Financial depth, debt, and growth

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Abstract

This thesis applies several econometric methods to a selection of country panels to study how growth is influenced by financial development and government debt. The first part presents the thesis discussion, including a synthesis on financial development, government debt, money supply, and economic growth. The second part deepens the discussion with three stand-alone essays.

The first essay models how financial development affects growth through utilization of technological innovation. Based on explicit modeling of the innovation channel of finance, the results show a significant and positive sign for the interaction term between the measure of a country's own innovation and financial development in the most important specifications. This suggests that the innovation channel of finance is likely to be positively relevant to growth.

The second essay examines effects of venture capital investment on economic growth in a similar framework. The findings demonstrate that the interaction of venture capital with innovation has a positive and statistically significant coefficient. Further, the joint impact related to venture capital and its interactions is positive in most specifications, suggesting that venture capital is probably a relevant factor for growth.

The third essay delves deeply in the effects of general government debt and general government external debt on growth of real GDP. It explores the long-standing endogeneity problem, includes other relevant debt concepts besides government total debt, revisits the issue whether there are threshold values for the government debt ratio, examines the effect of debt on GDP components and structure, uses timely and extensive datasets and extensive robustness analysis, and runs meta-regressions of the results of this and a many of other studies. Even with correction for endogeneity, the study finds modest evidence of a negative and significant growth impact for government debt. The evidence is not robust over all samples and specifications. The final essay also reports evidence of a negative and significant effect of government external debt in the sample of developed economies. The findings overall comport with those of recent papers that conclude that there is no universal threshold value for a government debt ratio that would hold across all countries. Further, government debt appears to decrease the private-investment-to-GDP ratio, but increases the GDP ratio for household consumption. The meta-regression analysis shows that the study's results on how specification features affect the estimate of the government debt coefficient are broadly in line with those of other studies.

Key words: economic growth, endogenous growth, financial depth, financial development, government debt, growth empirics, technological innovation, venture capital

JEL Codes: E44, G10, G20, G24, O16, O30, O40, O47, H63

Tiivistelmä

Soveltamalla eri ekonometrisia menetelmiä joukkoon maapaneeleita tässä väitöskirjassa selvitetään, miten rahoitusmarkkinoiden kehittyneisyys ja julkinen velka vaikuttavat talouskasvuun. Teoksen alun yleisosa sisältää myös synteesin rahoitusmarkkinoiden kehittyneisyydestä, julkisesta velasta, rahamäärästä ja talouskasvusta. Väitöskirjan jälkiosassa syvennetään pohdintaa kolmessa erillisessä esseessä.

Ensimmäisessä esseessä mallinnetaan, kuinka rahoitusmarkkinoiden kehittyneisyys vaikuttaa kasvuun teknisten innovaatioiden paremman tai tehokkaamman hyödyntämisen välityksellä. Tulosten kannalta keskeistä on rahoituksen innovaatiokanavan eksplisiittinen mallintaminen. Omien innovaatioiden ja rahoitusmarkkinoiden kehittyneisyyden välinen ristitermi on etumerkiltään positiivinen ja tilastollisesti merkitsevä tärkeimmissä estimointituloksissa. Tämä viittaa siihen, että rahoituksen innovaatiokanava todennäköisesti myötävaikuttaa kasvuun.

Toisessa esseessä tutkitaan ns. venture capital -sijoitusten vaikutusta talouskasvuun käyttämällä samaa viitekehystä. Venture capitalin ja innovaatioiden välinen ristitermi on etumerkiltään positiivinen ja tilastollisesti merkitsevä. Lisäksi venture capitalin ja sen ristitermien yhteisvaikutus on positiivinen useimmissa estimointituloksissa. Tämä viittaa siihen, että venture capitalilla todennäköisesti on merkitystä kasvun kannalta.

Kolmannessa esseessä analysoidaan syvällisesti julkisen velan ja ulkoisen julkisen velan vaikutusta reaalisen BKT:n kasvuvauhtiin. Esseen pääanti on endogeenisuusongelman perusteellisessa käsittelyssä, muunkin kuin julkisen kokonaisvelan huomioonotossa, mahdollisten julkisen velan kynnysarvojen etsimisessä vielä kerran, BKT:n osatekijöihin ja rakenteeseen kohdistuvien velan vaikutusten tutkimisessa, ajantasaisen ja laajan datan sekä monipuolisten robustisuustestien käytössä ja tämän sekä monien muiden tutkimusten tulosten käsittelyssä metaregressioiden avulla. Myös ottamalla endogeenisuusongelma huomioon etumerkiltään negatiivisesta ja tilastollisesti merkitsevästä julkisen velan kasvuvaikutuksesta on jonkin verran näyttöä, joskaan tämä näyttö ei säily kaikissa otoksissa ja estimoinneissa. Ulkoisen julkisen velan etumerkiltään negatiivisesta ja tilastollisesti merkitsevästä vaikutuksesta on niin ikään näyttöä kehittyneissä maissa. Tutkimus näyttää olevan sopusoinnussa niiden viimeaikaisten tutkimustulosten kanssa, joiden mukaan julkisella velkasuhteella ei ole samaa kynnysarvoa kaikkien maiden kannalta. Lisäksi julkinen velka näyttää pienentävän yksityisten investointien mutta kasvattavan yksityisen kulutuksen BKT-suhdetta. Metaregressioiden perusteella

tutkimuksen tulokset ovat suunnilleen muiden tutkimusten mukaisia siinä, miten estimointien eri piirteet vaikuttavat julkisen velan kertoimen estimaattiin.

Asiasanat: kasvuteoria, endogeeninen kasvuteoria, rahoitusmarkkinoiden syvyys, rahoitusmarkkinoiden kehittyneisyys, julkinen velka, kasvuteorian empiirinen tutkimus, tekniset innovaatiot, venture capital

JEL-luokittelu: E44, G10, G20, G24, O16, O30, O40, O47, H63

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Helsinki, May 2, 2017
Pasi Ikonen

Contents

Introduction

Enhancing economic growth is a central objective of economic and structural policies in many countries. While financial development has widely been considered an essential element in this process, more nuanced views have gained credence in the wake of the recent global financial crisis. The mainstream view is that mobilizing savings and allocating investment needs to be a function performed by open, voluntary, decentralized, and competitive private-sector capital markets operating at market interest rates (e.g. McKinnon, 1991; and Wachtel, 2003). Financial development is a shorthand for financial *system* development, with functional performance of financial markets and institutions the main criterion for degree of development.

Levine (1997) suggests that there are two possible channels to economic growth from functions performed by the systems of finance: *investment* and *technological progress*. If financial markets and intermediaries make efficiency gains it may boost economic growth overall by increasing the investment rate or rate of technological innovation in otherwise steady-state conditions.

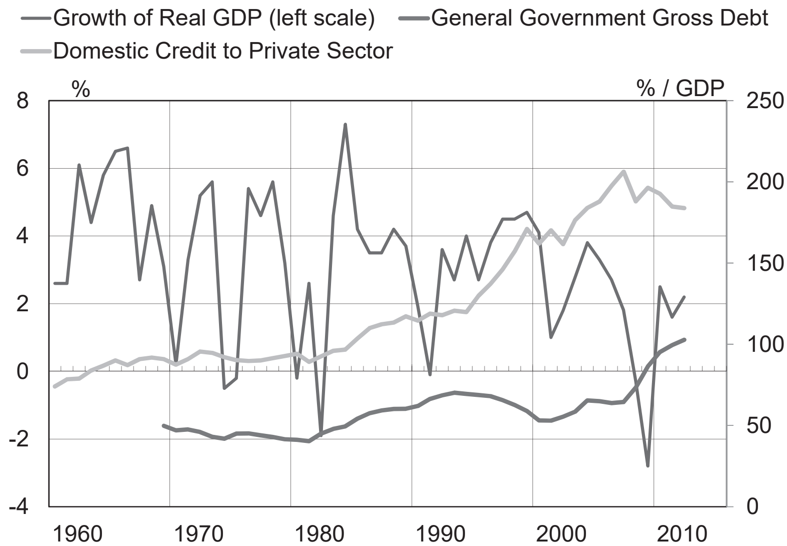
The hypothesis that financial development positively influences growth can be examined from several perspectives. Among these is financial depth,[1] which is often gauged by the ratio of private debt to gross domestic product (GDP). The positive effects of finance on growth have been addressed extensively in the empirical literature.

While financial development *per se* is considered beneficial for growth, high government debt is usually seen as detrimental for growth.[2] The classical view is that government debt crowds out productive private investment, i.e. reduces the amount of resources available for increasing growth. The hypothesis that growth is negatively affected by government debt has been a focus of research in recent years, partly in response to the ballooning public-sector debt seen in many advanced economies since the global financial crisis. To be fair, the rising debt phenomenon is nothing new and afflicts the private sector as well. Figure 1 presents historical development of public and private debt relative to gross domestic product in the US, as well as growth of real gross domestic product. We see that public and private debt have both risen steadily since the early 1980s. When the growth of

[1] The World Bank (2013) lists four financial system characteristics measuring the functioning of financial systems: depth, access, efficiency, and stability.
[2] In the short-run, fiscal deficits and rising government debt can be a rational instrument of counter-cyclical fiscal policy in recessions to stimulate aggregate demand.

public debt flattens or declines slightly, there is a commensurate acceleration in the growth of private debt, and vice versa.

Figure 1. **Debt and growth of real GDP in the US**



Sources: World Bank WDI, European Commission, BEA and Macrobond.

This thesis deals with the interplay of government debt and financial development with growth. The fourth chapter expands the discussion of financial development, government debt, money supply, and economic growth into a broader context.

Following presentation of the thesis, I include three stand-alone essays.

The first essay models how financial development affects growth through utilization of technological innovations. It includes explicit econometric modeling of the innovation channel of finance. Understanding this channel becomes increasingly relevant as countries approach the technological frontier, where their own innovation becomes critical to sustaining growth. Adequate financial development is needed to take advantage of a country's own ability to innovate for economic growth.

The second essay examines effects of venture capital investment on economic growth. With respect to other research examining how growth is affected by finance, its main contribution is in assessment of the impacts of venture capital on growth. Venture capital may be thought of either as a measure of financial development in general or can be studied for its own specific effects on growth.

The third essay analyzes the effect of general government debt and general government external debt on growth of real GDP on a large dataset. It contributes to the existing literature by addressing the endogeneity problem, and examining relevant concepts of debt other than government total debt. I revisit the issue of whether there is a threshold value for the government debt ratio and examine the effect of debt on GDP components and structure. Meta-regressions of the results and recent studies are included (see Stanley and Jarrell, 1989).

The thesis is structured as follows. The first chapter gives a short overview of growth theories. The second chapter discusses the theoretical background, augmented with an overview of previous empirical studies on how growth is affected by financial development. The third chapter goes through the theoretical considerations and previous studies on the effect of government debt on growth. The fourth chapter showcases the above-mentioned synthesis of financial development, government debt, money supply, and economic growth. The fifth chapter addresses methodological issues encountered. The final three chapters are the stand-alone essays.

1 On growth theories

In general, growth theories can be broken down into neoclassical exogenous growth theories and endogenous growth theories. The key distinction is that technological progress is assumed to be exogenous under the neoclassical view. Solow (1956) and Swan (1956) are generally credited with creating the basic neoclassical growth model. Building on the work of Ramsey (1928), Koopmans (1965) and Cass (1965) endogenized the savings rate into the classical model. Human capital was later used to augment the Solow-Swan model by Mankiw, Romer, and Weil (1992). The Solow-Swan model has little value here as it assumes items relevant to the discussion to be fixed.

Aghion and Howitt (2005) categorize endogenous growth theories around *the AK paradigm, the product-variety paradigm* of Romer (1990), and the *Schumpeterian paradigm* of Aghion and Howitt (1992). The discussion below follows the approach of Aghion and Howitt (2005).

The neoclassical AK model resembles the Solow-Swan model, but excludes diminishing returns. Simply stated, the product of capital stock and a constant determines aggregate output:

$$Y_t=AK_t, \tag{1}$$

where Y_t denotes output and K_t stock of capital at time t. A is a constant. The savings rate regulates the capital growth rate that determines the output growth rate.

Under the product-variety paradigm of Romer (1990), aggregate output is expressed in terms of

$$Y_t=N_t^{1-\alpha}K_t^{\alpha} \tag{2}$$

where the degree of intermediate product variety at time t is marked by N_t. K_t denotes aggregate stock of capital at time t and $0 < \alpha < 1$. The output-per capita growth rate over the long term is determined by the growth rate of N_t, which stands for labor-augmenting productivity. Here, the positive relationship between productivity and product array is explained by the notion that the stock of capital is allocated to additional purposes because of greater product variety. Returns on individual purposes, however, diminish.

Schumpeterian theory (Aghion and Howitt, 1992) specifies output for individual industries:

$$Y_{it}=A_{it}^{1-\alpha}K_{it}^{\alpha} \quad (3)$$

in which Y_{it} denotes industry-specific output in industry i at time t, the sum of which is aggregate output at time t. One unit of capital produces a unit of an industry-specific intermediate product K_{it}, which is utilized at time t in industry i. Newest technology employed during time t at the level of industry i defines labor-augmenting productivity marked by A_{it}. As in the model of Romer (1990), $0 < \alpha < 1$. The latest innovator produces and sells her intermediate product for industry i. She displaces the preceding innovator because her innovation increases productivity, which facilitates a monopoly for her intermediate product with respect to industry i. Under this process of "creative destruction," growth is determined by the rate at which existing companies are displaced by new ones. Calculating aggregate productivity merely involves summing industry-wide productivities. A Cobb-Douglas production function by worker is used and each industry is assumed to have identical characteristics such that

$$Y_{t}=A_{t}^{1-\alpha}K_{t}^{\alpha} \quad (4)$$

In this paradigm, productivity growth determines economic growth in the long-term, which is consistent with Solow-Swan model. However, any productivity increase is now endogenous to the innovation rate.

The work of Aghion and Howitt (1992) has been followed by many spin-off studies, including Aghion and Howitt (1998), a hybrid of neoclassical and Schumpeterian growth models, as well as the multi-country model of endogenous growth presented in Aghion, Howitt, and Mayer-Foulkes (2005), which accommodates incomplete protection of creditors.

2 Effect of finance on economic growth

2.1 How financial development affects growth

Financial markets and institutions exist to provide solutions to frictions related to transactions and information. Drawing on the presentation of Levine (1997), financial arrangements, intermediaries, and markets emerge because of specific transaction and information costs and their combinations. These underlie the mechanisms that transmit financial development to growth. He specifically mentions the argument of Merton and Bodie (1995) that assisting in resource allocation under uncertainty in time and space is the most important function of financial systems.

Broadly building on the ideas of Schumpeter (1911), Levine (1997) decomposes the principal function of financial systems into five categories: *reduction and management of risk, informed resource allocation, exerting corporate control and monitoring managers, mobilizing savings, and assisting in exchanges*. More recently, the World Bank has characterized financial development as quality amelioration of these basic functions (World Bank, 2013). Levine's (1997) argument can be summarized as follows:

Reduction and management of risk. There are many benefits that financial systems provide in reducing and managing risk. Stock markets decrease liquidity risk by facilitating trade. Illiquid high-return projects attract investment when stock market transaction costs decline. Healthy stock market liquidity generates higher steady-state growth when illiquid projects produce substantial externalities. Banks lower liquidity risk and boost investment in illiquid high-return assets. Banks, mutual funds, and securities markets provide mechanisms for trading, pooling, and diversifying risk. Risk diversification services offered by the financial system shift resource allocation and saving rates, and thus benefit long-term economic growth. Investors can hold diversified portfolios with multiple projects, thereby reducing risks and enhancing the ability of firms to pursue growth-generating innovative business projects. Financial systems generally facilitate growth and technological progress by allowing risk diversification.

Gathering investment information and allocating resources. The capacity for gathering and processing information is important for growth. Informed decisions result in better capital allocation that allows higher economic growth, i.e. systems of finance are effective at allocating capital to the best-managed firms with the most potential. Financial intermediaries can accelerate technological progress by identifying superior production technologies and entrepreneurs with the best likelihood of success in introducing new goods or production processes.

For an agent with an asymmetric information advantage, it may be worthwhile to use private information to make money in bigger and more liquid markets. Conversely, large, liquid stock markets create incentives for gathering information. Resource allocation may also be significantly enhanced by better information on companies, which is beneficial for economic growth.

Monitoring managers and imposing corporate control. Barriers to efficient investment are lowered by financial contracts that automatically reduce outlays for their implementation and monitoring. Use of collateral has similar effects. Financial institutions can reduce their monitoring costs through asset diversification, and thereby improve the efficiency of investments. A sophisticated stock market makes takeovers of ill-managed firms simpler, and thereby fosters better corporate control. Financial arrangements can improve corporate control. This makes the allocation of capital more effective in ways that generate higher rates of capital accumulation and higher long-term growth.

Mobilizing savings. Economic growth can be boosted by financial systems that effectively pool the savings of individuals and redeploy them to growth-generating projects. As savings are gathered, the capital stock rises. Putting in motion savings boosts allocation of resources, technological innovation, as well as economic growth.

Facilitating exchange. Specialization, technological innovation, and growth can be fostered by financial arrangements that reduce transaction costs. Specialization is usually accompanied with an increase in the volume of transactions. Financial arrangements reducing transaction costs can deepen specialization. Better facilitation of exchanges by markets may also raise productivity.

Levine (1997) notes two possible channels from finance to growth: *investment* and *technological progress.*

Investment. This applies for growth models (Rebelo, 1991; Lucas, 1988; and Romer, 1986) that create growth in steady-state utilizing either capital produced by employing renewable inputs in a production function returning constantly to scale, or external effects caused by investments. Aghion and Howitt (2005) refer to this set of endogenous growth models as the *AK paradigm*. Levine (1997) observes that this paradigm posits that steady-state economic growth can be modified via financial markets and intermediaries by adjusting the investment rate. He suggests two ways that finance affects investment. Savings can be allocated to more efficient capital-producing technologies or the savings rate can be modified.

Technological progress. Some models of growth (Aghion and Howitt, 1992; and Romer, 1990) focus on product innovation and production techniques. According to Aghion and Howitt (2005), this set of endogenous growth models embrace the two other paradigms of endogenous growth theories, i.e. the *product-variety paradigm* of Romer (1990) and the *Schumpeterian paradigm* of Aghion and Howitt (1992). Levine (1997) observes that both paradigms posit that steady-state economic growth can be modified via financial markets and intermediaries by adjusting the rate of technological innovation.

In principle, one could make the exogenous rate of technological progress dependent on financial development in growth models that are neoclassical so that they could be used in examining how finance affects growth. Such a growth model would not be categorized as neoclassical, however, as the long-term growth rate would be endogenous.

King and Levine (1993b) authored the seminal work on explicitly embedding financial development into a growth framework. In their model, the financial system assesses entrepreneur candidates, mobilizes savings to finance the most potential innovative projects that improve productivity, diversifies risks related to these projects, and reveals the expected profits from innovation compared to production of existing goods with existing methods. From this, it follows that enhanced systems of finance foster growth by increasing the likelihood of innovation success. Conversely, distortion of the financial sector may hamper economic growth by slowing the pace of innovation.

