Economica

Economica (2016) **83**, 356–384
doi:10.1111/ecca.12175

The Impact of Government Debt, Expenditure and Taxes on Aggregate Investment and Productivity Growth

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Final version received 22 August 2015.

In this paper we evaluate empirically the impact of fiscal policy on two key determinants of long-term growth, i.e., private investment and productivity growth. We mostly focus on a panel of 20 OECD economies from 1970 to 2009, although we also present some estimates based on data for 80 developing economies. Our findings suggest that high public debt adversely affects both aggregate investment spending and productivity growth, through distortions related to the size of the public sector. We also find weak evidence of some non-linear effects on productivity, with government debt becoming more detrimental in advanced economies when above 85–90% of GDP.

Introduction

The implications of fiscal imbalances for economic growth have attracted renewed interest in recent years (see, among others, Cottarelli and Jaramillo 2013; Alesina and Ardagna 2010). Both emerging and advanced economies have experienced large fiscal expansions in the past (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). However, the budgetary consequences of the Great Recession and of the 2010–13 turmoil in European sovereign debt markets, as well as the effects of age-related increases in government liabilities, have all refocused attention towards the prospects of mature economies. Particular emphasis is being placed on the potential implications for economic growth of high and/or rising public debt levels. For instance, Cecchetti *et al*. (2011a, p. iii) claim: '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.'

The historical record on government debt is one of ample variability both cross-sectionally and over time. 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%. Yet the data used by Reinhart and Rogoff come from 44 countries spanning more than 200 years. It is thus methodologically questionable to draw from such heterogeneous experiences tight policy recommendations valid for developed economies that are currently tackling their high levels of government debt. More fundamentally, the now widely debated '90% debt/GDP' threshold (see Herndon *et al*. 2013; *The Economist* 2013) comes from simple correlations between the debt burden and GDP growth. As such, it cannot account for other potentially relevant factors, or for critical reverse-causality issues (not only high debt may result in low growth, but low growth can lead to high debt/GDP levels). Finally, very little can be said about the channels through which debt may influence growth and its key determinants.

In this paper, we make a contribution that departs from the literature in various respects. We analyse the impact of fiscal policy on two fundamental determinants of economic growth, that is, capital accumulation and productivity growth, over a panel of

20 OECD economies from 1970 to 2009. We also present additional evidence on 80 emerging countries over the same period of time, although the data are for the most part less extensive and of a lower quality than those available for OECD economies. Although attempts to explain the dynamics of productivity and investment are pervasive in the growth literature (Durlauf *et al.* 2005), the possible long-term influence of fiscal policy has so far received relatively scant attention. The economy's response to fiscal policy shocks is likely to be detectable only after sizeable and persistent impulses, therefore our empirical models search primarily for an impact of government debt on both investment and productivity growth. We also investigate the effects of fiscal flow variables such as deficit/surplus, public expenditure and tax revenues. Including fiscal flow series among the explanatory variables is crucial in order to understand the reasons behind the relevance of fiscal policy in this context. Moreover, their addition also allows us to check for the presence of non-linear effects of fiscal policy. Finally, economic theory, as well as some empirical evidence, places great emphasis on capital accumulation and productivity growth as proximate causes/determinants of long-term growth (Acemoglu 2009; Bonfiglioli 2008). This is why we focus on those rather than on GDP growth, also in order to shed some light on the channels linking debt to the latter.

We study the effects of fiscal policy on investment and productivity growth by estimating several reduced-form models within a panel data framework. This allows us to exploit both the time and the cross-country dimensions of the marked variations in the levels of debt that many economies have experienced over recent decades. Besides, this choice maximizes the informational content of the annual frequency with which time series of fiscal data are typically collected (and are consistently available over long periods). The primary aim of our investigation is to measure the impact of fiscal policy variables, but our econometric results can also be interpreted in terms of conditional convergence. We use data at two different frequencies. First, we employ 5-year non-overlapping periods to concentrate on long-term growth patterns, thus avoiding the volatility that stems from short-term business cycle fluctuations. Second, we estimate the models with annual data via the system-GMM estimator to deal with possible endogeneity issues. Finally, we also present some estimates based on endogenous threshold models (Hansen 1999, 2000), to evaluate the existence of non-linear effects of debt on the determinants of growth.

Our main results prove that high debt levels are indeed associated with significant and sizeable declines of both private spending on investment and productivity growth. We estimate the elasticity of investment to the debt/GDP level to be up to −0.10 for levels of debt equal to the advanced countries' sample average of 54% (therefore accordingly higher when the debt/GDP ratio assumes higher values, as in most developed countries nowadays), while a 30% difference in the debt/GDP levels can explain about 0.30/0.35% lower annual productivity growth. Both effects are not only highly statistically significant, but also economically important. These findings prove to be robust to several sensitivity checks, such as the inclusion among the controls of the fiscal flow variables such as deficit, government size (which proves to be particularly insightful) and the shares over GDP of the four main types of government receipts (taxes on income, property, goods and services, and social security contributions) commonly used in the growth literature (see, among others, Myles 2000; Widmalm 2001; Karras and Furceri 2009). A similarly adverse effect on investment and on productivity growth seems to be also at work in emerging economies. Our explanation for these adverse impacts points to the build-up of distortions in labour and capital markets, and the presence of a sizeable public sector diverting large amounts of resources towards non-growth-enhancing uses.

We also find some limited evidence of non-linear effects, though just in the case of productivity: fiscal imbalances seem to be more harmful for productivity growth when the debt/GDP ratio is above 85–90% in advanced economies.

The remainder of the paper is organized as follows. Section I discusses the theoretical background motivating our analysis, and briefly reviews the existing empirical literature. Section II sets out the empirical strategy of our investigation. In Section III we present the estimation results and the tests for the presence of non-linearities. Section IV concludes.

I. Theoretical Considerations and Existing Literature

There are essentially two theoretical views about the impact of fiscal policies on macroeconomic performance. Endogenous growth theory claims that taxation and government spending can have permanent effects on economic growth. Many recent empirical studies have investigated this hypothesis. By contrast, according to a neoclassical perspective, fiscal policy 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 impact of flow variables like government deficit or its components, that is, spending and tax revenues (e.g. Muinelo-Gallo and Roca-Sagalés 2011). On the other hand, several microfounded general equilibrium models place more emphasis on the stock of government debt. However, the related empirical studies analyse its implications almost exclusively for interest rates (e.g. Muhleisen and Towe 2004; Ardagna *et al*. 2007). Overall, the literature is relatively thin on whether large debts interact with economic growth, and even more tenuous as to their effects on productivity and capital accumulation. We think that this is due, at least partly, to the fact that most contributions are prevalently focused on a short-to-medium-term perspective.

Large fiscal imbalances are thought to adversely affect GDP growth through the build-up of distortions in capital and labour markets. Such distortions would pull the economy away from its steady-state growth path, via several possible channels, such as suboptimally high wages and long-term interest rates, future distortionary taxation and higher inflation and macroeconomic volatility. By contrast, Barro–Ricardian effects (Barro 1990; Baxter and King 1993), real business cycle theory and, to some extent, also a number of New Keynesian models, all imply null—or modest—effects of debt-financed fiscal shocks on output. This is largely due to their negative impact on consumption: intertemporal smoothing and the ensuing Ricardian effects would offset the positive response of consumption to a fiscal expansion of the 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 the risk premia of investment opportunities. This is the basis for the well-known crowding-out effect on private investment and consumption choices. Further negative effects of high debt include an excessive role of government in the economy, which could in turn proxy for bad economic governance and the presence of wasteful or non-productive uses of resources (see Kourtellos *et al*. 2012). We will consider those potential channels in our empirical investigation.

At a first approximation, whether one evaluates the impact of fiscal imbalances by using flow quantities like spending, taxation and deficits, or by focusing on debt, should make little difference. However, we believe it to be questionable to study only the former as in much of the existing empirical literature (see, among others, Bergh and Henrekson 2011; Widmalm 2001). 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, 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 solely 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: that is why we include in our empirical models both debt and one of the flow variables mentioned above.

A few studies attempt to uncover the relationship of government debt with interest rates (see, among others, Ardagna *et al*. 2007), very often finding weak or outright insignificant responses. There are several possible explanations for this weak or unsupportive evidence. First, expansionary fiscal policy is often accompanied by accommodative monetary policies that blunt the response of interest rates to the fiscal shock (see Muscatelli *et al*. 2004). Second, finance theory argues that investors hold 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 may be limited or even 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 capture significant evidence of this channel in the transmission of fiscal shocks to long-term growth.

Recently, however, besides the influential work by Reinhart and Rogoff (2010), other contributions have analysed the direct effects of debt on economic growth. Overall, whereas some studies find support for adverse effects, there is very little evidence as to the mechanisms linking government debt to macroeconomic performance. For instance, Cecchetti *et al*. (2011b) focus on 18 OECD countries between 1980 and 2006, and conclude that debt appears to be a drag on GDP growth when above the 85% threshold with GDP.[1] Checherita-Westphal and Rother (2012) also detect, in a sample of 12 euro-area countries between 1990 and 2010, a non-linear impact of debt on per capita GDP growth. Baum *et al*. (2013), using the same sample and in the context of a dynamic panel threshold model, estimate 67% as the debt/GDP level above which the impact of debt on growth turns from not significant to negative. On the other hand, in a comprehensive study of advanced and emerging economies, Kumar and Woo (2010) uncover only limited evidence of non-linear effects of debt on GDP growth. Closer to our approach, these authors are among the few who look at the relationship with investment and the growth of both labour productivity and total factor productivity (TFP). In a growth-accounting exercise based on their estimates, Kumar and Woo find that the adverse impact largely reflects a slowdown in labour productivity growth, mainly owing to slower capital stock accumulation. Afonso and Jalles (2011) find that the debt/GDP ratio has a negative impact on both private and public investment, but a positive one on TFP growth and that of the capital stock, with differentiated effects across emerging and mature economies. By contrast, Panizza and Presbitero (2012) cast doubts on the measurement of these effects, essentially by questioning the robustness of the above approaches with respect to the endogeneity and reverse causality issues.[2] We broadly share these authors' concerns, and therefore pursue a different route in many respects, as explained in the next section.

