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Threshold Effect of Public Debt on Domestic Investment: Evidence from Selected African Countries

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Abstract. *In this paper, we study the non-linear relationship between total public debt and domestic investment, across a panel of 10 African economies from 1981 to 2010. Our analysis, based on a panel threshold approach proposed by Hansen (1999), confirms the significance of the nonlinear relationship between public debt and domestic investment. The results indicate that public debt lower than 47.31 percent of GDP is positively associated with domestic investment. However, once the debt exceeds this threshold, the relationship between public debt and investment becomes negative. Moreover, we find some evidence that at this level, public debt limits the government's ability to undertake countercyclical policies.*

Keywords: panel thresholds, nonlinear effect of public debt, investment, crowding-out effect, economic growth.

JEL Classification: E22, F34, H63.

1. Introduction

The global crisis that erupted in 2007 has revived the debate on the effects of public debt on economic growth. Therefore, many empirical studies have been elaborated to examine the existence of a non-linear relationship between government debt and economic growth. One of these is a contribution by Reinhart and Rogoff (2010) who find that if the public debt-to-GDP ratio exceeds 90%, economic growth slows down.

In the same vein, Cecchetti et al. (2011) focus on 18 OECD countries for the period 1980-2010 and find a debt threshold of 85% of GDP above which the relationship between public debt and growth becomes significantly negative. Using a large sample of developed and developing countries spanning a period from 1980 to 2008, Caner et al., (2010) estimate a public debt threshold at 77% of GDP. Once public debt exceeds this level, his effect switches from positive to negative. Similarly, the results obtained by Greenidge et al. (2012) for 12 Caribbean countries, indicate that public debt contributes positively to growth when it is below 30%. If public debt levels reaches 56% of GDP, it becomes a drag on growth.

Looking at the empirical literature on the topic, two features emerge. First, debt thresholds are obtained generally from growth equations without explaining theoretical mechanisms underlying the non-linearity between public debt and economic growth. Second, there have been only a few studies examining African countries.

In this paper, we study the non-linear relationship between total public debt and domestic investment, across a panel of 10 African economies from 1981 to 2010. We believe it is appropriate to examine the effect of public debt on investment instead of GDP growth for two reasons: First, many studies have identified investment as the most relevant transmission channel through which other variables may affect growth (Gomanee et al., 2002). Second, many theoretical hypotheses established a direct link between public debt and investment (Serieux, 2001).

Indeed, the consequences of growing public debt are causing concerns in the African context. In many countries, the crisis has led to a deterioration of public finances through external demand shock (Hernández and Gamarra, 2010; Ncube and Brixiová, 2013). Furthermore**,** fiscal sustainability has been affected by sovereign credit ratings downgrades[(1)].

Our analysis, based on a panel threshold regression (PTR) model, shows that there is a tipping point for the debt-to-GDP ratio of 47.31%, beyond which the effect of public debt on domestic investment switches from positive to negative.

The remainder of the paper is organized as follows: Section 2 discusses the theoretical background underlying our analysis. Section 3 illustrates the empirical methodology. Section 4 describes data. Section 5 presents the estimation results and discusses empirical findings. In Section 6, we run several robustness exercises. Finally, section 7 provides some policy recommendations and concludes.

2. Theoretical background

The literature concerning the potential effects of public debt on investment consists of two main visions. The first vision emphasized that countries, in their early stages of development, need to borrow in order to finance economic development. Accordingly, the accumulation of public debt could provide resources to finance public investment that is likely to promote private investment and economic growth (Lora, 2007).

According to the second vision, an increase in the debt financial burden could have a crowding out effect on public investment expenditure. In fact, a high debt burden may oblige government to divert spending originally destined to finance public investment in favor of those related to debt service (Serieux, 2001; Fosu, 2010). In cases where it is difficult to compress current expenditure or to raise taxes, capital expenditures may constitute the adjustment variable (Alesina and Perotti, 1997). According to Oxley and Martin (1991), this pattern reflects the political reality that it is easier to reduce or defer capital expenditures instead of lowering current expenditure. As a result, two types of effects can occur. A direct effect is materialized by a reduction in total investment, especially in emerging countries where public investment is an important part of the total investment. An indirect effect arises from the complementarity that may exist between public investment and private investment (Serieux and Samy, 2001).

