Journal of Indonesian Economy and Business
Volume 39, Number 2, 2024, 195 – 212

NONLINEAR ANALYSIS OF GROWTH'S EFFECT ON DEBT: FINDING THE THRESHOLD

Sugeng Triwibowo[1*], Defy Oktaviani[2], Nurfika[3]

[1] Department of Economics, Faculty of Economics and Business, Universitas Gadjah Mada, Yogyakarta, 55281, Indonesia

[2] Directorate General of Foreign Trade, Ministry of Trade, Jakarta, 10110, Indonesia

[3] Statistics Serang Regency, BPS-Statistics Indonesia, Serang, 42182, Indonesia

ABSTRACT

Introduction/Main Objectives: This paper explores the nonlinear effect of economic growth on the accumulation of public debt for groups of countries, based on their income levels, by finding its threshold estimator. **Background Problems:** The existing literature has discussed the debt's effect on growth intensively. Thus, empirical analysis to observe the inverse relationship between both variables is needed. **Novelty:** This paper confirms the negative and nonlinear impact of economic growth on public debt, and finds the threshold levels of economic growth on debt in high-income countries (HIC) and low-and middle-income countries (LMIC). **Research Methods:** We employed OLS panel regression with data covering 62 countries from 1970 to 2015. The fixed-effect panel threshold model is used to estimate the threshold level of economic growth that affects debt accumulation. **Finding/Results:** We found that economic growth reduces the public debt in the long run. In HIC, we find two threshold levels of economic growth, at 2.92% and at 8.41%. Moreover, in LMIC, a single threshold is found at 11.61%. **Conclusion:** It is proven that maintaining robust economic growth could reduce debt accumulation in the long run, the magnitude of the impacts varies between HIC and LMIC.

ARTICLE INFO

Article information:

Received: 10 October 2022. Received in revised version: 26 May 2023. Received in revised version: 15 July 2023. Accepted: 25 October 2023

Keywords:

economic growth, public debt, panel threshold model

JEL Code:

O40, H63, C24

ISSN:

ISSN 2085-8272 (print)
ISSN 2338-5847 (online)

[*] Corresponding Author at Department of Economics, Faculty of Economics and Business, Universitas Gadjah Mada, Jalan Socio Humaniora No. 1, Yogyakarta 55182, Indonesia.
E-mail address: sugengtriwibowo@mail.ugm.ac.id (author#1), defy.oktaviani81@alumni.ui.ac.id (author#2),nurfika@bps.go.id(author#3)

https://doi.org/10.22146/jieb.v39i2.5819 https://journal.ugm.ac.id/v3/jieb

INTRODUCTION

Economic growth is supposed to reduce government debt through various mechanisms. Economic growth due to higher levels of economic activity increases tax revenues. As businesses expand and individuals earn more income, the amount of tax collected increases. The additional tax revenue can be used to finance government expenditure, including debt repayment, reducing the overall public debt burden. Further, economic growth can reduce government spending on social expenditures, as economic growth incites lower unemployment and reduces poverty. Economic growth promotes public debt sustainability and erodes the debt burden. Robust growth boosts investor confidence, potentially lowering debt servicing costs and making it easier to refinance existing debt. Lastly, strong economic growth creates an opportune environment for implementing fiscal consolidation, which enhances the efficiency and effectiveness of government spending and revenue generation. Fiscal consolidation can strengthen fiscal health and reduce public debt.

Looking back on history, public debt has continuously risen following the occurrence of economic crises. In the last 60 years, at least four major global economic recessions have led to global debt soaring (Kose & Ohnsorge, 2020). In the domestic context, the economic turmoil in 1997-1998 resulted in mounting public debt in Indonesia. With the recent global COVID-led recession, governments worldwide responded to the recession caused by the health crisis by offering massive fiscal support. Since tax revenues declined during the recession, governments have had to borrow to finance the measures enacted to fight against the pandemic. Globally, public debt has surged to an unprecedented level (Kose et al., 2022).

As a countercyclical policy measure, public debt is not exclusively exogenous, nor merely a government decision isolated from the dynamics of the macroeconomic environment. Governments run budget deficits (by reducing revenue or increasing spending, or both) to serve as a countercyclical instrument to absorb shocks, accelerate economic recovery, and support sound economic growth in the aftermath of a crisis (Baldacci et al., 2009; Doraisami, 2011).

The rising public debt has evolved to be a threat to global financial stability, and in developing countries, over-indebtedness raises concerns about their ability to repay, and increases the possible default risk. Further, over-indebtedness is burdensome and compromises the countries' long-term development agendas. Therefore, remedies to avoid over-indebtedness should be discussed and thoroughly explored. One of which is supporting economic growth to reduce governments' indebtedness (Saungweme & Odhiambo, 2019). However, there is still a lack of discussion that can answer the critical question of whether public debt is caused by poor economic performance, or, on the other hand, does high economic growth reduce a country’s indebtedness? More precisely, the question is, which level of economic growth will lead to public debt accumulation’s reduction?

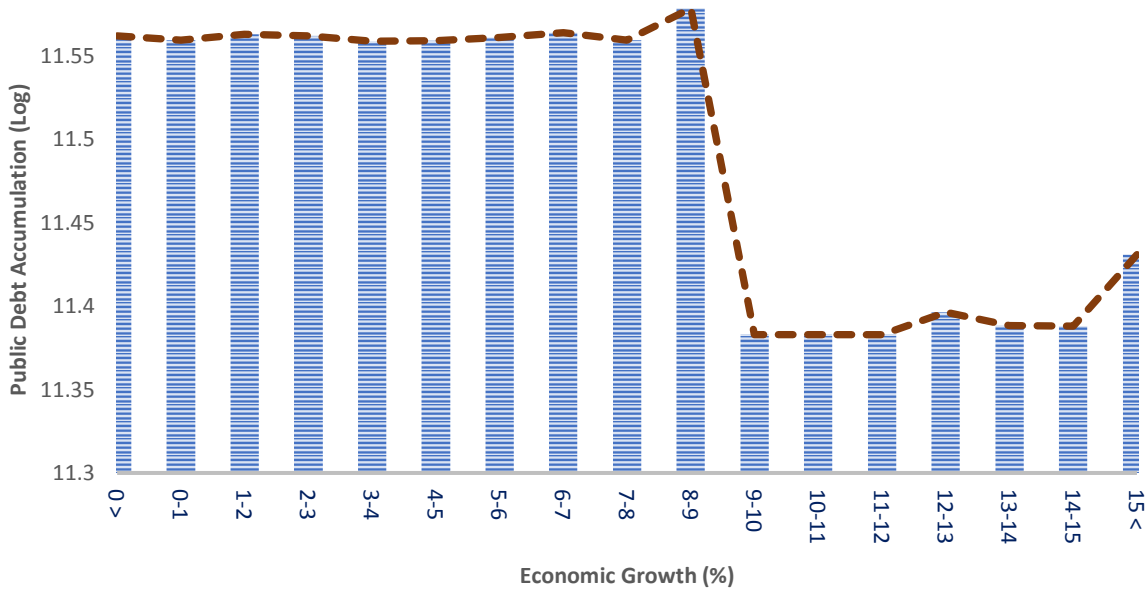
A large body of work revolves around the impact of public debt on growth. The observations mainly focus on the one-way relationship of debt's effect on economic growth. Since the massive financial crisis of 2007-2008, some notable academic studies have investigated public debt's impact on economic growth. The seminal paper by Reinhart and Rogoff (2010) finds a notable inference that countries with high debt-to-GDP levels are associated with lower economic growth. The subsequent studies also confirm the findings of Reinhart and Rogoff (2010) by uncovering the negative impact of high debt on long-run growth (Afonso & Jalles, 2013; Karadam, 2018; Mencinger et al., 2014;

