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The laffer curve and the debt-growth link in low-income Sub-Saharan African economies

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Abstract

The study of the link between debt and growth has been full of debates, both in theory and empirics. However, there is a growing consensus that the relationship is sensitive to the level of debt. Our paper tries to address the question of non linearity in the long term relationship between public debt and economic growth. Specifically, we set out to test if there exists an established 'laffer curve' type relationship, where debt contributes to economic growth up to a certain point (maximal threshold) and then starts to have a negative effect on growth afterwards. To carry out our tests, we have used a methodology that delivers a superior test of bell shapes, in addition to the traditional test based on a regression with a quadratic specification. The results show evidence of a bell-shaped relationship between economic growth and total public debt in a panel of low income Sub-Saharan African economies. This supports the hypothesis that debt has some positive contribution to economic growth in low-income countries, albeit up to a point. If debt goes on increasing beyond the level where it would be sustainable, it may start to be a drag on economic growth.

Key Words: public debt, economic growth, laffer curve, low-income countries, Sub-Saharan Africa

JEL Classification: E62, H63, N17, O55

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1. Introduction

Debt related problems are nothing new to low-income Sub-Saharan African (SSA) countries. In the 1980s and 90s, their debt burden climbed to monumental levels and they become insolvent from servicing it. Most of them have been granted relief and reduction schemes following the massive debt-forgiveness campaigns of the 1990s.[2] The subsequent fall in debt levels waived the worries about acute debt related problems in these countries. The past few years, however, saw a renewed interest in the possible relationship between economic growth and public debt. At the root of this interest is the rise in public debt in many countries. Nonetheless, much of this focus has been on advanced economies that are stuck in a high debt and low growth trajectory.[3] SSA's low-income countries have been 'relatively' resilient during the recent global economic crisis. A recent World Bank report (Global Development Finance, 2012) notes that the average debt stocks of developing countries have remained moderate at 21% of GNI and 69% of exports. However, it also adds that publicly guaranteed debt (already at 54% of all long term debt stock) is growing fast. As Panizza (2008) explains, another worrying recent trend is the rise of domestic debt. After the era of high external public debt, many developing countries are resorting to domestically issued debt. Even if the external subcomponent of total debt stocks is shrinking, and this has been widely hailed, the domestic subcomponent is rising.[4] Despite the recent waves of debt forgiveness and rescheduling, the fight against unsustainable debt is far from over in low-income countries. These countries will have to continue balancing their dire need for development financing with debt sustainability. Even if the historic waves of epic debt crisis are less likely to return anytime soon, many developing countries are experiencing (or will experience) some degree of debt distress. However, this leaves us with some interesting questions. Can public debt explain economic growth, ceteris paribus? Is its impact positive or negative? Does this outcome change across low and high levels of indebtedness?

While trying to address the debt-growth relationship in developing countries, we hypothesize a bell-shaped relationship. Our hypothesis tries to marry two major conceptions in the literature. On the one hand, there is a widespread thought that high debt levels are a drag to economic growth (Claessens, 1990; Reinhart et al. 2003; Reinhart and Rogoff, 2010[5]). On the other hand, growth theories claim that poor countries need to borrow in order to finance their development (Levine, 2005; Carlin and Mayer, 2003). However, there should be a middle

[2] Most low-income African countries have been beneficiaries of the heavily indebted poor countries (HIPCs) initiative and they had significant reduction and forgiveness of their debt (See Sanford, 2004; Cassimon and Vaessen, 2007; Freytag and Pehnelt, 2008). All the countries in our panel (except Kenya) have been categorized as HIPC.

[3] Developing countries have historically been the primary culprits and victims of debt crisis. The recent focus on developed countries' debt stocks goes against the norm. Yet, this is not surprising since rich countries have been facing weakened growth rates for years, while their debt levels has remained very high.

[4] A common way of measuring indebtedness in low-income countries has been looking at their external public debt, as it has historically been the largest element of their total debt stock. Given the rise of domestic public debt, we find it appropriate to consider total public debt, and not just external debt. Our study estimates indebtedness via the ratio of total public debt to GDP, as this is commonly done in the literature.

[5] This paper has been particularly influential in driving the debt sustainability (austerity) concerns in advanced economies during the recent global recession. At later date, it has attracted further attention due to some computational mistakes committed by its authors (see critique by Herndon et al., 2013).

ground where debt levels are 'safe' and contribute to economic growth. Put another way, poor countries at low levels of debt can go on borrowing more to finance their development, though up to a certain level. This process will expand their economy by delivering them with the much needed capital, which they lack. However, if they go on incurring higher and higher levels of debt (beyond what is sustainable) then, they start to experience growth rates that are lower and lower, then possibly negative. This translates to a relationship that can be better approximated by a bell-shaped curve, which is also known as the debt-laffer curve.[6]