II. Models and Data

The empirical investigation in this paper improves on the existing literature along several dimensions. First and foremost, the choice of data: we think that substantial country heterogeneity in a panel context is a double-edged methodological choice that has deciding implications for the estimation results. There is considerable evidence that the growth dynamics and fiscal trajectories of emerging countries differ from those experienced by mature economies. Therefore here we mainly focus on a group of 20 OECD countries for which the required high-quality data exist. However, we also extend the analysis beyond advanced economies, by offering additional evidence based on 80 emerging economies for which comparable series can be retrieved. We always control for country-specific effects. This is particularly important for the euro-area countries, which in 1999 gave up their own currencies to adhere to a common (and, as a matter of fact, foreign) currency. While this would suggest investigating the debt overhang argument (Krugman 1988; Sachs 1989) separately for the euro-area economies, the fraction of external debt over total debt is negligible in all of the 20 countries of our main sample.[3] The time interval covered by our annual data is longer than that of most existing studies and spans long-term developments such as the productivity slowdown of the 1970s, its revival in the late 1990s and 2000s and 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.

Another direction in which our approach departs from the extant literature is the focus on aggregate private investment and productivity growth rather than GDP growth. Methodologically, our choice is motivated by the need to mitigate the effects of the endogenous response of debt to growth. High debt could result in lower growth also because of crowding-out effects on private investment, which would thereby lower productivity growth. Moreover, we focus on a long-term perspective, whereby productivity and capital accumulation are the key channels linking government debt to economic performance. Accordingly, we study the impact of government debt on investment and productivity growth always controlling for fiscal flow variables. Finally, we estimate models whose conditional convergence spirit allows us to capture a more comprehensive picture than in most existing studies (see, for instance, Kumar and Woo 2010; Checherita-Westphal and Rother 2012; Afonso and Jalles 2011).

We employ two different specifications to capture the effects of debt on private investment.[4] First, we present panel fixed effects estimates based on 5-year non-overlapping periods: 1970–4, 1975–9, etc., up to 2005–9 (eight periods in total). The use of 5-year periods to analyse panel data is standard in the macroeconomics literature (see, for example, 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 non-stationarity and cointegration. We regress the dependent variable measured as a 5-year average on the beginning-of-the-period values of government debt and the remaining explanatory variables (as in Barro and Lee 2005; Furceri and Zdzienicka 2012). This method allows us to tackle not only reverse causality, but also business-cycle fluctuations. These benefits come at the cost of making it harder to detect possible asymmetric effects in the relationship between debt and our dependent variables. We therefore account for this potential drawback by also using annual data, where we take advantage of the larger number of available observations to carry out system-GMM estimates.

The investment model based on 5-year periods is[5]

$$(1)\qquad privinv_{i,[t,t+4]} = \alpha_1 debt_{i,t} + \alpha_2 deficit_{i,t} + \alpha_3 prof_{i,t} + \boldsymbol{\delta}\mathbf{W}_{i,t} + \xi_t + \eta_i + trend_t + \varepsilon_{i,t}.$$

For each country *i*, $privinv_{[t,t+4]}$ denotes the 5-year average of real expenditure on private investment (gross physical capital formation of the private sector) between years *t* and *t*+4, in logarithms. We also provide estimates based on a model with this variable in per capita terms, as in standard growth models. Moreover, we consider alternative specifications where we investigate the effects of debt on total (i.e., public and private) investment, since the impact on public investment outlays may differ from those relative to private expenditure. $debt_t$ is the gross government debt/GDP ratio at the beginning of the 5-year period (i.e. at *t*; the same goes for every right-hand-side variable).[6] $deficit_t$ is the deficit/GDP ratio, a fiscal flow variable whose coefficient may help us to detect potential non-linear responses of investment.[7] In further estimations we also replace deficit with the following series, one at a time: government size, the shares over GDP of income, property, goods and services taxes and the share of social security contributions. $prof_t$ is the logarithm of real business profits (gross operating surplus). $\mathbf{W}_t$ is a vector of control variables, including: the logarithm of the real stock of capital in the economy ($capstock_t$), whose coefficient may be interpreted in terms of conditional convergence; the real long-term interest rate ($rltrate_t$);[8] 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, $findev_t$);[9] the level of productivity measured as GDP per hour worked ($prod_t$); a proxy for the quality of institutions ($qual_t$);[10] and the price of oil (oil_t). Country and time fixed effects are included (η_i and ξ_t, respectively), while $\varepsilon_{i,t}$ is a disturbance term. The same variables are used at the annual frequency in the model estimated by system-GMM (Blundell and Bond 1998). Given the challenges in gathering appropriate exogenous instruments for the fiscal policy variables and for the convergence variable, we use their own lagged values as instruments and select them according to the results of tests for second-order autocorrelation (Arellano and Bond 1991); in most cases, this leads to the use of the second and third lags.

Textbook accounts of the demand for investment motivate the presence of real interest rates (proxying for the rental cost of capital and the compensation of risk) and profits among the regressors. All other variables find their way into the model because of their potential explanatory power either in theoretical models of the process of capital accumulation (in the cases of profits and population growth; see Acemoglu 2009) or in existing empirical studies (trade openness and financial development; see Yanikkaya 2003, Dreher 2006, Barro 1995). We include oil prices to control for potential exogenous shocks that can cause at the same time low growth, low investment and slower productivity growth while forcing authorities to engage in debt-generating stabilization policies. 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, although it is hard to develop 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 negative coefficients for real interest rates, population growth and oil prices, and positive ones for trade openness, financial development, the quality of institutions, productivity and profits. The potential impact of debt and deficit on investment is at the heart of our empirical analysis.

The model that we employ to study the effects on productivity growth stems from the rich growth literature based on regressions of that variable on an array of potential determinants. Typically, contributions analyse either total factor or labour productivity. Because of the contentious nature of these variables, here we offer evidence based on three different measures of productivity: two relate to labour productivity, that is, the growth rate of GDP per hour worked and the growth rate of real output per unit of labour input as measured by the OECD, while the third measure is TFP growth. In the empirical literature, TFP coefficients tend to exhibit excess sensitivity to conditioning variables, to minor changes in the econometric specification and to the business cycle. Accordingly, the usefulness of those regressions and of TFP as an appropriate measure of productivity has often been questioned (Durlauf *et al.* 2005). On the other hand, the correlation between per capita GDP and the two other measures of productivity is moderate.[11] Based on these caveats, we estimate the model

$$(2) \qquad prodgr_{i,[t,t+4]} = \varphi_1 debt_{i,t} + \varphi_2 deficit_{i,t} + \varphi_3 educ_{i,t} + \boldsymbol{\theta}\mathbf{W}_{i,t} + \psi_t + \omega_i + trend_t + v_{i,t},$$

in which $prodgr_{[t,t+4]}$ denotes the 5-year average of the growth rate of one of the above measures. They are all highly positively correlated with each other: the two labour productivity measures have a correlation of 0.77, while the correlations of TFP growth with the other two are 0.85 and 0.69, respectively. $educ_t$ 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 (2010)). $\mathbf{W}_t$ is the same vector of control variables as in equation (1), although in this case the convergence coefficient is associated to the level of productivity $prod_t$. Again, country and time fixed effects are allowed for. The annual data model estimated with system-GMM slightly differs from the one based on 5-year periods, and it excludes human capital, as the latter is available only every five years.

In line with standard growth theory (Acemoglu 2009; Durlauf *et al.* 2005), we expect a positive coefficient on the capital stock, as well as on openness and financial development. We also expect results to be compatible with the notion of conditional convergence (i.e. we expect β_{prod} 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 sign of all remaining coefficients. 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 the principle of diminishing returns to both physical and human capital (Miller and Upadhyay 2000).

As for the investigation of non-linear effects, we rely on an endogenous threshold model (Hansen 1999, 2000) estimated on annual data. Furthermore, and using data at both frequencies, we also estimated several specifications alternative to the baseline, including either the squared level of debt or various threshold dummies (based on values of the debt/GDP ratio) interacted with the debt level.

For our baseline estimation we employ 1970–2009 data on 20 OECD countries (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece,

TABLE 1
SUMMARY STATISTICS

	N	Mean	S.D.	Min	Max
privinv	759	18.02	1.31	15.19	21.41
privinvpc	759	8.13	0.40	6.90	9.14
totinv	799	18.06	1.30	15.51	21.53
totinvpc	799	8.23	0.42	7.02	9.26
prodgr:					
GDPhwgr	726	2.17	1.95	−8.75	9.96
LabprodgrOECD	708	1.59	1.87	−9.00	11.38
TFPgr	759	1.03	1.81	−8.74	7.87
debt	794	54.15	29.56	1.72	217.60
deficit	697	−0.12	3.12	−11.60	9.53
govsize	711	44.91	8.65	20.25	71.72
income_tax	800	12.93	5.14	2.37	31.16
social_tax	800	8.88	4.72	0.00	19.75
property_tax	800	1.92	1.01	0.30	7.75
good_tax	800	10.40	3.19	3.53	17.22
prof	791	25.57	1.37	21.89	29.12
capgdp	800	28.11	1.24	26.39	31.27
rltrate	733	3.19	2.57	−6.41	12.32
open	800	63.36	31.31	11.25	184.31
popgr	780	0.56	0.49	−1.10	3.44
findev	789	106.32	54.50	25.75	320.53
qual	740	9.95	1.57	0.00	11.00
oil	800	26.83	19.80	3.35	99.57
*dummy*30	794	0.81	0.39	0.00	1.00
*dummy*60	794	0.34	0.47	0.00	1.00
*dummy*90	794	0.11	0.32	0.00	1.00

Notes T = 40 years (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).

