

Public Debt and Economic Growth in Advanced Economies: A Survey^a

UGO PANIZZA^b and ANDREA F. PRESBITERO^c

JEL-Classification:: F33, F34, F35, O11

Keywords: Government Debt, Growth, OECD countries

*There is no simple relationship between debt and growth [...]
There are many factors that matter for a country's growth
and debt performance. Moreover, there is no single threshold
for debt ratios that can delineate the "bad" from the "good".*
(INTERNATIONAL MONETARY FUND, 2012, p. 9)

1. Introduction

This paper surveys the recent literature on the links between public debt and economic growth in advanced economies.¹ The paper also discusses several practical and conceptual issues related to the definition and measurement of public debt. We start with an overview of various theoretical models that link debt to economic growth. The literature shows that debt has a negative impact on growth through a standard crowding out effect, but back-of-the-envelope calculations indicate that this effect is quantitatively small. While uncertainty and policy credibility may amplify the negative effect of crowding out, hysteresis can lead to a situation in which expansionary fiscal policies have positive effect on long-run growth. It is also hard to find full-fledged theoretical models that predict non-monotonicity or threshold effects in the relationship between public debt and economic growth.

- a This paper was prepared for a special issue of the Swiss Journal of Economics and Statistics. We would like to thank the editor, Professor Klaus Neusser, for inviting us to write the paper and participants at the conference "The Swiss Debt Brake – Ten Years On" at the Gerzensee Study Center for helpful comments and suggestions. The usual caveats apply.
- b Ugo Panizza, The Graduate Institute, Geneva. E-mail: ugo.panizza@graduateinstitute.ch.
- c Andrea F. Presbitero, Università Politecnica delle Marche (Italy) and MoFiR. E-mail: a.presbitero@univpm.it.
- 1 For another recent survey with a different slant, see REINHART, REINHART, and ROGOFF (2012).

When we survey the empirical literature, we start with empirical models that analyze the bivariate relationship between debt and growth and show that smooth threshold regression methods yield non-linearities which are much more complex than those found in models that use exogenous thresholds. Moreover, the presence and level of debt thresholds do not appear to be robust to small changes in country coverage and data frequency. Next, we show that the presence of a negative correlation between debt and economic growth is robust to controlling for a host of covariates (including country and time fixed effects) which are correlated with both debt and growth. However, causality is hard to establish and, in our reading of the empirical evidence, there is no paper that can make a strong case for a causal relationship going from public debt to economic growth. Finally, we look at the existence of thresholds in a multivariate setting and, again, we find that the evidence for such thresholds is weaker than previously thought.

Our reading of the empirical literature is thus in line with the IMF statement in the opening quotation, which, instead, seems to contradict the IMF summary of a 2013 AEA session on sovereign debt crisis, according to which “Policymakers in advanced economies will have to resolve the problem of high government debt or they may face low growth prospects”.²

Our finding that there is no evidence of a causal negative relationship going from debt to economic growth does not mean that debt does not matter, and that countries should run profligate fiscal policies. First, saying that there is no evidence that debt is bad for growth is different from saying that there is evidence that debt does not matter for growth. Second, we think that the relationship between debt and growth is heterogeneous across countries and time periods and that future research should focus on these sources of heterogeneity.

2. Public Debt and Economic Growth: The Theory

We start with a short survey of what economic theory tells us about the relationship between public debt and economic growth. Throughout our discussion, we will assume that government expenditure in goods and services is fixed and we examine what happens if the government decides to temporarily reduce taxes and finance its expenditures by issuing debt. We will also assume that Ricardian Equivalence does not hold and that public debt can affect real

2 See the IMF website at: <http://www.imf.org/external/pubs/ft/survey/so/2013/NEW010813A.htm>.

variables.³ According to the “conventional view of public debt” (ELMENDORF and MANKIW, 1999), in the short-run output is demand-determined and fiscal deficits (or higher public debts) have a positive effect on disposable income, aggregate demand, and overall output. This positive short-run effect of budget deficits (and higher debt) is likely to be large when the output is far from capacity. According to ELMENDORF and MANKIW (1999), things are different in the long-run. If Ricardian Equivalence does not hold, the decrease in public savings brought about by a higher budget deficit will not be fully compensated by an increase in private savings. As a consequence, national savings will decrease, resulting in lower total investment, either at home or abroad. Lower investment at home will have a negative effect on GDP, as it will lead to a smaller capital stock, higher interest rates, lower labor productivity and wages. Lower foreign investment (or higher foreign inflows), instead, will have a negative effect on foreign capital income and will thus lower the country’s future GNP. This negative effect of an increase in public debt on future GDP (or GNP) can be amplified by the presence of distortionary taxes.

According to ELMENDORF and MANKIW’s (1999) back-of-the-envelope calculations, each additional dollar of government debt reduces steady-state gross output by about 10 cents (9 cents are due to the lower capital stock and one cent to future tax distortion).⁴ If we assume that annual real GDP growth is 3 percent and convergence speed is 2 percent, we find that this change in steady-state output has a fairly small growth effect. In particular, our calculations indicate that increasing debt by 100 per cent of GDP would reduce annual GDP growth by approximately 20 basis points in the first twenty years.

The negative effect of public debt could be much larger if high public debt increases uncertainty or leads to expectations of future confiscation, possibly through inflation and financial repression (see COCHRANE 2011a, 2011b for a discussion of these issues). In this case, higher debt could have a negative effect even in the short-run.

The conventional split between the short and long-run effects of debt disregards the fact that protracted recessions may reduce future potential output (as they increase the number of discouraged workers, with the associated loss of skills, and have a negative effect on organizational capital and investment on new

3 Ricardian Equivalence would require the following assumptions: lump-sum taxes; constant population composed of forward looking individuals characterized by intergeneration altruism; and perfect capital markets (BARRO, 1974).

4 ELMENDORF and MANKIW’s (1999) back-of-the-envelope calculations are based on US data, the results are likely to be similar if we were to concentrate on other OECD countries.

activities). In this case, running fiscal deficits (and increasing debt) may have a positive effect on output in both the short and long-run. In fact, DE LONG and SUMMERS (2012) argue that, in a low interest rate environment, expansionary fiscal policy is likely to be self-financing.⁵ There is, in fact, evidence that recessions have a permanent effect on the level of future GDP (CERRA and SAXENA, 2008). DE LONG and SUMMERS (2012) mention that the US Congressional Budget Office recognizes this fact and reduces its estimates of future potential output when output falls below potential for at least one year.

A large number of empirical papers find that the relationship between debt and growth is non-linear and characterized by the presence of a threshold above which debt starts having a negative effect on economic growth (for a detailed survey see Section 3 of this paper). While non-linearities and threshold effects could arise from the presence of debt overhang (KRUGMAN, 1988; SACHS, 1989), it is not clear whether a debt overhang argument could be easily applied to advanced economies in which the majority of debt-holders are resident (and therefore there is not an external transfer problem).