The 'debt-laffer curve' is one example of many bell-shaped relationships in economics. Originally introduced by Sachs (1989), it was used to establish the concept of 'debt-overhang'. This refers to a scenario where higher and unsustainable levels of borrowing by developing countries expose them to efficiency losses. A pronounced debt burden and the associated cost of servicing it will create difficulties for developing economies to properly invest their income. Sachs and Huizinga (1987) and Claessens (1990) explain about the potential efficiency losses and the rationale of 'debt forgiveness'.[7] They argue that, debt rescheduling negotiations between creditors and debtors are often time consuming and costly. The process will also have a further impact on the debtor country by bringing disruptions to its trading and investments arrangements. When the amount of nominal claims outstanding ascends excessively because of inefficiencies and deadweight losses, the present value of expected debt repayments begins to go down. This gives the relationship between the nominal and market value of debt a distinctive bell-shaped/laffer curve.

In this paper, we are dealing with an alternative form of the famous 'debt-laffer' curve. We are interested here in the long term relationship between debt and economic growth. Yet, the underlying logic is similar. Following Reinhart et al., 2003; Cordella et al., 2010; Panizza and Presbitero, 2013; we hypothesize that debt would be beneficial to economic growth up to a certain level and it will start to be a drag once it exceeds a certain internal threshold. Based on this established hypothesis, the primary objective of this research is to offer an evidence (if any) regarding the existence of the 'laffer curve' in the relationship between public debt and economic growth.[8]

A non-linear relationship is repeatedly noted in the literature regarding the long term link between public debt and economic growth.[9] However, there is no conformity regarding the

[6] The Laffer curve, in its initial form, represents the association among different tax rates and the ensuing amounts of government revenue (see Novales and Ruiz, 2002; Heijman and Ophem, 2005; Strulik and Trumborn, 2012). In later years, the word 'laffer' has become almost synonymous with bell-shaped (inverse-U) relationships.

[7] Following its introduction, the 'debt-overhang' concept has attracted the attention of many researchers (see Krugman, 1989; Claessens, 1990; Claessens and Diwan, 1991). The call for 'debt-forgiveness' was also backed by this line of research. It was argued that, debt-forgiveness for the countries sitting on the declining side of the curve was in the collective interest of both the creditors and the borrowers. For a historical account of 'debt-overhangs' (and recent directions in the mainstream literature) see Reinhart et al., 2012.

[8] The low-income category, according to the World Bank, implies a per capita income ≤ $1,035 http://data.worldbank.org/about/country-classifications

[9] The relationship between public debt and economic growth may depend on the time horizon under consideration. Panizza and Presbitero (2013), citing Elmendorf and Mankiw (1999), argue that in the short run output is demand driven. A rising level of public debt/deficit, hence, increases disposable income. This will, in turn, lead to an increase in demand and output .

pattern of non-linearity at low and high levels of debt.[10] There is also a big debate regarding what level of debt should be considered 'high' or 'unsustainable'. The empirical analysis by different researchers also comes up with different results, further complicating the issue. Whatever, the 'sustainable' level of debt may be, it is widely accepted that the threshold of debt sustainability should be lower for developing countries, compared to developed economies (see Reinhart et al., 2003; Caner et al., 2010).[11] Despite some of the divergences, most researchers seem to agree that the debt-growth relationship can be better captured by a non-linear model rather than a linear relationship. Panizza and Presbitero (2013), who deliver a thorough survey of the theoretical and empirical literature on the issue, argue that it is impractical to try to compute a single debt coefficient that could represent all countries and all time periods.

Building on the foregoing debate in the literature, we will head to the subsequent sections of the paper. In section 2 we present the methodology which our paper will follow. In section 3 we make a basic description of our data. In section 4 we demonstrate the key findings of our analysis. Finally, we conclude our paper in section 5.

2. Methodology: Testing for bell-shapes

Earlier studies mostly address the test of non linearity using externally imposed thresholds and fitting spline regressions (see Marsh and Cormier, 2002).[12] However, as Panizza and Presbitero (2013) explain, spline regressions suffer from arbitrariness even if they have the advantage of being flexible. The thresholds (cut-off points) are often chosen either to maximize the fit of the models being used or on the bases of a certain priory theory. Further, the techniques designed to capture a general form of non-linearity (heterogeneity) are not

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However, this may not hold in the long run. A rising public debt will result in reduced public saving. Often, the reduction in public savings will not be totally compensated by a rise in private savings. This will ultimately result in decreased investment levels, diminishing future output (GDP) levels. The effect might be further augmented if policy uncertainties follow high debt levels. The policy uncertainties might include expectations of inflation, tax distortions and various forms of financial repression (Cochrane, 2011).

