Government Debt and Economic Growth – Decomposing the Cause and Effect Relationship

Swamy, Vighneswara

Institute of Economic Growth, Delhi

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– Decomposing the Cause and Effect Relationship

Vighneswara Swamy
vs@iegindia.org

Abstract

The rising government debt levels in the aftermath of global financial crisis and the ongoing euro zone debt crisis have necessitated the revival of the academic and policy debate on the impact of growing debt levels on growth. This study provides a data–rich analysis of the dynamics of government debt and economic growth for a longer period (1960–2009). It spans across different debt regimes and involves a worldwide sample of countries that is more representative than that of studies confined to advanced countries. This study observes a negative relationship between government debt and growth. The point estimates of the range of econometric specifications suggest a 10-percentage point increase in the debt-to-GDP ratio is associated with 23 basis point reduction in average growth. Our results establish the nonlinear relationship between debt and growth. Further, by employing panel vector auto regressions (PVAR) approach, this study decomposes the cause and effect relationship between debt and growth and offers an answer to the question – Does high debt lead to low growth or low growth leads to high debt? The results derived from the impulse–response functions and variance decomposition show the evidence of long-term effect of debt on economic growth. The results indicate that the effect is not uniform for all countries, but depends mostly on the debt regimes and other important macroeconomic variables like; inflation, trade openness, general government final consumption expenditure and foreign direct investment.

Keywords: Government Debt, economic growth, panel data, nonlinearity, country groupings
JEL Classification: C33, C36, E62, O5, O40, H63

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1. Introduction

Post-global financial crisis, the debt trajectories in several economies around the world are felt to be unsustainable. Many countries in the euro zone (and more particularly Greece) are struggling with a combination of high levels of indebtedness, budget deficits and frail growth. This has necessitated the revival of the academic and policy debate on the impact of rising levels of government debt on economic growth. There is a growing concern among the policymakers, central banks, and international policy organizations to understand the effects of government debt on economic growth. An important policy question in this context has been – 'Do sovereign countries with high government debt tend to grow slowly?'

Reinhart and Rogoff (RR), in some of their influential articles, argue that higher levels of government debt are negatively correlated with economic growth, but there is no link between debt and growth when government debt is below 90% of GDP (Reinhart and Rogoff, 2010a; Reinhart, Reinhart and Rogoff 2012). RR's findings have sparked a new literature seeking to assess whether their results were robust to allow for non-arbitrary debt brackets, control variables in a multivariate regression setup, reverse causality, and cross-country heterogeneity. After the publication of the (critique) article by Herndon, Ash, and Pollin (2014) challenging some of RR's findings, the discussion on the relationship between debt and growth in advanced economies has become more animated. Krugman (2010), citing the case of Japan, argues that the link between debt and growth could be driven by the fact that it is low economic growth that leads to high levels of government debt. This argument needs an empirical investigation.

The evolving empirical literature reveals a negative correlation between government debt and economic growth. This correlation becomes particularly strong when government debt approaches 100% of GDP (Reinhart and Rogoff 2010a; 2010b; Kumar and Woo 2010; Cecchetti *et al.* 2011). Empirical research, of late, has begun to focus on possibilities of non-linearities within the debt-growth nexus, with specific attention to high government debt levels. The empirical literature on this issue remains sparse as very few studies employ non-linear impact analysis[1] and does not provide an examination of the cause-effect relationship to reveal the government debt-economic growth nexus.

[1] Chang and Chiang (2009) and Cecchetti *et al.*, (2011) employ non-linear panel threshold approach for non-dynamic panels.

We notice three inadequacies in the empirical literature on debt–growth nexus. First, there is a need to expand the horizon of the data sample, as averaging across OECD / advanced countries alone would make such inferences difficult. Second, we do not find studies emphasising the need for establishing the presence of a causal link going from debt to growth and finding what economists call an 'instrumental variable'. Third, we do not find studies that decompose the cause–effect relationship between government debt and economic growth.

This study endeavours to fill the above research gap by providing a sound empirical investigation based on well–established theoretical considerations. We first examine the debt–growth nexus, and then employing panel vector auto regression analysis, provide solution to the question – Does high debt lead to low growth or low growth leads to high debt? This study is unique as it overcomes the issues related to data adequacy, coverage of countries, heterogeneity, endogeneity, and non–linearities. We contribute to the current strand of literature on government debt and economic growth by extending the horizon of analysis by exploring a considerably large worldwide sample covering 122 countries. We provide a thorough econometric analysis that allows non–linearity estimation. Our data–intensive approach offers stylized facts, which is well beyond selective anecdotal evidence. This paper makes a distinct contribution to the debate by offering new empirical evidence based on a sizeable dataset.

The paper is organised as follows. We present our data in section 2. We provide in section 3, a detailed econometric analysis of the government debt–economic growth relationship. Section 4 describes the vector auto regression analysis to know whether debt causes growth or vice versa. Section 5 concludes.

2. Data

Our dataset explores annual macroeconomic data on 252 countries, over the period 1960–2009. To maintain homogeneity, as it is for a large sample of countries over the course of five decades, we employ a primarily source – World Development Indicators (WDI) database 2014 of World Bank. We strengthen our data with the use of supplementary data sourced from International Monetary Fund, World Economic Outlook 2014 database, International Financial Statistics and data files, and Reinhart and Rogoff dataset on debt–to–GDP ratios.

We group our sample countries into five debt regimes: 0–30%, 31–60%, 61–90%, 91–150%, and >151% comparable to RR groupings based on the *average debt/GDP* levels (Table 1). We place each of the 252 countries in the WDI list into its relevant category of debt regime. However, each country's entry into the group is dependent on the data adequacy. Exclusion of any country of the WDI list from our sampling is solely due to data considerations (either non–availability or inadequacy of data). The list of countries covered in the analysis is provided in *annexure 1*.

Table 1: Sample description for debt regimes

Panel A: Sample frame for debt regimes

Period	DR 0–30%	DR 31–60%	DR 61–90%	DR 91 & above	DR 151 & above	Total
1960–2009	29	56	18	14	5	122
1970-2009	32	52	20	14	4	122
1980-2009	24	53	24	16	5	122
1990-2009	24	51	24	18	5	122
2000-2009	24	45	20	13	5	107

Panel B: Government Debt and GDP Growth in debt regimes

Countries	observations	Debt Regime	GDP Growth		Government Debt	
			Mean	Median	Mean	Median
8	160	0-30%	5.06%	4.83%	27.15	27.79
31	620	31-60%	3.79%	3.68%	58.29	45.00
20	400	61-90%	2.71%	2.70%	80.08	82.87
13	260	91-150%	1.86%	1.88%	115.50	116.51
4	80	>151%	-1.08%	-1.32%	176.75	160.99
Total=76	1520					

