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Abstract

We estimate a panel vector autoregressive model to analyze the highly disputed relationship between debt and growth. While several studies indicate that high levels of sovereign debt hamper the growth prospects of a country, our results question this. Using data on 20 developed countries, we find no evidence for a robust effect on debt to growth, even for higher levels of sovereign debt. We do find a significant negative reverse effect of growth to debt, which explains the negative correlation.

JEL classification: H63, O43, C33
Keywords: Public debt, debt share, GDP growth

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1 Introduction

Since the outbreak of the financial turmoil in 2007 and the subsequent sovereign debt crisis in the euro area, the relationship between sovereign debt and economic growth has been at the heart of the economic policy debate. In an influential article, Reinhart and Rogoff (2010) document a historically negative correlation between the level of sovereign debt and economic growth, and argue that countries face a dramatic decline to their growth potential when their debt-to-GDP ratio reaches 90 percent. Herndon *et al.* (2013) uncover a number of computational errors in the results of Reinhart and Rogoff (2010). Although an observed negative correlation between debt and growth remains, Herndon *et al.* (2013) challenge the robustness of a '90 percent threshold'. In addition, it is not clear that the correlation implies causation. Does high debt lead to low growth, or does low growth lead to high debt?

In an attempt to decompose cause and effect, we estimate panel vector autoregressions (PVAR) that describe the dynamic relation between sovereign debt and economic growth, using data on debt and GDP for a panel of 20 developed countries ranging from the beginning of the 20th century. With both debt and GDP treated as endogenous, the PVAR allows us to estimate both the effect of debt on growth, as well as the reverse effect of growth on debt. We find that that the negative correlation between the variables is primarily driven by the impact of growth on debt rather than *vice versa*. We find that an increase in growth has a negative effect on debt, which makes sense given that government expenditure is in general counter-cyclical, while government revenue is pro-cyclical. When controlling for this negative effect, we find no evidence for a significant long-run reverse impact of debt on growth. Results also indicate that the dynamics of debt and growth are remarkably similar across different subsamples and periods.

Previous studies have also addressed the endogeneity problem in the relationship between debt and growth. For example, Baum *et al.* (2013) and Checherita-Westphal and Rother (2012) apply instrumental variables to identify the effect of debt on growth for euro area countries, while Minea and Parent (2012) use endogenous threshold estimation methods. These studies find that at low debt levels, deficit spending can have a positive impact on growth, which disappears or turns negative for higher levels of debt. The estimated turning points in the debt-to-GDP ratio vary substantially, with estimates ranging between 60 and 115 percent. What these studies have in common is that they aim to find the short-run elasticity of growth with respect to debt in different debt thresholds. Although this is certainly an important question, we are more interested in the long-run effects of debt on growth. A dynamic model like a VAR is a suitable choice for estimating such long-run effects. After modeling debt and GDP as a bivariate dynamic process, we produce impulse-response plots that visualize the path of both debt and GDP for ten years after a shock hits either of these two variables. The shocks are identified recursively.

2 Data and methodology

From the dataset of Reinhart and Rogoff (2009) we obtain data on gross government debt. Data on real GDP per capita comes from the Maddison database of the Groningen Growth and Development Centre. Our dataset comprises annual data on 20 developed countries, over the period 1954-2008. For a smaller subset of 10 countries, we are able to extend the length of the time-series, to the period 1905-2008. These countries are listed in Table 1. The table also marks those countries for which the average debt-to-GDP ratio over the period 1954-2008 exceeds 50 percent and for which the maximum debt-to-GDP ratio over the period 1954-2008 exceeds 90 percent. These subsets will be used in section 3 to compare the results for different subsamples classified by the degree of indebtedness.

To analyze the dynamic relationship between debt and GDP, we compute impulse-response functions from an estimated Panel VAR (PVAR), in a similar manner as Lof *et al.* (2013) assess the relationship between aid and GDP in developing countries. Using the growth rates (log-differences) of real GDP per capita ($\triangle Y$) and the growth rate of total gross government debt per capita ($\triangle D$) as our variables of interest, we estimate the following PVAR:

$$y_{it} = \mu_i + A y_{it-1} + \varepsilon_{it}, \tag{1}$$

in which $y_{it} = (\triangle D_{it}, \triangle Y_{it})'$, μ_i is a 2×1 country-specific intercept term (fixed effect), A is a 2×2 coefficient matrix and ε_{it} is a 2×1 residual term. The subscripts i and t denote country and year, respectively. The VAR includes only first-order lags, which is selected using the Bayesian Information Criterion (BIC).