CHECHERITA-WESTPHAL, HUGHES HALLETT, and ROTHER (2012) develop a theoretical model in which, over the business cycle, debt can only be issued to finance public investment and the optimal level of public debt is determined by the public to private capital ratio that maximizes economic growth.⁶ With such a set-up, they show that the level of debt that maximizes economic growth is a function of the output elasticity of the capital stock. CHECHERITA-WESTPHAL, HUGHES HALLETT, and ROTHER (2012) use the model to estimate optimal debt ratios for various subsamples of OECD countries and find values that range between 43 and 63 percent of GDP. However, GREINER (2012) shows that the results of CHECHERITA-WESTPHAL, HUGHES HALLETT, and ROTHER (2012) are driven by their assumption that the deficit is equal to public investment at each point in time. According to GREINER (2012), in such a set-up, debt is completely irrelevant and the non-linear relationship between debt and growth is given by the growth-maximizing tax rate. He then shows that allowing for a more general debt policy leads to a monotone and negative relationship between public debt and steady-state growth. GREINER (2011; 2013) also argues that the effect of debt on growth depends on the presence of rigidities in the economy. In particular, GREINER (2011) shows that, in a model with no rigidities and elastic

5 For a criticism to DE LONG and SUMMERS' (2012) views, see RAMEY (2012).

6 Note that here, and below, we deviate from our initial assumption that government expenditure is fixed and we will relate debt to the financing of public investment.

labor supply, public debt has a negative effect on labor supply, investment, and economic growth. In the presence of wage rigidities and unemployment, instead, public debt has no effect on the allocation of resources and can even have a positive effect if it is used to finance productive investment.

GREINER (2012) concludes that there is no well-specified model that can generate an inverted U-shaped relationship between debt and growth. Non-linearities may arise if there is a tipping point above which public debt suddenly become unsustainable (GHOSH et al., 2012, provide a formal model). However, we are not aware of any theoretical model that includes such tipping points in a growth framework.

It is also possible that high levels of debt pose constraints on a country's ability to conduct countercyclical policies, and thus increase output volatility and reduce economic growth (for the relationship between volatility and growth, see RAMEY and RAMEY, 1995). However, the relationship between debt and the ability of conduct countercyclical policies is more likely to depend on the composition of public debt than on the level of public debt (HAUSMANN and PANIZZA, 2011; DE GRAUWE, 2011). This suggests that countries with different debt structures and monetary arrangements are likely to start facing problems at very different levels of debt.

Summing up, simple back-of the envelope calculations suggest that debt may have a negative effect on growth, but the effect is likely to be small. More sophisticated models yield uncertain results on the relationship between debt and growth and show that the link between debt and growth depends on many cyclical and structural factors. These considerations suggest that trying to estimate a single debt coefficient that holds for all countries and all periods may be mission impossible.

3. Public Debt and Economic Growth: The Empirics

A good starting point for discussing the relationship between public debt and economic growth in advanced economies is REINHART and ROGOFF's (2010) finding that high levels of debt are negatively correlated with economic growth, but that there is no link between debt and growth when public debt is below 90 percent of GDP. REINHART and ROGOFF (2010) illustrate this threshold effect by collecting annual data on debt and output growth for 20 advanced economies over 1946–2009 and splitting their sample into four groups: (i) country-years for which public debt is below 30 percent of GDP (443 observations); (ii) country-years for which public debt is between 30 and 60 percent of GDP (442

observations); (iii) country-years for which public debt is between 60 and 90 percent of GDP (199 observations); and (iv) country-years for which public debt is above 90 percent of GDP (96 observations). Next, they compute median and average GDP growth for each group and show that there are no large differences among the first three groups, but that average and median GDP growth are substantially lower in the fourth group. In particular, REINHART and ROGOFF (2010) show that in the high debt group median growth is approximately 1 percentage point lower and average growth is nearly 4 percentage points lower than in other groups (see Figure 1).

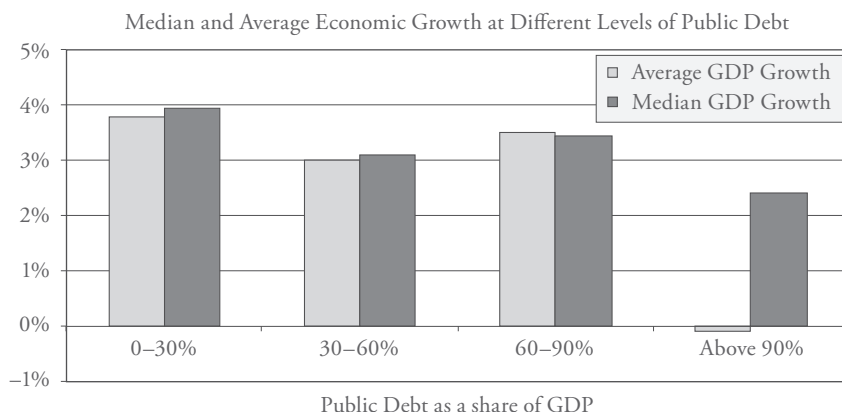
REINHART and ROGOFF's (2010) influential paper sparked a new literature aimed at assessing whether their findings were robust to allowing for non-arbitrary debt brackets, to controlling for other variables in a proper regression set-up, and to instrumenting public debt to assess its causal effect on economic growth. In this section, we review this new empirical literature.⁷

3.1 Endogenous Thresholds

Instead of comparing growth across a set of pre-established brackets, MINEA and PARENT (2012) study the relationship between debt and growth by using the Panel Smooth Threshold Regressions model originally proposed by GONZÁLEZ, TERÄSVIRTA, and VAN DIJK (2005). Using this approach, that allows for a gradual change in the regression coefficient when moving from one regime to the other, MINEA and PARENT (2012) find that public debt is negatively associated with growth when the debt-to-GDP ratio is above 90 percent and below 115 percent. However, they also find that the correlation between debt and growth becomes positive when debt surpasses 115 percent of GDP. While MINEA and PARENT's (2012) results should not be interpreted as an argument for fiscal profligacy, they suggest the existence of complex non-linearities, which may not be captured by models that use a set of exogenous thresholds.

MINEA and PARENT (2012) also note that, since REINHART and ROGOFF (2010) found that differences in median growth are much smaller than differences in average growth, researchers should be careful in examining the role of outliers and check whether their results are robust to using different sources of data. They illustrate the importance of these robustness tests by showing that alternative data sources yield results which are somewhat different from those of REINHART and

7 This article was written before the release of HERNDON et al.'s (2013) critique to REINHART and ROGOFF (2010). We briefly discuss how our article relates to this debate in PANIZZA and PRESBITERO (2013).

Figure 1: The Non-Linearity of the Debt-Growth Relationship

Source: REINHART and ROGOFF (2010).

ROGOFF (2010). In particular, they use data from MADDISON (2007) and the IMF Public Debt Database ABBAS (2011) and find that the reduction in average (and median) growth rate between countries with a debt-to-GDP ratio below and above 90 percent is small and not statistically significant (see Figure 1 in MINEA and PARENT, 2012). Similarly, AFONSO and JALLES (2013, see their Figure 2) show that, in a sample of OECD countries, the average growth rates over the period 1970–2008 of countries with low debt (debt-to-GDP ratio < 30%) is similar to that of high debt (debt-to-GDP ratio > 90%) countries.