Subsampling

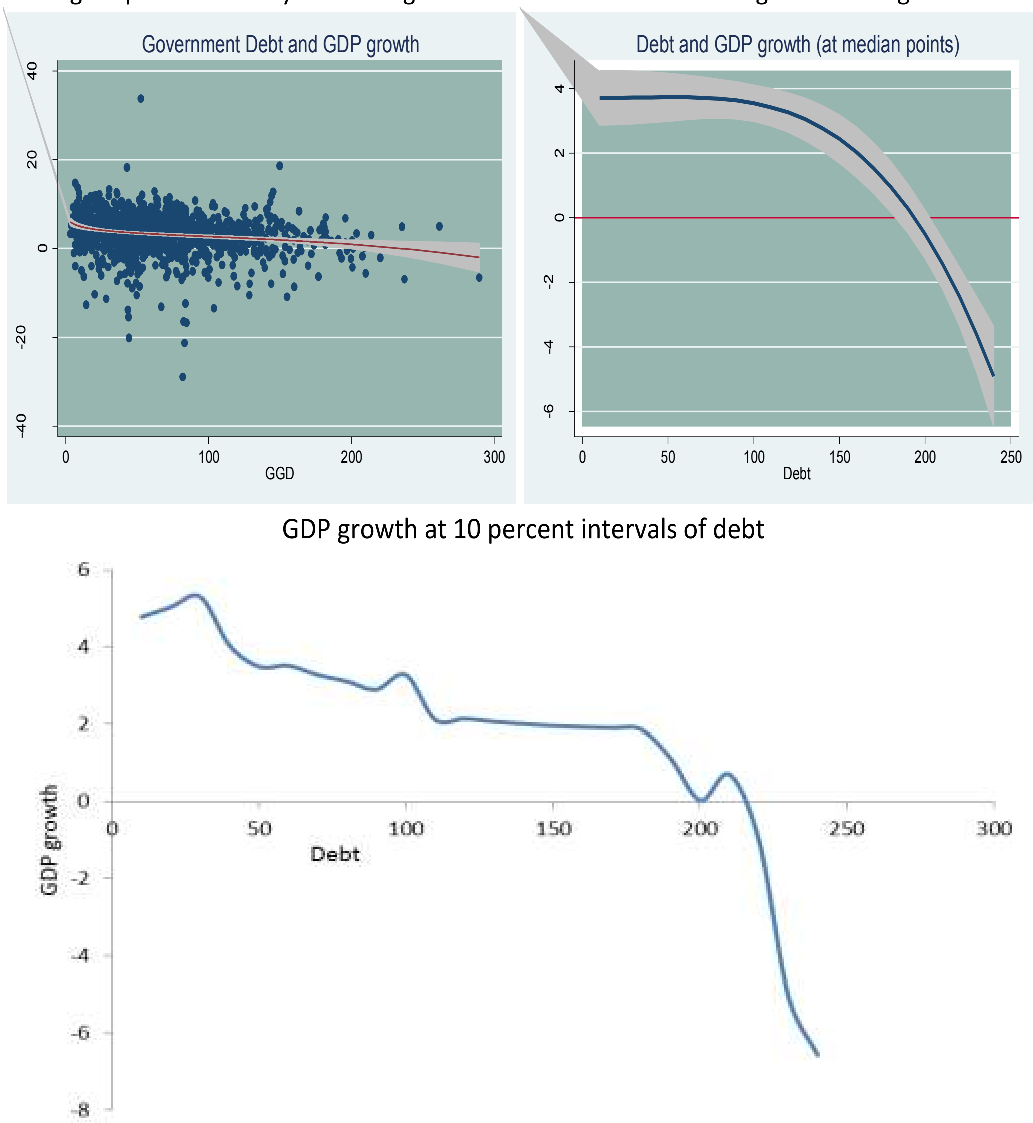
We explore the dimension of historical specificity by examining real GDP growth by government debt category for subsampled periods of the data: 1960-2009, 1970-2009, 1980-2009, 1990-2009, and 2000-2009. We do not extend our dataset beyond 2009, in view of the sudden and significant rise in government debt levels consequent to the government interventions in response to global financial crisis[2].

[2] In industrial countries, government debt has risen significantly. In 2009, the net sovereign borrowing needs of the United Kingdom and the United States were five times larger than the average of the preceding five years (2002–07). The huge stimulus and bailout package adopted by the US government to deal with the crisis delivered by irresponsible financial agents in 2009 took the net government debt to GDP ratio in the U.S. from 42.6 in 2007 to 72.4 percent in 2011. In advanced economies as a whole, government debt to GDP ratios are expected to reach 110 percent by 2015—an increase of almost 40 percentage points over pre-crisis levels (IMF 2010). Many middle-income countries also witnessed a deterioration of their debt positions, although the trends are not as dramatic as those of advanced economies are. In low-income countries, in 2009–10 the present value of the government debt to GDP ratio has deteriorated by 5–7 percentage points compared with pre-crisis projections (IDA and IMF 2010).

The descriptive statistics of the sample presented in Table 1 suggest that countries in lower debt regime (0-30) have higher growth and the countries in highest debt regime (151 and above) have lowest growth. We present in Figure 1, the interplay of government debt and growth. The first section of the figure illustrates the interaction of government debt with GDP growth in the sample for the period 1960-2009. We notice a declining growth as debt levels rise. The second section of the figure captures the interaction of debt and growth at the median points of debt. As debt surpasses the level of about 110 percent of GDP, the growth begins to decline swiftly and turns negative at the level of 210 percent of GDP. In the third section of the figure, we present the interaction of growth at ten–percent intervals of debt. Growth turns negative as debt moves beyond 210 percent of GDP.

Figure 1: Government Debt and GDP growth

This figure presents the dynamics of government debt and economic growth during 1960-2009



We present the movement of GDP growth and debt in the panel data sample for the period 1960-2009 in Figure 2. The corresponding growth with the debt in the sample period indicates a negative correlation suggesting that as government debt rises, growth tends to decline.

Figure 2: Movement of GDP growth and debt
in the panel data sample during 1960-2009

This figure illustrates the growth of government debt and corresponding GDP growth indicating the correlation that as debt increases GDP growth slides down over a period.

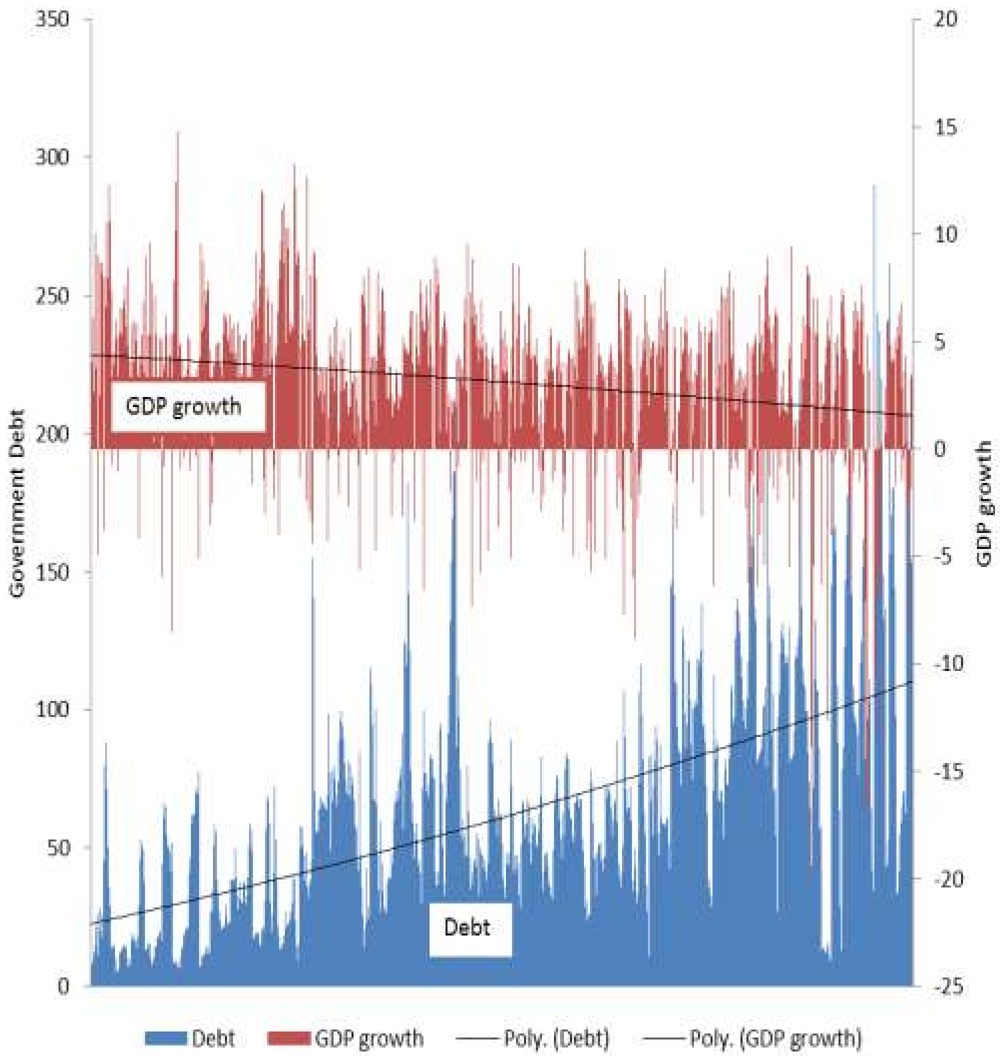
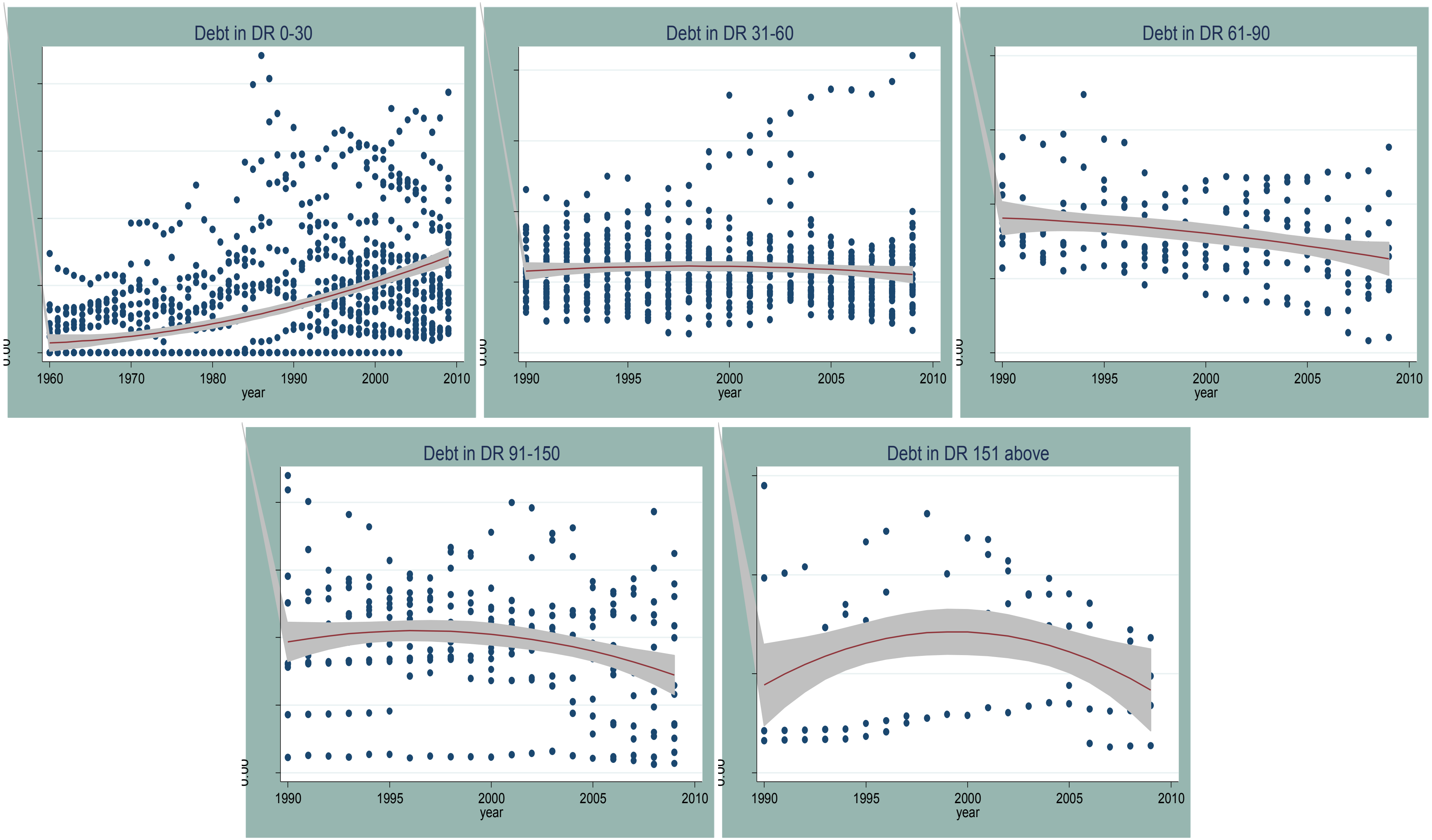