The theory states that, firstly, a reasonable level of public debt provides developing countries constrained by limited capital stock, necessary funds to finance productive investment. Moreover, according to the crowding out hypotheses, the accumulation of a large debt may stifle economic growth through lower investment.

Hence, we assume that public debt would be beneficial to investment up to a certain threshold. Once debt surpass this threshold, it will start to be a constraint to investment. Therefore, it is interesting to reconcile these two conception and introduce a nonlinear relationship between public debt and domestic investment. Here nonlinearity means that the debt effect on investment is conditioned by the level of public debt. Therefore, the main objective of this study is to determine the point at which the relationship between public debt and investment is reversed.

3. Empirical methodology

3.1. Model specification

Before evaluating the existence of a nonlinear effect of public debt on domestic investment, it is appropriate to begin with the specification of a linear model. This study is based on a basic investment equation that takes the following form:

$$Invest_{i,t} = \alpha_i + \beta X_{i,t} + \varepsilon_{i,t} \quad (1)$$

$Invest_{i,t}$ is the ratio of investment over GDP for each country i at time t. Following (Cohen, 1993; Serieux and Samy, 2001; Hansen, 2002; Presbitero, 2005), we do not distinguish between public and private investment. From a theoretical perspective, the public debt effect is directly related to public investment expenditure, but, given the complementarity of public and private investment, especially in developing countries,

debt may affect both private and public investment. Furthermore, public investment represents a major part of the total investment in these countries. $X_{it,}$ is a vector of explanatory variables including the inflation rate (inflation), as a measure of macroeconomic uncertainty, economic growth measured by the annual growth rate of real GDP per capita (growth), trade openness measured as imports plus exports over GDP (openness), a proxy for financial development measured by broad money *M2* as percentage of GDP (findev) and our variable of interest measured as the ratio of general government gross debt to GDP (pubdebt). During the last two decades, the composition of public debt has shifted from external to domestic in a number of developing countries (Panizza, 2008), including African countries (Ncube and Brixiová, 2013). Consequently, we find it appropriate to consider total public debt instead of external debt as done by other previous studies, dealing exclusively with the impact of foreign borrowing on growth in developing countries (see Clements et al., 2003; Pattillo et al., 2002). α_i denotes the country specific fixed effects and the error term $\varepsilon_{i,t}$ is assumed i.i.d. with mean zero and finite variance σ^2. The control variables included in the investment model are based on robust results highlighted in previous empirical studies (Ndikumana, 2000; Serieux and Samy, 2001; Hansen, 2002; Presbitero, 2005; Kumar and Woo, 2010; Salotti and Trecroci, 2014).

3.2. Panel threshold regression (PTR) model

To investigate the presence of nonlinearities in the relationship between public debt and investment, we apply the panel threshold approach proposed by Hansen (1999). This methodology allow us to estimate endogenously the threshold and to evaluate his statistical significance. The specification of the panel threshold regression (PTR) model is as follows:

$$Invest_{i,t} = \alpha_i + \beta_1 X_{i,t} I(D_{i,t} \leq \gamma) + \beta_2 X_{i,t} I(D_{i,t} > \gamma) + \varepsilon_{i,t} \quad (2)$$

As mentioned earlier, we choose the gross domestic investment rate as dependent variable. The threshold variable ($D_{i,t}$)is the public debt-to-GDP ratio, which is the key variable used to test whether there is threshold effect of public debt[(2)] on domestic investment[(2)]. γ denotes a threshold parameter, I (.) is an indicator function that takes the value 1 if the value public debt ($D_{i,t}$) is below a determined threshold value and 1 otherwise.

This methodology allows us to divide our sample into two regimes depending on whether the threshold variable is above or below the estimated threshold. The two regimes are distinguished by different regression slopes, β_1 and β_2. We must indicate that we can rewrite our investment equation for a single threshold as two equations:

$$Invest_{i,t} = \alpha_i + \beta_1 X_{i,t} + \varepsilon_{i,t} \quad \text{if} \quad D_{i,t} \leq \gamma \quad (3)$$

$$Invest_{i,t} = \alpha_i + \beta_2 X_{i,t} + \varepsilon_{i,t} \quad \text{if} \quad D_{i,t} > \gamma \quad (4)$$

Where the first represents the regime below the threshold and the second describes the regime above the threshold[(4)].