ÉGERT (2012) extends the time coverage of the REINHART and ROGOFF (2010) sample back to 1790.⁸ He finds a small negative correlation between debt and growth and, using an endogenous threshold model, some evidence of a non-linear relationship between debt and growth. However, the estimated endogenous debt-to-GDP thresholds are generally much lower than 90 percent. In addition, ÉGERT (2012) mentions that the presence and the level of the thresholds are not robust to small changes in country coverage, data frequency, and changes in the assumptions on the minimum number of observations included in each regime.

8 The 20 economies sample is the same as in REINHART and ROGOFF (2010) apart from the inclusion of Switzerland and the exclusion of Ireland. ÉGERT (2012) calculates the debt-to-GDP ratio using the public debt data published in another paper by REINHART and ROGOFF (2011) and the GDP data collected by Robert Barro and José Ursúa (available at: <http://rbarro.com/data-sets/>).

3.2 Controlling for Possible Covariates of Debt and Growth

In the presence of variables that are correlated with both debt and growth, the simple correlations discussed above may suffer from an omitted variable bias. Starting with KUMAR and WOO (2010), CECCHETTI, MOHANTY, and ZAMPOLLI (2012), and CHECHERITA-WESTPHAL and ROTHER (2012), the literature has tried to address this issue by estimating alternative versions of the following dynamic growth model:

$$GROWTH_{i,t-(t-n)} = \alpha \ln(GDP)_{i,t-n} + \beta DEBT_{i,t-n} + \gamma X_{i,t-n} + \tau_t + \eta_i + \varepsilon_{i,t} \quad (1)$$

In Equation (1), per-capita GDP growth (*GROWTH*) of country *i* over period *t*–*n* and *t* (with *n* ranging between 1 and 5) is regressed on the initial level of per capita GDP, the ratio of public debt over GDP (*DEBT*), and a set of controls *X*.⁹

To estimate Equation (1), researchers need to choose the length of the growth episode (*n*). There are several tradeoffs involved in this choice. While *n* = 1 (i.e., using annual GDP growth) maximizes the number of observations, this strategy may lead to estimates that are fully driven by business cycle fluctuations and suffer from serious endogeneity (as debt is only lagged by one year with respect to economic growth). To mitigate these problems, *n* is usually set equal to 5, with the objective of estimating the correlation between the current level of debt (and the other explanatory variables) and the 5-year forward GDP growth rate. However, this strategy greatly reduces the number of observations (which can be problematic in short panels) and introduces some arbitrariness about the choice of the first and last usable observations. An alternative is to use 5-year overlapping growth episodes, at the cost of introducing autocorrelation in the model.

CECCHETTI, MOHANTY, and ZAMPOLLI (2012) estimate Equation (1) using 5-year overlapping growth episodes for a sample of 18 OECD countries over the period 1980–2006.¹⁰ In their baseline estimations, they find that a 10 percentage point increase in the debt-to-GDP ratio is associated with an 18 basis points decrease in subsequent GDP growth. This is a large effect, about one order of

9 While the set of controls varies across studies, it often includes population growth, the ratio of investment over GDP, and a measure of the stock of human capital, as predicted by the augmented Solow model (MANKIW, ROMER, and WEIL, 1992).

10 Their *X* matrix includes: national gross savings (as a share of GDP), population growth, average number of years of secondary education, trade openness, inflation, age dependency ratio (the ratio between people younger than 15 or older than 64 and people in the 15–64 age range), a banking crisis dummy, and the ratio of liquid liabilities to GDP.

magnitude larger than what we obtained using the back-of-the envelope calculations of ELMENDORF and MANKIW (1999).

This result is robust to controlling for outliers and to specifications that include different sets of controls variables. However, CECCHETTI, MOHANTY, and ZAMPOLLI (2012) find that the public debt variable is not statistically significant in regressions that do not include time or country fixed effects.

After having established the presence of a negative correlation between debt and growth, CECCHETTI, MOHANTY, and ZAMPOLLI (2012) check for the existence of non-linearities. They find that standard regressions or group comparisons do not show evidence of a threshold effect. Nevertheless, they suggest that more sophisticated econometric techniques yield results which are consistent with the presence of such effect. Section 3.4 below discusses this exercise in detail.

3.3 *Endogeneity*

While there is evidence that public debt is negatively correlated with economic growth, the presence of such a correlation does not necessarily imply that debt reduces growth. The link between public debt and economic growth could be driven by the fact that it is low economic growth that leads to high levels of debt (REINHART, REINHART, and ROGOFF, 2012). Alternatively, the observed correlation between debt and growth could be due to a third factor that has a joint effect on these two variables.

In PANIZZA and PRESBITERO (2012), we describe the endogeneity problem and assess the likely direction of the bias by using a simple bivariate model in which growth (G) is a function of debt (D):

$$G = a + bD + u, \quad (2)$$

and debt is a function of growth:

$$D = m + kG + v. \quad (3)$$

The OLS estimator of b is then given by:

$$\hat{b} = \frac{b\sigma_v^2 + k\sigma_u^2}{\sigma_v^2 + k^2\sigma_u^2},$$

and the bias of the OLS estimates is:

$$E(\hat{b}) - b = \frac{k(1 - bk)}{\sigma_v^2 / \sigma_u^2 + k^2}. \quad (4)$$

Equation (4) shows that OLS estimations are unbiased if $k=0$ (i.e., debt is not endogenous). Given that stability requires that $bk < 1$, if $k < 0$ (as it is likely to be), OLS estimates are negatively biased.

Using lagged debt mitigates, but does not resolve, the endogeneity problem.¹¹ Assessing the presence of a causal relationship between debt and growth requires finding an instrumental variable that has a direct effect on debt but no direct (or indirect, except for the one going through debt) effect on economic growth.

One possible approach consists of using internal instruments (i.e., lagged values of the explanatory variables), as in the difference and system GMM estimators developed in ARELLANO and BOND (1991) and BLUNDELL, RICHARD, and STEPHEN BOND (1998). KUMAR and WOO (2010) study the relationship between debt and growth in a group of 30 advanced and emerging market economies over the period 1970–2007. They experiment with different estimations techniques and argue that the system GMM estimator allows them to address endogeneity. Their results are consistent with those of CECCHETTI, MOHANTY, and ZAMPOLLI (2012), as they imply that 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 approximately 20 basis points.¹²

These results should be interpreted with some caution. The difference and system GMM estimators were developed for micro data and are poorly suited for macroeconomic datasets with a relatively small number of cross-sectional units (BOND, 2002).¹³ Moreover, system GMM estimations of the relationship

- 11 Expectations of a slowdown may trigger counter-cyclical expansionary fiscal policy, resulting in a higher public debt-to-GDP ratio at time t . This would be correlated with lower growth in period $(t+1; t+n)$ even if public debt has no causal impact on growth in the future. Things may be different when n is sufficiently large. KOURTELLOS, STENGOS, and TAN (2012), for instance, suggest that focusing on 10-year growth further mitigates endogeneity concerns. This strategy, however, is not feasible when the cross-sectional dimension of the data set is small (i.e., when focusing on advanced economies).
- 12 Other papers that use GMM techniques to estimate the causal relationship between public debt and economic growth include PADOAN, SILA, and VAN DEN NOORD (2012) and CHECHERITA-WESTPHAL and ROTHER (2012).
- 13 The difference and system GMM estimators can suffer from weak instrument problems BUN and WINDMEIJER (2010). Moreover, the system GMM estimator assumes that the instruments

between debt and growth are similar to those obtained with standard OLS regressions (for instance, compare columns 2 and 4 and 5 and 7 of Table 1 of KUMAR and Woo, 2010).¹⁴ In fact, the system GMM coefficients are larger (in absolute value) than the OLS coefficients. There are two possible interpretations for this result: either public debt is not endogenous, or the system GMM estimator does not solve the endogeneity problem.

