Nonlinear Impact of Public Debt on Economic Growth: Evidence from Sub-Saharan African Countries

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Abstract

This paper empirically explores the impact of public debt on economic growth in Sub-Saharan African (SSA) countries over the period 1960 to 2015 by using a system Generalized Methods of Moments (*s-GMM*). Specifically, this work studies the nonlinear relationship between public debt and economic growth. To do so, we perform the Sasabuchi-Lind-Mehlum's test (or U-test) to check if the required and sufficient conditions are met for an inverted U-shape. The results strongly suggest the presence of a nonlinear relationship between public debt and economic growth. By applying the Delta method, this threshold is evaluated at about 36.18 percent ratio debt-to-GDP with its confidence interval associated (13, 59). The public debt boosts the economic growth when its level is less than this turning point. Above this threshold, an increase in public debt would lower the economic growth. Accordingly, a re-examination of the public debt level of some convergence policies which set this level (debt-to-GDP ratio) to 70 per cent (cf. Boxes 1 and 2) is proposed.

Keywords: Economic growth, U-test, Delta method.

1. Introduction

What about if African countries are preparing to undergo a similar crisis to that of the Greece in 2009? All the factors seem to be met to replicate this crisis. Some African countries have benefited from Heavily indebted poor countries (HIPC) initiative have had their debt reduced. Thus, they can borrow again from the financial market and the good notations they receive from the credit rating agencies (Fitch, Moody's and Standard &Poor's), the same ones that had minimized the risks of Greek debt, allow them to borrow unwisely from the international financial market. From 2009 to 2014, the amount of Eurobonds issued on the international market was multiplied by more than 30 for *SSA* (Sub-Saharan African) countries (cf. Figure 1[1]). Nevertheless, the current economic state raises many concerns about this type of practice. Indeed, one might question the capacity of these countries to repay these loans insofar as the price of the commodities is decreasing.

Stiglitz and Rashid (2013, June 26), rightly warn the governments of *SSA* countries about the negative effects this debt could have on their economies but nothing seems to stop African governments' appetite for this new financial tool. Furthermore, the interest rates on these bonds seem high. African countries borrow at rates of about 6 - 7% even more (Ghana, 8.5% and 10.75% in 2007 and 2015 respectively). These rates are similar to European countries like Greece in the midst of economic turmoil.

What is the level of debt that can be borne by the economies of SSA countries? Should we rely on some convergence criteria? Which set the level of public debt (debt-to-GDP ratio) to 70 per cent (cf. Boxes 1 and 2). In the present work, we're trying to answer these questions. Due to the availability of data which are downloaded from the World Bank database (2017) and the *PWT* (Penn World Table) 9 (Feenstra et al., 2015), this work is based on only a panel of 44 out of 49 SSA countries over the period 1960 to 2015.

One applies the Sasabuchi-Lind-Mehlum's test developed by Lind and Mehlum (2010) to check for U-shape between public debt and economic growth as "the usual test of nonlinear relationships is flawed and derive the appropriate test for a U-shaped relationship" (p. 1) [18]. As for the value of this turning point and its confidence interval associated, both are determined by the Delta method.

The results suggest the presence of an inverted U-shaped curve between public debt and economic growth and the turning point is estimated at around 36.18 percent ratio debt-to-GDP with a confidence interval associated of (13, 59). Above this threshold, an increase in public debt could reduce the economic growth. This nonlinearity is thoroughly confirmed by the different robustness tests performed (functional form, subsample stability, and model stability).

The rest of this work is structured as follows: Section 2 presents the theoretical and empirical literature review related to (only) the nonlinear relationship between public debt and economic growth; Section 3 is

[1] Figures, tables and boxes are presented in Annex.

devoted to the econometric approach and gives the different results of the estimations; Section 4 checks for the robustness of the findings, and then Section 5 gives the conclusion.

2. Literature review

For the Keynesians, in the short run, the market is not always able to achieve the full employment by itself, it is for the government to intervene to overcome market failures, reduce economic fluctuations and promote balanced growth. Debt is neither a burden for current generations nor for future generations, as it creates an increase in investment through the Keynesian multiplier, promoting economic recovery. Conversely, for the Classics, the loan is to be avoided because it allows the government to spend more than what is necessary for it to achieve its function (Novaresi, 2001). Hayek (1966) denounces the debt as being an artificial growth, based on an investment upper to the effort of savings of the nation. As for Meade (1958), he underlines the threshold above which the high level of debt could negatively affect the economic growth "a large deadweight debt is a burden; it does not follow that the optimum size for the deadweight is zero" (p.79) [19].

Accordingly, one can assert that the possible effect of public debt on economic growth can be either (i) positive, (ii) negative or (iii) both positive and negative (nonlinear relationship). Since this paper explores the nonlinear relationship between debt and economic growth, the empirical literature is based only on this matter (Cf. Table 1, for a summary)

Some recent papers investigate this particular relationship among public debt and economic growth. For instance, Reinhart and Rogoff (2010) have considered a panel of 44 countries (emerging and advanced economies) over two hundred years and found that the public debt lowers economic growth when its value is above 90 percent ratio debt-to-GDP. Besides, they showed that when the external debt is above 60 percent ratio debt-to-GDP, the annual economic growth could drop by more than 1 percent point.

As for Minea and Parent (2012), they questioned the relevance of the statistical method used by Reinhart and Rogoff (2010). Indeed, in the first part of their work they prove the limit of this methodology (statistical analysis). By applying a *PSTR* model, developed by Caner and Hansen (2004), to the same sample as Reinhart and Rogoff (2010), they found that the turning point is no longer 90 percent ratio debt-to-GDP but above: 115 percent ratio debt-to-GDP.