Aghion, Howitt, and Mayer-Foulkes (2005) present a multi-country growth model of endogenous growth that accommodates incomplete protection of creditors. In their model, a successful innovator becomes the incumbent and enjoys monopoly profits in innovating industries. As the most recent incumbent has lost her position, profits in non-innovating sectors are driven down to zero under perfect competition. Innovation requires investment, and for that the entrepreneur must borrow. By paying an outlay, the entrepreneur may cheat by masking a profitable innovation from those who provided the credit. As well-functioning institutions and an efficient judicial system increase the cost of cheating, this cost can be considered a measure of the degree of protection that creditors enjoy. The maximum amount the entrepreneur can borrow is positively dependent on this cost and its magnitude represents financial development in the model. Thus, it is more probable under conditions of lower financial development that innovating companies face constraints in terms of loans. This indicates that finance affects growth by enhancing possibilities for technological innovation, which leads to higher total factor productivity.

The model of Erosa and Hidalgo Cabrillana (2008) also embeds financial development. It is based on a general equilibrium (GE) model with multiple sectors in which the enforceability of contracts is a proxy for financial development. Adoption of inferior technology reflects weak contract enforcement. The authors argue that weak contract enforcement allows entrepreneurs to escape consequences of masking lucrative innovations from creditors. Moreover, prices in equilibrium make the adoption of inferior technology worthwhile. When lax contract enforcement inhibits production in a particular sector, productivity shifts to other sectors. Thus, productivity is highest in industries where contract enforcement is critical, i.e. sectors dependent on outside financing. A hurdle erected by weak enforcement hinders the mobilization of resources to sectors with stronger productivity, and their share of employment is reduced in comparison to perfect enforcement. Low enforcement creates incentives for entrepreneurs to maintain the prevailing status quo as they benefit from capital-market imperfections that, at equilibrium, raise prices of finished goods and lower wages. The ultimate result is low aggregate total factor productivity.

The study of Greenwood, Sanchez, and Wang (2010) plays off the costly state verification model of Townsend (1979). They construct a general equilibrium model that embeds costly state verification into a standard neoclassical growth framework. In their model, firms have incentive to cheat banks or other financial intermediaries by reporting a low state for a financed project rather than the true high state because payments to banks are higher in the high state. Banks are limited in their ability to ferret out cheaters as they must expend costly resources on monitoring. Thus, banks prefer to audit the report submitted by the firm. The high monitoring costs reflect informational frictions that lead to a distortion (spread) between interest on savings and the expected marginal product of capital. Technological progress in the financial sector makes monitoring cheaper and more efficient, thereby decreasing the spread. This leads to an increase in the economy's aggregate income: there is greater overall capital accumulation, capital is redirected toward the most productive investment opportunities, and resources for other economic activities are freed up as less labor is required to audit loans.

The effect of finance on growth has been extensively addressed empirically. Such studies as King and Levine (1993a and 1993b)

Table 1. **Summary of findings and financial development indicators in previous studies**

	King and Levine (1993)	Levine (1997)	Rajan and Zingales (1998)	Rousseau and Wachtel (2005)	Rousseau and Wachtel (2000)	Beck, Levine and Loayza (2000)	Demirgüc-Kunt and Maksimovic (1998)	Levine and Zervos (1998)	La Porta et al. (1998)	Aghion, Howitt, and Mayer-Foulkes (2005)
Support found for finance-growth nexus (+ clear support, +/- conflicting evidence, – clearly no support)	+	+	NA	+/-	+	+	+	+	NA	+
Financial development indicators										
Liquid liabilities (M3) to GDP	x	x		x	x	x				x
Deposit money bank domestic credit / sum of deposit money bank and central bank domestic credit	x	x				x				x
Claims on non-financial private sector / domestic credit	x	x								
Gross claims on private sector / GDP	x	x								
Value of domestic equities traded on domestic exchanges / market capitalization		x					x	x		
Value of domestic equities traded on domestic exchanges / GDP		x			x			x		
Ratio of deposits to GDP			x							
Ratio of equity issues by domestic corporations to gross fixed capital formation			x							
Stock market capitalization to GDP			x		x		x	x		
Number of listed companies per million people			x							
Sum of equity and bond issues by domestic firms to GDP			x							
Quasi-liquid liabilities (M3–M1) to GDP				x						
Private sector credit to GDP				x		x				x
Domestic assets of deposit banks / GDP							x			x
Measure of stock return volatility								x		
Bank credit to private sector / GDP								x		

	King and Levine (1993)	Levine (1997)	Rajan and Zingales (1998)	Rousseau and Wachtel (2005)	Rousseau and Wachtel (2000)	Beck, Levine and Loayza (2000)	Demirgüc-Kunt and Maksimovic (1998)	Levine and Zervos (1998)	La Porta et al. (1998)	Aghion, Howitt, and Mayer-Foulkes (2005)
APT measure of stock market integration								x		
CAPM measure of stock market integration								x		
Legal origin									x	
One share – one vote									x	
Anti-director rights									x	
Mandatory dividend									x	
Creditor rights									x	
Legal reserve required									x	
Judicial system efficiency									x	
Rule of law									x	
Corruption									x	
Expropriation risk									x	
Cancellation of contracts (by government)									x	
Accounting standards									x	
Ownership by 3 largest shareholders, 10 largest private firms									x	

support the hypothesis of a positive effect of finance on growth. The results of several studies are summarized in Table 1. Although these results helped in the mainstream embrace of the finance-growth nexus, I would note that there are numerous studies that provide contradictory evidence or do not support the hypothesis that growth is positively affected by financial development (e.g. Capelle-Blancard and Labonne, 2011; Rousseau and Wachtel, 2005).

Table 1 shows the various indicators for financial development used in previous studies. The indicators typically describe financial depth, which is often measured by private credit to GDP, a widely available indicator.[3] Since these financial intermediation variables are only correlated with financial development, however, it may be argued that they are not *optimal* indicators.

True, financial development (i.e. better-functioning financial institutions, markets, and policies) increases financial depth. Moreover, the focus on private sector borrowing should provide a measure of financial depth that captures efficiently allocated credit. In such case, financial development should correlate with higher levels of financial depth.

On the other hand, the ratio of domestic credit to private sector to GDP (private credit to GDP) may reflect something other than the quality of policies or institutions. Private credit to GDP is also an indicator of private indebtedness (private debt to GDP), which is a drag on growth. Kukk (2016) finds evidence of the importance of the debt service ratio as a channel through which household indebtedness influences consumption, and thereby growth. An intuitive explanation is that indebted consumers must reduce their consumption spending to service their debts. This, in turn, contributes to weaker aggregate demand as debt repayments to banks cause corresponding destruction of money and nobody is allocated additional resources. The same logic applies to indebted companies, which must cut their spending (including investment) and dividends to service debt. Juselius and Drehmann (2015) find that the aggregate debt service burden is a significant drag on credit and expenditure growth.

In other words, private credit to GDP seems to capture two aspects of growth: *the negative impact of excessive private indebtedness and the positive impact of financial development*.

This dual-capture feature may explain the results of Deidda and Fattouh (2001), and Arcand, Berkes, and Panizza (2011), who find

[3] Another commonly used measure is M3 to GDP. Stock market capitalization or turnover related indicators utilized in some studies are not considered here since they tend to be quite volatile and influenced by market sentiment.

threshold effects for private debt. It could also be behind the results of Rioja and Valev (2004), who divide the countries in their sample into three regions based on the level of private credit to show how the impact of private credit on growth differs across regions. In light of the recent financial crisis, a further problem with the private-credit-to-GDP ratio as a measure may be that bankers eventually forget the lessons of previous economic downturns, become more risk-loving, and grant credit to less creditworthy customers. This behavior triggers excessive growth of private credit to GDP and eventually the inevitable credit losses, financial system crash, and possible economic depression.[4] Schularick and Taylor (2012) show that financial crises are preceded by strong private credit growth, i.e. financial crises are caused by credit booms gone wrong. Using M3 to GDP instead would not help as it is strongly correlated with private credit to GDP. These two metrics should be closely related as private credit constitutes an important counterpart for M3 in consolidated balance sheets of monetary financial institutions (MFIs).

In my first stand-alone essay,[5] the empirical model implied by Aghion, Howitt, and Mayer-Foulkes (2005) is extended. The objective is to study whether financial development affects growth through better or more efficient utilization of technological innovations. A developed financial system would ease credit constraints of firms needing finance to implement technological innovations in their production process or commercialize technological innovations. This would lead to higher total factor productivity. The main feature of the discussion is econometric modeling of the innovation channel of finance that includes an interaction term between the measure of own innovation and financial development.

I preview several intuitions for possible formal extension of the theoretical specification of Aghion, Howitt, and Mayer-Foulkes (2005) and apply them in the empirical discussion. These intuitions overlay the standard-model assumption that the innovation rate in leader countries determines world technological frontier growth. Technology is diffused to other countries from the frontier as other countries utilize ideas established in the technologically leading countries. This effect is captured by the measure of imitation. However, as countries approach

[4] Cecchetti, Mohanty, and Zampolli (2011) argue that higher debt makes the ability to pay back more sensitive to drops in income or increases in interest rates. When lending stops, the real economy is affected. Thus, higher debt increases volatility and financial fragility, which reduces growth overall. The collapse of the financial system leads to an economic depression.

[5] The current essay has been developed from Ikonen (2010). A longer version of Ikonen (2010) was submitted as a licentiate thesis the same year.

the frontier, own innovation becomes increasingly important in sustaining high growth. Not only are there fewer innovations left to be imitated, but successful own innovations may give domestic companies a competitive edge or monopoly power in other countries. Since growth of companies with extensive foreign operations probably has a disproportionally beneficial impact in their home country compared to the growth effects in foreign countries, own innovation can be even be seen as growth enhancing in this respect. An adequate level of financial development is needed to realize the full potential of own innovation and imitation for economic growth.

The data cover the period 1960–2007 for advanced and emerging economies. Different regression specifications for the data panel are applied in estimation of the model. The robustness of results is tested in several ways. The results show a significant and positive sign for the interaction term between the measure of own innovation and financial development in the most important specifications. This suggests that the innovation channel of finance is likely to be positively relevant to growth.

2.2 Effect of venture capital on growth

Modigliani and Miller (1958) propose that financial structure (choice between debt and equity) has no material effect on the value of the firm or the cost or availability of capital. Taxes, bankruptcy costs, agency costs, or asymmetrical information alter this result.[6]

Although activities of banks reduce agency costs and information asymmetries, however, this may not be sufficient for technologically innovative start-ups or small firms where human capital is the main asset. Such firm characteristics are likely to create large information asymmetries and agency costs. Under these circumstances, venture capital (VC) could play a crucial role in financing small firms – a role that banks cannot perform. The relationship between entrepreneur and venture capitalist is essential as it affects the structure of venture financing (Hasan and Wang, 2008).

There is a large body of literature on how venture capital reduces agency problems through e.g. intensive monitoring, phased investment, and effective control mechanisms that lower capital constraints. Notable studies include Sahlman (1990), Admati and Pfleiderer (1994), Gompers (1995), Neher (1999), Hamilton (2000), Moskowitz and

[6] For a survey of research on capital structure, see Myers (2000).

Vissing-Jorgensen (2002), Kaplan and Stromberg (2001, 2003, and 2004), Gompers and Lerner (2004), as well as Kaplan et al. (2009). Hellman and Puri (2002) find that venture capitalists also participate in managerial services, adopting schemes for stock options, HR policy planning, communication proficiency, strategy planning, etc.

Venture capital necessarily focuses on small and innovative growth companies, and thereby may have an independent role in enhancing total factor productivity. Samila and Sorenson (2011) mention three factors as possible mechanisms through which venture capital can affect economic growth: selection and substitution of companies, positive expectation of success on the part of potential entrepreneurs (demonstration effect), and facilitation of spin-offs (training effect). Additionally, fierce competition from small innovative companies may provoke incumbent corporations to innovate themselves.

The second essay of the thesis considers venture capital as an alternative measure to financial development. The ratio of venture capital investment to GDP is proposed as a measure of financial development that partly overcomes shortcomings that afflict the M3-to-GDP and private-credit-to-GDP measures. Further, analyzing how growth is affected by VC provides insight into the effects of this form of financial intermediation.

This second essay, which uses several methods for cross-sectional and panel-data analysis, examines empirically the effects of VC investment on growth in Europe and the US. It highlights the interaction term between the measure of innovation and venture capital investment. This interaction term consistently shows a positive and statistically significant coefficient. Further, the joint impact related to VC and its interactions is positive in most specifications, suggesting that venture capital is a relevant factor for growth.

3 How government debt affects growth

While financial development is generally considered beneficial for growth, high government debt is seen as detrimental for growth. A classic argument is that government debt leaves less resources for other purposes.

In this vein, Boskin (2012) asserts large general government deficits (i.e. large increases in debt) create two long-term problems: *a crowding-out of private investment and intergenerational appropriation*.[7]

Crowding-out. Public debt crowds out private investment by displacing financial assets issued by the non-government sector in private portfolios. Reduced fixed investment lowers future income.[8,9] This impact is amplified as inadequate investment slows development and dissemination of new technology. Moreover, future taxes must rise to cover the higher interest expenditure caused by larger debt stock if future spending remains high. The resulting higher taxes and uncertainty about future fiscal policy hamper growth. They also increase the probability of higher inflation and a financial crisis, which raises risk premia and interest rates.

Intergenerational appropriation. The dynamic of future generations subsidizing the current generation's consumption has long been recognized (e.g. Modigliani, 1961). Cecchetti, Mohanty, and Zampolli (2011) argue that intertemporal welfare is justified if future generations are wealthier than the current generation. The

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[7] Boskin (2012) notes that large general government deficits (large increases in debt) may be desirable in certain transient situations such as war or recession. In recessions, fiscal deficits and rising government debt are a rational counter-cyclical fiscal policy response to stimulate aggregate demand. In the same spirit, Cecchetti, Mohanty, and Zampolli (2011) argue the government can borrow to smooth taxes over variable expenditures and over generations, much as individuals smooth consumption over variable income and firms smooth investment and production as sales vary. They also argue that government debt provides liquidity services that may ease credit for the private sector.

[8] Whether crowding-out of public investment decreases income to the overall economy depends on how government borrowing is used. If it is used for productive public investment to the same extent that private investors would use it for productive private investment if not investing in government debt, the effect on income of the overall economy is neutral.

[9] Reduced fixed capital formation lowers both capital and labor income as lower capital stock implies lower labor productivity and lower wages. Lower investment abroad leads to diminished foreign capital income. For more, see Elmendorf and Mankiw (1999).

contemporary generation assume the wealth of the future generation will be enhanced through increased human capital and higher-productivity technologies.[10] Unfortunately, this rosy assumption does not comport with the situation in advanced economies today. Baby boomers tend to be richer than their children, suggesting the poor future generations are financing the consumption of the present rich generation.

Boskin (2012) lists three factors that can amplify the damage of large deficits. Deficits do more detriment *during economic expansions* than in recessions as they curtail domestic investment and future income; they hurt creditworthiness more severely if *national debt to GDP is high or rapidly rising*; and when they go to *financing consumption* rather than productive public investments. Ostry, Ghosh, and Espinoza (2015) argue that an indebted economy will rationally choose to invest less in public capital.

When general government debt is held by domestic non-bank investors, there is a crowding-out of private investment by government debt. However, when the government borrows from domestic banks or foreign residents, there is no crowding out of private investment as domestically available resources are not decreased by foreign lending or domestic bank lending. Banks create money in the form of deposits when they grant loans or buy assets. The funds they provide are not distracted from any other use if the expansion of bank balance sheets is consistent with the capital requirements imposed on them (assuming reserve requirements are non-binding).[11] Foreign lending to government does not clearly reduce available domestic resources. In the case of foreign bank lenders, this has virtually no impact on available foreign resources. For foreign non-bank investors, domestically available foreign resources are only a minor issue as they are a tiny fraction of their overall resources (and even this fraction can be covered from resources previously allocated elsewhere).

Although foreign lending to the government has the advantage over domestic non-bank purchases of government debt in not reducing domestically available resources, it also has disadvantages. Tobin (1965) notes that internal and foreign debt are essentially different. Panizza and Presbitero (2014) argue that a higher share of external debt may hamper growth through e.g. transfer of resources to foreigners, reducing the tax base, or raising interest rates due to the impact on refinancing risk and perceived sustainability of debt. General

[10] See also Cukierman and Meltzer, 1989.

[11] In fractional reserve banking, banks are required to hold only a fraction of the amount of their deposit liabilities in reserves (i.e. vault cash and reserves in the central bank).

government debt held by foreign investors generates more losses than government debt held by domestic banks. While there is no crowding-out of private investment in either case, interest payments in the case of foreign investors are transferred to foreigners.[12] Feldstein (2012) maintains that servicing an increased external debt in the future implies an increase in net exports. This, in turn, requires a real depreciation of the currency that raises the cost of imports and reduces real incomes. Further, as recently seen in euro area, high government external debt can make countries vulnerable to sovereign debt crises as international capital flows can be relatively unstable.

On the other hand, domestic investors can be more patient as shown in Japan where no sovereign debt crisis has emerged despite astronomical public debt, because the bulk of this debt is held by domestic residents. According to Reinhart, Reinhart, and Rogoff (2012), external debt levels are difficult to reduce as it is not feasible to inflate foreign currencies or financially repress foreign populations without provoking a backlash.

Government debt can also hamper growth in other ways. Feldstein (2012) argues that while increased interest rate costs are relatively insignificant in the current environment of monetary policy operating close to the zero lower bound,[13] there are other costs generated by government debt. These relate to reduced real investment, increased economic vulnerability, and reduction in the room to maneuver on fiscal policy. Government debt reduces real investment and capital income outside the crowding-out channel even when real interest rates are low (as they are now) and unaffected by additional government borrowing. This is because firms remain worried that the government will raise taxes in the future to cover public deficits.[14]

Feldstein (2012) also notes that economic vulnerability to interest rate shocks increases with higher indebtedness because the rate increase has a bigger impact on interest expenses in absolute terms. This applies to new government debt, the rolled-over government debt stock, private debt, and equity markets. Such shocks are even more likely if there is a lack of confidence in budget controls or increased inflation

[12] Why borrow from abroad to relax the domestic resource constraint when there is a functioning domestic banking system? One reason is that resident banks cannot create money denominated in the foreign currency needed for imports of consumption and investment goods. Another reason is that foreign loans may offer lower interest rates. While this is an unconvincing argument for the overall economy, it may be viable argument an individual borrower, including a government.

[13] DeLong and Summers (2012) maintain that government borrowing is costless if the public debt earns interest that remains lower than real economic growth, i.e. the denominator for the debt-to-GDP ratio increases more rapidly than the numerator.

[14] Distortionary tax increases are likely to have wider effects on growth.

expectations. Reduced fiscal room to maneuver due to high debt makes it more difficult to implement counter-cyclical fiscal policy, spend on national security during acute crises, or bail out troubled banks.

There are also interactions between government debt and private debt. As seen recently in Ireland and Spain, private debt can be partly absorbed into the government balance sheet during major financial crises. Eggertson and Krugman (2012) propose that government can engage in borrowing and spending while private sector balance sheets are repaired. Cecchetti, Mohanty, and Zampolli (2011) counter that the borrowing capacity of governments is limited, arguing that private debt may have to be moved onto the government balance sheet in some cases (e.g. bank bail-outs), hampering the government's fiscal capacity.

Government debt is also integrated in many macroeconomic models. The Solow-Swan growth model predicts that a fiscal deficit or increase in government debt leads temporarily to lower growth on the transition to a new steady state. Aizenman et al. (2007) and Saint-Paul (1992) argue that steady-state per capita GDP growth and public debt are negatively linked. The same relationship prevails in Greiner's (2012) model when the government cuts spending to meet its intertemporal budget constraints. When lump-sum transfers are cut, however, this relationship vanishes.

