Even worse than you thought: The impact of government debt on aggregate investment and productivity

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Abstract

In this paper, we empirically assess the impact of government debt on two key determinants of long-term growth, i.e., private investment and productivity, on a panel of 20 OECD economies from 1970 to 2009. Our main finding is that high public debts are followed by significant and linear declines of both aggregate investment spending and productivity growth. Our analysis also finds evidence supporting conditional convergence of productivity growth among OECD countries.

Keywords: Government debt, economic growth, investment, productivity.
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1 Introduction

The historical record on government debt is one of ample variability, cross-sectionally and over time. Both emerging and developed economies have repeatedly experienced large fiscal expansions (especially, but not only, during wartime periods), often ending in costly debt restructuring or outright default, as eloquently documented by Reinhart and Rogoff (2009, 2010, 2011). The budgetary consequences of the 2007-2009 crisis, the current turmoil in European sovereign debt markets and the effects of age-related increases in government liabilities, have all re-focused attention towards the prospects of mature economies. For instance, Cecchetti et al. (2010) compute fiscal projections over the coming decades, factoring in some of these effects. They conclude (p. iii): "the path pursued by fiscal authorities in a number of industrial countries is unsustainable. Drastic measures are necessary to check the rapid growth of current and future liabilities of governments and reduce their adverse consequences for long-term growth and monetary stability".

Reinhart and Rogoff (2010, 2011) provide cross-country evidence revealing that real GDP growth is slower in economies whose government debt/GDP ratio is above 90%. However, since this result refers to simple correlations between the debt burden and GDP growth, it cannot account for other potentially relevant factors, for reverse causality (low growth can generate high debt), and for the influence of debt on the determinants of growth. To shed light on these issues, in this paper we analyze the impact of government debt on two key drivers of economic growth, i.e., capital accumulation and productivity growth, across a panel of 20 OECD economies from 1970 to 2009. We gather evidence on the direct effects of the stock of public debt on private investment and labour productivity growth, in a cross-country perspective. In principle, the impact of fiscal policies on the economy may be significant only following highly persistent fiscal imbalances. Therefore, we investigate the effects of government debt, rather than those of deficit/surplus dynamics more common in the literature, although we control for the budget balance in one of our empirical specifications.

We study the relationship between debt and investment and productivity, as opposed to GDP growth, for several additional reasons. First, with fiscal imbalances measured by the government debt/GDP ratio, using the rate of growth of GDP as a dependent variable would certainly introduce measurement issues and collinearity biases. Second, economic theory, as well as some empirical evidence, place great emphasis on capital accumulation and productivity as proximate causes/determinants of long-term growth (Acemoglu, 2009; Bonfiglioli, 2008). Finally, although attempts to

explain the dynamics of productivity are pervasive in the growth literature (Durlauf et al., 2005), the possible long-term implications of fiscal imbalances have so far received relatively scant attention. The primary aim of this investigation is to measure the impact of government debt, but our econometric results can be interpreted as estimates of a conditional convergence model.

We gauge the effects of government debt on investment and productivity by estimating reduced-form regressions, and by adopting a panel-data perspective. This permits to exploit both the time and cross-country dimensions of the marked variation in the level of debt experienced by advanced economies over the past decades, thus maximizing the informational content of the annual frequency with which time series of fiscal data are typically collected, or are consistently available over long periods.

Our main result is that high debt levels are associated with significant and sizeable declines of aggregate private spending on investment and of productivity growth. We estimate the elasticity of investment to the debt/GDP level to be -0.25, while a 30% difference in the debt/GDP levels can account for 0.26% lower annual productivity growth. Both effects are not only highly statistically significant, but also economically important. These adverse effects do not seem to be nonlinear, as we do not detect any asymmetry despite estimating several alternative specifications of the baseline model, and not even with the use of an endogenous threshold approach (Hansen 1999, 2000).

The remainder of the paper is organized as follows. Section 2 discusses the theoretical background motivating our analysis and briefly reviews the existing empirical literature. Section 3 sets out the empirical strategy of our investigation. In Section 4 we present estimation results and test for the presence of nonlinearities. Section 5 concludes.

2 Theoretical considerations and previous literature

The impact of fiscal policies on macroeconomic performance traces its academic interest back to two theoretical views. The vast majority of studies stem from the claim by endogenous growth theory that taxation and government spending can have permanent effects on economic growth, whereas according to a neoclassical perspective they should only have level effects (Barro, 1990; Baxter and King, 1993; Ludvigson, 1996; Sutherland, 1997; Engen and Hubbard, 2004). Empirical analyses in this latter strand mostly focus on the effects of either government deficits or their components like

spending and tax revenues (e.g. Muinelo-Gallo and Roca Sagalés, 2011). On the other hand, several micro-founded general equilibrium models tend to place more emphasis on the stock of government debt, and related empirical studies analyse its impact almost exclusively on interest rates (e.g., Muhleisen and Towe, 2004; Ardagna et al., 2007). Overall, the existing empirical literature is relatively thin on the extent to which large debts interact with potential growth. We think that this is, at least partly, down to measurement issues inherent with fiscal data, but also to most contributions being prevalently focused on a short-to-medium-term perspective.

