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EXPLORING THE RELATIONSHIP BETWEEN GOVERNMENT DEBT AND REAL GDP: A PANEL ARDL ANALYSIS

David HOJDAN*

Slovak Academy of Sciences, Institute of Economic Research, Sancova 56, 81105 Bratislava, Slovak Republic

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Abstract. This study explores the impact of government debt on real GDP in 37 high-income economies from 1990 to 2019, using quarterly data and panel ARDL models with the PMG estimator to distinguish between short-run and long-run effects. Despite identifying a non-linear relationship between government debt and real GDP, suggesting a long-term debt threshold of 95% to 110%, robustness checks using the Common Correlated Effects estimator to adjust for cross-sectional dependence find no significant long-term impact of government debt on real GDP. This conclusion calls into question the existence of a universal debt threshold affecting economic growth in high-income economies and contributes to the debate on the optimal level of government debt and its economic effects.

Keywords: government debt, economic growth, panel estimation, high-income economies.

JEL Classification: C33, E62, H63, O40.

1. Introduction

The issue of public debt came to the spotlight in the aftermath of the great financial crisis. The fall in GDP and the subsequent fiscal response to the crisis led to a sharp rise in public debt in the world's advanced economies. As the financial crisis spread from the United States to Europe, several euro area countries (Greece, Portugal, Ireland, Spain, Cyprus) began to experience problems in servicing their sovereign debt, and interest rates on their bonds rose sharply. Sovereign debt thus became the number one concern in the euro area countries and getting debt under control seemed to be a priority. A few years after the end of the euro area debt crisis, in 2020, the global economy was plunged into a new crisis caused by the Covid-19 pandemic, which led to severe restrictive measures, especially in 2020 and 2021. In addition to restricting mobility, governments support the economy with large fiscal stimulus packages, leading to a further accumulation of public debt. The question of the optimal debt threshold and the relationship between public debt and real economic performance is therefore topical again, and the study of this relationship should be continued.

In 2010, Reinhart and Rogoff published their influential paper pointing to a debt threshold of 90% above which economic growth starts to slow down. This paper received a strong response and the literature examining the relationship between public debt and economic growth has grown rapidly. Similar public debt thresholds have been estimated by Cecchetti et al. (2011) and Karadam (2018). Nevertheless, numerous studies show that the relationship between public debt and growth is complex and may vary depending on factors such as a country's income level (Kassouri et al., 2021), its institutional and economic structure (Ahlborn & Schweickert, 2018) or the quality of its democracy (Kourtellos et al., 2013). Recent studies extend this complexity: Bentour (2021) challenges the notion of a universal 90% threshold by applying a novel regression kink model, showing that debt thresholds vary significantly across countries. Butkus et al. (2022) focuses on the role of uncertainty in debt-growth dynamics and finds that the thresholds at which debt hampers growth are significantly lower under high uncertainty. Ostrihoň et al. (2023) challenge the notion of a universal debt threshold within the EU, showing that optimal debt levels vary significantly depending on factors such as euro area membership and government spending.

* Corresponding author. E-mail: *david.hojdan@euba.sk*

Their findings argue for fiscal policies tailored to the different economic conditions of EU countries, rather than a one-size-fits-all approach. Efforts to untangle reverse causality and endogeneity within this relationship have been made, with Panizza and Presbitero (2014) employing instrumental variables methods to find no significant debt effects, and Ash et al. (2017) using semi-parametric techniques to argue that the observed relationship between debt and growth is likely driven by reverse causality. Amann and Middleditch (2020) further contribute to this discourse by critically reassessing the debt threshold hypothesis through a time-series analysis of critical periods, especially around the financial crisis. Their analysis, which employs revised and high-frequency data, challenges the notion that high debt levels directly constrain economic growth. Instead, they suggest that economic recessions may lead to increases in debt, pointing towards a reverse causality scenario. Rahman et al. (2019) and a meta-analysis by Heimberger (2023) highlight the heterogeneous impact of public debt on growth and the importance of nuanced policy formulations. This diversity of evidence and lack of consensus in the literature is reflected in the comprehensive review by Heimberger (2023), which, after adjusting for publication bias in a large number of studies, concludes that there is no statistically significant evidence of a universal threshold above which economic growth is hampered. However, the literature often neglects the potentially different effects of debt in the short and long run, a distinction that is both theoretically and empirically supported (Elmendorf & Mankiw, 1999).