Swamy, 2020). Incremental public debt is related to the growth in the decline of real per capita income (Kumar & Woo, 2010).

Many studies observe the nonlinear relationship between public debt and growth, and find that the threshold level of public debt impacts economic growth. The literature suggests there is disagreement about the common threshold level, as existing studies find different threshold values. A study by Égert (2015) estimates that the tipping point, at which government debt begins to affect growth negatively, is around 20%-60%. However, much research finds the negative impact of debt on growth, with the threshold level being around 90% (Baum et al., 2013; Brida et al., 2017; Checherita-Westphal & Rother, 2012; Ghosh et al., 2013) and other studies suggest the threshold is over 100%, such as the studies conducted by Karadam (2018), Caner et al. (2021), and Swamy (2020).

One of the criticisms of a study by Reinhart and Rogoff (2010) is the possibility of reverse causality between debt and growth (Bell et al., 2015; Özmen & Mutascu, 2023). However, studies to observe the impact of economic growth on debt have mainly concentrated on delving into the bidirectional relationship between public debt and economic growth, such as empirical studies conducted by Panizza and Presbitero (2014), Gómez-Puig and Sosvilla-Rivero (2015), Di Sanzo and Bella (2015), Donayre and Taivan (2017), and De Vita et al. (2018). To the best of our knowledge, the investigation of the pattern of the causal nexus of economic growth on public debt is extremely rare, including exploration to find its threshold level. Due to concerns over debt distress, which many economies face, policies relevant to exploring the channels that would work best to lower government debt, one of which is the economic growth channel, need to be found. Accordingly, estimating the growth level which supports a debt-reducing strategy is necessary.

Figure 1. Debt Accumulation as Economic Growth Varies: 62 Countries represent High-, Middle-, and Low-Income Economies, 1970 – 2015.



Source: Processed from the World Bank Data

The figure above summarizes the average debt accumulation across varying levels of economic growth for 62 selected countries comprising high-, middle-, and low-income countries from 1970 to 2015. The pattern of the link between debt accumulation and economic growth has an apparent structural break over different levels of economic growth. The average debt accumulation from negative to 9% of growth has a relatively similar pattern, until the growth reaches over 9% when the average debt accumulation falls. The pattern strongly indicates the non-linear relationship between public debt and economic growth. Previous studies also confirmed that the non-linear causality estimation yielded a more precise result than the linear model (Di Sanzo & Bella, 2015; Özmen & Mutascu, 2023). Thus, a non-linear exercise to observe the relationship and gauge the threshold level, if any, is needed.

Hence, in this paper, we try to contribute to filling the gap in the empirical literature by finding the causal relationship between economic growth and public debt, specifically the impact of growth on debt, by exploring the possibility of a non-linear relationship between them. The analysis is conducted to find the threshold estimator at which economic growth has varying magnitudes of impacts on government debt. We consider the different development levels by separating the analysis into two groups of countries based on their per capita incomes, a high-income economy group, and a low and middle-income economies group. As the COVID-led crisis has resulted in surging global debt and many countries are facing over-indebtedness, this study is expected to serve as empirical evidence to support a pro-growth policy to reduce public debt.

The estimation results show that economic growth negatively affects public debt; this is consistent with previous works by Murwirapachena and Kapingura (2015) and Azolibe (2021), confirming the importance of economic expansion in reducing the debt-to-GDP ratio. However, when splitting the sample by the income level of the countries, we found that the nexus of economic growth and public debt is not linear, for both the high-income countries (HIC) and low- and middle-income countries (LMIC) groups. Two threshold estimators are found for HIC. An economic growth regime under the first threshold of 2.46% is not statistically significant for reducing debt accumulation, and a growth rate regime between 2.46% and 8.41% negatively affects the public debt. A growth rate above 8.41% is found to have a lesser magnitude of negative impact on debt. In the LMIC group, the threshold level of economic growth is 11.61%. Any level of GDP growth below the threshold will contribute to lowering the accumulation of public debt. However, this effect will disappear when the economy grows above the threshold. Our empirical findings also affirm the negative impact of the exchange rate on debt, as well as the positive correlation between the population and public debt in both sample groups. In addition, we also found that the asymmetric impact of inflation on debt depends on the countries' income levels.

The paper is organized as follows. Section 2 presents the theory and a literature review that discusses the relationship between economic growth and public debt. The datasets and analysis methods are in Section 3. Section 4 shows the empirical estimates of the model and discusses the results, and Section 5 concludes the paper. The appendix contains the results of the formal statistical testing and the supporting estimation results of the threshold model.

LITERATURE REVIEW

Three approaches can justify the impact of public debt on economic growth (Ferreira, 2016;

Filippakis & Stamatopoulos, 2021). The Keynesian notion of debt-driven economic growth is the first theoretical foundation explaining the nexus between those two variables. Based on the concept of IS-LM, it is predicted that the presence of public debt will promote economic growth (Ewaida, 2017; Filippakis & Stamatopoulos, 2021). Elmendorf and Mankiw (1998) argued that, in the short run, when a government creates a budget deficit by reducing taxes, debt-financed public expenditure will raise the aggregate demand and create a multiplier effect on the national output. This argument holds since Keynes assumed that prices and wages are sticky in the short run.

Secondly, the neoclassical school of thought posits that public debt will have a harmful effect on economic growth in the long run (Ferreira, 2016). Public debt will lower the national output since it crowds out private investment (Elmendorf & Mankiw, 1998; Dombi & Dedák, 2019). When a government applies a budget deficit policy, national savings will be reduced, and investment, domestic or abroad, will decrease. Thus, the decline in private investment will have a detrimental effect on economic growth. De Vita et al. (2018) summarizes that debt can negatively impact economic growth through uncertainty and long-term interest rates.