Greiner (2011) proposes that with no rigidities in the economy and an elastic labor supply, public debt decreases labor supply, investment, and growth. With wage rigidities and unemployment, there is no harmful effect on resource allocation and public debt can boost growth if used for productive investments. Teles and Mussolini (2014) present an endogenous growth model where the government debt level regulates how growth is influenced by fiscal measures. Their beneficial impact diminishes at higher levels. Under pressure created by interest expenditures, some resources by younger generations are extracted by tax authorities. To make it happen, an allocation exchange system across generations is needed, which results in changes in the saving rate. The authors verified the theoretical results with an econometric model. Padoan, Sila, and van den Noord (2012) suggest the existence of a "bad equilibrium" that allows for soaring fiscal deficits, debt, and high risk premia on public debt at the same time economic activity and confidence are decreasing. The "good equilibrium" features stable growth and debt levels, low risk premia, and a healthy economy. Their model suggests that governments can use short-run fiscal consolidation to escape a bad equilibrium. Financial backstops, structural reform, and fiscal consolidation help countries return to a sustainable path. Reviews for studies analyzing how government indebtedness affects growth are provided by Elmendorf and Mankiw (1999) and Panizza and Presbitero (2013).

Several recent empirical studies have analyzed how government debt affects economic growth. In their now-famous study, Reinhart and Rogoff (2010) explore growth and inflation in lengthy time series of public debt ratios for industrialized and developing countries. They demonstrate that median growth tends to be about 1% lower when the debt ratio exceeds 90%, and that the association of growth and debt is insignificant at lower debt levels. While differences in average growth were larger than differences in median growth, government debt threshold values were found to be quite similar for both country groups. Regarding external debt, the authors find thresholds to be lower for emerging economies, where annual growth declines by about 2% when external debt reaches 60% of GDP. Further, they find that growth rates are roughly halved at higher debt levels. Finally, they find no contemporaneous link between inflation and government debt levels in the advanced economy group, while inflation rises significantly as debt increases in the emerging market group. Combining the Reinhart-Rogoff data with other data, Hukkinen and Virén (2013) find further supporting evidence for this inverse relationship of public debt to growth.

Reinhart, Reinhart, and Rogoff (2012) use a long series of multi-country historical data for government indebtedness to explore how prolonged periods of exceptionally high government debt impact long-term economic growth. Defining exceptionally high government debt as government-debt-to-GDP ratios over 90%, they examine 26 public debt overhang events for industrialized countries since the beginning of the 19th century and conclude that they lowered growth by about 1.2% on average. When countries had debt ratios exceeding 90%, their average growth rate was 2.3%. In lower debt periods, growth was 3.5%. The cumulative output loss can be huge given that the average length of the studied debt overhang periods was 23 years. When the median debt overhang period comes to an end, GDP remains almost 25% weaker than in periods with lower debt levels. The authors conclude that the correlation of growth and government debt extends beyond cyclical explanations. They also consider correlation of real interest rates with government debt. Notably, they find that real interest rates were the same or less during eleven of the 26 debt overhang periods than in periods with lower levels of indebtedness. This implies that financial markets do not necessarily punish countries for higher default risk. The results of Reinhart and Rogoff (2010) and Reinhart, Reinhart, and Rogoff (2012) have been criticized by Pollin and Ash (2013), Herndon, Ash and Pollin (2013), and Égert (2013).

Cecchetti, Mohanty, and Zampolli (2011) examine the effect of government, non-financial corporate, and household debt on growth in 18 OECD countries during 1980–2010. Their results indicate that above certain thresholds, debt becomes a drag on growth. The thresholds (GDP ratios) they note are household and public debt at 85% and corporate debt at 90%. Their findings comport with those of Reinhart and Rogoff (2010).

Using a sample of industrialized and developing countries during 1970–2007 and many econometric methods, Kumar and Woo (2010) present evidence that growth can be affected by high government debt levels. Their regression analyses include several control variables considered relevant to growth. They identify methodological issues that might affect results, including reverse causality (low growth results in higher indebtedness) and omitted variables bias. They also consider nonlinearities, differences between advanced and emerging market economies, and threshold effects (whether growth is only affected negatively by debt above a certain threshold). They find that growth is negatively associated with previous-period-end debt. An increase in indebtedness of 10 percentage points on average reduces growth by 0.17 percentage points, but the influence is a bit weaker for industrialized countries as a group. The adverse growth impact seems to be amplified, however, as debt rises. Using a growth accounting framework, they find that the negative impact mostly manifests lower growth of labor productivity caused by smaller investments and more sluggish capital stock growth. The authors perform robustness tests to confirm their results.

There are many other studies of threshold effects or debt turning points that find inverse relations between levels of government debt and growth (or stability).[15] Most relevant to the current discussion are Checherita-Westphal and Rother (2012), Baum, Checherita-Westphal, and Rother (2013), and Salotti and Trecroci (2016).

Kourtellos et al. (2013) find that larger government debt implies weaker growth with small values of a “democracy” indicator. Notably, debt levels have little effect on growth in democratic countries. They note that low-democracy countries have higher public debt levels on average, and argue that their results reinterpret the existing literature. That is, the reason growth in some countries with high debt suffer more is the quality of their institutions, not debt *per se*. Kourtellos et al. (2013) further suggest that a high public debt level may be a proxy for excessive government size (non-productive use of resources).

[15] According to Ghosh et al. (2013), non-linearities may exist on the condition that debt no longer remains sustainable when a limit is exceeded.

The results of Dreger and Reimers (2013) indicate that non-sustainable public debt negatively affects growth in the euro area. In a large set of developed countries, however, this effect diminishes. With sustainable debt, the effect diminishes in the euro area but becomes positive in the larger set of developed economies. Smyth and Hsing (1995), in defining an optimal debt ratio for maximizing growth, conclude that contemporary debt ratios are generally higher than the optimal level.

Panizza and Presbitero (2013, 2014) dispute the existence of threshold effects and other non-linearities of government debt. Panizza and Presbitero (2013) argue that the debt-growth relationship involves cross-country, and possibly even cross-period, heterogeneity. Factors that may affect the relationship include institutional quality, government size, as well as the causes and channels for indebtedness, and the composition of the debt (e.g. share of external debt and average maturity) that may impact refinancing and debt sustainability. They also suggest that monetary frameworks and debt structures influence how much debt an economy can sustain. Panizza and Presbitero (2014) use FX-debt valuation effects due to changes in exchange rates as an instrument to public debt-to-GDP ratio. Without this correction for endogeneity (OLS), they find growth is negatively linked to indebtedness. With this correction, the association of growth with debt vanishes. The sign of the coefficient of government debt even turns positive with IV estimation. Their robustness tests show that results are not a product of weak instrument problems.

Several other recent studies question earlier findings of non-linearities of government debt. Recent econometric methods are engaged by Eberhardt and Presbitero (2013) to allow for country heterogeneity in the association of growth with debt. They find some proof of a nonlinear association over economies, but no universal threshold value for individual economies. Further, Pescatori, Sandri, and Simon (2014) conclude against finding a specific threshold above which government debt seriously hampers growth in the medium run. Their results show that countries with high, but declining, debt grow just as fast as countries with lower debt. Notably, they also find evidence that high debt correlates with high output volatility.

Several studies consider the effect of public debt on investment and physical capital. The results of Kumar and Woo (2010) suggest that public debt negatively affects the ratios of capital per worker and total domestic investment to GDP. Using a sample of 20 countries, Salotti and Trecroci (2016) find that the log of private investments, log of private investments per capita, log of total investments, and log of total investments per capita are all negatively influenced by public debt.

They find no evidence of a threshold effect of public debt with any of these dependent variables. Checherita-Westphal and Rother (2012) examine channels through which growth for euro area economies is affected by public debt. Their findings identify two channels: private savings to GDP and public investment to GDP. The coefficient for private investment to GDP remains insignificant in their study. Finally, the results of Afonso and Jalles (2011) show that the government debt ratio negatively affects private and public investment.

Most of the theoretical and empirical literature on the effects of high levels of total external debt (including private and government debt held by foreign residents) on growth pertains to developing economies. Conceivably, this framework could be used to analyze high levels of external government debt. Most of the discussion below on how growth is affected by external debt is based on Imbs and Rancière (2005).

One possible channel where growth might be negatively affected by high debt is a direct crowding-out effect, i.e. high levels of debt hamper growth by increasing the amount of redemptions due and interest payments that cannot be allocated to investment.

Another possible negative effect of high debt on growth mentioned in economic theory could be based on the debt Laffer curve. On the Laffer curve's "good" left side, rising face value of the debt means a rising expectation of debt repayment. On the curve's "wrong" right side, a rising face value means a reduced likelihood of repayment. (See Pattillo, Poirson, and Ricci, 2002.) The theoretical arguments for the curve's existence can be divided into two broad subsets. One category includes multiple-equilibria-based theories in which anticipating default after some debt level leads to minimizing punishment costs proportional to output by letting investments fall. The other category embraces theoretical considerations in which the present indebtedness level affects the optimum debt contract. As debt levels rise, a creditor with imperfect monitoring technology finds it increasingly difficult (and ultimately impossible) to assess the repayment efforts of the debtor. Consequently, the borrowing economy loses incentives to put into action favorable long-term policies with unpleasant short-term consequences.

The debt Laffer curve is related to the debt overhang theory. In the words of Krugman (1988): "A country has a debt overhang problem when the expected present value of potential future resource transfers is less than its debt." Analysis of debt overhang can also found in Sachs (1989). Pattillo, Poirson, and Ricci (2002) argue the debt overhang model implies that high indebtedness hampers growth by decreasing investment and the efficiency of investment.

Among the studies examining effects of total external debt on growth, Pattillo, Poirson, and Ricci (2002) present evidence that the marginal effect of external debt becomes unfavorable at roughly half of values where the average effect turns unfavorable. The average effect turns negative at a ratio of around 35–40% to GDP or a ratio of 160–170% to exports. Pattillo, Poirson, and Ricci (2004) also assert that growth is adversely affected by high external indebtedness through physical capital accumulation (per capita physical capital) and total factor productivity growth. The results of Cordella, Ricci, and Arranz (2005) point to debt overhang at moderate ratios. Clements, Bhattacharya, and Nguyen (2003) suggest that external debt has an impact on growth after reaching a threshold level, but through efficiency of resource use rather than private investment. Indirect effects through diminished public investment may be significant as funds that might otherwise be used for public investment are needed to pay interest on external debt.

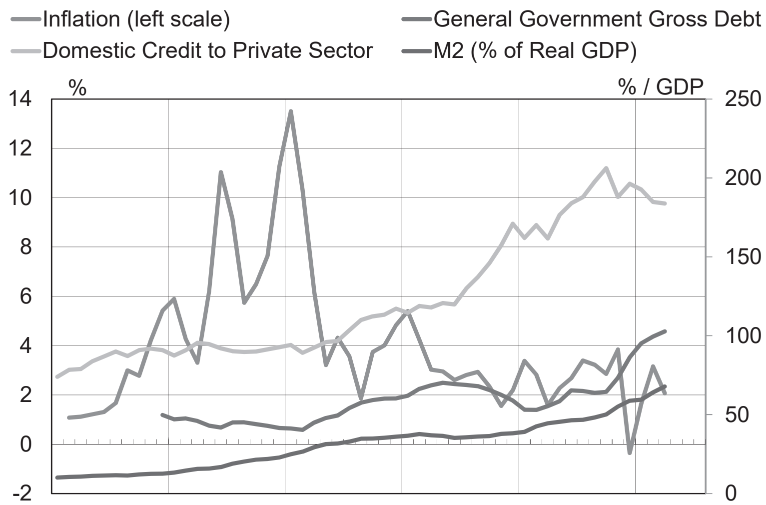
The third stand-alone essay provides an empirical analysis of the effects of general government debt and general government external debt on growth of real GDP. It contributes to the existing literature by addressing the endogeneity problem and including relevant concepts of debt other than government total debt. It revisits the issue of whether there actually are threshold values for the government debt ratio and examines the effect of debt on GDP components and structure. Timely and extensive data, and extensive robustness analysis are employed. Finally, the study uses meta-regression to summarize the results of this and other studies (see Stanley and Jarrell, 1989).

Even with a correction for endogeneity, the study finds some evidence for a negative and significant growth impact for government debt. However, this evidence is not robust over all samples and specifications. It also finds evidence for a negative and significant effect of government external debt in the sample of developed economies. The work confirms results of recent papers suggesting that there seems to be no universal threshold value for a government debt ratio that would hold across countries. Further, government debt appears decrease the GDP ratio of private investment but increase the GDP ratio of household consumption. The results of this and other studies seem to be broadly in line regarding how various features of specifications affect the estimate of the coefficient of government debt.

4 A synthesis of financial development, government debt, money supply, and economic growth

Figure 2 presents historical development in the US of public and private debt to GDP, as well as inflation and money supply. Similar trends are found for most advanced economies. While the rise in government debt gained attention during the political heyday of austerity following the global financial crisis, rising debt has been an issue since the 1980s and hardly limited to the public sector. Indeed, when public or private debt plateaued or declined slightly, the other form of debt tended to increase faster.[16] The period is also characterized by generally low inflation. Notably, when inflation was high in the 1970s, debt ratios were constant or declining.

Figure 2. **Debt, inflation, and money supply in the US**



Sources: World Bank WDI, European Commission, Federal Reserve, BEA and Macrobond.

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[16] There can also be interactions between the different forms of debt as private debt is often partly absorbed in government debt during major financial crises, as recently seen in Ireland.

Figure 2 includes M2 as a percentage share of real GDP.[17] This indicator generally rises, except during the early 1990s. The growth rate is lower from the early 1980s to the early 1990s than in other periods of growth. In the 1970s, the high growth in M2 as percentage share of real GDP is associated with high inflation. Starting in the early 1980s, this ratio appears to be associated with rising debt. Again, during the 1970s, high inflation prevented real debt levels from rising. As such, the close relationship between M2 and debt is trivial as domestic credit to private sector and domestic bank holdings of government debt are important counterparts of M3. The intuition here is that when banks grant loans or buy assets, they simultaneously create money (deposits).

The real question here is why growth of M2 as a share of real GDP that previously generated inflation later produced rising real debt to GDP? The implication is that this must have occurred with a simultaneous increase in the volume of assets, because somebody's debt in principle should match somebody else's assets. The financial system remarkably managed to absorb money supply growth above nominal GDP growth without inflating consumer prices.[18]

Particularly relevant to this discussion is the possibility that the financial system's ability to absorb money supply growth above nominal GDP growth may offer an alternative insight into financial development. The typical indicators of financial development – M3 and private credit to GDP – capture this aspect directly. Both represent accumulated money supply growth exceeding nominal GDP growth (the former directly as the most important measure of money and the latter indirectly as the most important counterpart to M3). The implicit assumption is that financial systems that perform well in this respect are likely to continue doing so. This aspect of financial development could also be considered to include government debt to GDP as a partial indicator as the government debt holdings of domestic banks are a counterpart of M3.

Alternatively, this aspect of financial development could be presented as an ability to absorb real money supply growth above real GDP growth. As indicators are stated relative to GDP, the impact of inflation is automatically eliminated. This interpretation of financial development is distinct from, but partly overlaps with, the interpretation

[17] The Federal Reserve Board of Governors has not published M3 since March 2006 as it was considered to add no information of value to M2 (see Federal Reserve Bank of New York, 2008).

[18] For more on financial assets absorbing money and restricting inflation, see Parsson, 1974. In addition, Cochrane (2011) mentions that government bond issues can soak up excessive money supply.

based on functions of the financial system summarized by Levine (1997), who also mentions an approach focused on money as potential alternative.

Fisher (1911) notes that T in the equation of exchange (MV=PT)[19] stands for volume of trade in goods that comprise all wealth, property, and services.[20] This contrasts with the more usual formulation of the quantity theory of money (MV=PY), where Y stands for aggregate income or output (GDP) that comprises only final goods and services. Here, V is the income velocity of money. This more usual formulation was applied by Milton Friedman as he observed empirically that income velocity was stable in his money demand studies (Friedman, 1959). Another likely reason for the popularity of this formulation is the availability of data. However, as income velocity became unstable in the 1980s in the US,[21] even Friedman (1988) included estimated volume of transactions in his money demand function. For M1, he finds evidence (partly conflicted) on the negative relationship between volume of transactions and income velocity. For M2, he finds no such evidence. The point is that money is needed both for GDP and asset transactions involving the purchase of shares, debt securities, and previously-built real estate.[22] If the financial system creates a large volume of asset transactions in which money is absorbed, the money supply can grow more rapidly without causing inflation. Thus, the growth of the money supply can exceed nominal GDP growth if the volume of asset transactions grows faster than nominal GDP.

The volume of asset transactions depends positively on the number of transactions and asset prices. If these asset transactions are omitted in the equation of exchange, and hence only GDP transactions are inserted, the corresponding income velocity of money must be lower than the overall velocity of money for the equation to hold. Thus, the income velocity of money is negatively correlated to the volume of asset transactions.

Jahan and Papageorgiou (2014) note that the income velocity of money was destabilized in the 1980s by changes in banking rules, and financial innovations related to money markets, mutual funds, and other assets. Such financial innovations are associated with an increased volume of asset transactions.

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[19] M = volume of money, V = velocity of money, and P = aggregate price level.
[20] Fisher (1911) includes as wealth real estate, commodities, stocks and bonds; as property mortgages, private notes, and time bills of exchange; and as services rented real estate, rented commodities and hired workers, including some or all of these combined.
[21] See Jahan and Papageorgiou (2014).
[22] Construction of new real estate is included in GDP.

Asset transactions can boost GDP by increasing aggregate demand: sellers of e.g. shares, debt securities and previously-built real estate obtain money they can use for consumption and real investment, although part of this money goes to new asset transactions. Aggregate demand is increased because a part of the received money is newly created and not taken from some other use by buyers to the extent that their purchases are financed by bank loans or to the extent that assets are purchased directly by banks. Thus, the aspect of financial development related to ability of the financial system to absorb money supply growth over nominal GDP growth is a positive factor of growth. Consequently, the indicators M3 or private credit to GDP should be related to higher growth. The cost of this benign effect is rising real debt to GDP.

The volume of asset transactions can grow as long as assets retain their credibility. If debt levels (public and private) become extremely high, the risk that debt is unsustainable increases to a point where markets start to express credibility concerns. This restricts growth of real debt to GDP, growth of money supply over nominal GDP growth, and growth in the volume of asset transactions. Rising real debt can no longer act as an "engine of growth" as at lower debt levels. At some point credibility is lost and debt becomes unsustainable. When this level is reached, assets lose credibility and the willingness of people to buy assets diminishes as the desire to sell assets increases. People may liquidate assets at reduced prices. This implies that both the number of asset transactions and asset prices go down, and thus lowers the ability of asset transactions to absorb money supply. This generates high inflation risk as the released money can only flow to GDP transactions (products and services).

Thus, the credibility of bank assets is crucial for financial stability. Strong credit expansions are often characterized by lending to unreliable borrowers or bad projects, and the credit boom of the last decade was no exception. To repeat, money supply is closely related to credit issuance as banks create money (deposits) by granting credit. When a bank's assets lose credibility, it is hard to issue new debt or capital. There is little demand for non-performing loan portfolios. There may be a bank run as depositors rush to withdraw savings as in the Great Depression.[23] Investors may stop buying (or start short-selling) short-term debt securities issued by banks as in the case of the Lehman Brothers collapse in 2008.[24] Such targeted banks usually experience great difficulties or liquidation.