Another important paper is that of Kumar and Woo (2010) which has studied 38 advanced and emerging economies for the period 1970–2007 by using two different econometric techniques: between estimator and s-GMM. Kumar and Woo (Op. cit.) found a strong evidence of the existence of a nonlinear relationship between public debt and economic growth and they estimate this threshold at about 90 percent ratio debt-to-GDP: the same value Reinhart and Rogoff (2010) found. Above this threshold, an increase of 1% in the debt level would slowdown the economic growth by about 0.02%.

Others studies also point out the nonlinearity between debt and economic growth and evaluate the turning point at about 90 percent ratio debt-to-GDP: Checherita and Rother (2010), Pier et al. (2012), Presbitero (2012).

Pattillo et al. (2002) examined a panel of 93 developing countries over the period 1969-1998 by computing a three-year average panel data. They add to their growth model a quadratic debt term. The s-GMM and FE estimate applied to their data yield a threshold at about 35-40 percent ratio debt-to-GDP.

Misztal (2010) has analyzed this inverted U-shaped curve between public debt and economic growth for 27 *EU* (European Union) countries for the period 2000-2010 through a VAR model. This technique estimated the turning point at about 65 percent ratio debt-to-GDP.

By using a PSTR, Grennes et al. (2010), Baum et al. (2012), Chang and Chiang (2012) and Egert (2014) pointed out the inverted U-shaped curve between public debt and economic growth.

Vranceanu and Besencenot (2013) also highlighted this nonlinear relationship between debt and economic growth in 26 *EU* countries over the period 1996 to 2011. By performing a panel *FE,* they estimate this threshold at 150 percent ratio debt-to-GDP.

Schclarek (2004) studied a panel of 59 developing countries and 24 industrial countries from 1970 to 2002 and found no evidence of a nonlinear relationship between public debt and economic growth as well. Nevertheless, he underpinned a negative relationship between debt and economic growth.

3. Empirical analysis, data, and results

This paper aims to explore the relationship between public debt and per-capita GDP growth in the SSA countries and, due to the availability of data it is based on 44 countries over the period 1960-2015 (cf. Table 2, for the list of countries included in this study). For the regressions, a five-year average data is preferred in order to cancel out the effect of short-term volatility which may appear huge in the said periods (Islam, 1995). The data is from the World Bank database (2017) and the Penn World Table (PWT 9) (Feenstra et al., 2015). The model is based on the convergence growth model by Solow (1956) and Baumol (1986). To take into account the goal of this paper, the public debt and its square term are added into this model.

The set of control variables (cf. Table 3, for the list and definition of variables) have been chosen according to the empirical studies about economic growth. Especially this choice is based on Sala-I-Martin et al. (2004)'s study: (i) Initial GDP per-capita (In. GDP per-capita) to capture the convergence process. The expected sign is negative; (ii) Investment (Inv) to highlight the importance of physical capital accumulation in the production process. Its coefficient is expected positive; (iii) Population growth (Pop-gr) to capture the country size. Its sign is expected negative because the y (dependent) variable is GDP per-capita growth rate. If other conditions are constant, rapid population growth will make the portion of one person smaller; (iv) Inflation (Inf) to apprehend the variation of the general level of prices on growth. Its coefficient is expected negative; (v) Trade openness (Open) to show the importance of the process of technology spillovers on economic growth. Its coefficient is expected positive; (vi) Primary completion rate (Pcr) is used to proxy the human capital. Its coefficient is expected positive; (vii) Government size (Gov_size) to show the impact of government expenditure on economic growth. The sign of its coefficient is undetermined.

The baseline equation is,

$$y_{i,t} = \alpha_0 + \beta_1 . log\ (D_{i,t}) + \beta_2 . (log(D_{i,t}))^2 + \ \gamma . X_{i,t} + \mu_i + \nu_t + \varepsilon_{i,t} \qquad (1)$$

Where $y_{i,t}$ is GDP per-capita growth rates, $D_{i,t}$ is public debt and $X_{i,t}$ is a set of control variables which contains initial GDP per-capita, investment, population growth rates, inflation, openness, primary completion rate and government size. μ_i is the country specific effect, ν_t is the time fixed effect and $\varepsilon_{i,t}$ the error term.

Due to (i) the possible inverse relationship between the variable of interest (public debt) and the dependent variable (GDP per-capita growth rates) and (ii) the apparent endogeneity of some control variables, the static panel techniques (*OLS*, *FE,* and *RE*) are inconsistent. Likewise, the presence of heteroskedasticity (cf. Table 4) makes the Generalized Method of Moments (GMM) estimator more efficient than the usual Instrumental Variables Estimator (IVE*)* (Baum et al., 2003). Therefore, to address these issues ((i) and (ii)), the GMM estimator is employed with a preference for the Blundell-Bond (1998) System GMM (s-GMM) since the pitfall of the difference GMM (d-GMM) is that sometimes the lagged-level used as instruments are weak[6]. So, according to this former method, Eq.(1) can be expressed as follows

$$\begin{pmatrix} y_{i,t} \\ \Delta y_{i,t} \end{pmatrix} = \beta_1 \begin{pmatrix} log\ (D_{i,t}) \\ \Delta log\ (D_{i,t}) \end{pmatrix} + \beta_2 \begin{pmatrix} (log(D_{i,t}))^2 \\ \Delta(log(D_{i,t}))^2 \end{pmatrix} + \gamma \begin{pmatrix} X_{i,t} \\ \Delta X_{i,t} \end{pmatrix} + \nu_t + \varepsilon_{i,t} \qquad (2)$$

Doing so**,** Blundell-Bond (Op. cit.) suggest choosing,

(i) the lagged first difference of the endogenous variables and the exogenous variables as instruments for the equation in levels;

(ii) the first difference of the exogenous variables and the lagged level of the endogenous variables as instruments for the equation in first difference.