Padoan et al. (2012) developed a framework to explain the debt and growth nexus which includes three equations.

$$\frac{\dot{Y}}{Y} = a - b\,\frac{D}{Y} \tag{1a}$$

The first equation straightforwardly depicts the negative relationship between public debt (D) and output (Y), where the dot over denotes the change in output. Parameter a describes exogenous structural reforms. This equation can be expanded by considering the real interest rate r and the ratio of primary balance to GDP (p).

$$\frac{\dot{Y}}{Y} = a - b\,\frac{D}{Y} - fr + gp \tag{1b}$$

This equation portrays the adverse impact of the interest rate on growth, and the fiscal deficit will induce growth. The second equation describes how the change in debt relates to the ratio of the primary balance to GDP and the interest rate.

$$\dot{D} = rD + pY \tag{2a}$$

Then, we divide both sides with D to obtain

$$\frac{\dot{D}}{D} = r + \frac{p}{D/Y} \tag{2b}$$

The last equation assumes that the interest rate is influenced by the growth of the debt-to-GDP ratio and exogenous factor h, such as the long-term interest rate and a change in market sentiment.

$$r = h + c\left(\frac{\dot{D}}{D} - \frac{\dot{Y}}{Y}\right) \tag{3}$$

To sum up, these three equations explain a possible loop relationship between: (a) the debt ratio and economic growth; (b) the debt ratio and the interest rate; and (c) economic growth and interest rates.

The third view on the relationship between public debt and economic growth is the Ricardian equivalence hypothesis (REH) (Hilton, 2021). This hypothesis claims that public debt has a neutral effect on the level of economic growth (Afzal, 2012; Ferreira, 2016). When a government financed its deficit by issuing bonds, the households would receive additional income (Barro, 1990). However, looking at the intertemporal timeframe, households may hold back on their desired consumption because they believe that the government will raise taxes in the future to repay the debt. Hence, the level of aggregate demand in the economy will remain unchanged.

After the global financial crisis in 2008, a vast amount of literature debating the relationship between public debt and economic

growth has emerged. The most widely known empirical work on the relationship between debt and economic growth is by Reinhart and Rogoff (2010). They found an inverted-U relationship between debt and economic growth. The optimum level of debt is about 90%; when the level of public debt is over this threshold, increasing the debt will decrease the level of economic growth (Cecchetti et al., 2010; Checherita-Westphal & Rother, 2012; Reinhart & Rogoff, 2010). Caner et al. (2021) investigated the impact of public and private debt on economic growth in 29 OECD countries. They also found a nonlinear relationship among the variables, with the threshold value for the public debt being around 53%-68%. When the ratios of public and private debt to GDP are combined, the combined threshold value of debt is approximately 220%. In addition, Eberhardt and Presbitero (2015) suggested that a negative relationship between debt and growth occurred in the long run, but they did not find a standard threshold across countries.

On the other hand, Panizza and Presbitero (2014) investigated the causality between debt and growth in OECD countries. They confirmed that the negative relationship among the variables vanished when the heterogeneity problem was handled. This result does not suggest that every country can survive any level of debt. There will be a certain point when high debt levels are not good for the economy. However, the debt-growth correlation cannot be used as the justification for fiscal consolidation.

More recent works have explored the possible causality of economic growth to public debt, or the bidirectional causality between them (Bell et al., 2015; De Vita et al., 2018; Reinhart et al., 2012). When the economy faces a low level of growth, the revenue from tax is not sufficient to cover the government's spending. Therefore, the government can finance the budget by increasing the debt.

Previous works suggested that the correlation between economic growth and debt is related to country-specific characteristics (Gómez-Puig & Sosvilla-Rivero, 2015; Donayre & Taivan, 2017). For the case of EU countries, Donayre and Taivan (2017) found that in capitalist countries, low levels of GDP growth will induce higher levels in the debt-to-GDP ratio. While for socialist countries, the causality test revealed that low economic growth causes debt accumulation, or there is bidirectional causality between them. Using multivariate analysis, Saungweme and Odhiambo (2019) described a unidirectional relationship between real GDP growth and public debt in the short and long run. When the loan is directed for the expansion and diversification of the economy, it can enhance the country's ability to repay its debt.

An empirical study by Ferreira (2016) has shown the causality of economic growth and the three types of debt (public, private, and foreign debt) in EU member countries. In the short run, bidirectional causality exists between GDP growth and public debt. The coefficient of causality between economic growth and public debt is negative and statistically significant, both before and after the global financial crisis. The study also indicates positive causality between economic growth and private debt. Regarding the foreign debt, the estimation shows bidirectional causality between these variables, yet the coefficient is not statistically significant. Jacobs et al. (2020) also found negative causality from a shock in economic growth to public debt through long-term real interest rate channels.

The existing literature suggests the mechanism through which economic growth affects the public debt. Higher economic growth is supposed to reduce government debt through various transmission channels. Economic growth

due to higher levels of economic activity increases tax revenues; businesses expand and individuals earn more income, tax revenues increase, which can be used to fund government expenditures (including debt repayment), reducing the overall public debt burden or vice versa (Bell et al., 2015; De Vita et al., 2018; Di Sanzo & Bella, 2015; Irons & Bivens, 2010). Further, economic growth can reduce government spending on social expenditures, as economic growth incites lower employment and reduces poverty. Economic growth promotes public debt sustainability and erodes the debt burden. Robust growth boosts investor confidence, potentially lowering debt servicing costs and making it easier to refinance existing debt. Lastly, strong economic growth creates an opportune environment for implementing fiscal consolidation, which enhances government spending and revenue generation efficiency and effectiveness (Hagemann, 2012). Lastly, fiscal consolidation can strengthen fiscal health and reduce public debt.

To summarize, most of the empirical studies into the relationship between debt and economic growth during the last decade, from all over the globe, which have covered almost all countries and economic groups, found a negative relationship between both the macroeconomic variables and a nonlinear relationship, by finding its threshold estimators. However, the threshold level varies among the studies. Furthermore, even though there are studies that have observed the impact of economic growth on debt, the statistical causality has only proven the direction of the causality. However, these studies have yet to investigate the nonlinearity effect of economic growth on debt, or find the threshold level at which the level of growth has varying impacts on public debt.

