980s and 1990s and the consequent debt crisis of that era (e.g., Elbadawi et al., 1997; Fosu, 1996, 1999; Iyoha, 1999; Pattillo et al., 2002). The second phase of the literature focuses more on the advanced countries and in some cases, a combination of the advanced and developing countries. The second phase of the literature has emerged in more

recent years following the seminal paper of Reinhart & Rogoff (2010) in the aftermath of the global financial crisis.

In phase one of the literature, several studies focus on SSA even when employing a larger sample comprising the developing countries. Fosu (1996), for example, employs an augmented production function to examine the direct effect of debt on growth for a sample of 29 SSA countries spanning 1970–1986. He finds that the debt burden, whether measured as debt service or debt outstanding, has adverse economic growth effects. Fosu (1999) extends the sample to 35 SSA countries from 1980 to 1990 to examine the nexus between the external debt burden and growth. Again, the results show that the external debt burden has a negative effect on growth for any given level of production inputs. Elbadawi et al. (1997) consider the effects of debt overhang on growth in SSA using an augmented growth regression and a sample of 99 developing countries which includes some SSA countries. Evidence from the fixed effects and random effects methods shows that public debt is good for growth up to a point, but that debt overhang has adverse growth effects. The study confirms the presence of a nonlinear effect with a threshold estimate of 97% for developing countries. Pattillo et al. (2002) similarly examines the nonlinear and threshold effects of external debt on growth in developing countries over 1969–1998 but present much lower threshold estimates ranging from 35% to 40%.

Phase two of the literature follows the seminal work of Reinhart & Rogoff (2010) with a shift in focus to the advanced and emerging market economies (e.g., Cecchetti et al., 2011; Checherita-Westphal & Rother, 2012; Chudik et al., 2017; Égert, 2012; Kumar & Woo, 2010). Reinhart & Rogoff (2010) show, inter alia, that debt ratios above 90% have adverse effects on growth and that emerging market economies suffer from the negative effects at a much lower ratio (60%). Motivated by these findings, researchers have focused more on examining the nonlinear and threshold effects of debt on growth. What is interesting about the debt–growth literature is that despite the large volume of published studies, the evidence is mixed, and no consensus has been reached (Heimberger, 2022). Several studies have found support for the evidence in Reinhart & Rogoff (2010) that debt may have deleterious economic effects beyond a certain level (e.g., Cecchetti et al., 2011; Checherita-Westphal & Rother, 2012; Égert, 2015; Kumar & Woo, 2010). But the threshold value tends to vary considerably from one study to another. This mix of evidence has been attributed to the differences in sample, modelling choices, and methods of estimation (Égert, 2015; Panizza & Presbitero, 2013). Other issues highlighted are the tendency to ignore key empirical such as endogeneity biases, cross-section dependence, and heterogeneity (Ahlborn & Schweickert, 2018; Eberhardt & Presbitero, 2015; Panizza & Presbitero, 2013).

Studies that examine the debt–growth nexus in SSA, particularly in recent years, are quite few. Some employ a linear specification assuming a linear nexus. In this case, one evidence supports a linear negative nexus (Kemoe & Lartey, 2022; Manasseh et al., 2022), while another evidence finds a linear positive nexus (Mensah et al., 2018). All three studies employ the system GMM approach. Also, all of these studies focus on the effects of external debt on growth except Kemoe and Lartey (2022) who employ the government gross debt measure. Senadza et al. (2018) experimented with both a linear and nonlinear specification and reported evidence from system GMM estimations that could only confirm a linear negative nexus between external debt and growth.

Only a few recent studies have taken the nonlinear or threshold approach to the debt–growth question for the case of SSA countries (Abate, 2023; Megersa, 2015; Nduricimpa, 2020; Olaoye, 2022). Megersa (2015) employs the pooled OLS along with the SLM test for U-shape and finds a bell-shaped nexus and a debt-to-GDP threshold value of 45% which seems quite representative for SSA as it accords with the benchmarks of the IMF for low-income countries. Nduricimpa (2020) focuses on the threshold effects using the Panel Smooth Transition Regression (PSTR) approach, a non-dynamic threshold regression technique. The study finds support for a nonlinear nexus with an estimated threshold value of between 62% and 65%. Olaoye (2022) employs a dynamic panel threshold model using a sample of 44 African countries and presents a threshold estimate of 34%

for the sample countries. Abate (2023) is a single country analysis focusing on Ethiopia. The study employs the nonlinear ARDL and a quadratic regression and finds a threshold estimate of about 66.8%. SSA countries are also sometimes considered in a broader sample of developing countries in studies that examine the nonlinear and threshold effects. Among such studies, Karadam (2018) presents a threshold estimate of 88% using the PSTR approach, Caner et al. (2010) establishes a threshold value of 64% using the Hansen non-dynamic threshold regression approach, and Law et al. (2021) presents a smaller threshold of 52% using the dynamic panel threshold regression method.