In this paper, the following variables are considered endogenous and treated according to Blundell-Bond (1998)'s recommendations: Initial GDP per-capita, public debt, and its square term, investment and trade openness.

One of the disadvantages of the GMM technique is that it sometimes generates too many instruments which could cause a weak instrument bias (Roodman, 2009). To deal with this issue Roodman (2009) advises "collapsing the instrument matrix" and/or limiting "the number of lagged levels in the instrument matrix" [30]. The s-GMM estimation in this work combines the two propositions for more efficiency. As the Windmeijer (2005)'s correction is applied to the s-GMM, one relies on the Hansen test of overidentifying restrictions instead of Sargan test since this latter is inconsistent under robust GMM (Roodman, 2006).

For a good estimate with s-GMM if the lagged dependent variable is persistent (coefficient lagged dependent variable → 1), it should lie between *FE* and *OLS* estimate (Roodman, 2006) as, both probably biased downwards for the former and upwards for the latter. In the growth model, the coefficient of lagged dependent variable (convergence rate) is characterized by the coefficient of initial GDP per-capita.

To check the U-shape, one usually relies on the coefficient β_2 (coefficient of power term). A negative sign of this latter is interpreted as the clue of a turning point between public debt and economic growth. However, Lind and Mehlum (2010) claim that this technique is inconsistent and inappropriate since "the problem arises when the true relationship is convex but monotone over relevant data values. A quadratic specification may then erroneously yield an extreme point and hence a U shape" (p. 110) [18]. Contrariwise, the U-test checks if the required and sufficient conditions are met for an inverted U-shape. The null and alternative hypotheses of this test are H0: Monotone or U shape and H1: Inverse U-shape respectively. This technique is applied to this paper.

To estimate the debt threshold, beyond which public debt hurts the economic growth, we differentiate Eq.(1) with respect to $D_{i,t}$ and set it to 0,

$$\frac{\Delta y_{i,t}}{\Delta D_{i,t}} = \frac{\beta_1}{D_{i,t}} + \frac{2\beta_2 \ln (D_{i,t})}{D_{i,t}} = 0 \Rightarrow (D_{i,t})_{max} = exp\,(-\frac{\beta_1}{2\beta_2})$$

The value of this turning point and the confidence interval associated are both determined by the Delta method. Based on the Taylor approximation, this technique computes the variance of a nonlinear function of random variables (the ratio, in this work) by linearization (Rao (1973)).

3.1 Descriptive statistics

The mean of public debt is estimated at about 65.59 percent ratio debt-to-GDP over the period 1960 to 2015 (cf. Table 5). This value is in line with the convergence criteria which set the level of public debt (debt-to-GDP ratio) to 70 per cent (cf. Boxes 1 and 2). The maximum and the minimum debt value are 318.66 and 3.85 percent respectively. For the same period, the mean of GDP per-capita growth rate is evaluated at 2.285 percent. Besides, the population growth rate in *SSA* countries is relatively high. Over the period of study, its mean and maximum values are estimated at 2.508 % and 6.101% respectively. This may be one of the reasons why *SSA* countries which have the highest growth rate in the world, paradoxically, fails to reduce the poverty rate: Its population grows faster than its economic growth.

The correlation matrix (Table 6) suggest (i) investment, trade openness and primary completion rate boost the economic growth while the inflation lowers this latter, (ii) the positive impact of public debt on economic growth would be a sign of a U-shaped between these two variables (iii) in the case of *SSA* countries, the high population rate could be explained by its level of public debt. The correlation between these variables are positive and statistically significant at 1 percent level and (iv) the public debt reduces the GDP per-capita and the primary completion rate.

3.2 Impact of debt on GDP per-capita growth

The results of the estimation of Eq.(2) by *s-GMM* are given in Table 7 (column (3) and (6)). All the variables have the expected signs such as defined at the beginning of Section 3. Government size which the sign of its coefficient was undetermined appears negative (-1.591) and statistically significant at 5 percent level. This could reflect the negative impact of government spending on economic growth.

The null hypothesis of Arellano-Bond (1991) test for no second order serial correlation in the linear regression (p-value=0.304) and the nonlinear regression (p-value=0.400) are not rejected. Furthermore, the Hansen test of overidentifying restrictions for these two regressions yields a p-value of 0.217 for the former and 0.310 for the latter. These values suggest a validity of instruments.

Linear relationship (column (3)). Since the results strongly suggest a nonlinear relationship between public debt and GDP per-capita growth rate (column (6)), this estimation (column (3)) is not efficient. This inefficiency is (also) underpinned by the coefficient of lagged dependent variable (-2.378) which is not included in the interval (-1.340, -1.133) as Roodman (2006) advised. For these reasons, the results are not interpreted.

Nonlinear relationship (column (6)). The lagged dependent variable got by *s-GMM* is still persistent (-1.102) but this time, it is comprised between the coefficients found by *FE* (-1.127) and *POLS* (-0.901). This range insinuates that our estimate is probably consistent. For this regression, the coefficient of power term is negative ($\beta_2 = -1.165$) and statistically significant at 5 percent level. This result bolsters the presence of a nonlinear relationship between public debt and economic growth. As mentioned above, the coefficient of power term alone doesn't guarantee the presence of an inverse U-shape between two variables. One needs an appropriate test: Sasabuchi-Lind-Mehlum's test. The null hypothesis of this test (H0: Monotone or U shape) is rejected at 5 percent level (cf. Table 8). This result suggests the presence of a threshold above which public debt would hurt the economic growth. The Delta method evaluates this turning point at about 36.18 percent ratio debt-to-GDP with a confidence interval equal to (13, 59). Above this limit, an increase in public debt could negatively affect the economic growth. This finding accentuates the importance to reexamine the convergence criteria for some communities (cf. Boxes 1 and 2 in Appendix A) and/or to limit the level of public debt at a ceiling less than 36.18 percent ratio debt to GDP.