Figure 3 illustrates the trend of government debt in debt regimes (0-30; 31-60; 61-90; 91-150; 151 and above). We notice a rising trend of debt with a median of 27.79 percent of GDP in DR 0-30. DR 31-60 exhibits a flat trend with a median debt at 45. A decreasing trend is noticed in DR 61-90 with the median level at 82.87. DR 91-150 has a declining trend with a median of 116.51. DR 151 & above displays the trend like an inverted crescent shape with a median debt of 161.

Figure 3: Government Debt in debt regimes

This figure illustrates the trend of government debt in debt regimes (0-30; 31-60; 61-90; 91-150; 151 and above).



Variables

We provide in Table 2 the description of variables and data sources.

Table 2: Description of variables and data sources

Variable	Description
adr Age dependency ratio (% of working–age population)	Age dependency ratio is the ratio of dependents--people younger than 15 or older than 64--to the working-age population--those ages 15-64. Data are shown as the proportion of dependents per 100 working-age population. Source: World Development Indicators (WDI)
fce Final consumption expenditure (% of GDP)	Final consumption expenditure is the sum of household final consumption expenditure (private consumption) and general government final consumption expenditure (general government consumption). Source: WDI
fdi Foreign direct investment, net inflows (% of GDP)	Foreign direct investments are the net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. Source: WDI
gdpgr *(GDPgrowth)* Real GDP growth (annual %)	Annual percentage growth rate of GDP at market prices based on constant local currency. Source: WDI
gfc General government final consumption expenditure (annual % growth)	Annual percentage growth of general government final consumption expenditure based on constant local currency. Source: WDI
gfcf Gross fixed capital formation (annual % growth)	Average annual growth of gross fixed capital formation based on constant local currency. Source: WDI
ggd *(debt)* General government gross debt	Gross debt consists of all liabilities that require payment or payments of interest and/or principal by the debtor to the creditor at a date or dates in the future. This includes debt liabilities in the form of SDRs, currency and deposits, debt securities, loans, insurance, pensions and standardized guarantee schemes, and other accounts payable. Source: World Economic Outlook (WEO) April 2012; Reinhart and Rogoff (RR) data set
infl Inflation (annual %)	Inflation as measured by the annual growth rate of the GDP implicit deflator shows the rate of price change in the economy as a whole. Source: WDI
pg Population growth (annual %)	Annual population growth rate for year t is the exponential rate of growth of midyear population from year t-1 to t, expressed as a percentage. Source: WDI
rir Real interest rate (%)	Real interest rate is the lending interest rate adjusted for inflation as measured by the GDP deflator. Source: WDI
tgdp *(openness)* Trade (% of GDP)	Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product. Source: WDI
ulf Unemployed labour force	Unemployment, total (% of total labor force) (national estimate). Unemployment refers to the share of the labor force that is without work but available for and seeking employment. Definitions of labor force and unemployment differ by country. Source: WDI

3. The debt – growth relationship

In economic theory, at moderate levels of government debt, following a typical Keynesian behaviour, fiscal policy may induce growth. The classical economic view argues that government debt (manifesting deficit financing) can induce growth by stimulating aggregate demand and output in the short run. Moderate levels of debt are found to have a positive impact on economic growth through a range of channels: improved monetary policy, strengthened institutions, enhanced private savings, and deepened financial intermediation (Abbas and Christensen, 2007). Government debt could be used to smoothen distortionary taxation over time (Barro, 1979). Barro's model predicts that debt responds to the temporary deviation in income or government expenditure and hence, in the absence of aggregate uncertainty, debt would be constant and equal to its 'initial' level. Expansionary fiscal policies that lead to debt accumulation are argued to have a positive effect on both short and long–term growth (DeLong and Summers, 2012). In a theoretical model integrating the government budget constraint and debt financing, Adam and Bevan (2005) find increase in growth during low debt levels as they observe interaction effects between deficits and debt stocks, with high debt stocks exacerbating the adverse consequence of high deficits.

Historically, the theoretical literature argues that growth models amplified with governments issuing debt to fund consumption or capital goods tend to exhibit a negative relationship between government debt and economic growth. Modigliani (1961) argues that government debt is a burden for the posterity that results in waning flow of income from a reduced stock of private capital. It is argued that government debt crowds out capital and leads to slowdown of output in the long–run (Elmendorf and Mankiw, 1999).

Both the neoclassical and endogenous growth models inform the negative effect of government debt on long–run growth. Government debt could have a substantial adverse effect on economic outcomes if it affects the productivity of public expenditures (Teles and Cesar Mussolini, 2014). Analyzing the impact of fiscal policy, proxied inter alia by the level of government debt, in endogenous growth models, Aizenman *et al.,* (2007) find a negative relationship. While standard growth theory advocates that an increase in government debt (due to a fiscal deficit) leads to slower growth, the neoclassical growth theory suggests a temporary decline in growth along with the transition path to a new steady state. However, the endogenous growth theory suggests a permanent decline in growth as the debt increases (Saint–Paul, 1992).