In generale, large fiscal imbalances are thought to adversely affect the economy essentially through the build-up of distortions in capital and labour markets that pull the economy away from the steady-state growth path. This can take place through several channels, such as higher long-term interest rates, future distortionary taxation, and higher inflation and macroeconomic volatility. Barro-Ricardian effects (Barro, 1990; Baxter and King, 1993), real business cycle theory and to some extent also New Keynesian models, all imply null – or modest – effects of debt-financed fiscal shocks on output. This is largely due to their adverse impact on consumption, because of intertemporal smoothing and the ensuing Ricardian effects, which offset the positive response of consumption to a fiscal expansion in traditional Keynesian theory. Well-known contributions (see Barro, 1990; Baxter and King, 1993; Elmendorf and Mankiw, 1999; Auerbach and Gale, 2009) claim that higher spending, taxes and deficits all trigger biases in real-wage settings and expectation formation, as well as distortions in labour supply. In addition, high levels of outstanding government debt may put upward pressure on both interest rates and risk premia on investment opportunities. This is the basis for the well-known crowding-out effect on private investment and consumption choices.

At a first approximation, it should make little difference whether one evaluates the impact of fiscal imbalances by studying flow quantities like spending, taxation and deficits, or by focusing on debt. Standard present-value accounting of government debt and deficits implies that the current (nominal) value of government liabilities equals the present (expected discounted) value of all future surpluses (Sargent and Wallace, 1981; Cochrane, 2011). However, even under Ricardian equivalence, with low discount (interest) and inflation rates, stable but high debt/GDP levels may coexist with moderate government deficits and even with sizeable but temporary primary surpluses. In fact, this seems to have occurred over the past two decades in some advanced economies such as Japan, Italy and Belgium. Therefore, using deficits and their components in

regressions of economic growth indicators on fiscal imbalances might end up blurring the real long-term impact of fiscal policies.

Indeed, studies attempting to uncover the transmission of government debt shocks onto the level of interest rates (see among others Ardagna et al., 2007) often find weak or outright insignificant reactions. There are several possible explanations for the weak evidence on the effects of high debt on bond yields and, in turn, on the crowding-out of private investment. First, expansionary fiscal policy is often accompanied by accommodative monetary policies, which lower interest rates and therefore dampen their estimated response to the fiscal shock (see Muscatelli et al. 2004). Second, mean-variance portfolio theory argues that investors select securities based on portfolio risk-return considerations. The demand for government securities is driven, at least partly, by the perception of their risk-free status, rather than simply by their return, whose response to sizeable but not extreme fiscal shocks might even be muted. Finally, financial market participants use government bonds as collateral to obtain funding, and, particularly at low interest rates, they might also prize their liquidity properties. All of the above effects could soften the (expected positive) correlation between government debt and interest rates, therefore making it hard to detect this channel in the transmission of fiscal shocks to long-term growth.

Recently, a few analyses of the direct effects of debt on growth have emerged. In a comprehensive study of advanced and emerging economies, Kumar and Woo (2010) find an inverse relationship between debt and GDP growth, controlling for reverse causality and endogeneity. There is also some evidence of nonlinearity, with higher levels of initial debt having a larger negative effect on subsequent growth. In a growth accounting exercise based on their estimates, the authors also find that the adverse impact would largely reflect a slowdown in labour productivity growth, mainly due to slower growth of the capital stock. Checherita and Rother (2010) too detect, in a sample of twelve euro-area countries, a nonlinear impact of debt on per-capita GDP growth, whereas Afonso and Jalles (2011) find that the debt-to-GDP ratio has a negative impact on the growth of GDP, TFP, and capital per worker, with differentiated impacts across emerging and mature economies.

3 Models and data

The empirical investigation in this paper departs from the existing literature along several dimensions. First, as there is substantial evidence that both the growth dynamics

and the fiscal trajectories of emerging countries differ from those experienced by mature economies, here we focus on a group of twenty OECD countries. Furthermore, we believe it appropriate to extend the sample beyond euro-area and European economies. The time interval covered by our annual data spans long-term developments such as the productivity slowdown of the 1970s, its revival in the late 1990s and 2000s, the opening-up of economies to international competition as well as the run-up to, and early phases of, the current financial and fiscal crises. Finally, we study the impact of government debt on investment and productivity growth through the estimation of comprehensive models whose conditional-convergence forms significantly depart from most existing studies (see for instance Kumar and Woo, 2010; Checherita and Rother, 2010; Afonso and Jalles, 2011).