3.2.1. Threshold identification

In order to identify the threshold, we estimate in the first step equation (2) by OLS. Then, we compute the sum of squared errors S_1 for all possible values of the threshold variable.

$$S_1(\gamma) = \hat{\varepsilon}(\gamma)' \hat{\varepsilon}(\gamma) \quad (5)$$

In the second step, the threshold parameter is obtained by minimizing S_1, such as:

$$\hat{\gamma} = \text{argmin}_\gamma S_1(\gamma) \quad (6)$$

3.2.2. Test for threshold

Once the endogenous threshold is estimated, it is essential to test whether the threshold effect is statistically significant. The null hypothesis of this test is presented as follows:

$$H_0 : \beta_1 = \beta_2 \quad (7)$$

The null hypothesis implies that the slope coefficients are equivalent in the two regimes. Therefore, under Ho, the model is equivalent to the linear model in equation (1), and there is no threshold effect. The likelihood ratio test of Ho is based on the statistics F1:

$$F_1 = (S_0 - S_1(\hat{\gamma})) / \hat{\sigma}^2 \quad (8)$$

S_0 and S_1 are the sum of squared errors under null and alternative hypotheses, whereas, $\hat{\sigma}^2$ is a convergent estimates of σ^2.

Given that the threshold value is not identified under H_0, the asymptotic distribution of F_1 is not standard. As a solution, Hansen (1999) proposes a bootstrap method to simulate the p-value for the statistics F_1.

4. Data

This paper uses data for a panel of 10 African countries, over the period 1981-2010 (Tunisia, Egypt, Morocco, Algeria, Côte d'Ivoire, Ghana, Senegal, Togo, Kenya, Zambia).

Table 1. *Variables description and data sources*

Variable	Description	Source
invest	The ratio of gross fixed capital formation to GDP	WDI
pubdebt	The ratio of total public debt stocks to GDP	Abbas et al.,(2010)
growth	Real GDP per capita growth	WDI
inf	Growth of GDP deflator	WDI
findev	Broad money M2 as percentage of GDP	WDI
openess	Imports plus exports divided by GDP	WDI

As shown in Table 1, most of the variables comes from the World Development Indicators (WDI) database of the World Bank. Government debt data are obtained from the dataset compiled by Abbas et al. (2010).

Descriptive statistics of the variables used in our analysis are reported in Table 2, while the pairwise correlations are presented in Table 3.

Table 2. *Descriptive statistics*

Variable	Observations	Mean	Std.dev	Min	Max
invest	300	20.212	10.583	1.44	54.95
pubdebt	300	78.8931	42.75	5.0423	244.523
growth	300	.7932	3.665	-17.114	12.258
inf	300	13.109	20.436	-11.248	165.533
findev	300	42.957	22.806	11.304	110.301
openess	300	63.922	20.434	14.27	124.06

Table 3. *Correlation matrix*

	invest	pubdebt	growth	inf	findev	openess
invest	1.0000					
pubdebt	-0.4125	1.0000				
growth	0.2618	-0.1759	1.0000			
inf	-0.1799	0.3118	-0.1497	1.0000		
findev	0.4632	-0.0795	0.2594	-0.2613	1.0000	
openess	0.2257	-0.3020	0.1427	-0.4629	0.2778	1.0000

5. Empirical Results

Once the threshold is identified, we can estimate the coefficients for each regime. As shown in Table 4, the point estimation of single threshold value is 47.31%. Small bootstrapped p-value suggest the existence of a highly statistically significant non-linear effect of the government debt ratio on the investment rate(5). The 95% confidence intervals are quite narrow, showing the precision of the threshold estimation.

