PUBLIC DEBT AND GROWTH

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This paper examines the impact of high public debt on long-run economic growth in a panel of advanced and emerging economies over four decades, while taking into account various estimation issues including reverse causality and endogeneity. Threshold effects, non-linearities, and differences between advanced and emerging market economies are also explored. High initial public debt is found to be significantly and consistently associated with slower subsequent growth, controlling for other determinants of growth. The adverse effect largely reflects a slowdown in labor productivity growth mainly due to reduced investment and slower growth of capital stock. Extensive robustness checks confirm the results.

1 Introduction

The recent global economic and financial crisis has led to an unprecedented increase in public debt across the world. By the end of 2012, public debt is expected to reach about 107 per cent of GDP in advanced economies – its highest level in 50 years. This has raised serious concerns about fiscal sustainability and their economic impact for many advanced economies amid the current European sovereign debt crisis. What are the effects on longer-term growth of high public debt? This is an important policy question. Surprisingly, however, there has been little systematic empirical analysis in the literature, despite the existence of a very large empirical growth literature (see, for example, Aghion and Durlauf, 2005).[1]

Public debt has important influence over the economy both in the short- and the long run. The conventional view is that debt can stimulate aggregate demand and output in the short run, but crowds out capital and reduces output in the long run (see Elmendorf and Mankiw, 1999 for a literature survey). This paper concerns the long-run effects of public debt. Standard growth theory predicts that an increase in government debt leads to slower growth: a temporary decline in growth along the transition path to a new steady state in the neoclassical model, such as the Solow model, and a permanent decline in growth in the endogenous growth model (Saint-Paul, 1992). Building on Barro's (1990) endogenous growth model with public good services, Aizenman *et al.* (2007) also show that with effective upper bound on tax revenue due to distortions and imperfect tax

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[1] A notable partial exception is Reinhart and Rogoff (2010) who examine economic growth and inflation at different levels of government debt in advanced and emerging economies based on long historical data series. However, their study only considers correlations between debt and growth, and does not take into account other determinants of growth via econometric analysis as well as issues such as reverse causality (*i.e.*, low growth can lead to large public debt). After the publication of the working paper version of our paper (Kumar and Woo, 2010), subsequent studies by others examined much smaller samples of countries and obtained the results that are quantitatively similar to ours: Checherita and Rother (2010) in 12 Euro economies for 1970-2008 and Cecchetti *et al.* (2011) in 18 OECD countries for 1980-2006. However, they mostly focus on identifying the threshold level of debt above which debt becomes harmful to growth. They do not explore the channels through which debt can affect growth nor consider the interaction between growth, debt, and a country's economic and financial position *vis-à-vis* the rest of the world (or currency composition of debt), not to mention the lack of rigorous discussion on related econometric issues.

enforcement, an increase in (initial) debt lowers the productive government spending, which reduces the return to capital and growth subsequently.

High debt may adversely affect medium- and long-run growth via several channels: high public debt can adversely affect capital accumulation and growth via higher long-term interest rates (Gale and Orzag, 2003; Baldacci and Kumar, 2010), higher future distortionary taxation (Barro, 1979; Dotsey, 1994) and lower future public infrastructure spending (Aizenmann *et al.*, 2007), higher inflation (Sargent and Wallace 1981; Barro 1995; Cochrane 2011), and greater uncertainty about prospects and policies. In more extreme cases of a debt crisis, by triggering a banking or currency crisis, these effects can be magnified (Burnside *et al.*, 2001; Hemming *et al.*, 2003). Also, high debt is likely to constrain the scope for countercyclical fiscal policies, which may result in higher volatility and further lower growth (Aghion and Kharroubi, 2007; Woo, 2009).

The purpose of this paper is to examine empirically the effects of high public debt on economic growth. To our knowledge, this paper presents the first econometric evidence on the impact of *initial* high public debt on *subsequent* growth of real GDP per capita in a panel of advanced and emerging economies for the period of 1970-2008 by carefully applying various econometric techniques. Here it is worth emphasizing that the paper uses *initial* level of government debt to examine the impact on *subsequent* growth over the next five to twenty years (or longer) so that it avoids reverse causality. Evidence strongly suggests an inverse relationship between initial debt and subsequent growth, controlling for other determinants of growth: on average, a 10 percentage point increase in the initial debt-to-GDP ratio is associated with a slowdown in real per capita GDP growth of around 0.2 percentage points per year, with the impact being somewhat smaller in advanced economies. This order of magnitude is robust to various specifications, estimation methods, samples and periods. There is some evidence of non-linearity with higher levels of initial debt (above around 90 per cent of GDP) having more significantly negative effects on subsequent growth.

Moreover, we find that the impact on growth of initial debt is conditional on a country's economic and financial position *vis-à-vis* the rest of the world and that the currency composition of public debt matters. The adverse impact of debt on growth is larger when the net foreign asset (NFA) position is low or the portion of foreign-currency denominated debt as a share of total public debt is high. Growth accounting exercises imply that the adverse effect largely reflects a slowdown in labor productivity growth mainly due to reduced investment and slower growth of capital stock, rather than through slower growth of TFP or human capital. Additional evidence on the impact of initial debt on subsequent investment renders strong support to this conclusion. We conduct extensive robustness checks. The results are robust to a number of alternative specifications, which control for the variables usually identified as the main determinants of economic growth (Sala-i-Martín *et al.*, 2004), as well as to different samples and periods. In particular, we carefully address a variety of econometric issues including reverse causality, endogeneity, and outliers.

Our paper is related to a few studies that have looked at the impact of *external* (public and private) debt on economic growth *exclusively* in the context of *low income economies*. Most of these studies were motivated by the "debt overhang" hypothesis – a situation where a country's debt service burden is so heavy that a large portion of output accrues to foreign lenders and consequently creates disincentives to invest (Krugman, 1988; Sachs, 1989). Imbs and Rancière (2009) and Pattillo *et al.* (2002, 2004) find a non-linear effect of external debt on growth: that is, a negative and significant impact on growth at high debt levels (typically, over 60 per cent of GDP), but an insignificant impact at low debt levels. Besides the differences in estimation strategies, however, we examine the growth impact of *public debt* in the context of *advanced (and emerging)*

economies that is largely domestic and denominated in domestic currency,[2] which may have different implications for the magnitude of growth impact and the operating channel(s), compared to those of external debt in the context of low income countries.

The rest of the paper is organized as follows: Section 2 briefly describes data and some stylized facts relating to public debt and growth; Section 3 discusses a number of methodological issues and estimation strategy, and then presents the main panel regression results on the relationship between debt and growth, followed by Section 4 Growth Accounting. Section 5 concludes. Appendixes 1-3 provide additional discussion regarding country sample, data sources and growth accounting.

2 Data and stylized facts

Data for the key variables such as GDP, population, investment, and government size are obtained primarily from the latest version 7.0 of Penn World Table (Heston *et al.*, 2011). Fiscal data including government debt are primarily from the IMF's World Economic Outlook database, and other variables are from World Bank's World Development Indicators, Barro and Lee (2011). The availability of data on public debt and other variables included in the regression dictated the sample size: the main analysis is based on a panel of 38 advanced and emerging economies with a population of over 5 million for the period 1970-2008, while we also present the results using the full sample of 79 countries (including advanced, emerging, and developing countries) without imposing a population size restriction (see Appendices 1-2 for the country list and data sources).

Some stylized facts: First, data on government debt and growth clearly show that there is a negative correlation between *initial* government debt and *subsequent* growth of real per capita GDP. Figure 1 shows a scatter plot of initial debt against subsequent growth of real per capita GDP over five-year periods in the sample of countries with population of over 5 million. According to the OLS fitted line, the coefficient of initial debt is –0.024. Taken at face value (*i.e.*, ignoring the potential endogeneity problem, and not controlling for other growth determinants), it suggests that a 10 percentage point increase in initial debt-to-GDP ratio is associated with a subsequent slowdown in per capita GDP growth of 0.24 percentage points. At shown below, this magnitude turns out to be surprisingly consistent with that obtained using robust econometric analysis. Similarly, *initial* debt is negatively associated with both *subsequent* growth of capital per worker (Figure 2) and domestic investment over 5-year periods (Figure 3).

Second, the *subsequent* growth rate of per capita GDP over five-year periods during high *initial* debt episodes (above 90 per cent of GDP) is on average lower than that during low *initial* debt episodes (below 30 per cent of GDP) across various groups of countries (Figure 4). In advanced economies, the difference in the average growth rates between low initial debt and high initial debt episodes is 0.9 percentage points; in emerging economies, it is more than twice that (1.7 percentage points). This pattern is consistent with econometric results discussed later. Similarly, the average growth differential in G7 countries between low and high initial debt periods is 1.7 percentage points. In the full sample (including developing countries), the growth differential is 2.8 percentage points. (See Appendix Table 10 for summary statistics on average growth rates of real GDP per capita, output per worker, TFP, capital stock per worker, and average levels of domestic investment at different levels of initial government debt for various country groupings).[3]

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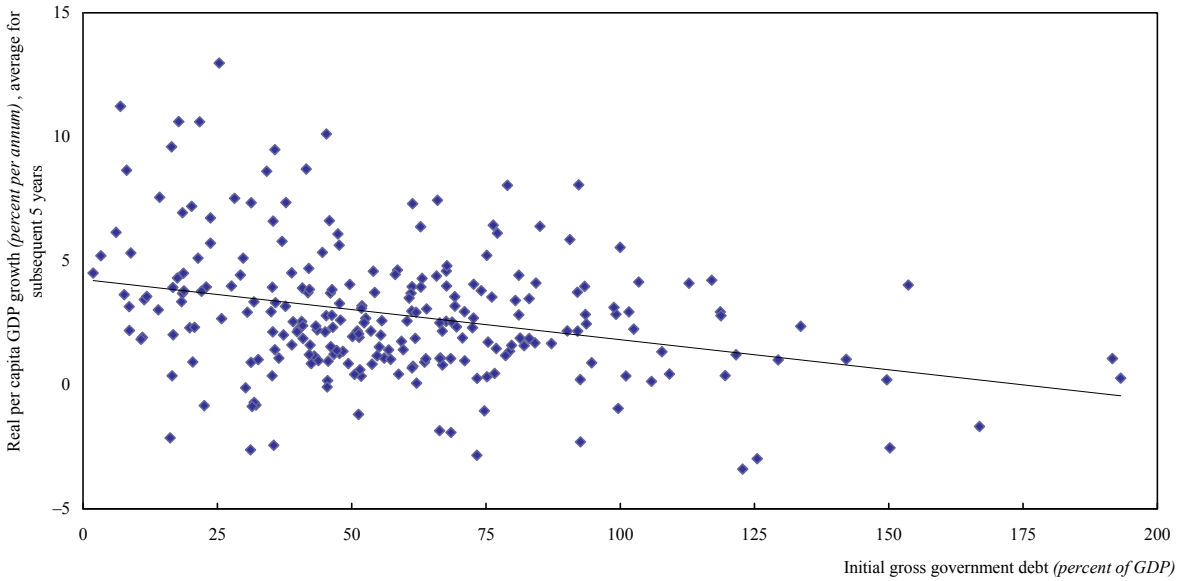
[2] This is not only true of advanced economies throughout the sample period, but also of emerging economies in the recent decades during which the portion of domestic-currency denominated debt has been increasing sharply.

[3] Also, high *initial* government debt levels at the start of recession are associated with a slower *subsequent* recovery and longer duration of recovery. See Woo *et al.* (2012) for details.

Figure 1

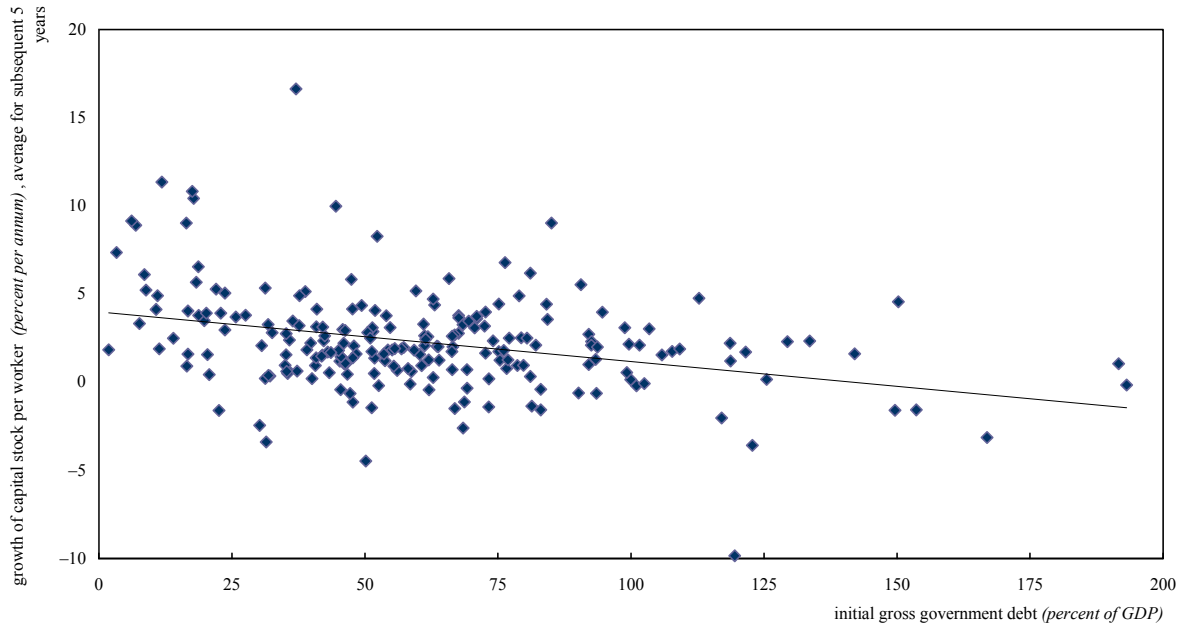
Initial Government Debt and Subsequent Growth of per Capita Real GDP Over Five-year Periods



Fitted line: Growth =4.24–0.024*Initial debt, where the initial debt coefficient is significant at 1 per cent.
Source: Authors' calculation.