The empirical issues raised hitherto are applicable to the studies that have focused on SSA countries. Endogeneity biases have mainly been addressed using the system GMM approach as in Mensah et al. (2018), Kemoe and Lartey (2022), and Manasseh et al. (2022), for example. Two key drawbacks with the use of this method have, however, been highlighted (Panizza & Presbitero, 2013). One is that OLS and GMM estimates are similar (see, for example, Kumar and Woo, 2010), which either suggests the absence of endogeneity or the inability of the system GMM to deal with it. The other is the fact that these models, having been developed in view of microdata, are thus poorly suited for macro datasets. The time dimension of cross-country panels often tends to have a negative effect on the asymptotic properties of the system GMM estimator (Roodman, 2009). With the exception of Law et al. (2021) who uses a dynamic threshold method, all of the other studies cited take the non-dynamic threshold approach thereby ignoring potential endogeneity biases. The issue of cross-section dependence has also been ignored in the studies focusing on SSA, which could have some implications for the reliability of the results.

Our approach in this study is to examine the nonlinear and threshold effects of debt on growth in SSA while addressing potential endogeneity and cross-section dependence using a variety of applicable econometric procedures to facilitate comparison of results. As for the issue of heterogeneity, we focus our analysis on SSA countries and argue that the countries of the sub-region are for the most part similar with regard to factors that influence the growth process (Collier & Gunning, 1999). For example, SSA countries are often commonly affected by terms of trade shocks given the large dependence on commodity exports. Similarly, many countries of the sub-region are faced with similar socio-political issues such as armed conflict and terrorism, which limits the growth of the economies. Most SSA countries are faced with the common issue of low quality of governance and institutions which is also an important determinant of economic growth. Also, it turns out that the majority of the countries of the sub-region were classified as HIPC's. In the section that discusses the methods of estimation, the foregoing argument motivates our choice of the fixed effects estimator which assumes homogeneous slopes while allowing the intercepts to differ.

3. Model specification, data, and methods of estimation

To examine the relationship between debt and growth in SSA, we follow the conventional approach in the literature to estimate a neoclassical Solow growth model augmented with government debt and its squared term. We extend the basic framework with control variables that we consider to be relevant in explaining SSA's economic performance in the literature. The model is specified as follows:

$$g_{it} = \alpha_0 + \alpha_1 ly_{it} + \alpha_2 d_{it} + \alpha_3 d_{it}^2 + \alpha_4 inv_{it} + \alpha_5 pgr_{it} + \alpha_6 lxp_{it} + \beta' Z_{it} + \gamma' Q_{it} + \varphi_i + \eta_t + \epsilon_{it} \quad (1)$$

where the dependent variable g_{it} stands for the growth rate of per capita GDP; φ_i and η_t are the country-specific and time-varying effects, respectively. ly_{it} is the log of real GDP per capita, which accounts for the role of initial income. equation (1) includes additional growth covariates, namely, the gross fixed capital formation as a ratio of GDP, a proxy for investment (inv_{it}), population growth (pgr_{it}), and the log of life expectancy (lxp_{it}), a proxy for human capital. Vector Z_{it} includes three region-specific determinants of economic performance, namely, terms of trade growth (tot_{it}),

conflict (con_{it}), and institutional quality ($xcon_{it}$). Terms of trade reflect the primary-commodity-centric characteristics of the majority of SSA exports (IMF, 2019; UNDP, 2016). Conflict accounts for the effects of armed conflict, insurgencies, and socio-political uprisings on growth in SSA. It is measured as a dummy variable based on the UCDP PRIO conflict intensity data which takes one if a country records at least 25 battle deaths in any given year from 1980 to 2018 and zero, otherwise. The role of social capital is captured using constraints on the executive, a Polity V governance indicator which refers to the extent to which the government institutions of checks and balances are effective.

Following the literature, some additional variables are included in the vector Q_{it} namely, inflation, log of government size, a financial crisis dummy, trade openness, and financial depth. Inflation is measured as the growth rate of the GDP deflator. Government consumption share in GDP is used as proxy for the effect of government size. A financial crisis dummy accounts for the role of the global financial crisis. The share of trade in GDP, defined as the sum of exports and imports of goods and services accounts for the open economy feature of SSA. Financial depth is measured using domestic credit to the private sector as a share of GDP.

The variable of interest is (d_{it}) denotes government gross debt as a share of GDP obtained from the Historical Public Debt Database (HPDD) as compiled by Abbas et al. (2011).⁴ To capture the possible nonlinear effect of public debt, the model includes a quadratic term (d^2) and follows the testing approach developed by Sasabuchi (1980) and Lind and Mehlum (2010), hereinafter referred to as the SLM test. Equations 2 and 3 specify the SLM model for testing within some interval whether the relationship between debt and growth is increasing at low values of debt but decreasing at high values of debt. Given equation (1), a rejection of the null hypothesis (equation 2) in favour of the alternative (equation 3) will affirm the validity of a nonlinear (inverted U) relationship:

$$H_0 : \beta_2 + 2\beta_3 D_L \leq 0 \text{ and/or } H_0 : \beta_2 + 2\beta_3 D_H \geq 0 \quad (2)$$

vs.

$$H_1 : \beta_2 + 2\beta_3 D_L > 0 \text{ and } H_1 : \beta_2 + 2\beta_3 D_H < 0 \quad (3)$$

Our analyses are aided by a dataset comprising 24 SSA countries over the yearly period 1980–2018. The sample and time-span are constructed based on data availability. We are constrained by the Polity V data on executive constraints to stop at 2018. Table A1 of the Appendix presents the list of variables and their sources, while Appendix Table A2 lists the countries that have been included in the sample. We report the summary statistics for the variables in Table 1.