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[23] Bernanke (1983).
[24] Zingales (2008).

Ivashina and Scharfstein (2010) report that banks had difficulties in rolling over money-market debt after a general run of money-market creditors caused by the Lehman Brothers collapse. Banks without strong deposit bases had no choice but to reduce their lending. The authors find an accompanying increase of business lending as debtors used their credit facilities to the limit.

Demirgüç-Kunt, Detragiache, and Gupta (2006) study the effects of the banking crisis on the banking system. While depositors abandon weaker banks for stronger ones, the bank-deposits-to-GDP ratio is not significantly decreased. On the other hand, the credit-to-GDP ratio is higher post-crisis even if credit growth slows substantially. Banks improve their cost efficiency and reallocate their asset portfolio away from loans, indicating a lack of loan demand or collateral.

As illustrated by Reinhart and Rogoff (2009), banking crises can have devastating effects on macroeconomic stability. Friedman and Schwartz (1963) argue that the banking crises during the Great Depression caused a contraction of the supply of money that was the leading reason for diminished aggregate demand and aggregate output. Bernanke (1983), a scholar of the Great Depression, agrees that this was an important factor, but doubts that it fully explains the connection between GDP and the financial sector. Bernanke and Blinder (1988) present a model that includes roles for both money and credit. Bernanke (1983) considers effects of credit constraints on aggregate supply that might limit the economy's productive capacity, i.e. the commonest view in the literature as to how financial development affects growth. In the presence of credit constraints, potential borrowers may be unable to obtain financing for profitable investments and individuals may be unable to allocate their savings to efficient purposes. As a result, the possibilities for risk diversification are reduced and it becomes hard to finance large projects.

The reluctance of cash-rich corporations to expand production during the Great Depression moved Bernanke (1983) to question whether consideration of the aggregate demand channel for credit market effects on output might not be more fruitful than the aggregate supply channel in analyzing the Great Depression, unless one accepts that the outputs of large and small businesses are not potential substitutes.

Bernanke (1983) proposes a *non-monetary aggregate demand channel* for credit market effects on output. The financial crisis reduced the quality of financial services as the collateral base of borrowers eroded and banks had to bear growing default risks, employ complicated and costly loan contracts, or even refuse loans to people. This raised the cost of credit, especially for small companies and households. Thus, for a given safe interest rate, borrowers face a higher effective cost of credit or the inability to borrow, implying a reduced demand by them for current-period goods and services (substitution of future consumption for present consumption).

Similar dynamics are discussed in Bernanke and Gertler (1989), who develop a real business cycle model. In good times, higher borrower net worth reduces agency costs of financing and increases real capital investment. This amplifies the upturn, so a financial accelerator effect emerges. Their assessment builds on Townsend's (1979) model of costly state verification. Bernanke, Gertler, and Gilchrist (1996) also find evidence that a larger portion of the fall of GDP during a recession is caused by debtors, who already face severe agency costs. The credit constraints for these debtors tighten more than for others during a recession.

The GE models discussed above exemplify attempts to integrate financial markets into modern macroeconomic models. While interest in this area has grown in recent years, modeling of the role of money and debt remains spotty. Friedman and Schwartz (1963) note money income and prices are strongly linked to the money stock. This linkage holds over the long-term and in individual cyclical movements. Their evidence also shows a close association between money stock and real income in cyclical movements. In long-term movements, however, the relationship between the two variables is "much less close." They conclude that secular money stock growth is "largely" uncorrelated with secular real-income growth, provided there is relatively stable growth of these two variables. However, significant instability in growth of the money stock is related to the instability in growth of real incomes.

The qualitative evidence presented by Friedman and Schwartz (1963) on US monetary history suggests that longer-term movements and major cyclical movements exhibit a clear causality from money to money income and prices, while there is far more mutual interaction in short-term and mild movements. It is worth noting that real business cycle models and neo-Keynesian models fail to fully capture the conclusions of Friedman and Schwartz (1963). Real business cycle models ignore the relationship between the money stock and real income altogether, while neo-Keynesian models accept only their cyclical relationship (and even then by introducing price and wage rigidities that capture just one aspect of the relationship). Thus, the real business cycle and neo-Keynesian model – even today – are challenged in providing a comprehensive analysis of money and debt. The discussion above illustrates the complexity of indicators of financial development and government debt, some of which relates to core issues in macroeconomics. Against this background, it is forgivable that meaningful empirical results on how financial development and government debt affect growth are scarce.

5 Methodological issues

5.1 Estimation

Regressions are mainly run using ordinary least squares (OLS).[25] Cross-sectional regressions are also run using generalized least squares (GLS) estimates, where the data are transformed to eliminate cross-sectional heteroscedasticity in the error term. When estimation involves instrumental variables, a two-step/n-step generalized method of moments (GMM) estimator is used. The two-step GMM is applied for equations in differences and for equations in orthogonal deviations. GMM weighting and covariance matrices are chosen to improve efficiency of estimation and consistency of standard errors.

The method names follow EViews conventions, and their descriptions are obtained from EViews (2013). Matrices associated with heteroscedasticity and autocorrelation (White period) are used when feasible (full rank of matrices is required). Where this is not feasible, matrices associated with same heteroscedasticity (across periods) and autocorrelation for all countries (period SUR), same heteroscedasticity (across periods) for all countries (period weights), or as a last resort, same heteroscedasticity (across countries) for all time periods (cross-section weights) are applied. In some GMM specifications, the data are first GLS transformed (cross-section weights). Comparing coefficients generated by different specifications and estimation methods gives an idea of potential biases and robustness.

Panel estimation is implemented with annual observations and regressions with five-year averages. Salotti and Trecroci (2016) observe that regressions with five-year averages provide a convenient way of addressing business cycle fluctuations. In cross-sectional regressions, observations in annual regressions are replaced by cross-sectional averages of variables to obtain a single cross-section, i.e. between estimator (BE). Hauk and Wacziarg (2009) note that the BE has lower total bias with respect to omitted variables bias and measurement errors compared to pooled OLS, fixed effects, or difference GMM estimators. The BE is quite similar to the cross-sectional estimator typically applied in growth regressions. The only relevant difference here is that the average of the frontier gap is used instead of the initial value of the frontier gap in the context of the BE.

[25] This chapter mainly concerns methodological details relevant to the third essay, but is also broadly applicable to the first two essays. For the first two essays, the relevant details are included in the essays themselves.

The properties of these two estimators are otherwise quite similar, with the BE performing slightly better (Hauk and Wacziarg, 2009).

To control for reverse causality, a modified cross-sectional estimator is also applied. It differs from the BE in that the initial values for both frontier gap and government debt are used instead of their averages.

Regressions with five-year averages and cross-sectional regressions take the long-term view beyond cyclical phenomena into account much better than annual regressions. This is important as the nature of reverse causality is cyclical and as the possible omission of variables describing business cycles becomes less relevant. Country-specific fixed effects control for country-specific heterogeneity; random effects are not applied. Time-specific fixed effects help in incorporation of global business cycles into the regression model.

5.2 Endogeneity

In the case of the OLS estimator, the explanatory variables need to be exogenous, i.e. they must not be correlated with the error term. Endogeneity can be caused by the impact of growth on the government-debt-to-GDP ratio (reverse causality), from omission of third variables that would be correlated with both economic growth and government-debt-to-GDP ratio, from simultaneous determination of economic growth and government-debt-to-GDP ratio (simultaneity), or from measurement errors of both growth and government-debt-to-GDP ratio. Endogeneity would render the least squares estimator biased and inconsistent. Instrumental variable (IV) estimation is implemented in an effort to eliminate possible endogeneity bias.

There is no obvious way to correct the bias due to measurement errors. The Wu-Hausman test is applied to analyze endogeneity in some baseline regressions. However, it is important to note that the outcome of the Wu-Hausman test depends on the alternative, which here is equivalent to replacing government-debt-to-GDP ratio with its fifth lag. An interpretation of government-debt-to-GDP ratio as a partial manifestation of cumulative money supply growth in excess of nominal GDP growth would reduce the risk of reverse causality, but does not completely eliminate it because of highly autocorrelated time series. Further, inclusion of controls and fixed effects as regressors reduce the risk of possible bias from omitted variables.

It is possible that there is reverse causality from growth to debt, i.e. an increase in debt caused by sluggish growth such that

$$(D/Y)_t = a + b^* g_t \quad (5)$$

The independent variable in Equation (5) is level of debt (to GDP), which can be approximated by sum of past deficits. While it is not obvious why the sum of past deficits should be determined by current or future growth, it is clear that the difference in debt is related to economic growth as a conventional policy reaction function. If the current deficit is in fact explained by current growth, a more plausible view is obtained, i.e.

$$\Delta(D/Y)_t = a + b^* g_t \quad (6)$$

R^2 is about twice as big in Equation (6), suggesting that the use of a level-of-debt term leads to a misspecified model.

With IV estimation, lagged value of government-debt-to-GDP ratio is used along with lagged values of other explanatory variables as columns in the instrument matrix for each regression. Even the second lags are not contemporaneous to any component in the dependent variable, but the fifth lag is likely to be even outside the same cyclical phase. This is important for the government-debt-to-GDP ratio as its lags inside the same cyclical phase could still generate endogeneity bias caused by an omitted variable describing business cycles. Instrumental variables estimation is not used in the cross-sectional regressions. The validity (exogeneity) of instruments is controlled with Sargan/Hansen J-test (p-value of J-statistic).

One problem with the use of IV estimation is that it reduces efficiency. The problem becomes bigger if the chosen instrument is only weakly correlated with the instrumented explanatory variable (weak instruments problem). This might influence the variance of the estimator and thus significance levels. It is therefore useful to run regressions without instrumental variables. To get some benchmark estimates and control endogeneity in regressions without instrumental variables, lagged value of government-debt-to-GDP ratio is used in the role of an independent variable for some analyses using lagged values of other independent variables. This is even less efficient than IV estimation. Additionally, for some analyses with a simple cross-section, initial values for government debt and frontier gap are used instead of their averages. Using initial values of explanatory variables in baseline regressions reduces the risk of reverse causality.

An example of possible omitted variables is the cross-section-specific fixed effect, which by definition is correlated with independent variables. Otherwise, the effect would be random. The inclusion of a lagged dependent variable as an explanatory variable in a regression including fixed or random effects automatically makes the relevant effect (regardless of whether it was originally fixed or random) correlated with an explanatory variable (i.e. the lagged dependent variable). This is because the effect is part of the regression model representation of the lagged dependent variable.

Unfortunately, the fixed effects estimator is no longer unbiased and consistent in the presence of a lagged dependent variable. With a large number of time periods, the bias becomes insignificant (Roodman, 2006). Difference and orthogonal deviations GMM (two-step/n-step) estimators are applied resolve the issue (Arellano and Bond, 1991; Arellano and Bover, 1995). Difference GMM uses first-differenced equations where the role of instruments is played by lags of levels. Differencing magnifies gaps in unbalanced panel data sets, which gives a reason for the existence of an alternative method of eliminating fixed effects, i.e. orthogonal deviations (Arellano and Bover, 1995). Dynamic panel GMM estimators may suffer from weak instruments problems (Bazzi and Clemens, 2009; Roodman, 2009).

Specifically, Blundell and Bond (2008) argue that lagged levels are weak instruments for first differences when there remains a moderately small number of periods and the dynamic panel autoregressive coefficient remains moderately large. They provide evidence that a system GMM estimator could suffer less from weak instruments in such case, because it employs even level equations where the role of instruments is played by lags of differences. Han and Phillips (2010) note that IV and one-step difference GMM estimators are asymptotically random if there remains a small number of periods and the autoregressive parameter remains at unity. With a large number of periods (and autoregressive parameter at unity), unweighted GMM may be inconsistent, efficient two-step GMM may behave in a nonstandard manner, and system GMM may exhibit issues related to the limit distribution. Thus, they argue that IV and one-step difference GMM are inappropriate when the autoregressive parameter is near unity. They further observe that the behavior of efficient two-step GMM has not been determined and system GMM is consistent in such case. However, this advantage of system GMM comes at a price: the method requires that changes in instruments are not correlated with fixed effects (Roodman, 2006). In any case, system GMM is not necessary here as the autoregressive parameter is unlikely to hover near unity. This is because the dependent variable real GDP growth lacks a unit root according to panel unit root tests. Additionally, its lagged value is, strictly speaking, not included in the regression equation.

5.3 Analysis of endogeneity risks of government debt and private credit

In all the three essays of this thesis, lagged values are generally used as instruments to address the problem of endogeneity.[26] First lags are enough to eliminate potential direct reverse causality. However, Panizza and Presbitero (2014) argue that using lagged values of the government debt ratio may be problematic as growth and debt tend to be "persistent." However, they fail to explain this any further. In any case, shorter lags may belong to the same cyclical phase as the instrumented original variable. Choosing lags inside the same cyclical phase for instruments could still generate endogeneity bias caused by an omitted variable describing business cycles. During and after an economic contraction, government revenues tend to be lower and expenditure higher for many years because of automatic stabilizers. These factors tend to increase the numerator of the government debt ratio. The denominator shrinks during the contraction. Thus, the government debt ratio increases during and after contraction. During mature expansion, the numerator of the government debt ratio tends to decrease or at least grow more slowly as government revenues tend to be higher and expenditure lower. At the same time, the denominator increases. Thus, the government debt ratio decreases during mature expansion. To make sure this business cycle connection of government debt ratio is absent from the instruments (i.e. lags) of government debt, the lag length must be long enough so that the instrumented original variable and its lag serving as the instrument are not from the same cyclical phase.

NBER (2017) calculates that the average expansion in the US after the end of WWII lasted 58.4 months, i.e. slightly less than five years. The corresponding average for contractions was only 11.1 months. Therefore, using fifth annual lags as instruments for the government debt ratio should be enough to ensure that growth and the instrument of government debt ratio are not from the same cyclical phase, i.e. the error term is not correlated with the instrument of government debt ratio. Further, it is not very likely that protracted slow growth over cyclical phases would increase debt too much. It is possible for the government to implement fiscal consolidation measures over the long term. Additionally, it may be that protracted high growth over cyclical phases

[26] The discussion in this section and section 5.5 on stationarity and multicollinearity apply to the thesis generally.

would not decrease debt as increased fiscal leeway will be used to increase government spending (Mayes and Virén, 2011).

However, the private credit ratio is more stable and its behavior is much less clear in relation to business cycle fluctuations in comparison to the government debt ratio. During the year of contraction, the denominator in the private credit ratio decreases while the numerator stays the same or decreases as less credit is demanded and supplied during contractions. As the contractions last less than one year on average, output starts to grow again in subsequent expansion years. Usually credit starts growing again, but there might also be a protracted period of deleveraging. Thus, the behavior of the private debt ratio is more stable and apparently unrelated to business cycle fluctuations.

Based on the conclusions of Friedman and Schwartz (1963), it is improbable that growth affects private credit strongly over the long term. Therefore, first lags may be sufficient to address the problem of endogeneity for private credit ratio by eliminating potential direct reverse causality. Similar arguments as to private credit also apply to venture capital investment.

5.4 Autocorrelation

Even without the fixed effects, the presence of a lagged dependent variable will render the least squares estimator automatically biased and inconsistent if there is autocorrelation in the disturbance. This is because the lagged error term can be found both within a representation of the lagged dependent variable as a regression model and within the contemporaneous error. In other words, autocorrelation in the presence of a lagged dependent variable automatically leads to an endogeneity problem. Since lagged real GDP per capita in USD is included in the explanatory variable frontier gap and growth of real GDP includes real GDP in domestic currency, it is possible, but unlikely, that this, combined with autocorrelation in disturbances, could render the OLS estimator biased and inconsistent. This potential problem is controlled in a usual way with autocorrelation tests, cross-sectional regressions, and the use of further lags of other explanatory variables as instruments for frontier gap (rather than lagged frontier gap) in some annual regressions and regressions with five-year averages.

Autocorrelation is measured by Durbin-Watson statistic, and, because of its known shortcomings, also by Ljung-Box Q-statistic and Breusch-Godfrey LM statistic. The Durbin-Watson test only takes first-order autocorrelation into account and is invalid when a lagged dependent variable is included. Since the Q-statistic is calculated separately for orders of autocorrelation up to ten, these results are not reported in the tables. The LM statistic is calculated for tenth-order autocorrelation in annual regressions and for second-order autocorrelation in five-year-average regressions. Both the Q and LM tests consider even lower-order autocorrelation than the order for which they are computed.

One might expect to detect some autocorrelation as a growth model is only supposed to capture long-term relationships and short-term variation as e.g. business cycles in annual regressions are not accounted for in any other way than time-specific fixed effects. Other candidates for potential missing variables would be lagged values of the dependent variable and the explanatory variables. However, adding lagged values of the dependent variable as explanatory variables would complicate estimation. One central explanatory variable implied by economic theory, frontier gap, is already related to the lagged dependent variable. Its inclusion would thus confuse the role of this key variable. Although the lagged dependent variable or frontier gap is included in many empirical studies on growth models, lagged explanatory variables are not commonly used in panel data estimations of growth models. A likely reason is that their effect is automatically included in the effect of lagged dependent variable in a restricted way.

5.5 Non-stationarity and multicollinearity

Difference stationarity can be analyzed with panel unit root tests (see EViews, 2013). For the dependent variable in the first two stand-alone essays (real GDP per capita growth), the hypothesis for the unit root is rejected by all panel unit root tests. In the third stand-alone essay, real GDP growth is used as the dependent variable and the hypothesis for the unit root is rejected for this dependent variable by all panel unit root tests. This implies that the dependent variable does not include a unit root, i.e. it is not an I(1) process or an integrated process of any higher degree.

This result is also intuitive when considering the nature of this variable. Since the dependent variable is not an I(1) process or an integrated process of any higher degree, it excludes the possibility of a cointegration relationship between it and any independent variables(s). A cointegration relationship can only exist between integrated variables of the same degree (at least of the first order).

For the same reason, the regressions are not spurious in the spirit of Granger and Newbold (1974). The dependent variable and independent variable(s) are not both non-stationary (difference stationary). However, the potential non-stationarity of some right hand-side variables still poses a problem in the sense that standard regularity conditions are invalidated, and thus the distributions of the relevant test statistics are not known (see e.g. Theil, 1971). It may also be difficult to derive a sensible long-run solution for the regression model if the degree of integration deviates between different variables.

In the frameworks of all three essays, the panel unit root tests reveal that some independent variables contain or may contain a unit root. Possible problems are controlled for by comparing the results of panel regressions to cross-sectional regressions that do not include a time dimension, and thus are free from time-series problems. If the results are about the same, possible unit roots in independent variables are unlikely to crucially affect the results. This is confirmed as the essential results of all the three essays also broadly hold in cross-sectional regressions.

As robustness checks, regressions with first differences are run to eliminate unit roots and to check whether the relationship is strong enough to stand differencing (see Plosser and Schwert, 1977, 1978). Differencing can be expected to have a negative impact on significance levels. Differencing is also used in the context of a difference GMM estimator. Differences are taken with respect to previous year even in the case of regressions with five-year averages.

The time-series properties of the data may not be equally relevant for panel estimations. Greene (2008, p. 767) observes that the data properties related to time-series characteristics (including stationarity) remain secondary problems and mostly raise only limited concern in the context of panel setups with small numbers of time periods and large numbers of cross-sectional units. If, however, both numbers are large, time-series properties become important and pose challenges for the standard methodology. On the other hand, a pooled estimator is consistent and has a normal limit distribution in the presence of nonstationary time series also with a moderate number of cross-sectional units and a large number of time periods (Phillips and Moon, 1999). Thus, the time-series properties are not critical in panel regressions with five-year averages and many countries (or even in annual regressions with a large number of periods and a moderate number of countries).