An alternative strategy for identifying the causal effect of public debt on growth consists of using external instruments. We are aware of two papers that use an external instrument for public debt.

CHECHERITA-WESTPHAL and ROTHER (2012) focus on 12 euro-area countries over the period 1970–2008 and instrument the debt-to-GDP ratio of country i at time t with the average debt-to-GDP ratio in the other 11 countries at time t . With this strategy, the authors find a non-linear hump-shaped relationship between debt and growth. Their estimations suggest that growth reaches a maximum when the debt-to-GDP ratio is around 90–100 percent.

There are two problems with the instrument used by CHECHERITA-WESTPHAL and ROTHER (2012). The first relates to the fact that the instrument is only valid if: “there is no strong relationship between debt levels in other euro area countries and the per-capita GDP growth rate in one specific country” (CHECHERITA-WESTPHAL and ROTHER, 2012, p. 1398). This assumption is hard to defend. If it is true that debt in country j has a negative effect on growth in country j , claiming that debt levels in other euro-area countries have no effect on growth in the excluded country is equivalent to saying that GDP growth in the euro area (calculated by excluding a specific country from the group) has no effect on GDP growth of the excluded country. Defending such an assumption is even harder at time of crisis, when there is overwhelming evidence of large cross-country spillover effects (DE SANTIS, 2012).

Second, as in the GMM estimations discussed above, the instrumental variable approach of CHECHERITA-WESTPHAL and ROTHER (2012) yields results which are very close to those of the OLS regressions. Again, this may either mean that debt is not endogenous, or that the instrument is not appropriate.

are strong, without properly testing this assumption. Using many lags does not solve the weak instrument problem, which may lead to spurious results (BAZZI and CLEMENS, 2013). In fact, instrument proliferation (i.e. the use of many lags), especially when endogenous explanatory variables are highly persistent (as in the case of debt ratios), can undermine the validity of internal instruments in the system estimator (ROODMAN, 2009).

14 See also Tables 2 and 3 of CHECHERITA-WESTPHAL and ROTHER (2012).

In PANIZZA and PRESBITERO (2012), we use the same specification of CECCHETTI, MOHANTY, and ZAMPOLLI (2012) but instrument public debt with the valuation effects brought about by the interaction between foreign currency debt and movements in the exchange rate. In the paper, we show that the instrument is relevant (as demonstrated by a strong first-stage correlation and a battery of weak instrument tests) but, as our model is exactly identified, we cannot test the validity of our exclusion restriction. However, we discuss in detail the conditions under which the exclusion restriction is likely to be valid. We suggest that, besides public debt, our instrument may affect economic growth through two additional channels. First, valuation effects are correlated with the share of foreign currency debt, which, in turn, could hinder economic growth through financial and macroeconomic instability (BORDO, MEISSNER, and STUCKLER, 2010; HAUSMANN and PANIZZA, 2011). Second, the valuation effect is a (debt-weighted) effective exchange rate, which, in turn, is likely to be correlated with the trade-weighted effective exchange rate and economic growth (RODRIK, 2008). We conclude that our exclusion restriction is valid as long as we augment the model with the share of foreign currency debt and the real effective exchange rate.

In our paper, we show that the negative correlation between debt and GDP growth vanishes in the instrumental variable regressions. We point out that our findings are consistent with theoretical considerations suggesting that OLS estimates are negatively biased. In the paper, we ran a large number of robustness tests and discuss a series of possible problems with our identification strategy. While not all readers will be convinced of our results, we hope that, as minimum, our paper will serve as cautionary tale, and stimulate more research aimed at identifying the causal effect of public debt on growth.

3.4 *Non-Linearities*

We now move to papers that use multivariate regressions to assess the presence of a non-linear relationship between debt and growth. Before going into details, it is worth noting that most of the papers surveyed in this subsection suffer from the endogeneity problems discussed above.

The simplest way to test for non-linearities consists of including a quadratic term in the growth regression. CHECHERITA-WESTPHAL and ROTHER (2012) follow this approach and examine the relationship between public debt and growth in 12 euro area countries. Using a quadratic specification, estimated by fixed effects, system GMM, and two stages least squares, they find that the relationship between debt and growth can be described as an inverted U, and that the marginal effect of debt becomes negative when the debt-to-GDP ratio

is between 90 and 105 percent.¹⁵ This approach, however, is sensitive to extreme values and a hump-shaped relationship may be driven by few observations. Unfortunately, the paper does not show whether semi-parametric estimations support the quadratic relationship imposed by the authors or check if the presence of a U-shaped relationship is supported by the Sasabuchi-Lind-Mehlum test (LIND and MEHLUM, 2010).

An alternative approach consists of fitting a spline regression, allowing for one or more knots (MARSH and CORMIER, 2002).¹⁶ KUMAR and WOO (2010) follow this methodology and explore the presence of non-linearities in their sample of advanced and emerging economies by estimating the following model:

$$\begin{aligned} GROWTH_{i,t} - (t - 4) = & \alpha \ln(GDP)_{i,t-4} + \beta_1 DEBT_{i,t-4} \times D_{30} \\ & + \beta_2 DEBT_{i,t-4} \times D_{30-90} + \beta_3 DEBT_{i,t-4} \\ & \times D_{90} + \gamma X_{i,t-4} + \tau_t + \eta_i + \varepsilon_{i,t} \end{aligned} \quad (5)$$

where all variables are the same as in Equation (1) and, D_{30} is a dummy that takes a value of one when $DEBT < 30$, D_{30-90} is a dummy takes a value of one when $30 < DEBT < 90$, and D_{90} is a dummy takes a value of one when $DEBT > 90$.

After estimating Equation (5) with different panel estimators, KUMAR and WOO (2010, p. 21) conclude that they find “evidence of nonlinearity, with only high (above 90 percent of GDP) levels of debt having a significant negative effect on growth”. It is hard to interpret the results of Kumar and Woo as evidence of non-linearities in the relationship between debt and growth. Consider, for instance, their system GMM estimations of column 4, Table 5: β_2 and β_3 are identical (they are both equal to -0.18), the only difference is that β_3 is marginally significant (with a t-statistics of 1.78, corresponding to a p-value of 0.08) and β_2 insignificant (with a t-statistics of 1.24, corresponding to a p-value of 0.22). It

15 The authors suggest that the hump-shaped relationship between debt and growth is robust to fitting a more general polynomial functional forms. However, ÉGERT (2012, see his Figure 5) provides contrasting evidence: the estimation of a quadratic specification (without additional control variables) on a sample of 20 advanced economies over the period 1946–2009 shows the presence of a U-shaped curve, so that the relationship between debt and growth is increasing above the 90 percent debt-to-GDP threshold.