The average ratio of the gross government debt to GDP is around 57% for the 24 countries in the sample during the period 1980–2018. The large standard deviation (33.4%) indicates substantial variabilities in the ratio across the countries. It is observed that, on average, the sample countries have experienced low economic growth rates during the study period and that the small average value (0.85%) relative to the standard deviation of 5% shows a significant degree of cross-country variabilities in the growth of per capita income as well. This is supported by the wide margin between the minimum and maximum values.

Following Alejo et al. (2015) we employ an approach for testing for normality that is suitable for panel data models. The results (Table 2) show that the data is normally distributed. This can be observed in the lower part of the table where the individual-specific error (e) and the usual symmetric disturbance (u) both present test statistics that are jointly insignificant in support of a non-rejection of the null hypothesis.

Table 1. Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
real GDP per capita growth	936	.85	5.199	−47.503	37.535
Real GDP per capita	936	1808	2086	215.7	10335.9
government gross debt/GDP	936	57.52	33.4	0	193.67
investment	936	19.46	8.965	1.931	89.386
population growth	936	2.579	1.022	−6.766	8.118
life expectancy	936	54.88	7.140	26.17	74.51
terms of trade	936	119.47	44.14	21.40	357.58
GDP deflator growth	936	8.699	15.790	−27.049	219.00
government shares in GDP	936	0.169	0.079	0.005	0.577
conflict	936	.166	0.372	0	1
constraints on the executive	936	3.594	2.156	0	7
domestic credit/GDP	936	19.8	22.08	0.691	142.422

3.1. Methods of estimation

Several estimation approaches have been employed in the debt–growth literature. The choice of estimation methods in this study is, however, motivated by our concern with addressing the issues of endogeneity and cross-section dependence which have largely been ignored in the literature, particularly that focusing on African economies. Since we employ a dataset comprising 24 countries and a time series spanning 39 years, we make use of dynamic panel specifications. However, as in Bittencourt (2015) we do not take the panel cointegration approach here because of the nature of most of our variables, which are either measured as ratios of GDP (e.g., debt, liquid liabilities, investment, and trade) or bounded in intervals (e.g., conflict, executive constraints, and global financial crisis), and are thus stationary by default. Moreover, since the primary balance responds systematically to changes in the public debt burden (Bohn, 1998), fiscal policy will be sustainable, which means debt will be mean reverting. This of course requires that the government is satisfying its intertemporal budget constraint. We are also aware of the argument that spurious regression may not be that much of a problem in panel settings where averaging helps to reduce the noise (Phillips & Moon, 2000).⁵

Given our aim to address potential endogeneity of the debt variable,⁶ we begin with the fixed effects instrumental variables (FE-IV) method as it allows for the presence of potentially endogenous regressors in addition to the usual unobserved effects. We assume that government debt is potentially endogenous, particularly with respect to reverse causation, as slow or negative economic growth rates are likely to give rise to higher debt burdens. Our initial approach in the baseline regressions is to instrument government debt using its lags (up to the 4th lag). In the robustness section, we calculate, for each country year, the average debt burden of all other countries in the sample and use this as an instrument for government debt in alternative FE-IV regressions following Checherita-Westphal and Rother (2012).

Having specified a dynamic model to be estimated with the fixed effects estimator, we are aware of the criticism that our model may suffer from the dynamic panel bias (Nickell, 1981). We argue, however, that the panel has a long time dimension (>30) which should diminish the potential bias (Bond, 2002; Judson & Owen, 1999; Kiviet, 1995).⁷ Furthermore, although the fixed effects estimator assumes homogeneity of the slope coefficients, it allows heterogeneity of the intercepts which is a reasonable assumption considering that there are some diversities among SSA countries.

Another empirical problem that we address is that of cross-section dependence. Cross-country macro panels are highly susceptible to this problem as countries have become increasingly interdependent due, perhaps, to the growing levels of economic and financial integration taking place across countries and regions (Chudik & Pesaran, 2015; Hoyos De & Sarafidis, 2006). Cross correlations could bias the standard errors and sometimes lead to inconsistent estimates. It turns out that our preliminary check using the Breusch-Pagan LM test led us to reject the null of cross-section independence in our model, which seems to suggest that cross-section dependence is a problem in our sample. Cross correlation is the result of unobserved common factors that may or may not be uncorrelated with the included regressors. Typical examples of common factors to which all countries in the sample may respond are the oil shocks of the 1980s and more recently, the global financial crisis. SSA countries, even in recent years, have been affected by global conditions such as movements in commodity prices and climate shocks that constrain agricultural production (IMF, 2019). The IV fixed effects estimator allows us to employ robust standard errors that control for cross-section dependence in addition to heteroscedasticity and autocorrelation, but we have mainly addressed this problem using the Fixed Effects estimator with Driscoll and Kraay standard errors (Driscoll & Kraay, 1998).