Before estimating the PVAR, we apply first-differencing, such that the fixed effect μ_i drops out of the model. Afterwards, we estimate the differenced model by GMM, while applying lagged values as instruments. This is a standard procedure for estimating dynamic models with panel data, since the standard fixed-effects estimator is in general inconsistent for such models (Nickel 1981). The resulting estimate of A is used to compute the impulse-response functions. Confidence intervals for the impulse-response functions are computed by bootstrap simulation, see Lof *et al.* (2013) for details.

To identify the shocks, we impose a recursive structure, which makes the order of the variables relevant. We follow Caldara and Kamps (2008), who note that because of the delay between political decision making and actual government spending, fiscal policy may have an instantaneous effect on GDP, while the reverse effect can only occur after a lag. We therefore place debt before GDP. As a robustness check, however, we will also consider the VAR in the reverse recursive order. In this case, it turns out that the imposed order has no substantial effect on the estimated long-run impulse-responses.

3 Results

Figure 1 depicts the impulse-response functions derived from the estimated VAR (Eq. 1). The figure shows the impact on debt (left column) and GDP (right column) for a period of ten years after a positive shock to either debt (top row) or GDP (bottom row). Both debt and GDP are measured in per capita terms and are transformed to growth rates by log-differencing. From the diagonal panels (top left and bottom right) it appears that shocks to both growth rates of debt and GDP are transitory: The effects of a shock die out within a couple of years, with shocks to GDP (bottom-right) being clearly less persistent than shocks to debt (top-left).

The off-diagonal panels show the impact on debt, after a shock to GDP (bottom-left) and the reverse impact on growth, after a shock to debt (top-right), which is of our main interest. The top-right impulse response shows no evidence for any significant effect of debt on GDP growth. A positive shock to GDP growth does however have a significant negative effect on debt (bottom left), which persists for about three years, after which the effect dies out. Based on these figures, it seems the negative correlation between debt and GDP therefore results from the negative impact of GDP growth on debt, rather than the negative impact of debt on GDP growth.

The same results apply when we look at the levels instead of differences. Figure 2 depicts the cumulative impulse response functions from the VAR. By cumulating the impact over time, these plots show the effect on the levels, rather than on the differences of debt and GDP (both in logs). Although the plots look different from Figure 1, the interpretation is the same. The top-left panel shows that after a shock to debt, debt starts to accumulate for a couple of years, after which the level of debt stabilizes. This shock to debt has no significant impact on GDP (top-right). After a shock hits GDP, however, we can clearly see a negative impact on the level of debt (bottom-left). GDP itself stabilizes nearly immediately at the new level (bottom-right).

In Figure 3, we display the cumulative impulse response functions from four alternative PVAR specifications. Compared to Figure 2, we display only the off-diagonal panels, showing the dynamic effects of debt on growth (top) and vice versa (bottom). First we consider the VAR with debt and GDP measured in aggregate terms, rather than per capita (Figure 3.A). Next, we replace the level of debt with the debt-to-GDP ratio (Figure 3.B). For Figure 3.C the recursive order is reversed, such that GDP is placed before debt. Finally, in Figure 3.D, we consider a subset of 10 countries (listed in Table 1), for which the VAR is estimated using a longer time-series that spans from 1905 to 2008. Overall, the results in Figure 3 seem highly similar to those presented in Figure 2. The long-run effect of debt on GDP is found to be insignificant for all four alternatives. Growth is found to have a negative effect on debt. The only exception is Figure 3.B, where a GDP shock seems to have no clear effect on the debt-to-GDP ratio. However, considering a 'structural shock' that hits GDP but not the debt-to-GDP ratio is actually paradoxical, given that these variables are by construction so intertwined. A recursive VAR is therefore arguably not a suitable tool in this particular case.

Finally, Figure 4 reproduces the off-diagonal panels of Figure 2, for four different subsamples (listed in Table 1). Figure 4.A is produced using only the data on 9 high-debt countries, for which the average debt-to-GDP ratio during the period 1954-2008 is higher than 50%. The remaining 11 countries are used for figure 4.B. Next we look at 7 countries for which the maximum debt-to-GDP ratio recorded during the period 1954-2008 exceeds 90%, which is the threshold reported by Reinhart and Rogoff (2010). The remaining 13 countries are used for figure 4.D. Like in the previous figures, we find no significant long-term impact of debt on GDP. Regarding the reverse impact of GDP on debt, we find either negative or insignificant effects. In general, the reported confidence bounds are wider than in the previous figures, presumably due to the smaller sample sizes.

The overall picture from Figures 1-4 is clear: We find no significant long-run effect of sovereign debt on economic growth. This result is robust to alternative VAR specifications and to alternative samples.