Figure 2

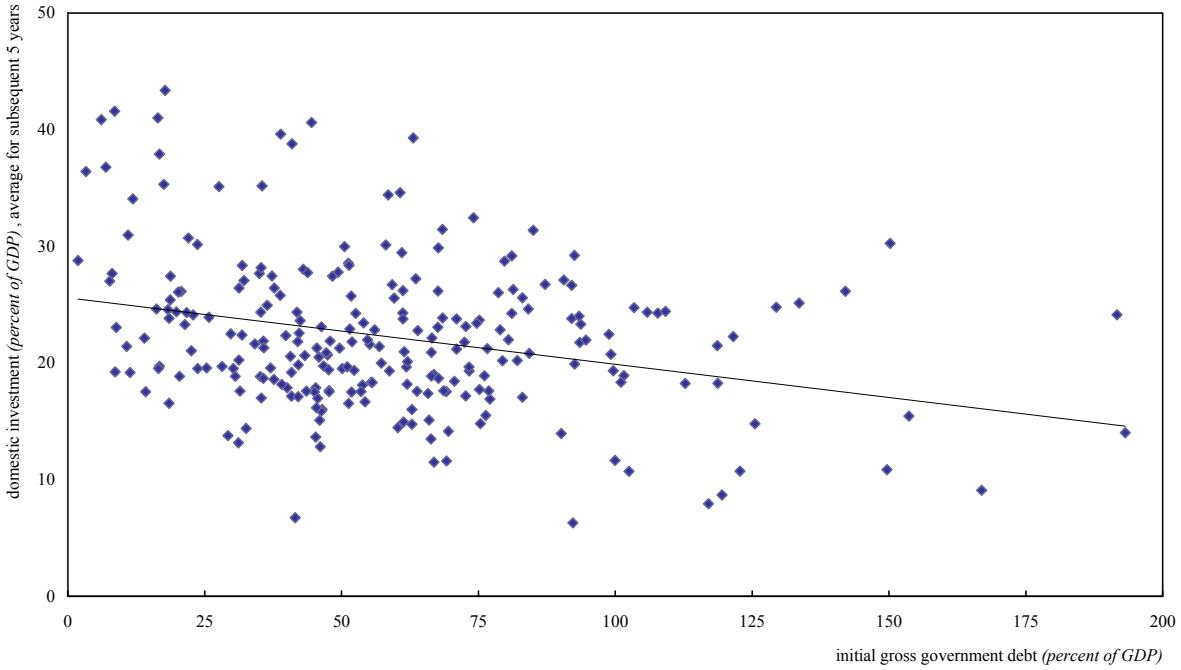
Initial Government Debt and Subsequent Growth of Capital Stock per Worker Over Five-Year Periods



Fitted line: Growth of capital per worker=3.99–0.028*Initial debt, where the debt coefficient is significant at 1 per cent.
Source: Authors' calculation.

Figure 3

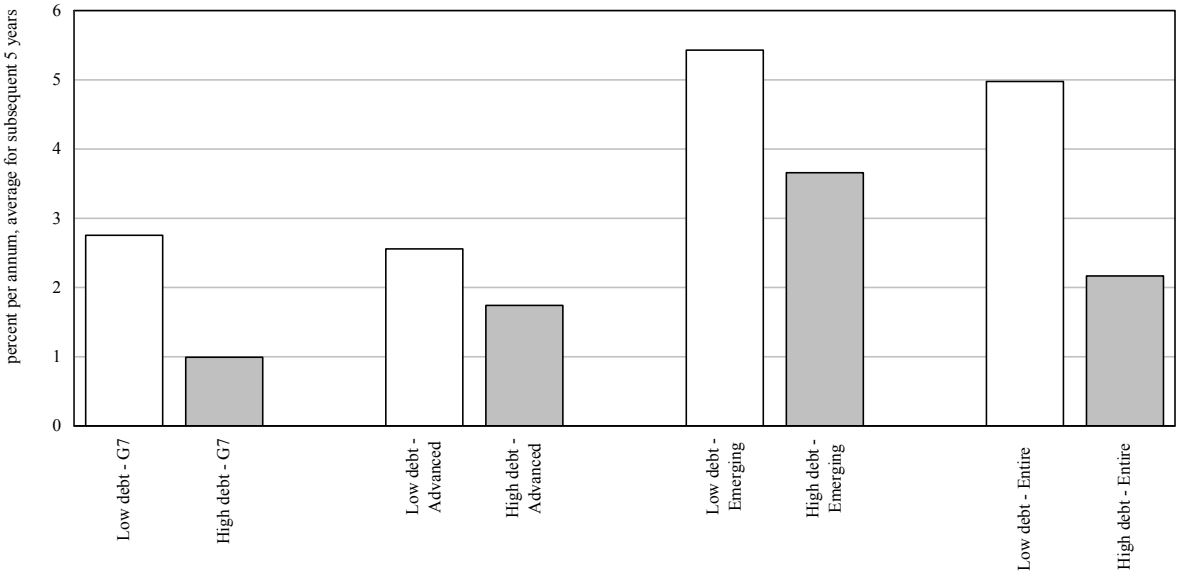
Initial Government Debt and Subsequent Domestic Investment over Five-Year Periods



Fitted line: Investment=25.6–0.057*Initial debt, where the debt coefficient is significant at 1 per cent.
Source: Authors' calculation.

Figure 4

Subsequent Growth of Real GDP per capita
Between High and Low Initial Government Debt Episodes
(low debt <30% of GDP and high debt>90% of GDP)



Source: Authors' calculation.

3 Econometric analysis

3.1 Model specification

The formal analysis focuses on the medium/longer-run relationship between initial government debt and subsequent economic growth, while exploiting both cross-sectional and time-series dimensions of the data. Our panel spans 39 years from 1970 to 2008, and comprises eight non-overlapping five-year periods (1970-74, 1975-79, … , 2000-04, 2005-08), except for the last period spanning four years. In addition, cross-country OLS regressions are estimated for longer time periods – for example, two or three decades (see Appendix Tables 11-12 for the results).

The baseline panel regression specification is as follows:

$$y_{i,t} - y_{i,t-\tau} = \alpha y_{i,t-\tau} + \boldsymbol{X}_{i,t-\tau}\beta + \gamma Z_{i,t-\tau} + \eta t + \nu_i + \varepsilon_{i,t} \quad (1)$$

where a period is a five-year time interval (*i.e.*, τ=4); t denotes the end of a period and $t-\tau$ denotes the beginning of that period; i denotes country; y is the logarithm of real per capita GDP; ν_i is the country-specific fixed effect; ηt is the time-fixed effect; $\varepsilon_{i,t}$ is an unobservable error term; $\boldsymbol{X}_{i,t-\tau}$ is a vector of economic and financial variables; $Z_{i,t-\tau}$ is the initial government debt (in percent of GDP).[4]

A core set of explanatory variables that have been shown to be consistently associated with growth in the literature is fully taken into account.[5] The variables X in the baseline specification are as follows: (i) initial level of real GDP per capita, to capture the catching-up process; (ii) human capital, to reflect the notion that countries with an abundance of it are more likely to have a greater ability to attract investors, absorb ideas from the rest of the world, and engage in innovation activities (Grossman and Helpman, 1991). As a proxy for human capital, we use the log of average years of secondary schooling in the population over age 15 in the initial year, taken from Barro and Lee (2011); (iii) initial government size (as measured by government consumption share of GDP) is also included, in the light of the robust results obtained by Sala-i-Martín *et al.* (2004);[6] (iv) initial trade openness (sum of export and import as a percent of GDP); (v) initial financial market depth (liquid liabilities as a percent of GDP); (vi) initial inflation as measured by CPI inflation (to be precise, logarithm of (1+inflation rate)); (vii) terms of trade growth rates (averaged over each time period); (viii) a measure of banking crisis incidence is also included (based on Reinhart and Reinhart, 2008), reflecting Reinhart and Rogoff's (2009) finding that banking crises are typically accompanied by large increases in government debt. At the same time, banking crises typically result in slow growth; (ix) fiscal deficit is included to take into account the finding that fiscal deficits are negatively associated with longer-run growth (see Fischer, 1993; Baldacci *et al.*, 2004).

To check the robustness of results, parsimonious specifications are tried and additional variables also considered, such as population (a proxy of country size), aged-dependency ratio (a

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[4] To be precise, the average growth rate of real per capita GDP per year over the period t–τ and t is $(y_{i,t} - y_{i,t-\tau})/\tau$, which is actually used in the empirical application of equation (1). All the explanatory variables in $\mathbf{X}_{i,t-\tau}$ are measured at the beginning of period, except for the terms of trade growth, incidences of banking crisis, and fiscal deficit that are measured over the period $t-\tau$ and t.

[5] In particular, the findings of Sala-i-Martín *et al.* (2004) and Sala-i-Martín (1997) are closely followed in selecting the core set of growth determinants.

[6] Also, it can be motivated by a consideration of fiscal sustainability. Huang and Xie (2008) derive a fiscal sustainability frontier in an endogenous growth framework, and show that higher levels of government spending reduce the sustainable level of government debt. This implies that estimating a threshold effect on growth based on a widely used single-dimensional perspective of fiscal sustainability such as debt in excess of a particular level may be difficult. What matters is the ability to finance any given level of debt, which in part depends on the availability of savings and the preferences of the savers. Related, Woo (2003) finds that financial market depth is one of the robust determinants of public deficits for various estimation techniques and extensive robustness checks including an extreme-bounds analysis. Thus, a measure of financial depth is included in the baseline regression.

proxy for population aging), investment,[7] fiscal spending volatility, urbanization, private saving, and checks and balances or constraints on executive decision-making (as a proxy of durable institutionalized constraints; see Glaeser *et al.*, 2004).

In addition to taking into account the "core set" of growth determinants which are mostly embodied in the initial conditions, it is worth emphasizing that our estimation uses *initial* level of debt to examine the impact on *subsequent* growth over the next five to two decades (or longer) and thereby avoid the reverse causality problem. Reverse causality may not be a trivial issue as slower economic growth can lead to high debt buildup, rather than high debt lowering growth.[8] However, most of other studies (for example, Checherita and Rother, 2010; Patillo *et al.*, 2002, 2004) have run regressions of growth on the contemporaneous debt ratios, compounding the potential reverse causality problem.

3.2 Sources of bias and estimation strategies

There are a number of sources of biases that can cause inconsistent estimates of the coefficients in panel growth regressions.[9] Yet, each of the estimators involves some trade-off: estimators that may seem attractive to address a specific econometric problem can lead to a different type of bias. For example, when an omitted variables bias coexists with measurement errors that are likely in the cross-country data, dealing with the first problem may exacerbate the second. With this in mind, we employ a variety of estimation techniques, such as pooled OLS, robust regression, between estimator (BE), fixed effects (FE) panel regression, and system GMM (SGMM) dynamic panel regression (Blundell and Bond, 1998). Speaking of the important sources of biases, the first is the omitted-variables bias (so-called heterogeneity bias) resulting from possible correlation between country-specific fixed effects (ν_i) and the regressors, affecting the consistency of pooled OLS and BE (between estimator) estimates. The second is the endogeneity problem due to potential correlation between the regressors and the error term, which would affect the consistency of pooled OLS, BE and FE. Specific to dynamic panels, there is a dynamic panel bias which will make FE estimates inconsistent.[10] The third is classical measurement errors (errors in variables) in the independent variables, which affects the consistency of pooled OLS, BE, and FE estimator, although the bias tends to be exacerbated in FE and moderated in BE.

Specifically, the BE estimator (which applies the OLS to a single cross-section of variables averaged across time periods) tends to reduce the extent of measurement error via time averaging of the regressors, but does not deal with the omitted-variables bias; pooled OLS and BE suffer from both heterogeneity bias and measurement errors but will reduce the heterogeneity bias because other things equal, measurement errors tend to reduce the correlation between the regressors and the country fixed effects; FE addresses the problem of the omitted-variables bias via controlling for

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[7] The *proximate* causes of growth, such as investment or capital per worker, are not included in the core set of growth determinants, but are examined in the growth accounting exercises instead. Nonetheless, we check whether including investment in the regression changes the estimated coefficients of initial government debt.

[8] Easterly (2001) argues that slow growth contributed to debt explosion in the developing countries in 1980s. However, Imbs and Rancière's (2009) findings contradict Easterly's argument in an event study of external debt: investment actually builds up *prior to* the onset of debt overhang, which argues against the possibility that an investment slump predates the overhang and explains the debt build-up. Related, Reinhart *et al.* (2012) find that public debt overhang episodes are lasting long (typically for more than a decade), and thus refute the view that the negative association between public debt and growth is caused mainly by debt buildups during recessions.

[9] See Durlauf *et al.* (2005) for more details on econometric issues in the empirical growth literature.

[10] To see this more clearly, one can rewrite the equation (1) as $y_{i,t} = (1+\alpha)y_{i,t-\tau} + \mathbf{X}_{i,t-\tau}\beta + \gamma Z_{i,t-\tau} + \eta_t + \nu_i + \varepsilon_{i,t}$. The endogeneity bias (often called dynamic panel bias) arises due to inevitable correlation between $y_{i,t-\tau}$ and ν_i in the presence of lagged dependent variable because $y_{i,t-\tau}$ is endogenous to the fixed effects (ν_i) in the error term. In the FE, the fixed effects (ν_i) are eliminated via within-transformation, but there is now a correlation between the transformed lagged dependent variable and the transformed error term, causing the FE to be inconsistent and biased downward.

fixed-effects, but tends to exacerbate the measurement error problem, relative to BE and OLS. This measurement error bias under FE tends to get even worse when the explanatory variables are more time-persistent than the errors in the measurement (Hauk and Wacziarg, 2009).[11] Furthermore, in the dynamic panel setting, the within-transformation in the estimation process of FE introduces a correlation between transformed lagged dependent variable and transformed error, which also makes FE inconsistent. Theoretically, the dynamic panel GMM estimator addresses a variety of biases such as the omitted-variables bias, endogeneity, and measurement errors (as long as instruments are uncorrelated with the errors in measurement, for example, if they are white noise as in the classical case), but it may be subject to a weak instruments problem (Roodman, 2009; Bazzi and Clemens, 2009). While the SGMM that is used in this paper is generally more robust to weak instruments than the difference GMM, it can still suffer from weak instrument biases.[12] In sum, it is difficult to see which estimator yields the smaller *total bias* in the presence of various sources of bias a priori.

However, an important conclusion from the Monte Carlo study of growth regressions by Hauk and Wacziarg (2009) is that the BE performs the best among the four estimators (pooled OLS, BE, FE, and difference GMM) in terms of the extent of *total bias* on each of the estimated coefficients in the presence of both potential heterogeneity bias and a variety of measurement errors.[13] Therefore, the BE and SGMM estimators are the preferred estimation techniques in this paper, while we utilize the other techniques also.