Although we prefer to use the FE-IV estimator given its applicability to the model we have set up, there is need to employ other alternative estimators for robustness and for comparability with the literature. Bruno (2005) proposes the bias corrected least-squares dummy variable (LSDV) approach which is applicable to our dynamic panel data model and presents some efficiency gains in large T panels. Although the LSDV estimator assumes that the regressors are strictly exogenous, it is important to see how the results compare with the evidence from the FE-IV estimations. Alternatively, we also employ the limited information maximum likelihood (LIML) estimator with standard errors robust to heteroscedasticity, autocorrelation, and cross section dependence. The LIML estimator has better properties than GMM estimators in the case of weak instruments (see Stock et al., 2002). The fixed effects with Driscoll and Kraay (1998) is also employed as an alternative approach to dealing with cross correlations. As we show in the next section, the results do not differ substantially across the various alternative estimators. We therefore deem the results to have passed the robustness tests.

4. Results and discussion

Table 2 reports the baseline FE-IV estimations where we instrument for government debt using its lags (up to lag 4). Initial estimations using government debt in a linear specification yield a positive but insignificant coefficient on government debt.⁸ We therefore work with a nonlinear specification that includes the squared term of debt. Column 1 includes only the basic growth regressors in addition to our debt variables of interest. These are initial income, investment, population growth, and human capital. Column 2 extends the model with the inclusion of the terms of trade growth, armed conflict, and a measure of institutional quality. The model is further extended in columns 3–7 with the inclusion of some relevant variables following the literature. These additional variables, namely GDP deflator growth (inflation), log of government consumption (% of GDP), a financial crisis dummy, trade openness, and domestic credit to the private sector (% of GDP), are added one at a time.

Across all the regressions in columns 1–7, we report a consistently significant nonlinear (inverse U) relationship between government debt and economic growth regardless of the variations in

Table 2. Tests for normality

	Coefficient	Std error	p-value
Skewness_e	−154.903	117.346	.187
Kurtosis_e	12118.080	8927.454	.175
Skewness_u	1.804	0.912	.048
Kurtosis_u	−2.368	3.786	.532

Joint test for Normality on e: $\chi^2(2) = 3.59$ Prob > $\chi^2 = 0.1665$

Joint test for Normality on u: $\chi^2(2) = 4.31$ Prob > $\chi^2 = 0.1162$

control variables. The results are strongly supported by the SLM test for nonlinearity as proposed by Sasabuchi (1980) and Lind and Mehlum (2010). The threshold for debt-to-GDP ratio ranges from 78% to 85% along with their 90% Fieller interval estimates which themselves lie within the data range (see lower part of Table 3). The results show that the relationship between debt and growth in SSA is positive at debt levels below the estimated thresholds. Above these thresholds, an increase in the debt burden could lead to deleterious economic growth effects in SSA economies.

The evidence of a nonlinear effect is consistent with much of the literature focusing on developing countries (e.g., Caner et al., 2010; Karadam, 2018; Megersa, 2015). The results point to the widely reported difficulty of finding a tipping point that is applicable to all countries in the sample (e.g., Égert, 2015; Ndoricimpa, 2020; Panizza & Presbitero, 2013). Diagnostic tests are reported in the lower part of the table, namely, the Kleibergen-Paap LM test for under-identification and the Hansen J test for overidentifying restrictions. The former test leads us to reject the null hypothesis that the instruments are weak, while the latter test leads to the non-rejection of the null that the instruments are valid. Both tests give support for the instrument set.

Regarding the included control growth regressors, the initial income presents a positive effect which goes contrary to the conditional convergence hypothesis, but the results are not significant. Most of the other growth covariates carry their expected signs and are often significant. For example, investment/GDP, the terms of trade, and executive constraints are positive and significant. On the contrary, population growth presents a positive effect, while trade openness gives a negative effect.

4.1. Robustness tests

We carry out several checks on the foregoing results. To begin, we replace the instrument set with the average government debt of other countries in the sample and rerun the regressions of Table 2 using the IV fixed effects. The results (Table A3 of the Appendix) are very similar to the baseline regressions in Table 2. There is only a slight difference in the threshold value which now ranges between 78% and 84%. The threshold effects are strongly retained in these regressions. Similar to Table 2, the first-stage results show strong correlation between the excluded instrument and the endogenous government debt which gives support for the model. The diagnostic tests, reported in the lower part of Appendix Table A3, also provide further support for identification.

Next in our series of robustness tests, we present some alternative results from the LIML, LSDV, and the fixed effects with Driscoll and Kraay (1998) robust standard errors (FE-DK). The results (Table A4 of the Appendix) continue to support the significance of a nonlinear nexus between debt and growth. The variation in the threshold effect is significant between the LIML estimator, on the one hand, and the LSDV and Fixed effects with the Driscoll and Kraay standard errors on the other. The LIML estimator estimates 69%, whereas the LSDV and Fixed effects with Driscoll and Kraay standard errors estimate 89% and 90%, respectively. The estimates are fully supported by the SLM test which leads to the rejection of the null hypothesis of U-shape in favour of the alternative.