[10] Apart from the issue of non-linearity, there is a long list of questions raised by the literature. One debate is over the question of causality, i.e. whether debt explains growth or growth explain debt (Panizza and Presbitero, 2012; Jalles, 2011). While some focus on growth theories and parameter heterogeneity (kourtellos et al., 2013; Elmendorf and Mankiw, 1999), others focus on cross-country institutional differences and how this impacts the debt-growth relationship (Cordella et al., 2010; Jalles, 2011; Presbitero, 2012). It is, however, impossible for this paper to address all of the arguments observed within the literature. We, therefore focus on the issues directly linked to non-linearity and public debt thresholds.

[11] The link between public debt and economic growth is likely to depend on many structural and cyclical elements of an economy, which tend to differ among countries. The level of public debt and its composition will set different countries on different tracks, regarding how they are affected by higher level of indebtedness and how well they can cope with it (De Grauwe, 2012; Hausmann and Panizza, 2011). Institutional and policy differences also play a crucial role as to how debt is utilized to finance growth (Panizza and Presbitero, 2013; Cordella et al., 2010; Kourtellos et al., 2013). As our mere objective is to identify the non-linearity in the debt-growth link at *different levels of debt,* we will not be dealing with the cross-country divergences of debt sustainability thresholds. Further, the assessment of categories (income, geography, institutions etc.) becomes crucial in a broad panel with significant heterogeneity. A comparison of 'debt intolerance' levels is not only outside the scope of the paper but also less relevant for the panel, given that we use a 'relatively homogeneous' pool of low-income countries in Sub-Saharan Africa.

[12] Apart from spline regressions, some researchers use threshold regression models that are designed to detect a general form of panel heterogeneity and non-linearity. For instance, Caner et al., 2010 and Kourtellos et al., 2013 use Hansen's threshold regression and sample splitting techniques (see Hansen, 2000).

good enough to detect a specific form of non linearity like bell shapes. This is easy to deduce, since not all non-linear associations display hump shapes.

Researches that specifically try to detect hump shapes often include a quadratic term within a typical regression equation. They will conclude the presence of such a relationship if the quadratic term happens to be significant and the extreme value lies within the range of the dataset. Lind and Mehlum (2010) argue that such a criterion alone is weak.[13] By expanding on a general framework of non-linearity tests that were previously developed by Sasabuchi (1980), they offer a more robust way of testing 'U' and 'inverse-U' shapes. For a proper test of a hump-shape, it is necessary to check if the relationship is increasing at lower values and decreasing at higher values, within the interval. To address these dual requirements, their methodology operates on a composite hypothesis.[14] The *Sasabuchi-Lind-Mehlum* method of testing bell-shapes (or U-shapes) is superior to the customary techniques because it delivers stronger tests for bell-shapes and also enables us to make tests at a certain (α) level of significance, given the estimates of a regression model.

Let us next consider a typical neo-classical growth regression that is often adopted by the literature.[15] The model has been augmented to incorporate public debt and other control variables;

$$Yg_{it} = \alpha + \beta Debt_{it} + \lambda f\,(Debt_{it}) + \eta zit + \varepsilon_{it},\ i=1,\ldots,\ n \qquad (1)$$

Here, Y_g represents per-capita GDP growth, *Debt* represents the ratio of total public debt to GDP, *z* represents a set of control variables (initial GDP per capita, investment, population growth, openness, inflation, school attendance i.e. human capital, terms of trade growth and official development assistance) and ε constitutes the random error. Based on the β and λ parameters, function *f* might formulate equation (1) as a bell-shape relationship.

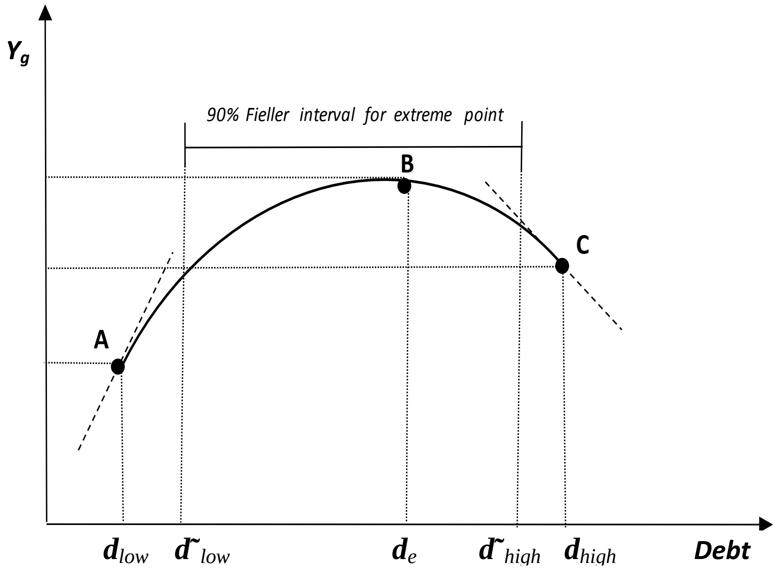
If we assume that there is only one extreme point in a given interval; for a bell-shaped relationship to be there, the slope of the curve should be positive at the start of the interval and negative at the end of the interval. In figure 1, given the range of *Debt* values [$\boldsymbol{d}_{low}$, $\boldsymbol{d}_{high}$], the slope should be positive at point A ($f'_{\boldsymbol{d}low}$) and should be negative at point B ($f'_{\boldsymbol{d}high}$). We expect f' to be a monotone over the range of the dataset [$\boldsymbol{d}_{low}$, $\boldsymbol{d}_{high}$] so that there is one extreme point, at most, in the interval.