Several studies report a negative non–linear correlation between government debt and economic growth in advanced and emerging market economies (Reinhart and Rogoff, 2010; Reinhart *et al.,* 2012; Kumar and Woo, 2010; Cecchetti *et al.,* 2011; Checherita–Westphal and Rother, 2012). There is growing evidence that government debt is negatively correlated with economic growth, and very few studies make a strong case for a causal relationship going from debt to growth. Lof and Malinen (2014) using data on 20 developed countries, estimate panel vector auto regressions to analyze the relationship between government debt and economic growth and find no evidence for a robust effect of debt on growth, even for higher levels of debt. However, they observe significant negative correlation due to reverse effect of growth on debt. This study intends to provide a thorough analysis based on a larger data set and further refining with the analyses of debt–growth nexus in debt regimes.

3.1 Estimation Strategy

We embark on a multi–step approach to explore our secular dataset covering the period from 1960 to 2009 and thoroughly investigate the nexus between government debt and growth. We employ both the descriptive statistics approach (as relied by Reinhart and Rogoff (2010) in their influential paper) and econometric approach to illustrate the government debt and economic growth nexus.

Testing the bivariate relationship

In our econometric approach to address the topic, we begin by probing the bivariate linear relationship between debt and growth with the following specification:

$$GDPgrowth_t^j = \alpha + \beta\, debt_t^j + \varepsilon_t \text{ -------- Eqn (2)}$$

Where $GDPgrowth_t^j$ is the annual GDP growth and $debt_t^j$ is the outstanding gross government debt to GDP ratio for country '*j*' in year't'. We estimate the Eqn (2) with a pooled panel and with country fixed effects.

Testing the linear relationship

We probe the linear relationship with an empirical specification based on the empirical growth literature (e.g. Barro and Sala–i–Martin, 2004). We introduce other significant macroeconomic variables in order to account their simultaneity of impact. We are motivated by Islam (1995), in estimating our panel data growth regressions with country specific fixed effects and time–specific fixed effects, which allows us to estimate the impact of a change in any one factor on growth *within* a country in the data panel.

$$GDPgrowth_t^j = \alpha + \beta\, GDP_{t-1}^j + \gamma\, debt_t^j + \varphi(\mathrm{gfcf}_t^j, \mathrm{fce}_t^j, tgdp_t^j, fce_t^j, fdi_t^j) + \mu_j + \nu_t + \varepsilon_{jt}$$

--- Eqn (3)

Where μ_j is country fixed effects; v_t is time fixed effects; ε_{jt} is the error term.

The augmented Solow growth regression model

We extend our econometric specification using a Solow growth model. Following this model, our specification assumes that the structural growth for country '*j*' conforms to a linear relationship over a period't' and is common across the panel of countries.

$$GDPgrowth_t^j = \hat{\beta} X_t^j + \mu_j + \nu_t + \varepsilon_{jt}$$

$$GDPgrowth_t^j = \hat{\beta}_S S_j + \gamma\, debt_t^j + \mu_j + \nu_t + \varepsilon_{jt} \text{ ------- Eqn (4)}$$

Where S_j is a vector of Solow regressors including *gfcf, gfc, tgdp, fce, fdi, infl*, *lagged GDP, pg,* and *adr*. It also includes the constant. μ_j is country–specific fixed effects; ν_t is time–fixed effects; ε_{jt} is the unobservable error term. Given the strong potential for endogeneity of the debt variable, we use instrumental variable (IV) estimation technique. In our instrumental variables model, we use Solow instruments in their lagged variables. As Easterly and Rebelo (1993) observe, one of the most likely sources of simultaneity is business cycle effects and hence the tendency of government expenditure is positively correlated with the level of GDP per capita. Many studies on growth regressions exploring panel data have made use of IV approach to deal with the issue of simultaneity bias Hiebert *et al.,* (2002). With the use of GMM estimator, we seek to correct for the possible heteroskedasticity and autocorrelation in the error structure by using the consistent estimator. The two–step GMM provides some efficiency gains over the traditional IV/2–SLS estimator derived from the use of the optimal weighting matrix (Baum *et al.,* 2013).

Testing for nonlinearity

In the debt–growth dynamics literature, the nonlinearity of the impact of debt on economic growth has been examined in different specifications. Reinhart and Rogoff (2010) use the correlations between debt and growth. On the other hand, Kumar and Woo (2012) and Egert (2015) study the relationship using the growth framework. While many empirical papers identify non–linearities in the relationship between debt and growth, very few studies make a clear theoretical argument for the presence of such non–linearities (Greiner, 2013).

We investigate the nonlinearity of the debt–growth relationship (in view of the negative correlations at higher levels of debt with growth) by considering a specification that accounts for the polynomial trend of the debt variable. To introduce the smooth transition around a turning point in debt level, we transform the Eqn (4) to formulate the following specification by introducing a square term of the debt to GDP ratio as an additional regressor:

$$GDPgrowth_t^j = \hat{\beta}_s S_j + \gamma\, debt_t^j + \hat{\gamma}\, debt_t^{2j} + \mu_j + \nu_t + \varepsilon_{jt} \text{ ------- Eqn (5)}$$

Robustness checks

In order to ensure that the outliers do not influence the results, we identify the outliers by drawing the scatterplot of the partial correlation between debt and growth obtained with the IV regression and estimate the models by dropping them. We also employ robust least squares (RLS) regression method designed to be less sensitive to outliers. We use M–estimation method of RLS. Using the Huber–White sandwich correction, serially correlated residuals are dealt with in the context of the presence of within–country time dependence and heteroscedacity of unknown form. An alternative approach of using the Newey and West estimator (allow modeling the autocorrelation process in the error term) is also employed. The method of PCSEs (suggested by Beck and Katz) is very robust when there is little or no correlation between unit effects and explanatory variables. It is argued that its performance declines as the correlation strengthens. We use the fixed effects estimator with robust standard errors that appears to do better in these situations (Kristensen and Wawro, 2003). In addition, we test for the causality running from debt to growth employing Pairwise Demitrescu–Hurlin Panel Causality Tests. The results shown in Table 3 are significant and indicate causality running in both directions i.e. from debt to growth and growth to debt.

Table 3: Results of Pairwise Demitrescu–Hurlin Panel Causality Tests

Specification	Null Hypothesis:	W–Stat.	Zbar Stat.	Prob.
1	GDP growth does not homogeneously cause debt	4.6265	6.0140	2.00E-09
	Debt does not homogeneously cause GDP growth	3.5252	3.0872	0.002

We provide in Figure 4, a graphical analysis of the correlation between debt and growth in the debt regimes discretely. In the debt regimes: 0-30%, 31-60% and 61-90% debt/GDP levels, the GDP growth hovers in the positive level and tends to glide into the negative zone in the debt regime 91-150%. In the debt regime >151% debt/GDP level, the GDP growth runs in the negative zone demonstrating the negative relationship with debt level.

Figure 4: Government Debt and Growth in Debt Regimes

This figure presents the dynamics of government debt and economic growth in debt regimes: 0-30; 31-60; 61-90; 91-150; 151 % above for the period from 1960-2009.