This paper attempts to fill this gap by using estimates from panel ARDL models to examine the impact of debt on quarterly data in high-income economies, a focus not often found in the literature.

The main objective of this paper is to provide a comprehensive analysis of the impact of government debt on economic performance in high-income economies, employing quarterly frequency data and cointegration techniques. To achieve this, we specify the following sub-objectives: 1) to examine the differential impact of government debt in the short and long-run; 2) to examine the existence and implications of non-linearities within the relationship between government debt and economic performance, including the identification of potential government debt thresholds.

Our study analysed the impact of public debt on real GDP in 37 high-income economies from 1990 to 2019, using quarterly data and panel ARDL models with the PMG estimator. This approach revealed a significant non-linear relationship between government debt and real GDP, identifying a debt threshold of 95% to 110% in the long run. We also conducted robustness checks using the Common Correlated Effects estimator to account for cross-sectional dependencies, a common problem in panel studies. However, after adjusting for cross-sectional dependence, our analysis finds no significant evidence that government debt affects real GDP in the long run.

The paper is organised as follows. It starts with the methodology in section 2, presents the data in section 3, discusses the results in section 4 and concludes in the last section.

2. Methodology

In examining the dynamics between government debt and real GDP, our methodology uses a panel autoregressive distributed lag (ARDL) approach for a sample of 37 high-income economies with unbalanced quarterly data from 1990 to 2019. The panel ARDL model is chosen for its robustness in capturing the multiple interactions over time and its flexibility in dealing with data with different levels of integration. In addition, the ARDL model can estimate both short-run and long-run coefficients simultaneously, allowing for a comprehensive economic interpretation. This dual estimation provides insights into both the immediate effects and the eventual long-run relationships. Recognizing that the economies under consideration may react differently to variations in government debt, the panel ARDL model incorporates cross-sectional heterogeneity, allowing for country-specific variations. This aspect is crucial as it recognizes that high-income economies are likely to exhibit unique responses due to differences in fiscal policies and economic structures. To estimate the models, we use the Pooled Mean Group (PMG) estimator, a technique that is in line with the objectives of our study. The PMG estimator, developed by Pesaran et al. (1999) assumes homogeneity in the long-run coefficients while allowing for heterogeneity in the short-run dynamics, a premise that is particularly appropriate for high-income economies, which may share similar long-term economic trends while experiencing distinct short-term fluctuations. The PMG approach is also well suited to panels with many cross-sections and time periods, which is the structure of our dataset.

Many studies have pointed to the presence of a non-linear relationship between public debt and economic growth, where debt may increase growth, but after a certain threshold, further debt accumulation is associated with a slowdown in growth (Reinhart & Rogoff, 2010; Baum et al., 2013). In this analysis, we tested the hypothesis of a nonlinear impact of government debt by estimating the following regression using the PMG estimator:

$$\Delta rGDP_{i,t} = \sum_{j=1}^{p-1} \phi \Delta rGDP_{i,t-j} + \sum_{j=0}^{q-1} \Pi_i \Delta debt_{i,t-j} + \sum_{j=0}^{q-1} \rho_i \Delta debt^2_{i,t-j} + \sum_{j=0}^{r-1} \theta_i \Delta X_{i,t-j} + \beta_{0,i}(rGDP_{i,t-1} - \beta_1 debt_{i,t} - \beta_2 debt^2_{i,t} - \sum_{j=3}^{u} \beta_j \Delta X_{i,t} - \mu) + \in_{i,t}, \quad (1)$$

where $rGDP_{i,t}$ is the log of the real GDP index in country i and quarter t. The $debt$ variable is the general government debt as a percentage of GDP and the vector X