Table 3. Baseline and extended regressions using FE-IV (1980–2018)

Dependent variable: GDP per capita growth							
Variables	1	2	3	4	5	6	7
debt/GDP	0.174*** (0.051)	0.171*** (0.049)	0.181*** (0.051)	0.178*** (0.050)	0.195*** (0.058)	0.186*** (0.052)	0.175*** (0.048)
debt/GDP sq.	−0.001*** (0.0003)	−0.001*** (0.0003)	−0.001*** (0.0003)	−0.001*** (0.0003)	−0.001*** (0.0003)	−0.001*** (0.0003)	−0.001*** (0.0003)
initial income	3.529** (1.646)	2.429 (1.651)	2.712 (1.728)	2.571 (1.617)	2.429 (1.672)	2.448 (1.625)	4.560** (1.774)
investment	0.092** (0.042)	0.088** (0.040)	0.088** (0.041)	0.080* (0.042)	0.082** (0.040)	0.098** (0.048)	0.079** (0.040)
population growth	0.598** (0.240)	0.518*** (0.195)	0.529*** (0.194)	0.534** (0.223)	0.557*** (0.205)	0.534*** (0.194)	0.432** (0.175)
Life expectancy	2.070** (0.814)	1.620* (0.932)	1.467 (0.963)	1.419 (0.994)	1.155 (0.957)	1.396 (0.956)	1.870* (1.084)
terms of trade		1.298 (0.909)	1.319 (0.937)	1.499 (0.920)	1.325 (0.920)	1.455 (0.895)	1.298 (0.937)
conflict		−0.494 (0.598)	−0.509 (0.616)	−0.466 (0.617)	−0.497 (0.630)	−0.521 (0.631)	−0.726 (0.654)
exec constraints		0.298** (0.128)	0.286** (0.117)	0.289** (0.123)	0.288** (0.120)	0.324*** (0.117)	0.281** (0.116)
inflation			0.020 (0.014)				

(Continued)

Table 3. (Continued)

Dependent variable: GDP per capita growth							
Variables	1	2	3	4	5	6	7
govt consumption				−0.651 (0.551)			
fin crisis dummy					0.685 (0.668)		
trade/GDP						−0.016 (0.024)	
domestic cred							−0.091*** (0.035)
K-Paap test (χ^2)	17.63 (0.002)	17.21 (0.002)	17.13 (0.002)	16.48 (0.002)	17.19 (0.002)	16.88 (0.002)	17.56 (0.002)
Hansen J-stat (χ^2)	0.684 (0.877)	0.577 (0.902)	1.471 (0.689)	1.637 (0.651)	1.282 (0.733)	1.377 (0.711)	1.487 (0.685)
Threshold est.	80***	84***	83***	84***	85***	84***	84***
90% Filler interval	[70; 86]	[76; 96]	[76; 95]	[76; 96]	[77; 98]	[77; 96]	[76; 96]
N	24	24	24	24	24	24	24
Observations	840	840	840	840	840	840	840

Note: * * * denote significance at 5% and 10%, respectively; robust standard errors are in parenthesis in the upper part of the table. The lower part of the table presents some diagnostic tests and their p-values: K-Paap test denotes the Kleibergen-Paap LM test for under-identification which employs the null hypothesis that instruments set is under-identified/weak; Hansen J test for overidentifying restrictions evaluates the instruments for validity using the null hypothesis that the instruments are valid. The turning points and the corresponding 90% Filler are from the Sasabuchi-Lind-Mehlum test for nonlinearity (U-shape). In all, the first stage regression presents a Shea partial R-squared value of between 0.33–0.34 with a highly significant F-statistic which gives some support for the correlation between the instrument set and endogenous government gross debt.

When we exclude the two largest economies (Nigeria and South Africa) from the sample and re-estimate them with IV fixed effects, the results (Table A5 of the Appendix) remain largely the same as in Table 2. The threshold values remain significant and range from 80% to 84%, suggesting that the economic performance in Table 2 is not being driven by the largest economies in the sample. We also observed results from estimations that exclude countries with relatively large GDP per capita (5000 dollars and above). Again, the key findings remain unchanged.⁹

Lastly, using a more direct approach to the nonlinearity question, we consider the growth effects of debt at different debt ratios using dummy variables to capture some exogenously determined thresholds. The motivation for this approach, which has quite often been used in previous studies, is that a large amount of debt relative to GDP is likely to impact negatively on growth. We create dummy variables that take 1 where the debt burden is: $d > 30\%$, $30\% > d > 60$, and $d \geq 60\%$. Each of these dummy variables is then interacted with the gross debt ratio. The *a priori* expectation is that a low amount of debt relative to income will have a positive effect, while a high amount of debt ratio will have the opposite effect (e.g., Pattillo et al., 2002). Debt ratios below 30% are categorized as low-debt, ratios between 30% and 60% as medium-debt, and ratios of 60% and above as high-debt.