As further robustness checks, we also run a single cross-country regression of the type that is most commonly used in the empirical growth literature for longer time periods. This helps address the issue that the five-year time interval in the panel may not be long enough to smooth out short-term business cycle fluctuations. The cross-country regression results (including the order of magnitude of the coefficients) however turn out to be broadly similar to those from panel regressions. On the other hand, the least squares estimates tend to be sensitive to outliers, either observations with unusually large errors or influential observations with unusual values of explanatory variables (often called leverage points). In an extensive evaluation of growth regressions in relation to macroeconomic policy variables, Easterly (2005) argues that some of the large effects on growth of a policy variable in the earlier empirical studies are often caused by outliers that represent "extremely bad" policies. Thus, to ensure that our results are not unduly driven by outliers, robust regression is also implemented.[14]

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[11] Intuitively, the within-transformation (*i.e.*, demeaning) under FE may exacerbate the measurement error bias by decreasing the signal-to-noise ratio (Grilliches and Hausman, 1986).

[12] A standard test of weak instruments in dynamic panel GMM regressions does not currently exist (Bazzi and Clemens, 2009). See Stock *et al.* (2002) on why the weak instrument diagnostics for linear IV regression do not carry over to the more general setting of GMM.

[13] The BE estimator applies the OLS to perform estimating of the following equation:

$$\overline{y_{i,}} - \overline{y_{i,-1}} = \alpha \overline{y_{i,-1}} + \overline{X_{i,-1}}\beta + \gamma \overline{Z_{i,-1}} + v_i + \bar{\varepsilon}_i$$

where the upper bar indicates the average of each variable across time periods (up to eight periods), for example, $\overline{X_{i,-1}} = \sum_t X_{i,t-\tau} / T_i$. Thus, time-fixed effects are not appropriate and suppressed by the BE. As one can see, the BE estimator does not correspond to the cross-sectional estimator most commonly used in the literature in which in which the dependent and explanatory variables are averaged, say, over 1970-2008, except for the initial income level in 1970.

[14] It is essentially an iterated re-weighted least squares regression in which the outliers are dropped (if Cook's distance is greater than 1) and the observations with large absolute residuals are down-weighted.

3.3 Basic results

The main results for advanced and emerging economies are presented in Table 1. Columns 1-4 show that the coefficients of initial debt are negative and are significant at the 1-5 per cent levels, with their values ranging from –0.015 to –0.030 across the various estimation techniques.[15] The BE regression in column 1 suggests that a 10 percentage points of GDP increase in initial debt is associated with a slowdown in subsequent growth in real GDP per capita of around 0.25 percentage points per year. The pooled OLS and FE in columns 2 and 3 yield results similar to that of the BE regression, although their estimates of initial debt coefficient become somewhat smaller (around –0.02). The SGMM estimate of initial debt coefficient is also in a similar range (–0.03) and significant at the 1 per cent level.

The coefficients on other explanatory variables (initial income per capita, average years of schooling, financial market development, inflation, banking crisis, and fiscal deficit) are of the expected sign and mostly significant at conventional levels across various estimation techniques. The OLS and FE estimators are likely to be biased in the opposite direction in the context of lagged dependent variables in short panels, with OLS biased upwards, and FE downwards. The *consistent* GMM estimator should lie between the two (Bond 2002). In the growth regressions, this means that the OLS understates the convergence rate (reflected by the coefficient of initial income per capita), while the FE estimator overstates it. Consistent with this reasoning, the OLS coefficient of initial real per capita GDP is –1.88, whereas the FE coefficient is –3.92. The SGMM coefficient of the initial income per capita (–2.34) is between those two estimates, indicating that the reported SGMM estimate in column 4 is likely to be a *consistent* parameter estimate of the convergence rate.

Consistency of the SGMM estimator depends on the validity of the instruments. We consider two specification tests, suggested by Arellano and Bover (1995) and Blunedell and Bond (1998). The first is a Hansen J-test of over-identifying restrictions, which tests the overall validity of the instruments by analyzing the sample analog of the moment conditions used in the estimation process. This indicates that we cannot reject the null hypothesis that the full set of orthogonality conditions are valid (p-value=0.65).[16] The second test examines the hypothesis that the error term $\varepsilon_{i,t}$ is not serially correlated. We use an Arellano-Bond test for autocorrelation, and find that we cannot reject the null hypothesis of no second-order serial correlation in the first-differenced error terms (p-value=0.24).[17]

The regressions in columns 2-4 do not include the time-fixed effects. It is possible that global factors can simultaneously affect both domestic growth and public debt which may bias the results toward finding a stronger relationship between debt and growth. At the same time, however, as global factors can be correlated with domestic fiscal or economic variables, one can expect that the inclusion of time-fixed effects may understate the estimated effects of these variables. Columns 5-7 include time-fixed effects in the regression to allow for global factors. The pooled OLS and SGMM coefficients of initial debt remain significant at 5-10 per cent, and the size of

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[15] In the OLS and robust regressions, dummies for OECD, Asia, Latin America, and sub-Saharan Africa are included. Results for robust regressions are similar to those of pooled OLS, so they are not reported to save space.

[16] Importantly, the difference-in-Hansen tests of exogeneity of instrument subsets do not reject the null hypothesis that the instrument subsets for the level equations are orthogonal to the error (p-value=0.34), that is, the assumption that lagged differences of endogenous explanatory variables that are being used as instruments in levels is uncorrelated with the errors. This is the additional restriction that needs to be satisfied for the SGMM estimator.

[17] The dynamic panel GMM can generate too many instruments, which may overfit endogenous variables and run a risk of a weak-instruments bias (Roodman, 2009; Bazzi and Clemens, 2009). Given that, one recommendation when faced with a weak-instrument problem is to be parsimonious in the choice of instruments. Roodman (2009) suggests restricting the number of lagged levels used in the instrument matrix or collapsing the instrument matrix or combining the two. Some studies including Beck and Levine (2004) use the technique of collapsing instrument matrix. The reported SGMM results in our paper are obtained by combining the "collapsed" instrument matrix with lag limits.

Table 1

Baseline Panel Regression – Growth and Initial Government Debt, 1970-2008 (Five-year Period Panel)
Sample: Advanced and Emerging Economies (with Population of Over 5 Million)
(dependent variable: real per capita GDP growth)

Explanatory Variables	(1) BE	(2) Pooled OLS	(3) FE	(4) SGMM	(5) Pooled OLS	(6) FE	(7) SGMM
Initial real GDP per capita	–2.123***	–1.877**	–3.924***	–2.336***	–1.707**	–4.744**	–2.229***
	(–5.02)	*(–2.54)*	*(–2.74)*	*(–3.47)*	*(–2.14)*	*(–2.36)*	*(–2.95)*
Initial years of schooling	4.813***	3.143**	3.388	4.508*	3.136**	2.394	3.161
	(3.94)	*(2.57)*	*(1.64)*	*(1.93)*	*(2.55)*	*(1.07)*	*(1.55)*
Initial inflation rate	2.151	–2.100***	–2.630***	–2.666**	–2.457***	–2.454***	–2.678**
	(0.82)	*(–3.32)*	*(–5.38)*	*(–2.49)*	*(–3.21)*	*(–5.81)*	*(–2.05)*
Initial government size	0.109**	0.109**	0.147	0.162	0.111**	0.055	0.138
	(2.06)	*(2.43)*	*(1.68)*	*(1.36)*	*(2.38)*	*(0.70)*	*(1.23)*
Initial trade openness	–0.002	–0.004	0.023*	–0.013**	–0.005	0.023	–0.004
	(–0.43)	*(–0.78)*	*(1.73)*	*(–2.03)*	*(–1.11)*	*(1.57)*	*(–0.57)*
Initial financial depth	0.022**	0.020**	0.001	0.035***	0.023**	0.006	0.027**
	(2.15)	*(2.13)*	*(0.07)*	*(3.18)*	*(2.50)*	*(0.64)*	*(2.31)*
Terms of trade growth	0.204**	–0.013	0.009	–0.032	–0.017	–0.003	–0.044*
	(2.33)	*(–0.52)*	*(0.33)*	*(–1.14)*	*(–0.70)*	*(–0.13)*	*(–1.97)*
Banking crisis	–1.077	–0.617	–0.638***	–1.033	–0.612*	–0.513*	–1.838
	(–0.61)	*(–1.58)*	*(–2.96)*	*(–1.55)*	*(–1.75)*	*(–1.98)*	*(–1.24)*
Fiscal deficit	0.028	–0.044***	–0.047***	–0.046***	–0.045***	–0.035***	–0.062***
	(0.80)	*(–4.27)*	*(–4.07)*	*(–2.96)*	*(–4.72)*	*(–3.50)*	*(–3.10)*
Initial government debt	–0.025**	–0.022***	–0.015**	–0.030***	–0.018**	–0.004	–0.019*
	(–2.28)	*(–3.29)*	*(–2.17)*	*(–4.14)*	*(–2.34)*	*(–0.67)*	*(–1.89)*
Arellano-Bond AR(2) test *p*-value[1]				0.65			0.45
Hansen *J*-statistics (*p*-value)[2]				0.24			0.29
Number of observations	166	166	166	166	166	166	166
R^2	0.68	0.51	0.39		0.58	0.51	
Time-fixed effects	N/A	No	No	No	Yes	Yes	Yes

Note: Heteroskedasticity and country-specific autocorrelation consistent *t*-statistics are in parentheses. Time dummies are not reported. Levels of significance: *** 1%, ** 5%, * 10%. In the OLS regressions, dummies for OECD, Asia, Latin America, and Sub-Saharan Africa are also included in each regression (not reported to save space). FE refers to the fixed-effects panel regressions and BE is the between estimator. For the dynamic panel estimation, a two-step system GMM (SGMM) with the Windmeijer's finite-sample correction for the two-step covariance matrix.
1) The null hypothesis is that the first-differenced errors exhibit no second-order serial correlation.
2) The null hypothesis is that the instruments used are not correlated with the residuals.

those coefficients is reduced as expected. The estimated effects suggest that a 10 percentage point increase in the initial debt-to-GDP ratio is associated with a slowdown in growth of per capita GDP around 0.2 per cent per year.

In contrast, the FE results on initial debt turn out to be particularly sensitive to whether time-fixed effects are included or not in the regression (compare column 6 with column 3). The FE coefficient of initial debt is now insignificant and reduced to –0.004. It is well known in the literature that the FE can bias toward zero the slope estimates on the determinants of the steady-state level of income – the accumulation and depreciation variables in the Solow model (Islam, 1995). Given that the FE estimator tends to identify parameters on the basis of within-country variation, compared to cross-sectional alternatives such as pooled OLS and BE, it is not surprising that the within-country variation in each of regressors (especially time-persistent variables) is further reduced once time-fixed effects are accounted for.[18] Moreover, the measurement error bias can also be exacerbated under FE. With these caveats, time-fixed effects are included in the remaining regressions.

3.4 Robustness of results

A variety of robustness checks were conducted: First, to account for the possibility that there may have been structural changes over the sample period, including changes in global trend growth or global risk factors, time-fixed effects were included. In addition, we restricted the sample to the second half of the period to check whether there are significant changes in the estimated coefficients. Thus columns 1-4 in Table 2 repeat the same sets of regressions (BE, pooled OLS, FE, and SGMM) for the period of 1990-2008. The results are quite similar to those for the entire period. Except for the FE estimate, the impact of initial debt is significant, ranging from –0.020 to –0.024, indicating that a 10 percentage point increase in initial debt-to-GDP ratio is associated with decline in per capita GDP growth of around 0.2-0.24 per cent per year.

Second, columns 5-8 and 9-12 of Table 2 replicate the regression exercises for 46 advanced and emerging economies and the full sample of 79 countries (46 advanced and emerging economies and 33 developing countries) regardless of the population size for the entire period, respectively. Again, the results are broadly the same as those from the 38 advanced and emerging economies with a population of over 5 million, although the size of the debt coefficients becomes slightly smaller.

Third, Table 3 presents the results based on a parsimonious specification that excludes the fiscal deficit term.[19] The coefficients of initial debt are negative and significant at 1-5 per cent, ranging from –0.014 to –0.026, except for the FE result in which the coefficient of initial debt loses statistical significance (columns 1-4). It is noteworthy that the BE estimates of initial debt coefficient are stable around 0.21 to 0.26 across different samples, periods, and specifications. Using average debt instead of initial debt also yields a similar range of –0.019 to –0.030 for the debt coefficients under BE, OLS and SGMM, which are all significant at 1-10 per cent (columns 5, 6 and 8), except for the FE in column 7.

Fourth, additional variables are considered, such as population size (a proxy of country size), aged-dependency ratio (a proxy of population aging), investment, fiscal volatility, urbanization, and checks and balances or constraints on executive decision-making (as a proxy of durable

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[18] With the time-fixed effects included, the coefficients of years of schooling and initial debt are often insignificant under FE in contrast to those under SGMM, as one can see throughout this paper.

[19] Qualitatively similar results are obtained in various parsimonious specifications, such as also dropping a measure of banking crisis and/or financial market depth.