Table 4. *Threshold regression estimation of the non-linear effect of public debt on domestic investment*

Dependent variable : Invest		
Explanatory variables	**Regime 1 : pubdebt ≤ 47.31**	**Regime 2 : pubdebt > 47.31**
pubdebt	0.090 (1.875)*	-0.028 (-2.834)***
growth	-0.214 (-0.955)	0.067 (0.874)
inflation	-0.013 (-0.4)	-0.020 (-1.193)
findev	0.194 (2.994)***	0.098 (3.493)***
openness	0.077 (1.713)*	0.094 (4.441)***
Threshold estimate	47.31%	
F_1 statistic bootstrap p-value	0.000	
95% confidence intervals for the threshold	{47.31,50.02}	

Notes: robust t-statistics are in parentheses; *, **and *** denotes significance at the 10%, 5% and 1% level; the p-value is obtained from 300 bootstrap replications.

Our results suggest that, when public debt as a share of GDP is lower than the estimated threshold of 47.31 percent, the impact of debt on investment is positive and statistically significant. Above the estimated threshold value, the debt effect on investment becomes negative and remains statistically significant. In others words, in the low regime, additional debt increases investment. Nevertheless, in the high regime, a rise in the public debt ratio tends to reduce investment.

This finding seems to confirm the hypotheses that public debt, when kept at reasonable levels, provides developing countries constrained by limited capital stock, the needed

funds to finance investment. Nevertheless, at some point, it becomes an obstacle to capital accumulation as payments of debt service absorb resources available originally to public investment. That is to say, public debt can stimulate domestic investment up to a certain level. Once this level is reached, public investment (and thus total) is crowded-out by the debt burden.

Moreover, we find that the growth-investment nexus depends also on the 47.31 percent threshold. At debt levels below this threshold, growth has a negative impact on investment (Välilä and Mehrotra, 2005 obtain the same result for Sweden.), while, above the threshold, the relationship between investment and growth becomes positive. Although not statistically significant, this result may seem counter-intuitive. Here, in the low regime, the negative coefficient associated with growth confirms the countercyclical behavior of public investment. In the high regime, higher public debt leads to narrow fiscal space and public investment loses his countercyclical character as well as his power to respond to economic recessions. This result supports the hypothesis that beyond a certain threshold, public debt limits government's ability to undertake countercyclical policies(6).

Turning to the other variables included in the model, we find that, the coefficient of inflation is negative but non-significant. This result indicates that reducing inflation is a necessary condition to stimulate domestic investment. On the other hand, the positive and significant coefficients we find on both trade openness and financial development are consistent with the majority of previous empirical studies (7) (Ndikumana, 2000).

6. Robustness checks

In order to check the validity of this study, we conduct several robustness tests.

6.1. Three-year averages data

Following a common practice in many empirical studies, we use three-year averages of all the variables to eliminate short-run fluctuations. The results in table 5 indicate that, the threshold estimate of debt-to-GDP increases to a 51.63% and still significant but the confidence interval widens considerably. The impact of public debt turns out to be statistically insignificant in the first regime but remains highly significant in the second regime.

Table 5. *Threshold regression estimation of the non-linear effect of public debt on domestic investment based on average data*

Dependent variable : Invest		
Explanatory variables	**Regime 1 : pubdebt ≤51.63**	**Regime 2 : pubdebt>51.63**
pubdebt	0.110 (1.35)	-0.048(-2.48)***
growth	-1.448 (-2.96)**	-0.085(-0.34)
inflation	-0.195 (-2.34)*	-0.017(-1.04)*
findev	0.034 (0.53)	0.08 (1.48)
openness	0.150 (2.61)*	0.082(2.12)**
Threshold estimate	51.63%	
F_1 statistic bootstrap p-value	0.02	
95% confidence intervals for the threshold	{38.69,128,68}	

Notes: robust t-statistics are in parentheses; *, **and *** denotes significance at the 10%, 5% and 1% level; the p-value is obtained from 300 bootstrap replications.

6.2. Dropping aberrant observations

The second test consists in re-estimating our threshold model by dropping aberrant observations. The observations excluded are those of Ghana and Zambia. As can be seen from table 6, we do not find profoundly different results. Although the statistical significance of some coefficients is affected. The estimated threshold value is the same and remains highly significant (p-value=0).