[13] Traditional tests of bell-shapes that simply look at the significance of the quadratic term (in a quadratic ally specified regression equation) may erroneously conclude a relationship to be hump shaped, while it is actually monotone on an available data range.

[14] For a hump-shape to be there, the null hypothesis states that the relationship is increasing at the left-hand side of the interval and/or is decreasing at the right-hand side of the interval.

[15] Most researchers (in this body of literature) use different variants of Robert Solow's neo-classical growth regression (formalized in Solow, 1956).

Figure 1: A bell-shaped debt-growth relationship



Building on equation (1), the presence of a bell-shape would imply the following;

$$\beta+\lambda f'(\mathbf{d}_{low}) > 0 > \beta+\lambda f'(\mathbf{d}_{high}) \quad (2)$$

To test whether or not these inequalities are satisfied by our dataset, we test if the following composite null hypothesis can be rejected, in support of the alternative hypothesis.[16]

$$H0: \beta+\lambda f'(\mathbf{d}_{low}) > 0 \text{ and } \beta+\lambda f'(\mathbf{d}_{high}) < 0 \quad (3)$$

$$H1: \beta+\lambda f'(\mathbf{d}_{low}) \leq 0 \text{ and/or } \beta+\lambda f'(\mathbf{d}_{high}) \geq 0 \quad (4)$$

If we specify equation (1) in a quadratic form, we get;

$$Yg_{it} = \alpha + \beta Debt_{it} + \lambda f(Debt_{it})^2 + \eta z_{it} + \varepsilon_{it},\ i=1,\ldots,n \quad (5)$$

Given this, the presence of a bell-shape would imply the following;

$$\beta+2\lambda f'(\mathbf{d}_{low}) > 0 \text{ and } \beta+2\lambda f'(\mathbf{d}_{high}) <0 \quad (6)$$

The composite null and alternative hypothesis in equations (3) and (4) can be re-specified for the quadratic growth function in equations (5) as;

[16] If the inequalities are not satisfied, we will have a U-shape or a monotonic relationship. For details of the test, see Sasabuchi (1980) and Lind and Mehlum (2010).

$$H0: \beta+2\lambda f'(\mathbf{d}_{low}) > 0 \text{ and } \beta+2\lambda f'(\mathbf{d}_{high}) < 0 \quad (7)$$

$$H1: \beta+2\lambda f'(\mathbf{d}_{low}) \leq 0 \text{ and/or } \beta+2\lambda f'(\mathbf{d}_{high}) \geq 0 \quad (8)$$

The above tests can be carried out via ordinary t-tests. Lind and Mehlum deliver a STATA module for this purpose.[17] Their module also calculates the Fieller confidence interval, whose boundaries deliver the cut-off points for the acceptance or rejection of the hypothesis given by equations (3) and (4).[18] Conducting an (α) level significance test on the null and alternative hypothesis translates to testing if the (1-2α) confidence interval for *the maximal* point (point B in figure 1) is within the data range, i.e. $[\tilde{\mathbf{d}}_{low}, \tilde{\mathbf{d}}_{high}] \subset [\mathbf{d}_{low}, \mathbf{d}_{high}]$.[19]

3. Data description

Our study is based on a panel of 22 low-income SSA countries, covering the time frame 1990 to 2011.[20] Table 1 reports the lists of variables used and their sources, alongside some notes on the specifics. The data on per capita GDP growth, initial income, population growth, openness, school enrollment, terms of trade and official development assistance (ODA) come from the World Bank's World Development Indicators (WDI) database. The data on investment, inflation and general government gross debt as percent of GDP come from the World Economic Outlook (WEO) database of the IMF.

Table 1: List of variables, data sources and description

Variable	Note	Source
GDP per capita growth	Per capita GDP growth (log-difference of GDP per capita)	WDI
Initial GDP per capita	Initial per capita GDP at 1990 (Log form)	WDI
Investment	Gross investment as percentage of GDP (Log form)	WEO
Population growth	Population growth (log-difference of total population)	WDI
openness	Openness of the economy (calculated as a ratio of total trade to GDP)	WDI
Inflation	Growth in average consumer price index (calculated as log-difference of average CPI)	WEO
Schooling (primary)	Log of primary school enrollment (% of gross)	WDI
Terms of trade growth	Growth in net barter terms of trade (calculated as log difference of Net barter terms of trade index)	WDI
Official development assist.	Net ODA received as % of GNI (log form)	WDI
Debt	General government gross debt as % of GDP (log form)	WEO

Table 2 reports the basic statistical summary of the variables used in the study. Focusing on the total public debt to GDP ratio, we have a mean value of 84.22%. However, this masks the differences in mean public debt to GDP ratios among the individual countries (see Table 3).