Table 2

Robustness Checks—Time Period and Sample

(dependent variable: real per capita GDP growth)

Explanatory Variables	(1) BE	(2) Pooled	(3) FE	(4) SGMM	(5) BE	(6) Pooled	(7) FE	(8) SGMM	(9) BE	(10) Pooled	(11) FE	(12) SGMM
	Period: 1990-2008 Sample: OECD and Emerging Economies				Period: 1970-2008 Sample: OECD and Emerging Economies Without Population Size Restriction				Period: 1970-2008 Sample: Full Sample (Including Developing Countries) Without Population Size Restriction			
Initial real GDP per capita	–1.794***	–1.711**	–3.325*	–2.376**	–1.796***	–1.074*	–5.843***	–2.072*	–0.962***	–1.021**	–4.495**	–1.566**
	(–4.67)	*(–2.22)*	*(–1.99)*	*(–2.21)*	*(–4.37)*	*(–1.80)*	*(–3.09)*	*(–1.96)*	*(–2.79)*	*(–2.09)*	*(–2.13)*	*(–2.12)*
Initial years of schooling	3.815***	3.491***	–0.784	3.903	3.768***	1.809*	4.629**	2.956	1.550*	0.887	2.624	2.346*
	(3.35)	*(2.78)*	*(–0.17)*	*(0.92)*	*(3.10)*	*(1.68)*	*(2.56)*	*(0.87)*	*(1.79)*	*(0.98)*	*(1.11)*	*(1.79)*
Initial inflation rate	1.258	–2.918***	–2.308***	–1.717	2.227	–1.201**	–2.262***	–1.112	2.727	0.324	–0.899	–0.251
	(0.51)	*(–3.19)*	*(–4.33)*	*(–1.14)*	*(0.92)*	*(–2.14)*	*(–5.37)*	*(–0.93)*	*(1.14)*	*(0.46)*	*(–1.12)*	*(–0.33)*
Initial government size	0.120**	0.119**	0.074	0.205*	0.030	–0.018	–0.039	–0.180*	–0.020	–0.026	–0.023	–0.092
	(2.41)	*(2.45)*	*(0.68)*	*(1.73)*	*(0.77)*	*(–0.44)*	*(–0.56)*	*(–1.75)*	*(–0.63)*	*(–1.00)*	*(–0.41)*	*(–1.23)*
Initial trade openness	0.001	–0.007	0.030*	–0.006	0.009**	0.003	0.015	0.003	0.003	0.004	0.002	0.000
	(0.19)	*(–1.55)*	*(1.76)*	*(–0.72)*	*(2.38)*	*(0.78)*	*(1.63)*	*(0.24)*	*(0.83)*	*(1.29)*	*(0.15)*	*(0.03)*
Initial financial depth	0.016*	0.027**	0.002	0.032	0.002	0.001	0.007	–0.001	–0.000	–0.004	–0.006	0.006
	(1.71)	*(2.68)*	*(0.13)*	*(1.66)*	*(0.27)*	*(0.07)*	*(0.76)*	*(–0.06)*	*(–0.05)*	*(–0.60)*	*(–0.54)*	*(0.39)*
Terms of trade growth	0.223***	–0.016	–0.018	–0.049	0.187**	–0.001	0.008	–0.046	–0.033	0.028	0.062**	0.024
	(2.79)	*(–0.29)*	*(–0.36)*	*(–0.94)*	*(2.14)*	*(–0.04)*	*(0.31)*	*(–1.03)*	*(–0.64)*	*(0.92)*	*(2.05)*	*(0.74)*
Banking crisis	0.632	–0.358	–0.576	–1.233	–1.445	–0.867**	–0.837***	–1.003	–3.566**	–1.357***	–1.026***	–1.861***
	(0.38)	*(–0.68)*	*(–1.15)*	*(–0.90)*	*(–0.80)*	*(–2.23)*	*(–2.80)*	*(–1.16)*	*(–2.32)*	*(–3.85)*	*(–3.53)*	*(–3.21)*
Fiscal deficit	0.009	–0.055***	–0.046***	–0.057*	0.050*	–0.037***	–0.045***	–0.045**	–0.028**	–0.034***	–0.041***	–0.035**
	(0.27)	*(–4.18)*	*(–2.92)*	*(–1.71)*	*(1.72)*	*(–3.40)*	*(–4.25)*	*(–2.46)*	*(–2.17)*	*(–3.80)*	*(–5.50)*	*(–2.13)*
Initial government debt	–0.024***	–0.020**	–0.008	–0.023*	–0.019*	–0.020**	–0.011*	–0.021*	–0.021***	–0.017***	–0.011*	–0.016*
	(–2.85)	*(–2.26)*	*(–0.65)*	*(–2.02)*	*(–1.94)*	*(–2.62)*	*(–1.78)*	*(–1.74)*	*(–3.22)*	*(–3.31)*	*(–1.66)*	*(–1.83)*
Arellano-Bond AR(2) test *p*-value[1]				0.42				0.59				0.59
Hansen J-statistics (*p*-value)[2]				0.13				0.98				0.36
Number of observations	124	124	124	124	208	208	208	208	297	297	297	297
R^2	0.72	0.61	0.44		0.56	0.44	0.51		0.37	0.36	0.43	
Time-fixed effects	N/A	Yes	Yes	Yes	N/A	Yes	Yes	Yes	N/A	Yes	Yes	Yes

Note: Heteroskedasticity and country-specific autocorrelation consistent *t*-statistics are in parentheses. Time dummies are not reported. Levels of significance: *** 1%, ** 5%, * 10%. In the OLS regressions, dummies for OECD, Asia, Latin America, and Sub-Saharan Africa are also included in each regression (not reported to save space). FE refers to the fixed-effects panel regressions and BE is the between estimator. For the dynamic panel estimation, a two-step system GMM (SGMM) with the Windmeijer's finite-sample correction for the two-step covariance matrix.

1) The null hypothesis is that the first-differenced errors exhibit no second-order serial correlation.

2) The null hypothesis is that the instruments used are not correlated with the residuals.

Table 3

Robustness Checks – Parsimonious Specification: Advanced and Emerging Economies

(dependent variable: real per capita GDP growth)

Explanatory Variables	(1) BE	(2) Pooled OLS	(3) FE	(4) SGMM	(5) BE	(6) Pooled OLS	(7) FE	(8) SGMM
Initial real GDP per capita	–2.007***	–2.068**	–5.835**	–2.545***	–1.722***	–1.786**	–6.157***	–2.014**
	(–5.08)	*(–2.41)*	*(–2.59)*	*(–3.37)*	*(–4.45)*	*(–2.17)*	*(–3.25)*	*(–2.36)*
Initial years of schooling	4.576***	3.486**	1.404	6.493**	3.393***	2.749**	1.057	3.654*
	(3.89)	*(2.68)*	*(0.51)*	*(2.42)*	*(2.93)*	*(2.25)*	*(0.38)*	*(1.91)*
Initial inflation rate	1.469	–1.276*	–1.692***	–0.683	2.467	–1.376	–2.318*	–4.405
	(0.60)	*(–1.73)*	*(–5.52)*	*(–0.97)*	*(1.20)*	*(–1.30)*	*(–1.79)*	*(–1.49)*
Initial government size	0.117**	0.093**	0.001	0.011	0.094*	0.084*	0.009	0.264
	(2.26)	*(2.03)*	*(0.01)*	*(0.08)*	*(1.88)*	*(2.01)*	*(0.12)*	*(1.14)*
Initial trade openness	–0.004	–0.001	0.038***	0.000	–0.005	–0.002	0.030**	–0.005
	(–0.79)	*(–0.15)*	*(2.83)*	*(0.04)*	*(–1.16)*	*(–0.58)*	*(2.59)*	*(–0.45)*
Initial financial depth	0.024**	0.017*	0.002	0.005	0.024**	0.020**	0.002	0.026
	(2.47)	*(1.98)*	*(0.32)*	*(0.51)*	*(2.61)*	*(2.21)*	*(0.30)*	*(1.38)*
Terms of trade growth	0.169**	0.005	0.003	–0.014	0.006	–0.007	0.021	–0.031
	(2.24)	*(0.15)*	*(0.11)*	*(–0.46)*	*(0.07)*	*(–0.25)*	*(0.67)*	*(–1.06)*
Banking crisis	–0.880	–0.483	–0.402	–1.311	–2.004	–1.199***	–1.208***	–0.614
	(–0.50)	*(–1.21)*	*(–1.48)*	*(–0.85)*	*(–1.35)*	*(–2.74)*	*(–2.97)*	*(–0.42)*
Initial government debt	–0.026**	–0.014**	0.010	–0.014*				
	(–2.39)	*(–2.12)*	*(1.36)*	*(–1.95)*				
Government debt, average					–0.030***	–0.019**	–0.004	–0.023*
					(–2.87)	*(–2.36)*	*(–0.56)*	*(–1.86)*
Arellano-Bond AR(2) test *p*-value[1]				0.08				0.14
Hansen *J*-statistics (*p*-value)[2]				0.33				0.27
Number of observations	166	166	166	166	181	181	181	181
R^2	0.67	0.52	0.45		0.59	0.49	0.47	
Time-fixed effects	N/A	Yes	Yes	Yes	N/A	Yes	Yes	Yes

Note: Heteroskedasticity and country-specific autocorrelation consistent *t*-statistics are in parentheses. Time dummies are not reported. Levels of significance: *** 1%, ** 5%, * 10%. In the OLS regressions, dummies for OECD, Asia, Latin America, and Sub-Saharan Africa are also included in each regression (not reported to save space). FE refers to the fixed-effects panel regressions and BE is the between estimator. For the dynamic panel estimation, a two-step system GMM (SGMM) with the Windmeijer's finite-sample correction for the two-step covariance matrix.

1) The null hypothesis is that the first-differenced errors exhibit no second-order serial correlation.

2) The null hypothesis is that the instruments used are not correlated with the residuals.

institutional quality; see Glaeser *et al.*, 2004). The results do not change appreciably (Table 4). Columns 1-4 add the log of initial population to the baseline specification: the coefficients of initial debt are negative and significant at 5 per cent level except for the FE in column 3 in which it is insignificant. According to the BE, OLS, and SGMM, the estimated effects of initial debt suggest that a 10 percentage point increase of initial debt-to-GDP ratio is associated with slowdown in growth of per capita GDP of around 0.18 to 0.25 per cent per year. In contrast, the coefficients of population size are insignificant except for FE in which it becomes significant.

The results when initial domestic investment (as a percent of GDP) is added to the baseline specification are shown in columns 5-8 of Table 4. Under OLS and SGMM, the coefficients of initial debt ratio are significant at 5 per cent level, whereas the coefficients of investment are of the expected positive sign and significant at 5 per cent under BE and OLS. Under SGMM, the investment coefficient becomes insignificant, and its coefficient size is slightly smaller than that under BE. However, the FE estimates of the coefficients of initial debt and initial investment are not only insignificant, but the coefficient of initial investment even changes its sign to negative.

In columns 9-12 of Table 4, we include a measure of fiscal spending volatility (as measured by a logarithm of standard deviations of annual growth in real general government expenditures) in the regressions. Recently, Fatás and Mihov (2003) have argued that excessive discretionary fiscal policies that are not related to dealing with business cycle fluctuations can lead to higher output volatility and lower growth.[20] At the same time, this excessive fiscal activism may lead to a large debt buildup. According to this view, excessive fiscal discretion may be an underlying force behind the negative relation between government debt and growth. If this is so, one may expect the coefficient of initial debt in the growth regression to become weaken or at least to get smaller in its absolute value, once the fiscal volatility term is included in the regression. However, our analysis does not find evidence in support of this view.[21] The coefficients of fiscal volatility are insignificant, and even change sign across different estimations. By contrast, the coefficients of initial debt remain largely significant, and the size of estimated coefficients is quite similar to that in the baseline regressions.

Finally, we run a single cross-country regression of the type that is most commonly used in the empirical growth literature for longer time periods. The cross-country regression results are presented in Appendix Tables 11 and 12. They are remarkably similar to the above panel regression results. In particular, the size of estimated initial debt coefficients which is around –0.02~–0.03 is remarkably similar to that found in the baseline panel regression.

3.5 Non-linearities and differences between advanced and emerging economies

To explore potential non-linearities, Table 5 (columns 1-4) shows regressions that include the interaction terms between initial debt and dummy variables for three ranges of initial debt: Dum_30 for low debt (below 30 per cent of GDP); Dum_30-90 for medium debt (30-90 per cent of GDP); and Dum_90 for high debt (over 90 per cent of GDP). The coefficients of low initial debt (*i.e.*, initial debt*Dum_30) are all insignificant and of the positive sign, which seems to suggest that

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[20] Ideally, the measure of fiscal policy volatility (that is, excessive discretionary policy changes undertaken for reasons other than smoothing out business cycle fluctuations) can be constructed in a more sophisticated manner. For example, it can be obtained as a standard deviation of the residuals from time-series regression of government spending growth on macroeconomic variables such as output growth and inflation. Given such a short time duration of each period, it is impossible to run a meaningful time-series regression for each five-year period. However, the qualitative behavior of such a measure of fiscal volatility is very similar to that of a crude measure of fiscal volatility as used in this paper (Woo, 2009).

[21] While there is significant evidence that fiscal volatility is positively correlated with output volatility and that output volatility is negatively associated with growth (Fatás and Mihov, 2003; Ramey and Ramey, 1995), there is little analysis in the literature regarding the relationship between government debt and fiscal behavior such as fiscal volatility or fiscal cyclicality.

Table 4

Robustness Checks – Additional Variables: Advanced and Emerging Economies

(dependent variable: real per capita GDP growth)

Explanatory Variables	(1) BE	(2) Pooled OLS	(3) FE	(4) SGMM	(5) BE	(6) Pooled OLS	(7) FE	(8) SGMM	(9) BE	(10) Pooled OLS	(11) FE	(12) SGMM
Initial real GDP per capita	–1.798***	–1.581**	–4.361***	–2.478**	–2.412***	–2.506***	–3.832	–2.909***	–2.110***	–1.737**	–4.762**	–1.830**
	(–3.39)	*(–2.14)*	*(–2.76)*	*(–2.43)*	*(–6.07)*	*(–2.82)*	*(–1.64)*	*(–2.74)*	*(–4.32)*	*(–2.17)*	*(–2.36)*	*(–2.53)*
Initial years of schooling	4.611***	2.994**	–1.364	6.483*	4.385***	3.729***	2.057	5.403	4.818***	3.037**	2.358	3.173
	(3.73)	*(2.52)*	*(–0.48)*	*(1.68)*	*(3.93)*	*(3.08)*	*(0.94)*	*(1.60)*	*(3.86)*	*(2.49)*	*(1.08)*	*(1.14)*
Initial inflation rate	2.481	–2.313***	–2.642***	–5.741	2.099	–2.659***	–2.484***	–5.742	2.140	–2.351***	–2.444***	–3.296*
	(0.94)	*(–3.15)*	*(–5.48)*	*(–0.90)*	*(0.89)*	*(–3.53)*	*(–5.54)*	*(–0.94)*	*(0.80)*	*(–2.94)*	*(–5.15)*	*(–1.68)*
Initial government size	0.094*	0.109**	0.079	0.251	0.128**	0.119**	–0.010	0.174	0.110*	0.108**	0.055	0.245**
	(1.72)	*(2.44)*	*(0.91)*	*(0.95)*	*(2.64)*	*(2.71)*	*(–0.14)*	*(1.08)*	*(1.98)*	*(2.31)*	*(0.70)*	*(2.17)*
Initial trade openness	0.002	–0.001	0.042***	–0.009	0.001	–0.003	0.020	–0.012	–0.003	–0.004	0.023	0.002
	(0.34)	*(–0.21)*	*(3.08)*	*(–0.75)*	*(0.15)*	*(–0.95)*	*(1.18)*	*(–1.06)*	*(–0.39)*	*(–0.87)*	*(1.49)*	*(0.27)*
Initial financial depth	0.015	0.021**	0.007	0.019	0.021**	0.024***	0.005	0.025	0.022*	0.022**	0.005	0.019
	(1.20)	*(2.38)*	*(0.88)*	*(0.89)*	*(2.32)*	*(3.12)*	*(0.53)*	*(1.48)*	*(1.97)*	*(2.38)*	*(0.64)*	*(1.46)*
Terms of trade growth	0.219**	–0.014	–0.012	–0.028	0.300***	–0.011	–0.005	–0.026	0.205**	–0.017	–0.003	–0.048**
	(2.47)	*(–0.56)*	*(–0.50)*	*(–0.63)*	*(3.45)*	*(–0.47)*	*(–0.20)*	*(–0.45)*	*(2.24)*	*(–0.65)*	*(–0.13)*	*(–2.35)*
Fiscal deficit	0.039	–0.043***	–0.032***	–0.041*	0.015	–0.047***	–0.038***	–0.064	0.028	–0.044***	–0.035***	–0.043***
	(1.07)	*(–4.68)*	*(–3.83)*	*(–1.71)*	*(0.45)*	*(–5.21)*	*(–3.68)*	*(–1.58)*	*(0.76)*	*(–4.54)*	*(–3.45)*	*(–2.84)*
Banking crisis	–1.506	–0.687*	–0.298	–0.747	–0.434	–0.543	–0.391	–2.481	–1.059	–0.597*	–0.510*	–1.523
	(–0.83)	*(–2.02)*	*(–1.07)*	*(–0.55)*	*(–0.27)*	*(–1.38)*	*(–1.34)*	*(–0.99)*	*(–0.58)*	*(–1.73)*	*(–1.98)*	*(–1.12)*
Initial government debt	–0.025**	–0.018**	0.003	–0.018**	–0.015	–0.014**	–0.008	–0.025*	–0.025**	–0.017**	–0.004	–0.014
	(–2.24)	*(–2.49)*	*(0.50)*	*(–2.29)*	*(–1.40)*	*(–2.59)*	*(–1.17)*	*(–1.74)*	*(–2.24)*	*(–2.36)*	*(–0.66)*	*(–1.28)*
Initial population size (log)	0.275	0.200	9.096***	0.094								
	(1.01)	*(1.02)*	*(2.81)*	*(0.09)*								
Initial investment					0.106**	0.076**	–0.079	0.080				
					(2.65)	*(2.50)*	*(–1.42)*	*(0.78)*				
Fiscal volatility									0.031	–0.194	–0.016	0.133
									(0.06)	*(–0.76)*	*(–0.07)*	*(0.28)*
Arellano-Bond AR(2) test *p*-value[1]				0.12				0.25				0.27
Hansen *J*-statistics (*p*-value)[2]				0.88				0.24				0.99
Number of observations	166	166	166	166	166	166	166	166	166	166	166	166
R^2	0.69	0.59	0.56		0.75	0.61	0.53		0.68	0.59	0.51	
Time-fixed effects	N/A	Yes	Yes	Yes	N/A	Yes	Yes	Yes	N/A	Yes	Yes	Yes