16 While more flexible than a quadratic specification, the spline regression is also arbitrary, because the number and the cutoff of the knots are often chosen on the ground of some (a-theoretical) prior and/or in order to maximize the fit of the model.

is thus clear that a formal t-test of $\beta_2 = \beta_3$ will not reject the null of equality, and thus reject the presence a non-linear effect of debt on growth.¹⁷

ÉGERT (2012) estimates a simplified version of Equation (5) (he does not include X and τ_t) on a sample of advanced economies, allowing for two (with a threshold at 90 percent), three (with thresholds at 30 and 90 percent), and four (with thresholds at 30, 60, and 90 percent) regimes. His estimations for 20 advanced economies over the period 1946–2009 find a negative and statistically significant correlation between debt and growth, but do not find any significant threshold effect. In fact, ÉGERT's (2012) results suggest that the negative correlation between debt and growth *decreases* (in absolute value) when the debt-to-GDP ratio increases.¹⁸

Panel threshold regression (PTR) models (HANSEN, 1999, 2000) allow estimating *exogenous* thresholds, rather than fixing them at arbitrary values. CECCHETTI, MOHANTY, and ZAMPOLLI (2012) define $D\Psi$ as a dummy variable that takes a value of one when the debt-to-GDP ratio is below Ψ and estimate the following threshold regression for $\Psi \in (50, 120)$:

$$\begin{aligned} GROWTH_{i,t+1,t+6} = & \alpha y_{i,t} + \gamma' X_{i,t} + \varphi D\Psi_{i,t} + \beta_1 \left(\frac{Debt_{i,t}}{GDP_{i,t}} D\Psi_{i,t} \right) \\ & + \beta_2 \left(\frac{Debt_{i,t}}{GDP_{i,t}} (1 - D\Psi_{i,t}) \right) + \mu_i + \tau_t + \varepsilon_{i,t} \end{aligned} \quad (6)$$

Next, they use HANSEN's (1999) likelihood ratio (LR) statistics to show that $\Psi = 96$ maximizes the fit of Equation (6). They find that when the debt-to-GDP ratio is below 96 percent, a ten percentage point increase in the debt-to-GDP ratio is correlated with a 7 basis point decrease in GDP growth (and the coefficient is not statistically significant) and when the debt-to-GDP ratio is above 96 percent a ten percentage point increase in the debt-to-GDP ratio is correlated with a 14 basis point decrease in GDP growth (and the coefficient is statistically significant).¹⁹

17 The results of the OLS regressions (column 2 of Table 5) are even more damning for the non-linearity hypothesis, as both β_2 and β_3 are statistically significant and $|\beta_2| > |\beta_3|$.

18 For instance, in the three regimes model, he finds that the correlation between debt and GDP growth is -0.038 when $DEBT < 90\%$, -0.029 when $60\% < DEBT < 90\%$, and -0.021 when $DEBT > 90\%$.

19 PADOAN, SILA, and VAN DEN NOORD (2012) conduct a similar experiment using an unbalanced sample of 28 OECD economies and find debt thresholds close to 90 percent. AFONSO and JALLES (2013) also follow a similar strategy and estimate a threshold close to 60 percent in a large sample of developed and developing countries.

Although these results are consistent with the presence of a threshold at around 90 percent of GDP, there are some issues with interpreting these findings as evidence for the existence of a non-linear relationship between debt and growth. The first problem has to do with the fact that Hansen's derivations assume a static model with *iid* errors, and it is not clear whether the results apply to a dynamic model with heteroscedastic errors.

The second problem has to do with the fact that Hansen's LR statistics cannot be used to test for the existence of a threshold. It can only be used to build a confidence interval around a threshold, under the assumption that such a threshold does exist (HANSEN, 1999, p. 351). Testing for the presence of a threshold requires a more complicated procedure, and the papers surveyed above do not report this test.

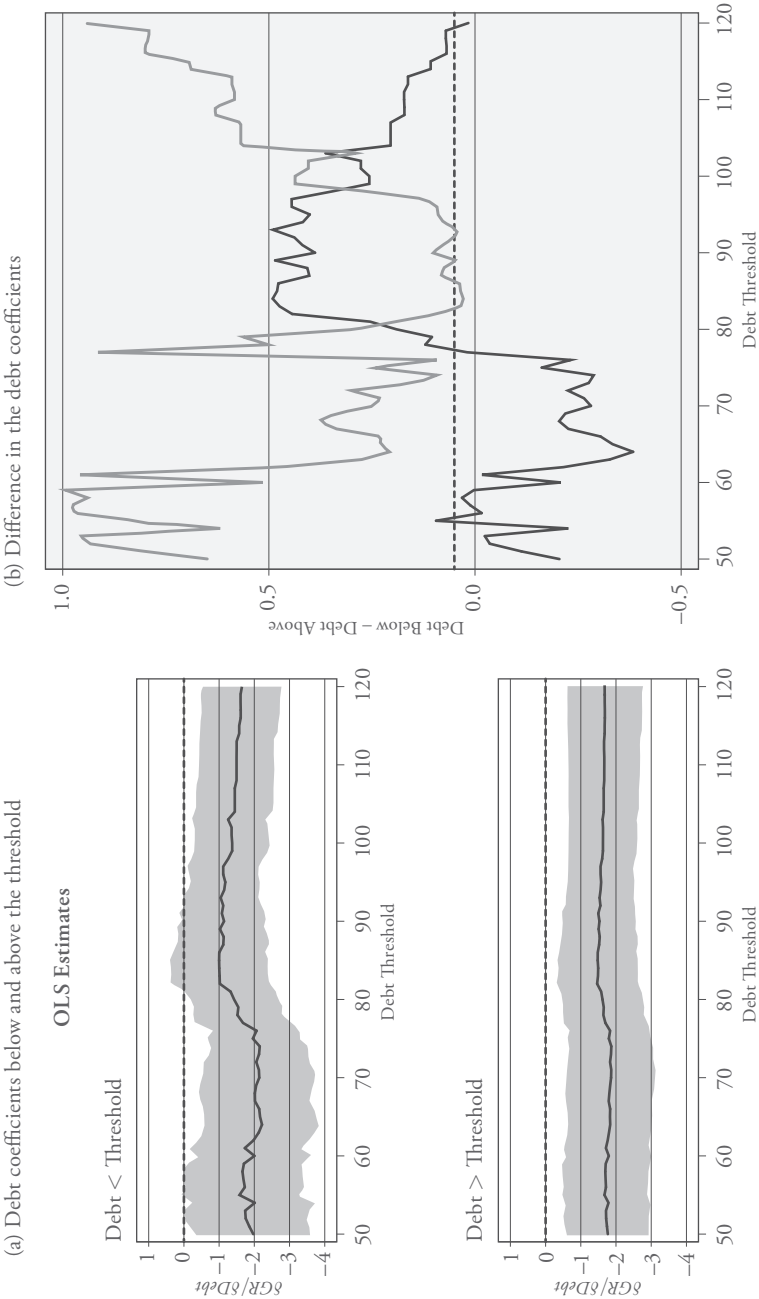
Finally, if non-linearities do exist they might be more complicated than what could be described by a simple one-threshold model. In PANIZZA and PRESBITERO (2012), we estimate and describe the coefficients of β_1 and β_2 for all for $\bar{O} \in (50, 120)$. We find that the point estimates are fairly stable (and often statistically significant), but that the difference between the two coefficients is rarely statistically significant. Moreover, we show that at very high levels of debt the difference between β_1 and β_2 converges to zero (see Figure 2). This puzzling result (which is, however, consistent with the findings of MINEA and PARENT, 2012, and ÉGERT, 2012) casts some doubts on the validity of Equation (6).