Ireland, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the UK and the USA). Details on the construction and sources of the variables are in the Appendix. Table 1 contains some descriptive statistics. To get 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.[12] Higher levels of debt are clearly associated with slower growth of per capita GDP and productivity, as well as with weaker capital accumulation. However, simple contemporaneous correlations do not allow us 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 to shed light on these and the other issues that we discussed above. The first three subsections of Section III present the results based on the models illustrated above. The final subsection of Section III offers evidence based on models similar to models (1) and (2) but estimated on data for 80 developing countries, for which similar, but in most cases slightly different, series are available.

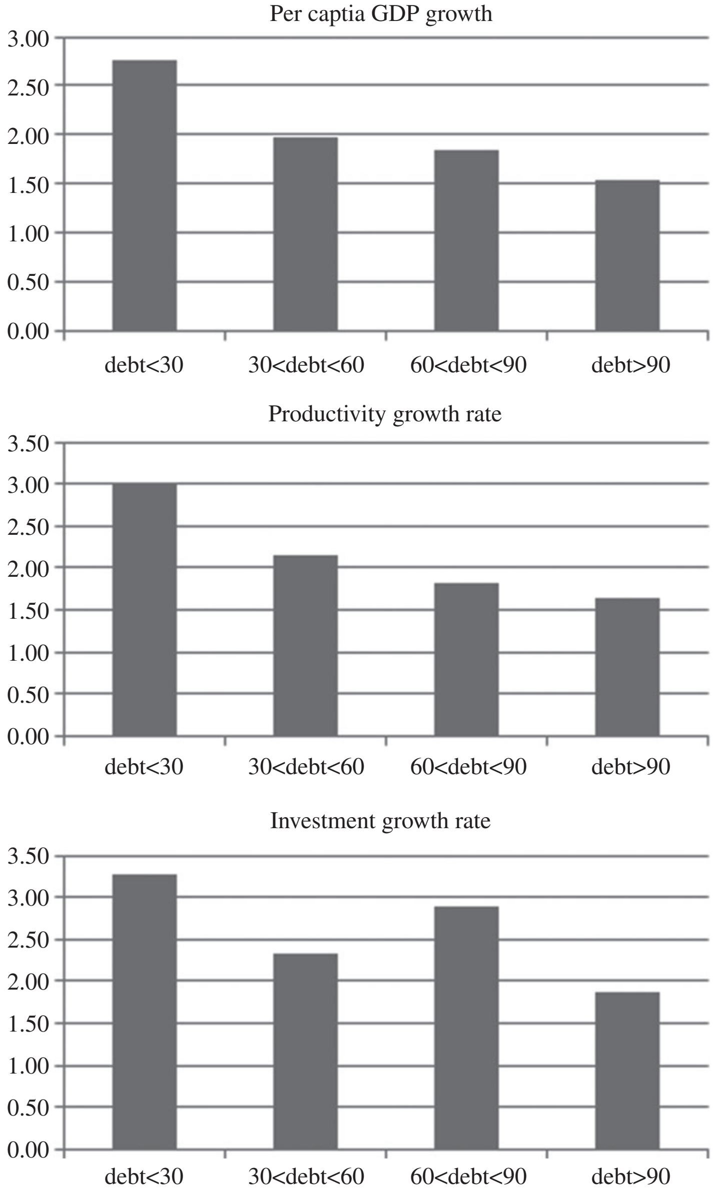

FIGURE 1. Average growth rates of GDP, investment and productivity.
Notes: The charts plot the average growth rate of real per capita GDP (top panel), the average growth rate of real GDP per hour worked (middle panel) and the average investment growth rate (bottom panel), for different levels of the government debt/GDP ratio.

III. ESTIMATES

We begin the empirical analysis by showing in Table 2 some estimates of the effects of government debt and deficit on the growth rate of real GDP per capita, within a conditional convergence model in line with the two presented above and with the existing literature. Results based on 5-year averages show that public debt seems to adversely

TABLE 2
REAL PER CAPITA GDP GROWTH

	5-year FE		Annual sys-GMM	
debt	−0.0092**	(−1.96)	−0.0056	(−1.32)
deficit	−0.0227	(−0.57)	0.1030**	(2.05)
GDPpc	−4.6195***	(−3.79)	−1.1269	(−1.39)
educ	−0.2367*	(1.93)		
rltrate	0.0234	(0.43)	−0.0343	(−0.49)
open	0.0501***	(3.05)	0.0089	(1.57)
popgr	−0.9082***	(3.22)	0.0212	(0.10)
findev	−0.0101***	(−2.84)	0.0003	(0.09)
qual	0.0038	(0.05)	0.1132	(1.17)
oil	0.0137	(0.61)	0.0149	(0.36)
No. of obs.	143		633	
R^2 (within)	0.65			
Hansen *J*-statistic			1.00	
AR(1)			0.005	
AR(2)			0.348	

Notes The dependent variable is either $gdppcgr_{[t,t-4]}$ (5-year period estimates) or $gdppcgr_t$ (annual estimates). *t*-statistics (*z*-statistics for the annual estimates) in parentheses based on robust standard errors. ***, **, * denote significance at 1%, 5%, 10%, respectively. Country and time fixed effects included but not reported. *p*-values of the Hansen statistic and of the AR(1) and AR(2) tests are reported.

affect per capita GDP growth. However, this does not hold up with system-GMM estimates based on annual data. This lack of clear-cut evidence when accounting for endogeneity is at least partially in line with the findings by Panizza and Presbitero (2012), although their empirical methods differ from ours. We checked for non-linear effects such as those suggested by Reinhart and Rogoff (2010) by experimenting with alternative specifications: we included either the squared level of debt or alternative interaction terms between debt and a dummy accounting for different thresholds (we use 17 different dummies accounting for the potential thresholds 40%, 45%, 50%, and so on, up to 120%). These attempts did not yield any significant evidence in favour of non-linear effects (results not reported but available on request).

Private investment

Table 3 presents the estimates of model (1) based on both the 5-year periods and the annual data. We employed as dependent variable two alternative definitions of private investment: either aggregate (columns (a) and (b)) or per capita (columns (c) and (d)) physical capital formation of the private sector. Consistently across specifications, the debt/GDP ratio exhibits a negative association with private investment (although the coefficient of the former is not statistically significant at standard levels in the last specification). The average elasticity of private investment to changes in government debt can be quantified by multiplying the debt coefficient by the average value of the debt/GDP ratio (54.45, see Table 1): the effect lies between −0.06 and −0.10. Clearly, for higher debt ratios such elasticity rises, and it doubles those values where debt is equal to 100% of GDP. This sizeable and negative effect is always statistically significant and thus validates the intuition drawn from the graphical evidence of the previous section.

TABLE 3
PRIVATE INVESTMENT

	Aggregate investment		Per capita investment	
	(a) 5-year FE	(b) Annual sys-GMM	(c) 5-year FE	(d) Annual sys-GMM
debt	−0.0018***	−0.0015*	−0.0011***	−0.0008
	(−4.16)	(−1.81)	(−2.71)	(−1.20)
deficit	0.0108***	0.0193***	0.0104***	0.0149***
	(3.93)	(4.42)	(3.32)	(3.00)
capstock	0.2015***	0.1472*	−0.0041	−0.3434***
	(3.05)	(1.86)	(−0.06)	(−4.37)
gdphw	0.2584**	0.0677	0.332***	0.7999***
	(2.20)	(0.93)	(2.76)	(12.23)
rltrate	−0.0176***	−0.0244***	−0.0174***	−0.0229***
	(−3.68)	(−2.69)	(−3.81)	(−2.88)
prof	0.2700***	0.7760***	0.1963***	0.2326***
	(4.26)	(9.45)	(4.44)	(3.16)
open	0.0012	−0.0065	0.0025*	−0.0029***
	(0.79)	(−0.19)	(1.84)	(−4.13)
popgr	0.1035***	−0.0065	0.1042***	0.0591**
	(3.26)	(−0.19)	(3.46)	(2.41)
findev	0.0006	0.0024***	0.0003	0.0034***
	(1.41)	(7.36)	(0.96)	(5.11)
qual	0.0050	−0.0021	0.0048	0.0155
	(0.50)	(−0.18)	(0.62)	(1.33)
oil	−0.0096***	0.0002	−0.0030	0.0016
	(−4.25)	(0.12)	(−1.48)	(0.90)
No. of obs.	134	589	134	589
R^2 (within)	0.92		0.88	
Hansen J-statistic		1.00		1.00
AR(1)		0.056		0.239
AR(2)		0.103		0.202

Notes
The dependent variable is either $privinv_{[t,t-4]}$ (5-year period estimates) or $privinv_t$ (annual estimates). t-statistics (z-statistics for the annual estimates) in parentheses based on robust standard errors. ***, **, * denote significance at 1%, 5%, 10%, respectively. Country and time fixed effects included but not reported. p-values of the Hansen statistic and of the AR(1) and AR(2) tests are reported.

As for the other explanatory variables, there is a negative effect of the real interest rate, robust across all the specifications presented in Table 3; a wide range of standard theoretical models support this finding. The estimates also suggest that the initial levels of the capital stock, profits, productivity and government deficit all positively affect subsequent private investment. The positive and significant coefficient that we find on the budget deficit highlights two important facts. First, the negative association of government debt with investment goes beyond the conventionally explored deficit channel, and is therefore very strong. Second, fiscal expansions financed via debt would have a broadly expansionary effect (through the aggregate demand channel), but at the same time they are also likely to exert a contractionary confidence effect in the long run, via higher debt levels.