Note: Heteroskedasticity and country-specific autocorrelation consistent *t*-statistics are in parentheses. Time dummies are not reported. Levels of significance: *** 1%, ** 5%, * 10%. In the OLS regressions, dummies for OECD, Asia, Latin America, and Sub-Saharan Africa are also included in each regression (not reported to save space). FE refers to the fixed-effects panel regressions and BE is the between estimator. For the dynamic panel estimation, a two-step system GMM (SGMM) with the Windmeijer's finite-sample correction for the two-step covariance matrix.

1) The null hypothesis is that the first-differenced errors exhibit no second-order serial correlation.

2) The null hypothesis is that the instruments used are not correlated with the residuals.

Table 5

Panel Regression – Different Levels of Initial Debt and Advanced vs. Emerging Economies

(dependent variable: real per capita GDP growth)

Explanatory Variables	(1) BE	(2) Pooled OLS	(3) FE	(4) SGMM	(5) BE	(6) Pooled OLS	(7) FE	(8) SGMM
Initial real GDP per capita	–2.014***	–1.875***	–4.912**	–2.227***	–2.796***	–2.539***	–4.705**	–2.897***
	(–5.13)	*(–2.79)*	*(–2.65)*	*(–3.14)*	*(–4.51)*	*(–2.96)*	*(–2.35)*	*(–4.07)*
Initial years of schooling	4.377***	3.185***	2.260	3.988	4.691***	3.127***	2.232	2.074
	(3.77)	*(3.10)*	*(1.00)*	*(1.42)*	*(3.91)*	*(2.79)*	*(1.03)*	*(1.06)*
Initial inflation rate	1.551	–2.773***	–2.329***	–2.352**	0.503	–3.213***	–2.390***	–9.852**
	(0.59)	*(–3.67)*	*(–5.06)*	*(–2.65)*	*(0.18)*	*(–3.17)*	*(–5.17)*	*(–2.31)*
Initial government size	0.135**	0.127***	0.033	0.199**	0.096*	0.086*	0.056	0.293**
	(2.65)	*(3.06)*	*(0.40)*	*(2.03)*	*(1.82)*	*(2.02)*	*(0.70)*	*(2.65)*
Initial trade openness	–0.003	–0.005	0.026*	–0.007	–0.002	–0.005	0.023	–0.005
	(–0.65)	*(–1.37)*	*(1.77)*	*(–1.02)*	*(–0.30)*	*(–1.18)*	*(1.56)*	*(–0.76)*
Initial financial depth	0.023**	0.023***	0.006	0.026***	0.022**	0.024***	0.005	0.032***
	(2.18)	*(3.02)*	*(0.68)*	*(2.84)*	*(2.24)*	*(2.87)*	*(0.57)*	*(3.06)*
Terms of trade growth	0.183*	–0.018	–0.003	–0.038	0.235**	–0.008	–0.002	–0.050**
	(1.93)	*(–0.65)*	*(–0.18)*	*(–1.23)*	*(2.66)*	*(–0.32)*	*(–0.10)*	*(–2.26)*
Fiscal deficit	0.011	–0.046***	–0.033***	–0.045**	0.019	–0.050***	–0.034***	–0.059***
	(0.32)	*(–4.75)*	*(–3.14)*	*(–2.23)*	*(0.53)*	*(–4.94)*	*(–3.24)*	*(–3.69)*
Banking crisis	–1.270	–0.563	–0.468	–0.612	–0.992	–0.588*	–0.506*	–1.163
	(–0.72)	*(–1.60)*	*(–1.61)*	*(–0.83)*	*(–0.57)*	*(–1.75)*	*(–1.94)*	*(–1.13)*
Initial debt*Dum below30	0.016	0.0002	0.017	0.030				
	(0.17)	*(0.01)*	*(0.65)*	*(1.25)*				
Initial debt*Dum 30 90	–0.037	–0.028**	0.007	–0.015				
	(–1.43)	*(–2.66)*	*(0.79)*	*(–1.26)*				
Initial debt*Dum above90	–0.010	–0.015***	–0.001	–0.015***				
	(–0.79)	*(–2.79)*	*(–0.08)*	*(–2.91)*				
Initial debt*Dum advanced					–0.017	–0.012**	–0.005	–0.014*
					(–1.35)	*(–2.19)*	*(–0.75)*	*(–1.95)*
Initial debt*Dum emerging					–0.044**	–0.042***	0.001	–0.038*
					(–2.62)	*(–2.97)*	*(0.08)*	*(–1.95)*
Arellano-Bond AR(2) test *p*-value[1]				0.34				0.14
Hansen *J*-statistics (*p*-value)[2]				0.86				0.85
Number of observations	166	166	166	166	166	166	166	166
R^2	0.75	0.62	0.52		0.7	0.61	0.51	
Time-fixed effects	N/A	Yes	Yes	Yes	N/A	Yes	Yes	Yes

Note: Heteroskedasticity and country-specific autocorrelation consistent *t*-statistics are in parentheses. Time dummies are not reported. Levels of significance: *** 1%, ** 5%, * 10%. In the OLS regressions, dummies for OECD, Asia, Latin America, and Sub-Saharan Africa are also included in each regression (not reported to save space). FE refers to the fixed-effects panel regressions and BE is the between estimator. For the dynamic panel estimation, a two-step system GMM (SGMM) with the Windmeijer's finite-sample correction for the two-step covariance matrix.

1) The null hypothesis is that the first-differenced errors exhibit no second-order serial correlation.

2) The null hypothesis is that the instruments used are not correlated with the residuals.

relatively low levels of public debt is not significantly harmful to growth. In the OLS, the coefficient of medium level of debt (initial debt*Dum_30-90) is significant at 5 per cent, and its estimated coefficient is –0.028. But they are all insignificant in other estimations (BE, FE and SGMM). By contrast, the coefficients of high debt (initial debt*Dum_90) are negative and significant at 1 per cent under OLS, and SGMM.

Interestingly, the negative effect of initial debt on growth in advanced economies tends to be smaller than that in emerging economies. Columns 5-8 in Table 5 use the interaction terms between initial debt and dummy variables for advanced and emerging economies.[22] The coefficients of both interaction terms are negative and significant at various levels, except for the FE results and the coefficient of the initial debt*Dum_advanced term in BE. Under BE, OLS, and SGMM, the coefficients of initial debt in advanced economies range from –0.012 to –0.017, whose absolute size is smaller than that of emerging economies (–0.038 to –0.044): a 10 percentage point increase in initial debt-to-GDP ratio is associated with growth slowdown around 0.12-0.17 per cent in advanced economies, compared to 0.38-0.4 per cent in emerging economies.[23] This may reflect limited borrowing capacity of emerging economies due to less-developed domestic financial markets or fragile access to international capital markets.

3.6 Net foreign asset position, foreign liabilities, and domestic vs. foreign currency-denominated portion of public debt

An important question that arises is whether and the extent to which the impact on growth of initial debt is conditional on a country's economic and financial position *vis-à-vis* the rest of the world. For example, does the NFA (net foreign asset) position of a country or aggregate foreign liabilities matter for the magnitude of the relationship between public debt and growth?[24] Is it the case that the adverse impact of high debt on growth would be smaller if at the same time the aggregate foreign liabilities of a country are relatively low? This could be related to the fact that high public debt is being financed by private domestic savings rather than from abroad. Conversely, excessive foreign liabilities may compound the fiscal vulnerability arising from public debt *per se*, to the extent that foreign creditors may be more sensitive to changes in global risk appetite, or they may have shorter time horizons. Another channel could be in terms of signaling: high public debt when foreign liabilities are also high may indicate that the imbalances facing a country are broader than just the public sector. Similar arguments could be used with regard to the NFA, rather than only foreign liabilities *per se*.

In order to investigate this issue, we considered the NFA and foreign liabilities (as percent of GDP) as an additional variable, as well as an interactive term. It is the case that the bilateral correlation between government debt and the NFA or foreign liabilities is low (correlation coefficients are –0.10 and 0.11, respectively), and neither the NFA nor foreign liabilities are not significant in growth regressions, as shown in columns 1-4 of Table 6 (the results on foreign liabilities are not reported). However, the logic of the above argument would suggest that the interaction of initial public debt with NFA or liabilities might be more important. This was assessed by examining the interaction of debt with a dummy that took a value of 1 if the NFA exceeded the

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22 See Appendix 1 for the list of advanced and emerging economies.

23 The same pattern is also found in the regressions on components of output per worker growth that the negative effects on growth of high debt are greater in emerging economies than in advanced economies.

24 The current sovereign debt crisis in Europe suggests that there is a strong correlation between the NFA positions and sovereign yields, indicating the market perceptions of fiscal risks associated with high debt (such as debt default and fiscal unsustainability) may depend on the NFA position. Conversely, some commentators observe that the currently very low yields on Japanese government bonds despite the very high level of debt (about 230 per cent of GDP) are possibly due to its high level of NFA in addition to Japan's haven status.

Table 6

Panel Regression – Different Levels of Initial NFA and Foreign Liabilities

(dependent variable: real per capita GDP growth)

Explanatory Variables	(1) BE	(2) Pooled	(3) FE	(4) SGMM	(5) BE	(6) Pooled	(7) FE	(8) SGMM	(9) BE	(10) Pooled	(11) FE	(12) SGMM
Initial real GDP per capita	–2.127***	–1.698**	–4.772**	–1.852**	–2.273***	–1.863**	–4.754**	–2.182***	–1.909***	–1.816**	–4.949**	–1.881***
	(–4.95)	*(–2.23)*	*(–2.29)*	*(–2.51)*	*(–5.43)*	*(–2.66)*	*(–2.38)*	*(–3.86)*	*(–4.40)*	*(–2.35)*	*(–2.46)*	*(–2.78)*
Initial years of schooling	4.760***	3.044**	2.345	2.580	4.458***	3.076***	2.396	3.749***	5.066***	3.308***	2.250	1.592
	(3.81)	*(2.51)*	*(1.04)*	*(1.11)*	*(3.72)*	*(2.92)*	*(1.08)*	*(2.77)*	*(4.22)*	*(2.76)*	*(1.04)*	*(0.67)*
Initial inflation rate	2.019	–2.397***	–2.483***	–1.402	2.874	–2.098***	–2.418***	–1.905	–0.277	–2.621***	–2.527***	–2.514**
	(0.75)	*(–3.20)*	*(–5.82)*	*(–1.21)*	*(1.12)*	*(–3.06)*	*(–5.53)*	*(–1.58)*	*(–0.09)*	*(–3.57)*	*(–5.84)*	*(–2.15)*
Initial government size	0.108*	0.115**	0.057	0.142	0.096*	0.115**	0.059	0.114	0.117**	0.117**	0.053	0.111
	(2.00)	*(2.44)*	*(0.73)*	*(1.50)*	*(1.86)*	*(2.70)*	*(0.74)*	*(0.68)*	*(2.26)*	*(2.61)*	*(0.67)*	*(1.32)*
Initial trade openness	–0.003	–0.006	0.023	0.008	0.0003	–0.004	0.024	–0.007	–0.001	–0.002	0.026*	0.003
	(–0.50)	*(–1.28)*	*(1.51)*	*(1.07)*	*(0.06)*	*(–1.17)*	*(1.58)*	*(–1.40)*	*(–0.13)*	*(–0.39)*	*(1.90)*	*(0.28)*
Initial financial depth	0.019	0.021**	0.006	0.018	0.014	0.021**	0.006	0.027**	0.020*	0.022**	0.006	0.021*
	(1.47)	*(2.18)*	*(0.66)*	*(1.24)*	*(1.29)*	*(2.62)*	*(0.66)*	*(2.33)*	*(1.98)*	*(2.26)*	*(0.64)*	*(1.66)*
Terms of trade growth	0.199**	–0.016	–0.003	–0.034	0.167*	–0.021	–0.004	–0.034	0.161*	–0.022	–0.007	–0.051***
	(2.22)	*(–0.62)*	*(–0.13)*	*(–0.77)*	*(1.92)*	*(–0.90)*	*(–0.17)*	*(–0.99)*	*(1.81)*	*(–0.95)*	*(–0.28)*	*(–2.75)*
Fiscal deficit	0.028	–0.044***	–0.035***	–0.034	0.021	–0.045***	–0.035***	–0.044	–0.0002	–0.050***	–0.039***	–0.067***
	(0.79)	*(–4.80)*	*(–3.59)*	*(–1.44)*	*(0.62)*	*(–5.40)*	*(–3.52)*	*(–1.59)*	*(–0.00)*	*(–5.03)*	*(–3.55)*	*(–2.78)*
Banking crisis	–0.943	–0.570	–0.525*	–2.219*	–1.468	–0.510	–0.489*	–1.077	–0.672	–0.550	–0.485*	–0.427
	(–0.52)	*(–1.66)*	*(–1.88)*	*(–1.96)*	*(–0.85)*	*(–1.46)*	*(–1.83)*	*(–1.19)*	*(–0.38)*	*(–1.56)*	*(–1.81)*	*(–0.54)*
Initial government debt	–0.024**	–0.017**	–0.004	–0.015*								
	(–2.14)	*(–2.40)*	*(–0.72)*	*(–1.81)*								
Initial NFA (net foreign assets)	0.003	0.005	–0.002	–0.013								
	(0.39)	*(0.84)*	*(–0.21)*	*(–1.26)*								
*Initial debt*Dum NFA above median*[3]					*–0.020**	*–0.015***	*–0.004*	*–0.023**				
					(–1.80)	(–2.64)	(–0.60)	(–1.84)				
Initial debt*Dum NFA below median					–0.042***	–0.029***	–0.006	–0.029*				
					(–2.88)	*(–3.17)*	*(–0.70)*	*(–1.95)*				
Initial debt*Dum Foreign Liabilities below_75percentile[4]									–0.013	–0.015*	–0.003	–0.017*
									(–0.99)	*(–1.98)*	*(–0.38)*	*(–1.85)*
Initial debt*Dum Foreign Liabilities above_75percentile									–0.036***	–0.025***	–0.010	–0.025*
									(–2.81)	*(–2.74)*	*(–1.19)*	*(–1.71)*
Arellano-Bond AR(2) test *p*-value[1]				0.16				0.28				0.36
Hansen J-statistics (*p*-value)[2]				0.47				0.16				0.90
Number of observations	166	166	166	166	166	166	166	166	166	166	166	166
R^2	0.68	0.59	0.51		0.71	0.61	0.51		0.7	0.59	0.52	
Time-fixed effects	N/A	Yes	Yes	Yes	N/A	Yes	Yes	Yes	N/A	Yes	Yes	Yes