Finally, problems due to multicollinearity are possible. The regularity condition needed for consistency of the least squares estimator requires that, as the sample size approaches infinity, **X’X** converges toward a finite nonsingular matrix. Non-existence of asymptotical multicollinearity is needed for the limit to be nonsingular. (See e.g. Verbeek, 2008, p. 33–34.) Multicollinearity can be analyzed with correlation tables, variance inflation factor (VIF), and the condition number of **X’X** (statistics not reported) (see e.g. Greene 2008, p. 59–61).

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6 Effect of finance in driving growth through technological innovation

6.1 Introduction

Many empirical studies address the effects of finance on growth. Partly based on these results, the finance-growth nexus is today an accepted concept in mainstream economics.[27]

In their influential paper, King and Levine (1993a) augment the growth regressions of Barro (1991) with variables on financial development to find that later real GDP growth is linked to financial development in a statistically significant, positive, and robust way. Their data cover 80 countries over the period 1960–1989. The authors claim that various indicators for level of financial development are clearly related to investment, productivity, and growth. In a second paper, King and Levine (1993b) present an endogenous growth model in which more enhanced systems of finance foster growth by increasing the likelihood that innovations succeed. They extend their earlier work with additional evidence that the financial system is a major factor in economic and productivity growth.

The findings of Levine and Zervos (1998) suggest that highly developed banking environments and liquid stock markets enhance growth of GDP in a statistically significant way. However, introducing outlier controls to Levine and Zervos (1998) makes the statistically significant growth effect of liquidity of stock markets disappear according to Andong, Ash, and Pollin (2004).

Rousseau and Wachtel (2000) estimate vector autoregressions that indicate boosting financial depth and liquidity of stock markets substantially and positively affects GDP per capita.

Demirgüc-Kunt and Maksimovic (1998) show that growth of companies receiving outside finance is associated with a developed banking industry and functioning stock markets, and that proportionally more companies receive long-term external finance in countries with efficient judicial systems. La Porta et al. (1998) argue that investor protection provided by the judicial system is medium in societies with

[27] I thank the participants in the 2010 Annual Meeting of the Finnish Economic Association in Tampere and participants at Bank of Finland research workshops in 2009 for their useful comments.

Scandinavian and Germanic civil law, lowest in societies with French codified civil law, and highest in societies that follow the English common law.

More generally, Levine, Loayza, and Beck (2000) observed that accounting and judicial systems help explain differences in national financial development. They also detect growth having a positive relationship with the exogenous aspects of financial development by utilizing both dynamic panel methods and cross-sectional IV estimation.

Beck, Levine, and Loayza (2000) discover a substantially beneficial effect of financial intermediation on total factor productivity (TFP) growth. Rajan and Zingales (1998) find that industries requiring proportionately more external financing advance quicker in financially sophisticated countries.

Applying their Schumpeterian growth model, Aghion, Howitt, and Mayer-Foulkes (2005) find that countries can move closer to the world technological frontier if their state of financial development exceeds a critical value. Using cross-sectional regressions, they find the coefficient for the interaction term of financial development with distance to technological frontier (the US) at the beginning of the sample to be negatively large and statistically significant. Their study is analyzed in detail below. Howitt (2000) notes that convergence clubs arise from differences in R&D productivity.

Rousseau and Wachtel (2005) find the linkage of growth with financial development is positive for poorer societies, but non-existent in high-wealth countries. The linkage is generally stronger in the 1960–1989 period than in the later years of their study. They find that including random or fixed country effects causes disappearance of previously found evidence. They analyze the possibility of financial development variables correlating with some missing variables that are invariant within countries. Benhabib and Spiegel (2000), including fixed effects into growth regressions, obtain similar results, i.e. financial development variables become insignificant and coefficients unstable.

The list of Rousseau and Wachtel (2005) of other studies that question the positive empirical results for financial depth in promoting economic growth or reduce their generality include Rioja and Valev (2004), Wachtel (2003), Arestis, Demetriades and Luintel (2001), Rousseau and Wachtel (1998), Arestis and Demetriades (1997), and Demetriades and Hussein (1996). The later study of Capelle-Blancard and Labonne (2011) also deserves mention in this respect.

This study aims at examining whether financial development raises growth by promoting more efficient utilization of technological innovations. The empirical model is based on an extension of the empirical model of Aghion, Howitt, and Mayer-Foulkes (2005). The main contribution of this study is its explicit econometric modeling of the innovation channel of finance. It is based on the intuition that a substantial technological innovation is more likely to get the required financing when financial institutions and markets function well, which, in turn, enhances growth. The discussion focuses on the interaction term for measures of innovation and financial development.

6.2 Estimation and results

6.2.1 Specification and data

Aghion, Howitt, and Mayer-Foulkes (2005), AHM hereafter, present a model of endogenous growth for multiple countries that accommodates incomplete protection of creditors. Their framework foresees that countries converge toward the global technological frontier growth when their state of financial development exceeds a critical value. Countries unable to reach this critical value face weaker than frontier growth over the long term and they fall behind. AHM approximate their theoretical model with:

$$g_i - g_1 = \beta_0 + \beta_1 F_i + \beta_2 (y_i - y_1) + \beta_3 F_i (y_i - y_1) + \beta_4 X_i + \varepsilon_i, \qquad (7)$$

where $g_i - g_1$ denotes mean real GDP per capita growth with relation to the US in country i, F_i the average level of financial development, $y_i - y_1$ logarithmic 1960 real GDP per capita with relation to the US, X_i further independent variables, and ε_i an error term. AHM stress that Equation (7) represents conventional growth regressions augmented by $F_i(y_i - y_1)$. The subindex value one remains reserved for the technologically leading country, which AHM assume to be the US. As countries develop financially, the probability of their convergence toward growth of the technological frontier rises, which forms the primary conclusion of their theory. Thus, their main hypothesis is that $\beta_3 < 0$.

The second essential implication of their theory is that a beneficial, but vanishing, influence on the steady-state distance to the frontier is exerted by financial development for countries converging toward frontier growth. This produces the additional hypothesis that $\beta_1 = 0$.

According to AHM, the technology gap of a credit-constrained country develops as follows:

$$a_{t+1} = \tilde{\mu}(\omega a_t) + \frac{1-\tilde{\mu}(\omega a_t)}{1+g} a_t \qquad (8)$$

where $\tilde{\mu}(\omega a_t)$ marks likelihood of innovation (ω being financial development), g technology frontier growth, and a_t technology gap in terms of productivity at time t. Notably, the innovation probability $\tilde{\mu}(\omega a_t)$ refers to innovation realized in production activities of a company that produces a monopoly in a sector by creative destruction. This is different from the concept of own innovation, which refers to underlying own innovation that needs adequate finance to be realized in production activities. A similar distinction is made in King and Levine (1993b).

Regarding the theoretical AHM model, technology gap and financial development together determine $\tilde{\mu}(\omega a_t)$. Equation (7) mirrors this, although AHM have included a varying set of conditioning variables.

Taking Equations (7) and (8) as the starting point, the empirical model of AHM can be extended to account for other factors that affect realized innovation $\tilde{\mu}(\omega a_t)$ to make it more complete.

The notion of *own innovation* is important because it allows for explicit modeling of the innovation channel of finance on growth, and more specifically, to focus on the interaction term between the measures of innovation and financial development. The notion that an adequate level of financial development is needed to realize the potential of own innovation for growth is captured by the interaction term. In frontier growth models, own innovation becomes essential as countries approach the technological frontier. In the AHM model, the innovation rate of leader countries determines world technological frontier growth. Technology is diffused to other countries from the frontier as they utilize ideas established in technologically leading countries. This effect is captured by the explicit measure of imitation in the extended empirical model, where the interaction term between the measure of imitation and financial development is included to capture the notion that an adequate level of financial development is needed to realize the potential of imitation for growth.

It is important to note that these two terms should not affect realized innovation $\tilde{\mu}(\omega a_t)$. Imitation is closely related to convergence dynamics, so there is likely to be redundancy between these variables. As countries approach the frontier, own innovation becomes essential to sustaining high growth as there are fewer innovations to imitate. Near the frontier, a great proportion of growth must originate from own innovation as a greater number of intermediate sectors are already at the technological frontier. In the extreme, if the technological frontier consists of only one leading country, each of its intermediate sectors has to innovate to preserve growth. Moreover, successful own innovations can give domestic companies competitive edge or even monopoly power in some sectors in other countries. Since growth of domestic companies with extensive foreign operations likely has a disproportionally beneficial impact on domestic growth compared to growth effects in foreign countries, own innovation may also enhance growth for this reason.

AHM's primary conclusion that the probability of convergence toward technological frontier growth rises as countries develop financially is preserved in the extended empirical model here. The implication of the original AHM model that an ameliorative, yet ultimately disappearing, influence on the steady-state distance to the frontier is exerted by financial development for countries converging on the frontier growth rate also hold in the extended model. However, it is useful to consider a minor modification in this respect. As most growth comes from realized innovation near the technological frontier, this may pose a different set of challenges for financial markets. Many innovations come from small companies or start-ups. Raising capital to exploit such innovations may require more sophisticated financial intermediation (e.g. hyper-efficient banks, venture capital, angel investor guidance, or a large IPO market) than what is needed at locations far from the frontier. Thus, to realize the necessary innovation near the frontier to attain and sustain a closer steady-state distance to the frontier, additional financial development is required.

AHM briefly mention this possibility by noting that accommodating continued effort and moral hazard are other ways to model credit constraints. Precisely as assumed here, AHM suggest this could induce a model where steady-state productivity is consistently influenced by financial development. In the AHM model proper, differences in financial development ω in highly financially developed countries should not affect the steady-state distance to frontier. Their model sets the upper limit for borrowing with the latent incentive constraints underlying ω. When this restriction is non-binding, ω loses its decisive role for productivity development.

Additionally, growth of physical capital per capita, its interaction term with financial development, human capital, and size of government are added to the empirical model and the regression equation. Aghion and Howitt (1998) incorporate physical capital per capita and human capital into their Schumpeterian growth theory. The interaction term of financial development with growth of physical capital per capita captures how capital investment efficiency is affected by financial development. The higher government consumption, the greater the tax burden. This implies less after-tax monopoly profits for successful innovators, thereby reducing incentive for innovation. This is a typical feature of Aghion and Howitt (1992) and its derivatives. Some of the variables of the extended empirical model are typical variables for neoclassical growth models. From the perspective of such models, logarithmic 1960 real GDP per capita with relation to the US could be seen as capturing convergence over time and countries (a typical feature of growth in such models).

A constant coefficient term (β_0) is omitted in the extended empirical model. There are several reasons for this. First, a constant term is not necessary in growth equations induced by neoclassical growth theory. Second, the better the coverage for variables affecting economic growth, the lower the need for a constant term in the regression equation. Third, the Patent Cooperation Treaty (PCT) applications-per-capita-based measures for own innovation and imitation are in fact country-specific constants since they are constructed by extrapolating the most recent observation available for each country (typically 2006 for own innovation) to every single year over the period 1960–2007 (the full sample period). This is done because the PCT data only cover a relatively short period of time and different countries join the PCT at different times. Thus, only the most recent observations describe differences in own innovation across countries with any accuracy.

As changes in own innovation in a country are not likely to occur over a short period of time, extrapolating the most recent observation to the full sample period should not radically affect the results. In a way, it is assumed that this own innovation variable measures underlying country-specific innovation that goes deeper and changes much more slowly over time than patent applications, and in fact can be treated as a constant for the full sample period, implying that it measures contemporaneous own innovation each year. Moreover, using yearly observations for PCT applications per capita for only those years they are available would leave the time dimension short and reduce the number of observations in the panel.

In general, the same arguments that apply to PCT applications-per-capita-based measures above also apply to some extent to the aggregate patent originality-per-capita-based measures for own innovation and imitation. Thus, constant country-specific averages extrapolated to 1960–2007 are used in some regressions and yearly country-specific observations for those years they are available are used in other regressions. The use of time-varying observations for aggregate patent originality-per-capita-based measures for own innovation and imitation in some regressions is why N_{it} and M_{it} in Equation (9) contain the subscript t.

However, the literature suggests that technological diffusion can be driven by trade or foreign direct investment (see e.g. Keller, 2004). Since the measure of patent originality is calculated on patents granted in the United States, later yearly observations, in particular, are likely to reflect the positive trends in these factors as a result of globalization.

Finally, the extended empirical model uses mean real GDP per capita growth instead of growth relative to the US. This approach is also followed by Aghion, Howitt and Mayer-Foulkes (2004). Additionally, variation in the growth rate of the United States in panel data is relatively minor with respect to GDP variations in many other countries. If mean real GDP per capita growth with relation to the US were used, it would be natural to use other variables relative to the US.

The regression equation representation of the extended empirical model takes the following form:

$$\Delta y_{it} = \beta_1 F_{it} + \beta_2 \left(y_{i(t-1)} - y_{1(t-1)}\right) + \beta_3 F_{it}\left(y_{i(t-1)} - y_{1(t-1)}\right) + \beta_4 N_{it} + \beta_5 F_{it} N_{it} + \beta_6 M_{it} + \beta_7 F_{it} M_{it} + \beta_8 \Delta k_{it} + \beta_9 F_{it} \Delta k_{it} + \beta_{10} h_{it} + \beta_{11} G_{it} + \varepsilon_{it} \quad (9)$$

where Δy_{it} is country i's real GDP per capita growth at time t (long series for real GDP per capita and its growth available for many countries by using WDI).[28] β_1, β_2, β_3, β_4, β_5, β_6, β_7, β_8, β_9, β_{10} and β_{11} are constant coefficients.

F_{it} is an indicator of financial development at time t in country i. Long series (1960–2007) is available for domestic credit to private sector and nominal GDP from WDI for many countries. Short series (1987–2007) is available for domestic credit to private non-financial corporations of financial accounts statistics from OECD.Stat for a set of countries close to OECD. The dummies in La Porta et al. (1998) based on Reynolds and Flores (1996) and extended by Levine, Loayza, and Beck (2000) describing English, Scandinavian, German, or French judicial origins in many countries are used as alternative instruments of financial development. AHM prefer private credit in measuring financial development.

Period t–1's technology gap in country i is denoted by $(y_{i(t-i)} - y_{1(t-1)})$, i.e. logarithmic real GDP per capita – logarithmic real GDP per capita in the United States (technology frontier) (dollar-denominated real GDP per capita available for many periods and countries from WDI). N_{it} is the log of own innovation (PCT applications

[28] World Development Indicators by World Bank.

filed by domestic residents per capita in a year) at time t in country i. Short PCT applications series are available from OECD.Stat for many countries (PCT contracting states). Long series for population is available for many countries from WDI. M_{it} is the log of scope of imitation (national patent applications filed by domestic residents in a year divided by PCT applications filed by domestic residents in a year) at time t in country i (long national patent applications series available from WIPO (World Intellectual Property Organization) for many countries).

Alternatively, both N_{it} and M_{it} can be based on the patent originality measure suggested first by Trajtenberg, Jaffe, and Henderson (1997) and calculated by Hall, Jaffe, and Trajtenberg (2001) on patents granted during 1975–1999 in the United States to applicants from different countries. In the alternative measures, PCT applications is replaced by originality aggregated over all patents granted to applicants from a country of first inventor in a year.

Δk_{it} is period t's growth of country i's per capita physical capital. Physical capital stock for many countries during 1960–1990 is supplied by Nehru and Dhareshwar (1993). The period of coverage is extended by adding gross investment using WDI and subtracting depreciation assumed to amount to 4% of the physical capital stock.[29] h_{it} is the log of human capital at time t in country i. The tertiary education attainment ratio is available from Barro and Lee (2000) for a large cross section of countries for the period 1960–1999. The period of coverage is extended by linear interpolation (and to small extent linear extrapolation). G_{it} is an indicator for size of government as percentage of GDP at time t in country i. The WDI long series for general government final

[29] Nehru and Dhareshwar (1993) make the same assumption for the rate of depreciation.

consumption expenditure is available for many countries. ε_{it} is a disturbance term at time t in country i.[30,31]

In this study, H_0: $\beta_5 <= 0$, where H_0 denotes the zero hypothesis, and H_1: $\beta_5 > 0$, where H_1 is its alternative hypothesis whereby growth is positively affected by own innovation interacted with financial development. When H_0 is rejected, H_1 is accepted. Mean GDP per capita growth over 1960–2007 versus the average financial development level over the same period is laid out in Figure 1. For variable name explanations, see Appendix Table 1 at the end of this chapter. The scatter plot shows data that are broadly coherent with the AHM theoretical conclusion, i.e. as countries develop financially, the probability of their convergence toward growth of the technological frontier rises. Figure 2 plots average GDP per capita growth over 1960–2007 against a measure of own innovation, PCT applications per capita. This figure provides modest support to the notion that own innovation is beneficial for growth.

[30] Altogether, data has been gathered for 209 countries over a sample period of 1960–2007. Since all variables are not available for the entire time period and most countries, the panel regressions include significantly fewer time periods and countries. The number varies according to specifications.

In the baseline regressions with PCT applications per capita used to describe technological innovations, the panel includes 60 countries: Algeria, Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, China, Colombia, Costa Rica, Cyprus, Denmark, Ecuador, Egypt, Finland, France, Germany, Greece, Guatemala, Iceland, India, Indonesia, Iran, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kenya, Korea, Kuwait, Malaysia, Malta, Mexico, Netherlands, New Zealand, Norway, Pakistan, Panama, Peru, Philippines, Portugal, El Salvador, Singapore, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Thailand, Trinidad and Tobago, Tunisia, Turkey, United Kingdom, United States, Uruguay, Venezuela, and Zimbabwe.

In baseline regressions with aggregate patent originality per capita used to describe technological innovations, the panel includes 65 countries. The country set is largely the same as above. It does not include Algeria, Jordan, and Kuwait, but adds Bolivia, Dominican Republic, Honduras, Haiti, Mauritius, Malawi, Nicaragua, and Paraguay.

In baseline regressions with loans to non-financial corporations used for financial development, the panel includes 15 countries: Australia, Austria, Belgium, Germany, Denmark, Spain, Finland, France, Greece, Italy, Mexico, Netherlands, Norway, Portugal, and Sweden, i.e. a subset of the 60- and 65-country sets. Separate regressions are run for all those countries for which there is sufficient data, industrialized countries and emerging markets combined, and industrialized countries only.

[31] The dataset draws on the original data of the data sources, augmented with author's own calculations where needed.