METHOD, DATA, AND ANALYSIS

1. Data

To examine the effect of economic growth on public debt, this study used panel data from 62 countries that covered low-income, middle-income, and high-income countries from 1970 to 2015, on an annual basis. In the empirical work, the sample countries were classified into two groups; high-income countries (HIC) and low- and middle-income countries (LMIC) based on their income classifications from the World Bank. During the observation period, some low-income countries succeeded in raising their income status, and we argue that there were similar institutional aspects for both groups; thus, we grouped them into one category, low- and middle-income countries (LMIC). This paper considered public debt as the dependent variable and economic growth as the threshold variable. The control variables were the inflation rate, exchange rate and population. Table 1 shows the detailed variables.

2. Empirical Model

This part discusses the model to observe the long-run causal relationship economic growth has on public debt, followed by the models used to explore the linearity of growth's impact on debt among high-income countries and low- and middle-income countries.

Table 1. List of Variables

Variables	Description	Source
Debt (D)	Public debt accumulation in U.S dollar	IMF
Growth (G)	GDP growth in percentage (%)	World Bank
Population (Pop)	Total population in millions	World Bank
Exchange Rate (ER)	Domestic currency per U.S dollar	IMF
Inflation (INF)	Consumer Price Index (%)	IMF

2.1. OLS Panel Regression

In the first step, the analysis focused on observing the structural relationship between growth and debt. We employed standard OLS panel regression with all the observed countries' data. The model's specifications were as below:

$$D_{it} = \beta_0 + \beta_1 L.ER_{it} + \beta_2 L.INF_{it} + \beta_3 Pop_{it} + \beta_4 L.G_{it} + u_i \quad (4)$$

Where D_{it} represented the public debt of country i at time t, Pop_{it} was the population, ER_{it} was the exchange rate, $\beta_3 INF_{it}$ was the inflation rate, and G_{it} denoted economic growth. β_4 was the interest parameter, denoting the long-run structural impact of economic growth on public debt. L was the lag operator used to address the endogeneity problem, as the empirical finding suggested the bidirectional causality relationship between the independent variables (except population) and public debt, such as had been suggested by prior empirical studies (Bittencourt, 2015; De Vita et al., 2018; Donayre & Taivan, 2017).

2.2 Fixed-Effect Panel Threshold Model

As suggested by Rahman et al. (2019) and de Soyres et al. (2022), income classification can affect the causal nexus of economic growth and debt. Hence, further analysis concentrated on observing the possibility of an asymmetric effect of economic growth on public debt, based on the different levels of income. By applying the panel threshold model by Hansen (1999), we could explore the possibility of a nonlinearity relationship and address the heterogeneity problem that arises from a standard panel data regression. The threshold model captures the idiosyncratic features of each individual country and the variation in the structural relationship by its ability to estimate the structural break of the relationship between variables. The structural break estimation could inform us of the threshold level of economic growth for the debt relationship. The development of the model is explained below.

The general model for fixed-effect panel single threshold models was as follows:

$$y_{it} = \mu + X_{it}(q_{it} < \gamma)\beta_1 + X_{it}(q_{it} \geq \gamma)\beta_2 + u_i + e_{it} \quad (5)$$

Where y_{it} represented the dependent variables of country i at time t, u_i reflected the country-specific fixed effects, q_{it} was the threshold variable, and γ was the threshold parameter that separated the equations into two equation regimes, with β_1 and β_2 being the coefficients. We could also remodel Equation (5) into:

$$y_{it} = \mu + X_{it}(q_{it}, \gamma)\beta + u_i + e_{it} \quad (6)$$

Where

$$X_{it}(q_{it}, \gamma) = \{X_{it} I(q_{it} < \gamma) X_{it} I(q_{it} \geq \gamma) \quad (7)$$

With the OLS estimator of β at a given value of γ being:

$$\hat{\beta} = \{X^*(\gamma)' X^*(\gamma)\}^{-1} \{X^*(\gamma)' y^*\} \quad (8)$$

Where X^* and y^* were within-group deviations. γ's estimator was the value that minimized the residual sum of squares (RSS), that is:

$$\hat{\gamma} = arg\ min S_1(\gamma)\ \gamma \quad (9)$$

For γbeing unknown, the γ estimator's distribution was nonstandard. Hansen (1999) proved that $\hat{\gamma}$ is a consistent estimator for γ and it has been argued that the best approach to check $\gamma = \gamma_0$ is to construct a confidence interval with the "no-rejection region" method with a likelihood-ratio (LR) statistic, as below:

$$LR_1(\gamma) = \frac{\{LR_1(\gamma) - LR_1(\hat{\gamma})\}}{\hat{\sigma}^2} Pr \rightarrow \xi$$

$$Pr\ Pr(x < \xi) = (1 - e^{\frac{-x}{2}})^2 \quad (10)$$

Following Wang (2015), at a certain level of significance, α, the lower (less than α quantile) and upper (more than α quantile) limits relate to

the maximum and minimum values of the LR series respectively. The α quantile can be estimated as follows:

$$c(\alpha) = -2log(1 - \sqrt{1-\alpha}) \quad (11)$$

The presence of the threshold effect can be tested by examining whether the coefficient in each regime is significantly the same or different. With the hypotheses' construction as follows:

$$H_0 : \beta_1 = \beta_1$$
$$H_a : \beta_1 \neq \beta_1 \quad (12)$$

With F-statistics being defined as:

$$F_1 = \frac{(S_0 - S_1)}{\hat{\sigma}^2} \quad (13)$$

Where S_0 was the linear model's RSS, since the threshold (γ) was unobserved under H_0, the significance of the threshold effect test used a bootstrap on critical values of the F statistic. The bootstrap design and threshold model with more than one threshold followed Wang and Lin (2010).

Applying the fixed-effect panel threshold model, we constructed our empirical threshold model as follows:

$$\begin{aligned} D_{it} = {} & \beta_0 + \beta_1 ER_{it-1} + \beta_2 INF_{it-1} + \beta_3 Pop_{it} \\ & + \beta_4 G_{it-1} D(G_{it-1} \leq \gamma_1) + \cdots \\ & + \beta_k G_{it-1} D(G_{it-1} > \gamma_k) + u_i + e_{it} \end{aligned} \quad (14)$$

Where D_{it} was public debt, Pop_{it} was population, ER_{it-1} was lagged exchange rate, $\beta_3 INF_{it-1}$ was lagged inflation rate, and G_{it-1} denoted lagged economic growth for both the regime dependent regress or and the threshold variable. We applied two separate data sets, for high-income countries and low- and middle-income countries. The first step was to fit the model with a single threshold estimation, and if the single threshold estimator proved significant, we moved to the higher order. We trimmed the threshold variable, G, by 5% on both sides and set the bootstrap to bs(300) and used grip(400) for computational efficiency.

