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Granger causality between public debt and economic growth: further evidence from panel data

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ABSTRACT

This paper examines the causal relationships between public debt and economic growth. To that end, we employ the novel homogeneous approach to testing for Granger non-causality in a heterogeneous panel to a sample of 115 countries from 1995 to 2016. This methodology suits high persistence, moderate time dimension and heterogeneous nuisance parameters. Our results indicate that when examining the pairwise relationship, in most of cases, there is a unidirectional Granger-causality relationship running from debt to growth. Nevertheless, when controlling for the explanatory variables that have been consistently identified as drivers of growth in the literature, in all the cases, we find evidence of bidirectional Granger-causality between public debt and economic growth.

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I. Introduction

The global financial crisis stimulated burgeoning literature examining the impact of high public debt on economic growth. The COVID-19 pandemic has further reactivated the academic debate on the public debt and economic growth nexus as government debt reached an unprecedented level of nearly 100% of global GDP in 2020 and, despite falling in 2021–2022, remains high.

While neoclassical economists argue that debt-financed public expenditures do not compensate for the negative impact of crowding out of private investment (Domar 1944; or; Modigliani 1961, among others), the Keynesians contend that it can lead to a positive multiplier effect on national output (Barro 1979).

A strand of the literature has analysed the Granger (1969) causality between economic growth and public debt using panel data techniques (see, e.g. Reinhart and Rogoff 2010; or; Donayre and Taivan 2017), founding ambiguous results across countries and periods considered.

Our contribution is fourfold. Firstly, we use the panel Granger non-causality test proposed by Juodis *et al.* (2021), which offers superior size and power performance to existing tests and has power against both homogeneous as well as heterogeneous alternatives. Secondly, we can control for the usual macroeconomic factors in the economic growth model. Third, we do not assume a unidirectional causality between public debt and economic growth. Finally, we examine the debt-growth nexus attending to different country classifications.

The paper proceeds as follows. Section II presents the econometric methodology. Section III introduces the analytical framework. Section IV describes the data set and reports the empirical results. Section V offers some concluding remarks.

II. Econometric methodology

The authors consider the following linear dynamic panel data model:

$$y_{it} = \alpha_{0,i} + \sum_{p=1}^{P} \alpha_{p,i} y_{i,l-p} + \sum_{p=1}^{P} \beta_{p,i} x_{i,l-p} + \in_{i,t} i = 1, \ldots, N; t = 1, \ldots, T \quad (1)$$

where $\alpha_{0,i}$ represents the individual-specific effects, $\alpha_{p,i}$ denote the heterogeneous autoregressive coefficients, $\beta_{p,i}$reflects the Granger causality parameters or

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the so-called heterogeneous feedback coefficients and $\in_{i,t}$ is the error term.

Under the null hypothesis, it is assumed that the Granger-causality parameters are zero, therefore this implies that the feedback coefficients are homogeneous as follows:

$$H0 : \beta_{p,i} = 0 \; for \; all \; iandp \tag{2}$$

and the alternative hypothesis is:

$$H1 : \beta_{p,i} \neq 0 \; for \; some \; iandp \tag{3}$$

When the null hypothesis is rejected, it can be interpreted as $x_{i,t}$ does Granger-cause the dependent variable y_{it}. One of the main and novel characteristics is that Juodis *et al.* (2021) apply the pooled fixed effects-type estimator that is more convenient given the faster convergence rate.

Concretely, the pooled least squares estimator of β is computed as follows:

$$\hat{\beta} = \left(\sum_{i=1}^{N} X_i' M_{Z_i} X_i \right)^{-1} \left(\sum_{i=1}^{N} X_i' M_{Z_i} y_i \right) \tag{4}$$

where $M_{Z_i} = I_T - Z_i (Z_i Z_i)^{-1} Z_i$. According to Fernández-Val and Lee (2013), under general conditions and as N, T$\rightarrow \infty$ with N/T $\rightarrow$ k^2 $\in$[0; ∞], we have

$$\sqrt{NT}\left(\hat{\beta} - \beta_0\right) \rightarrow J^{-1} N(-B, V)$$

where $J = p \lim_{N,T\rightarrow\infty} (NT)^{-1} \sum_{i=1}^{N} X_i' M_{Z_i} X_i$, V represents the variance-covariance matrix and B is the bias since N and T are the same order. Therefore, to subtract the bias associated with the pooled estimator, these authors implement the Half-Panel Jackknife estimator defined as:

$$\tilde{\beta} = \hat{\beta} + \left(\hat{\beta} - \frac{1}{2} \left(\hat{\beta}_{\frac{1}{2}} + \hat{\beta}_{\frac{2}{1}} \right) \right) = \hat{\beta} + T^{-1} \hat{B} \tag{5}$$