4 Conclusion

High levels of sovereign debt are surely a burden to a country, but does it hamper the macroeconomic performance in the longer run? According to our results, the effect of debt on growth is ambiguous, at best. We find no statistically significant long-run effect on debt to economic growth, for any elevated level of debt. GDP per capita growth, on the other hand, is found to have a statistically significant negative effect on sovereign debt. This implies that the negative correlation between sovereign debt and GDP growth is mainly driven by the negative effect of economic growth on sovereign debt. Our results are in line with Kimball and Wang (2013), who claim in a recent blog post not to find "even a shred of evidence in the Reinhart and Rogoff data for a negative effect of government debt on growth".

We have chosen a rather simple model for growth and debt, in which the variables are treated as a bivariate process that is rather homogeneous across countries.

Although this method is useful for decomposing the correlation, it is not very informative about the economic channels through which debt and GDP affect each other. Moreover, due to the recursive structure, the VAR is not well equipped to estimate short-run effects. Directions for future research on the on the relationship between debt and growth should therefore include multiple variables to uncover these structural channels, which could also address possible omitted-variable biases. Regardless of these issues, the results of this paper make clear that when estimating the long-run effect of sovereign debt on growth, it is important to control for the reverse effect of growth on debt.

Acknowledgements

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Table 1: Country list

Country	1954-2008	1905-2008	av. debt >50%	max. debt >90%
Australia	x	x	-	-
Austria	x	-	-	-
Belgium	x	-	x	x
Canada	x	x	x	-
Denmark	x	x	-	-
Finland	x	x	-	-
France	x	-	-	-
Germany	x	-	-	-
Greece	x	-	x	x
Ireland	x	-	x	x
Italy	x	x	x	x
Japan	x	-	x	x
Netherlands	x	-	x	x
New Zealand	x	x	-	-
Norway	x	-	-	-
Portugal	x	x	-	-
Spain	x	-	-	-
Sweden	x	x	-	-
UK	x	x	x	x
USA	x	x	x	-

Notes: First column marks the countries for which time-series for 1954-2008 are available (N=20, T=55). Second column marks the countries for which time-series for 1905-2008 are available (N=10, T=104). Third column marks the countries for which the average debt-to-GDP ratio during the period 1954-2008 exceeds 50% (N=9). Fourth column marks the countries for which the maximum debt-to-GDP ratio during the period 1954-2008 exceeds 90% (N=7).

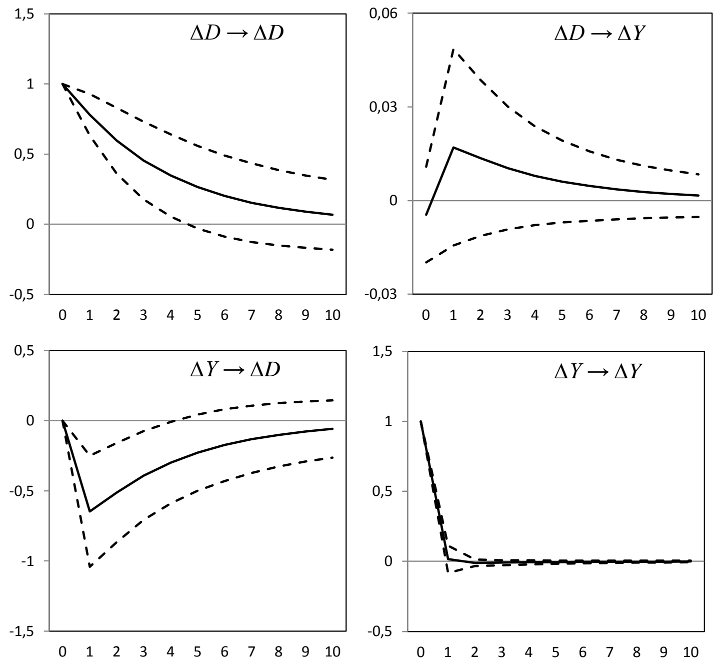

Figure 1: Impulse-response functions computed from estimated PVAR (Eq. 1), for 20 countries (See Table 1) over the period 1954-2008. 95% confidence bounds are based on 10,000 bootstrap simulations.