is a set of control variables. The variable *debt*^{2}, represents government debt as a percentage of GDP squared. This approach to modelling non-linear effects is also common in the literature on the debt-growth nexus (Checherita-Westphal & Rother, 2012; Afonso & Alves, 2015). The coefficient β_1 expresses the estimated long-run effect of government debt on economic growth, while Π_i is the short-run effect of debt accumulation. $\beta_{0,i}$ represents the error correction term, which expresses the speed of adjustment to the long-run equilibrium. From the coefficient estimates in the long-run equation, we can then express the debt threshold beyond which further public debt accumulation is detrimental to economic performance.

Prior to estimation, we conducted panel unit root tests to assess the stationarity of the variables in our dataset, and the results are detailed in the appendix. These included the Im, Pesaran, and Shin (IPS) test, which allows for heterogeneity between cross-sectional units, and traditional tests such as the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests, which account for autocorrelation and heteroskedasticity. Both levels and first differences of the variables were tested to detect non-stationarity, while maintaining the null hypothesis of each test. For all panel unit root tests, the null hypothesis was that all panels have a unit root. Specifically, for the IPS test, the alternative hypothesis is that some panels are stationary. In contrast, for the ADF and PP tests, the alternative hypothesis is that at least one panel is stationary. The choice of lag lengths was guided by the Akaike Information Criterion to ensure optimal test specifications for the subsequent analysis. Determining whether variables are integrated of order zero or order one is a crucial step when using the Pooled Mean Group (PMG) estimator. This distinction ensures the validity of long-run equilibrium relationships and the reliability of the error correction mechanism of the PMG.

In our analysis, to assess the long-run relationships between the variables, we employ robust cointegration tests, specifically the Kao (1999), Pedroni (1999), and Westerlund (2005) tests. These tests are designed to detect whether a cointegrating relationship exists within panel data. The Kao test is a residual-based test that assumes homogeneity of the cointegration vector across cross-sections. The Pedroni test accommodates heterogeneity across different units in the panel. Lastly, the Westerlund test allows for the examination of cointegration in the presence of cross-sectional dependence, providing a more flexible framework for understanding the dynamic interactions among the panel data. By employing these tests, we ensure a thorough investigation into the potential long-run equilibrium relationships present in our data, which is crucial for the validity of our subsequent PMG estimation.

In the robustness checks of our analysis, we address the issue of cross-sectional dependence, a common problem in panel data models where unobserved common factors can lead to spurious correlations between cross-sectional units. Ignoring these cross-dependencies can lead to biased and inconsistent estimators. To correct for this, we use the Common Correlated Effects Pooled Mean Group (CCEPMG) estimator, as proposed by Pesaran (2006) and further developed by Chudik and Pesaran (2015). The CCEPMG estimator extends the standard PMG approach by incorporating cross-sectional averages of the dependent and independent variables as proxies for the unobserved common factors. This technique effectively captures cross-sectional dependence and allows for heterogeneous coefficients across panel units, while preserving long-run relationships and short-run dynamics consistent with the PMG model. By using CCEPMG, we ensure a more robust estimation in the presence of cross-sectional dependence, thereby enhancing the credibility and reliability of our findings.

3. Data

Our dataset consists of an unbalanced panel of quarterly data from 37 high-income economies, covering the period from 1990 to 2019. We deliberately excluded the period of the global pandemic to avoid the unusual and heightened volatility observed in the global economy during this period. This decision was driven by the significant economic disruptions between 2020 and 2022, characterised by large fluctuations in quarterly data and sharp declines in GDP due to government restrictions. By ending our analysis in 2019, we aimed to focus our study on more stable economic conditions, thereby increasing the reliability and consistency of our findings. The selection of countries for our study was guided by the World Bank's income level classification, with a focus on high-income economies. However, not all high-income countries were included in our analysis due to a lack of data for some countries. A detailed list of these countries is presented in Table 1. The literature on the impact of government debt on economic performance, especially at frequencies higher than annual, is scarce, with notable exceptions such as Lim (2019). To the best