Figure 1. **Mean GDP per capita growth and mean financial development, 1960–2007**

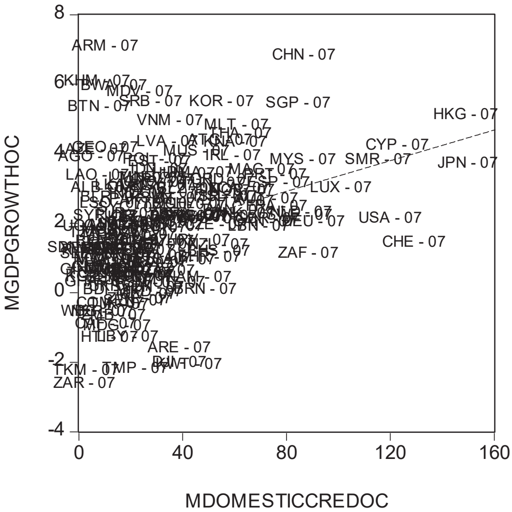
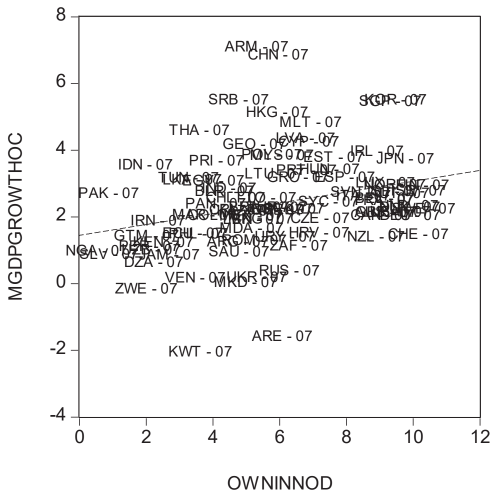


Figure 2. **Mean GDP per capita growth 1960–2007 versus PCT applications per capita**



6.2.2 Methodology

The AHM is replicated to the greatest extent possible to control for differences in data. The basic AHM setup runs cross-country IV regressions. Citing Hauk and Wacziarg (2004), AHM justify their choice of cross-sectional analysis with their belief that the growth impact of financial development was probably undervalued in panel-data analysis due to persistence problems and the challenges of measuring financial development. They argue that the same undervaluation explains the 92-country-panel finding for 1960–1985 of no statistically significant coefficient for financial development interacted with initial GDP obtained by Benhabib and Spiegel (1997, 2000).

Data panels are needed to augment the pure cross-sectional analysis as adding explanatory variables requires more observations – not least because interaction terms are likely to create some degree of multicollinearity. Panel estimation is implemented by yearly observations and for five-year means for all variables (except frontier gap, for which the initial value is used). For each of the three setups, separate analyses are run for the full set of countries, industrialized countries and emerging markets combined, and industrialized countries only. In addition to GDP per capita growth, total factor productivity could be regressed on financial development, technological innovations, and other relevant variables. AHM and many other studies have found that this has no effect on the results, so this alternative is not considered here. Instead, two financial development variables, three own innovation variables, and three imitation variables are used.

The names of methods follow EViews convention and their descriptions are obtained from EViews (2013). OLS, OLS with White diagonal standard errors, and GLS (cross-section weights) with period SUR standard errors are estimated for each yearly or 5-year-panel setup. OLS, OLS with cross-section weights standard errors, and GLS (cross-section weights) with cross-section weights standard errors are estimated for each cross-sectional setup. With GLS (cross-section weights), the data are first transformed to eliminate cross-sectional heteroscedasticity in the error term. White diagonal standard errors preserve consistency under heteroscedastic errors, cross-section weights standard errors preserve consistency under heteroscedasticity across countries, and period SUR standard errors preserve consistency under heteroscedasticity across periods and autocorrelation. It is useful to compare results obtained using different standard errors as this can illustrate their possible impact on conclusions.

To control for possible endogeneity of financial development, GMM with initial values of financial development as instruments (for financial development) and least squares with initial values as explanatory variables are carried out in addition to least squares with contemporaneous values in each of the setups. As an exception, least squares with initial values as explanatory variables is not estimated for single cross-sections. GMM here equals two-stage least squares.

In the IV estimation, both financial development and its interaction terms with other variables are instrumented. Instruments for the interaction terms are generated by replacing the financial development variable by its initial value within the original interaction term. Legal origins in La Porta et al. (1998) based on Reynolds and Flores (1996) and extended by Levine, Loayza, and Beck (2000), hereafter LLB, are utilized as alternate instruments of financial development in separate cross-sectional regressions. In annual regressions, initial values for independent variables including financial development equal their first lags. Here, the standard estimator of Arellano and Bond (1991) is not applicable in most setups as it assumes differencing that would eliminate own innovation and imitation variables in most setups.

The instruments based on initial values of financial development should be relevant since they are strongly correlated with the original variables. Legal origins have been considered relevant by other authors. The validity (exogeneity) of instruments is controlled with Sargan/Hansen J-test (p-value of J-statistic). A Wu-Hausman test is used to check whether regressions could have been run with least squares in the first place.

An interpretation of financial development as a manifestation of cumulative money supply growth in excess of nominal GDP growth would reduce the risk of endogeneity. However, since GDP per capita forms a part of the dependent variable and lagged GDP per capita forms a part of the explanatory variable frontier gap, it is possible that this combined with autocorrelation in disturbances could render the least squares estimator biased and inconsistent. Autocorrelation is measured by the reported Durbin-Watson statistic and the Ljung-Box Q-statistic. Since the Q-statistic is calculated for several lags, these results are not reported in the tables.

6.2.3 Replicating the AHM results

AHM estimate Equation (7) using cross-sectional data averaged over 1960–1995 for the 71 countries also present in the LLB data. They discover the coefficient of the interaction term $F_i(y_i{-}y_1)$ to be statistically significant and negative ($\beta_3 < 0$). They find F_i to be insignificantly negative ($\beta_1 = 0$). These results imply that their hypotheses are supported. These findings do not essentially change if other regressors are included, the reported direct coefficients and interactions with $y_i - y_1$ for other regressors are insignificant. The AHM findings also hold after removing outliers or changing financial development indicators and estimation methods. As instruments, AHM use legal origins in La Porta et al. (1998) based on Reynolds and Flores (1996) and extended by LLB. Moreover, the AHM findings remain unchanged when initial financial intermediation (F_0) along with the corresponding interaction term $F_0(y_i–y_1)$ are used as instruments. Even rejecting instruments and using OLS yields the same result. Additionally, AHM find the coefficient of initial value for relative per capita real GDP to be significantly positive ($\beta_2 > 0$).

To set the starting point and control for differences in the data, AHM estimations are replicated as far as the data of this study allow.[32] Specifically, Equation (7) is estimated by OLS, using initial financial intermediation (F_0) along with its interaction term $F_0(y_i–y_1)$ as instruments, using legal origins by LLB and the corresponding interaction term with frontier gap as instruments, and also OLS with initial values. No other regressors are included. According to the results, the coefficient of the interaction term $F_i(y_i–y_1)$ is still significantly negative ($\beta_3 < 0$), but the coefficient of F_i, β_1, is positive (mostly insignificantly). Additionally, the coefficient of initial value for relative per capita real GDP is still significantly positive ($\beta_2 > 0$). These results do not change much if the time period is 1960–2007 or 1960–1995, and if all countries or only AHM countries (except Taiwan) are included. Thus, switching from AHM data to the data of this study appears to have no impact on the essential results. Only the negative, but insignificant, coefficient of financial intermediation becomes positive (mostly insignificant).

By applying data from the Penn World Tables (PWT) for the initial value for relative per capita real GDP used by AHM and LLB, the signs of financial intermediation turn negative in estimation configurations without initial values of financial intermediation. PWT consist of figures that are supposed to be based on purchasing power parity (PPP) methodology. The PWT data were popularized by Summers and Heston (1991), but there are more recent versions of the datasets. Johnson et al. (2009) argue that estimates of GDP obtained by PWT methods do not reflect PPP prices. In any case, these figures generally make differences

[32] The replicated results are available from the author at request.

in per capita real GDP smaller between nations in comparison to the traditional constant dollar figures used in this study.

Further, if the financial intermediation measure used in this study is replaced by the financial intermediation measure used by AHM and LLB, the signs of financial intermediation become negative even in regression configurations with initial values for financial intermediation. A probable reason for this effect is the fact that the financial intermediation measure used by AHM and LLB is calculated as the average of 1960 and 1995, while here the average is calculated as a simple average of financial intermediation over all the years in the sample period. There are also some minor differences in the calculation of the measure. Additionally, AHM's and LLB's data for financial intermediation are obtained from the IMF International Financial Statistics (IFS), while WDI data is used here.

Finally, the results do not change using mean real GDP per capita growth instead of that with relation to the US, as done by Aghion, Howitt and Mayer-Foulkes (2004). It is worth noting that regressions including the financial intermediation variable of AHM and LLB, their initial value for relative per capita real GDP, or both, produce in GLS configuration a (highly) significant negative sign for financial development's direct impact. This is consistent with the fact that GLS is more efficient than OLS.

To control the effect of the panel-data approach on results, AHM estimations are implemented by using panel data instead of cross-sectional averages according to Equation (10):

$$g_{it} - g_{1t} = \beta_0 + \beta_1 F_{it} + \beta_2 \left(y_{i(t-1)} - y_{1(t-1)}\right) + \beta_3 F_{it} \left(y_{i(t-1)} - y_{1(t-1)}\right) + \beta_4 X_{it} + \varepsilon_{it} \quad (10)$$

The results are similar to those of the cross-sectional approach, but now the coefficient of financial development β_1 becomes negative (and in many cases significant). In regressions using all countries for 1960–2007, the coefficient is insignificant in all configurations. Thus, the data of this panel study gives exactly the same results qualitatively as AHM data in a corresponding cross-sectional specification. Switching to AHM countries for the period 1960–1995 makes the sign of β_1 significant in GLS specifications. Finally, using mean real GDP per capita growth instead of that with relation to the US makes the sign highly significant in all specifications. In any case, the AHM main result holds, i.e. that the coefficient of $F_i(y_i–y_1)$ is significantly negative ($\beta_3 < 0$).

6.2.4 Main results

6.2.4.1 General

Tables 1–4 present the basic results for the full set of countries with yearly observations. These results are the most important as they are the most general and based on the greatest number of observations. The tables differ with respect to the choice of own innovation and financial development variables.[33] Loans to non-financial corporations are only used in annual regressions and only in connection with PCT applications or average aggregated originality because of concerns over an excessively low number of observations. All the period frequencies and country sets are considered in reporting of the results, although Tables 1–4 are given more weight in the overall judgement and in reporting of the details.

In general, R^2 seems relatively high across different specifications. It increases significantly as the frequency of time periods diminishes. Typically, Sargan tests accept the use of initial values of domestic credit to private sector and their interaction terms with other variables as instruments (see Tables 1–3). However, in Tables 2–3, where aggregated originality per capita plays the role of the own innovation variable, Sargan tests accept the use of these instruments only in GLS specifications. Further, Sargan tests reject the use of initial values of loans to non-financial enterprises and their interaction terms with other variables as instruments (see Table 4). The Wu-Hausman test does not reject the exogeneity assumption of the variables on the right-hand-side of the equation, except in the case of legal origins and their interaction terms with other variables as instruments for the full set of countries. This is only a problem for some pure cross-sectional regressions as legal origins are used as alternate instruments for financial development only in these regressions.[34] The Durbin-Watson statistic indicates the presence of first-order autocorrelation. The same indication is also given by the Ljung-Box Q-statistic for both first and second orders.

[33] Tables of results for panels of 5-year-averages, pure cross-sectional analysis, and other country sets are available from the author upon request.

[34] Tables of these results are also available from the author upon request.

Table 1. **Regressions with Domestic Credit to Private Sector / GDP as the financial intermediation variable and PCT Applications Per Capita as the own innovation variable**

Dependent Variable: Annual Growth Rate of Per-Capita Real GDP, 1961-2007, All Countries									
	Contemporaneous Values			Lagged Value of Financial Intermediation used as Instrument for Financial Intermediation			Lagged Value for Independent Variables		
	OLS	OLS, White Diagonal s.e.	GLS (Cross-Section Weights), Period SUR s.e.	GMM	GMM, White Diagonal s.e.	GMM (GLS Cross-Section Weights), Period SUR s.e.	OLS	OLS, White Diagonal s.e.	GLS (Cross-Section Weights), Period SUR s.e.
Domestic Credit to Private Sector / GDP	-0.041549***	-0.041549***	-0.047189***	-0.040099***	-0.040099***	-0.049277***	-0.055454***	-0.055454***	-0.055930***
	(0.012412)	(0.014989)	(0.014234)	(0.012606)	(0.014069)	(0.014444)	(0.013456)	(0.016149)	(0.017509)
Frontier Gap	-0.544317***	-0.544317***	-0.351511**	-0.525855***	-0.525855***	-0.333790**	-0.520425***	-0.520425***	-0.438781***
	(0.117085)	(0.135602)	(0.144475)	(0.118056)	(0.135542)	(0.146070)	(0.126234)	(0.144375)	(0.165284)
(Frontier Gap)*(Domestic Credit to Private Sector / GDP)	-0.007138***	-0.007138**	-0.008683***	-0.007529***	-0.007529***	-0.009346***	-0.012338***	-0.012338***	-0.011604***
	(0.002685)	(0.002946)	(0.002689)	(0.002725)	(0.002740)	(0.002713)	(0.002907)	(0.003176)	(0.003434)
PCT Applications Per Capita	0.277814***	0.277814***	0.197031***	0.279622***	0.279622***	0.198707***	0.474701***	0.474701***	0.415471***
	(0.047601)	(0.055476)	(0.053452)	(0.048146)	(0.056718)	(0.054391)	(0.051240)	(0.060363)	(0.057375)
(PCT Applications Per Capita)*(Domestic Credit to Private Sector / GDP)	0.002991**	0.002991*	0.003613***	0.002896**	0.002896**	0.003753***	0.004103***	0.004103**	0.003929**
	(0.001252)	(0.001533)	(0.001399)	(0.001274)	(0.001430)	(0.001423)	(0.001355)	(0.001700)	(0.001705)
National Patent Applications / PCT Applications	-0.188245**	-0.188245*	-0.110791	-0.172623**	-0.172623	-0.100204	-0.037120	-0.037120	-0.021348
	(0.086356)	(0.105423)	(0.107908)	(0.087168)	(0.106007)	(0.109339)	(0.093105)	(0.117377)	(0.124191)
(National Patent Applications / PCT Applications)*(Domestic Credit to Private Sector / GDP)	0.000972	0.000972	0.000854	0.000730	0.000730	0.000897	0.001501	0.001501	0.002239
	(0.001428)	(0.001294)	(0.001299)	(0.001447)	(0.001356)	(0.001324)	(0.001540)	(0.001435)	(0.001612)

Dependent Variable: Annual Growth Rate of Per-Capita Real GDP, 1961-2007, All Countries

	Contemporaneous Values			Lagged Value of Financial Intermediation used as Instrument for Financial Intermediation			Lagged Value for Independent Variables		
	OLS	OLS, White Diagonal s.e.	GLS (Cross-Section Weights), Period SUR s.e.	GMM	GMM, White Diagonal s.e.	GMM (GLS Cross-Section Weights), Period SUR s.e.	OLS	OLS, White Diagonal s.e.	GLS (Cross-Section Weights), Period SUR s.e.
Per-Capita Physical Capital Growth	0.450089***	0.450089***	0.483916***	0.436575***	0.436575***	0.475663***	0.191085***	0.191085***	0.198834***
	(0.036344)	(0.047237)	(0.044239)	(0.037083)	(0.049430)	(0.044997)	(0.039006)	(0.057561)	(0.047512)
(Per-Capita Physical Capital Growth)*(Domestic Credit	0.001037*	0.001037*	0.000911	0.001234*	0.001234*	0.000978	0.000262	0.000262	0.000312
to Private Sector / GDP)	(0.000613)	(0.000615)	(0.000620)	(0.000631)	(0.000658)	(0.000642)	(0.000656)	(0.000845)	(0.000722)
Human Capital	0.128037	0.128037	0.168938*	0.099225	0.099225	0.157230*	-0.181454**	-0.181454*	-0.205474*
	(0.084325)	(0.097727)	(0.093762)	(0.085246)	(0.097541)	(0.094968)	(0.091607)	(0.105230)	(0.106866)
Government Consumption / GDP	-0.064798***	-0.064798***	-0.045027**	-0.064074***	-0.064074***	-0.043923**	-0.087620***	-0.087620***	-0.059956***
	(0.015606)	(0.019573)	(0.017967)	(0.015684)	(0.019854)	(0.018118)	(0.016861)	(0.019985)	(0.019973)
R-squared	0.271996	0.271996	0.333722	0.270338	0.270338	0.331204	0.146127	0.146127	0.167076
Periods	47	47	47	47	47	47	46	46	46
Cross-sections	60	60	60	60	60	60	60	60	60
Total observations	2446	2446	2446	2427	2427	2427	2423	2423	2423
J-statistic				0.236858	0.236858	1.907152			
P-value				0.626485	0.626485	0.167280			
Wu-Hausman statistic				1.572677					
P-value				0.164383					
Durbin-Watson	1.354614	1.354614	1.406751	1.346307	1.346307	1.403295	1.365567	1.365567	1.402321

Notes: *** significant at 1% level, ** significant at 5% level, * significant at 10% level, (standard errors in parentheses).

Table 2. **Regressions with Domestic Credit to Private Sector / GDP as the financial intermediation variable and Average Aggregated Originality Per Capita as the own innovation variable**

Dependent Variable: Annual Growth Rate of Per-Capita Real GDP, 1961-2007, All Countries									
	Contemporaneous Values			Lagged Value of Financial Intermediation used as Instrument for Financial Intermediation			Lagged Value for Independent Variables		
	OLS	OLS, White Diagonal s.e.	GLS (Cross-Section Weights), Period SUR s.e.	GMM	GMM, White Diagonal s.e.	GMM (GLS Cross-Section Weights), Period SUR s.e.	OLS	OLS, White Diagonal s.e.	GLS (Cross-Section Weights), Period SUR s.e.
Domestic Credit to Private Sector / GDP	-0.042439**	-0.042439**	-0.032121*	-0.047111***	-0.047111***	-0.038770**	-0.032123*	-0.032123*	-0.018193
	(0.017170)	(0.016746)	(0.018308)	(0.017411)	(0.017027)	(0.018674)	(0.018892)	(0.017580)	(0.022928)
Frontier Gap	0.186359**	0.186359*	0.157998	0.242773**	0.242773**	0.190746	0.351588***	0.351588***	0.317808**
	(0.094051)	(0.107201)	(0.121525)	(0.095195)	(0.106440)	(0.122261)	(0.103465)	(0.115247)	(0.144891)
(Frontier Gap)*(Domestic Credit to Private Sector / GDP)	-0.014146***	-0.014146***	-0.011212***	-0.016456***	-0.016456***	-0.013041***	-0.016113***	-0.016113***	-0.012517***
	(0.003202)	(0.002787)	(0.003270)	(0.003276)	(0.002781)	(0.003331)	(0.003530)	(0.002999)	(0.004112)
Average Aggregated Originality Per Capita	0.139291***	0.139291***	0.081714	0.130456***	0.130456***	0.080827	0.208184***	0.208184***	0.171055***
	(0.044533)	(0.049187)	(0.050097)	(0.045016)	(0.049443)	(0.050701)	(0.048779)	(0.053895)	(0.057780)
(Average Aggregated Originality Per Capita)*(Domestic Credit to Private Sector / GDP)	0.002955**	0.002955**	0.002153*	0.003520***	0.003520***	0.002643**	0.002402*	0.002402**	0.001369
	(0.001233)	(0.001152)	(0.001265)	(0.001254)	(0.001166)	(0.001291)	(0.001356)	(0.001200)	(0.001567)
Average National Patent Applications / Aggregated Originality	0.095607	0.095607	0.091640	0.130138*	0.130138	0.108446	0.300506***	0.300506***	0.297717***
	(0.071996)	(0.085069)	(0.091591)	(0.072951)	(0.085296)	(0.092518)	(0.079200)	(0.094845)	(0.108271)
(Average National Patent Applications / Aggregated Originality)*(Domestic Credit to Private Sector / GDP)	-0.001277	-0.001277	-0.000850	-0.001841	-0.001841	-0.000946	-0.001962	-0.001962	-0.001664
	(0.001469)	(0.001409)	(0.001508)	(0.001493)	(0.001480)	(0.001528)	(0.001612)	(0.001553)	(0.001831)

Dependent Variable: Annual Growth Rate of Per-Capita Real GDP, 1961-2007, All Countries

	Contemporaneous Values			Lagged Value of Financial Intermediation used as Instrument for Financial Intermediation			Lagged Value for Independent Variables		
	OLS	OLS, White Diagonal s.e.	GLS (Cross-Section Weights), Period SUR s.e.	GMM	GMM, White Diagonal s.e.	GMM (GLS Cross-Section Weights), Period SUR s.e.	OLS	OLS, White Diagonal s.e.	GLS (Cross-Section Weights), Period SUR s.e.
Per-Capita Physical Capital Growth	0.501422***	0.501422***	0.519808***	0.487641***	0.487641***	0.506194***	0.218626***	0.218626***	0.236025***
	(0.033089)	(0.040124)	(0.041489)	(0.033764)	(0.041539)	(0.042137)	(0.036286)	(0.053562)	(0.046883)
(Per-Capita Physical Capital Growth)*(Domestic Credit to Private Sector / GDP)	0.001037*	0.001037*	0.000783	0.001217**	0.001217*	0.000973	0.000983	0.000983	0.000467
	(0.000597)	(0.000601)	(0.000626)	(0.000615)	(0.000644)	(0.000645)	(0.000655)	(0.000853)	(0.000735)
Human Capital	0.118602	0.118602	0.126435	0.081786	0.081786	0.107277	-0.228410**	-0.228410**	-0.273480**
	(0.081840)	(0.086482)	(0.095094)	(0.082551)	(0.086750)	(0.096052)	(0.090274)	(0.095391)	(0.110943)
Government Consumption / GDP	-0.053830***	-0.053830***	-0.030218*	-0.051305***	-0.051305***	-0.028704	-0.060070***	-0.060070***	-0.037016*
	(0.015165)	(0.018723)	(0.017794)	(0.015232)	(0.018824)	(0.017846)	(0.016654)	(0.020230)	(0.020531)
R-squared	0.259503	0.259503	0.308589	0.256952	0.256952	0.307820	0.102967	0.102967	0.124783
Periods	47	47	47	47	47	47	46	46	46
Cross-sections	65	65	65	65	65	65	65	65	65
Total observations	2658	2658	2658	2639	2639	2639	2630	2630	2630
J-statistic				5.160195	5.160195	1.824901			
P-value				0.023110	0.023110	0.176731			
Wu-Hausman statistic				1.726797					
P-value				0.125001					
Durbin-Watson	1.378482	1.378482	1.398920	1.370669	1.370669	1.394476	1.354125	1.354125	1.380126

Notes: *** significant at 1% level, ** significant at 5% level, * significant at 10% level, (standard errors in parentheses).