Likewise, these results are roughly the same with those found by Pattillo et al. (2002) in their study. Indeed, this latter based on a sample containing only developing countries (93) estimates the turning point at around 35-40 percent ratio debt-to-GDP.

As for the explanatory variables, the Initial GDP per-capita is negative and statistically significant at 10 percent level. This result sheds light on the conditional convergence such as defined by Barro (1991). According to him, the poor countries (low Initial GDP per-capita) have high per-capita growth rate to catch up the rich countries, all other things being equal. As for the investment, it positively affects the per-capita GDP growth rate. Its coefficient (0.241) is statistically significant at 1 percent level.

4. Robustness tests

As Kumar and Woo (2010), Checherita and Rother (2010) and other important researchers, this paper also examines for the robustness of these findings through three tests: functional form, subsample stability and model stability. All the tests are performed by using a *s-GMM*.

The consistency of the polynomial functional form. According to Checherita and Rother (2010), if the form of Eq.(2) is well specified, the concavity shape should remain unchanged even when the power term changes. That is, one re-estimate Eq.(2) by *s-GMM* by varying the power term from 1.2 to 3 (Cf. Table 9). To save the place, the results of Arellano-Bond (1991) test for no second order serial correlation and the Hansen test of overidentifying restrictions are not presented even if the p-values of those tests fail to reject the null hypothesis in each case. By varying the power term, its coefficient remains negative and statistically significant at 5 percent (power 1.2-2) and 10 percent (power 2.2-3) level which confirms the presence of an inverted U-shaped curve between public debt and economic growth. Changing the power term does not affect the concavity shape of the relationship between debt and economic growth.

Subsample stability (Cf. Table 10)**.** The consistency of the turning point is tested through the subsample stability by (i) modifying the period of estimation (columns (2)), (ii) removing from the sample (a) the five most indebted countries (columns (4)) and (b) the five least indebted countries (columns (6)) and (iii) changing the period of estimate and removing from the sample (a) the five most indebted countries (columns (8)) and (b) the five least indebted countries (columns (10)). For all the regressions, the coefficient of power term (β_2) remain negative and statistically significant at 1 percent level (columns (6) and (10)), 5 percent level (columns (4) and (8)) and 10 percent level (columns (2)) confirming the presence of the turning point. The value of these thresholds associated with each new sample is between 30.79-41.79 percent ratio debt-to-GDP: values roughly identical to the value found previously (Section 3): 36.18 percent ratio debt-to-GDP.

Model stability (Cf. Table 11)**.** To check for the validity of the main equation (Eq.(1)), we control for some important variables which are supposed to have a strong relationship with the dependent variable but not included into the model: Exchange rate (column(3)) (Habib et al., 2016), Urbanization (column(6)) as a proxy for the quality of Institutions (Glaeser et al., 2004; Kumar and Woo, 2010) and Foreign direct investment (column(9)). Regardless the new variable introduced into the model, the coefficient of power term (β_2) is still negative and statistically significant at 5 percent level (column(6)) and 10 percent level (column(3) and (9)), reflecting the presence of a turning point in each case. The different thresholds associated to β_2 (32.91 (column(3)); 39.63 (column(6)) and 34.07 (column(9)) percent ratio debt-to-GDP) are quite similar to that got in Section 3 (36.18 percent ratio debt-to-GDP) and suggest that Eq.(1) is well specified.

5. Conclusions and Policy Implication

This paper mainly investigates the impact of public debt on economic growth. The results suggest the presence of a threshold above which the debt would hurt the economic growth. This turning point is estimated at about 36.18 percent ratio debt-to-GDP with a confidence interval associated of (13, 59).

Irrevocably these results highlight the need to reduce the level of public debt in order to stimulate the economies. In particular, we (highly) recommend a re-examination of the public debt level for the convergence policies which set this level to 70 per cent ratio debt-to-GDP. This value is about twice the value of the threshold that these economies can bear without triggering the negative impact of the public debt. To make the debt reduction policy more effective, it should be accompanied by an improvement in the political and economic environment. Indeed, the negative impact of GDP per-capita on credits to the private sectors shows that capital flight from sub-Saharan Africa is due to political instability (insecurity, embezzlement).

Lastly, in Africa 14 countries (*CEMAC*[2] and *WAEMU*[3] countries) have they currency which is pegged to Euro, it could be noteworthy to investigate how this link between these currencies affect the relation between debt and economic growth: does the currency pegged matter for the value of turning point?