Table 1. List of countries

Australia	Greece	Poland
Austria	Hong Kong	Portugal
Belgium	Hungary	Romania
Canada	Israel	Saudi Arabia
Chile	Italy	Singapore
Croatia	Japan	Slovak Republic
Cyprus	Latvia	Spain
Czech Republic	Lithuania	Sweden
Denmark	Luxembourg	Switzerland
Estonia	Malta	United Kingdom
Finland	Netherlands	United States
France	New Zealand	
Germany	Norway	

of our knowledge, no study has yet examined the relationship between debt and growth using panel ARDL models at a quarterly frequency. The choice of quarterly data offers important advantages. First, it allows for a more granular and timely analysis of economic activity than is possible with annual data. This granularity is particularly useful when estimating panel ARDL regressions that distinguish between short and long-term effects of government debt. In addition, the increased frequency of data points should improve the robustness and reliability of our statistical analysis, leading to more precise and nuanced insights.

When working with quarterly data, seasonality has to be taken into account. In our study, most variables were already seasonally adjusted or had minimal seasonality. For variables not seasonally adjusted, such as gross fixed capital formation, trade openness and government consumption, we applied the TRAMO-SEATS method of adjustment, including the detection of outliers and calendar effects, a practice recommended by organisations such as Eurostat. Another issue is the occasional lack of data points, as many indicators are traditionally collected annually. To fill these gaps, we used linear interpolation for annual variables to produce quarterly estimates. This method was used for the GDP (PPP) per capita and educational attainment variables.

In our analysis, the dependent variable is seasonally adjusted real GDP, which we express as an index with an initial value of 100 for the first observation of each country. Contrary to the usual approach in growth regressions, which focuses on growth rates, we use the level of this variable. This choice is motivated by the requirement of the Pooled Mean Group (PMG) estimator that variables in the long-run equation should exhibit cointegration. Using a dependent variable that is non-stationary in its levels improves the statistical properties of our analysis, as noted in the work of Asteriou et al. (2021). Therefore, we use the logarithm of the real GDP index in our regressions. This approach means that in the short-run equation we effectively have quarter on quarter growth in percentage terms on the left-hand side. Data for seasonally adjusted quarterly real GDP are taken from the IMF's International Financial Statistics database.

The main variable we are interested in is government debt. We have chosen general government debt as a percentage of GDP, which is widely used in studies of the relationship between debt and growth. We obtained this data from the World Bank's Quarterly Public Debt Database, which provides comprehensive coverage. For a handful of countries where the World Bank data had gaps, we supplemented our dataset with data from the Bank for International Settlements database.

Our choice of control variables was guided by the prevailing literature on the relationship between debt and growth. We aimed to keep the number of variables in each model to a minimum to avoid the risk of multicollinearity. As a control variable, we included logarithm of lagged GDP per capita at purchasing power parity (PPP) in current prices, which primarily reflects income disparities between countries. This variable allows us to account for the convergence hypothesis, which suggests that countries with lower incomes tend to experience faster growth rates, as highlighted by Patel et al. (2021). The GDP (PPP) per capita data were taken from the Penn World Table (Feenstra et al., 2015) and linearly interpolated to fit our quarterly data model. In addition, we included the investment rate, another variable that is commonly found to be significant in growth regressions. We used gross fixed capital formation as a percentage of GDP to represent the investment rate, a choice consistent with established practice in economic research (Ahlborn & Schweickert, 2018). The quarterly data on gross fixed capital formation, obtained from the IMF database, showed significant seasonal patterns, which led us to perform seasonal adjustment on this variable. Gross fixed capital formation and GDP (PPP) per capita are our main control variables and are included in all specifications. We also tested a number of other control variables, which are described below.