One may argue that a negative response of private investment to debt does not necessarily imply overall detrimental effects on GDP growth. On the one hand, the existing cross-country evidence confirms a positive relationship between capital accumulation and GDP growth at the medium-to-long-term horizon (see Acemoglu 2009). Alternatively, the same literature also shows that overaccumulation of capital is unlikely to be a significant factor in explaining differences in GDP growth rates across countries. A more relevant issue is whether public investment might offset the weakening of private investment that we observe at higher debt levels. To this end, we present in Table 3a additional estimates where we replace private investment with total investment, which also includes the public portion of it. These alternative estimates essentially confirm all of the previous findings, as public debt is found to impact adversely on total investment too, with coefficients of a magnitude similar to that estimated above. Overall, our evidence on aggregate investment implies much more circumstantiated support to claims of a negative effect of debt on macroeconomic performance than in the existing

TABLE 3A
TOTAL INVESTMENT

	Aggregate investment		Per capita investment	
	(a) 5-year FE	(b) Annual sys-GMM	(c) 5-year FE	(d) Annual sys-GMM
debt	−0.0021***	−0.0013*	−0.0014***	−0.0016**
	(−5.88)	(−1.66)	(4.01)	(−2.46)
deficit	0.0120***	0.0138***	0.0115***	0.0142***
	(3.99)	(3.15)	(3.71)	(3.28)
capstock	0.1668***	0.1788**	−0.0377	−0.2891***
	(3.02)	(2.44)	(−0.67)	(−3.36)
gdphw	0.0758	0.0164	0.1509	0.7586***
	(0.57)	(0.23)	(1.16)	(11.85)
rltrate	−0.0175**	−0.0155	−0.0174***	−0.0152*
	(−2.54)	(−1.28)	(−2.77)	(−1.81)
prof	0.2653***	0.7534***	0.1916***	0.1862**
	(4.57)	(9.91)	(4.67)	(2.18)
open	−0.0016	−0.0005	−0.0004	−0.0016**
	(−1.05)	(−0.70)	(−0.27)	(−2.33)
popgr	0.0516**	−0.0265	0.0522**	0.0052
	(2.24)	(−0.82)	(2.53)	(0.13)
findev	0.0009**	0.0029***	0.0006*	0.0041***
	(2.22)	(6.63)	(1.90)	(4.91)
qual	0.0110	0.0024*	0.0108	−0.0029
	(0.96)	(1.76)	(1.21)	(−0.25)
oil	0.0148***	−0.0008	0.0083***	−0.0005
	(7.89)	(−0.54)	(5.73)	(−0.31)
No. of obs.	135	594	135	594
R^2 (within)	0.94		0.92	
Hansen *J*-statistic		1.00		1.00
AR(1)		0.009		0.564
AR(2)		0.354		0.150

Notes
The dependent variable is either $totinv_{[t,t-4]}$ (5-year period estimates) or $totinv_t$ (annual estimates). t-statistics (z-statistics for the annual estimates) in parentheses based on robust standard errors. ***, **, * denote significance at 1%, 5%, 10%, respectively. Country and time fixed effects included but not reported. p-values of the Hansen statistic and of the AR(1) and AR(2) tests are reported.

evidence based on GDP growth (Reinhart and Rogoff 2010; Checherita-Westphal and Rother 2012; Kumar and Woo 2010; Afonso and Jalles 2011).[13]

We now turn to the results for various alternative specifications of model (1), with the aim of shedding some light on the channels through which fiscal policy affects private investment. Table 3b reports the estimates of model (1) where we use government size as the fiscal policy variable, instead of the budget deficit. Table 3c offers results of a similar model where instead we use the shares over GDP of four primary types of government receipts (taxes on income, property, goods and services and social security contributions), separately, one at a time. As for the model with government size (Table 3b), there is still evidence of a negative effect of public debt arising from the annual estimates, but not from those based on the 5-year periods. Moreover, government size has a negative and significant impact on private investment in three out of four cases

TABLE 3B
PRIVATE INVESTMENT AND GOVERNMENT SIZE

	Aggregate investment		Per capita investment	
	(a) 5-year sFE	(b) Annual sys-GMM	(c) 5-year FE	(d) Annual sys-GMM
debt	−0.0010	−0.0023**	−0.0030	−0.0015*
	(−1.47)	(−2.41)	(−0.38)	(−1.83)
govsize	−0.0077**	−0.0004	−0.0081**	−0.0100***
	(−2.28)	(−0.09)	(−2.38)	(−3.23)
capstock	0.2057***	0.1628	0.0151	−0.3537***
	(2.60)	(1.45)	(0.18)	(−3.19)
gdphw	0.2331**	0.0422	0.3117***	0.8991***
	(2.01)	(0.46)	(2.73)	(12.50)
rltrate	−0.0192***	−0.0166**	−0.0176***	−0.0177***
	(−3.97)	(−2.30)	(−3.81)	(−4.15)
prof	0.2930***	0.7753***	0.2273***	0.2373**
	(5.73)	(7.01)	(6.19)	(2.39)
open	0.0013	−0.0006	0.0025*	−0.0022***
	(0.92)	(−0.55)	(1.93)	(−4.16)
popgr	0.1082***	−0.0378	0.1032***	−0.0435
	(2.83)	(−0.74)	(2.63)	(−1.41)
findev	0.0002	0.0024***	−0.0000	0.0028***
	(0.84)	(4.62)	(−0.07)	(4.47)
qual	0.0040	0.0027	0.0037	0.0134
	(0.32)	(0.19)	(0.35)	(1.33)
oil	−0.0076***	0.0016	−0.0048***	0.0020
	(−4.28)	(1.03)	(−2.74)	(1.33)
No. of obs.	125	550	125	550
R^2 (within)	0.91		0.87	
Hansen *J*-statistic		1.00		1.00
AR(1)		0.005		0.004
AR(2)		0.229		0.165

Notes
The dependent variable is either $privinv_{[t,t-4]}$ (5-year period estimates) or $privinv_t$ (annual estimates). *t*-statistics (*z*-statistics for the annual estimates) in parentheses based on robust standard errors. ***, **, * denote significance at 1%, 5%, 10%, respectively. Country and time fixed effects included but not reported. *p*-values of the Hansen statistic and of the AR(1) and AR(2) tests are reported.

TABLE 3C
PRIVATE INVESTMENT AND TAX SHARES

	Aggr. investment		P. C. investment		Aggr. investment		P. C. investment	
	5-year FE	Sys GMM	5-year FE	Sys GMM	5-year FE	Sys GMM	5-year FE	Sys GMM
	Income tax				Social security tax			
debt	−0.0019***	−0.0020***	−0.0011***	−0.0023***	−0.0012**	−0.0021***	−0.0005	−0.0012
	(−4.43)	(−2.86)	(−2.82)	(−4.32)	(−2.47)	(−2.69)	(−0.94)	(−1.55)
tax_share	0.0063	0.0097**	0.0046	0.0096*	−0.0242**	0.0019	−0.0217*	−0.0104**
	(1.13)	(2.08)	(0.86)	(1.79)	(−2.15)	(0.30)	(−1.70)	(−2.45)
No. of obs.	136	598	136	598	136	598	136	598
R^2(within)	0.91		0.87		0.91		0.87	
Hansen J-statistic		1.00		1.00		1.00		1.00
AR(1)		0.004		0.019		0.002		0.061
AR(2)		0.104		0.065		0.130		0.164
	Property tax				Goods and services tax			
debt	−0.0012***	−0.0020***	−0.0011**	−0.0015**	−0.0019***	−0.0018**	−0.0012***	−0.0016**
	(−3.90)	(−2.77)	(−2.40)	(−2.12)	(−4.14)	(−2.14)	(−2.62)	(−2.01)
tax_share	0.0163	0.0132	0.0148	0.0008	−0.0020	0.0069	0.0062	−0.0070
	(1.01)	(0.79)	(1.01)	(0.04)	(−0.09)	(0.58)	(0.32)	(−0.46)
No. of obs.	136	598	136	598	136	598	136	598
R^2(within)	0.91		0.87		0.91		0.87	
Hansen J-statistic		1.00		1.00		1.00		1.00
AR(1)		0.001		0.002		0.002		0.003
AR(2)		0.179		0.098		0.123		0.085

Notes
The dependent variable is either $privinv_{[t,t-4]}$ (5-year period estimates) or $privinv_t$ (annual estimates). t-statistics (z-statistics for the annual estimates) in parentheses based on robust standard errors. ***, **, * denote significance at 1%, 5%, 10%, respectively. Controls (same as in Table 3), country and time fixed effects included but not reported. p-values of the Hansen statistic and of the AR(1) and AR(2) tests are reported.

(columns (a), (c) and (d)), broadly in line with the crowding-out hypothesis. In sum, government size in our estimates appears to somewhat proxy for the distortions that one would expect from large fiscal imbalances. This means that such relevant distortions likely do not arise, in a statistical sense, from the traditional interest-rate channel. The results from the specifications based on the receipts shares (Table 3c) confirm the negative effects of public debt on private investment. However, when social security contributions are used, the debt coefficients are not statistically significant in the per capita investment case, suggesting that the channel through which fiscal policy affects the accumulation of capital works through social security contributions, which turn out to be particularly detrimental. The explanation for this finding may lie in the redistributive nature of such contributions, and is not related to economic growth objectives.