[17] See the STATA module 'UTEST'

[18] The 'Fieller confidence interval' within this test is based on the confidence interval calculation technique developed by Fieller (1954).

[19] Having the right sign and significance for λ is both a necessary and sufficient condition for rejecting the null hypothesis in equation (3); given the data range is taken in its entirety. If the sample data range is any subset of the overall data range, the significance of λ would still be a necessary condition but not a sufficient one.

[20] The list of the 22 SSA's low-income countries included in our panel are: Benin, Burkina Faso, Burundi, Central African Republic, Chad, Comoros, Eritrea, Ethiopia, The Gambia, Guinea, Guinea-Bissau, Kenya, Madagascar, Malawi, Mali, Mozambique, Niger, Rwanda, Sierra Leone, Tanzania, Togo and Uganda. Of the 36 countries classified as 'low-income' by the World Bank as of 2013, 27 are in Africa. Out of these, we did not include 5 countries (Congo Dem. Rep., Liberia, Mauritania, Somalia and Zimbabwe) due to lack of adequate data.

Table 2: Basic statistical summary of variables

Variable	Mean	Std. Dev.	Min	Max
GDP per capita growth (log. diff.)	0.015428	0.046809	-0.17608	0.315687
GDP per capita growth (% change)	1.667683	4.906806	-16.1452	37.1201
Initial GDP per capita (log form)	5.471433	0.392559	4.851155	6.373827
Initial GDP per capita (nominal US$)	257.7983	111.1797	127.888	586.297
Investment (log form)	2.86104	0.405376	1.517761	4.295897
Investment (% GDP)	18.98135	8.327955	4.562	73.398
Population growth (log. diff.)	0.030427	0.009725	-0.01135	0.102585
Population growth (% change)	2.911309	0.973057	-1.39236	9.7705
Openness (ratio)	0.523715	0.230126	0	1.275
Inflation (log. diff.)	0.071456	0.069838	-0.08826	0.399029
Inflation (% change)	190.2707	205.6386	22.219	1485.28
School , Primary (log form)	3.816863	0.162565	3.293029	4.010448
Schooling, Primary (% gross)	46.00725	6.471592	26.9243	55.17157
Terms of trade growth (log. diff.)	0.001334	0.12402	-0.97518	0.347106
Official development assist. (log form)	2.509554	0.554724	0.892079	4.009007
Official development assist. (% change)	14.2647	8.176399	2.440198	55.09213
Debt (log form)	4.254141	0.627367	2.641055	5.573951
Debt (% GDP)	84.21994	48.63964	14.028	263.473

Table 3 gives the basic summary statistics of the total public debt to GDP ratios (in percentages) for the countries within the panel. As we can see from the second column of the table, the country averages for total public debt to GDP ratio range from roughly 33.4% in Burkina Faso to 186.36% in Guinea-Bissau. The country differences in public debt levels and how this affects their debt sustainability ratings is explained in section 4.

Table 3: public debt profile by country

Country	Mean	Std. Dev.	Min	Max
Burkina Faso	33.3978	10.94924	22.035	48.669
Benin	36.10158	14.38845	14.682	60.388
Chad	41.47908	18.07518	23.598	74.775
Mali	45.56208	27.81348	20.288	104.929
Tanzania	50.5644	12.39595	36.01	66.668
Kenya	51.6885	4.735888	45.561	60.587
Niger	57.14312	32.59643	14.028	91.208
Uganda	62.94673	28.44063	22.117	97.555
Central African Republic	73.13787	30.78826	37.036	109.17
Comoros	73.59667	18.77659	44.714	107.216
Mozambique	76.08062	37.87631	36.787	138.38
Malawi	77.2799	52.50257	32.207	151.907
Togo	87.65064	22.8983	47.226	109.362
Rwanda	95.60818	13.12475	70.687	119.541
Ethiopia	97.86863	38.80212	30.453	156.815
Sierra Leone	98.79191	54.101	41.121	162.097
Madagascar	101.5574	33.26179	44.502	143.743
Guinea	101.6345	19.37488	71.595	150.231
Gambia, The	108.6897	38.26892	62.507	157.943
Burundi	115.9983	51.91728	35.266	181.041
Eritrea	158.8758	17.30964	133.824	192.03
Guinea-Bissau	186.3594	73.87542	41.555	263.473