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ANNEXES

Box 1: CEMAC convergence criteria

Basic fiscal balance[1] (≥ 0)
Consumer price inflation (≤ 3%)
Level of public debt (≤ 70%)
Non-accumulation of government arrears[2] (≤0)

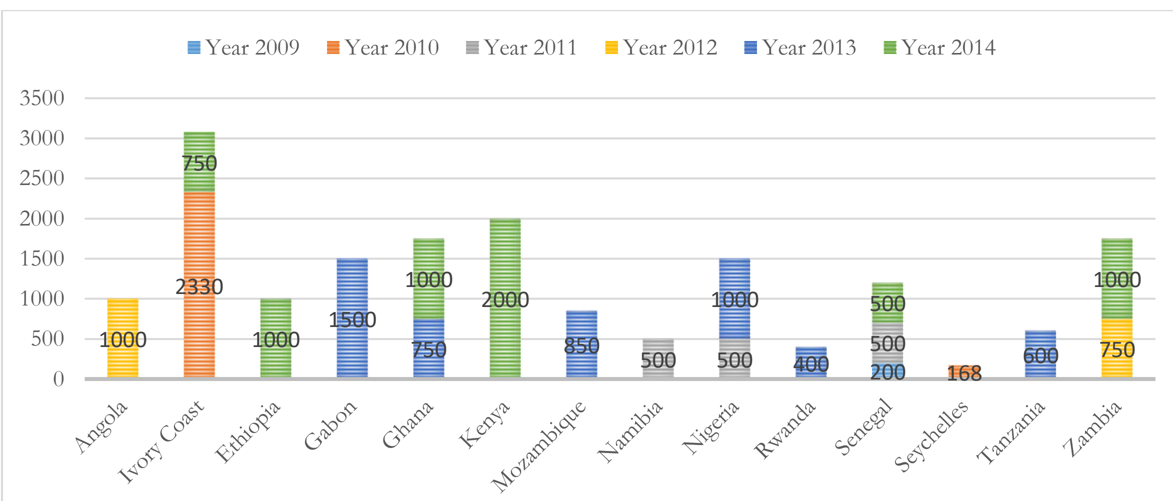
Source: CEMAC
[1]Overall budget balance, excluding grants and foreign-financed investment.
[2]External and domestic arrears.

Box 2: WAEMU convergence criteria

First-order criteria
Overall Balance/GDP (≥ −3 percent)
Average consumer price inflation (≤ 3 percent)
Total debt[1]/GDP (≤70 percent)
Second-order criteria
Wages and salaries/tax revenue (≤35 percent)
Tax revenue/GDP (≥20 percent)

Source: WAEMU
[1]Public debt

Figure 1: Bond issuances in *SSA* 2009-2014 (without South Africa) (US$ Millions)



Source: *ODI*, 2015 and Author's calculation

Table 1: Summary literature

Author(s)	Type of Data, Countries and Time Period	Empirical Approach	Threshold (%GDP)	Journal
Pattillo et al. (2002)	Panel data, 93 developing countries, 1969-1998	Fixed Effect (FE) and system Generalized Method of Moments (s-GMM)	35-40%	*Working Paper*, IMF.
Schclarek, A. (2004)	Panel data, 59 developing countries and 24 industrial countries	Method of Moments (s-GMM)	No evidence of presence of nonlinearity	*Working Paper*, Department of Economics, Lund University, Sweden.
Checherita, C., Rother, P. (2010)	Panel data, 12 *EU* countries over the period 1970-2010	Fixed Effect (FE) models and Instrumental Variables (IVREG) models	90-100%	*European Economic Review*
Kumar and Woo (2010)	Panel data, 38 advanced and emerging economies for the period 1970–2007	between estimator (BE), Generalized Method of Moments (s-GMM)	90%	*Working Paper*, IMF.
Reinhart and Rogoff (2010)	Panel data, 44 countries (emerging and advanced economies) over two hundred years	Statistical analysis	About 90%	*American Economic Review*
Grennes et al. (2010)	Panel data, 101 countries (developing and advanced economies), 1980-2008	Panel Smooth Transition Regression (PSTR) Model	77% (full sample) 64% (developing countries)	*Econometric Theory,* Cambridge University Press
Misztal (2010)	Panel data, 27 *EU* countries, 2000-2010	Vector Auto-Regression model (VAR)	65%	*Journal of Applied Economic Sciences*
Baum et al. (2012)	Panel data, 12 *EU* countries, 1990-2010	Panel Smooth Transition Regression (PSTR) Model	95%	*American Economic Review*
Minea and Parent (2012)	Re-evaluate the work of Reinhart and Rogoff (2010)	Panel Smooth Transition Regression (PSTR) Model	115%	*Working Paper*, Center for Studies and Research on International Development
Egert (2014)	Panel data, 21 developed and 28 emerging economies, 1960-2010	Panel Smooth Transition Regression (PSTR) Model	20-60%	*Working Paper, OECD*
Chang and Chiang (2012)	Panel data, 19 *OECD* countries, 1993-2007	Panel Smooth Transition Regression (PSTR) Model	97.82%	*Journal for Economic Forecasting*
Pier et al. (2012)	34 *OECD* countries, 1960-2011	System Generalized Method of Moments (s-GMM)	90%	*OECD Journal*
Presbitero (2012)	Panel data, low and middle-income countries, 1990-2007	System Generalized Method of Moments (s-GMM)	90%	*European Journal of Development Research*
Vranceanu and Besencenot (2013)	Panel data, 26 EU countries, 1996-2011	Panel *FE*	150%	*Applied Economics Letters*

Source: Authors' compilation

Table 2: List of Sub-Saharan African Countries by Region

1.Central Africa region	South Sudan[1]	***4.West Africa region***
Burundi	Sudan	Benin
Cameroon	Tanzania	Burkina Faso
Central African Republic	Uganda	Cote d'Ivoire
Chad	***3.South Africa region***	Ghana
Congo, Dem	Angola	Niger
Rep. Congo	Botswana	Nigeria
Equatorial Guinea	Lesotho	Togo
Gabon	Madagascar	Cabo Verde
Rwanda	Malawi[1]	Gambia
2.East Africa region	Mauritius	Guinea
Comoros	Mozambique	Guinea-Bissau
Djibouti	Namibia	Liberia
Kenya	South Africa	Mali
Eritrea[1]	Swaziland	Mauritania
Ethiopia	Zambia	Sao Tome And Principe[1]
Seychelles	Zimbabwe	Senegal
Somalia[1]		Sierra Leone

[1] These countries are not included in this study.