RESULT AND DISCUSSION

The first analysis was from the output estimations of OLS panel regression from Equation (4) which is presented in Table 2. The model was specifically built to analyze the long run economic growth effect on public debt. Based on the statistical tests conducted, the best model to select was the fixed-effect model. Thus, the analysis has been based on the results from column (6) in Table 2. The results of the tests to select the best panel model are in the appendix.

The estimation results showed that, on average, economic growth reduced public debt in the long run. The higher economic growth generated more government revenue from taxes and non-taxes, since economic activities were expanded. Economic growth also induced personal and firm income and asset accumulation, subject to tax duty. This finding supported the previous observation by Bell et al. (2015), De Vita et al. (2018), Di Sanzo & Bella (2015) and Irons & Bivens (2010). Further, higher economic growth would create greater employment and accelerate poverty reduction, alleviating the government spending burden on its social protection programs. Incremental government revenue from taxes and non-taxes, and a reduced government expenditure burden would increase fiscal space and encourage governments to curb their propensity to finance government programs with loans. This finding also affirmed the previous empirical work, which found the causal relationship between economic growth and public debt, such as the study by Dritsaki (2013), Panizza and Presbitero (2014), Gómez-Puig and Sosvilla-Rivero (2015), Bittencourt (2015), Ferreira (2016), De Vita et al. (2018) and Özmen and Mutascu (2023).

Table 2. Panel Regression Model Estimates: High, Middle, and Low-Income Countries

Public Debt	Pooled OLS		Random Effect		Fixed Effect	
	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Exchange Rate	-0.0269157**	0.0078774	-0.0230981	0.014191	- 0.0356*	0.0147746
Inflation	-0.0001215**	0.0000425	0.0000218*	0.0000105	0.0000271*	0.0000102
Population	0.9882011**	0.0182874	1.979914**	0.1494129	2.30915**	0.2188318
Economic Growth	-0.066939**	0.0080433	-0.024747**	0.0060185	-0.02278**	0.0059604
Constant	8.209439**	0.3021105	-8.449761	2.470237	-13.8721**	3.618681
Adjusted R^2	0.5112		0.4992		0.4987	
Probability > F	0.0000		0.0000		0.0000	

Note: * p<0.05, ** p<0.01

Previous studies suggested there is a positive relationship between the exchange rate and debt. This means that depreciation leads to a higher level of external debt, especially when the level of depreciation is large and the debt is denominated in a foreign currency (Alam & Taib, 2013; Fisera et al., 2021). However, in our work, the exchange rate was empirically found to have a significant negative relation to public debt. When the exchange rate depreciated by a small proportion, it led to cheaper or more competitive domestic products. If the volume effect of depreciation, i.e. the improvement in exports, was sufficient to offset the negative impact of rising import prices; the government would collect more revenue from export duty and could increase its fiscal capacity and reduce its dependency on external debt (Fisera et al., 2021; Greenidge et al., 2010).

Inflation's effect on public debt was found to be statistically significant. The literature offers a range of findings on the impact of inflation on public debt. There is no common agreement on the direction of the relationship between inflation and public debt (Aimola & Odhiambo, 2021). Inflation affects public debt through channels such as inflation, which can sway the real value of debt and interest rates, influence the debt burden, the expectations and confidence of investors, and the perception of fiscal credibility. Furthermore, the result also showed the positive and significant impact of population and public debt growth. A larger population leads to higher pressure on the public budget. High-population countries need to borrow to finance their welfare and social needs, since their domestic endowment may not be adequate to fulfill them (Azolibe, 2021).

Hereinafter, further analysis was conducted to observe the pattern of the causal relationship between economic growth and public debt. The fixed-effect panel threshold model from Equation (14) was exercised. The exercise was conducted on a separate dataset to disentangle the analysis based on the income level. The first data set included18high-income countries and the other covers 44 low- and middle-income countries. The initial exercise was done to test for the single threshold effect. If the result was significant, we would proceed to test for the higher order threshold effect. Table 3 exhibits the results of the regression estimations for high-income countries, and Table 4 shows the regression estimation results for low- and middle-income countries. The estimated results of the threshold estimators for high-income, and low- and middle-income countries, and the threshold effect models for both groups, are provided in the appendix.

From the threshold model estimation of Equation (14), we found the presence of double threshold values for the impact magnitude of economic growth on public debt in high-income economies. The first threshold was estimated at 2.4578%, and the second one was at 8.4135%, with a 95% confidence interval for both thresholds. The F-statistic values for both thresholds are significant, with a 5% confidence level. These results express that in high-income economies, there are two structural breaks in the relationship pattern of economic growth's impact on public debt.

The results of the fixed-effect panel threshold regression model with two threshold estimators are shown in Table 3. In high-income countries, economic growth did not significantly affect public debt when the economy grew at a rate below 2.4578%, or under the first threshold. When the economic growth rate was between the first and the second threshold (2.458% - 8.4135%), the economic growth significantly reduced public debt at the rate of 0.079%. When output grew at a rate above 8.414%, economic growth lost its strength to reduce public debt at a level of 0.037%. This finding confirmed the nonlinear relationship between economic growth and public debt. The impact of economic growth in high-income economies on debt depended on its rate. At a low growth rate (relative to the first threshold), output growth had no impact on public debt; however, at very high growth rates (relative to the second/highest threshold), the magnitude of the impact of economic growth on reducing public debt also decreased.

A further exercise was conducted for low- and middle-income economies. The first estimation was conducted for the single threshold. The threshold estimator was at 11.613% with a 95% confidence interval, and the F-statistic was significant with a 5% confidence level. Therefore, we accepted the nonlinear model by accepting Ha and conducted an exercise for a double threshold model. The second threshold estimator was found to be insignificant, with a 95% confidence interval. Therefore, we accepted H0 as the single threshold model. The determined single threshold was found at the level of 11.613%, and broke the relationship pattern line into two.