Table A6 of the Appendix presents evidence using these interaction effects from the IV fixed effects and LIML estimations. In both sets of results, we continue to instrument gross government debt using its lags (up to lag 4) and include the key growth covariates, namely initial income, investment, population growth, human capital, a conflict dummy, terms of trade, and executive constraints. For brevity, however, we present only the results of interest. The results show that public debt below 30% of GDP, though positive, is only significant in the LIML regressions. Debt ratios between 30% and 60% have no significant effect, while debt ratios above 60% present a strong negative and significant growth effect in both sets of results. The results seem to affirm that high debt ratios (from 60% and above) are deleterious for growth in SSA.

5. Conclusion

This study contributes to the long-standing and ongoing debate on the nexus between debt and growth. It approached the debate from the viewpoint of SSA countries where previous research, particularly, since the outset of the global financial crisis is limited. Potential endogeneity issue is addressed along with that of cross-section dependence. Focusing on SSA countries allowed us the opportunity to account for region-specific factors, such as the quality of institutions and policies, conflict, and terms of trade shocks. The study finds a nonlinear effect on per-capita GDP growth of public debt across 24 SSA countries from 1980 to 2018. Evidence from the Sasabuchi-Lind-Mehlum test shows an inverted U-shape nexus between public debt and economic growth, with a debt threshold of about 80–85% of GDP in most cases. This implies that public debt levels exceeding this range are associated with lower long-run growth rates. We note that some estimations yield a much smaller threshold value of 69%, while others give larger values of about 89–90%. Thus, while it is relatively easier to establish a nonlinear relationship between debt and growth as in previous studies, modelling the threshold effect is not as easy as it tends to vary with the method of estimation and the covariates included. Égert (2015) expresses similar concern, arguing that threshold effects tend to change over time, across countries, and economic conditions.

We note that although the results agree with previous findings on developing countries, the estimates fail to mirror the sustainable threshold for SSA countries where the debt-carrying capacity is low, in light of the IMF's Debt Sustainability Framework. SSA countries have commonalities, even if partly so, with regard to the factors that determine the growth process. But the possibility remains that some important country-specific factors that one may not easily account for in a panel setting are playing out to differentiate the threshold effect from case to case. The debt-growth literature could benefit from future research that concentrates on individual case studies of countries, as this would offer a debt-growth nexus that is idiosyncratic (Afonso &

Ibraimo, 2020). Similarly, future debt-growth research focusing on African countries should explore the heterogeneous panel techniques of the sort employed in Chudik et al. (2017) to further unravel the relationship in the sub-region.

Several policy recommendations can be derived from the study. Given the evidence of a non-linear relationship between public debt and economic growth, policymakers should prioritize maintaining debt sustainability. Establishing and closely monitoring a debt threshold within the range that is sustainable could help prevent the negative effects of excessive debt accumulation on economic growth. Further to this, regular assessments of debt levels relative to the sustainable thresholds can guide borrowing decisions. Then, there is the need to adopt targeted debt management strategies that involve diversifying sources of financing, negotiating favorable terms for borrowing and considering the composition of debt (long term vs. short term). One of the key ways to diversify financing sources is to expand the tax base by improving tax collection mechanisms and exploring non-tax revenue streams. Lastly, in view of the variations in threshold estimates based on empirical techniques, policymakers should tailor their approaches to the unique characteristics of their countries. Conducting country-specific analyses and considering individual economic, political, and institutional contexts will yield more accurate and actionable results.

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Notes

1. Debt overhang refers to the loss of confidence on the part of creditors, in the ability of the debtor country to fully repay its debt (Krugman, 1988).
2. This includes Chad, Mozambique, and Congo Republic.
3. The debt-neutrality argument is popularly referred to as the Ricardian Equivalence hypothesis, which though attributed to David Ricardo, was extended, and popularized by Barro (1974), and thus sometimes called the Ricardo-Barro hypothesis. It simply refers to the lack of difference between debt and tax finance for any given amount of government expenditure.
4. Abbas et al. (2011) employs a variety of databases and sources in compiling the HPDD. As such there are also a variety of definitions of debt.
5. Nevertheless, we include unit root test results in Appendix Table A7. As expected, the results confirm that the variables are stationary in levels except log of real GDP which is first difference stationary. However, when we included lag of per capita GDP growth rate instead of lag GDP per capita, we found that the results stay the same. We therefore retained log real GDP per capita as a proxy for initial income following the literature.

6. The rate of growth is determined by the level of debt and vice versa. To wit, slow growth could induce high levels of debt while a high debt burden could slow down the rate of growth.
7. According to these authors, the dynamic panel bias of the FE estimator tends to be negligible when T is medium to large.
8. These results are not reported for brevity but can be provided on request.
9. There are four countries in this category namely, Botswana, Gabon, Mauritius, and South Africa. For brevity, these regressions are not reported but can be made available upon request.