Note: Heteroskedasticity and country-specific autocorrelation consistent *t*-statistics are in parentheses. Time dummies are not reported. Levels of significance: *** 1%, ** 5%, * 10%. In the OLS regressions, dummies for OECD, Asia, Latin America, and Sub-Saharan Africa are also included in each regression (not reported to save space). FE refers to the fixed-effects panel regressions and BE is the between estimator. For the dynamic panel estimation, a two-step system GMM (SGMM) with the Windmeijer's finite-sample correction for the two-step covariance matrix.

1) The null hypothesis is that the first-differenced errors exhibit no second-order serial correlation.

2) The null hypothesis is that the instruments used are not correlated with the residuals.

3) The median value of NFA in the sample of 36 advanced and emerging economies is –17 per cent of GDP.

4) The 75 percentile level of foreign liabilities in the sample of 36 advanced and emerging economies is 89 per cent of GDP.

sample median value (–17 per cent of GDP), or if foreign liabilities were greater than the 75th percentile (89 per cent of GDP), and 0 otherwise. The results are shown in columns 5-8 and 8-12 of Table 6, respectively. The results bear out the basic hypothesis: when foreign liabilities are high or NFA low, the adverse impact of public debt on growth is about *one and a half to two* times as large as is the case otherwise. These results are striking from an economic perspective, and statistically significant. Perhaps what they are really implying is the notion that if the economy as a whole is operating essentially outside its means, the impact of high public debt on growth is substantially worse than when it is operating within it.

Next, we turn to the question of whether the currency composition of public debt also matters. The larger the portion of foreign-currency denominated debt as a share of total public debt, the larger the extent of exposure to foreign currency risk. This is related to the "Original Sin" problem highlighted by Eichengreen and Hausmann (1999), which could have adverse macroeconomic consequences. If a country affected by original sin has net foreign debt, then this country is likely to have a currency mismatch in its national balance sheet and large swings in the real exchange rate will have an effect on aggregate wealth and affect a country's ability to service its debt. As a consequence, original sin tends to make debt riskier, increase volatility, and affect a country's ability to conduct an independent monetary policy. Table 7 shows the results when we included the interaction of debt with a dummy that took a value of 1 if the domestic-currency portion exceeded the sample median value (89 per cent of total debt), or if it is greater than the 25th percentile (59 per cent of total debt), and 0 otherwise. The regression coefficients of the interaction terms are mostly significant and of the expected sign. They suggest that when the foreign-currency debt portion is large, the negative impact of public debt on growth can be more than twice as large as is the case otherwise.

4 Growth accounting

A detailed growth accounting exercise was also undertaken to explore channels (factor accumulation versus total factor productivity) through which government debt influences growth.[25] Taking a standard neoclassical framework, we consider a Cobb-Douglas production function $Y=AK^{\alpha}(HL)^{1-\alpha}$, where α is capital income share; K is physical capital; L is labor input; H is human capital; and A is TFP (total factor productivity). In terms of per worker, the production function can be written as $y=Ak^{\alpha}H^{1-\alpha}$, where $y=Y/L$ (output per worker) and $k=K/L$ (capital per worker). Then, growth of output per worker ($\dot{y}/y$) can be decomposed to TFP growth ($\dot{A}/A$) and contributions from growth of capital per worker ($\dot{k}/k$) and growth of human capital ($\dot{H}/H$).

$$\dot{y}/y = \dot{A}/A + \alpha(\dot{k}/k) + (1-\alpha)(\dot{H}/H) \tag{2}$$

Table 8 presents results from panel regression on output per worker growth and its components (TFP growth ($\dot{A}/A$) and growth of capital per worker ($\dot{k}/k$)), using the same baseline specification (Equation 1).[26] First, the coefficients of initial debt in the regressions of output per worker growth are significant at 5-10 per cent under BE, OLS, and SGMM, ranging from –0.012 to –0.022, whereas it becomes insignificant under FE (columns 1-4). The estimated

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[25] See Appendix 3 for details about the growth accounting. The relation between labor force participation and initial debt is also examined, but the results are not significant (not reported).

[26] In terms of regression specification, y now denotes the logarithm of output per worker (Y/L) in the regressions on growth of output per worker (columns 1-4 of Table 8); y is the logarithm of level of TFP in the TFP growth regressions (columns 5-8); y is the logarithm of capital stock per worker (K/L) in the regressions on growth of capital stock per worker (columns 9-12). In the investment regressions of Table 9, the dependent variable is the average level of domestic investment (percent of GDP) over the period t and $t-\tau$.

Table 7

Panel Regression – Domestic vs. Foreign Currency-Denominated Portion of Public Debt

(dependent variable: real per capita GDP growth)

Explanatory Variables	(1) BE	(2) Pooled OLS	(3) FE	(4) SGMM	(5) BE	(6) Pooled OLS	(7) FE	(8) SGMM
Initial real GDP per capita	–2.531***	–2.092***	–4.927**	–2.337**	–2.178***	–1.856**	–4.818**	–2.688**
	(–4.79)	*(–2.96)*	*(–2.32)*	*(–2.29)*	*(–4.40)*	*(–2.44)*	*(–2.35)*	*(–2.37)*
Initial years of schooling	5.311***	3.293***	3.195	4.209	5.054***	3.110**	3.030	2.578
	(4.01)	*(3.10)*	*(1.32)*	*(1.54)*	*(3.63)*	*(2.52)*	*(1.22)*	*(0.74)*
Initial inflation rate	0.946	–2.471***	–2.393***	–3.002**	2.136	–2.652***	–2.401***	–2.521*
	(0.30)	*(–3.53)*	*(–5.90)*	*(–2.28)*	*(0.69)*	*(–2.98)*	*(–4.73)*	*(–1.67)*
Initial government size	0.081	0.091*	0.086	0.182	0.111*	0.112**	0.095	0.118
	(1.30)	*(2.01)*	*(1.19)*	*(1.64)*	*(1.80)*	*(2.32)*	*(1.24)*	*(1.05)*
Initial trade openness	–0.002	–0.005	0.025	–0.012*	–0.001	–0.004	0.026	0.001
	(–0.32)	*(–0.93)*	*(1.51)*	*(–1.72)*	*(–0.18)*	*(–0.90)*	*(1.48)*	*(0.12)*
Initial financial depth	0.018	0.017**	0.005	0.026*	0.022	0.023**	0.004	0.024*
	(1.40)	*(2.08)*	*(0.50)*	*(1.84)*	*(1.54)*	*(2.36)*	*(0.41)*	*(1.97)*
Terms of trade growth	0.211**	0.004	0.003	–0.032	0.212**	–0.018	–0.000	–0.040*
	(2.27)	*(0.14)*	*(0.10)*	*(–0.99)*	*(2.18)*	*(–0.72)*	*(–0.00)*	*(–1.70)*
Banking crisis	–1.613	–0.832*	–0.588*	–0.501	–0.547	–0.612	–0.577*	–2.577
	(–0.67)	*(–2.03)*	*(–2.00)*	*(–0.34)*	*(–0.23)*	*(–1.33)*	*(–1.98)*	*(–1.48)*
Fiscal deficit	0.008	–0.051***	–0.036***	–0.074***	0.028	–0.047***	–0.035***	–0.063***
	(0.19)	*(–4.36)*	*(–3.24)*	*(–4.01)*	*(0.66)*	*(–4.61)*	*(–3.11)*	*(–4.43)*
Initial debt*Dum_domdebt_below25pctile[3]	–0.047**	–0.054***	–0.039***	–0.060*				
	(–2.35)	*(–2.86)*	*(–2.79)*	*(–1.94)*				
Initial debt*Dum_domdebt_above25pctile	–0.021*	–0.017**	–0.004	–0.023*				
	(–1.72)	*(–2.50)*	*(–0.77)*	*(–1.74)*				
Initial debt*Dum_domdebt_belowMedian[4]					–0.025	–0.028**	–0.011	–0.033**
					(–1.63)	*(–2.71)*	*(–1.04)*	*(–2.24)*
Initial debt*Dum_domdebt_aboveMedian					–0.025*	–0.018**	–0.006	–0.019**
					(–1.90)	*(–2.40)*	*(–0.87)*	*(–2.20)*
Arellano-Bond AR(2) test *p*-value[1]				0.68				0.89
Hansen J-statistics (*p*-value)[2]				0.41				0.55
Number of observations	151	151	151	151	151	151	151	151
R^2	0.7	0.63	0.51		0.67	0.6	0.51	
Time-fixed effects	N/A	Yes	Yes	Yes	N/A	Yes	Yes	Yes

Note: Heteroskedasticity and country-specific autocorrelation consistent *t*-statistics are in parentheses. Time dummies are not reported. Levels of significance: *** 1%, ** 5%, * 10%. In the OLS regressions, dummies for OECD, Asia, Latin America, and Sub-Saharan Africa are also included in each regression (not reported to save space). FE refers to the fixed-effects panel regressions and BE is the between estimator. For the dynamic panel estimation, a two-step system GMM (SGMM) with the Windmeijer's finite-sample correction for the two-step covariance matrix.

1) The null hypothesis is that the first-differenced errors exhibit no second-order serial correlation.

2) The null hypothesis is that the instruments used are not correlated with the residuals.

3) The 25 percentile level of domestic currency-denominated public debt portion in the sample 36 advanced and emerging economies is 59 per cent of total public debt.

4) The median level of domestic currency-denominated public debt portion in the sample 36 advanced and emerging economies is 89 per cent of total public debt.