Table 3. Double Threshold Regression Estimates: High-Income Countries

Debt	**Coef.**	**Std.Err.**	**t**	**P>t**	**[95%Conf. Interval]**	
Exchange rate	-0.062	0.015	-4.11	0.000	-0.092	-0.032
Inflation	-0.055	0.005	-10.96	0.000	-0.065	-0.045
Population	3.094	0.177	17.44	0.000	2.745	3.442
Economic Growth						
$G_{it-1} \leq 2.458\%$	**0.004**	**0.017**	**-0.28**	**0.780**	**-0.039**	**0.028**
$2.458\% < G_{it-1} < 8.414\%$	**-0.079**	**0.010**	**-8.02**	**0.000**	**-0.099**	**-0.059**
$G_{it-1} \geq 8.414\%$	**-0.037**	**0.011**	**-3.48**	**0.001**	**-0.058**	**-0.016**
_cons	-24.986	2.996	-8.34	0.000	-30.877	-19.095
sigma_u		sigma_u				
sigma_e		sigma_e				
rho	0.973	(fraction of variance due to u_i)				

F test that all u_i=0: F(8, 390) = 47.84 Prob> F = 0.0000

Table 4. Single Threshold Regression Estimates: Low- and Middle-Income Countries

Debt	**Coef.**	**Std.Err.**	**t**	**P>t**	**[95% Conf. Interval]**	
Exchange rate	-0.027	0.007	-4.09	0.000	-0.039	-0.014
Inflation	0.000	0.000	1.26	0.209	-0.000	0.000
Population	1.929	0.102	18.84	0.000	1.728	2.129
Economic Growth						
$G_{it-1} \leq 11.613$	**-0.035**	**0.006**	**-6.21**	**0.000**	**-0.046**	**-0.024**
$G_{it-1} > 11.613$	**0.002**	**0.008**	**0.28**	**0.779**	**-0.013**	**0.017**
_cons	-8.029	1.665	-4.82	0.000	-11.298	-4.76
sigma_u			sigma_u			
sigma_e			0.637			
rho	0.912	(fraction of variance due to u_i)				

F test that all u_i = 0: F(15, 699) = 120.75 Prob> F = 0.0000

Table 4 shows the results of a fixed-effect panel threshold regression model with a single threshold estimator in low- and middle-income countries. The result implied that an incremental unit of economic growth significantly reduced public debt by 0.035%, at a growth regime below the threshold level of 11.613%. Above the threshold, economic growth had no significant effect on public debt. This finding also suggested that there was still more room in low- and middle-income countries to boost economic growth to the level that would still support debt reduction.

The estimation output from tables 3 and 4 shows the asymmetric impact of economic growth on public debt with two aspects, in the groups of high-income and low- and middle-income countries. The first asymmetry was found from its magnitude level. The economic growth's impact on public debt was more potent in high-income economies than in low- and middle-income economies. Furthermore, the second asymmetry showed the direction or pattern of the impact. In high-income countries, economic growth had a significant and negative impact on public debt only when economic growth was relatively high (above the threshold value of 2.4578%). However, the strength was less, and there was no ceiling rate for economic growth to reduce public debt. Meanwhile, in low- and middle-income countries, economic growth had a significant and negative impact on the public debt until it reached the ceiling rate at the threshold level; then, economic growth had no significant impact on the debt.

This asymmetry was suggested to lie in several factors. Public sector spending would increase faster in response to the economic activity's growth in high-income economies. Meanwhile, this condition does not prevail in developing countries. The higher share of public spending to gross domestic product (GDP) also annunciated the bigger drive to maintain economic growth by increasing government expenditure. It was also suggested that the public expenditure target, set by the government, would be encouraged by the intention of stabilizing debt accumulation, a motivation that can be assumed to be greater in developing countries than in developed countries, which were characterized by the lower and higher debt to GDP ratios respectively.

The fixed-effect panel threshold regression model's estimated results showed that the exchange rate negatively impacted public debt in both high-income and low-and middle-income economies. However, the magnitude of the exchange rate's impact on public debt was

higher in high-income economies than in low- and middle-income economies. The fact that high-income economies have greater central bank independence maybe the factor that amplifies the impact of exchange rate depreciation on reducing the debt, since they will be more competent in managing expectations and keeping interest rates at a lower level (Fisera et al., 2021). This result was consistent with the OLS panel regression estimation.

Further, mixed results were found on the impact of inflation on public debt in both groups. Inflation in high-income countries caused public debt to subside. Meanwhile, in middle-income countries, inflation pressured public debt to rise. According to Sinha et al. (2011) and Bittencourt (2015), the existence of low interest rates, or interest rate controls in high-income countries, can explain the negative effect of inflation on public debt. Conversely, middle-income countries tend to have high and volatile interest rates, which would generate higher debt ratios in the economy.

Lastly, the synchronous direction was also found in the effect of the population on debt; the population in both countries' groups positively affected public debt. The large population in developing countries forces their governments to spend more on infrastructure, raising the budget deficit (Bittencourt, 2015). In developed countries, a large aging population causes an increase in the budget allocation for pension funds, health insurance, and other social security expenditures (Imrohoroglu & Sudo, 2011).

CONCLUSION AND SUGGESTION

Following the recent mounting global public debt, the relevant discussion on how countries around the world overcome over-indebtedness should be explored. This paper provides empirical evidence of the negative impact of economic growth on public debt accumulation. We employ a fixed-effect panel threshold model for 62 countries to find the nonlinear nexus between economic growth and the accumulation of public debt.

The economic growth rate negatively affects public debt accumulation. However, the magnitude is asymmetric. In high-income countries, the impact of economic growth on debt differs along the growth path. We found two threshold levels; the first threshold is at 2.46%, and the second is at 8.41%. With economic growth below the first threshold, we discover that economic growth has no significant impact on debt accumulation. Economic growth starts to have a negative impact on debt when the economy grows above 2.46%. The power of the impact subsides when the growth reaches a level above the second threshold.

The investigation of low- and middle-income economies found that there is a single threshold estimator of economic growth's impact on government debt accumulation. The estimated threshold level is at 11.61%. Economic growth below the threshold level is proven to significantly and negatively affect debt. However, economic growth above the threshold diminishes the significance of the impact.

These findings reiterate the role of sound economic growth in supporting governments to reduce debt and keep their debt sustainable. Governments should manage economic growth, to achieve economic growth levels that could bring down indebtedness. Since the threshold estimator is relatively high, developing countries still have room for improvement to achieve higher economic growth, which could reduce public debt. Thus, maintaining pro-growth policies is suggested, and we encourage such governments to implement fiscal consolidations, or structural fiscal reforms, during high-growth periods to promote efficient expenditure and effective tax collection, which improve fiscal

credibility and capability, and act as a shock absorber to maintain macroeconomic stability.