Table 3: Variables and definition

Variables	Source	Definition
GDP growth	*WDI*	Gross Domestic Product growth
In. GDP per-capita	*WDI*	Initial GDP per capita (constant, US$) = GDP per capita (constant, US$) at the beginning of each five-year period
PCR	*WDI*	Primary completion rate as Proxy of Human capital
Inf	*WDI*	Inflation rate
Gov-size	*WDI*	Government-size (%GDP)
Open	*WDI*	Openness(%GDP) = Export(%GDP) + Import(%GDP)
Inv	*WDI*	Investment (%GDP)
Pop-growth	*WDI*	Population growth
Debt	*WDI*	Public debt (%GDP)
Exc-rate	*WDI*	Exchange rate (LCU per US$)
Cred-ps	*WDI*	Credits to private sector (%GDP)
FDI	*WDI*	Foreign direct investment (%GDP)
Bm	*WDI*	Broad money (%GDP)
Irs	*WDI*	Interest rate spread (lending rate minus deposit rate, %)
TFP	*PWT* 9	Total Factor Productivity

Table 4: White's test for heteroscedasticity

$Chi(square)$	$Degrees\ of\ freedom$	$P - value$
117.94	94	0.0480

Note. The null hypothesis of this test is homoscedasticity.

Source: World Development Indicators (World Bank, *WDI* 2015), and Author's calculation

Table 5: Descriptive statistics

N=144 observations (Variables present in Eq.(1))

Variables	**Mean**	**Median**	**Standard Deviation**	**Minimum**	**Maximum**
GDP per-capita growth	2.285	1.600	5.580	-11.778	51.623
GDP per-capita (constant 2000 US$)	2406.969	834.798	3752.088	211.102	23211.5
Investment (%GDP)	22.963	20.497	17.313	5.231	173.374
Population growth	2.508	2.667	1.004	-4.105	6.101
Inflation rate	11.434	5.191	32.844	0.918	303.782
Trade Openness	81.903	69.893	51.893	23.877	436.572
Primary completion rate	60.020	59.665	22.458	15.183	108.625
Government-size (%GDP)	14.956	14.327	6.114	2.804	41.330
Public debt (%GDP)	65.590	55.901	48.778	3.848	318.662

Source: *WDI* 2015, and Author's calculation

Table 6: Correlation matrix, 1960-2015

	gdpgr_pc	gdpc	Inv	pop_gr	inf	open	pcr	gov_size	debt
gdpgr_pc	1								
gdpc	0.0463	1							
Inv	0.5514***	0.2584***	1						
pop_gr	0.0654	-0.1870***	0.0393	1					
inf	-0.1452***	-0.0311	-0.0761	-0.0089	1				
open	0.3712***	0.3327***	0.7192***	-0.0259	-0.0020	1			
pcr	0.1650***	0.4064***	0.2034***	-0.2492***	-0.0193	0.3092***	1		
gov_size	-0.0304	0.1089**	0.1891***	-0.0853*	-0.0218	0.3701***	0.1326**	1	
debt	0.0520	-0.1659**	-0.0192	0.1881***	-0.0043	0.0734	-0.1964***	0.0055	1

Note. */**/***: statistically significant at 10%, 5% and 1% respectively

Source: *WDI* 2015, and Author's calculation

Table 7: Impact of public debt on economic growth, 1960-2015 (Five-year average panel data)
(Dependent variable: GDP per-capita growth)

Explanatory variables	**Linear relationship**			**Nonlinear relationship**		
	(1) FE	**(2) POLS**	**(3) S-GMM**	**(4) FE**	**(5) POLS**	**(6) S-GMM**
In. GDP per-capita (log)	-1.340 (1.978)	-1.133* (0.576)	-2.378*** (0.694)	-1.127 (1.827)	-0.901 (0.562)	-1.102* (0.636)
Inv	0.306*** (0.076)	0.243*** (0.039)	0.258*** (0.049)	0.287*** (0.075)	0.227*** (0.037)	0.241*** (0.027)
Pop-growth (log)	0.276 (1.024)	-0.559 (0.860)	-1.617* (0.876)	0.402 (1.045)	-0.193 (0.873)	-0.303 (0.817)
Inf (log)	-2.520*** (0.561)	-0.427 (0.545)	-1.112** (0.482)	-2.481*** (0.550)	-0.267 (0.576)	-0.561 (0.516)
Open	0.034 (0.020)	0.012* (0.007)	0.018 (0.026)	0.037* (0.021)	0.020** (0.009)	0.028** (0.012)
Pcr (log)	-4.140** (1.956)	0.698 (1.162)	1.416 (1.323)	-4.081** (1.932)	0.452 (1.131)	0.991 (1.131)
Gov-size (log)	-4.762** (2.187)	-0.611 (0.908)	-1.365* (0.775)	-4.710** (2.268)	-0.764 (0.843)	-1.591** (0.683)
Log(Debt)	-1.236 (0.760)	-0.775* (0.402)	-0.821 (0.628)	3.127 (2.097)	6.848** (3.037)	8.364* (4.418)
$(Log(Debt))^2$	-	-	-	-0.561** (0.253)	-1.007** (0.401)	-1.165** (0.585)
Constant	43.587*** (15.754)	7.670 (5.446)	17.245 (8.496)	33.636** (16.157)	-7.162 (8.466)	-9.361 (10.638)
AR(2) p-value[1]			0.304			0.400
Hansen p-value[2]			0.217			0.310
Nb. obs.	143	143	143	143	143	143
R-squared	0.788	0.682		0.791	0.698	
Time fe	Yes	Yes	Yes	Yes	Yes	Yes
(Delta method)						
Turning-point	NA	NA	NA	16.22	30.01***	36.18***
95% CI nlcom	NA	NA	NA	(-12, 44)	(15, 45)	(13, 59)

Note. */**/***: statistically significant at 10%, 5% and 1% respectively; () = standard error;
[1]H0: no autocorrelation of order 2; [2]H0: no correlation between instruments and the residuals.