We rely on the following specification to investigate the effects of debt on investment:

$$privinv_{i,[t,t+4]} = \alpha_1 debt_{i,t} + \alpha_2 prof_{i,t} + \beta_{inv} capstock_{i,t} + \boldsymbol{\delta}\mathbf{W}_{i,t} + \xi_t + \eta_i + \varepsilon_{i,t} \quad (1)$$

For each country i, $privinv_{[t,t+4]}$ denotes the five-year average of real expenditure on investment (gross fixed capital formation of the private sector)[1] between year t and $t+4$, in logarithms; $debt_t$ is the gross government debt/GDP ratio at the beginning of the five-year period (t - the same goes for every right-hand-side variable); $prof_t$ is the logarithm of real business profits (gross operating surplus); $capstock_t$ is the logarithm of the real stock of capital of the economy. $\mathbf{W}_t$ is a vector of control variables, including: the long-term interest rate ($ltrate_t$); trade openness ($open_t$, measured as imports plus exports over GDP); the population growth rate ($popgr_t$); a proxy for the level of financial market depth (private credit over GDP[2], $findevt_t$); the CPI inflation rate ($infl_t$). Country and time fixed effects are included (η_i and ξ_t, respectively), while $\varepsilon_{i,t}$ is a disturbance term.

Textbook accounts of the demand for investment motivate the presence of interest rates (proxying for the rental cost of capital and the remuneration of risk) and profits among the regressors. All other variables find their way in the model because of their explanatory power either in theoretical explanations of the process of capital

[1] The use of a series that includes public investment does not alter our main findings. However, in the light of the theoretical considerations in the previous section, we think it more appropriate to employ private investment only.

[2] Using a proxy for financial integration (sum of foreign assets and liabilities over GDP: finint) instead of financial development does not alter the results. The same applies to the productivity model below.

accumulation (in the cases of profits and population growth; see Acemoglu, 2009) or in existing empirical studies (trade openness, financial development, inflation; see Yanikkaya, 2003; Dreher, 2006; and Barro, 1995, respectively). We insert all the above variables jointly as regressors also to pin down the marginal power of the correlations with the dependent variable.

The coefficient on the capital stock can be interpreted in terms of conditional convergence. We do not have definite priors for it, because a negative coefficient would imply convergence in investment levels across developed economies, a phenomenon that has not been extensively studied in the literature. Furthermore, we expect a negative coefficient for interest rates, inflation and population growth, and a positive one for trade openness, financial development and profits. The potential negative impact of debt on investment is the focus of the empirical analysis. We include the deficit/GDP ratio ($deficit_t$) in the vector of controls in a further specification to account for the possible effects of this policy variable[3].

We employ a different model to study the effects of debt on productivity, taking as a starting point the rich growth literature based on regressions of productivity on an array of potential determinants. Typically, contributions employ either total factor or labour productivity. However, computed parameter estimates tend to exhibit excess sensitivity to conditioning variables, or to minor changes to the econometric specification. Consequently, the usefulness of those regressions and of TFP as an appropriate measure of productivity has often been questioned (Durlauf et al., 2005). Based on this evidence, we estimate the following model:

$$prodgr_{i,[t,t+4]} = \varphi_1 debt_{i,t} + \varphi_2 capstock_{i,t} + \varphi_3 educ_{i,t} + \beta_{prodgr} gdphw_{i,t} + \boldsymbol{\theta}\mathbf{W}_{i,t} + \psi_t + \omega_i + \nu_{i,t} \tag{2}$$

in which $prodgr_{[t,t+4]}$ denotes the five-year average of the growth rate of real GDP per hour worked; $capstock_t$ is the logarithm of the real stock of capital in the economy; $educ_t$ is human capital (measured by the log of average years of secondary schooling in the population over age 15 in the initial year, taken from Barro and Lee, 2000); $gdphw_t$ is the logarithm of real GDP per hour worked. $\mathbf{W}_t$ is the same vector of control variables as in equation (1). Again, country and time fixed effects are allowed for.

[3]The literature offers a few examples of models where both debt and deficit have been included at the same time as explanatory variables in various contexts (see Ardagna et al., 2007; Faini, 2006; Bernoth et al., 2004). In the light of this, our findings for this specification are, if anything, to somewhat understate the impact of debt.

In line with basic growth theory (Acemoglu, 2009; Durlauf et al., 2005), we expect a positive coefficient on the capital stock and a positive one on openness and financial development. We also expect results to be compatible with the idea of conditional convergence (i.e., we expect β_{prodgr} to be negative), as in the existing empirical literature on the issue (e.g., Van Biesebroeck, 2009). However, there is no similar consensus as to the coefficient signs for all remaining variables. For instance, while higher education in principle should foster productivity, there is substantial evidence that in advanced countries its effect could be muted or even adverse, according to a notion of diminishing returns to both physical and human capital (Miller and Upadhyay, 2000). As with the investment model, we report the results of an alternative specification where the deficit/GDP ratio is included in the controls' vector.