The degree of openness of an economy is often associated with higher economic growth (Sakyi et al., 2015; Jamel & Maktouf, 2017). Given this, we included a measure of economic openness in our regressions, defined as the sum of the value of exports and imports as a share of GDP. The source of this variable is the IMF database and the data have been seasonally adjusted. We have also included consumer inflation as an indicator of macroeconomic stability, as suggested by Cecchetti et al. (2011). This variable is calculated as the quarter-on-quarter percentage change in the Consumer Price Index (CPI), with

Table 2. Summary statistics

Variable	Unit	Obs	Mean	St. Dev.	Min	Max
Real GDP	Index	3131	159.7	49.9	92.9	504.8
General government debt	% of GDP	3131	69.0	39.7	1.6	212.1
Gross fixed capital formation	% of GDP	3131	22.5	3.8	9.6	40.9
GDP (PPP) per capita in current prices	PPP, USD	3131	38701.3	16349.6	7701.0	112000.0
Trade openness	% of GDP	3131	110.7	84.7	17.4	454.0
Consumer CPI inflation	% QoQ	3131	0.6	0.9	–2.8	9.9
Real effective exchange rate	Index	3131	98.5	10.2	63.2	150.6
Average years of schooling	Years	3131	11.3	1.6	5.9	15.8

data taken from the IMF database. Human capital, often represented by educational attainment, is a common component in growth regressions (Mankiw et al., 1992; Panizza & Presbitero, 2014). In our analysis, we measure human capital using the average years of schooling of the population aged 25 and over. These annual data are taken from the Penn World Table (Feenstra et al., 2015) and converted to quarterly frequency by linear interpolation. Changes in exchange rates can have a significant impact on economic performance, especially in the short term, by changing the relative price of products and affecting price competitiveness. We therefore included the real effective exchange rate (REER), based on the consumer price index (CPI), as a control variable in one of our models. We obtained the quarterly REER data from the IMF database. Table 2 presents the summary statistics for the variables analysed in this study.

4. Results

This section presents the results of our estimates, which are based on quarterly data from 37 high-income economies over the period 1990 to 2019. To examine the relationship between public debt and growth, we estimate various panel ARDL models using a pooled mean group (PMG) estimator. Prior to the estimation, we also conducted panel unit root tests, the results of which are presented in Tables A1-A4 in the Appendix. In addition, the panel ARDL specification allows us to focus on the long-run effect of debt on real GDP, which is more relevant for our analysis, in addition to the short-run effects, which may be driven more by mechanical effects and reverse causality. Additionally, the potential long-term relationship between these variables is supported by cointegration tests, detailed in Table 3.

In Table 4, we present the estimates from models that assess the nonlinear impact of government debt on economic growth. In line with the methodology used by researchers such as Ostrihoň et al. (2023), we adopt a quadratic form of government debt in order to capture its nonlinear effects. This approach not only allows for the analysis of non-linearity, but also facilitates the identification of debt thresholds above which additional debt accumulation becomes detrimental to economic performance. In developing our models, we follow the approach by Asteriou et al. (2021), focusing on a clear specification of each model and maintaining a limited number of control variables per regression. Consistently across models, we include as controls the log of lagged GDP per capita in purchasing power parity and the share of gross fixed capital formation in GDP. In addition, we include other variables such as trade openness, inflation, exchange rate and schooling. For the short-run equation, controls are limited to those variables with quarterly observations that are not based on linear interpolation. Due to the limited space available, only the short-run effects of government debt and investment are shown in Table 4.

Table 3. Panel cointegration tests for baseline specification (p-values in parentheses)

Westerlund	Without trend	With trend
Variance ratio – Ha some panels	−2.9113	−4.8133
	(0.0018)	(0.0000)
Variance ratio – Ha all panels	−1.2531	−3.5296
	(0.1051)	(0.0002)
Pedroni	Without trend	With trend
Modified Phillips–Perron t	−1.2371	−6.5517
	(0.108)	(0.0000)
Phillips–Perron t	−0.4465	−6.0439
	(0.3276)	(0.0000)
Augmented Dickey–Fuller t	0.313	−5.214
	(0.3772)	(0.0000)
Kao		
Modified Dickey–Fuller t	4.4172	
	(0.0000)	
Dickey–Fuller t	5.0401	
	(0.0000)	
Augmented Dickey–Fuller t	5.1607	
	(0.0000)	
Unadjusted modified Dickey–Fuller	4.1607	
	(0.0000)	
Unadjusted Dickey–Fuller t	4.5826	
	(0.0000)	