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Appendices

Appendix

Table A1. Variables and sources of data

Variable	Source
real GDP per capita growth	World Development Indicators
real GDP per capita (logged)	World Development Indicators
government gross debt/gdp	Historical Public Debt Database (IMF HPDD)
investment	World Development Indicators
population growth	World Development Indicators
Life expectancy (logged)	World Development Indicators
terms of trade	World Development Indicators
GDP deflator growth	World Development Indicators
government shares in GDP	Penn World Tables, Version 10.0
conflict	UCDP PRIO
constraints on the executive	Polity V
domestic credit to the private sector	World Development Indicators

Table A2. List of countries

Variable	
Benin	Mali
Botswana	Mauritius
Burkina Faso	Niger
Burundi	Nigeria
Cameroon	Rwanda
Central African Republic	Senegal
Chad	South Africa
Comoros	Togo
Cote d' Ivoire	Zimbabwe
Eswatini	
Gabon	
Gambia	
Ghana	
Kenya	
Madagascar	

Table A3. Alternative FE-IV regressions: instrumenting debt with the average debt of all other countries

Variables	1	2	3	4	5	6	7
debt/gdp	0.176*** (0.051)	0.180*** (0.050)	0.177*** (0.050)	0.176*** (0.050)	0.205*** (0.060)	0.182*** (0.052)	0.172*** (0.048)
debt/gdp sq.	-0.001*** (0.0003)	-0.001*** (0.0003)	-0.001*** (0.0003)	-0.001*** (0.0003)	-0.001*** (0.0003)	-0.001*** (0.0003)	-0.001*** (0.0003)
initial income	3.908*** (1.583)	2.841* (1.609)	3.026* (1.670)	2.876* (1.554)	2.642 (1.641)	2.797* (1.565)	4.827*** (1.748)
investment	0.099** (0.045)	0.093*** (0.042)	0.094** (0.042)	0.086** (0.042)	0.081* (0.041)	0.098** (0.047)	0.084** (0.041)
population growth	0.605*** (0.205)	0.501*** (0.162)	0.511*** (0.163)	0.517*** (0.183)	0.578*** (0.177)	0.508*** (0.156)	0.415*** (0.149)
life expectancy	3.363** (1.320)	2.647* (1.482)	2.607* (1.455)	2.543* (1.527)	1.871 (1.356)	2.613* (1.511)	3.042* (1.582)
terms of trade		1.405 (1.037)	1.381 (1.040)	1.572 (1.019)	1.367 (1.004)	1.468 (1.021)	1.365 (1.049)
conflict		-0.599 (0.626)	-0.591 (0.609)	-0.547 (0.613)	-0.554 (0.634)	-0.603 (0.632)	-0.803 (0.661)
exec constraints		0.343*** (0.111)	0.328*** (0.109)	0.330*** (0.116)	0.314*** (0.114)	0.357*** (0.107)	0.328*** (0.113)
inflation			0.022 (0.016)				
government size				-0.662			

(Continued)

Table A3. (Continued)

Variables	1	2	3	4	5	6	7
fin crisis dummy				(0.574)	1.154* (0.607)		
trade/gdp						-0.008 (0.024)	
dom credit/gdp							-0.089** (0.038)
K-Paap test (χ^2)	17.80 (0.001)	18.39 (0.001)	18.54 (0.001)	17.95 (0.001)	18.59 (0.001)	18.53 (0.001)	18.97 (0.001)
Hansen J-stat (χ^2)	1.163 (0.738)	0.954 (0.812)	0.915 (0.822)	0.933 (0.817)	0.567 (0.904)	0.940 (0.816)	0.872 (0.832)
Threshold est.	78***	82***	81***	82***	84***	82***	82***
90% Filler interval	[64; 81]	[73; 93]	[73; 92]	[73; 93]	[77; 97]	[74; 93]	[74; 93]
N	24	24	24	24	24	24	24
Observations	840	840	840	840	840	840	840

Note: ** & * denote significance at 5% and 10%, respectively; robust standard errors are in parenthesis in the upper part of the table. The lower part of the table presents some diagnostic tests and their p-values where K-Paap test denotes the Kleibergen-Paap LM test for under-identification which employs the null hypothesis that instruments set is under-identified/weak; Hansen J test for overidentifying restrictions evaluates the instruments for validity using the null hypothesis that the instruments are valid. Threshold estimates and their corresponding 90% Filler SLM test for U-shape. In all, the first stage regression presents a Shea partial R-squared value of between 0.32–0.36 with a highly significant F-statistic which gives support for the correlation between the instrument set and endogenous government gross debt.

Table A4. Further robustness tests using a variety of alternative estimators

Variables	LIML	LSDV	FE-DK
debt/gdp	0.092*** (0.027)	0.060*** (0.011)	0.063*** (0.009)
debt/gdp sq.	−0.001*** (0.0002)	−0.0003*** (0.0001)	−0.0004*** (0.0001)
Initial income	−0.024 (0.234)	0.060** (0.030)	2.383 (1.722)
investment	0.116*** (0.024)	0.016 (0.025)	0.016 (0.051)
population growth	−0.005 (0.177)	0.269 (0.231)	0.361 (0.379)
life expectancy	2.557** (1.200)	2.516** (1.111)	2.635** (1.127)
terms of trade	0.621 (0.578)	1.022 (0.756)	0.361 (0.950)
conflict	−0.408 (0.483)	−1.023 (0.631)	−1.010** (0.399)
exec constraints	0.257*** (0.089)	0.347*** (0.099)	0.312** (0.114)
Constant	−11.762*** (3.618)		−26.701** (11.189)
K-Paap test (χ^2)	18.25		
p-val	(0.002)		
Sargan (χ^2)	2.054		
p-val	(0.561)		
Threshold est.	69***	89**	90***
90% Fieller interval	[59; 76]	[72; 127]	[71; 112]
N	24	24	24
Observations	840	912	912