Concerning estimation, several approaches are in principle available: pooled OLS, between estimator (BE), fixed effects (FE), and system GMM dynamic panel regressions. Since the relationship between government debt and growth is likely to be affected by multiple sources of bias, each methodology implies a trade-off between parameterization and robustness. We choose to estimate our baseline models via panel fixed effects estimation on five-year non-overlapping periods: 1970-1974, 1975-1979, etc., up to 2005-2009 (8 in total). The use of five-year periods to analyze panel data is standard in the macroeconomic literature (see e.g. Aizenman and Sushko, 2011), and particularly in the study of economic growth (Durlauf et al., 2005; see also Bonfiglioli, 2008; Demirguc-Kunt and Levine, 2008), not least because of widespread concerns related to nonstationarity and cointegration in a panel context. By regressing the dependent variable expressed as a five-year average on the initial-period values of government debt and the remaining explanatory variables (as in Barro and Lee, 2005; Furceri and Zdzienicka, 2011), the methodology permits to tackle the reverse causality issue, and it is also a convenient way to smooth out business cycle fluctuations. These advantages come at the cost of making it harder to detect possible asymmetric effects in the relationship between debt and our dependent variables, precisely because of the smoothing. We deal with this drawback by estimating four specifications alternative to the baseline (one including the squared level of debt, three with different threshold dummies interacted with the debt level) and, more importantly, by performing a threshold analysis based on an endogenous threshold model (Hansen, 1999, 2000), on annual data.

We employ data for 20 OECD countries (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, the Netherlands,

Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, the USA). Government debt data are from the IMF's World Economic Outlook and Historical Public Debt databases. Details on the construction and the sources of the variables are in the Data Appendix. Table 1 contains some descriptive statistics of the variables used in this part of our analysis.

For a very preliminary glance at the phenomena of interest, Figure 1 shows the average growth rate of real per capita GDP (top panel), the average investment growth rate (middle panel) and the average growth rate of real GDP per hour worked (bottom panel), for different levels of the government debt/GDP ratio[4]. The thresholds here are chosen to mimic those used by Reinhart and Rogoff (2010) for a wider and longer dataset. Higher levels of debt are clearly associated with slower rates of growth of per capita GDP and productivity, as well as with weaker capital accumulation. For instance, a debt/GDP ratio higher than 90% is on average associated with productivity growth slower by about 1.5 percentage points compared with a below-30% debt ratio. A similar effect is at work for investment spending and growth of GDP per capita. As to the latter, Reinhart and Rogoff (2010) detect a significant association only for above-90% debt/GDP ratios, whereas our chart captures a seemingly linear negative relationship. This divergence is easily explained by the different countries and years considered in the samples. However, simple contemporaneous correlations do not allow to derive meaningful inferences as to the significance, shape (whether linear or not), and direction of causality of the relationship among the variables. We turn to the econometric analysis in the next section to shed light on these and other important issues, like possible asymmetric effects of debt on macroeconomic performance.

4 Estimates

4.1 Private investment

Table 2 contains our estimates of a few alternative specifications of equation (1). The first column reports results for the baseline model; the second to the fifth columns show results for specifications that deal with possible nonlinearities in the relationship between government debt and investment; the last column reports the alternative specification in which deficit is among the controls.

[4]We plot the growth rate of investment, in place of the level of investment spending that we use in the estimation, for illustration purposes only.

Across all specifications, debt/GDP ratios, initial levels of the capital stock, population growth and the long-term interest rate are the regressors most closely associated with investment spending. In the baseline specification, estimates suggest that there is a strong and significant negative effect of government debt on investment. Its impact can be quantified by the semi-elasticity of investment with respect to debt (computed by multiplying the estimated coefficient by 100, being this a log-level model), equal to -0.25. This negative effect is highly significant and confirms the intuition based on the graphical evidence of the previous Section. Interestingly, it is fully confirmed in the alternative specification including the deficit/GDP ratio (see the last column of Table 2). Overall, the evidence provides more circumstantiated support to claims of a negative effect of debt on macroeconomic performance than what found in the existing evidence based on GDP growth (Reinhart and Rogoff, 2010; Checherita and Rother, 2010; Kumar and Woo, 2010; Afonso and Jalles, 2011)[5].

Turning to the convergence issue, as the estimated coefficient on the capital stock turns out positive, there seems to be no conditional convergence of private investment spending among the OECD countries of our sample. The estimates for the remaining controls offer additional interesting insights. In particular, the long-term interest rate is negatively related to investment, as suggested by standard theoretical models. On the other hand, profits (an aggregate measure of the return on capital) exhibit the expected positive coefficient, but it is not statistically significant at standard levels. Lastly, population growth is positively associated with investment, with a highly significant coefficient. None of the above results is altered by the inclusion of deficit as an additional explanatory variable.