4. Results

Table 4 gives the results from a pooled least squares regressions with various specifications. The results in the table mirror the growth regressions in earlier studies and also reflect the benchmark neoclassical growth theory.[21] There is a positive relationship between economic growth and investment, openness, schooling, terms of trade growth and development assistance. On the other hand, the result shows a negative relationship between growth and initial income, population growth, inflation and public debt. Out of these, there is a significant relationship between economic growth and investment, population growth, schooling, development assistance and debt. Consistent with the literature, the linear estimation of the growth model shows a negative long term relationship between economic growth and public debt.[22]

Table 4: pooled LS with different specifications

	PLS1	PLS2	PLS3
Initial GDP per capita	-0.00493	-0.00512	-0.0081
	(0.009)	(0.009)	(0.008)
Investment	0.0148*	0.0138*	0.0137*
	(0.008)	(0.008)	(0.008)
Population growth	-0.827*	-0.823*	-0.836*
	(0.477)	(0.474)	(0.462)
openness	0.00118	0.000822	-0.00457
	(0.017)	(0.017)	(0.018)
Inflation	-0.0155	-0.0135	-0.0115
	(0.070)	(0.070)	(0.069)
Schooling (primary)	0.0317**	0.0322**	0.0287**
	(0.014)	(0.013)	(0.013)
Terms of trade growth	0.0368*	0.0360*	0.0393*
	(0.022)	(0.021)	(0.021)
Official development assist.	0.0163**	0.0168**	0.0183**
	(0.008)	(0.008)	(0.008)
Debt	-0.0101**		0.120**
	(0.005)		(0.049)
$Debt^2$		-0.00136**	-0.0157**
		(0.001)	(0.006)
Constant	-0.0933	-0.111	-0.324***
	(0.072)	(0.072)	(0.116)
r^2	0.141	0.144	0.16
N	285	285	285

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.010

As we can see in the last two columns of table 4, the coefficient of the quadratic term is significant and negative, implying a concave-down/laffer curve. The calculation of the inflection point also renders a debt/GDP ratio of about 45%, which lies well within the data range. With a joint significance of the linear and the quadratic terms, a negative second derivative of the quadratic term, and an extreme point within the data range, we are inclined to conclude the presence of a bell-shaped relationship between public debt and economic growth. [23] However, as we have argued above in section 2, this test is weak. Simply checking

[21] See Bond et al., 2001; Cordella et al., 2010; Presbitero, 2012

[22] Our panel is unbalanced due to data limitation. However, robustness checks show no significant impact. By dropping three countries (Central African Republic, Ethiopia, and Rwanda) and 12 years (1990-2001), we set up a balanced-panel spanning ten years (2002-2011). The balanced-panel yields comparable results. The Breusch-Pagan Lagrange-multiplier test also confirms absence of significant panel effects. Specification exercises of lagged debt values yield fairly similar results. Further experiments with weighted least squares, fixed effects and two-Stage System-GMM models (with internal instruments to account for endogeneity), confirm the conclusions drawn from table 4.

[23] Compared to estimates derived from broad panels, our results better fit the average low-income country of SSA. However, there are notable differences in the debt profiles of the low-income countries of the region (see table 3). Therefore, any form of debt sustainable thresholds derived from multi-country panels should be received with some margins. Two countries with similar long term economic growth rates need not have similar thresholds for what is considered as 'sustainable debt'. It has

if the extreme point is within the data range and that the curve is concave-down (i.e. traditional method) would render weak results in cases where the slopes at the bounds are nearly flat and/or where the extreme point is too close to the end points of the data range. Lind and Mehlum address this by testing the significance of the slopes at both ends of the dataset and also determining the Fieller confidence interval for the extreme point. This makes their approach a much more robust technique of detecting u-shapes and inverse u-shapes.

Table 5 delivers the results from the Lind-mehlum test for an inverse U-shape. As we can see from the table, the extreme point and also the 90% Fieller interval for the extreme point lie within the lower and upper bounds of the dataset. About a quarter of the observations (25.26 %) lie to the left of the extreme point and the rest of the observation (74.74%) lie to the right of the extreme point. The slope at the lower bound is positive and significant at 5%, while the slope at the upper bound is negative and significant at 1%. Given these results, the overall test for the presence of an inverse U-shape is significant at 5%. Thus, we are unable to reject our null-hypothesis of an inverse u-shape (equation 3), in favor of the alternative hypothesis of a monotone or a u-shape (equation 4).