Table 3D
Private Investment and Macroeconomic Volatility

	Aggregate investment		Per capita investment	
	(a) GDP volatility	(b) Inflation volatility	(c) GDP volatility	(d) Inflation volatility
debt	−0.0019***	−0.0019***	−0.0012***	−0.0012***
	(−4.90)	(−4.40)	(−3.22)	(−3.11)
deficit	0.0107***	0.0108***	0.0103***	0.0104***
	(3.91)	(3.80)	(3.30)	(3.27)
gdp_vol	−0.0322**		−0.0267*	
	(−2.17)		(−1.81)	
infl_vol		−0.0278**		−0.0223*
		(−2.15)		(−1.78)
capstock	0.2236***	0.2251***	0.0143	0.0149
	(4.18)	(3.21)	(0.29)	(0.23)
gdphw	0.3021***	0.2202**	0.3681***	0.3013***
	(2.83)	(2.17)	(3.52)	(2.67)
rltrate	−0.0185***	−0.0193***	−0.0181***	−0.0187***
	(−3.43)	(−4.09)	(−3.55)	(−4.19)
prof	0.2706***	0.2690***	0.1968***	0.1955***
	(4.53)	(4.42)	(4.71)	(4.61)
open	0.0012	0.0014	0.0024**	0.0026**
	(0.84)	(0.98)	(1.98)	(−2.02)
popgr	0.1035***	0.1156***	0.1125***	0.1139***
	(3.73)	(3.62)	(3.84)	(3.72)
findev	0.0005	0.0007*	0.0003	0.0004
	(1.35)	(1.71)	(0.90)	(1.23)
qual	0.0078	0.0036	0.0071	0.0037
	(0.77)	(0.35)	(0.91)	(0.46)
oil	−0.0099***	0.0092***	0.0033*	0.0027
	(−4.59)	(4.27)	(1.70)	(1.31)
No. of obs.	134	134	134	134
R^2 (within)	0.92	0.92	0.88	0.88

Notes
The dependent variable is always $privinv_{[t,t-4]}$ (5-year period estimates). *t*-statistics in parentheses based on robust standard errors. ***, **, * denote significance at 1%, 5%, 10%, respectively. Country and time fixed effects included but not reported.

Among the potential channels linking fiscal policy to investment, it could be envisaged that large government debt and/or expenditure may adversely affect investment by increasing macroeconomic volatility (see Pescatori *et al*. 2014). To investigate this hypothesis, we extended model (1) by adding, separately, a standard indicator of output volatility (the standard deviation over five years of the growth rate of real GDP per capita), and one accounting for inflation volatility (the standard deviation over five years of the inflation rate). Due to the construction of such variables, only the specifications with 5-year periods can be estimated. Results in Table 3d prove that macroeconomic volatility is indeed detrimental to the accumulation of private capital. However, this channel appears to be merely complementary to that of fiscal policy, as the coefficients associated with debt and deficit are in all cases comparable to those of the baseline specification (Table 3).

Finally, while the various specifications of our model allow for the marginal effects of government debt to vary with the level of the debt/GDP ratio, so far they do not allow for the notion (and the now widely debated evidence) that a negative effect of debt on macroeconomic performance materializes only above certain thresholds of the debt/GDP ratio (e.g. 60% or 90%). We check for this by estimating several alternative specifications of the baseline model with additional terms meant to capture possible non-linearities. None of the 18 alternative specifications (one including the squared level of debt, the others adding the dummies and interaction terms mentioned above) yields evidence in favour of non-linear effects (results are not reported to save space, but are available on request). The same holds with total investment used as the dependent variable. However, this simple way of accounting for non-linearities is not flawless, because of the arbitrary definition of the thresholds and because of their possible multiplicity. This is why we run a more comprehensive test by implementing the endogenous threshold procedure envisaged by Hansen (1999, 2000), whose results we illustrate in the subsection below entitled ‘Threshold effects and further robustness checks’.

Productivity growth

Table 4 reports the estimates of the productivity model in equation (2), again based on data for both annual and 5-year periods. We provide evidence based on three alternative measures of productivity, as explained in Section II.

All specifications point towards a significant and sizeable negative effect of government debt on labour productivity growth, no matter how it is measured (see columns (a), (b), (c) and (d) of Table 4). The quantitative effect is substantial, as a 30% difference in the debt/GDP ratio accounts for a subsequent deceleration of productivity growth (measured as GDP per hour worked) by 0.31%/0.59% per year (note that the average growth rate in the sample is around 2%). The effect is quantitatively similar when one uses the OECD measure of labour productivity growth, while the TFP specifications do not uncover any significant response (apart from a weakly significant negative effect of deficit when using 5-year periods). The TFP exception is in line with previous findings, for example by Kumar and Woo (2010), and it is probably due to the above-mentioned measurement issues characterizing the Solow residual. Also, it might be caused by the loose correlation of TFP with the capital stock (given its construction), whose rate of change (investment) we found to be negatively affected by debt. All in all, the estimates show that diverging debt levels can lead to relevant differences in productivity. The cases of Italy, Belgium, Greece and Portugal seem to offer a neat

TABLE 4
PRODUCTIVITY GROWTH

	GDPhwgr		*LabprodgrOECD*		*TFPgr*	
	(a) 5-year FE	(b) Sys-GMM	(c) 5-year FE	(d) Sys-GMM	(e) 5-year FE	(f) Sys-GMM
debt	−0.0102***	−0.0143***	−0.0066**	−0.0069**	0.0003	−0.0021
	(−2.98)	(−4.00)	(−2.33)	(−2.20)	(0.09)	(−0.85)
deficit	−0.0016	0.0043	−0.0474**	−0.0581**	−0.0528*	−0.0395
	(−0.04)	(0.11)	(−2.06)	(−2.12)	(−1.72)	(−1.43)
prod	−3.3923***	−0.4637	−0.1050***	−0.0319	−0.0587***	−0.0200
	(−3.67)	(−0.97)	(−9.68)	(−1.62)	(−7.51)	(−1.32)
capstock	0.6869	0.1023	0.0118	−0.0430	−0.4321	0.0957
	(1.12)	(0.54)	(0.02)	(−0.49)	(−0.84)	(1.42)
educ	−0.2864*		−0.4578***		−0.2947***	
	(−1.73)		(−4.79)		(−3.74)	
rltrate	0.0036	−0.0402	0.1180**	−0.0445	0.0292	−0.0222
	(0.07)	(−0.49)	(2.36)	(−0.84)	(0.65)	(−0.50)
open	0.0058	0.0164*	0.0059	0.0038	0.0227**	0.0085**
	(0.50)	(1.69)	(0.66)	(1.05)	(2.13)	(1.99)
popgr	−0.3611***	−1.0422***	0.0466	−0.5410***	−0.3700**	−0.2813**
	(−2.93)	(−2.75)	(0.34)	(−3.58)	(−2.08)	(−2.08)
findev	0.0003	0.0060	0.0000	0.0014	−0.0056**	−0.0023
	(0.09)	(1.10)	(0.00)	(0.55)	(−2.03)	(−0.94)
qual	−0.0055	0.0404	−0.0562**	0.0227	−0.0081	0.0607
	(−0.17)	(0.35)	(−2.33)	(0.34)	(−0.31)	(0.84)
oil	0.0170	−0.0066	0.0628***	0.0622**	−0.0361***	0.0475***
	(0.94)	(−0.24)	(3.64)	(2.11)	(−3.67)	(2.82)
No. of obs.	136	595	130	572	142	631
R^2 (within)	0.59		0.71		0.58	
Hansen *J*-statistic		1.00		1.00		1.00
AR(1)		0.167		0.001		0.008
AR(2)		0.142		0.131		0.340

Notes
The dependent variable is either $prodgr_{[t,t-4]}$ (5-year period estimates) or $prodgr_t$ (annual estimates). *t*-statistics (*z*-statistics for the annual estimates) in parentheses based on robust standard errors. ***, **, * denote significance at 1%, 5%, 10%, respectively. Country and time fixed effects included but not reported. *p*-values of the Hansen statistic and of the AR(1) and AR(2) tests are reported.

narrative supporting this empirical result. The very high debt levels in those countries (essentially all above 100% of GDP since the early 1990s) have been accompanied by poor productivity records over the same time span (Mas *et al*. 2008). Since productivity growth is a prime driver of long-term economic growth and it is often employed to measure macroeconomic performance, these findings are particularly valuable.

Further interesting insights emerge from the baseline specification. The negative coefficients associated with the initial level of productivity in most of the estimates suggest that conditional convergence is indeed at work. We also detect significant negative effects of population growth and education. While at first the latter may appear counterintuitive, this is not an uncommon finding in the empirical literature that focuses on developed economies (see, for example, Miller and Upadhyay 2000). As for the other explanatory variables, there are no consistent regularities across the specifications, therefore we refrain from drawing additional conclusions.

Similarly to what we did for private investment, we now turn to alternative specifications dealing with other fiscal flow variables, as well as with macroeconomic volatility. Table 4a reports the results of model (2) where we replace the fiscal deficit with government size. Estimates suggest that the impact of public debt on productivity growth may indeed depend on the size of the public sector. In most cases, the coefficient estimated for government expenditure is negative and significant, while the statistical significance of the one on debt is mostly reduced with respect to the benchmark estimates. One possibility is that high debt may be detrimental to productivity among other reasons owing to an excessive diversion of resources towards non-productive uses.