Therefore, the Wald test for Granger non-causality can be computed as follows:

$$\hat{W}_{HPJ} = NT\tilde{\beta} \left(\hat{J}^{-1} \hat{V} \hat{J}^{-1} \right)^{-1} \tilde{\beta} \rightarrow \mathcal{X}^2(P) \tag{6}$$

where $\hat{J} = (NT)^{-1} \sum_{i=1}^{N} X_i^{M_{Z_i}} X_i$. It is important to mention that assuming homoscedastic along time and cross-sectional dimensions for errors, then:

$$\hat{V} = \hat{\sigma}^2 \hat{J} \tag{7}$$

with

$$\hat{\sigma}^2 = \frac{1}{N(T-1-P) - P} \sum_{i=1}^{N} \left(y_i - X_i \hat{\beta} \right) M_{Z_i} \left(y_i - X_i \hat{\beta} \right) \tag{8}$$

Nevertheless, if the errors are cross-sectionally heteroskedastic:

$$\hat{\sigma}^2 = \frac{1}{N(T-1-P) - P} \sum_{i=1}^{N} \left(y_i - X_i \hat{\beta} \right) M_{Z_i} \left(y_i - X_i \hat{\beta} \right) \tag{9}$$

III. Analytical framework

We test for the presence of Granger-causality linear relationships between public debt and economic growth pairwise and after controlling for the usual growth drivers. We consider a Solow model augmented with public debt, where the growth rate of real per capita GDP for a given country *i* in time *t* (g_{ti}) is given by:

$$g_{it} = \alpha + \gamma y_{it+1} + \sum_{j=1}^{n} \delta_{ij} X_{ijt} + \beta d_{it} + \varepsilon_{it} \tag{10}$$

where y_{it-1} is the logarithm of initial real per capita GDP (to capture the 'catch-up effect'), d_{ti} is the public debt-to-GDP ratio. Regarding X_{it}, we consider explanatory variables that are consistently associated with growth in the literature [see, e.g. Aghion and Howitt (2009)]: population growth rate; the ratio of gross capital formation to GDP; life expectancy at birth, a proxy for the level of human capital; openness to trade; GDP deflator inflation rate and a traditional indicator of financial depth.

IV. Data and empirical results

We use annual data for 91 countries over the period 1995–2020.[1] We use the World Bank's World Development Indicators as our primary source.

[1]The selection of the countries and the period under study have been conditioned to data availability for all the economic variables to achieve a balanced panel.

Table 1 reports the results obtained when testing pairwise Granger causality between debt and growth for the whole sample and by grouping countries exogenously into groups based on income levels (using both the IMF and the World Bank classification) and on levels of government indebtedness (based on the public debt to GDP levels).[2] As a further test to ensure the reliability of the empirical results, we have applied the grouped fixed effect (GFE) estimator recently proposed by Bonhomme and Manresa (2015) to classify countries into groups endogenously, considering the possibility that different countries experience distinct dynamics in the debt-growth relationship, with the group-specific time patterns and individual group membership being left

Table 1. Pairwise Granger causality between public debt and economic growth.