Source: *WDI* 2015, and Author's calculation

Table 8: Sasabuchi-Lind-Mehlum's test

Extreme point: $(Log(Debt))_{max}$= 3.588623
Test:
H1: Inverse U-shape
vs. H0: Monotone or U-shape

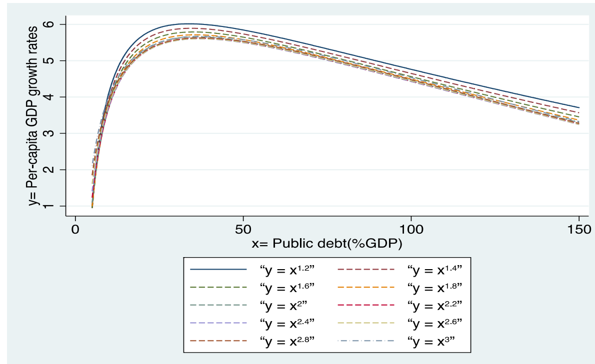
	Lower bound	**Upper bound**
Interval	1.347553	4.300000
Slope	5.223036	-1.657935
t-value	1.817412	-1.678673
P>t	0.035624	0.047700

Overall test of presence of an Inverse U-shape:
t-value = 1.68
P>|t| = 0.0477

Source: *WDI* 2015, and Author's calculation

Table 9: Robustness checks –The consistency of the polynomial functional form

Powers	**Coefficient power term**	**Turning point**	**95% CI**
1.2	-26.1986**	33.78***	(13, 54)
1.4	-8.8456**	34.51***	(13, 56)
1.6	-4.0384**	35.15***	(13, 57)
1.8	-2.0938**	35.71***	(13, 58)
2	**-1.1653****	**36.18*****	**(13, 59)**
2.2	-0.6785*	36.58***	(13, 60)
2.4	-0.4076*	36.90***	(12, 61)
2.6	-0.2506*	37.15***	(12, 63)
2.8	-0.1567*	37.32***	(11, 64)
3	-0.0994*	37.42***	(10, 65)



Note. */**/***: statistically significant at 10%, 5% and 1% respectively

Source: *WDI* 2015, and Author's calculation

Table 10: Robustness checks -Subsample stability
(Dependent variable: GDP per-capita growth)

Explanatory variables	**Period: 1996-2015 Sample: Full sample**		**Period: 1960-2015 Sample:(-)the 5-HIC (SGMM-h) and the (-) the 5-LIC(SGMM-l)**				**Period: 1996-2015 Sample:(-)the 5-HIC (SGMM-h) and the 5-LIC(SGMM-l)**			
	(1) FE	**(2) SGMM**	**(3) FE-h**	**(4) SGMM-h**	**(5) FE-l**	**(6) SGMM-l**	**(7) FE-h**	**(8) SGMM-h**	**(9) FE-l**	**(10) SGMM-l**
In. GDP per-capita	-8.188***	-0.768	-0.792	-1.239**	-1.341	-1.038	-7.786***	-0.954	-8.136***	-0.984
(log)	(1.582)	(0.846)	(1.853)	(0.505)	(1.775)	(0.683)	(1.674)	(0.672)	(1.911)	(0.757)
Inv	0.240***	0.259***	0.300***	0.218***	0.280***	0.226***	0.249***	0.230***	0.231***	0.239***
	(0.053)	(0.038)	(0.076)	(0.024)	(0.068)	(0.035)	(0.055)	(0.033)	(0.055)	(0.027)
Pop-growth (log)	-0.446	0.038	0.404	-0.579	0.142	-0.335	-0.424	-0.073	-0.400	-0.214
	(1.040)	(0.853)	(1.021)	(0.717)	(1.240)	(1.086)	(1.027)	(0.919)	(1.304)	(0.899)
Inf (log)	-1.445***	-0.491	-2.508***	-0.777	-2.458***	-0.101	-1.469***	-0.767	-1.444**	-0.211
	(0.492)	(0.622)	(0.542)	(0.494)	(0.523)	(0.676)	(0.500)	(0.489)	(0.537)	(0.637)
Open	0.005	0.018	0.033	0.038***	0.050**	0.039***	0.002	0.031**	0.017	0.030***
	(0.015)	(0.015)	(0.021)	(0.011)	(0.022)	(0.013)	(0.015)	(0.014)	(0.016)	(0.011)
Pcr (log)	-2.149	0.379	-4.387**	0.342	-4.408**	0.633	-2.239	-0.219	-2.002	0.090
	(1.557)	(1.375)	(1.998)	(1.149)	(2.021)	(1.467)	(1.632)	(1.351)	(1.762)	(1.338)
Gov-size (log)	-2.658	-1.291	-3.972*	-1.312**	-5.360**	-1.130	-2.188	-1.042	-3.299	-1.123
	(2.337)	(0.876)	(2.267)	(0.634)	(2.428)	(1.138)	(2.419)	(0.929)	(2.633)	(0.956)
Log(Debt)	1.178	9.028*	1.655	8.248**	2.227	9.244***	0.613	9.673**	0.613	9.198***
	(1.466)	(4.689)	(1.912)	(4.117)	(2.291)	(2.941)	(1.684)	(4.454)	(1.551)	(3.210)
(Log(Debt))²	-0.199	-1.209*	-0.378	-1.203**	-0.520*	-1.344***	-0.122	-1.365**	-0.196	-1.294***
	(0.164)	(0.635)	(0.236)	(0.577)	(0.264)	(0.398)	(0.196)	(0.628)	(0.169)	(0.445)
Constant	69.628***	-12.908	32.90**	-5.280	41.120**	-11.267	66.382***	-9.165	72.357***	-9.990
	(13.029)	(11.657)	(16.00)	(10.285)	(18.956)	(10.860)	(12.909)	(11.513)	(15.544)	(10.548)
AR(2) p-value[1]		0.287		0.315		0.467		0.232		0.283
Hansen p-value[2]		0.165		0.365		0.226		0.167		0.457
Nb. obs.	133	133	134	134	125	125	124	124	116	116
R-squared	0.854		0.795		0.828		0.856		0.875	
Time fe	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Delta method)										
Turning-point	-	41.79**	-	30.79***	8.52	31.16***	-	34.61***	-	34.95***
95% CI nlcom	-	(8, 75)	-	(14, 48)	(-13, 3)	(10, 52)	-	(13, 56)	-	(16, 54)