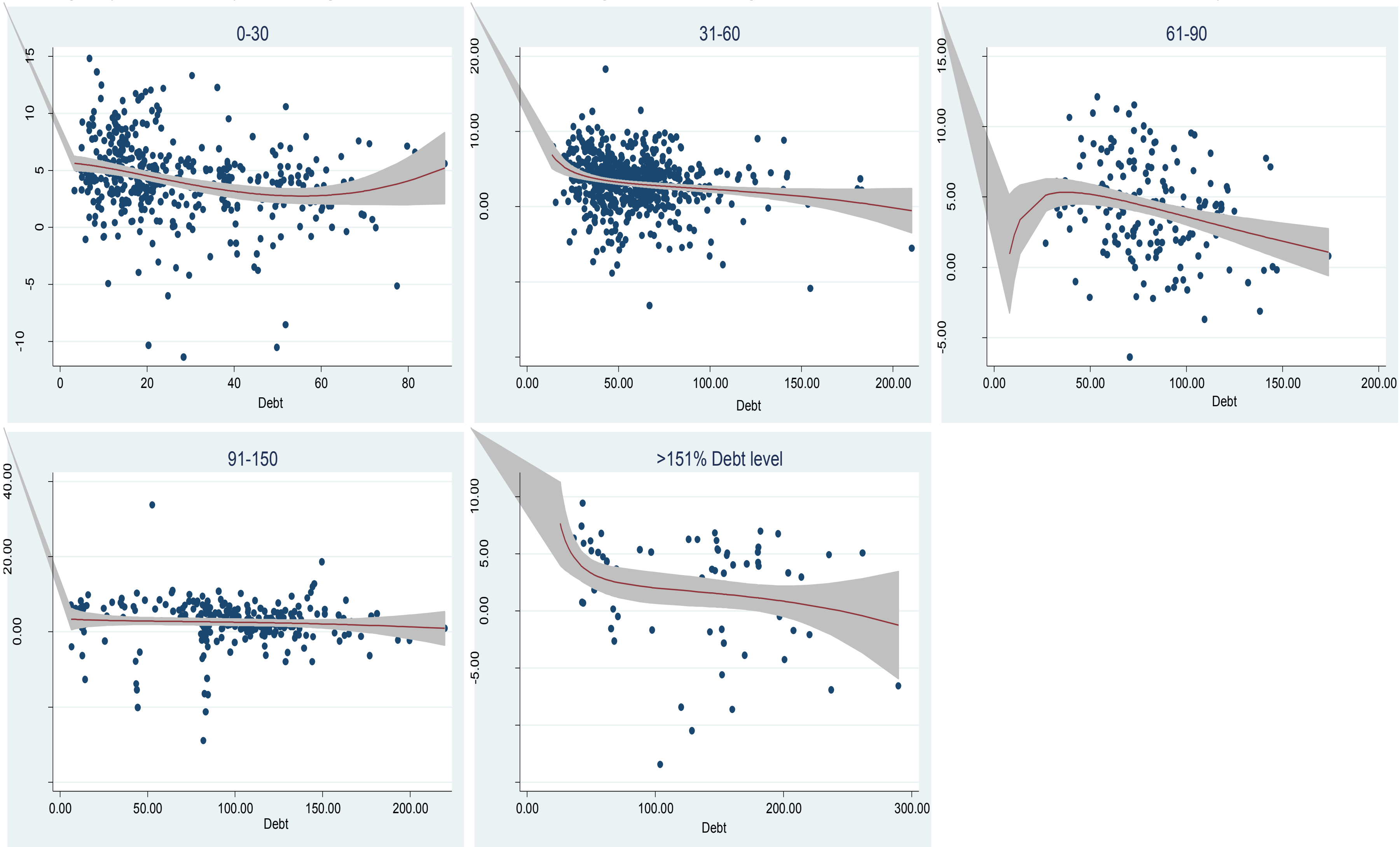


Table 4: Debt and Growth – Regression Results

This table presents the results of the regressions for understanding the effect of debt on the long–term growth of countries. Our dependent variable is the GDP growth. Columns (1), (2) and (5) present the results of the Panel Least Squares (PLS). Columns (3) and (6) present the results of the Panel Generalized Method of Moments (PGMM) (Cross–section weights (PCSE) standard errors & covariance). Columns (4), (5) and (7) present the results of Robust Least Squares. We report the coefficient values marked with significance levels in the first row followed by the standard errors (in the parenthesis) in the second row. Asterisks ***, ** indicate levels of significance at 1%, and 5% respectively.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Eqn. (2)	Eqn. (3) PLS	Eqn. (3) PGMM	Eqn. (4) RLS	Eqn. (5) PLS	Eqn. (5) PGMM	Eqn. (5) RLS
Explanatory Variables	Mean (Std. Dev.)	Linear models				Non–linear models		
General government gross debt (Debt)	56.116 (56.46)	-0.014*** (0.002)	-0.003* (0.002)	-0.003* (0.002)	-0.002*** (0.001)	-0.013*** (0.004)	-0.023*** (0.005)	-0.0079*** (0.0025)
Debt Sq.	3912 (31139)					0.0000178 (0.0000166)	0.0000466** (0.0000210)	1.24E-05** (1.06E-05)
GDPGR(-1)	3.8542 (5.49)		0.218*** (0.018)	0.218*** (0.029)	0.261*** (0.011)	0.306*** (0.018)	0.189*** (0.028)	0.249*** (0.011)
Gross fixed capital formation	5.8572 (42.10)		0.015*** (0.002)	0.015*** (0.004)	0.181*** (0.001)	0.014*** (0.002)	0.015*** (0.004)	0.181*** (0.0009)
Government expenditure	4.6668 (18.54)		0.013*** (0.003)	0.013** (0.005)	0.015*** (0.002)	0.040*** (0.006)	0.033*** (0.008)	0.017*** (0.003)
Trade Openness	72.892 (51.74)		0.001 (0.005)	0.001 (0.005)	0.005*** (0.001)	0.002 (0.002)	0.004 (0.005)	0.005 (0.001)
Final consumption expenditure	81.241 (13.71)		-0.069*** (0.014)	-0.069*** (0.016)	-0.012*** (0.004)	-0.019*** (0.006)	-0.063*** (0.016)	-0.011*** (0.004)
Foreign direct investment	2.7357 (4.62)		0.061*** (0.020)	0.059*** (0.022)	-0.003 (0.011)	0.063*** (0.018)	0.053** (0.021)	-0.0019** (0.0114)
Population growth	1.6975 (1.22)				0.198*** (0.042)	0.292*** (0.067)	0.126 (0.218)	0.223 (0.042)
Inflation	45.131 (552.47)				-0.0001* (0.0001)	-0.0003*** (0.0001)	-0.0003** 0.0001	-0.00075** (7.41E-05)
Intercept		4.682*** (0.109)	8.128*** (1.254)	8.140*** (1.389)	2.259*** (0.341)	3.732*** (0.544)	8.197*** (1.526)	2.468*** (0.346)
R-squared		0.179	0.293	0.292	0.350	0.219	0.308	0.35545
Obs		3607	2643	2640	2640	2621	2621	2621

We discuss the results of the econometric analysis of the debt–growth relationship encompassing the econometric specifications for (a) testing the bivariate relationship as modelled in Eqn. (2); (b) testing the linear relationship as modelled in Eqn. (3); (c) testing the augmented Solow growth model in Eqn. (4); and (d) testing for nonlinearity as modelled in Eqn. (5). Table 4 presents the results of the analyses. As observed in other studies as well, simple bivariate panel regression reveals a negative relation between growth and government debt. Though the coefficient is always negative, its size is mostly not substantial in economic terms. The point estimates of the range of econometric specifications suggest that a 10–percentage point increase in the debt–to–GDP ratio is associated with 2 to 23 basis points reduction of average growth.

Our results are comparable to the estimates of Kumar and Woo (2010) and Égert Balázs (2015) for advanced and emerging economies over almost four decades[3]. Studying a sample of 17 OECD countries, Panizza and Presbitero (2014) observe that a 10–percentage point increase in the debt–to–GDP ratio is associated with an 18 basis point decline in average growth.

4. Decomposing the Cause and Effect Relationship

In this section, we decompose the cause and effect relationship between debt and growth and try to find answer to the question – *Does high debt lead to low growth or low growth leads to high debt?*. Our approach here is to study the macroeconomic analyses of debt–growth relationship by considering the interdependencies existing across sectors, markets and countries, and national economic issues that are required to be confronted from a global perspective. That is different channels of transmission need to be considered. A useful approach to dealing with interdependent economies is to construct panel vector auto regressions (PVARs[4]) models.

[3] Kumar and Woo (2010) report that on average, a 10 percentage point increase in the initial debt-to-GDP ratio is associated with a slowdown in annual real per capita GDP growth of around 0.2 percentage points per year. Égert Balázs (2015) 10 percentage increase in the government debt ratio is associated with 0.1 to 0.2 percentage point lower economic growth.

[4] These PVARs seek to capture the dynamic interdependencies using a minimal set of restrictions. Shock identification then transform these reduced form models into structural ones allowing for typical exercises such as impulse response analyses or policy counterfactuals. PVARs are mostly suited to capture both static and dynamic interdependencies while treating the links across units in an unrestricted fashion. They easily incorporate time variations in the coefficients and account for cross sectional dynamic heterogeneities. They are a powerful tool to address interesting policy questions related e.g. to the transmission of shocks across borders.