ÉGERT (2012) casts further doubts on the presence of a 90 percent threshold. When he looks at non-overlapping multi-year growth episodes for his sample of 20 advanced economies spanning the period 1946–2009, he finds unstable results that generally suggest that the correlation between debt and growth *decreases* when countries move from intermediate to high debt regimes.

As discussed above, standard PTR techniques assume a static model with spherical errors (HANSEN, 1999), two conditions which are not met by the dynamic growth model of Equation (6). BAUM, CHECHERITA-WESTPHAL, and ROTHER (2012) address this issue by identifying their thresholds with a method which is appropriate for dynamic panels (CANER and HANSEN, 2004), and then use these thresholds in a set of standard system GMM regressions. By applying this methodology to 12 euro-area countries over the period 1990–2010, they find a positive correlation between debt and growth when the debt-to-GDP ratio is below 67 percent, no significant correlation when debt is between 67 and 95 percent of GDP, and a negative correlation when debt surpasses 95 percent of GDP. According to the authors, the negative correlation between debt and growth is related to the specificity of the 2008–2010 financial crisis.

KOURTELLOS, STENGOS, and TAN (2012) use the structural threshold regression model developed by KOURTELLOS, STENGOS, and TAN (2011) to estimate

Figure 2: Debt Coefficients in Panel Threshold Regressions



Notes to Figure 2: In panel (a), the solid lines plot the debt coefficients β_1 and β_2 of Equation (6) at different thresholds and the gray areas are within the 95% confidence intervals. In panel (b), the black line plots

$$\left(\frac{\partial GROWTH}{\partial Debt} \mid Debt < Threshold \right) - \left(\frac{\partial GROWTH}{\partial Debt} \mid Debt > Threshold \right).$$

Since $(\partial GROWTH / \partial Debt)$ is always negative, a positive value indicates that the negative effect of debt on growth is larger above the threshold. The gray line plots the p-value for the null hypothesis that

$$\left(\frac{\partial GROWTH}{\partial Debt} \mid Debt < Threshold \right) - \left(\frac{\partial GROWTH}{\partial Debt} \mid Debt > Threshold \right) = 0.$$

The horizontal line is at 0.05. Therefore, whenever the dotted line is above the horizontal line the difference between coefficients is not different from zero at the 5 percent confidence level.

Source: PANIZZA and PRESBITERO (2012, Figures 11 and 12).

an augmented Solow growth model for a sample of 82 countries over three non-overlapping 10-year growth episodes.²⁰ One main contribution of KOURTELLOS, STENGOS, and TAN (2012) is to investigate other threshold variables besides the debt-to-GDP ratio. In this way, they overcome one conceptual problem of the literature that tests the hypothesis of the presence of a debt threshold against the alternative of no threshold. KOURTELLOS, STENGOS, and TAN (2012) correctly point out that the effect of public debt on economic growth could be influenced by variables such as trade openness or institutional quality, and that not accounting for parameter heterogeneity may lead to spurious results.²¹ KOURTELLOS, STENGOS, and TAN (2012) find that the main source of heterogeneity in the debt-growth relationship is the quality of institutions. Specifically, they show that the association between public debt and growth depends on democracy and that higher public debt is correlated with lower growth in the low-democracy regime. The correlation between debt and growth, instead, is not statistically significant in the high-democracy regime.

20 This estimation technique allows for endogenous thresholds and regime specific heteroscedasticity.

21 Looking exclusively at a debt threshold is a peculiarity of the recent studies that focus on public debt in advanced economies. The development literature shows that there are non-linearities in the relationship between external debt and growth that depend on the level of institutional quality (CORDELLA, RICCI, and RUIZ-ARRANZ, 2010; PRESBITERO, 2012).

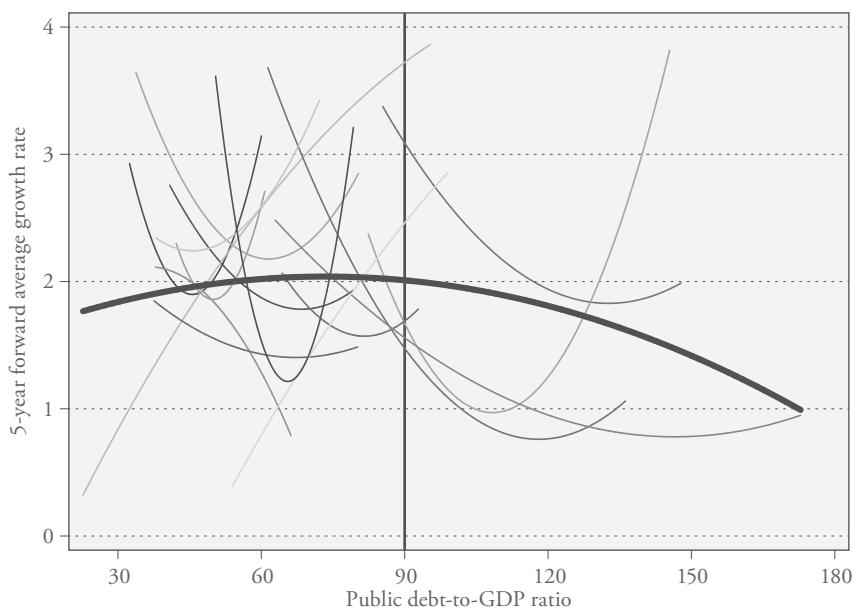
KOURTELLOS, STENGOS, and TAN's (2012) finding that public debt is not a good variable for sample-splitting casts further doubts on the presence of a 90 percent debt threshold. Moreover, all advanced economies included in their sample belong to the high-democracy regime. Therefore, the results of KOURTELLOS, STENGOS, and TAN (2012) suggest that there is no statistically significant relationship between debt and growth in advanced economies.

3.5 *What Can the Data Say?*

Summing up, we think that the case for a debt threshold still needs to be made. The negative relationship between debt and growth and the classic 90 percent threshold are not robust across samples, specifications, and estimation techniques. In particular, there is evidence that the effect of debt depends on the quality of institutions and that its negative effect is confined to non-democratic developing countries (KOURTELLOS, STENGOS, and TAN, 2012). This finding is consistent with the lack of evidence of a causal impact of debt on growth in OECD economies (PANIZZA and PRESBITERO, 2012).