			Debt→Growth			Growth→Debt		
			Coeff.	HPJ Wald test	BIC	Coeff.	HPJ Wald test	BIC
All countries		Lag1_debt	−0.0446***	11.3489	4681.7379	−0.1483	9.8993	7859.6974
			(0.0180)	[0.0034]		(0.1393)	[0.0071]	
		Lag2_debt	0.0255			−0.2604***		
			(0.0173)			(0.0834)		
WB income classification	Low income	Lag1_debt	−0.0702**	6.0448	932.2585	−0.3774***	10.4336	1513.7373
			(0.0321)	[0.0487]		(0.1270)	[0.0054]	
		Lag2_debt	0.0715***			−0.0488		
			(0.0291)			(0.1747)		
	Lower-middle income	Lag1_debt	−0.0072	0.0509	1022.1225	−0.6272**	7.3487	1765.6505
			(0.0571)	[0.9749]		(0.2726)	[0.0254]	
		Lag2_debt	0.0073			−0.4543**		
			(0.0436)			(0.2234)		
	Upper-middle income	Lag1_debt	−0.0530**	4.5263	1254.4089	−0.0494	0.7369	2018.2369
			(0.0266)	[0.1040]		(0.1406)	[0.6918]	
		Lag2_debt	0.0390			0.0736		
			(0.0258)			(0.1308)		
	High income	Lag1_debt	−0.0423**	12.7627	1350.5103	0.2530	33.8897	2324.3566
			(0.0218)	[0.0017]		(0.3889)	[0.0000]	
		Lag2_debt	0.0203			−0.8694***		
			(0.0277)			(0.1551)		
IMF income classification	Advanced economies	Lag1_debt	−0.1321***	105.1504	1561.9792	−0.4402***	10.1206	2358.6046
			(0.0422)	[0.0000]		(0.1551)	[0.0063]	
		Lag2_debt	0.0678			0.0070		
			(0.0463)			(0.0775)		
	Emerging economies	Lag1_debt	−0.0114	2.2473	2065.0094	−0.1295	6.7075	3476.6660
			(0.0277)	[0.3251]		(0.2558)	[0.0350]	
		Lag2_debt	0.0201			−0.2932***		
			(0.0229)			(0.1231)		
	Low income developing countries	Lag1_debt	−0.0707***	11.7723	1038.8011	0.1027	11.8683	1784.4150
			(0.0207)	[0.0028]		(0.2139)	[0.0026]	
		Lag2_debt	0.07019***			−0.7234***		
			(0.0257)			(0.2172)		
GFE classification	Group 1	Lag1_debt	0.1430***	21.0353	479.5344	−0.7090**	5.7115	779.0096
			(0.0510)	[0.0000]		(0.3149)	[0.0575]	
		Lag2_debt	−0.0700**			−0.2455		
			(0.0361)			(0.2616)		
	Group 2	Lag1_debt	−0.1038***	35.9202	2218.6608	−0.6553***	63.5095	3491.8177
			(0.0297)	[0.0000]		(0.0842)	[0.0000]	
		Lag2_debt	0.0659**			−0.2291***		
			(0.0296)			(0.0722)		
	Group 3	Lag1_debt	−0.1764***	13.1109	314.0730	0.0772	49.7882	546.8291
			(0.0530)	[0.0014]		(0.5649)	[0.0000]	
		Lag2_debt	0.2009***			−1.3329***		
			(0.0569)			(0.2473)		
	Group 4	Lag1_debt	−0.0072	5.2168	1414.2359	0.6955***	5.8742	2554.9644
			(0.0155)	[0.0737]		(0.2873)	[0.0530]	
		Lag2_debt	−0.0079			0.0701		
			(0.0165)			(0.1483)		

Notes: In the ordinary brackets below the parameter estimates are the corresponding *z*-statistics, computed using White (1980)'s heteroskedasticity-robust standard errors. In the square brackets below the specification tests are the associated *p*-values. *, ** and *** indicate significance at 10%, 5%, and 1% levels, respectively.

[2]As a further test to ensure the reliability of the empirical results, we also considered groups of countries by region using the World Bank (WB) classification. These additional results are not shown here to save space, but they are available from the authors upon request.

unrestricted and estimated from the data. In our case, the GFE estimator classifies countries into four groups for which debt impacts growth differently. In Figure 1, the reader can find a mapping of the countries belonging to each group.[3]

As seen in Table 1, we find unidirectional Granger causality relationships running from growth to debt for the low-middle and emerging economies. Our results also suggest bidirectional Granger causality for the panel of all the countries, low-income countries, high-income countries, advanced economies, low-income developing countries and all groups endogenously identified by the GFE estimator (although for Group 4 only at the 10% significant level). Upper-middle-income countries are the only category for which we found no causal relationship between public debt and economic growth during the sample.

Turning now to the case of testing for Granger causality controlling for potential economic variables, Table 2 reports the results.[4] Our results indicate bidirectional Granger causality between debt and economic growth in all cases, regardless of the criteria used to classify the countries. This finding calls into question the inference based on conventional panel models that examine the linear relationship between public debt (regressor) and economic growth (dependent variable) across countries since the estimated partial effect of the regressor on the dependent variable is biased and inconsistent due to endogeneity.