Table 6. *Threshold regression estimation of the non-linear effect of public debt on domestic investment excluding aberrant observations*

Dependent variable : Invest		
Explanatory variables	**Regime 1 : pubdebt ≤ 47.31**	**Regime 2 : pubdebt > 47.31**
pubdebt	0.093 (1.53)	-0.035 (-1.88)*
growth	-0.782 (-2.08)**	0.016 (0.19)
inflation	0.038 (0.31)	0.028 (0.74)
findev	0.204(2.22)**	0.133 (4.17)***
openness	0.070 (1.08)	0.066 (2.67)***
Threshold estimate	47.31%	
F_1 statistic bootstrap p-value	0.000	
95% confidence intervals for the threshold	{47.31,50.46}	

Notes: robust t-statistics are in parentheses; *, **and *** denotes significance at the 10%, 5% and 1% level; the p-value is obtained from 300 bootstrap replications.

6.3. Including lagged values of public debt

Finally, in order to avoid potential simultaneity bias, we include lagged than contemporaneous values of public debt in the investment equation. Table 7 shows that this exercise does not alter sharply our main results as the estimated threshold is almost the same (47.5%), and still highly significant.

Table 7. *Threshold regression estimation of the non-linear effect of public debt on domestic investment using lagged values of public debt-to-GDP ratio*

Dependent variable : Invest		
Explanatory variables	**Regime 1 : pubdebt ≤ 47.50**	**Regime 2 : pubdebt > 47.50**
pubdebt	0.009(0.19)	-0.030(-3.05)***
growth	0.155(0.70)	0.125(1.60)
inflation	0.020(0.54)	-0.017(-1.04)
findev	0.300(4.90)***	0.071(2.48)***
openness	0.033(0.75)	0.114(5.3) ***
Threshold estimate	47.5%	
F_1 statistic bootstrap p-value	0.000	
95% confidence intervals for the threshold	{47.44,48.79}	

Notes: robust t-statistics are in parentheses; *, **and *** denotes significance at the 10%, 5% and 1% level; the p-value is obtained from 300 bootstrap replications.

7. Conclusion

This paper contributes to the existing empirical literature on the debt-growth nexus in different ways. First, instead of using GDP growth as endogenous variable, we use domestic investment. This choice is motivated by the fact that investment is directly affected by public debt and it constitutes an important determinant of economic growth.

Second, we look directly at African countries challenged simultaneously by a vast infrastructure gap and debt sustainability problems.

Our analysis, based on a panel threshold regression (PTR) model, confirms the significance of the nonlinear relationship between public debt and domestic investment. The results for a panel of 10 African countries over the period 1981-2010, indicates that public debt lower than 47.31 percent of GDP is positively associated with domestic investment. However, once the debt exceeds this threshold, the relationship between public debt and investment becomes negative. Moreover, we find some evidence that at this level, public debt becomes a constraint to undertaking countercyclical fiscal policies. Besides the fact that the 40%-50% public debt ratio is frequently suggested as a prudent limit that developing countries should not surpass (Ncube and Brixiová, 2013), our results are consistent with the idea that those countries face low debt thresholds (Greenidge et al., 2012; Reinhart and Rogoff, 2010; Caner et al., 2010).

The immediate policy recommendation is that countries with public debt ratio above 47.31% need to undertake fiscal adjustment. Bringing public sector debt to controllable levels free up space to countercyclical fiscal policies and contributes to achieving development objectives through funding productive investment. Such policy can be achieved via the maximization of domestic resource mobilization (especially taxes) and the adoption of appropriate complementary monetary policies. This is not easy to set up especially in countries whose economies are characterized by the predominance of informal economy.

However, threshold levels must be interpreted with some caution. As showed by Panizza and Presbitero (2013) and Égert (2015), thresholds are sensitive to the time dimension, the set of countries considered and their economic conditions. Keeping this in mind, our results will be particular to our sample.

Notes

(1) As for example in Tunisia and Egypt.
(2) Public debt variable is used both in the regression and as the threshold variable.
(3) Notice that the estimation of the threshold model requires the use of a balanced panel, so the lack of data exclude detailed analysis that desegregate investment into public and private.
(4) This framework could be extended to multiple thresholds.
(5) The test for a second threshold is not significant.
(6) The test of this hypothesis is not the main objective of this paper.
(7) Harrison (1996), shows that openness appear to have the most consistent relationship with investment.

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