The results show that there is a statistically significant non-linear effect of government debt in all our model specifications. In line with our expectations, the debt variables suggest a positive but diminishing effect on real GDP, suggesting that above a certain threshold, debt slows economic performance. In all models, the coefficients on the error correction term are negative and statistically significant, suggesting a consistent, but relatively slow speed of adjustment towards long-run equilibrium. For each model in which the debt effect was significant, we calculated the government debt threshold and estimated it to be between 95% and 110% of GDP, depending on the model. These results are consistent with previous research by Reinhart & Rogoff (2010), Baum et al. (2013) and Checherita-Westphal and Rother (2012). Among the control variables, we found a positive effect for fixed investment and also for the level of economic development as measured by GDP per capita at purchasing power parity. Trade openness has no statistically significant effect on real GDP. Estimation results show that an increase in consumer prices, as indicated by the quarter-on-quarter change in the CPI, is associated with a decrease in the real GDP index in the long-run equation. The real effective exchange rate (REER) also shows a negative relationship with real GDP, with a significant coefficient in column (4), suggesting that an appreciation of the exchange rate is associated with a decline in real GDP. Average years of schooling are positively associated with real GDP, reflecting the positive role of human capital in economic development. In the short run, higher debt accumulation is associated with slower quarter-on-quarter real GDP growth. These results are statistically significant in all specifications in Table 4.

In our robustness check, we address the issue of cross-sectional dependence. To address this and reduce the potential for bias, we use the Common Correlated Effects Pooled Mean Group (CCEPMG) estimator developed by Pesaran (2006) and later by Chudik and Pesaran (2015). This estimator extends the PMG approach by incorporating cross-sectional means that capture unobserved common factors. In the debt-growth nexus literature, a similar approach has been taken by Asteriou et al. (2021). We applied the CCEPMG estimator to re-evaluate the models presented in Table 4, which examines the non-linear effects of government debt. The use of a method that allows for cross-sectional dependence strengthens the validity of our initial findings.

The results of the robustness tests using the Common Correlated Effects estimator are summarized in Table 5, which shows the non-linear impact of government debt on real GDP across different model specifications. Neither the linear nor the squared government debt terms appear to have a consistent and statistically significant impact across models. The squared debt term, which is intended to capture the non-linear effects, predominantly shows an insignificant impact in these models, suggesting that the non-linear relationship between government debt and real GDP may not be robust. The results for other variables, such as gross fixed capital formation and GDP per capita, are generally consistent and significantly positive, indicating their robust contribution to economic growth. Overall, the robustness tests suggest that the effect of government debt on real GDP may not be as clear-cut as suggested by the results of the PMG estimator. The lack of consistent significance of the government debt variables across models implies that the relationship between debt and growth is complex and may be influenced by a variety of factors not captured by the debt variables alone. The error correction term in

Table 4. Nonlinear impact of government debt on real GDP (standard errors are displayed within parentheses)