TABLE 4A
PRODUCTIVITY GROWTH AND GOVERNMENT SIZE

	GDPhwgr		*LabprodgrOECD*		*TFPgr*	
	(a) 5-year FE	(b) Sys-GMM	(c) 5-year FE	(d) Sys-GMM	(e) 5-year FE	(f) Sys-GMM
debt	−0.0035	−0.0069	−0.0079*	−0.0015	−0.0006	0.0022
	(−0.63)	(−1.44)	(−1.67)	(−0.43)	(−0.10)	(0.98)
govsize	−0.0292	−0.0726***	0.0067	−0.0323**	0.0135	−0.0325*
	(−1.23)	(−3.66)	(0.32)	(−2.14)	(0.52)	(−1.67)
prod	−2.9073***	0.1074	−0.0813***	−0.0412***	−0.0709***	−0.0299***
	(−3.04)	(0.22)	(−5.94)	(−3.03)	(−5.95)	(−2.89)
capstock	1.2879*	0.1328	1.0310*	−0.0583	−0.1861	0.0933
	(1.83)	(0.47)	(1.81)	(−0.64)	(−0.26)	(1.05)
educ	−0.4754***		−0.3795**		−0.3976***	
	(−3.27)		(−2.33)		(−4.20)	
rltrate	0.0309	0.0212	0.1198**	0.0090	0.0608	0.0206
	(0.63)	(0.20)	(2.25)	(0.15)	(1.24)	(0.44)
open	−0.0043	0.0189**	−0.0053	0.0039	0.0185	0.0089*
	(−0.35)	(2.36)	(−0.46)	(1.40)	(1.41)	(1.75)
popgr	−0.2024	−1.3071***	0.1490	−0.6181***	−0.3914	−0.4783***
	(−0.95)	(−3.13)	(0.64)	(−5.01)	(−1.58)	(−4.05)
findev	−0.0024	−0.0010	−0.0003	−0.0002	−0.0045	−0.0036*
	(−0.64)	(−0.17)	(−0.14)	(−0.11)	(−1.51)	(−1.90)
qual	0.0215	−0.0363	−0.0643***	−0.0233	−0.0405	0.0506
	(0.65)	(−0.30)	(−2.83)	(−0.35)	(−1.35)	(0.63)
oil	0.0321	−0.0098	0.0531**	0.0548*	−0.0302**	0.0416**
	(1.45)	(−0.39)	(2.36)	(1.93)	(−2.41)	(2.44)
No. of obs.	129	563	128	563	131	585
R^2 (within)	0.60		0.69		0.62	
Hansen *J*-statistic		1.00		1.00		1.00
AR(1)		0.123		0.001		0.001
AR(2)		0.105		0.105		0.194

Notes
The dependent variable is either $prodgr_{[t,t-4]}$ (5-year period estimates) or $prodgr_t$ (annual estimates). *t*-statistics (*z*-statistics for the annual estimates) in parentheses based on robust standard errors. ***, **, * denote significance at 1%, 5%, 10%, respectively. Country and time fixed effects included but not reported. *p*-values of the Hansen statistic and of the AR(1) and AR(2) tests are reported.

TABLE 4B
PRODUCTIVITY GROWTH AND TAX SHARES

	GDPhwgr		*LabprodgrOECD*		*TFPgr*	
	(a) 5-year FE	(b) Sys-GMM	(c) 5-year FE	(d) Sys-GMM	(e) 5-year FE	(f) Sys-GMM
debt	−0.0083***	−0.0101***	−0.0062***	−0.0046	0.0030	0.0002
	(−2.96)	(−2.87)	(−2.60)	(−1.45)	(0.95)	(0.06)
inc_tax_share	−0.0656	−0.0932**	−0.0244	−0.0295*	−0.0970***	0.0018
	(−1.15)	(−2.18)	(−0.43)	(−1.71)	(−2.85)	(0.10)
No. of obs.	142	623	136	600	144	640
R^2 (within)	0.61		0.67		0.59	
Hansen *J*-statistic		1.00		1.00		1.00
AR(1)		0.151		0.052		0.007
AR(2)		0.129		0.215		0.298
debt	−0.0125***	−0.0125***	−0.0077*	−0.0059*	−0.0009	−0.0006
	(−3.23)	(−3.52)	(−1.79)	(−1.77)	(−0.18)	(−0.21)
soc_tax_share	0.1149**	−0.0105	0.0472	0.0002	0.0718	−0.0438*
	(2.13)	(−0.33)	(0.62)	(0.01)	(1.14)	(−1.77)
No. of obs.	142		136	600	144	640
R^2 (within)	0.61		0.67		0.57	
Hansen *J*-statistic		1.00		1.00		1.00
AR(1)		0.322		0.001		0.006
AR(2)		0.353		0.125		0.280
debt	−0.0093***	−0.0104***	−0.0066**	−0.0044	0.0012	−0.0006
	(−2.71)	(−2.76)	(−2.39)	(−1.20)	(0.29)	(−0.15)
pro_tax_share	−0.0466	−0.1126	−0.0647	−0.2005**	0.1675	−0.0395
	(−0.28)	(−0.71)	(−0.48)	(−2.30)	(1.15)	(−0.32)
No. of obs.	142	623	136	600	144	640
R^2 (within)	0.61		0.67		0.57	
Hansen *J*-statistic		1.00		1.00		1.00
AR(1)		0.104		0.005		0.008
AR(2)		0.091		0.114		0.289
debt	−0.0062*	−0.0082**	−0.0053*	−0.0053	0.0023	−0.0009
	(−1.65)	(−1.99)	(−1.74)	(−1.28)	(0.57)	(−0.28)
g&s_tax_share	−0.2772***	0.0239	−0.1431*	−0.0332	−0.1639*	−0.0320
	(−2.74)	(0.22)	(−1.74)	(−0.43)	(−1.93)	(−0.75)
No. of obs.	142	623	136	600	144	640
R^2 (within)	0.64		0.68		0.58	
Hansen *J*-statistic		1.00		1.00		1.00
AR(1)		0.159		0.051		0.007
AR(2)		0.167		0.118		0.294

Notes
The dependent variable is either $privinv_{[t,t-4]}$ (5-year period estimates) or $privinv_t$ (annual estimates). *t*-statistics (*z*-statistics for the annual estimates) in parentheses based on robust standard errors. ***, **, * denote significance at 1%, 5%, 10%, respectively. Controls (same as in Table 3), country and time fixed effects included but not reported. *p*-values of the Hansen statistic and of the AR(1) and AR(2) tests are reported.

TABLE 4C
PRODUCTIVITY GROWTH AND MACROECONOMIC VOLATILITY

	GDPhwgr		*LabprodgrOECD*		*TFPgr*	
	(a) GDP vol.	(b) Infl. vol.	(c) GDP vol.	(d) Infl. vol.	(e) GDP vol.	(f) Infl. vol.
debt	−0.0010***	−0.0110***	−0.0068**	−0.0068**	−0.0006	−0.0010
	(−3.16)	(−3.25)	(−2.36)	(−2.42)	(−0.20)	(−0.32)
deficit	−0.0008	−0.0002	−0.0479**	−0.0476**	−0.0520*	−0.0516*
	(−0.02)	(0.00)	(−2.04)	(−2.03)	(−1.74)	(−1.73)
gdp_vol	−0.0071		−0.0437		−0.1418*	
	(−0.76)		(−0.64)		(−1.79)	
infl_vol		−0.1789		−0.0288		−0.1479
		(−1.13)		(−0.32)		(−1.62)
prod	−3.2907***	−3.6405***	−0.1039***	−0.1054***	−0.0520***	−0.0619***
	(−3.29)	(−3.92)	(−10.03)	(−9.62)	(5.54)	(−9.19)
capstock	0.7380	0.8461	0.0432	0.0478	−0.3280	−0.3320
	(1.20)	(1.41)	(0.09)	(0.10)	(−0.60)	(−0.68)
educ	−0.2730*	−0.2510	−0.4462***	−0.4554***	−0.2436***	−0.2670***
	(−1.68)	(−1.52)	(−4.58)	(−4.75)	(−3.05)	(−3.43)
rltrate	0.0026	−0.0056	0.1190**	0.1171**	0.0329	0.0234
	(0.05)	(−0.11)	(2.36)	(2.36)	(0.70)	(0.56)
open	0.0056	0.0070	0.0057	0.0061	0.0219**	0.0237**
	(0.48)	(0.60)	(0.63)	(0.67)	(2.13)	(2.31)
popgr	−0.3411***	−0.2941**	0.0589	0.0563	−0.3694**	−0.3451**
	(−2.86)	(−2.53)	(0.43)	(0.38)	(−2.13)	(−2.29)
findev	0.0003	0.0012	0.0000	0.0001	−0.0054*	−0.0050*
	(0.09)	(0.32)	(0.01)	(0.04)	(−1.90)	(−1.82)
qual	0.0001	−0.0154	−0.0528**	−0.0577**	−0.0232	−0.0403*
	(0.00)	(−0.57)	(−2.22)	(−2.22)	(−1.30)	(1.75)
oil	0.0170	0.0123	0.0625***	0.0620***	0.0001	−0.0017
	(0.94)	(0.66)	(3.65)	(3.56)	(0.01)	(−0.12)
No. of obs.	136	136	130	130	142	142
R^2 (within)	0.60	0.60	0.71	0.71	0.59	0.59

Notes
The dependent variable is always $prodgr_{[t,t-4]}$ (5-year period estimates). t-statistics in parentheses based on robust standard errors. ***, **, * denote significance at 1%, 5%, 10%, respectively. Country and time fixed effects included but not reported.

Table 4b contains the estimates of four specifications of model (2) where the receipts shares over GDP are used in place of the deficit. The results suggest again that distortions created by higher taxes on income and on goods and services may account for the adverse impact of debt on productivity growth. In many cases, the relevant coefficients are negative and statistically significant, and the debt coefficients are negative but not always statistically different from zero.

Finally, Table 4c reports the estimates of model (2) enriched with the two variables measuring macroeconomic volatility, that is, output and inflation volatility, added separately. Contrary to the model for private investment, estimates do not suggest that macroeconomic volatility plays a significant role for productivity growth. The coefficients associated to the volatility variables are in all cases not statistically significant, whereas those on the fiscal variables are consistent with the baseline findings (Table 4).