Table 8

Growth Accounts and Panel Regression: Advanced and Emerging Economies

Explanatory Variables	(1) BE	(2) Pooled OLS	(3) FE	(4) SGMM	(5) BE	(6) Pooled OLS	(7) FE	(8) SGMM	(9) BE	(10) Pooled OLS	(11) FE	(12) SGMM
	dependent variable: growth of output per worker				*dependent variable: growth of TFP*				*dependent variable: growth of capital stock per worker*			
Lagged dependent variable[1]	–1.728**	–2.034**	–6.198**	–2.338**	–2.851***	–3.783***	–9.309***	–2.768**	–0.425	–0.515	–3.698*	–2.547
	(–2.25)	*(–2.40)*	*(–2.47)*	*(–2.71)*	*(–3.33)*	*(–4.62)*	*(–3.95)*	*(–2.61)*	*(–0.50)*	*(–0.79)*	*(–1.88)*	*(–1.57)*
Initial years of schooling	3.669***	2.649*	–1.829	3.894	2.507***	1.858**	–3.418	2.016	2.089	1.240	–1.809	10.654**
	(3.09)	*(2.01)*	*(–0.63)*	*(1.40)*	*(3.29)*	*(2.62)*	*(–1.33)*	*(1.12)*	*(1.26)*	*(0.91)*	*(–0.40)*	*(2.58)*
Initial inflation rate	1.443	–1.830**	–2.928***	–4.783	1.565	–1.241**	–2.260***	–4.515	0.190	–2.450***	–2.824***	–8.658
	(0.44)	*(–2.34)*	*(–5.72)*	*(–1.35)*	*(0.72)*	*(–2.04)*	*(–5.06)*	*(–1.64)*	*(0.04)*	*(–3.18)*	*(–4.73)*	*(–1.03)*
Initial government size	0.134**	0.104**	–0.076	0.102	0.070*	0.052	–0.031	0.143*	0.182**	0.114*	–0.330***	0.388
	(2.32)	*(2.28)*	*(–0.69)*	*(1.08)*	*(1.80)*	*(1.60)*	*(–0.27)*	*(1.73)*	*(2.31)*	*(1.96)*	*(–3.20)*	*(1.62)*
Initial trade openness	–0.009	–0.005	0.006	–0.009	–0.003	–0.001	0.016	–0.004	–0.016	–0.011	–0.015	–0.026
	(–1.14)	*(–1.06)*	*(0.47)*	*(–1.14)*	*(–0.56)*	*(–0.37)*	*(1.23)*	*(–0.28)*	*(–1.48)*	*(–1.52)*	*(–1.30)*	*(–0.93)*
Initial financial depth	0.030**	0.023**	0.012	0.026**	0.021**	0.017***	0.010	0.023*	0.025	0.015	0.003	0.027
	(2.33)	*(2.27)*	*(1.39)*	*(2.13)*	*(2.39)*	*(2.81)*	*(1.22)*	*(2.03)*	*(1.43)*	*(1.29)*	*(0.49)*	*(1.12)*
Terms of trade growth	0.342**	–0.038	–0.023	–0.059	0.237**	–0.021	–0.011	–0.048**	0.305*	–0.019	–0.007	–0.022
	(2.69)	*(–1.24)*	*(–0.82)*	*(–1.52)*	*(2.73)*	*(–0.89)*	*(–0.45)*	*(–2.19)*	*(1.79)*	*(–0.32)*	*(–0.15)*	*(–0.16)*
Banking crisis	–0.484	–0.033**	–0.027**	–0.010	–0.165	–0.032***	–0.022**	–0.033	–0.271	–0.010	–0.014	0.068
	(–0.26)	*(–2.55)*	*(–2.30)*	*(–0.28)*	*(–0.13)*	*(–3.53)*	*(–2.61)*	*(–1.00)*	*(–0.11)*	*(–0.77)*	*(–1.42)*	*(0.66)*
Fiscal deficit	0.061	–0.430	–0.539	–0.273	0.020	–0.327	–0.466	0.108	0.091	–0.128	–0.118	0.612
	(1.48)	*(–0.88)*	*(–1.29)*	*(–0.43)*	*(0.74)*	*(–0.77)*	*(–1.37)*	*(0.11)*	*(1.59)*	*(–0.28)*	*(–0.31)*	*(0.68)*
Initial government debt	–0.022*	–0.012*	0.005	–0.020**	–0.009	–0.004	0.009	–0.008	–0.034*	–0.023**	–0.014*	–0.045**
	(–1.78)	*(–1.75)*	*(0.69)*	*(–2.45)*	*(–1.11)*	*(–1.16)*	*(1.33)*	*(–0.60)*	*(–2.06)*	*(–2.13)*	*(–1.79)*	*(–2.04)*
Arellano-Bond AR(2) test *p*-value[2]				0.16				0.9				0.14
Hansen J-statistics (*p*-value)[3]				0.25				0.42				0.28
Number of observations	159	159	159	159	159	159	159	159	159	159	159	159
R^2	0.75	0.5	0.45		0.79	0.51	0.44		0.58	0.41	0.55	
Time-fixed effects	N/A	Yes	Yes	Yes	N/A	Yes	Yes	Yes	N/A	Yes	Yes	Yes

Note: Heteroskedasticity and country-specific autocorrelation consistent *t*-statistics are in parentheses. Time dummies are not reported. Levels of significance: *** 1%, ** 5%, * 10%. In the OLS regressions, dummies for OECD, Asia, Latin America, and Sub-Saharan Africa are also included in each regression (not reported to save space). FE refers to the fixed-effects panel regressions and BE is the between estimator. For the dynamic panel estimation, a two-step system GMM (SGMM) with the Windmeijer's finite-sample correction for the two-step covariance matrix.

1) The log of initial level of output per worker for columns 1-4; the log of initial level of TFP for Columns 5-8; and the log of initial level of capital stock per worker for columns 9-12, respectively.

2) The null hypothesis is that the first-differenced errors exhibit no second-order serial correlation.

3) The null hypothesis is that the instruments used are not correlated with the residuals.

coefficients of initial debt from the preferred estimators (BE and SGMM) indicate that a 10 percentage point increase in initial debt-to-GDP ratio is associated with a slowdown in growth of labor productivity (output per worker) of around 0.2 per cent per year.

Columns 5-8 show the regression results for TFP growth. There seems to be significant (conditional) convergence in the level of TFP, as indicated by the significant and negative coefficients of the log of initial level of TFP (in the first row). However, the coefficients of initial debt are insignificant across all four regressions, while they have a negative sign (except for FE). The estimated coefficients of initial debt under BE and SGMM are around –0.01.

The regression results for growth of capital per worker are stronger (columns 9-12). The initial debt coefficients are all significant at the conventional levels across estimation techniques, ranging from –0.014 to –0.045. Since the capital income share (α) is assumed to be 0.35 in the growth accounting exercise, the estimated coefficients of initial debt under BE and SGMM suggest that a 10 percentage point increase in initial debt-to-GDP ratio induces slowdown in growth of output per worker around 0.1-0.2 per cent per year via the channel of reduced growth in capital per worker. Taken together, the individual effects of initial debt on TFP growth and capital per worker growth roughly add up to 0.2-0.3 per cent per year, which is approximately in line with the regression outcomes for growth of output per worker shown in columns 1-4. However, there are no significant effects on human capital growth from debt and are not reported.

Table 9 presents panel regressions for domestic investment (percent of GDP, averaged over each five-year time period). Columns 1-3 show the regression results using the baseline specification except for the dependent variable which is the average domestic investment. The coefficients of initial debt are all significant at 1-10 per cent, ranging from –0.06 to –0.1. Columns 4 and 5 present the dynamic panel SGMM regressions in which the lagged term of the average investment is included instead of initial income per capita. The coefficient of initial debt in column 4 is significant at 5 per cent, and its estimate suggests that a 10 percentage point increase in initial debt-to-GDP ratio is associated with decline in domestic investment by about 0.4 percentage points of GDP. Column 5 includes interaction terms between initial debt and dummy variables for advanced and emerging economies. The coefficients of both interaction terms are significant at 5-10 per cent, and the estimated effects suggest that the adverse impact on domestic investment from debt in emerging economies is almost twice as large as that in advanced economies.

In addition, we considered the potential relationship between high debt and macroeconomic volatility. Intuitively, high debt may not only increase uncertainty about economic prospects and policies but also raise vulnerability to crises, leading to greater macroeconomic volatility. A simple scatter plot of macroeconomic volatility against initial government debt suggests a mild positive correlation. We ran regressions on macroeconomic volatility as measured by the log of standard deviation of annual real GDP growth rates using the baseline specification. The coefficient of initial debt in the regressions for volatility is only significant and of expected positive sign under FE when time-fixed effects are not included. However, they are all insignificant in all other estimations (with or without time dummies). Similarly, the coefficient of high debt (as captured by the interaction term, initial debt*Dum_90) is only significant under FE with no time-fixed effects included, as is the coefficient of initial debt for advanced economies (*i.e.*, initial debt*Dum_advance) in a separate FE regression (not reported to save space).

From the growth accounting perspective, therefore, the adverse effects on growth of initial debt largely reflect a slowdown in labor productivity growth mainly due to reduced investment and slower growth of capital per worker.

Table 9

Panel Regression on Investment: Advanced and Emerging Economies

Explanatory Variables	(1) BE	(2) Pooled OLS	(3) FE	(4) SGMM	(5) SGMM
Lagged dependent variable				0.763***	0.773***
				(8.35)	*(5.62)*
Initial real GDP per capita	–3.028*	2.645	8.700***		
	(–1.90)	*(0.89)*	*(3.76)*		
Initial years of schooling	3.361	–3.261	–2.197	5.029	–0.682
	(0.73)	*(–0.74)*	*(–0.34)*	*(1.56)*	*(–0.27)*
Initial inflation rate	–10.390	–1.632	–2.371***	–3.305*	–4.949***
	(–1.05)	*(–0.81)*	*(–3.15)*	*(–1.71)*	*(–3.27)*
Initial government size	–0.027	–0.056	–0.429**	0.367*	0.147
	(–0.14)	*(–0.32)*	*(–2.31)*	*(1.75)*	*(0.73)*
Initial trade openness	–0.011	0.000	–0.051*	–0.043***	–0.027***
	(–0.54)	*(0.02)*	*(–1.88)*	*(–2.94)*	*(–3.08)*
Initial financial depth	0.046	0.010	–0.009	0.031	0.022
	(1.19)	*(0.27)*	*(–1.00)*	*(1.56)*	*(1.43)*
Terms of trade growth	–0.157	0.062	0.069	0.200**	0.144*
	(–0.48)	*(0.70)*	*(0.91)*	*(2.42)*	*(1.81)*
Fiscal deficit	0.161	–0.002	–0.058***	–0.017	–0.069
	(1.21)	*(–0.07)*	*(–4.67)*	*(–0.31)*	*(–1.36)*
Banking crisis	1.178	–0.488	0.663	–1.519	–1.240
	(0.18)	*(–0.32)*	*(0.71)*	*(–1.06)*	*(–0.38)*
Initial government debt	–0.110**	–0.057*	–0.055***	–0.041**	
	(–2.64)	*(–1.67)*	*(–5.12)*	*(–2.48)*	
Initial debt*Dum_advanced					–0.032***
					(–2.94)
Initial debt*Dum_emerging					–0.077**
					(–2.61)
Arellano-Bond AR(2) test *p*-value[1]				0.54	0.79
Hansen *J*-statistics (*p*-value)[2]				0.59	0.40
Number of observations	166	166	166	159	159
R^2	0.45	0.48	0.53		
Time-fixed effects	N/A	Yes	Yes	Yes	Yes

Note: Heteroskedasticity and country-specific autocorrelation consistent *t*-statistics are in parentheses. Time dummies are not reported. Levels of significance: *** 1%, ** 5%, * 10%. In the OLS regressions, dummies for OECD, Asia, Latin America, and Sub-Saharan Africa are also included in each regression (not reported to save space). FE refers to the fixed-effects panel regressions and BE is the between estimator. For the dynamic panel estimation, a two-step system GMM (SGMM) with the Windmeijer's finite-sample correction for the two-step covariance matrix.

1) The null hypothesis is that the first-differenced errors exhibit no second-order serial correlation.

2) The null hypothesis is that the instruments used are not correlated with the residuals.

5 Concluding Remarks

Given the sharp increase in advanced country sovereign debt as a result of the global economic and financial crisis, there have begun to be serious concerns about its broader economic and financial market impact including an acute sovereign debt crisis in Europe. In particular, a number of observers have alluded to the risk that large debts may discourage capital accumulation and reduce economic growth. This could occur through higher long-term interest rates, higher future distortionary taxation, higher inflation, greater vulnerability to a debt crisis, and reduced scope for future counter-cyclical fiscal policy. If growth is indeed reduced, fiscal sustainability issues are likely to be exacerbated, with further adverse consequences.

Empirical evidence, based on a range of econometric techniques, strongly suggests an inverse relationship between initial debt and subsequent growth, controlling for other determinants of growth: on average, a 10 percentage point increase in the initial debt-to-GDP ratio is associated with a slowdown in real per capita GDP growth of around 0.2 percentage points per year, with the impact being smaller (around 0.15) in advanced economies and/or smaller when (net) foreign liabilities are relatively high. Also, the currency composition of public debt matters. There is some evidence of non-linearity, with only high (above 90 per cent of GDP) levels of debt having a significant negative effect on growth. This adverse effect largely reflects a slowdown in labor productivity growth, mainly due to reduced investment and slower growth of the capital stock per worker. On average, a 10 percentage point increase in initial debt ratio is associated with a decline of investment by about 0.4 percentage points of GDP, with a larger impact in emerging economies. Various robustness checks yield largely similar results. They underline the need to take measures to not just stabilize public debt but to place them on a downward trajectory in the medium and long term.

APPENDIX 1
COUNTRY LIST

The sample of countries is dictated by the availability of data. The following 38 advanced and emerging economies with a population of over 5 million are included in the baseline panel regressions.

Country	Country
Australia	Japan
Austria	Korea
Belgium	Malaysia
Brazil	Mexico
Canada	Netherlands
Chile	Pakistan
China	Peru
Colombia	Philippines
Czech Republic*	Poland
Denmark	Portugal
Egypt	Russian Federation*
France	Slovak Republic*
Germany	South Africa
Greece	Spain
Hong Kong	Sweden
Hungary	Switzerland
India	Turkey
Indonesia	United Kingdom
Italy	United States

Note:
1. Three countries with the asterisk mark (*) in the above list are not included in the growth accounting exercise because necessary data in computing TFP are not available.
2. Eight additional countries are also available in the panel regressions for all available 46 advanced and emerging economies without the over-5-million-population size restriction: Finland, Iceland, Ireland, Israel, Jordan, Norway, New Zealand, and Singapore.

3 Thirty three developing countries that are included in the full sample of 79 countries are: Barbados, Bolivia, Bulgaria, Costa Rica, Croatia, Cyprus, Ecuador, Gambia, Guinea-Bissau, Guyana, Honduras, Iran, Jamaica, Kuwait, Lesotho, Mauritania, Mauritius, Mozambique, Nicaragua, Panama, Romania, Rwanda, Senegal, Slovenia, Sri Lanka, Sudan, Swaziland, Syria, Togo, Trinidad & Tobago, Tunisia, Uganda, and Uruguay.

4 The list of advanced economies includes Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Netherlands, New Zealand, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States, which were the OECD member nations as of 1990, except for Turkey which is classified as an emerging market economy.

APPENDIX 2
DESCRIPTION OF DATA

A. Dependent variables

The following dependent variables are measured over the five-year period in the panel (or the relevant time period in the cross-country regression).

1) Growth of real per capita GDP, PWT7.0 (2011)
2) Growth of output per worker, PWT7.0 (2011)
3) TFP growth, constructed using PWT7.0 (2011) and Barro and Lee (2011)
4) Growth of capital per worker PWT7.0 (2011)
5) Domestic investment (percent of GDP), PWT7.0 (2011)
6) Volatility of output (log of standard deviation of annual real GDP growth rates over the five-year period), PWT7.0 (2011)

B. Explanatory variables

Initial values of explanatory variables – for example, initial real GDP per capita or initial government size – are measured at the measured at the beginning of each five-year period in the panel (or the relevant time period in the cross-country regression). Otherwise, the variables, such as terms of trade growth or average government debt, are averaged over the five-year period.