Dep.: log (real GDP index)	(1)	(2)	(3)	(4)	(5)
	PMG	PMG	PMG	PMG	PMG
Long-run equation					
Government debt	0.01658*** (0.00273)	0.00961* (0.00544)	0.01066** (0.00477)	0.01482*** (0.00236)	0.01480*** (0.00201)
Government debt squared	−0.00008*** (0.00001)	−0.00005* (0.00003)	−0.00005** (0.00002)	−0.00007*** (0.00001)	−0.00007*** (0.00001)
Gross fixed capital formation	0.03879*** (0.00658)	0.03677** (0.01448)	0.03801*** (0.01294)	0.03290*** (0.00557)	0.03236*** (0.00527)
L.GDP per capita (PPP)	0.41198*** (0.01964)	0.46100*** (0.04357)	0.46523*** (0.03448)	0.50554*** (0.02167)	0.16320*** (0.03730)
Trade openness		0.00133 (0.00156)			
Consumer inflation			−0.07279** (0.03693)		
REER				−0.00779*** (0.00172)	
Schooling					1.13302*** (0.17322)
Short-run equation					
Error correction	−0.01099*** (0.00401)	−0.00674*** (0.00077)	−0.00780*** (0.00097)	−0.01258*** (0.00421)	−0.01071** (0.00481)
D.Government debt	−0.00551*** (0.00119)	−0.00476*** (0.00121)	−0.00528*** (0.00117)	−0.00565*** (0.00120)	−0.00566*** (0.00113)
D.Government debt squared	0.00004* (0.00003)	0.00004 (0.00003)	0.00004 (0.00003)	0.00005* (0.00002)	0.00005* (0.00003)
D.Gross fixed capital formation	0.00235*** (0.00059)	0.00156*** (0.00049)	0.00240*** (0.00058)	0.00235*** (0.00059)	0.00237*** (0.00059)
Debt threshold (% of GDP)	109.4	95.0	97.4	99.0	105.3
Observations	3220	3220	3220	3140	3220
Countries	37	37	37	37	37

the robustness test is significant in three model specifications, suggesting an inconsistent adjustment towards the long-run equilibrium. However, when significant, the use of the Common Correlated Effects Pooled Mean Group (CCEPMG) estimator generally indicates a higher speed of adjustment than the standard PMG estimator. In the short-run equation, the coefficient on government debt in linear form is consistently negative and significant across specifications, suggesting that increases in government debt may have a dampening effect on real GDP growth in the short run.

5. Conclusions

In this study, we have examined the impact of government debt on real GDP using quarterly data for a panel of 37 high-income economies over the period from 1990 to 2019. Our methodological approach involved the use of panel ARDL models estimated using the PMG estimator, which distinguishes between short-run and long-run effects and assumes uniform long-run coefficients while allowing for short-run heterogeneity. Using this approach, our long-run equation identified a statistically significant non-linear relationship between public debt and real GDP, with an estimated debt threshold ranging from 95% to 110%. We then conducted robustness checks using the Common Correlated Effects estimator, which adjusts the PMG estimator to account for cross-sectional dependence, a common problem in panel data analyses. However, the results point to a lack of conclusive evidence in support of a robust debt threshold for high-income economies. This finding challenges the notion of a one-size-fits-all economic approach and underlines the complexity of debt dynamics in influencing economic performance. By using quarterly data, this research contributes to a deeper and more detailed understanding of the time dynamics between government debt and economic growth, going beyond the typical

Table 5. Nonlinear impact of government debt on real GDP – robustness test using the common correlated effects estimator (standard errors are displayed within parentheses)

Dep.: log (real GDP index)	(6)	(7)	(8)	(9)	(10)
	CCEPMG	CCEPMG	CCEPMG	CCEPMG	CCEPMG
Long-run equation					
Government debt	0.00060 (0.00293)	–0.00026 (0.00253)	0.00043 (0.00680)	0.00017 (0.00139)	–0.00035 (0.00240)
Government debt squared	–0.00000 (0.00002)	–0.00000 (0.00002)	–0.00000 (0.00003)	–0.00000 (0.00001)	–0.00000 (0.00001)
Gross fixed capital formation	0.00499*** (0.00132)	0.00326*** (0.00115)	0.00517*** (0.00197)	0.00402*** (0.00140)	0.00309 (0.00251)
L.GDP per capita (PPP)	0.25594*** (0.07647)	0.30233*** (0.07601)	0.24811*** (0.08058)	0.21665*** (0.05626)	0.25672 (0.38014)
Trade openness		0.00037 (0.00030)			
Consumer inflation			–0.00380 (0.00881)		
REER				–0.00109* (0.00065)	
Schooling					0.10760 (3.68711)
Short-run equation					
Error correction	–0.20087* (0.11390)	–0.23323* (0.12549)	–0.19676 (0.21037)	–0.24622** (0.11115)	–0.26592 (0.19092)
D.Government debt	–0.00277** (0.00108)	–0.00238** (0.00102)	–0.00234** (0.00108)	–0.00282** (0.00114)	–0.00246** (0.00108)
D.Government debt squared	0.00001 (0.00001)	0.00001 (0.00001)	0.00000 (0.00001)	0.00001 (0.00001)	0.00001 (0.00001)
D.Gross fixed capital formation	0.00023 (0.00041)	0.00027 (0.00044)	0.00026 (0.00042)	0.00043 (0.00043)	0.00028 (0.00042)
CD Statistics p-value	–2.62 (0.0088)	–2.29 (0.0218)	–2.71 (0.0067)	–1.30 (0.1929)	–2.90 (0.0037)
Observations	3050	3050	3050	3050	3050
Countries	37	37	37	37	37