Note: *, **, & *** denote significance at 10%, 5%, and 1%, respectively. Standard errors in are in parenthesis. The LSDV estimation employs the Blundell-Bond estimator for bias correction. The LIML regression employs the lags of government debt (up to lag 4) as in the baseline. FE-DK is the fixed effects method with Driscoll and Kraay standard errors.

Table A5. FE-IV estimation excluding Nigeria and South Africa

Variables	1	2	3	4	5	6	7
debt/gdp	0.209*** (0.063)	0.209*** (0.065)	0.209*** (0.065)	0.207*** (0.063)	0.224*** (0.075)	0.216*** (0.067)	0.186*** (0.061)
debt/gdp sq.	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)
initial income	3.035* (1.623)	2.368 (1.662)	2.570 (1.723)	2.344 (1.512)	2.269 (1.660)	2.136 (1.553)	5.143*** (1.645)
investment	0.137*** (0.046)	0.125*** (0.045)	0.127*** (0.046)	0.129*** (0.041)	0.120*** (0.043)	0.149*** (0.052)	0.111** (0.046)
population gr	0.614*** (0.233)	0.522*** (0.201)	0.539*** (0.200)	0.555** (0.258)	0.562*** (0.210)	0.547*** (0.206)	0.467** (0.188)
Life expectancy	2.301** (0.944)	1.903* (1.088)	1.851* (1.086)	1.752 (1.191)	1.531 (1.094)	1.672 (1.074)	2.469** (1.157)
terms of trade		1.030 (0.978)	0.990 (0.985)	1.079 (0.910)	1.023 (0.964)	1.227 (0.941)	0.941 (0.978)
conflict		-0.563 (0.721)	-0.553 (0.706)	-0.613 (0.753)	-0.552 (0.725)	-0.590 (0.742)	-0.505 (0.713)
exec const.		0.243** (0.115)	0.221** (0.110)	0.181* (0.102)	0.224** (0.114)	0.274*** (0.104)	0.219* (0.118)
inflation rate			0.022 (0.015)				
govt consumption				-1.440*			

(Continued)

Table A5. (Continued)

Variables	1	2	3	4	5	6	7
fin crisis dummy				(0.781)			
trade/gdp					0.695 (0.749)		
domestic cred/gdp						-0.028 (0.024)	
							-0.128*** (0.026)
Threshold est.	80*** [71; 91]	83*** [74; 97]	82*** [74; 97]	84*** [75; 100]	84*** [75; 99]	82*** [75; 97]	82*** [74; 100]
N	22	22	22	22	22	22	22
Observations	770	770	770	770	770	770	770

Note: ** & * denote significance at 5% and 10%, respectively; robust standard errors are in parenthesis in the upper part of the table. As in Table 2 in the main text, all threshold estimates are significant.

Table A6. Instrumental variable estimation using arbitrarily set thresholds

variables	FE-IV			LIML		
	1	2	3	1	2	3
govt_debt/gdp	0.030** (0.013)	0.026*** (0.010)	0.056*** (0.020)	0.007*** (0.007)	-0.002*** (0.006)	0.023** (0.011)
gd_30	0.993 (0.813)			1.156** (0.538)		
gd30_60		0.563 (0.536)			0.138 (0.379)	
gd_60			-2.672*** (1.028)			-2.079*** (0.699)
N	24	24	24	24	24	24
Obs.	863	839	840	888	888	888

Note: *, **, & *** denote significance at 10%, 5%, and 1%, respectively; executive constraints and a conflict dummy along with the standard growth covariates, namely initial income, investment, population growth, debt ratios from 30% and below (gd30), above 30% but below 60% (gd3060) and from 60% and above (gd60).

Table A7. Panel unit root tests

	Im-Pesaran-Shin (2003)		Levin-Lin-Chu (2002)	
	test statistics	p-value	Test statistics	p-value
real GDP per capita growth	−20.61***	.000	−14.94***	.000
Log Real GDP per capita	−0.012	.495	−0.7452	.228
government gross debt/gdp	−1.918**	.027	−1.452*	.073
investment	−4.293***	.000	−1.765**	.038
population growth	−3.623***	.000	−2.492***	.006
Log life expectancy	−6.920***	.000	−1.287*	.099
terms of trade growth	−1.983**	.024	−1.357*	.087
GDP deflator growth	−17.71***	.000	−12.72***	.000
Log government shares in GDP	−1.444*	.074	−3.596***	.000
domestic credit/gdp	−0.307	.379	−2.949***	.002

Note: ***, ** & * denote significance at 1%, 5%, and 10% levels, respectively. Discrete variables are not considered. The lag structure is determined automatically by the AIC criterion.