Table 3. **Regressions with Domestic Credit to Private Sector / GDP as the financial intermediation variable and Aggregated Originality Per Capita as the own innovation variable**

Dependent Variable: Annual Growth Rate of Per-Capita Real GDP, 1975–1999, All Countries									
	Contemporaneous Values	Lagged Value of Financial Intermediation used as Instrument for Financial Intermediation			Lagged Value for Independent Variables				
	OLS	OLS, White Diagonal s.e.	GLS (Cross-Section Weights), Period SUR s.e.	GMM	GMM, White Diagonal s.e.	GMM (GLS Cross-Section Weights), Period SUR s.e.	OLS	OLS, White Diagonal s.e.	GLS (Cross-Section Weights), Period SUR s.e.
Domestic Credit to Private Sector / GDP	-0.076730***	-0.076730***	-0.060558**	-0.076761***	-0.076761***	-0.062434***	-0.077238***	-0.077238**	-0.039225
	(0.025167)	(0.027595)	(0.023466)	(0.025547)	(0.027631)	(0.023964)	(0.028230)	(0.031289)	(0.027232)
Frontier Gap	-0.090654	-0.090654	0.034321	-0.117376	-0.117376	0.053551	0.142920	0.142920	0.112265
	(0.197180)	(0.205608)	(0.162880)	(0.198473)	(0.213159)	(0.163844)	(0.220237)	(0.233515)	(0.183720)
(Frontier Gap)*(Domestic Credit to Private Sector / GDP)	-0.012745**	-0.012745**	-0.014205***	-0.012270**	-0.012270**	-0.015234***	-0.014950***	-0.014950**	-0.011014*
	(0.005074)	(0.005356)	(0.004754)	(0.005152)	(0.005407)	(0.004769)	(0.005685)	(0.006173)	(0.005673)
Aggregated Originality Per Capita	0.201395**	0.201395*	0.138055*	0.205054**	0.205054*	0.147531**	0.199257**	0.199257*	0.223457***
	(0.086404)	(0.111470)	(0.072557)	(0.087347)	(0.116875)	(0.073681)	(0.096333)	(0.111825)	(0.082432)
(Aggregated Originality Per Capita)*(Domestic Credit to Private Sector / GDP)	0.003450*	0.003450*	0.003212*	0.003273*	0.003273	0.003263*	0.003957*	0.003957	0.001655
	(0.001823)	(0.002032)	(0.001662)	(0.001874)	(0.002101)	(0.001693)	(0.002044)	(0.002498)	(0.001897)
National Patent Applications / Aggregated Originality	-0.296907**	-0.296907*	-0.195902*	-0.301179**	-0.301179*	-0.194776*	-0.002641	-0.002641	0.021279
	(0.129845)	(0.158262)	(0.112732)	(0.133254)	(0.171432)	(0.116351)	(0.145377)	(0.197987)	(0.125042)
(National Patent Applications / Aggregated Originality)*(Domestic Credit to Private Sector / GDP)	0.003682	0.003682	0.001214	0.003940*	0.003940	0.001281	0.003196	0.003196	0.001400
	(0.002242)	(0.002298)	(0.001907)	(0.002306)	(0.002487)	(0.001993)	(0.002502)	(0.003106)	(0.002054)

Dependent Variable: Annual Growth Rate of Per-Capita Real GDP, 1975–1999, All Countries									
	Contemporaneous Values	Lagged Value of Financial Intermediation used as Instrument for Financial Intermediation			Lagged Value for Independent Variables				
	OLS	OLS, White Diagonal s.e.	GLS (Cross-Section Weights), Period SUR s.e.	GMM	GMM, White Diagonal s.e.	GMM (GLS Cross-Section Weights), Period SUR s.e.	OLS	OLS, White Diagonal s.e.	GLS (Cross-Section Weights), Period SUR s.e.
Per-Capita Physical Capital Growth	0.617104***	0.617104***	0.590857***	0.582346***	0.582346***	0.573159***	0.363659***	0.363659***	0.269083***
	(0.071192)	(0.094232)	(0.071599)	(0.072431)	(0.101974)	(0.073146)	(0.079227)	(0.139061)	(0.093187)
(Per-Capita Physical Capital Growth)*(Domestic Credit	0.000256	0.000256	0.000657	0.000720	0.000720	0.000834	-0.000449	-0.000449	0.000127
to Private Sector / GDP)	(0.001017)	(0.001199)	(0.000975)	(0.001063)	(0.001397)	(0.001016)	(0.001133)	(0.001818)	(0.001276)
Human Capital	0.514728***	0.514728***	0.461665***	0.475533***	0.475533***	0.438622***	0.166389	0.166389	0.019623
	(0.168984)	(0.173378)	(0.156698)	(0.168762)	(0.172040)	(0.155756)	(0.188045)	(0.213834)	(0.176587)
Government Consumption / GDP	-0.046550*	-0.046550	-0.029306	-0.039390	-0.039390	-0.029504	-0.039413	-0.039413	-0.030999
	(0.024500)	(0.031468)	(0.021628)	(0.024608)	(0.031741)	(0.021645)	(0.027264)	(0.033269)	(0.024449)
R-squared	0.261367	0.261367	0.393494	0.260925	0.260925	0.347905	0.090815	0.090815	0.067147
Periods	25	25	25	25	25	25	25	25	25
Cross-sections	65	65	65	65	65	65	65	65	65
Total observations	895	895	895	886	886	886	894	894	894
J-statistic				6.533286	6.533286	2.406242			
P-value				0.010587	0.010587	0.120852			
Wu-Hausman statistic				1.097470					
P-value				0.360195					
Durbin-Watson	1.183256	1.183256	1.349153	1.186599	1.186599	1.346913	1.114255	1.114255	1.278859

Notes: *** significant at 1% level, ** significant at 5% level, * significant at 10% level, (standard errors in parentheses).

Table 4. **Regressions with Loans to Non-Financial Corporations / GDP as the financial intermediation variable and PCT Applications Per Capita as the own innovation variable**

Dependent Variable: Annual Growth Rate of Per-Capita Real GDP, 1987-2007, All Countries									
	Contemporaneous Values			Lagged Value of Financial Intermediation used as Instrument for Financial Intermediation			Lagged Value for Independent Variables		
	OLS	OLS, White Diagonal s.e.	GLS (Cross-Section Weights), Period SUR s.e.	GMM	GMM, White Diagonal s.e.	GMM (GLS Cross-Section Weights), Period SUR s.e.	OLS	OLS, White Diagonal s.e.	GLS (Cross-Section Weights), Period SUR s.e.
Loans to Non-Financial Corporations / GDP	-12.20546*	-12.20546*	-13.34086	-16.84444**	-16.84444**	-17.66291*	-13.02576*	-13.02576**	-10.96693
	(6.669618)	(6.480240)	(8.963169)	(6.686183)	(6.773142)	(9.205380)	(6.686368)	(6.177116)	(8.504707)
Frontier Gap	1.617685*	1.617685*	1.519224	2.649694***	2.649694***	2.558879**	2.557778***	2.557778***	2.451018**
	(0.854448)	(0.882591)	(1.167245)	(0.867048)	(0.836341)	(1.062626)	(0.852863)	(0.897145)	(1.211432)
(Frontier Gap)*(Loans to Non-Financial Corporations / GDP)	-5.820366**	-5.820366**	-5.269558	-8.018320***	-8.018320***	-7.686903**	-8.483498***	-8.483498***	-7.419601**
	(2.473855)	(2.359005)	(3.398967)	(2.506960)	(2.405926)	(3.329665)	(2.479200)	(2.298565)	(3.248030)
PCT Applications Per Capita	-0.110887	-0.110887	-0.202285	-0.365818*	-0.365818*	-0.435538*	-0.340733	-0.340733*	-0.408711
	(0.212145)	(0.193314)	(0.239854)	(0.216461)	(0.193766)	(0.242327)	(0.209084)	(0.191781)	(0.250605)
(PCT Applications Per Capita)*(Loans to Non-Financial Corporations / GDP)	1.280413**	1.280413**	1.457922*	1.815013***	1.815013***	1.977687**	1.556448***	1.556448***	1.460385*
	(0.589415)	(0.572535)	(0.789247)	(0.595223)	(0.593820)	(0.800798)	(0.591212)	(0.541654)	(0.741751)
National Patent Applications / PCT Applications	1.303823**	1.303823***	1.182954*	1.617459***	1.617459***	1.494309***	1.733132***	1.733132***	1.593066**
	(0.533646)	(0.425891)	(0.621542)	(0.575504)	(0.442301)	(0.554299)	(0.533372)	(0.487825)	(0.663709)
(National Patent Applications / PCT Applications)*(Loans to Non-Financial Corporations / GDP)	-2.557939**	-2.557939***	-2.092352*	-3.015149***	-3.015149***	-2.619631**	-3.213401***	-3.213401***	-2.859853**
	(1.001880)	(0.835226)	(1.185803)	(1.061911)	(0.874147)	(1.073263)	(0.995761)	(0.927616)	(1.248550)
Per-Capita Physical Capital Growth	0.142499	0.142499	0.539339	0.341025	0.341025	0.726320	0.025923	0.025923	0.355813
	(0.436502)	(0.408012)	(0.469287)	(0.476251)	(0.389144)	(0.448004)	(0.437860)	(0.423714)	(0.507081)
(Per-Capita Physical Capital Growth)*(Loans to Non-Financial Corporations / GDP)	0.771576	0.771576	0.347273	0.663059	0.663059	0.223768	-0.033697	-0.033697	-0.571854
	(0.822114)	(0.695868)	(0.902422)	(0.879848)	(0.670073)	(0.896482)	(0.826344)	(0.754224)	(0.924626)

Dependent Variable: Annual Growth Rate of Per-Capita Real GDP, 1987-2007, All Countries

	Contemporaneous Values			Lagged Value of Financial Intermediation used as Instrument for Financial Intermediation			Lagged Value for Independent Variables		
	OLS	OLS, White Diagonal s.e.	GLS (Cross-Section Weights), Period SUR s.e.	GMM	GMM, White Diagonal s.e.	GMM (GLS Cross-Section Weights), Period SUR s.e.	OLS	OLS, White Diagonal s.e.	GLS (Cross-Section Weights), Period SUR s.e.
Human Capital	0.354155	0.354155	0.360740	0.862166*	0.862166*	0.838808	0.817818*	0.817818*	0.886257
	(0.447813)	(0.428412)	(0.575745)	(0.464661)	(0.475865)	(0.630478)	(0.441000)	(0.429415)	(0.582800)
Government Consumption / GDP	0.034916	0.034916	0.027461	0.035553	0.035553	0.021994	0.057965	0.057965	0.046741
	(0.053933)	(0.047369)	(0.063201)	(0.053633)	(0.045765)	(0.062650)	(0.053520)	(0.047519)	(0.065391)
R-squared	0.150962	0.150962	0.243922	0.206867	0.206867	0.367105	0.116514	0.116514	0.129449
Periods	21	21	21	20	20	20	20	20	20
Cross-sections	15	15	15	15	15	15	15	15	15
Total observations	204	204	204	189	189	189	203	203	203
J-statistic				21.92363	21.92363	19.37624			
P-value				2.84E-06	2.84E-06	1.07E-05			
Wu-Hausman statistic				0.579669					
P-value				0.715532					
Durbin-Watson	1.018229	1.018229	1.008601	1.045808	1.045808	1.049537	1.097690	1.097690	1.111005

Notes: *** significant at 1% level, ** significant at 5% level, * significant at 10% level, (standard errors in parentheses).

The most appropriate estimation method used for this study is GMM (here, two-stage least squares) as it controls for possible endogeneity of financial development. It is more efficient than least squares with initial values as explanatory variables, which also controls for endogeneity in the panel setting.

Among the GMM specifications used, the most efficient are those where the data are first GLS (cross-section weights) transformed to eliminate cross-sectional heteroscedasticity in the error term. These same specifications also use robust standard errors, which in the case of a country panel are chosen to be consistent in the presence of heteroscedasticity across periods and autocorrelation. This GLS transformation and these robust standard errors are natural as tests show some autocorrelation and the large set of heterogeneous countries is likely to generate heteroscedasticity. Thus, among all the used methods these specifications would be the most appropriate, particularly where instruments are accepted by the Sargan test. However, given the benign results of the Wu-Hausman tests and the fact that the estimation method or possible estimator bias does not seem to affect the conclusions on the central variables of interest (see discussion below), the other used methods can also be appropriate. This is why all the methods are considered in reporting of the results, although the most appropriate methods are given the most weight in the overall judgement.

An interesting observation is that the signs, standard errors, and magnitudes for the interaction term between financial intermediation and own innovation remain roughly the same in different specifications in most cases. This holds for almost all specifications in Tables 1–3, where domestic credit to private sector is used as the financial development variable. A similar observation can be made for most other variables. It does not apply to the sign of the distance to frontier in Tables 2–3, where aggregated originality per capita serves as the own innovation variable.

Further, the observation above does not hold completely across regressions that have different financial intermediation variables. When comparing the results between regressions including the variable domestic credit to private sector per GDP and regressions including the variable loans to non-financial corporations per GDP, several points need to be considered. Loans to non-financial corporations per GDP is only available for more developed countries and only recently. Its variability is thus smaller. Most importantly, domestic credit to private sector per GDP is expressed as a percentage, but loans to non-financial corporations per GDP is presented as a fraction (in decimals). Further, the scale of the latter is about half that of the former. Thus, coefficients including loans to non-financial corporations per GDP should be divided by about two hundred to make them comparable coefficients in a meaningful sense. Thus, the signs and magnitudes of the central coefficients of interest become much closer with the exceptions of the sign of own innovation and the magnitude of interaction between distance to frontier and loans to non-financial corporations per GDP. All in all, the estimation method or possible estimator bias does not seem to affect conclusions regarding the main variables of interest.

The relative stability of signs, standard errors, and magnitudes also reduces the risk that multicollinearity (see section 6.2.5) affects the main conclusions. As the results of the 5-year average or cross-sectional regressions are broadly in harmony with results in regressions with annual observations, non-stationarity of financial development variables and their interaction terms (see section 6.2.5), as well as possible endogeneity caused by frontier gap in the presence of autocorrelation are unlikely to crucially affect the results.

6.2.4.2 Financial development variables and their interactions with other variables

The sign of the interaction term between financial intermediation and own innovation is usually found to be positive and its coefficient in many cases to be significant. Considering the set of regressions with domestic credit to private sector per GDP as financial intermediation, the interaction term coefficients in specifications where period frequency is annual, PCT applications or average aggregate originality per capita stands for own innovation and the country set is full (or OECD countries and emerging markets) are consistently significant with few exceptions. These are the most important specifications since they cover the entire period and all or most important countries. Significance weakens as period frequency decreases, in OECD countries, or when aggregate originality per capita is used as own innovation.

Negative signs are almost exclusively restricted to three small groups of regressions with a low number of observations (not reported). The first group includes cases with aggregate originality per capita as own innovation when using initial values for all variables as regressors in five-year-average regressions (annual in the case of the OECD subset). The second group includes cases with average aggregate originality per capita as own innovation for the OECD subset in annual or five-year-average regressions. The third group includes cases with PCT applications per capita as own innovation when using legal origins and their interaction terms with other variables as instruments. This is problematic for some pure cross-sectional regressions where legal origins are used as alternate instruments for financial development. It is encouraging, however, that there is at least one alternative measure for own innovation in each of the three groups that shows a positive sign. Furthermore, when loans to non-financial corporations per GDP stands for financial intermediation, the signs for interaction between own innovation and financial intermediation are positive in all regressions and significant in almost all cases.

The coefficient of financial intermediation variable is found to be significant in many instances and usually negative. This applies both to private credit and corporate loans. AHM argue that this sign should be zero as long-term growth is not affected by financial development in the leading economy (or economies). However, coefficients of AHM also have negative signs, but all are insignificant. Rousseau and Wachtel (2005) report many negative and some significantly negative signs for financial intermediation variables for 1960–2003. King and Levine (1993a) use data for 1960–1989 and obtain significantly positive signs. Rousseau and Wachtel (2005) get similar results when cutting their data for the same period.

Rousseau and Wachtel (2005) note possible explanations for a statistically significant positive sign for 1960–1989. They suggest that, due to financial depth, countries were able to more easily cope with the great nominal disturbances of the period (oil shocks and high inflation). They further suggest that the financial liberalization that started in the 1980s was carried out without appropriate regulatory and supervisory competence, monitoring frameworks, or improvement in lending practices.

The usually negative and in many cases significant direct coefficient of financial intermediation is somewhat puzzling. Since the financial intermediation variables used for measuring financial depth are only correlated with financial development, it could be argued that perhaps domestic credit to private sector or loans to non-financial enterprises are not optimal indicators.