The model

Our PVAR has almost the same structure as VAR models in the sense that all variables are assumed to be endogenous and interdependent, but we add a cross sectional dimension to the expression. Let us consider that Y_t is the stacked version of y_{it} being the vector of G variables where for each country of $i = 1,.....N, i.e., Y_t = (y'_{1t}, y'_{2t},......y'_{Nt})'$. Accordingly, our PVAR specification is

$$y_{it} = A_{0i}(t) + A_i(l)Y_{t-1} + u_{it} \quad i = 1,....,N \quad t = 1,.....,T \quad \text{------ Eqn (1)}$$

The subscripts *i* and *t* denote country and year, respectively. u_{it} is a $G \times 1$ vector of random disturbances and as the notation suggests, $A_{0i}(t)$ and A_i depend on the country. $A_{0i}(t)$ is a country specific fixed effect intercept term. Thus, Eqn (1) includes constants, seasonal dummies and deterministic polynomial in time. The coefficient matrix A_i and the covariance matrix of the residuals are assumed as homogeneous. With this assumption, we estimate the pooled estimates of A_i that can be used to compute the impulse-response (IR) functions. The confidence intervals of IR functions are estimated with bootstrap simulations. We impose a recursive structure to identify the shocks that makes the order of the variables pertinent. We also consider the PVAR in reverse recursive order as a robustness check to find out whether the imposed order has substantial effect on the results.

In order to test the robustness of the model, *Autocorrelation LM Test* is performed which reports the multivariate LM test statistics for residual serial correlation up to the specified order. We perform *White Heteroskedasticity Test* wherein the test regression is run by regressing each cross product of the residuals on the cross products of the regressors and testing the joint significance of the regression. The test is with both options of “no cross terms” and “with cross terms”.

To analyse the dynamic association between debt and GDP growth, we compute the impulse–response functions from the estimated PVAR. We estimate the PVAR using the fixed–effects (FE) estimator. Baltagi, (2008) suggests first differencing the panel models to eliminate the fixed effect to the inconsistencies. Since our sample size is adequately large, we go ahead with FE estimator. However, as a robustness check, we find the GMM estimates of the first–differenced model with similar results.

We use the same data sets as detailed in Section 2 and consider all the five debt regimes (0-30%, 31-60%, 61-90%, 91-150%, and >151%) as well as the full sample (including all debt regimes) for PVAR analysis.

Table 5: Sample description for debt regimes for PVAR analysis

Period	DR 0-30%	DR 31-60%	DR 61-90%	DR 91 & above	DR 151 & above	Total
1960-2009	29	56	18	14	5	122

Results

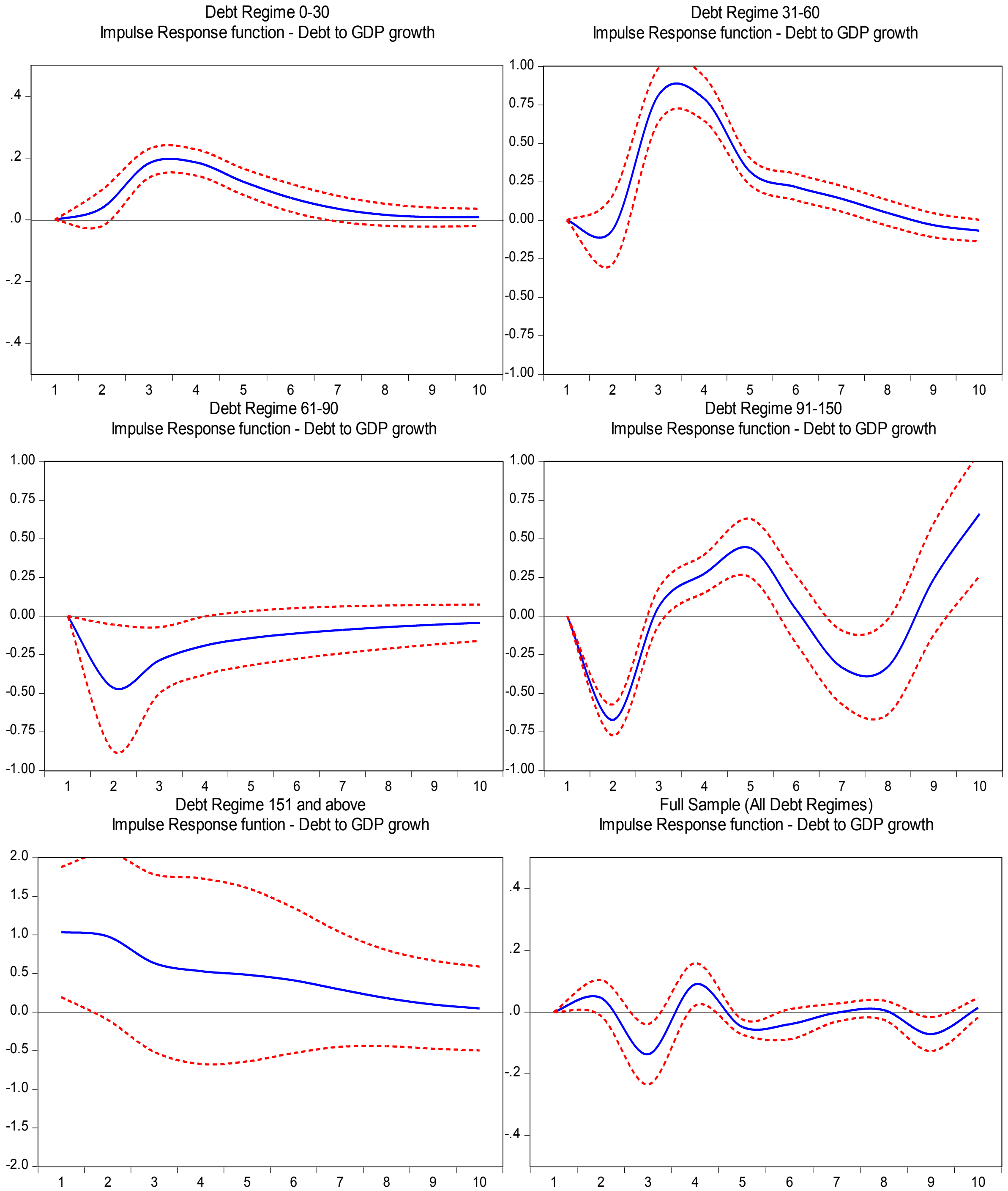
We present the impulse–response functions derived from the estimated PVAR in Figure 5. The figure shows the effect of debt on GDP growth for a period of ten years after a positive shock. In the debt regime 0–30, the impulse response function of GDP growth to one standard deviation shock to debt reaches the peak level of 1.17% in the fourth year and gradually recedes. When we extend the period to 30 years, we notice the response touching almost zero level (0.04% in the 11th year to 0.0006% in the 30th year).

In the case of debt regime 31–60, the impulse response function of GDP growth to one standard deviation shock to debt reaches the peak of 0.86% in the third year and gradually decreases to 0.03% in the tenth year. When the period is extended to 30 years, the response continues to be in the range of 0.03% to 0.07% but never merges into zero.

Debt regime 61–90 has an interesting behaviour. The impulse response of GDP growth to one standard deviation shock to debt moves from negative zone to positive zone (-0.5% in the second year, -0.04% in the tenth year, 0.002% in the 16th year and 0.03% in the 30th year). In the debt regime 91–150, the impulse response of GDP growth moves in the range of -0.32% in 2nd year to 0.13% in the 10th year. When the period is extended to 30 years, the impulse response of GDP growth reaches 0.02% in the 30th year.

Figure 5: Impulse Response Function of GDP growth to Debt Innovation

This figure illustrates the Impulse–response functions of GDP growth to Cholesky[5] One standard deviation Debt innovation computed from estimated PVAR (Eqn. 1) in all the five debt regimes (0-30; 31-60; 61-90; 91-150; and 151 and above) and for the full sample covering all debt regimes. The dashed lines enclose intervals of plus or minus two standard errors.