1) Initial real GDP per capita (in log), PWT7.0 (2011)
2) Initial average years of schooling of population of age over 15 (in log), Barro and Lee (2011)
3) Initial government size (percent of GDP), PWT7.0 (2011)
4) Initial trade openness (percent of GDP), PWT7.0 (2011)
5) Initial inflation rate (log of $(1+\pi)$), WDI (2011)
6) Initial financial market depth (liquid liabilities, percent of GDP), WDI (2011)
7) Terms of trade growth (in percent), IMF, WEO (2011)
8) Banking crisis (total number of incidences over five-year period), Reinhart and Reinhart (2008)
9) Initial population size (in log), PWT7.0 (2011)
10) Fiscal deficit (percent of GDP), IMF, WEO (2011)
11) Population growth (in percent), PWT7.0 (2011)
12) Initial domestic investment (percent of GDP), PWT7.0 (2011)
13) Fiscal volatility (log of standard deviation of annual growth rates of real general government expenditures over the five-year period), WDI (2011)
14) Aged-dependency ratio (ratio of population of age over 65 to working population), WDI (2011)
15) Urbanization, WDI (2011)
16) Checks and balances, Database of Political Institutions (2009)
17) Constraints on executive decision-making, Polity IV (2009)
18) Initial gross government debt (percent of GDP), IMF, WEO (2011)
19) Average gross government debt (percent of GDP), IMF, WEO (2011)

APPENDIX 3
GROWTH ACCOUNTING

Taking a standard neoclassical approach, let us consider a Cobb-Douglas production function $Y=AK^{\alpha}(HL)^{1-\alpha}$, where α=capital income share; K=physical capital; L=labor input; H=human capital; and A= TFP (total factor productivity). In terms of per worker, the production function can be written as $y=Ak^{\alpha}H^{1-\alpha}$, where $y=Y/L$ (output per worker) and $k=K/L$ (capital per worker). Then, growth of output per worker ($\dot{y}/y$) can be decomposed to TFP growth ($\dot{A}/A$) and contributions from growth of capital per worker ($\dot{k}/k$) and growth of human capital ($\dot{H}/H$):

$$\dot{y}/y = \dot{A}/A + \alpha(\dot{k}/k) + (1-\alpha)(\dot{H}/H).$$

The growth accounting is consistent with a wide range of alternative production functional forms linking the factor inputs and output. It is only necessary to assume a degree of competition sufficient so that the earnings of the factors are proportionate to their factor productivity. Then we can measure TFP growth rates, using the shares of income paid to the factors to measure their importance in the production process as described above (see Caselli, 2005 for details about TFP). Since consistent measures of factor income shares are often difficult to obtain for individual countries, most studies assume that income shares are identical across time and space. Yet, Gollin (2002) provides strong evidence in support of such an assumption of constant income shares across time and space, which is consistent with the Cobb-Douglas function approach. Also, Bernanke and Gürkaynak (2001) find no systematic tendency for labor shares to vary with real GDP per capita or the capital-labor ratio nor systematic tendency to rise or fall over time, and most estimated labor income shares lie between 0.6 and 0.8, the average being 0.65. In this paper, we tried both a fixed labor share of 0.65 and actual income shares from Gollin (2002) and Bernanke and Gürkaynak (2001). The results using alternative income share measures are very similar, suggesting that using a fixed labor income share is not a serious problem.

We construct a new data set on TFP for a large number of developed and developing countries in the period 1970-2008. National income and product account data and labor force data are obtained from the latest version 7.0 of the Penn World Table (Heston *et al.*, 2011). To construct the labor quality index for human capital (H), we take average years of schooling in the population over 15 years old from the international data on educational attainment by Barro and Lee (2011). We follow Hall and Jones (1999) to give larger weight to more educated workers as follows: $H = e^{\phi(E)}$, where E is average years of schooling; the function $\phi(E)$ is piece linear with slope of 0.134 for $E \leq 4$, 0.101 for $4 < E \leq 8$; and 0.068 for $8 < E$. The rationale behind this functional form for human capital is as follows. The wage of a worker with E years of education is proportional to her human capital. Since the wage-schooling relationship is widely believed to be log-linear, this would imply that human capital (H) and education (E) would have a log-linear relation as well, such as H=exp($const \times E$). However, international data on education-wage profiles (Psacharopulos, 1994) suggests that in sub-Saharan Africa (which has the lowest levels of education), the return to one extra year of education is about 13.4 per cent, the world average is 10.1 per cent, and the OECD average is 6.8 per cent.

We estimate the capital stock, K, using the perpetual inventory method: $K_t = I_t + (1-\delta)K_{t-1}$, where I_t is the investment and δ is the depreciation rate. Data on I_t are from PWT 7.0 as real aggregate investment in PPP. For many countries in our sample, investment data go back to as early as 1950-55. We estimate the initial value of the capital stock, say, in year 1950 as I1950/(g+δ) where g is the average compound growth rate between 1950 and 1960, and δ is the depreciation rate (δ=0.06 is assumed). We further adjust these capital stocks for the portion of

residential capital stock that is not directly related to production activity.[27] Batteries of consistency checks suggest that our estimates of TFP growth are reasonable.

[27] PWT 5.6 provides data on residential capital per worker as a fraction of nonresidential capital per worker for 63 countries. For these countries, we use the average ratio of nonresidential capital to total capital to impute the nonresidential capital stock in our data set. For the remaining countries, we assume that nonresidential capital is two-thirds of the total capital, which is about the average value of 0.69 for the countries for which the data are available.

APPENDIX

Table 10

Level of Initial Government Debt, Growth, and Investment, 1970-2008: Countries with a Population of Over 5 Million

Group of Countries	Initial Debt below 30 per cent of GDP	Initial Debt between 30 and 60 per cent of GDP	Initial Debt between 60 and 90 per cent of GDP	Initial Debt above 90 per cent of GDP
		Average: Real per capita GDP Growth Rate *(annualized over the subsequent 5 years)*		
Entire	5.0	2.7	2.6	2.2
Advanced[1]	2.6	1.8	2.1	1.7
Emerging	5.4	3.1	2.9	3.7
Developing	6.6	4.4	3.1	2.2
		Average: Output per worker Growth Rate *(annualized over the subsequent 5 years)*		
Entire	4.4	1.9	2.0	1.7
Advanced	2.3	1.2	1.6	1.5
Emerging	4.7	2.3	2.3	3.4
Developing	5.9	3.3	2.4	1.6
		Average: TFP Growth Rate *(annualized over the subsequent 5 years)*		
Entire	1.3	0.3	0.7	1.1
Advanced	0.3	0.1	0.5	0.4
Emerging	2.0	0.8	0.7	2.4
Developing	2.1	-0.3	1.1	1.4
		Average: Capital stock per worker Growth Rate *(annualized over the subsequent 5 years)*		
Entire	4.6	2.4	2.2	1.5
Advanced	4.2	1.8	2.2	2.1
Emerging	5.8	1.8	1.9	0.9
Developing	2.5	5.7	2.3	1.2
		Average: Domestic Investment *(percent of GDP over the subsequent 5 years)*		
Entire	25.8	21.7	21.6	18.5
Advanced	25.2	20.7	21.9	23.9
Emerging	30.5	22.1	21.8	16.4
Developing	21.0	23.7	21.0	15.8

Note: Initial debts are the government gross debt to GDP (percent) in the first year of each five-year sub-period (*i.e.*, 1970, 1975, 1980, 1985, 1990, 1995, 2000, 2005). Average growth rates (percent per annum) are over each five-year sub-period (*i.e.*, 1970-74, 1975-79, 1980-84, 1985-89, 1990-94, 1995-99, 2000-04, 2005-08).
1) Advanced economies are defined as the OECD Members as of 1990, excluding Turkey, which is classified as an emerging economy.

Table 11

Cross-country Regression – Government Debt and Real per Capita GDP Growth: Advanced and Emerging Economies (Without Restriction on Population Size)

(dependent variable: real per capita GDP growth)

Explanatory Variables	(1) OLS 1975-2008	(2) OLS 1985-2008	(3) OLS 1990-2008	(4) OLS 1995-2008	(5) OLS 2000-2008	(6) OLS 1990-2008	(7) OLS 1995-2008	(8) OLS 2000-2008
Initial real GDP per capita	1.862	–2.928*	–2.464***	–1.726**	–0.480	–1.353	–1.121*	–0.494
	(1.91)	*(–2.00)*	*(–4.44)*	*(–2.37)*	*(–0.58)*	*(–1.63)*	*(–1.84)*	*(–0.61)*
Initial years of schooling	0.393	0.576	2.462**	2.944**	1.021	1.419	2.204**	1.286
	(0.38)	*(0.50)*	*(2.66)*	*(2.08)*	*(0.63)*	*(1.15)*	*(2.09)*	*(0.82)*
Initial inflation rate	8.395**	–1.578	0.400	8.932**	1.628	–0.059	2.831**	1.300
	(4.37)	*(–0.77)*	*(0.99)*	*(2.12)*	*(0.43)*	*(–0.38)*	*(2.19)*	*(0.38)*
Initial government size	–0.127*	–0.024	–0.027	0.021	0.114**	–0.020	0.020	0.101*
	(–2.86)	*(–0.40)*	*(–0.85)*	*(0.58)*	*(2.25)*	*(–0.72)*	*(0.57)*	*(1.96)*
Initial trade openness	0.012*	0.016	0.010**	0.014***	0.001	0.008	0.004	–0.0002
	(3.93)	*(1.39)*	*(2.18)*	*(3.04)*	*(0.21)*	*(1.43)*	*(0.81)*	*(–0.04)*
Terms of trade growth	0.039	–0.036	–0.192	–0.189*	0.071	–0.195	–0.124	0.049
	(0.54)	*(–0.20)*	*(–1.13)*	*(–1.97)*	*(0.78)*	*(–1.31)*	*(–1.60)*	*(0.61)*
Banking crisis			–0.428	–0.728	0.061	0.082	–0.825	–0.044
			(–1.26)	*(–1.33)*	*(0.11)*	*(0.22)*	*(–1.60)*	*(–0.08)*
Initial government debt	–0.020**	–0.009	–0.018***	–0.029***	–0.020			
	(–4.49)	*(–1.07)*	*(–3.29)*	*(–3.73)*	*(–1.65)*			
Government debt, average						–0.021**	–0.022**	–0.018*
						(–2.21)	*(–2.68)*	*(–1.83)*
Number of observations	10	20	30	37	44	42	46	46
R^2	0.99	0.60	0.85	0.67	0.63	0.53	0.51	0.62

Note: Heteroskedasticity-consistent t-statistics are in parentheses. Levels of significance: *** 1%, ** 5%, * 10%. An intercept term and dummies for OECD, Asia, Latin America, and Sub-Saharan Africa are included in each regression, except for column (1) in which the number of observations is small relative to the number of covariates (not reported to save space).

Table 12

Growth Accounting and Cross-Country Growth Regression: Advanced and Emerging Economies
(without restriction on population size)

Explanatory Variables	(1) OLS 1990-2008	(2) OLS 1995-2008	(3) OLS 1990-2008	(4) OLS 1995-2008	(5) OLS 1990-2008	(6) OLS 1995-2008	(7) OLS 1990-2008	(8) OLS 1995-2008	(9) OLS 1990-2008	(10) OLS 1995-2008	(11) OLS 1990-2008	(12) OLS 1995-2008
	dependent variable: growth of real output per worker				*dependent variable: growth of TFP*				*dependent variable: growth of capital stock per worker*			
Initial real GDP per capita	–2.278***	–1.490**	–1.219	–1.033	–1.810***	–1.070**	–1.276**	–1.001***	–1.438*	–1.080	–0.041	–0.119
	(–4.35)	*(–2.19)*	*(–1.44)*	*(–1.68)*	*(–5.14)*	*(–2.57)*	*(–2.52)*	*(–2.87)*	*(–1.89)*	*(–1.21)*	*(–0.04)*	*(–0.16)*
Initial years of schooling	2.653***	3.076**	1.692	2.620**	2.972***	2.810***	2.352***	2.790***	1.350	2.387	0.004	1.300
	(2.90)	*(2.10)*	*(1.40)*	*(2.17)*	*(4.37)*	*(3.04)*	*(3.12)*	*(3.79)*	*(0.86)*	*(1.24)*	*(0.00)*	*(0.85)*
Initial inflation rate	0.739*	11.195**	0.079	3.680*	0.762**	7.907***	0.239	2.529**	0.029	8.876	–0.440	2.710
	(1.89)	*(2.54)*	*(0.33)*	*(1.91)*	*(2.84)*	*(3.08)*	*(1.41)*	*(2.04)*	*(0.05)*	*(1.23)*	*(–1.39)*	*(0.98)*
Initial government size	–0.030	0.038	–0.033	0.015	–0.026	0.038*	–0.026	0.019	–0.037	0.006	–0.038	–0.012
	(–0.87)	*(1.10)*	*(–1.01)*	*(0.40)*	*(–1.51)*	*(1.86)*	*(–1.24)*	*(0.84)*	*(–0.68)*	*(0.13)*	*(–0.99)*	*(–0.25)*
Initial trade openness	0.010**	0.013**	0.007	0.002	0.011***	0.011***	0.009**	0.005	–0.002	0.004	–0.006	–0.008
	(2.35)	*(2.64)*	*(1.14)*	*(0.35)*	*(3.47)*	*(4.05)*	*(2.30)*	*(1.54)*	*(–0.32)*	*(0.60)*	*(–0.94)*	*(–1.27)*
Terms of trade growth	–0.063	–0.187*	–0.089	–0.171**	–0.054	–0.165**	–0.031	–0.138**	–0.082	–0.071	–0.176	–0.098
	(–0.43)	*(–1.80)*	*(–0.64)*	*(–2.29)*	*(–0.59)*	*(–2.64)*	*(–0.38)*	*(–2.66)*	*(–0.33)*	*(–0.44)*	*(–1.07)*	*(–1.00)*
Banking crisis	–0.014	–0.628	0.432	–0.837	0.030	–0.467	0.372	–0.299	–0.345	–0.204	0.092	–1.295*
	(–0.04)	*(–1.01)*	*(1.15)*	*(–1.55)*	*(0.14)*	*(–1.28)*	*(1.59)*	*(–0.93)*	*(–0.62)*	*(–0.23)*	*(0.18)*	*(–1.75)*
Initial government debt	–0.021***	–0.029***			–0.012***	–0.018***			–0.020*	–0.027*		
	(–3.33)	*(–2.86)*			*(–3.93)*	*(–3.21)*			*(–1.77)*	*(–1.80)*		
Government debt, average			–0.020**	–0.017**			–0.010	–0.008			–0.026**	–0.026**
			(–2.08)	*(–2.20)*			*(–1.68)*	*(–1.68)*			*(–2.33)*	(–2.69)
Number of observations	30	36	44	45	30	36	44	45	30	36	44	45
R^2	0.85	0.64	0.48	0.46	0.87	0.69	0.56	0.51	0.65	0.42	0.45	0.38

Note: Heteroskedasticity-consistent t-statistics are in parentheses. Levels of significance: *** 1%, ** 5%, * 10%. An intercept term and dummies for OECD, Asia, Latin America, and Sub-Saharan Africa are included in each regression (not reported to save space).

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