use of annual data aggregates. It points to the need for policymakers to tailor fiscal strategies to their specific economic context, rather than relying on generalised debt benchmarks. Future research could extend these findings by including different economic settings and examining the influence of macroeconomic policies and institutional characteristics on the relationship between debt and growth. This approach would further enrich our understanding of how different conditions affect the effectiveness of fiscal strategies, and guide more nuanced and effective policy formulations in different economies.

Disclosure statement

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APPENDIX

Table A1. Panel unit root tests I – level of variables

		Real GDP	Gov. debt	Gross fixed inv.	GDP in PPP p.c.	Trade openness	CPI QoQ	REER	Years of school
	Number of panels	37	37	37	37	37	37	37	37
	Average number of periods	85	85	85	85	85	85	85	85
Im-Pesaran-Shin	P-value	0.93	1.00	0.00	0.30	0.16	0.00	0.01	1.00
Dickey-Fuller	Inverse chi-squared, p-value	0.05	1.00	0.00	0.00	0.80	0.00	0.02	0.00
	Inverse normal, p-value	0.63	1.00	0.00	0.00	0.50	0.00	0.01	0.00
	Inverse logit, p-value	0.56	1.00	0.00	0.00	0.49	0.00	0.01	0.00
	Mod. inv chi-squared, p-value	0.04	0.99	0.00	0.00	0.80	0.00	0.01	0.00
Phillips-Perron	Inverse chi-squared, p-value	0.05	1.00	0.00	0.00	0.80	0.00	0.02	0.00
	Inverse normal, p-value	0.63	1.00	0.00	0.00	0.50	0.00	0.01	0.00
	Inverse logit, p-value	0.56	1.00	0.00	0.00	0.49	0.00	0.01	0.00
	Mod. inv chi-squared, p-value	0.04	0.99	0.00	0.00	0.80	0.00	0.01	0.00

Note: P-values are provided for each panel unit root test. In these tests, the null hypothesis (H0) asserts the existence of a unit root across all panels. The alternative hypothesis (Ha) of the Im-Pesaran-Shin test indicates stationarity in some panels, whereas for the Dickey-Fuller and Phillips-Perron tests, the Ha suggests that there is stationarity in a minimum of one panel.

Table A2. Panel unit root tests I – first differences of variables.

		Real GDP	Gov. debt	Gross fixed inv.	GDP in PPP p.c.	Trade openness	CPI QoQ	REER	Years of school
	Number of panels	37	37	37	37	37	37	37	37
	Avg. number of periods	85	85	85	85	85	85	85	85
Im-Pesaran-Shin	P-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dickey-Fuller	Inverse chi-squared, p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Inverse normal, p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Inverse logit, p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mod. inv chi-squared, p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Phillips-Perron	Inverse chi-squared, p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Inverse normal, p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Inverse logit, p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mod. inv chi-squared, p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: P-values are provided for each panel unit root test. In these tests, the null hypothesis (H0) asserts the existence of a unit root across all panels. The alternative hypothesis (Ha) of the Im-Pesaran-Shin test indicates stationarity in some panels, whereas for the Dickey-Fuller and Phillips-Perron tests, the Ha suggests that there is stationarity in a minimum of one panel.