The baseline specification posits the marginal effects of government debt to be constant at any level of the debt/GDP ratio, contrary to the widespread notion and some evidence that the negative effects of debt on macroeconomic performance are significant and increasing only above certain thresholds, like 30%, 60% or 90% of the debt/GDP ratio. Here we deal with this possibility by estimating several alternative specifications of the baseline model with additional terms meant to capture possible nonlinearities[6]. The second to the fifth columns of results in Table 2 report estimates for four alternative specifications of the model. The second column details results for a model that adds the squared level of the debt/GDP ratio: its estimated coefficient

[5] Alesina et al. (2002) find an adverse effect on investment very similar to ours in the context of regressions based on government spending and tax revenues rather than debt.

[6] As a further check, in subsection 4.3 we adopt the endogenous threshold approach for panel estimation envisaged by Hansen (1999, 2000).

is small and statistically not different from zero. Therefore, this simple modification does not support nonlinear effects of government debt on investment. The next three specifications include an interaction term between *debt* and a dummy assuming the value of 1 when that ratio is above a certain threshold (third, fourth, and fifth column for 30%, 60%, and 90% thresholds, respectively), and zero elsewhere. As can be seen, there is no evidence of a nonlinear relationship between *debt* and investment neither at 60% nor at 90%, as the interaction terms are not statistically different from zero at standard levels (only the 60% interaction term is barely different from zero at the 10% level). These findings are consistent with results reported by Checherita and Rother (2010) for the euro area. As for the 30% threshold, it seems that the interaction term captures the adverse effect on investment better than the *debt* variable does, possibly suggesting negative effects for debt levels above 30% only. However, this simple way of accounting for nonlinearities is not flawless, because of the arbitrary definition of thresholds, their possible multiplicity and the use of data smoothed over five-year periods. This is why we rely more on the results of the endogenous-threshold procedure illustrated in section 4.3 below.

4.2 Productivity growth

Table 3 reports estimates of the productivity model of equation (2). Columns are organized the same way as Table 2, referring first to the baseline model, then to the four alternative equations accounting for nonlinear effects of debt, and finally to the specification including the deficit.

The baseline results reveal a significant and sizeable negative effect of government debt on productivity growth. In particular, a 30% difference in the debt/GDP ratio can explain a subsequent deceleration of productivity growth by 0.26% per year (note that the average growth rate in the sample is 2.23%). With persistently diverging debt levels, the resulting differences in productivity can become markedly relevant. Italy, Belgium, Greece and Portugal seem to offer a neat narrative supporting our empirical result. The very high debt levels in those countries (essentially all above 100% of GDP since the early 1990s) are notoriously coupled with a poor productivity performance over the same time span (Mas et al. 2008). As for the results of the investment model, our estimates indirectly bear out existing evidence of an adverse impact of debt on GDP growth. Since productivity growth is a prime driver of long-term economic growth and it is often utilized to measure macroeconomic performance, our results appear to be

particularly valuable[7].

There are other interesting insights emerging from our baseline estimates. The negative coefficient associated with the initial level of real GDP per hours worked suggests that conditional convergence in the case of productivity is indeed at work. We also detect significant negative effects of inflation, and a positive relationship with the capital stock level. Once again, the inclusion of deficit/GDP ratios (last column of Table 3) does not alter our main conclusions, although in this case it does affect the statistical significance of the coefficients on the capital stock and population growth.

With respect to possible nonlinearities in the debt-productivity relationship, Table 3 reports the results of four alternative variants of the baseline model. The second column shows that the coefficient associated with the squared level of *debt* is zero, pointing to a linear effect on productivity growth. Results in the third, fourth and fifth columns support this finding, as the coefficients of the debt interaction terms in each of these three alternative specifications are also equal to zero. In this case, our results depart from those by Checherita and Rother (2010), who find evidence of a concave relationship between debt and productivity. Besides methodological issues, there are important differences to take into account: first, the authors employ annual data and focus on total factor productivity; second, their sample is limited to euro-area countries.

4.3 Threshold effects and robustness checks

Reinhart and Rogoff (2010) provide descriptive cross-country evidence that economies with a government debt/GDP ratio above 90% exhibit GDP growth significantly lower than less indebted countries. Similar regularities emerge in Afonso and Jalles (2011), but their estimates too are based on a *ad hoc* 60% threshold. As a final step devoted to investigate the presence of nonlinearities, we follow Hansen (1999, 2000) and apply his endogenous threshold approach.

Hansen's method is developed for non-dynamic panels with individual-specific fixed effects. The algorithm allows sequential testing of the null of m thresholds versus the alternative hypothesis of $m + 1$ thresholds, for $m = 1, 2, \ldots, K$. We set $K = 5$, but found that a triple threshold model fares best according to standard goodness-of-fit

[7] Of course, we are aware of the risk that the relationship we find is the result of persistent poor growth driving fiscal imbalances, rather than the other way round. However, we believe that our inference is robust thanks to the adoption of a long-term perspective, our focus on debt in place of deficits, and the use of five-year averages for the dependent variable and initial-period values for the regressors.

criteria. Following least-squares estimation of the coefficients and thresholds, non-standard asymptotic inference permits the determination of confidence regions and test of hypotheses. The relatively small number of five-year observations (160) does not allow consistent estimation; therefore, we switch to the annual frequency, finding evidence broadly consistent with our baseline specification[8].