Note. */**/***: statistically significant at 10%, 5% and 1% respectively; () = standard error;
[1]H0: no autocorrelation of order 2; [2]H0: no correlation between instruments and the residuals
(-) the 5-HIC: sample restriction, without the 5 most indebted countries;
(-) the 5-LIC: sample restriction, without the 5 least indebted countries.

Source: *WDI* 2015, and Author's calculation

Table 11: Robustness checks -Model stability

(Dependent variable: GDP per-capita growth)

Explanatory variables	(1) FE	(2) POLS	(3) SGMM	(4) FE	(5) POLS	(6) SGMM	(7) FE	(8) POLS	(9) SGMM
In. GDP per-capita (log)	-1.169	-0.925*	-1.055	-0.942	-0.680	-0.843	-1.168	-0.744	-1.081
	(1.906)	(0.556)	(0.677)	(1.814)	(0.650)	(0.660)	(1.924)	(0.557)	(0.707)
Inv	0.283***	0.231***	0.246***	0.290***	0.227***	0.239***	0.258***	0.215***	0.232***
	(0.079)	(0.037)	(0.033)	(0.075)	(0.037)	(0.026)	(0.084)	(0.039)	(0.030)
Pop-growth (log)	0.436	-0.169	-0.104	0.226	-0.061	-0.131	0.541	-0.219	-0.458
	(1.106)	(0.874)	(0.858)	(1.102)	(0.900)	(0.744)	(1.052)	(0.880)	(0.750)
Inf (log)	-2.399***	-0.197	-0.435	-2.590***	-0.314	-0.608	-2.470***	-0.276	-0.589
	(0.748)	(0.600)	(0.488)	(0.582)	(0.571)	(0.540)	(0.550)	(0.573)	(0.504)
Open	0.038*	0.019**	0.029**	0.036*	0.020**	0.029***	0.039*	0.013	0.023
	(0.022)	(0.009)	(0.013)	(0.021)	(0.009)	(0.010)	(0.022)	(0.011)	(0.016)
Pcr (log)	-3.995**	0.374	0.393	-4.090**	0.642	1.146	-4.208**	0.372	0.912
	(1.973)	(1.124)	(1.092)	(1.880)	(1.131)	(1.137)	(1.876)	(1.117)	(0.937)
Gov-size (log)	-4.599*	-0.948	-1.518**	-4.901**	-0.785	-1.490**	-4.686**	-0.795	-1.600**
	(2.364)	(0.839)	(0.683)	(2.269)	(0.854)	(0.716)	(2.229)	(0.834)	(0.662)
Log(Debt)	3.301	7.068**	8.281*	3.008	7.278**	9.112**	2.413	6.647**	7.630
	(2.159)	(3.017)	(4.642)	(2.168)	(3.097)	(3.921)	(2.238)	(3.090)	(4.732)
$(Log(Debt))^2$	-0.592**	-1.035**	-1.185*	-0.530**	-1.036**	-1.238**	-0.465	-0.987**	-1.081*
	(0.265)	(0.399)	(0.617)	(0.262)	(0.404)	(0.510)	(0.301)	(0.407)	(0.628)
Exc-rates	-0.000	-0.000*	-0.000						
	(0.000)	(0.000)	(0.000)						
Urb				0.123	-0.024	-0.028			
				(0.143)	(0.021)	(0.029)			
FDI							0.071	0.071	0.035
							(0.109)	(0.053)	(0.088)
Constant	28.481	-9.159	-8.576	23.629	-12.346	-12.929	31.114*	-9.337	-6.979
	(17.330)	(8.668)	(11.492)	(16.750)	(9.370)	(10.657)	(15.977)	(8.857)	(11.773)
AR(2) p-value[1]			0.373			0.443			0.430
Hansen p-value[2]			0.361			0.616			0.667
Nb. obs.	142	142	142	143	143	143	143	143	143
R-squared	0.786	0.705		0.794	0.701		0.794	0.702	
Time fe	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Delta method)									
Turning-point	16.24	30.44***	32.91***	17.10	33.55***	39.63***	13.39	29.03***	34.07***
95% CI nlcom	(-11, 43)	(16, 45)	(11, 55)	(-14, 48)	(17, 50)	(17, 62)	(-14, 41)	(14, 44)	(9, 59)

Note. */**/***: statistically significant at 10%, 5% and 1% respectively; () = standard error

[1]H0: no autocorrelation of order 2; [2]H0: no correlation between instruments and the residuals.

Source: *WDI* 2015, and Author's calculation