Heterogeneity is important and the aggregate non-linear relationship between debt and subsequent growth may be the result of very diverse country-specific patterns. Figure 3 uses data for 16 OECD countries over the period 1982–2008 to plot the aggregate and country-specific quadratic fits obtained by regressing $GROWTH_{t-(t-5)}$ over $DEBT_{t-5}$. The aggregate data produce an inverted-U curve (the thick line) and a 90 percent threshold. However, the country-specific regressions yield different results. Interestingly, in many countries the relationship between debt and growth is U-shaped and, in some cases, we observe a positive relationship between debt and growth.

Figure 3 suggests that the sample may not be poolable and that researchers should not try to identify common threshold effects across countries. This points to a fallacy of the conventional interpretation of the presence of a debt threshold, which is generally used to argue that if a country raises its public debt-to-GDP ratio above 90 percent, GDP growth will decline. EBERHARDT and PRESBITERO (2013) make a similar argument by studying a larger sample of advanced and developing countries, and showing that there is no evidence of a debt threshold within countries.

Figure 3: The Non-Linearity of the Debt-Growth Relationship

Notes: Calculations based on a sample of 16 OECD countries, for which there are non-missing annual observations on the public debt-to-GDP ratio and the 5-year average forward GDP growth rate. Data and variables are from PANIZZA and PRESBITERO (2012). The thin lines represent the quadratic fit of country-specific yearly data; the thick line represents the quadratic fit of the whole data points. The vertical line has been drawn in correspondence to the 90 percent debt-to-GDP threshold.

4. Which is the Right Measure of Public Debt?

One issue that is rarely discussed in the empirical literature on the relationship between public debt and economic growth relates to the definition of debt itself. In particular, should researchers focus on gross or net debt? Should they concentrate on explicit debt, or also consider the government's implicit liabilities? Should standard measures of public debt also include the expected value of the government's contingent liabilities? These are difficult questions for which we do not have clear answers.

Gross government debt measures the stock of outstanding government debt and net government debt is the difference between gross debt and the financial

assets held by the government. The difference between gross and net debt can be very large. Table 1 shows that at the end of 2012, average gross debt in OECD countries was close to 110 percent of the group's GDP, but net debt was almost 40 percentage points lower than gross debt. The table includes 8 countries for which the difference between gross and net debt is greater than 50 percent of GDP and two countries for which the difference is greater than 100 percent of GDP. Moreover, the table shows that there are 5 OECD countries with positive gross debt but negative net debt (in these countries the government's financial assets are larger than the government's liabilities).

Large differences between net and gross debt are sometimes due to the fact that the government holds a large fraction of its own debt. For instance, some US government debt is held in the US Social Security Trust Fund. Therefore, US statistical sources often mention a measure of debt ("debt held by the public") that nets out these cross-holdings, and it is thus similar to a concept of net debt. In other cases, large difference between gross and net debt are linked to the accumulation of international reserves or sovereign wealth funds.²²

While net debt may seem the best measure government indebtedness, calculating net debt requires a precise evaluation of the government's assets and liability. This is a difficult exercise, full of practical and conceptual challenges.²³ As a consequence, while the definition of gross debt is fairly homogenous across country, each country has its own definition of net debt.²⁴

22 This is the case for the countries with negative net debt in Table 1.

23 EUROSTAT defines net government debt as the government's "financial liabilities minus all financial assets; financial assets of the general government sector have a corresponding liability outside that sector; it is, however, at the government's discretion whether to list monetary gold and special drawing rights, financial assets for which there is no counterpart liability, as financial assets" (see http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:Public_debt).

24 To see the conceptual problems involved in moving from gross to net debt consider the following example: country A, B, and C have the same economic size and the same level of gross debt (say, 100 percent of GDP). The government of country A does not have any financial or real asset. The government of country B does not have any financial asset but owns a profitable toll highway. The net present value of the highway's future profits is equal to 10 percent of country's B GDP. The government of country C used to have a profitable highway, but it sold it and used the privatization revenues (which amounted to ten percent of the country's GDP) to buy liquid financial assets. According to conventional accounting, country A and B have a net debt equal to 100 percent of GDP and country C has net debt of 90 percent of GDP. This does not seem to make much sense because, in terms of net present value, the governments of countries B and C have exactly the same wealth. This line of reasoning leads to the conclusion that when countries compute their net debt they should subtract from their gross debt all of their assets. However, this would be an incredibly difficult exercise, full of arbitrary choices,

Table 1: General Government Debt as Percent of GDP in 2012

	Gross debt	Net debt	Difference
Australia	29.3	7.9	21.4
Austria	83.1	47.9	35.2
Belgium	103.2	82.5	20.6
Canada	85.8	34.9	51.0
Denmark	61.0	7.3	53.7
Finland	62.3	-51.4	113.7
France	105.1	66.4	38.7
Germany	87.6	50.3	37.3
Greece	181.3	145.7	35.6
Iceland	124.7	48.7	76.0
Ireland	123.2	79.9	43.3
Italy	127.0	98.1	28.9
Japan	214.3	134.3	80.0
Luxembourg	29.8	-40.8	70.7
Netherlands	82.5	42.6	39.9
New Zealand	51.3	14.7	36.6
Norway	44.7	-165.3	210.0
Portugal	125.6	82.5	43.0
Spain	93.8	58.0	35.7
Sweden	48.6	-19.9	68.5
Switzerland	39.5	-3.1	42.6
United Kingdom	105.3	73.0	32.3
United States	109.8	86.5	23.3
Euro area	100.6	63.3	37.4
Total OECD	108.7	69.6	39.1

Source: OECD estimates

as most government assets do not have a market value. Also notice that restricting the netting to assets that generate a direct positive cash flow (and could thus be evaluated on the basis of the net present value of this future cash flow) would also be wrong as assets that do not generate cash flow may have an effect of output growth and future tax revenues.

Even netting cross-holdings of public sector bonds by separate public entities, and between national and sub-national governments is not a simple exercise. For instance, COWAN et al. (2006) show that social security reforms can have very large effects on debt ratios even when they have no effect whatsoever on government net assets.

While net debt is usually much lower than gross debt, measures of debt that include the government's future implicit liabilities would yield much higher debt ratios. HAGIST et al. (2009) estimate the net present value of future government liabilities and revenues and use the difference between the net present value of future liabilities and revenues to build a measure of implicit government debt. Their calculations suggest that the total debt-to-GDP ratio is often twice as large as gross debt and, in some cases, more than five times the level of the explicit debt-to-GDP ratio (see Table 2).

Table 2: Gross and Implicit Debt in 2004 (as Percent of GDP)

	Gross debt	Implicit debt	Total debt	Total over gross
Spain	45.4	35.4	80.8	1.78
Switzerland	55.2	64.8	120.0	2.17
Austria	62.8	179.9	242.7	3.86
Germany	62.5	252.6	315.1	5.04
France	60.4	254.9	315.3	5.22
United States	57.1	350.8	407.9	7.14
Norway	40.6	250.8	291.4	7.18
United Kingdom	37.2	510	547.2	14.71

Source: HAGIST et al. (2009).