REFERENCE

Afonso, A., & Jalles, J. T. (2013). Growth and productivity : The role of government debt. *International Review of Economics and Finance*, *25*, 384–407. https://doi.org/10.1016/j.iref.2012.07.004

Afzal, M. (2012). Ricardian equivalence hypothesis: Evidence from Pakistan. *E3 Journal of Business Management and Economics*, *3*(6), 258–265. http://www.e3journals.org

Aimola, A. U., & Odhiambo, N. M. (2021). Public debt and inflation nexus in Nigeria: An ARDL bounds test approach. *Cogent Economics and Finance*, *9*(1). https://doi.org/10.1080/23322039.2021.1921905

Alam, N., & Taib, F. M. (2013). an Investigation of the Relationship of External Public Debt With Budget Deficit, Current Account Deficit, and Exchange Rate Depreciation in Debt Trap and Non-Debt Trap Countries. *European Scientific Journal August*, *9*(22), 1857–7881. https://doi.org/10.19044/esj.2013.v9n22p%25p

Azolibe, C. B. (2021). Determinants of External Indebtedness in Heavily Indebted Poor Countries: What Macroeconomic and Socio-Economic Factors Matter? *American Economist*, *66*(2), 249–264. https://doi.org/10.1177/0569434520938326

Baldacci, E., Gupta, S., & Mulas-Granados, C. (2009). How Effective is Fiscal Policy Response in Systemic Banking Crises? *IMF Working Papers*, *09*(160), 1. https://doi.org/10.5089/9781451873078.001

Barro, R. J. (1990). Government Spending in a Simple Model of Endogeneous Growth. *Journal of Political Economy*, *98*(5, Part 2), S103–S125. https://doi.org/10.1086/261726

Baum, A., Checherita-westphal, C., & Rother, P. (2013). Debt and growth : New evidence for the euro area. *Journal of International Money and Finance*, *32*, 809–821. https://doi.org/10.1016/j.jimonfin.2012.07.004

Bell, A., Johnston, R., & Jones, K. (2015). Stylised fact or situated messiness? The diverse effects of increasing debt on national economic growth. *Journal of Economic Geography*, *15*(2), 449–472. https://doi.org/10.1093/jeg/lbu005

Bittencourt, M. (2015). Determinants of government and external debt: Evidence from the young democracies of South America. *Emerging Markets Finance and Trade*, *51*(3), 463–472. https://doi.org/10.1080/1540496X.2015.1025667

Brida, J. G., Gómez, D. M., & Seijas, M. N. (2017). Debt and growth: A non-parametric approach. *Physica A: Statistical Mechanics and Its Applications*, *486*, 883–894. https://doi.org/10.1016/j.physa.2017.05.060

Caner, M., Fan, Q., & Grennes, T. (2021). Partners in debt: An endogenous non-linear analysis of the effects of public and private debt on growth. *International Review of Economics and Finance*, *76*, 694–711. https://doi.org/10.1016/j.iref.2021.07.010

Cecchetti, S. G., Mohanty, M. S., & Zampolli, F. (2010). The future of public debt: prospects and implications. *BIS Working Paper*, *300*.

Checherita-westphal, C., & Rother, P. (2012). The impact of high government debt on economic growth and its channels: An empirical investigation for the euro area. *European Economic Review*, *56*(7), 1392–1405. https://doi.org/10.1016/j.euroecorev.2012.06.007

de Soyres, C., Wang, M., & Kawai, R. (2022). Public Debt and Real GDP: Revisiting the Impact. *IMF Working Papers*, *2022*(076). https://doi.org/10.5089/9798400207082.001

De Vita, G., Trachanas, E., & Luo, Y. (2018). Revisiting the bidirectional causality between debt and growth: Evidence from linear and nonlinear tests. *Journal of*

International Money and Finance, *83*, 55–74. https://doi.org/10.1016/j.jimonfin.2018.02.004

Di Sanzo, S., & Bella, M. (2015). Public debt and growth in the euro area: Evidence from parametric and nonparametric Granger causality. *B.E. Journal of Macroeconomics*, *15*(2), 631–648. https://doi.org/10.1515/bejm-2014-0028

Dombi, Á., & Dedák, I. (2019). Public debt and economic growth: what do neoclassical growth models teach us? *Applied Economics*, *51*(29), 3104–3121. https://doi.org/10.1080/00036846.2018.1508869

Donayre, L., & Taivan, A. (2017). Causality between Public Debt and Real Growth in the OECD : A Country-by-country Analysis. *Economic Papers*, 1–15. https://doi.org/10.1111/1759-3441.12175

Doraisami, A. (2011). Countercyclical fiscal policy issues challenges in Malaysia etc. In *ADBI Working Paper Series No. 288* (Issue 288). https://www.adb.org/sites/default/files/publication/156143/adbi-wp288.pdf

Dritsaki, C. (2013). Causal Nexus Between Economic Growth, Exports and Government Debt: The case of Greece. *Procedia Economics and Finance*, *5*(13), 251–259. https://doi.org/10.1016/S2212-5671(13)00031-2

Eberhardt, M., & Presbitero, A. F. (2015). Public debt and growth: Heterogeneity and non-linearity. *Journal of International Economics*, *97*(1), 45–58. https://doi.org/10.1016/j.jinteco.2015.04.005

Égert, B. (2015). Public debt, economic growth and nonlinear effects: Myth or reality? *Journal of Macroeconomics*, *43*, 226–238. https://doi.org/10.1016/j.jmacro.2014.11.006

Elmendorf, D. W., & Mankiw, N. G. (1998). *Government debt* (pp. 182–183). National Bureau of Economic Research. https://doi.org/10.1787/factbook-2015-77-en

Ewaida, H. Y. M. (2017). The impact of sovereign debt on growth: An empirical study on GIIPS versus JUUSD countries. *European Research Studies Journal*, *20*(2), 607–633.

Ferreira, C. (2016). Debt and Economic Growth in the European Union: A Panel Granger Causality Approach. *International Advances in Economic Research*, *22*(2), 131–149. https://doi.org/10.1007/s11294-016-9575-y

Filippakis, N., & Stamatopoulos, T. V. (2021). Public Debt and Economic Growth: A Review of Contemporary Literature. *South-Eastern Europe Journal of Economics*, *19*(1), 33–50. https://orcid.org/0000-0002-9710-0870.

Fisera, B., Tiruneh, M. W., & Hojdan, D. (2021). Currency depreciations in emerging economies: A blessing or a curse for external debt management? *International Economics*, *168*, 132–165. https://doi.org/10.1016/j.inteco.2021.09.003

Ghosh, A. R., Kim, J. I., Mendoza, E. G., Ostry, J. D., & Qureshi, M. S. (2013). Fiscal Fatigue, Fiscal Space and Debt Sustainability in Advanced Economies. *Economic Journal*, *123*(566), 4–30. https://doi.org/10.1111/ecoj.12010

Gómez-puig, M., & Sosvilla-rivero, S. (2015). The causal relationship between debt and growth in EMU countries. *Journal of Policy Modeling*, *37*(6), 974–989. https://doi.org/10.1016/j.jpolmod.2015.09.004

Greenidge, K., Drakes, L., & Craigwell, R. (2010). The external public debt in the Caribbean Community. *Journal of Policy Modeling*, *32*(3), 418–431. https://doi.org/10.1016/j.jpolmod.2010.02.004

Hagemann, R. P. (2012). What are the Best Policy Instruments for Fiscal Consolidation? *OECD Economic Department Policy Notes, No.12, April*, *12*, 1–12.