Table 4 shows the test statistics and their bootstrapped p-values, whereas Table 5 reports the point estimates of the thresholds for the most significant model, alongside their asymptotic 95% confidence intervals. The test for a single threshold turns out as not significant in the models for both investment and productivity, with bootstrapped p-values well above 0.05. The test for a double threshold is marginally significant for productivity only, with a bootstrapped p-value of 0.07. The validity of a triple threshold is rejected for both models. Therefore, there is only very weak evidence that the estimated adverse effects of higher debt/GDP ratios operate according to a double threshold specification on productivity growth; there is no trace of such an effect at work for investment spending.

Erring a little on the side of a nonlinear response, the point estimates of the thresholds for the productivity model are 35.96 and 71.46. This latter value is higher than the sample average of the government debt/GDP ratio. The asymptotic confidence interval, however, is very wide, indicating substantial uncertainty as to the level of this threshold (see Kahn and Senhadji, 2000). We conclude overall that there is no or very weak evidence supporting the presence of thresholds in the relationships between government debt and investment and productivity. This result is in line with some of the previous literature, such as Afonso and Jalles (2011).

5 Conclusions

Lately, there has been a surge of interest in the implications of high public debt levels. Relative to existing studies, this paper provides new and less coarse evidence on the long-term impact of public debt, by focusing on two key determinants of economic growth, namely investment and productivity. Our cross-country analysis, based on data covering the 1970-2009 period for 20 OECD economies, shows that rising public debt levels are associated with significant declines of private spending on investment and with lower rates of productivity growth. Our methodology and the use of five-year periods permit to overcome reverse causality issues and neutralize the effects of

[8] Full results are available upon request.

business cycle fluctuations on estimates. The adverse effects of debt seem to be linear, as the estimation of several alternative specifications of the baseline model and of an endogenous threshold model yield no or very little evidence of asymmetry.

Our results provide underpinnings to the notion that high debt levels have adverse effects on the dynamics of productivity and investment spending, which in turn have well-known bearings on long-term growth. This crucial effect would have not shown up had we employed, as in most of the literature, budget deficits or narrative approaches to identify major fiscal policy changes. Some straightforward policy implications ensue. First, economic growth following marked expansions of government debt is likely to be sluggish, at least partly as a result of the slower dynamics of investment spending and productivity that our exercise helps to uncover. Second, high debt implies much narrower room for stabilization purposes, but likely for growth-enhancing government policies as well. The cost of high debt in advanced countries should therefore be evaluated in the light of these severe and complex long-term consequences.

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Figure 1
Average growth rates of investment and productivity

The charts plot the average growth rate of real per capita GDP (top panel), the average investment growth rate (middle panel) and the average growth rate of real GDP per hour worked (bottom panel), for different levels of the government debt/GDP ratio.