Table 2 illustrates another problem with the calculations of standard debt-to-GDP ratio figures. According to the gross and total debt figures reported by HAGIST et al. (2009), in 2004 Spain did not seem to have a debt sustainability problem. In fact, Spain was the country with the lowest total debt. The situation looks very different right now (see Table 1). The fact that Spain is at the epicenter of the European debt crisis suggests that, in a perfect world, debt statistics should also include government guarantees and the expected value of contingent liabilities.²⁵

25 CAMPOS, JAIMOVICH, and PANIZZA (2006) show that sudden debt explosions are often caused by factors that are completely unrelated to fiscal policy.

Another issue relates to valuation effects. DIPPELSMAN, DZIOBEK, and GUTIÉRREZ MANGAS (2012, p. 15) ask the following question: “Did Greece’s debt rise by approximately 10 percent between 2009 and 2010 or did it fall by 10 percent?” Next, they show that both answers are true, as the face value of Greek debt was increasing while its market value was decreasing. What figure should researchers use? This is a very important question, especially when countries issue securities below or above par (consider the case of a country that only issues long-dated zero-coupon bonds).

Finally, there is the issue of institutional coverage. Should we focus on central government debt or on general government debt, including debt issued by local governments? DIPPELSMAN, DZIOBEK, and GUTIÉRREZ MANGAS (2012) conduct an exercise for Canada and show that, depending on the level of aggregation, in 2010 the Canadian debt-to-GDP ratio ranged between 38 and 104 percent. This is an enormous range. DIPPELSMAN, DZIOBEK, and GUTIÉRREZ MANGAS (2012) suggest that headline indicators should focus on the broader concept of gross debt (the concept that, in the case of Canada, finds that debt is 104 percent of GDP). However, very few countries report the data necessary to compute this broad measure of debt.

Since net debt is hard to compute and rarely comparable across countries, most papers that study the relationship between debt and growth use gross debt, even if this measure of debt is not a good indicator of the government’s financial situation.²⁶ Moreover, even data on gross debt are not strictly comparable, as definitions of government vary across countries. Finally, it is now recognized that vulnerabilities depend on both debt levels and debt composition (see, for instance, INTER-AMERICAN DEVELOPMENT BANK, 2006), and, unfortunately, it is very hard to find cross-country data on the composition of public debt in advanced and developing economies.

26 One reason for focusing on gross debt has to do with the fact that the government needs to refinance all of its debt. Large refinancing needs may erode investors’ confidence and ignite a vicious circle which could ultimately lead to a debt crisis.

5. Conclusions

The global recession and the European sovereign debt crisis have stimulated an intense debate about the effectiveness of fiscal policy and the consequences of rising government debt. Some economists and commentators suggest that this is the right time to apply the lessons learned during the great depression and that countries should not shy away from expansionary fiscal policy (see, among others, KRUGMAN, 2011; DELONG and SUMMERS, 2012). Other economists argue that high levels of public debt have a negative effect on economic growth and that fiscal consolidation is necessary to anchor expectations and restore confidence (COCHRANE, 2011b). This latter view, which is distilled in the IMF summary of a 2013 AEA session on sovereign debt mentioned in the introduction, is in line with a series of empirical papers that found a negative association between debt accumulation and economic growth.

In this paper, we survey the theoretical and empirical literature that studies the relationship between public debt and economic growth in advanced economies. We conclude that the case for a causal effect running from high debt to low growth still needs to be made. Apart from causality issues, we also show that the evidence of a common debt threshold above which growth collapses is far from being robust.

Our findings should not be interpreted as suggesting that debt accumulation is not a relevant policy issue or that high debt levels are not a serious problem. First of all, stating that there is no evidence that debt has an effect on economic growth is different from stating that there is evidence that debt has no effect on economic growth. Second, there are different ways through which a large public debt may harm the economy. In PANIZZA and PRESBITERO (2012), we suggest that a fully solvent government with a high level of debt may decide to put in place restrictive fiscal policies to reduce the probability that a sudden change in investors sentiments would push the country towards a bad equilibrium. These policies, in turn, may reduce growth (JARAMILLO and COTTARELLI, 2012; PEROTTI, 2012), especially if implemented during a recession. In this case, it would be true that debt reduces growth, but only because high levels of debt lead to contractionary policies. While such an interpretation would justify long-term policies aimed at reducing debt levels, it also implies that countries should not implement restrictive policies in the middle of a crisis (DELONG and SUMMERS, 2012).

In our view, future research on the links between public debt and economic growth should focus on cross-country heterogeneity and on the mechanisms and transmission channels through which public debt may hinder economic growth. Addressing the latter point would require a unified theory aimed at explaining

under what conditions and through which mechanisms debt may reduce economic growth.

The relationship between debt and growth is characterized by large cross country heterogeneity (Figure 3) and may also vary over time within countries. The way in which debt affects growth may depend on institutional quality, on the dimension of the public sector, on how and why debt has been accumulated, and on the structure and composition of public debt (INTER-AMERICAN DEVELOPMENT BANK, 2006).²⁷

Cross-country heterogeneity may lead to large biases in the estimated relationship between debt and growth. New panel time series econometric techniques allow moving beyond simple interactive effects and sample splitting and dealing explicitly with a variety of issues related to unobserved heterogeneity and cross-section dependence. EBERHARDT and PRESBITERO (2013) apply these techniques to estimate the relationship between debt and growth in a large sample of advanced and developing countries. By disentangle short-run and long-run effects and allowing for the presence of non-linearities and asymmetric effects of public debt on growth, EBERHARDT and PRESBITERO's (2012) findings cast several doubts on the pooled model approach used by the majority of the papers that study the empirical relationship between debt and growth.

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27 The average maturity and the relative share of domestic and foreign holders may influence refinancing risk (ARSLANALP and TSUDA, 2012) and the overall perceived sustainability of debt, affecting interest rates and, ultimately, GDP growth. So far, analysis in this direction has been constrained by lack of detailed data on debt structure. However, data availability is now improving (see, for instance, MAURO et al. (2013) and the International Financial Institutions are working towards building comprehensive dataset on debt levels and structure (see, for instance, the Public Sector Debt Statistics (PSD) database, jointly developed by the World Bank and the International Monetary Fund, at: <http://go.worldbank.org/9PIAZORON0>).

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SUMMARY

This paper surveys the recent literature on the links between public debt and economic growth in advanced economies. We find that theoretical models yield ambiguous results. Whether high levels of public debt have a negative effect on long-run growth is thus an empirical question. While many papers have found a negative correlation between debt and growth, our reading of the empirical literature is that there is no paper that can make a strong case for a causal relationship going from debt to economic growth. We also find that the presence of thresholds and, more in general, of a non-monotone relationship between debt and growth is not robust to small changes in data coverage and empirical techniques. We conclude with a discussion of the challenges involved in measuring and defining public debt and some suggestions for future research which, in our view, should emphasize cross-country heterogeneity.