Hansen, B. E. (1999). Threshold effects in non-dynamic panels: Estimation, testing, and

inference. *Journal of Econometrics*, *93*, 345–368.

Hilton, S. K. (2021). Public debt and economic growth: contemporary evidence from a developing economy. *Asian Journal of Economics and Banking*, *5*(2), 173–193. https://doi.org/10.1108/ajeb-11-2020-0096

Imrohoroglu, S., & Sudo, N. (2011). *Will a Growth Miracle Reduce Debt in Japan?* (pp. 44–56).

Irons, J., & Bivens, J. (2010). Government Debt and Economic Growth Overreaching Claims of Debt "Threshold" Suffer from Theoretical and Empirical Flaws. *Economic Policy Institute*, *271*, 1–9.

Jacobs, J., Ogawa, K., Sterken, E., & Tokutsu, I. (2020). Public Debt, Economic Growth and the Real Interest Rate: A Panel VAR Approach to EU and OECD Countries. *Applied Economics*, *52*(12), 1377–1394. https://doi.org/10.1080/00036846.2019.1673301

Karadam, D. Y. (2018). An investigation of nonlinear effects of debt on growth. *Journal of Economic Asymmetries*, *18*(March), e00097. https://doi.org/10.1016/j.jeca.2018.e00097

Kose, M. A., Nagle, P. S. O., Ohnsorge, F., & Sugawara, N. (2022). What Has Been the Impact of COVID-19 on Debt? Turning a Wave into a Tsunami. *SSRN Electronic Journal*, *November*. https://doi.org/10.2139/ssrn.3980291

Kose, M. A., & Ohnsorge, F. (2020). Emerging and Developing Economies: Ten Years After the Global Recession. *Policy Research Working Paper*, *9148* (February). https://doi.org/10.2139/ssrn.3541418

Kumar, M. S., & Woo, J. (2010). Public Debt and Growth. *IMF Working Paper 174*.

Mencinger, J., Aristovnik, A., & Verbič, M. (2014). The impact of growing public debt on economic growth in the European union. *Amfiteatru Economic*, *16*(35), 403–414.

Murwirapachena, G., & Kapingura, F. M. (2015). Determinants of external debt in South Africa: A VAR-based approach. *International Journal of Economic Policy in Emerging Economies*, *8*(2), 138–152. https://doi.org/10.1504/IJEPEE.2015.069593

Özmen, İ., & Mutascu, M. (2023). Public Debt and Growth: New Insights. In *Journal of the Knowledge Economy* (Issue June). https://doi.org/10.1007/s13132-023-01441-3

Padoan, P., Sila, U., & Noord, P. Van Den. (2012). Avoiding debt traps: Fiscal consolidation, financial backstops and structural reforms. *OECD Journal: Economic Studies*, *2012*(1), 151–177. http://www.oecd.org/eco/public-finance/AvoidingdebttrapsFiscalconsolidationfinancialbackstopsandfinancialreforms.pdf

Panizza, U., & Presbitero, A. F. (2014). Public debt and economic growth: Is there a causal effect? *Journal of Macroeconomics*, *41*, 21–41. https://doi.org/10.1016/j.jmacro.2014.03.009

Rahman, N. H. A., Ismail, S., & Ridzuan, A. R. (2019). How does public debt affect economic growth? A systematic review. *Cogent Business and Management*, *6*(1), 1–16. https://doi.org/10.1080/23311975.2019.1701339

Reinhart, B. C. M., & Rogoff, K. S. (2010). *Growth in a Time of Debt*. *100*(May), 573–578.

Reinhart, C. M., Reinhart, V. R., & Rogoff, K. S. (2012). Public debt overhangs: Advanced-economy episodes since 1800. *Journal of Economic Perspectives*, *26*(3), 69–86. https://doi.org/10.1257/jep.26.3.69

Saungweme, T., & Odhiambo, N. M. (2019). Government debt, government debt service and economic growth nexus in Zambia: a multivariate analysis. *Cogent Economics and Finance*, *7*(1), 1–17. https://doi.org/10.1080/23322039.2019.1622998

Sinha, P., Arora, V., & Bansal, V. (2011). Determinants of Public Debt for middle income and high income group countries using Panel Data regression. *Munich Personal RePEc Archive*, *32079*, 27.

Swamy, V. (2020). Debt and growth: Decomposing the cause and effect relationship. *International Journal of Finance and Economics*, *25*(2), 141–156. https://doi.org/10.1002/ijfe.1729

Wang, C.-H., & Lin, E. S. (2010). *Panel Threshold Regression Models with Endogenous Threshold Variables*.

Wang, Q. (2015). Fixed-effect panel threshold model using Stata. *Stata Journal*, *15*(1), 121–134. https://doi.org/10.1177/1536867x1501500108

APPENDIX

Appendix 1: The Results of Statistical Test for Model Selection

Test	Models to select	Prob> F, chi^2	Selected Model
Chow Test	CEM vs FEM	0.0000	FEM
Hausman Test	REM vs FEM	0.0000	FEM
BP LM Test	CEM vs REM	0.0000	REM

Note: FEM= Fixed Effect Model, REM= Random Effect Model, CEM=Common Effect Model. FEM is selected based the results of Chow and Hausman Tests.

Appendix 2: Threshold Estimator: High-Income Countries

Model	Threshold	Lower	Upper
Th-1	2.973	1.968	2.982
Th-21	2.458	0.607	2.490
Th-22	8.414	8.054	8.466

Threshold effect test (bootstrap = 300 300)

Appendix 3: Threshold Effect in Double Threshold Model Estimates: High-Income Countries

Threshold	RSS	MSE	Fstat	Prob	Crit10	Crit5	Crit1
Single	76.494	0.212	12.330	0.117	12.873	14.966	18.462
Double	74.070	0.206	11.780	0.030	8.975	10.623	14.640

Appendix 4: Threshold Estimator: Low- and Middle-Income Countries

Model	Threshold	Lower	Upper
Th-1	11.613	10.998	11.777

Threshold effect test (bootstrap = 300)

Appendix 5: Threshold Effect in Single Threshold Model Estimates: Low- and Middle-Income Countries

Threshold	RSS	MSE	Fstat	Prob	Crit10	Crit5	Crit1
Single	282.966	0.419	15.060	0.007	10.250	12.228	14.961