Table 5: bell-shape test

H0: Monotone or U shape vs. H1: bell shape[24]		
Bounds	Lower	Upper
Interval	*2.641055*	*5.573951*
Slope	*.0365894*	*-.0556093*
t-value	*2.134979*	*-2.814674*
Test for slope : P>t	*.0168249*	*.0026184*
Overall test of presence of a bell shape Extreme point: 3.804986 90% Fieller interval for extreme point: [3.3070168; 4.0333611]		
t-value	*P>t*	
2.13	*.0168*	

To make sure that we are not forcing a quadratic specification, we examined a non-parametric relationship between growth and public debt. An Epanechnikov kernel smoothes for various degrees of polynomials reveal similar patterns of concave-down relationship (see figure 2).[25]

been shown in the literature that countries with good policies and institutions are often better suited to cope with shocks. Such countries, thus, deserve higher thresholds. However, the exclusion of policy variables would not change the notion of non-linearity (which we are trying to study here). It would, rather, make the sustainability limit lower for some and higher for others.

[24] In the STATA package, the alternative hypothesis is a bell-shape (i.e. reversing equations 7 & 8 in section 2). The low p-values in table 5 reject the null hypothesis in favor of a bell-shape.

[25] Apart from an Epanechnikov kernel, we also used Gaussian and Parzen kernels for polynomials of different degrees (2, 3 and 4). The results are almost identical to figure 2. Further, to internally determine the appropriate degrees of polynomials and bandwidths, we used the Libois-Verardi semi parametric local polynomial smoothing procedure. This is done via the xtsemipar command in STATA (see Libois and Verardi, 2013). The results, once again, show a clear presence of a bell-shape.

Figure 2: local polynomial smoothing (Kernel-weighted)

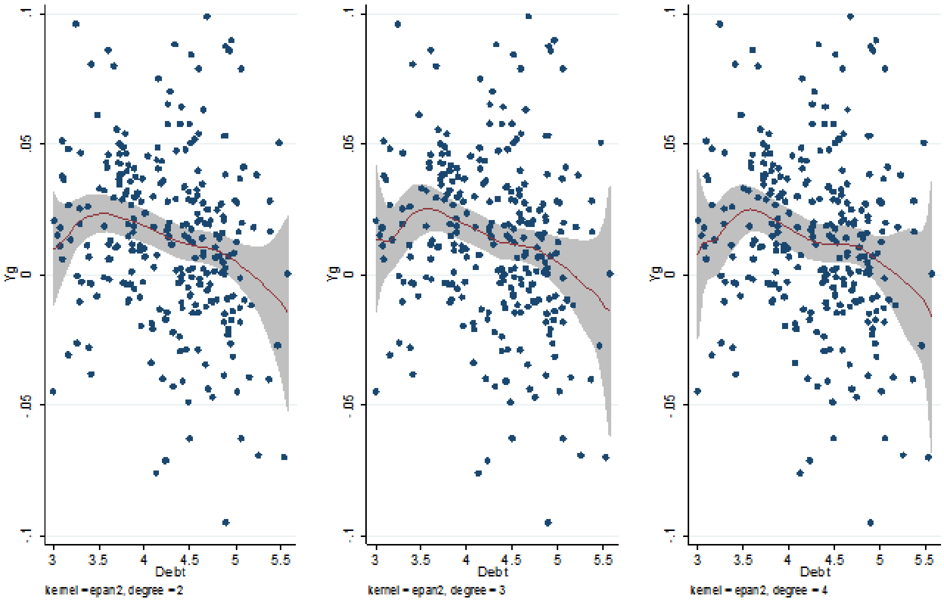
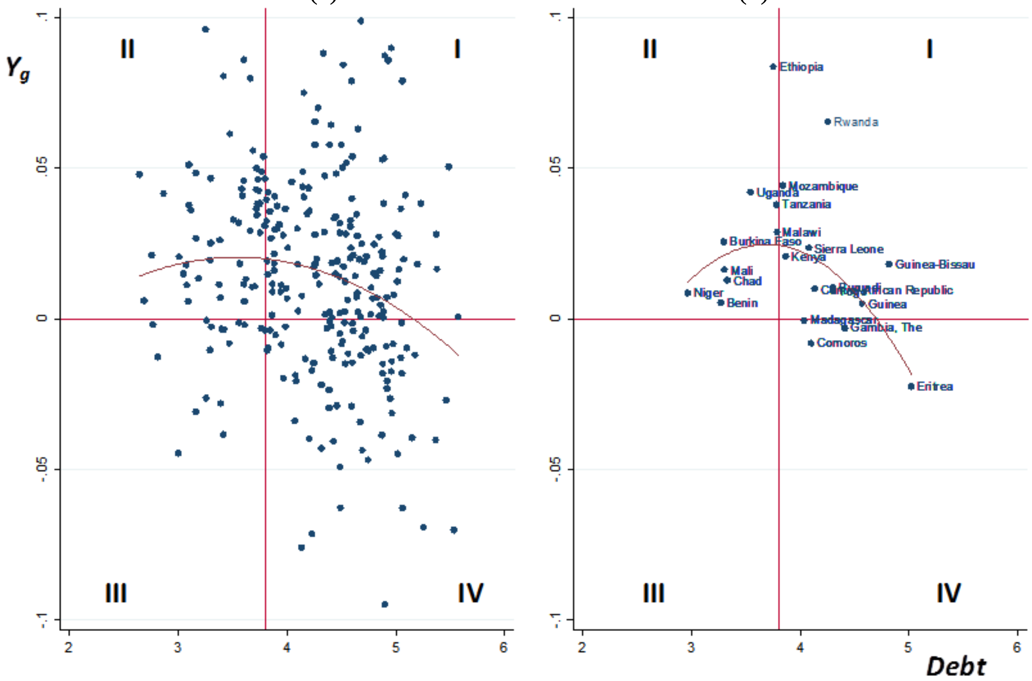