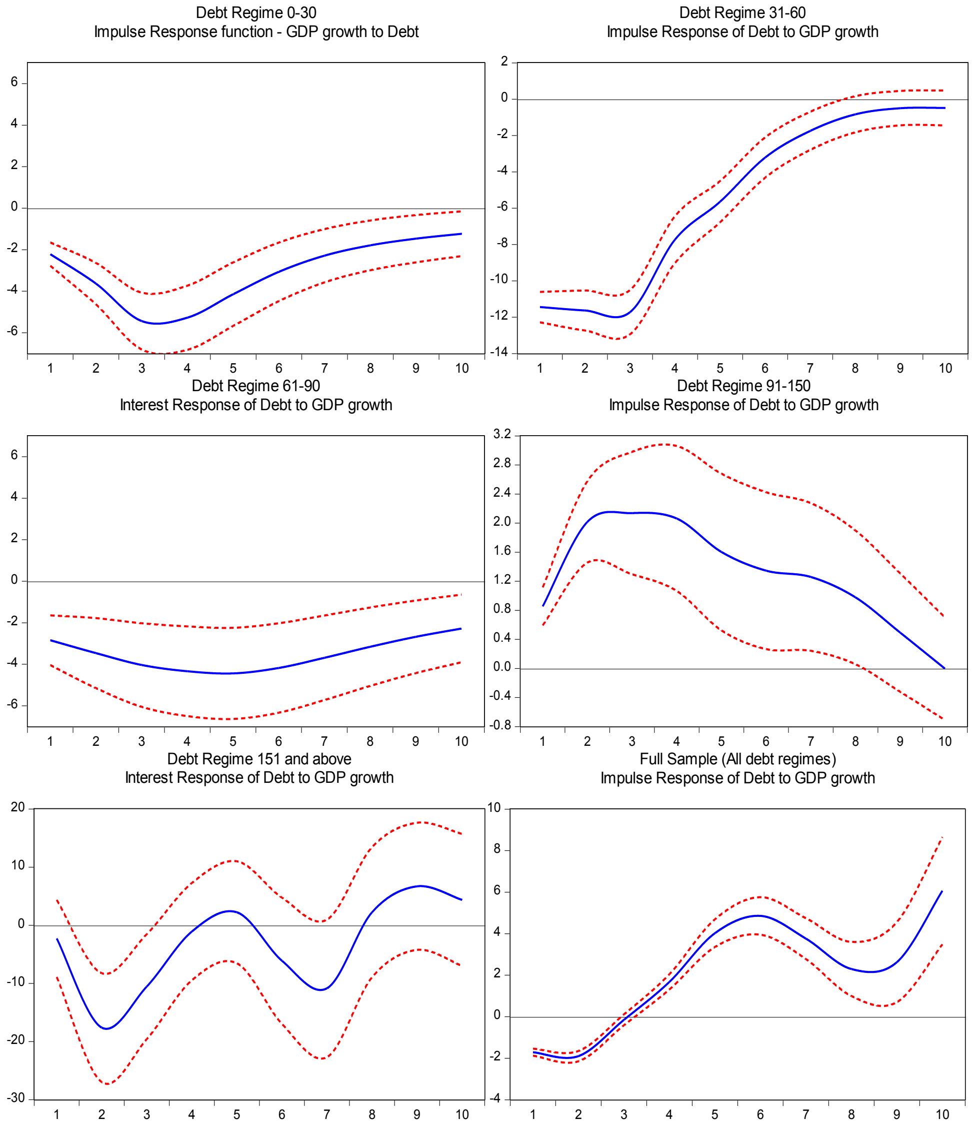


[5] It uses the inverse of the Cholesky factor of the residual covariance matrix to orthogonalize the impulses. This option imposes an ordering of the variables in the VAR and attributes all of the effect of any common component to the variable that comes first in the VAR system.

Debt regime 151 and above experiences a distinct behaviour. The impulse response of GDP growth moves in the range of 1.03% in the first year to 0.04% in the tenth year. In the extended period (upto 30 years), the impulse response of GDP growth reaches almost zero (0.000038%). We also analyse the impulse response of GDP growth in the full sample (including all the debt regimes). The impulse response of GDP growth moves in the range of 1.26% in the second year to -0.87% in the 10th year. The above results suggest that the impulse response function for the effect of debt on GDP growth is dependent on the debt regimes and there is no uniformity of effect across the debt regimes. We notice a long–term effect of debt on growth.

Figure 6: Impulse Response Function of Debt to GDP growth

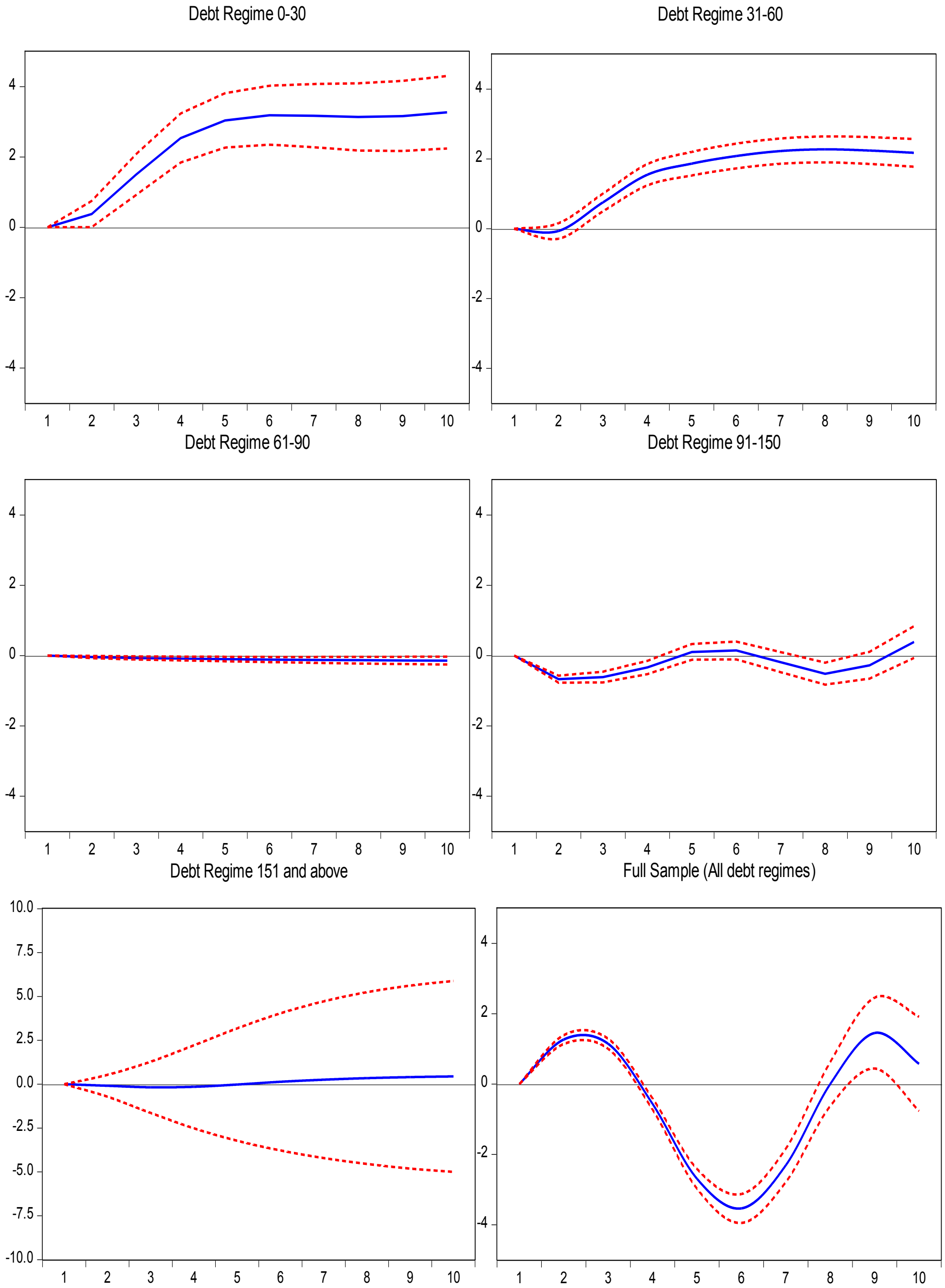
This figure illustrates the Impulse–response functions of Debt to Cholesky One standard deviation Growth innovation computed from estimated PVAR (Eqn. 1) in all the five debt regimes (0-30; 31-60; 61-90; 91-150; and 151 and above) and for the full sample covering all debt regimes. The dashed lines enclose intervals of plus or minus two standard errors.



From the Figures 5 and 6, it appears that the negative relationship between debt and GDP growth is the consequence of the negative effect of GDP growth on debt, rather than the negative effect of debt on GDP growth. Thus, there is evidence of GDP growth having a significant negative effect on debt.