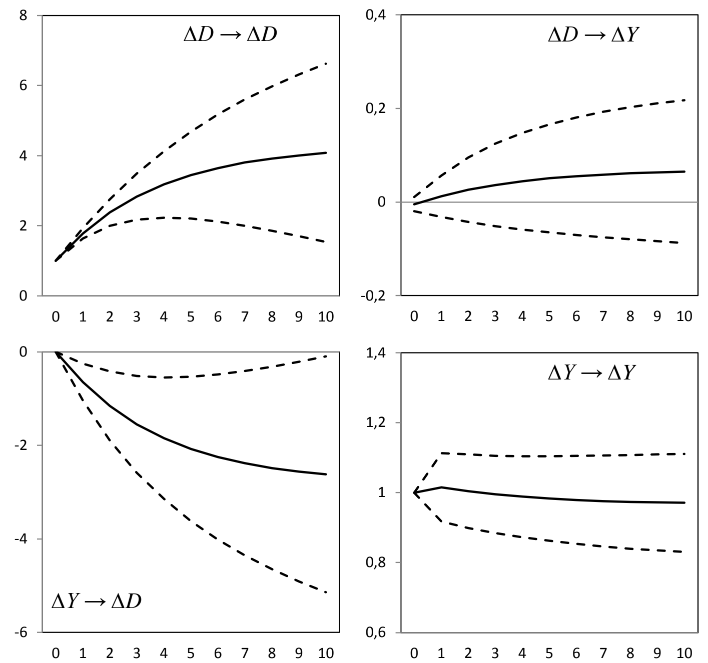

Figure 2: Cumulative impulse-response functions. See Figure 1.

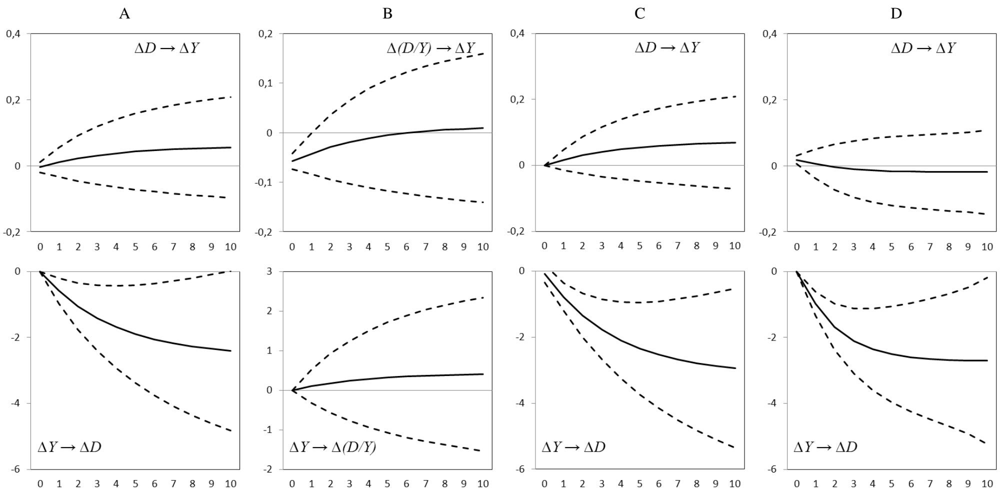

Figure 3: Cumulative impulse-response functions (See Figure 2) for alternative VAR specifications. (A) Debt and GDP measured in aggregate terms instead of per capita. (B) Debt measured as Debt-to-GDP ratio. (C) Recursive order reversed. (D) Sub-sample of 10 countries (See Table 1) with longer time-series (1905-2008).

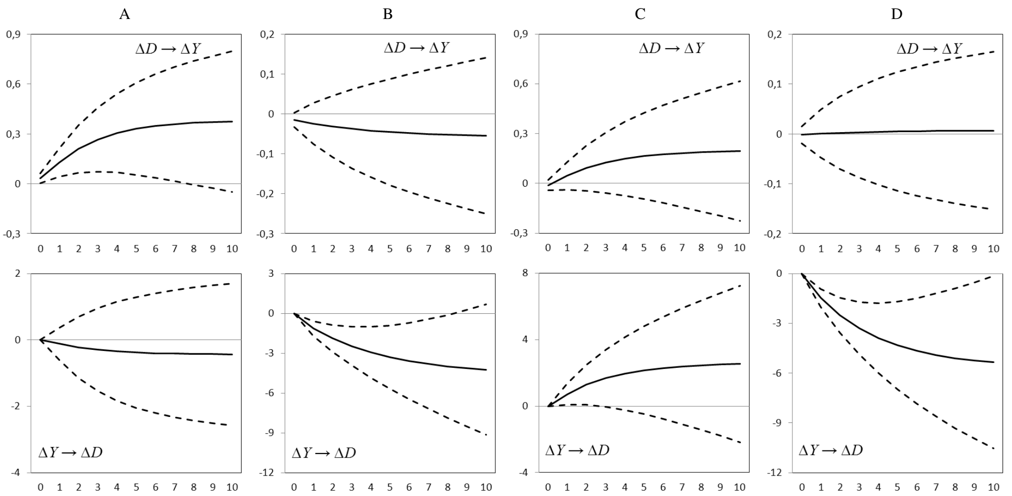

Figure 4: Cumulative impulse-response functions (See Figure 2) for different subsamples (See Table 1). (A) Av. Debt-to-GDP ratio>50% (N=9). (B) Av. Debt-to-GDP ratio<50% (N=11). (C) Max. Debt-to-GDP ratio>90% (N=7). (D) Max. Debt-to-GDP ratio<90% (N=13).