With respect to possible non-linearities in the debt–productivity relationship, we first re-estimated the specifications in Table 4 by adding either the squared level of debt or the dummies and interaction terms for different levels of debt/GDP. The annual estimates obtained via system-GMM (not reported for the sake of brevity) suggest that there is indeed a non-linear relationship between public debt and productivity. When the two measures of labour productivity growth are used, in most cases a large negative coefficient is associated to the threshold dummy and a positive coefficient to the interaction term (normally not large enough to offset the negative effect estimated for the debt/GDP ratio). In the case of TFP growth, debt seems to start exerting negative effects only when above 100% of GDP. Therefore our results are roughly consistent with those of Checherita-Westphal and Rother (2012), who find evidence of a concave relationship between debt and productivity in a sample of euro-area countries. This evidence calls for further analysis of non-linearity, which we offer in the next subsection.

Threshold effects and further robustness checks

Reinhart and Rogoff (2010) report the (now infamous) result that economies with a government debt/GDP ratio above 90% experience significantly lower GDP growth than less indebted countries. Similar regularities emerge in Afonso and Jalles (2011), but their estimates too are based on an *ad hoc* threshold. The final step of our analysis using advanced economies' data investigates the presence of non-linearities by applying the widely followed endogenous threshold approach proposed by Hansen (1999, 2000).

Hansen's method is developed for non-dynamic panels with individual-specific fixed effects. This makes its use questionable for most specifications of the problem at hand, and critically constrains its usefulness in the context of purely dynamic models, particularly for those with a short time dimension and non-normal data (see, for instance, Baum *et al*. 2013; Kourtellos *et al*. 2012). In spite of the method's limited appeal, and given the lack of more robust alternatives, it can still be used to offer some ballpark indication as to the likelihood of non-linear effects. The algorithm allows sequential testing of the null of m thresholds versus the alternative hypothesis of m+1 thresholds, for m=1,2,. . .,K. We set K = 5, but we found that a triple threshold model fares best according to standard goodness-of-fit criteria.

Following the least squares estimation of the coefficients and thresholds, non-standard asymptotic inference allows us to determine confidence regions and test hypotheses. The algorithm simply does not work with the limited time dimension implied by 5-year periods; therefore we switch to data at annual frequency, finding evidence broadly consistent with our baseline specification. Table 5 shows the test statistics and their bootstrap p-values, whereas Table 6 reports point estimates only for the significant thresholds, alongside their asymptotic 95% confidence intervals. The test for a single threshold turns out as not significant in the models for investment, however defined, with bootstrap p-values well above 0.05. As for productivity growth, the test is significant at less than 1% with the OECD measure of labour productivity, only at 10% with the other indicators. The test for a double threshold is only marginally significant (with bootstrap p-values below 10%) for per capita investment, whereas it is much more significant for non-TFP measures of productivity growth. The validity of a triple threshold is rejected for the latter, and puzzlingly accepted, although only at the margin, for investment. Results similar to those for productivity growth hold for per capita GDP growth (see the final column of Table 5).

TABLE 5
TESTS FOR THRESHOLD EFFECTS

LR test:	Private investment		Productivity growth			GDP growth
Threshold	Investment	Investment P.C.	Δ(GDPhw)	Δ(OECD)	ΔTFP	
Single						
F_1 (p-value)	9.65 (0.46)	8.83(0.44)	8.55 (0.08)	11.82 (0.00)	9.77 (0.06)	10.81 (0.01)
[10,5,1%]	[37.6,57.3,176.2]	[32.3,45.0,171.5]	[7.9,9.9,11.6]	[8.0,9.7,11.7]	[8.5,9.9,15.9]	[8.1,9.4,11.3]
Double						
F_1 (p-value)	24.55 (0.14)	24.11 (0.09)	10.92 (0.05)	12.71 (0.01)	8.78 (0.10)	12.07 (0.06)
[10,5,1%]	[27.8,32.0,39.1]	[22.7,29.2,41.9]	[8.5,11.0,24.1]	[8.6,10.5,13.7]	[8.8,10.4,12.6]	[10.0,12.6,25.2]
Triple						
F_1 (p-value)	15.60 (0.06)	14.31 (0.09)	4.42 (0.46)	3.80(0.59)	3.02 (0.75)	4.16 (0.59)
[10,5,1%]	[13.9,17.9,24.8]	[13.7,17.4,26.8]	[8.9,10.3,11.7]	[7.4,8.7,11.3]	[7.9,10.2,16.7]	[8.7,9.7,12.8]

Notes
Estimates are based on 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,. . .,K. p-values are obtained via a bootstrap procedure involving 500 replications to approximate the sampling distribution.

TABLE 6
THRESHOLD ESTIMATES

	Productivity growth (OECD): double threshold		Productivity growth (TFP): single threshold	
	Estimate	95% confidence region	Estimate	95% confidence region
g1	86.19	[76.35,90.23]	87.92	[71.08,93.15]
g2	102.51	[98.51,105.49]		

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

TABLE 7
TOTAL INVESTMENT—EMERGING ECONOMIES

	Aggregate investment		Per capita investment	
	(a)	(b)	(c)	(d)
	5-year FE	Sys-GMM	5-year FE	Sys-GMM
debt	−0.0017*	−0.0080**	−0.0015*	−0.0096***
	(−1.90)	(−2.40)	(1.66)	(−3.77)
govsize	0.0042	0.0260*	0.0052	0.0498***
	(0.60)	(1.77)	(0.84)	(2.69)
capstock	0.0723	0.9902***	0.0425	0.3689***
	(0.79)	(23.27)	(0.59)	(−4.15)
tfp	0.0126***	0.0100**	0.0139***	0.0026
	(7.34)	(2.29)	(7.65)	(0.52)
rltrate	−0.00003	0.0001	−0.00001	−0.00002
	(−1.09)	(0.37)	(−0.50)	(−0.14)
open	−0.00005	0.0039***	0.0002	0.0134***
	(−0.05)	(4.18)	(0.24)	(−3.10)
popgr	0.1120*	0.0579**	0.0721	−0.0109
	(1.87)	(2.58)	(1.58)	(−0.14)
findev	−0.0002	0.0034**	0.0003	0.0082*
	(−0.14)	(2.11)	(0.28)	(1.91)
qual	0.0103	0.0756***	0.0041	0.1276***
	(0.63)	(4.56)	(0.29)	(3.13)
oil	0.0237***	−0.0069	0.0094***	−0.0021
	(7.06)	(−1.56)	(3.79)	(−0.41)
No. of obs.	383	1506	382	1506
R^2 (within)	0.57		0.51	
Hansen *J*-statistic		1.00		1.00
AR(1)		0.306		0.285
AR(2)		0.306		0.477

Notes
The dependent variable is either $totinv_{[t,t-4]}$ (5-year period estimates) or $totinv_t$ (annual estimates). *t*-statistics (*z*-statistics for the annual estimates) in parentheses based on robust standard errors. ***, **, * denote significance at 1%, 5%, 10%, respectively. Country and time fixed effects included but not reported. *p*-values of the Hansen statistic and of the AR(1) and AR(2) tests are reported.

Overall, we interpret these and our previous regression results in a somewhat conservative way, and conclude that there is some evidence that the estimated adverse effects of higher debt/GDP ratios operate according to a double threshold specification

TABLE 8
PRODUCTIVITY GROWTH—EMERGING ECONOMIES

	TFPgr			
	5-year FE		Sys-GMM	
debt	0.0054	(0.81)	−0.0160**	(−2.54)
govsize	−0.0761	(−1.19)	−0.0780	(−1.47)
tfp	−0.0536***	(−3.85)	−0.0362***	(−2.62)
capstock	−0.8902	(−1.49)	0.0772	(0.48)
educ	−0.6121	(−1.62)		
rltrate	0.0008**	(2.41)	−0.0014	(−1.18)
open	0.0015	(0.06)	0.0090	(0.85)
popgr	0.1617	(0.56)	−0.2219	(−0.97)
findev	−0.0179**	(−2.13)	−0.0018	(−0.18)
qual	0.0550	(0.68)	−0.0399	(−0.70)
oil	0.0476	(1.54)	0.0470	(1.14)
No. of obs.	382		1525	
R^2 (within)	0.24			
Hansen *J*-statistic			1.00	
AR(1)			0.155	
AR(2)			0.193	

Notes
The dependent variable is either $tfpgr_{[t,t-4]}$ (5-year period estimates) or $tfpgr_t$ (annual estimates). *t*-statistics (*z*-statistics for the annual estimates) in parentheses based on robust standard errors. ***, **, * denote significance at 1%, 5%, 10%, respectively. Country and time fixed effects included but not reported. *p*-values of the Hansen statistic and of the AR(1) and AR(2) tests are reported.

for productivity growth. In contrast, the evidence on such an effect being at work for investment spending appears more ambiguous. Erring a little on the side of a non-linear response, the point estimates of the thresholds for productivity are around 86% and 88% (single and double threshold model, respectively) and 102% (double threshold). These values accord with the sparse existing literature (e.g. Afonso and Jalles 2011), while being somewhat higher than in other studies and higher than the sample average of the government debt/GDP ratio. The asymptotic confidence interval is relatively tight; not so for investment (unreported), however, confirming substantial uncertainty as to the significance of threshold effects for this variable (see Afonso and Jalles 2011).

Evidence on developing countries

This subsection illustrates the findings related to a sample of 80 additional countries.[14] We estimated models (1) and (2) using series in most cases comparable to those for the OECD economies, although in some cases we had to cope with the lower quality of the data either by excluding variables from the models or by replacing them with similar series. Table 7 displays the estimated coefficients of model (1). Only the total investment results are reported due to the lack of data for private investment. Profits had to be excluded from the model for the same reason. Government size (general government final consumption expenditure over GDP) is used as the fiscal policy flow variable rather than government deficit, due to data availability.