Figure 7: Accumulated Response of GDP growth to Debt Innovation

This figure illustrates the accumulated Impulse-response functions of GDP growth to Cholesky One standard deviation Debt innovation computed from estimated PVAR (Eqn. 1) in all the five debt regimes (0-30; 31-60; 61-90; 91-150; and 151 and above) and for the full sample covering all debt regimes. The dashed lines enclose intervals of plus or minus two standard errors.



We now present the results based on the accumulated responses. Figure 7 provides the cumulative impulse response functions estimated from PVAR for all the debt regimes and full sample. By accumulating the impact over time, these plots indicate the accumulated impulse–response functions of GDP growth to Cholesky one standard deviation Debt innovation. The results are interesting. For the debt regime 0–30, we find that a shock to debt has significant positive effect on GDP growth. The accumulated response of GDP growth for the impulse from debt appears to be positive in the long–run as we notice an increasing cumulative response for one standard deviation shock to debt (1.81% in the 4th year, 3% in the 7th year and 3.19% in the 10th year). We verify the relationship for a 30–year period as well, and notice the response as high as 3.81%. Variance decomposition of GDP growth for the 10–year period in the debt regime 0-30 shows that upto 10% of variation in GDP growth could be dependent on variation in debt.

We find that a shock to debt has significant positive effect on GDP growth in the debt regime 31-60 as well. The cumulative response of GDP growth (for one standard deviation shock to debt) rises from 0.75 % in the 3rd year to a high of 2.17 % in the 10th year. When we extend the period upto 30 years, the response continues to be upward (2.31% in the 30th year). The results suggest that countries in the debt regime 31–60 experience a phenomenon wherein debt has a long run positive effect on GDP growth. Variance decomposition of GDP growth for the 10–year period in the debt regime 31-60 shows that upto 4.39% of variation in GDP growth could be explained by variation in debt. We notice an interesting behaviour of GDP growth towards debt shock in the case of debt regime 61–90. The cumulative response of GDP growth, for one standard deviation debt innovation at 34.40, hovers around a petite negative range of -0.04% to -0.14 % in a period of ten years. When we extend the period to 30 years, the cumulative response hovers around the same tiny range of -0.04% -0.15%. These results suggest that countries in this debt regime 61–90 fail to generate significant growth response for debt shocks. Variance decomposition of GDP growth for the 10–year period in the debt regime 61–90 suggests that upto 2.16% of variation in GDP growth could be due to variation in debt. Debt regime 91–150 displays an interesting behaviour of GDP growth to debt shock. The accumulated response of GDP growth to debt shock continues to be negative upto the initial three years and traverses slightly into positive zone during the 4th and 5th years and again moves back into negative zone from sixth to eighth year. When we extend the analysis for a longer period (upto 30 years), we notice the response of GDP growth (for one standard deviation shock to debt) to be swinging in the range of -1.6% to

1.62%. The results show that GDP growth has no straightforward association with debt during this debt regime. It is affected largely by other determining macroeconomic factors such as inflation, trade openness, gross capital formation, and foreign direct investment. Variance decomposition of GDP growth for the 10–year period in the debt regime 91–150 suggests that upto 29.41% of variation in GDP growth could be due to variation in debt.

In the case of debt regime 151 and above, the cumulative response of GDP growth remains negative for the first four years and then turns gradually into a small positive territory. During the 10 year period of analysis, we notice the cumulative response of GDP growth (for one standard deviation shock to debt) to hover in the range of -0.17% to 0.49%. When we extend to period to 30 years, the GDP growth response to reaches a high of 0.52%. Variance decomposition of GDP growth for the 10–year period in the debt regime 91-150 suggests that upto 19.82% of variation in GDP growth could be due to variation in debt. The accumulated response of GDP growth to debt shock swings in the range of -3.53% in the 6th year to 1.45% in the 9th year for the full sample including all debt regimes. Variance decomposition of GDP growth for the 10–year period for the full sample suggests that upto 40.04% of variation in GDP growth could be due to variation in debt.

This analysis has thus provided useful insights about debt dynamics in debt regime groupings: 0-30%, 31-60%, 61-90%, 91-150%, and >151% comparable to Reinhart & Rogoff groupings based on *average debt/GDP* levels. The mean GDP growth rates are DR 0-30: 5.06%; DR 31-60: 3.79%; DR 31-60: 2.71%; DR 91-150: 1.86%; and DR 151 and above -1.08%. Countries in DR 0-30 experience a rising trend of debt. It suggests that in these countries with debt (mean 27.15, median 27.79) has a positive effect on economic growth. Countries in DR 31-60 experience a flat trend of debt (mean 58.29, median 45), suggesting that, countries reach their optimum gains for boosting their economic growth at this level of debt. Countries in DR 61-90 with debt (mean 80.08, median 82.87) on the other hand experience a gentle declining trend. It shows that countries tend to experience no incremental gains from debt and perhaps approaching their debt thresholds. Countries in DR 91-150 with debt (mean 115.50, median 116.51) show a downward trend suggesting that most of them might have hit their debt thresholds. Finally, countries in DR 151 & above with debt (mean 176.75, median 160.99), experience a sweeping downward growth indicating the negative effects of excess debt.

Our results derived from PVAR estimations clearly show the evidence of effect of debt on economic growth. Therefore, our results do not concur with the conclusion of Lof and Malinen (2014) that there is no evidence of for a robust effect of debt on growth, even for higher levels of debt in their analysis of 20 developed countries. Our results also indicate that the effect is not uniform for all countries, but mostly depends on the debt regimes and other important macroeconomic variables such as inflation, trade openness, general government final consumption expenditure and foreign direct investment.

5. Conclusion

This study has presented a thorough data–rich analysis of the dynamics of government debt and economic growth for a longer period 1960–2009, as it spans across different debt regimes and involves a worldwide sample of countries that is more representative. The sources on which the study draws are more authentic and well accepted. We do not claim that the results are infallible, but do state that they are based on widely accepted econometric tools and techniques besides based on sound economic logic. One of the contributions of this study is that it is the first of its kind in providing a meticulous analysis of debt–growth nexus supported with a VAR analysis. The study provides an original analysis of the debt and growth beyond the popular discourse mostly surrounding the advanced countries. This study observes a negative relationship between government debt and growth. The point estimates of the range of econometric specifications suggest a 10–percentage point increase in the debt–to–GDP ratio, which is associated with 2 to 23 basis point reduction in average growth. Our results establish the nonlinear relationship between debt and growth. The study answers the question – *Does high debt lead to low growth or low growth leads to high debt?* by providing an analysis of the decomposition of cause and effect relationship between debt and growth. The panel vector auto regressions (PVAR) approach was used to study the macroeconomic analyses of debt–growth relationship by considering the interdependences existing across sectors, markets and countries, and national economic issues. The results derived from the impulse–response functions and variance decomposition suggest the evidence of long–term effect of debt on economic growth. The results indicate that the effect is not uniform for all countries, but depends mostly on the debt regimes and other important macroeconomic variables such as inflation, trade openness, general government final consumption expenditure and foreign direct investment.

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Appendices

Annexure 1: Countries covered in Debt Regime groupings

1	DR 0-30 (21)	Azerbaijan, Bahrain, Botswana, Chile, China, Colombia, Congo, Rep., Czech Republic, Estonia, Finland, Germany, Guatemala, Kazakhstan, Latvia, Namibia, Norway, Oman, Paraguay, Romania, Slovenia, and Thailand.
2	DR 31-60 (31)	Argentina, Austria, Brazil, Canada, Denmark, Dominican Republic, Ecuador, El Salvador, France, Ghana, Iceland, India, Indonesia, Japan, Kenya, Malaysia, Mexico, Netherlands, New Zealand, Peru, Philippines, Portugal, South Africa, Spain, Sweden, Tunisia, Turkey, United Kingdom, United States, Uruguay, and Venezuela, RB.
3	DR 61-90 (22)	Algeria, Bolivia, Costa Rica, Cote d'Ivoire, Egypt, Arab Rep., Egypt, Arab Rep., Greece, Ireland, Panama, and Singapore.
4	DR 91-150 (8)	Belgium, Burundi, Central African Republic, Honduras, Italy, Jamaica, Jordan, Kyrgyz Republic, Madagascar, Nigeria, Seychelles, Sri Lanka, and Tajikistan.
5	DR 151 and above (5)	Congo, Dem. Rep., Cyprus, Malta, Nicaragua, and Zambia