Figure 3: Fitting the debt-laffer curve with quadratic prediction plots

(a) (b)



Note: we have four quadrants formed by two categories of per capita GDP growth (above or below zero) and two categories of debt (above or below the extreme point of Debt/GDP ≈ 44.925% i.e. ≈ 3.805 in natural log form). Quadrant I ⇒ high debt & positive growth; Quadrant II ⇒ low debt & positive growth; Quadrant III ⇒ low debt & negative growth; Quadrant IV ⇒ high debt & negative growth

Given the confirmed presence of a bell-shaped (concave-down) relationship between public debt and per capita GDP growth, figure 3 (a) & (b) superimpose the debt-laffer curve over the distribution of dataset using quadratic prediction plots. Figure 3(a) shows the distribution for the whole dataset and figure 3(b) shows the average distribution by country, since 2005. This later period is picked for comparative purpose to mark the launch of the IMF/WB Debt Sustainability Analysis (DSA), which is the current standard framework of debt sustainability assessment for LICs (see IMF and WB, 2012). Generally, the results displayed in figure 3(b) conform to the DSA's debt distress ratings for the individual countries.[26] For instance, recent DSA ratings grade Comoros, Eritrea and The Gambia with high risk; Central African Republic, Guinea, Guinea Bissau, Rwanda, Sierra Leone and Togo with moderate risk; Benin, Ethiopia, Tanzania and Uganda with low-risk. Unsurprisingly, these three groups of countries lie in quadrants IV (high debt & negative growth zone), I (high debt & positive growth zone), and II (low debt & positive growth zone) of figure 3(b), respectively.[27]

5. Conclusion

This paper tries to contribute to the ongoing debate on the debt-growth linkage in developing countries. By focusing on low-income Sub-Saharan African countries, the paper tests the presence of a 'laffer-curve' type relationship, where the contribution of debt to growth is theorized to be positive at lower levels and negative at higher levels. The results show robust evidence in support of this. Higher and lower debt values are associated with lower and higher growth rates, respectively. Further, the results from our debt sustainability exercise (i.e. classifying countries in to distinct groups of debt-growth combination) generally match the risk ratings of the existing debt sustainability framework (DSA) for low-income countries.

To arrive at a final conclusion of the debt-growth link, an exhaustive array of tests and plenty of further research will be required. Thus far, no one has been able to deliver indisputable evidence of causality, where higher levels of debt reduce growth rates or vice-versa. This will require in-depth studies of transmission channels linking the two. This notion is repeatedly reflected in recent contributions to the literature. However, as this paper shows, there is an association between lower/higher debt levels and higher/lower growth rates. As some might suggest, this could possibly depend on the set of countries examined and their heterogeneity, or even on the time period considered. Bearing this in mind, our conclusions will be specific to our panel. Despite its limited objectives and scope, however, the paper shades some useful insights. For one thing, the association (if not causation) of high debt levels and low growth rates is a potential warning for the necessity of debt sustainability in low-income countries. In this regard, mentioning the past 'third world debt crisis' is more than enough. For another thing, debt sustainability, even without its spin-offs, is an essential policy target to which every country must adhere to.

[26] Country reports from the DSA analysis can be accessed on the websites of the IMF at https://www.imf.org/external/pubs/ft/dsa/lic.aspx

[27] Even if the results mostly mirror the debt sustainability ratings of the DSA, there are some countries that appear to be miss categorized. Some of these countries are close to the boundaries of the quadrants and, therefore, easily fall to adjacent categories. Tough, Kenya and Mozambique are within the moderate risk zone (figure 3b), they are close to the low risk zone and are categorized to be so in the latest DSA reports. Malawi is just at the edge of our moderate risk group and is categorized as such in the DSA. The rest of the countries; Burkina Faso, Chad, Mali and Niger are categorized as moderate risk group by the DSA (considering their heightened contemporary political/economic risks) while they appear to be well within the low risk group when we look at their recent public debt levels, vis-à-vis their growth records. These divergences are evident, given the methodological difference between the DSA and the foregoing analysis. The DSA considers various shocks that may give extra vulnerability to countries and is focused on the short and medium term debt sustainability outlooks. On the other hand, the analysis here is focused on the basic long-term association between public debt and economic growth.

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