Results are very much in line with those arising from the sample of advanced countries. A negative relationship between government debt and total investment stands out, in both aggregate and per capita terms. This finding is consistent across different estimators and data frequencies. The GMM estimates also seem to suggest a positive influence of government expenditure (although barely statistically significant when focusing on aggregate investment). Adding the 20 OECD countries of the main sample into this second sample does not alter the findings (results not reported but available on request).

Table 8 presents the coefficients of model (2) estimated using data for the developing economies. The only productivity measure available is TFP, therefore we are unable to present results with alternative series. In this case the two alternative estimators yield different results. According to the GMM estimates, there is again a statistically significant negative influence of debt on productivity growth, but this does not show up in the FE estimates obtained with 5-year period. In both cases, the government size coefficient is estimated to be negative, but never significant at standard levels. As for the investment specification, including the 20 initial countries does not alter the results. All in all, these additional estimates broadly confirm the findings for the sample of advanced countries. We recall that for those countries results also turned out to be sensitive to different specifications, and in particular to different definitions of the productivity variables.

IV. Conclusions

Recently, the implications of high government debt levels have gained remarkable attention in the policy debate. 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 private investment spending and productivity growth. Our analysis, based on data covering the 1970–2009 period for a group of 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. We find some evidence that the adverse effects of debt on productivity growth are non-linear; the evidence is much less clear for investment. These results are consistent and robust across the different specifications and estimators that we employ, and, in contrast with some of the previous literature, are not based on restrictive identification and estimation assumptions. The additional evidence that we offer on 80 developing countries broadly agrees with the findings for OECD economies.

Our results provide underpinnings to the notion that high debt levels have harmful effects on the dynamics of productivity and investment spending, which in turn have well-known bearings on long-term growth. This regularity would have not shown up had we employed, as in much of the literature, either 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 also for growth-enhancing government policies. The cost of high debt in advanced countries should therefore be evaluated in the light of these severe and complex long-term consequences.

APPENDIX

We give definitions and sources of the variables for the 20 OECD countries sample [in square brackets those for the 80 developing countries when different].

Private investment (*privinv*−*privinvpc* in per capita terms). Logarithm of gross real (expressed in 2000 PPP USD) fixed capital formation of the private sector. Source: AMECO [not available for the developing countries sample].

Total investment (*totinv*−*totinvpc* in per capita terms). Logarithm of gross real (expressed in 2000 PPP USD) fixed capital formation of the economy. Source: World Development Indicators (World Bank).

Productivity growth (*prodgr*). Three different measures: (a) growth rate of real (expressed in 2000 PPP USD) GDP per hour worked (sources: WDI (real GDP) and OECD (hours worked)); (b) growth rate of output per unit of labour (source: OECD); (c) growth rate of total factor productivity, total economy (source: AMECO [Penn World Tables 8.0: Feenstra *et al*. (2013)]).

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

Fiscal deficit (*deficit*). Deficit divided by GDP. Source: OECD [not available for the developing countries sample].

Government size (*govsize*). General government total disbursements over GDP. Source: OECD [general government final consumption expenditure over GDP; source: WDI].

Profits (*prof*). Logarithm of real (expressed in 2000 PPP USD) business profits (gross operating surplus). Source: AMECO [not available for the developing countries sample].

Capital stock (*capgdp*). Logarithm of real (expressed in 2000 PPP USD) capital stock (total economy). Source: AMECO [Penn World Tables 8.0].

Real long-term interest rate (*rltrate*). Nominal long-term interest rate (source: AMECO and OECD [lending interest rate; source: WDI]) minus trend inflation calculated by applying a Hodrick–Prescott filter to the annual inflation rate calculated from the CPI (source: MEI-OECD [WDI]).

Trade openness (*open*). Imports plus exports divided by GDP. Source: Penn World Tables 8.0.

Population growth (*popgr*). Annual growth rate of population. Source: Penn World Tables 8.0.

Financial development proxy (*findev*). Private credit divided by GDP. Source: WDI.

Institutional quality (*qual*). Ordinal-scaled variable taking into account the effectiveness of legislature, the competitiveness of the nominating process, the existence of government coalitions, and the party legitimacy. Source: Cross-National Time-Series Data Archive, Banks and Wilson (2011).

Oil price (*oil*). Logarithm of the spot price of a barrel of oil. Source: Dow Jones & Co.

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

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).

ACKNOWLEDGEMENTS

A previous version of this paper circulated with the title ‘Even worse than you thought: the impact of public debt on aggregate investment and productivity’. We are grateful to Nicola Acocella, Silvia Ardagna, Pierluigi Balduzzi, Fabrizio Carmignani, Giancarlo Corsetti, Chiara Dalle Nogare, Davide Furceri, John McHale, Maria Laura Parisi, Fidel Perez Sebastian, Fabio Schiantarelli and Franco Spinelli for comments and suggestions. We thank seminar participants at the National University of Ireland Galway, the University of Brescia, the 16th T2M conference, the 2012 CEUS workshop, the 10th INFINITI conference, the 2012 EcoMod conference, the 2012 MMF conference, the Conference on Fiscal Policy Coordination in Europe organized by the Central Bank of Slovakia, and the XVII DEGIT conference. All errors are solely ours.

NOTES

1. Cecchetti *et al*. (2011b) use overlapping 5-year forward averages of the per capita income growth rate, and also explore the impact of corporate, private-sector and household debt.
2. Panizza and Presbitero (2012) employ the share of foreign currency-denominated debt on total debt to instrument debt in growth regressions on overlapping 5-year averages. However, such choice is problematic

given the potentially weak correlation between the instruments and the instrumented variables. Indeed, the share of foreign currency debt is very small in the countries that we study, which also tend to have very stable or even fixed exchange rates over most of the sample. As a result, estimates obtained through IV techniques may be biased and, more generally, tests of hypotheses may have low power.

3. Panizza and Presbitero (2012) also argue that the case of developing countries is different. In Kourtellos *et al*. (2012) too, the main results seem to be driven by country heterogeneity (82 countries) over too few observations (just three 10-year periods).
4. 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 parametrization and robustness, which is the reason why we decided to rely on two different methods/data frequencies.
5. We estimate the model with fixed effects, because the use of 5-year periods definitely complicates the apparently dynamic nature of the model. With a 'standard' dynamic model, we have $capitalstock_{t+1} - capitalstock_t = \beta capitalstock_t + othercontrols$. Instead, here we estimate $\frac{1}{5}[(stock_{t+5} - stock_{t+4}) + (stock_{t+4} - stock_{t+3}) + (stock_{t+3} - stock_{t+2}) + (stock_{t+2} - stock_{t+1}) + (stock_{t+1} - stock_t)] = \beta\, stock_t + other$. This makes the application of standard corrections (e.g. Kiviet) far from obvious. Second, as argued by Cecchetti *et al*. (2011b), who follow Judson and Owen (1999), the use of a different estimator on such a small sample would yield much less reliable results. Nevertheless, we also offer system-GMM estimates based on annual data. (We treat the fiscal policy and the conditional convergence variables as endogenous, and we restrict the number of lagged levels to two in the instrument set.)
6. From a debt-sustainability perspective, it is gross debt and its refinancing that matter, and essentially all existing studies employ gross government debt or gross financial liabilities of total government. More important, economic theory shows that the potential distortions of high debt levels are associated with the issuance *per se* of government debt, not with the nature, either public or private, of its holders.
7. The literature offers a few examples of models where both debt and deficit have been included at the same time as explanatory variables (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 government debt on investment.
8. This is computed by subtracting trend inflation (proxied by the low-frequency component of the inflation calculated on annual data using a Hodrick–Prescott filter as in Orr *et al*. 1995) from the nominal long-term interest rate. Note that none of our results changes when we include both inflation and the nominal interest rate instead.
9. Using a proxy for financial integration (sum of foreign assets and liabilities over GDP, $finint_t$) instead of financial development does not alter the results. The same applies to the productivity model below.
10. We use a variable accounting for political pluralism (see the Appendix for details). In principle, alternative variables on the quality of governance could have been used, but data going back to 1970 are hard to find (e.g. the widely used governance indicators by Kaufmann *et al*. (2004) start only in 1996).
11. GDP per capita can be separated into a component related to labour utilization and one that quantifies the contribution of labour productivity, which is the OECD measure that we employ. The OECD Productivity Database uses total hours worked as the labour input measure for all countries, where this is defined as the product of series for average hours per worker or per job multiplied by total number of workers or the total number of jobs.
12. 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.
13. 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.
14. The countries are: Argentina, Armenia, Bahrain, Barbados, Benin, Bolivia, Botswana, Brazil, Bulgaria, Burundi, Cameroon, Central African Republic, Chad, Chile, China, Colombia, Costa Rica, Cote d'Ivoire, Croatia, Cyprus, Czech Republic, Dominican Republic, Ecuador, Egypt, Estonia, Fiji, Gabon, Guatemala, Honduras, Hungary, Iceland, India, Indonesia, Iran, Israel, Jordan, Kenya, Korea Republic, Kuwait, Kyrgyzstan, Latvia, Lesotho, Lithuania, Maldives, Malta, Mauritius, Mexico, Moldova, Mongolia, Morocco, Mozambique, Namibia, Niger, Panama, Paraguay, Peru, Philippines, Poland, Qatar, Romania, Russia, Rwanda, Senegal, Sierra Leone, Singapore, Slovakia, Slovenia, South Africa, Sri Lanka, Swaziland, Tajikistan, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Ukraine, Uruguay, Venezuela and Zimbabwe.

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