V. Concluding remarks

Our study sheds light on the importance of formulating the causal hypothesis itself along with the model-building stage, following available well-established theories and background knowledge, not examining only the pairwise

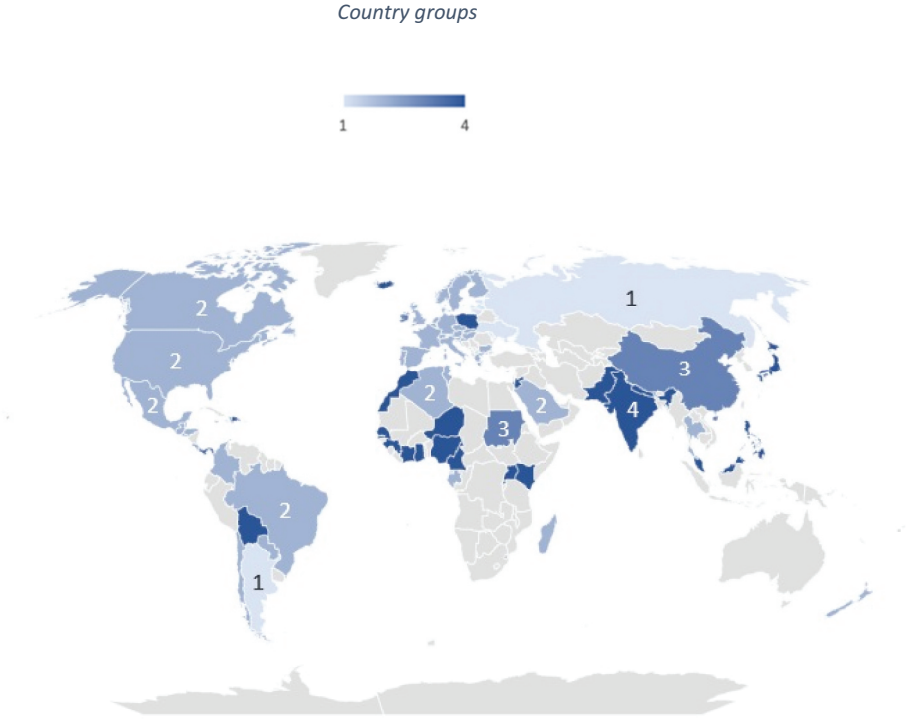

Figure 1. Groups of countries identified by the GFE estimator.

[3]A list of the estimated classification of the countries belonging to each group is available from the authors upon request.
[4]The estimation results suggest that the coefficients on the explanatory variables are of the expected sign and mostly significant at conventional levels. In particular, the results substantiate the findings of empirical literature that public debt hinders economic growth.

Table 2. Pairwise Granger causality between public debt and economic growth controlling for potential economic variables.

		Debt→Growth		Growth→Debt	
		HPJ Wald test	BIC	HPJ Wald test	BIC
All countries		3.0e + 03 [0.0000]	2632.7683	253.9473 [0.0000]	5830.9258
WB income classification	Low income	1.7e + 04 [0.0000]	596.4242	4.3e + 03 [0.0000]	1196.9777
	Lower-middle income	3.9e + 03 [0.0000]	656.8663	852.0370 [0.0000]	1417.4658
	Upper-middle income	527.0525 [0.0000]	685.3492	209.7138 [0.0000]	1428.8611
	High income	271.2316 [0.0000]	1752.7813	271.2316 [0.0000]	1752.7813
IMF income classification	Advanced economies	1.0e + 03 [0.0000]	802.4818	495.5385 [0.0000]	1726.1389
	Emerging economies	3.1e + 03 [0.0000]	1246.4400	340.5877 [0.0000]	2749.2246
	Low income developing countries	9.8e + 03 [0.0000]	577.2350	9.4e + 03 [0.0000]	1231.7144
GFE classification	Group 1	4.2e + 03 [0.0000]	331.6245	1.8e + 04 [0.0000]	630.9640
	Group 2	1.2e + 04 [0.000]	1240.1576	1.1e + 05 [0.0000]	2567.2509
	Group 3	53.4160 [0.0000]	196.7595	192.7621 [0.0000]	388.1778
	Group 4	106.0489 [0.0000]	726.6162	208.7539 [0.0000]	1907.8965

Notes: In the square brackets below the specification tests are the associated *p*-values.

relationship. It also shows the relevance of controlling in empirical estimations for the possible endogeneity of the public debt-to-GDP ratio making use of the two-stage least squares methodology with panel-corrected standard errors clustered by countries, using the exogenous variables and their lags as instruments.

Exploring the existence of a tipping point or threshold of the debt ratio to the GDP and the nonlinear effects of public debt on economic growth would be logical expansions of the analysis presented in this paper. Our research agenda for the future includes exploring these avenues of research when new causality tests are proposed that contemplate them.

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