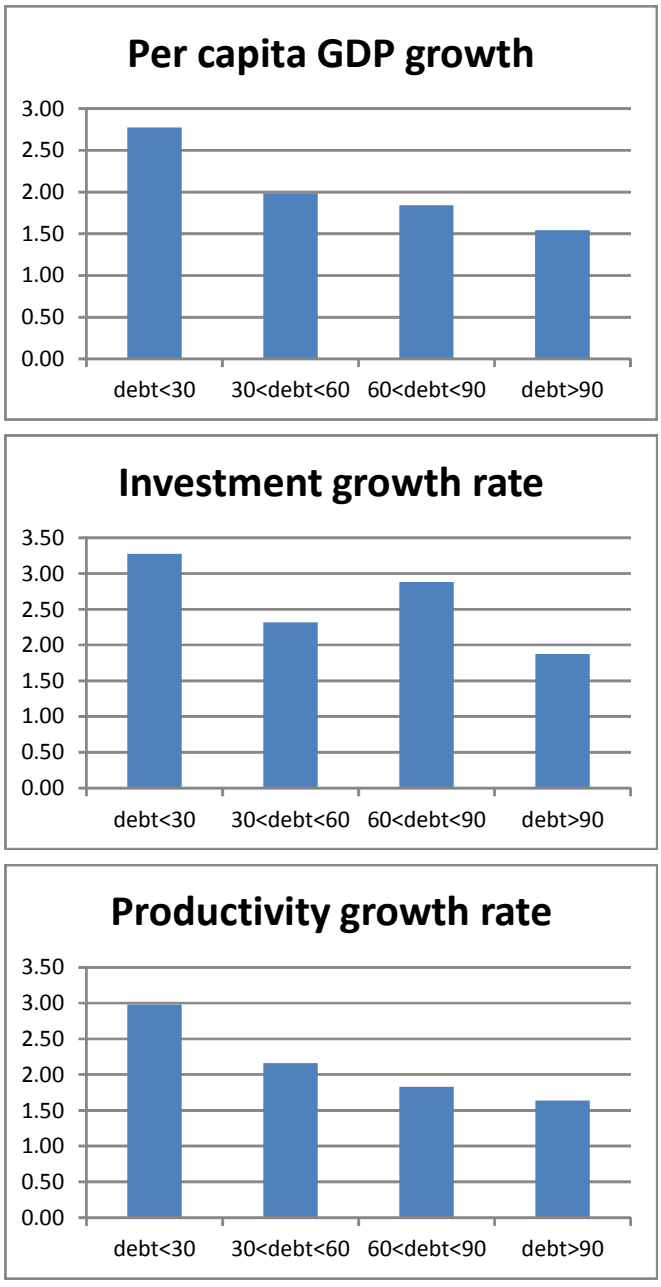

Table 1 - Summary statistics

Note: $T = 8$ non-overlapping five-year periods (1970-2009); $N = 20$ OECD countries (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece Ireland, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the UK, the USA).

	N	Mean	Std.dev.	Min	Max
$privinv_{[t,t+4]}$	160	18.06	1.30	15.66	21.46
$debt_t$	159	52.09	29.00	1.98	191.64
$capstock_t$	160	28.14	1.25	26.4	31.15
$prof_t$	159	25.51	1.39	21.89	29.06
$prodgr_{[t,t+4]}$	150	2.23	1.39	-1.02	5.70
$deficit_t$	152	0.06	3.39	-9.23	8.15
$gdphw_t$	150	16.97	0.39	15.94	17.84
$educ_t$	160	8.98	1.87	3.79	12.71
$ltrate_t$	153	8.82	4.12	1.39	27.74
$open_t$	160	62.92	31.29	11.27	184.01
$popgr_t$	160	0.59	0.55	-0.87	3.44
$findev_t$	159	100.89	52.28	25.75	312.85
$infl_t$	158	6.01	4.79	-0.71	22.05
$dummy30$	160	0.79	0.41	0.00	1.00
$dummy60$	160	0.31	0.46	0.00	1.00
$dummy90$	160	0.11	0.32	0.00	1.00

Table 2 - Private investment estimates

This table contains coefficient estimates for the model in equation (1). Note: dependent variable: $privinv_{[t,t-4]}$; t-statistics in parenthesis based on robust standard errors; ***, **, * denote significance at 1%, 5% and 10%, respectively. Country and time fixed effects included but not reported.

	baseline	debtsq	dum30	dum60	dum90	alternative
$debt_t$	-0.0025***	-0.0045***	0.0012	-0.0038***	-0.0026***	-0.0024***
	(-4.49)	(-2.68)	(0.88)	(-3.84)	(-2.83)	(-3.92)
$debtsquared_t$		0.000				
		(-1.32)				
$dummy{*}debt_t$			-0.0034***	0.0010*	0.000	
			(-2.82)	(1.73)	(0.06)	
$deficit_t$						0.0110***
						(3.41)
$prof_t$	0.0622	0.0649	0.0768	0.0546	0.0618	0.0545
	(0.80)	(0.91)	(1.10)	(0.72)	(0.79)	(0.71)
$capstock_t$	0.2306***	0.2103**	0.2104**	0.2154**	0.2310***	0.2253**
	(2.75)	(2.57)	(2.32)	(2.40)	(2.72)	(2.53)
$ltrate_t$	-0.0167**	-0.0186***	-0.0205***	-0.0167**	-0.0168**	-0.0143**
	(-2.42)	(-2.58)	(-2.70)	(-2.16)	(-2.44)	(-2.22)
$open_t$	0.0032	0.0033*	0.0032	0.0031	0.0032	0.0023
	(1.57)	(1.75)	(1.59)	(1.47)	(1.57)	(1.08)
$popgr_t$	0.0913**	0.0893**	0.0828**	0.0993***	0.0913**	0.0935***
	(2.54)	(2.47)	(2.31)	(2.77)	(2.53)	(2.58)
$findev_t$	0.0009	0.0007	0.0008	0.0009*	0.0009	0.0009
	(1.60)	(1.18)	(1.59)	(1.66)	(1.57)	(1.56)
$infl_t$	0.002	0.0037	0.0052	0.0022	0.0021	0.0013
	(0.31)	(0.53)	(0.80)	(0.34)	(0.32)	(0.23)
Obs.	143	143	143	143	143	141
R^2 $(within)$	0.88	0.89	0.89	0.89	0.88	0.89

Table 3 - Productivity estimates

This table contains coefficient estimates for the model in equation (2). Note: dependent variable: $prodgr_{[t,t-4]}$; t-statistics in parenthesis based on robust standard errors; ***, **, * denote significance at 1%, 5% and 10%, respectively. Country and time fixed effects included but not reported.

	baseline	debtsq	dum30	dum60	dum90	alternative
$debt_t$	-0.0088***	-0.0113	-0.0099	-0.0099**	-0.0073	-0.0098***
	(-2.80)	(-1.08)	(-0.59)	(-2.21)	(-1.19)	(-3.11)
$debtsquared_t$		0.000				
		(0.27)				
$dummy{*}debt_t$			0.0011	0.0008	-0.0013	
			(0.07)	(0.29)	(-0.27)	
$deficit_t$						-0.0049
						(-0.14)
$capstock_t$	1.4721***	1.4603***	1.4732***	1.4566***	1.4584***	0.9142
	(2.99)	(2.88)	(2.96)	(2.82)	(3.00)	(1.40)
$educ_t$	-0.237	-0.2299	-0.2395	-0.2361	-0.2444	-0.2805
	(-1.33)	(-1.29)	(-1.33)	(-1.33)	(-1.42)	(-1.52)
$gdphw_t$	-3.3887***	-3.3882***	-3.3819***	-3.3433***	-3.4038***	-3.9387***
	(-5.25)	(-5.13)	(-5.28)	(-4.97)	(-5.35)	(-4.98)
$ltrate_t$	0.0232	0.0215	0.0241	0.0237	0.0244	0.020
	(0.41)	(0.36)	(0.36)	(0.41)	(0.40)	(0.35)
$open_t$	0.0035	0.0035	0.0035	0.0033	0.0038	0.0088
	(0.29)	(0.29)	(0.29)	(0.27)	(0.30)	(0.73)
$popgr_t$	-0.179	-0.1853	-0.1749	-0.1762	-0.1763	-0.2818**
	(-1.23)	(-1.17)	(-0.98)	(-1.22)	(-1.19)	(-2.05)
$findev_t$	0.0011	0.0009	0.0011	0.0011	0.0013	0.0016
	(0.35)	(0.26)	(0.35)	(0.34)	(0.38)	(0.44)
$infl_t$	-0.0691***	-0.0681**	-0.0697**	-0.0686**	-0.0717**	-0.0651**
	(-2.59)	(-2.54)	(-2.40)	(-2.48)	(-2.41)	(-2.03)
Obs.	142	142	142	142	142	136
$R^2(within)$	0.64	0.64	0.64	0.64	0.64	0.63

Table 4 - Tests for threshold effects

Results for the endogenous threshold approach by Hansen (1999, 2000). The test is on the null of m thresholds versus the alternative hypothesis of $m+1$ thresholds, for $m = 1, 2, \ldots, K$.

	Investment	Productivity
LR test for Single threshold		
F_1	8.52	35.96
Bootstrap p-value	0.89	0.50
[10%, 5%, 1% critical values]	[44.6, 54.5, 69.6]	[13.6, 15.6, 19.8]
LR test for Double threshold		
F_2	12.12	10.64
Bootstrap p-value	0.57	0.07
[10%, 5%, 1% critical values]	[30.3, 37.2, 53.7]	[9.7, 11.6, 16.9]
LR test for Triple threshold		
F_3	9.00	7.41
Bootstrap p-value	0.67	0.27
[10%, 5%, 1% critical values]	[24.0, 32.0, 47.9]	[9.8, 11.3, 15.2]

Table 5 - Threshold estimates

Hansen endogenous threshold model, point estimates of the thresholds for most significant model, and asymptotic 95% confidence intervals.

	Investment: Double threshold model		*Productivity: Double threshold model*	
	Estimate	95% Confidence region	Estimate	95% Confidence region
γ_1	36.24	[12.08, 142.05]	35.96	[4.49, 133.79]
γ_2	58.99	[32.99, 73.32]	71.46	[4.49, 125.57]

Data Appendix: variables' description and sources

Investment (*inv*). Logarithm of gross real (expressed in 2000 PPP USD) fixed capital formation of the private sector. Source: AMECO.

Productivity (*prodgr*). Growth rate of real (expressed in 2000 PPP USD) GDP per hours worked. Source: WDI (real GDP) and OECD (hours worked).

Public debt (*debt*). Public debt divided by GDP. Source: IMF Historical debt database.

Profits ($prof$). Logarithm of real (expressed in 2000 PPP USD) profits. Source: AMECO.

Capital stock (*capgdp*). Logarithm of real (expressed in 2000 PPP USD) capital stock (total economy). Source: AMECO.

Human capital stock proxy (*educ*). Average years of total schooling. Source: Barro and Lee (2010).

Long-term interest rate (*ltrate*). Nominal long-term interest rate. Source: AMECO and OECD.

Openness (*open*). Imports plus exports divided by GDP. Source: Penn World Tables.

Population growth (*popgr*). Annual growth rate of population. Source: Penn World Tables.

Financial development proxy ($findev$). Private credit divided by GDP. Source: World Development Indicators (World Bank).

Financial integration proxy ($finint$). Foreign assets and foreign liabilities divided by GDP. Source: updated and extended version of dataset constructed by Lane and Milesi-Ferretti (2007).

Inflation ($infl$). Annual inflation rate calculated from the CPI. Source: MEI-OECD.

Deficit ($deficit$). Deficit divided by GDP. Source: OECD.