True, financial development (i.e. better-functioning financial institutions, markets, and policies) increases financial depth. Moreover, the focus on private sector borrowing should provide a measure of financial depth that captures efficiently allocated credit. In such case, financial development should correlate with higher levels of financial depth.

On the other hand, the ratio of domestic credit to private sector to GDP (private credit to GDP) may reflect something other than the quality of policies or institutions. Private credit to GDP is also an indicator of private indebtedness (private debt to GDP), which is a drag on growth. Kukk (2016) finds evidence of the importance of the debt service ratio as a channel through which household indebtedness influences consumption, and thereby growth. An intuitive explanation is that indebted consumers must reduce their consumption spending to service their debts. This, in turn, contributes to weaker aggregate demand as debt repayments to banks cause corresponding destruction of money and nobody is allocated additional resources. The same logic applies to indebted companies, which must cut their spending (including investment) and dividends to service debt. Juselius and Drehmann (2015) find that the aggregate debt service burden is a significant drag on credit and expenditure growth.

In other words, private credit to GDP seems to capture two aspects of growth: the negative impact of excessive private indebtedness and the positive impact of financial development. This dual-capture feature may explain the results of Deidda and Fattouh (2001), and Arcand, Berkes, and Panizza (2011), who find threshold effects for private debt. It could also be behind the results of Rioja and Valev (2004), who divide the countries in their sample into three regions based on the level of private credit to show how the impact of private credit on growth differs across regions. In light of the recent financial crisis, a further problem with the private-credit-to-GDP ratio as a measure may be that bankers eventually forget the lessons of previous economic downturns, become more risk-loving, and grant credit to less creditworthy customers. This behavior triggers excessive growth of private credit to GDP and eventually the inevitable credit losses, financial system crash, and possible economic depression. Schularick and Taylor (2012) show that financial crises are preceded by strong private credit growth, i.e. financial crises are caused by credit booms gone wrong.

The sign of the interaction variable between financial intermediation and distance to frontier is usually found to be negative and its coefficient in many cases significant. Significance becomes more seldom as period frequency decreases and within the subset of OECD countries. According to AHM this coefficient should be negative so that financial development would strengthen convergence probability. Even AHM find its sign significantly negative, but the magnitude larger.

To get a view of the magnitudes of the financial intermediation, interaction between distance to frontier and financial intermediation and interaction between own innovation and financial intermediation, the regression in the sixth column of Table 1 provides perhaps the most important specification. The magnitudes of these variables are fairly small in the sense that an increase of one unit in the value of financial intermediation implies a decrease of roughly five one-hundredths of a percentage point in the growth rate, an increase of one unit in the absolute value of the interaction term between distance to frontier and financial intermediation implies an increase of roughly nine one-thousandths of a percentage point in the growth rate, and an increase of one unit in the value of the interaction term between own innovation and financial intermediation implies a growth increase of roughly four one-thousandths of a percentage point. However, notable differences in growth rate can be obtained with plausible values of these variables since the variables can attain both relatively small and large values. As all these variables include financial intermediation, it makes more sense to analyze the magnitude of their joint effect on growth than to analyze magnitudes of the individual effects. No additional variables are needed in the analysis as there are no other statistically significant variables including financial intermediation in this specification. Beginning at zero and going halfway up the scale of each of the three variables implies an increase of roughly one percentage point in growth rate. Thus, although the direct effect of financial intermediation is negative, its interactions with distance to frontier and own innovation render its total effect positive, and this total effect can be substantial.

6.2.4.3 Other variables

The sign of own innovation variable is usually found to be positive and its coefficient in many cases significant. Significance becomes more seldom with smaller country sets. PCT applications or average aggregate originality per capita as the own innovation variable is more often significant than aggregate originality per capita. Even the magnitude is relatively large. Specifications with loans to non-financial enterprises as the financial intermediation variable are exceptions with a negative, and almost always insignificant coefficient. In these cases, the coefficient of distance to frontier usually turns positive. Correlation between these two variables is high, implying that the swapped signs could be a result of multicollinearity.

The coefficient of distance to frontier is negative in many cases and significant in some cases. Coefficients are usually negative when PCT applications per capita is used for own innovation and domestic credit to private sector for financial intermediation. In these cases, the coefficient is usually significant in the full set of countries. However, the sign tends to turn positive if average aggregate originality per capita is used for own innovation or if loans to non-financial corporations is used for financial intermediation. A negative sign indicates a direct convergence effect. A positive sign indicates a direct non-convergence effect, i.e. an economy will lag farther behind other countries over time if the starting point is below its long-term relative GDP. According to all AHM and replicating specifications, the direct effect of initial value for relative per capita real GDP is significantly positive.

The sign for the imitation variable is usually negative and its coefficient insignificant. The sign of financial intermediation interacted with imitation remains usually positive but its coefficient insignificant. Typically, the coefficients of these two variables switch signs when loans to non-financial corporations per GDP stands for financial intermediation. In theory, imitation is closely related to convergence dynamics, so there is likely to be redundancy between it and distance to frontier. The same applies to corresponding interaction variables. The frequent insignificance of imitation and the interaction variable between imitation and financial intermediation can probably be traced back to the close relation of these variables to convergence dynamics.

The sign for physical capital per capita growth is almost always positive and its coefficient in most cases significant when domestic credit to private sector per GDP stands for financial intermediation. The magnitude is large. The interaction variable of physical capital per capita growth and financial intermediation is usually negative and insignificant with the exception of regressions for the full set of countries (usually positive, but insignificant). Human capital usually remains positive. This variable typically attains significance at specifications where period frequency is annual, domestic credit to private sector per GDP stands for financial intermediation, and the country subset is OECD countries and emerging markets, or OECD countries (not reported). The sign for government consumption variable is usually negative when domestic credit to private sector per GDP stands for financial intermediation, and its coefficient is significant in many cases. The notions that the private sector is more efficient than the public sector in many instances and that higher taxes hamper growth by reducing incentives are in harmony with these negative signs.

6.2.5 Robustness checks

To assess robustness of results, several checks have been implemented. These include recursive least squares, panel unit root tests, regressions with differenced data, regressions using financial intermediation variables expressed as a percentage of trend GDP, regressions including cross-sectional or period dummies or both, and multicollinearity tests. Outliers have already been removed from the data when estimating the basic results. Robustness checks use the regressions in Tables 1–4 as a starting point. In reporting of the results, all the specifications related to the robustness checks are considered in the overall judgement and in the detailed reporting.[35]

Figures 3–5 present paths for coefficients for domestic credit to private sector, PCT applications per capita, and aggregate patent originality per capita from recursive ordinary least squares regressions. The presented coefficient paths for domestic credit to private sector and PCT applications per capita are from the same set of recursive regressions for 1960–2007. The presented coefficient path for aggregate patent originality per capita is from a separate set of recursive regressions for 1975–1999. All coefficients seem to more or less converge as number of years is increased, except for aggregate patent originality per capita.[36] The shorter time period for this variable is a good candidate for explanation. It is worth noting that this coefficient starts to decrease as globalization accelerates in the 1990s. Globalization may affect this variable in a way that is not necessarily reflected only through own technological innovation. The coefficient for domestic credit to private sector is positive in the early years and turns negative as time goes on, a finding consistent with Rousseau and Wachtel (2005).

In other series than financial development variables and their interaction terms with other variables, the hypothesis for unit root is generally rejected by the panel unit root tests. The hypothesis for unit root is also accepted for distance to frontier by some tests. Figure 6 presents the series for GDP per capita growth and domestic credit to private sector as medians of countries in the period 1960–2007. As GDP per capita growth appears stationary, series for domestic credit to private sector seems non-stationary. Regressions with first differences are run to control for non-stationarity and to see whether the relationship is strong enough to stand differencing. Differencing is implemented in a regular way and by differencing only the financial development variables. Regular differencing can be carried out only in the case of aggregate patent originality per capita as the own innovation variable; differencing a country-specific constant like PCT applications per capita or average aggregate patent originality per capita would remove the own innovation variable altogether. In most cases, differencing appears to have no effect on the qualitative results for the

[35] Tables for robustness test results are available from the author upon request.

[36] The coefficients considered include even average aggregate patent originality per capita, loans to non-financial corporations, and interaction terms between financial development and the three own innovation variables. The detailed results are available from the author upon request.

sign of the interaction term between the own innovation variable and financial development even though significance levels are lower.

Figure 3. **Path of coefficient for Domestic Credit to Private Sector, Recursive Least Squares 1960–2007**

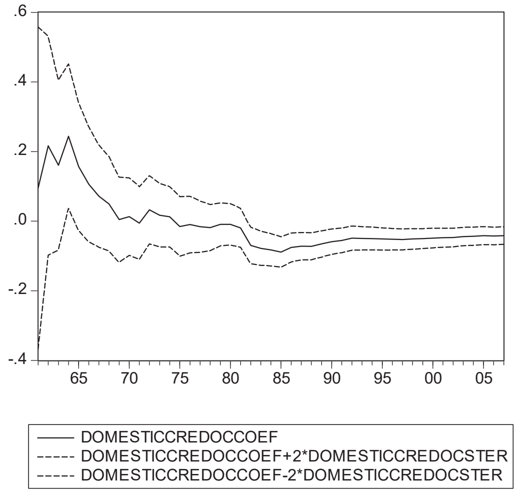


Figure 4. **Path of coefficient for PCT Applications Per Capita, Recursive Least Squares 1960–2007**

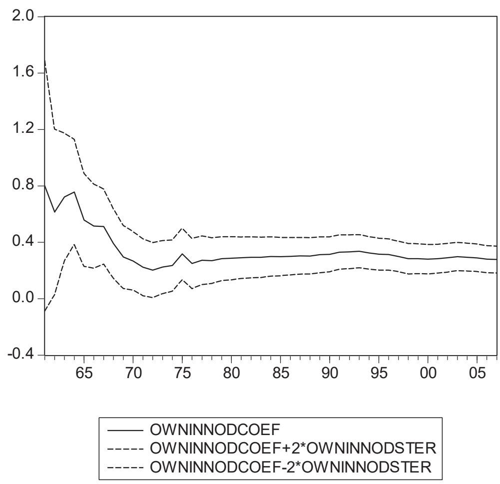


Figure 5. **Path of coefficient for Aggregate Patent Originally Per Capita, Recursive Least Squares 1975–1999**

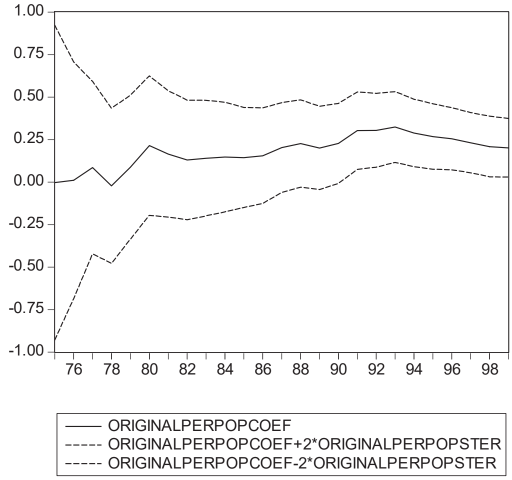
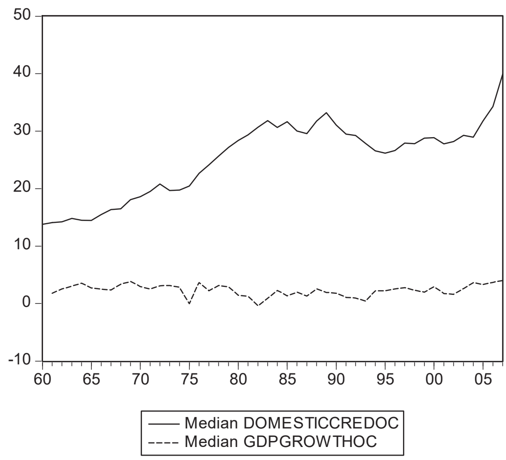


Figure 6. **GDP Per Capita Growth and Domestic Credit to Private Sector, median of countries 1960–2007**



Using financial intermediation variables that are expressed in percent of trend GDP instead of regular financial intermediation variables also does not alter the results much, but only reduces the significance levels. Notably, the significance levels for the interaction between aggregate patent originality per capita and financial development becomes more significant than with the regular financial intermediation variable.

Regressions including cross-sectional, period fixed effects, or both, are run to test the robustness of the baseline results in those specifications where it is technically possible. It is common practice to include such fixed effects in panel growth regressions to include unmodeled country- or period-specific factors. They are not included in the baseline regressions here because they are not induced by the theoretical model. It is implicitly assumed that the variables PCT applications per capita or average aggregated patent originality per capita could replace cross-sectional fixed effects.

Furthermore, **X’X** becomes nearly singular if cross-section dummies are introduced in regressions that include country-specific constants such as PCT applications per capita or average aggregate patent originality per capita, which are highly correlated with fixed effects (see section 6.2.6 below). This renders estimation unfeasible. Introducing cross-sectional fixed effects for regressions using aggregate patent originality per capita makes the sign for the interaction term between aggregate patent originality per capita and financial development negative in other specifications than GMM and reduces its significance levels to insignificance. If both cross-sectional and period fixed effects are added, the sign remains positive (but insignificant) in other specifications except in LS with initial values as explanatory variables. Introducing only period fixed effects does not change the sign of the interaction term between financial development and PCT applications per capita or average aggregate patent originality per capita, but reduces significance levels to insignificance in regressions with domestic credit to private sector. If aggregate patent originality per capita is used as the own innovation variable, the sign of the interaction term becomes negative in all cases.

The problem of multicollinearity is evident from all indicators: correlation tables, variance inflation factor (VIF), and the condition number of **X’X**. All indicators suggest that the problem is lowest when PCT applications per capita or average aggregate patent originality per capita is used as the own innovation variable, higher when aggregate patent originality per capita stands for own innovation, and highest when loans to non-financial corporations divided by GDP is the financial development variable. The correlation always exceeds 0.90 in the following instances: between financial development and its interaction with own innovation, between frontier gap and the own innovation variable when loans to non-financial corporations divided by GDP stands for financial development or aggregate patent originality per capita is used for the own innovation variable, and for financial development with its interaction with national patent applications divided by aggregate patent originality.

6.2.6 Own innovation vs. fixed effects

Constant country-specific own innovation variables may be candidates for omitted unobserved country-specific variables behind significant country-specific fixed effects commonly present in panel cross-country studies. The problem is that it is not possible to include both country-specific fixed effects and these variables in the same regression as **X’X** would become nearly singular as PCT applications per capita and average aggregate patent originality per capita are highly correlated with fixed effects. Thus, it is not possible to verify whether country-specific fixed effects are significant in the presence of constant country-specific own innovation variables.

With the regressions in previous sections, it was shown that own technological innovation measures show the correct sign and enjoy high significance in most specifications. This implies that they are relevant for growth regressions. What happens, however, when own technological innovation and imitation variables are removed and replaced by country fixed effects? The own technological innovation variable could be a plausible candidate for replacing abstract fixed effects if the regression results do not change essentially – and here they do not. Further, the similarity of coefficients for own technological innovation variables and estimated fixed effects would support this hypothesis. Indeed, the high correlations between fixed effects and PCT applications per capita and average aggregate patent originality per capita illustrated in Figures 7–8 suggest that the own innovation variables could be plausible candidates for replacing abstract fixed effects.

Figure 7. **PCT Applications Per Capita and fixed effects from OLS regressions *with* initial values as explanatory variables and *without* PCT Applications Per Capita and National Patent Applications divided by PCT Applications, 1960–2007**

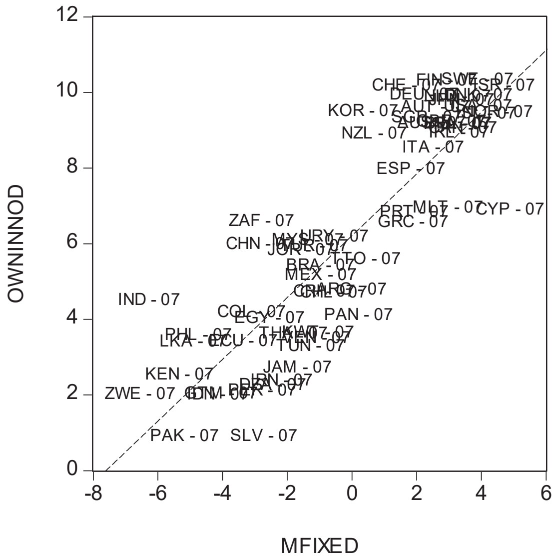
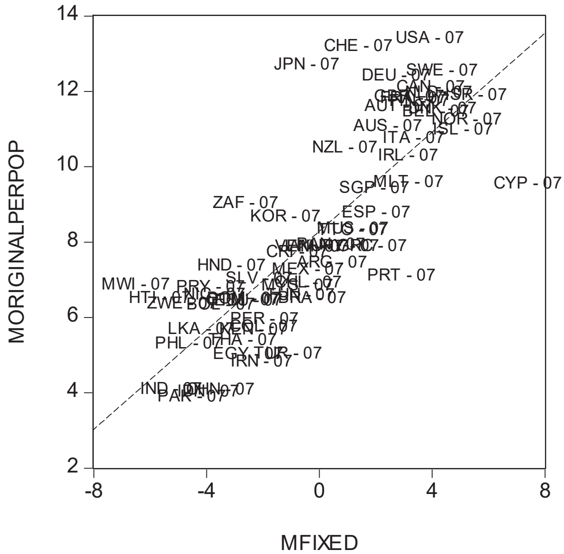


Figure 8. **Average Aggregate Patent Originally Per Capita and fixed effects from GMM regressions *with* initial values as instruments and GLS weights and *without* Average Aggregate Patent Originally Per Capita and Average National Patent Applications divided by Aggregate Patent Originality, 1960–2007**



6.3 Conclusions

This study extended the empirical research of Aghion, Howitt, and Mayer-Foulkes (2005) by examining whether financial development affects growth through more efficient utilization of technological innovations. This hypothesis was based on the notion that a promising growth-enhancing technological innovation is more likely to get the required financing when financial institutions and markets function well.

In estimation of the model, various regression specifications for the data panel were applied. They varied in estimation method, instrumental variables used, measures used, period frequency, and set of countries. The robustness of results was tested in several ways. The sign of the interaction term between financial development and own innovation was usually found to be positive and its coefficient in many cases significant. In the most important specifications, the results show a significant and positive sign for this interaction term. The evidence suggests that the innovation channel of finance is likely to be positively relevant to growth. The positive role is consistent with Aghion and Howitt's (1992) Schumpeterian growth model and its derivatives.

The coefficient for the interaction term of financial intermediation with distance to frontier is found to be significant in many cases, and usually negative. This result provides support for the earlier result of Aghion, Howitt, and Mayer-Foulkes (2005) that financial development strengthens the probability of convergence. The direct effect of the financial development variable is usually found to be negative and significant in many cases. An explanation of this result may be that the indicators used are only correlated with financial development and do not necessarily just reflect sound policies and institutions, but could reflect e.g. over-indebtedness.

The direct effect of the own innovation variable is usually found to be positive and in many cases significant. This result suggests that own innovation is an important component in the growth process. Most robustness tests support the results. There is some conflicting evidence and potential econometric problems, the most serious of which is presence of multicollinearity in the data. However, the big picture suggests that the results are likely to hold and unlikely to be a product of econometric problems as estimation is implemented with many setups and the robustness of results has been tested in a variety of ways.

As a policy implication, availability of finance should be improved particularly in conditions where promising own innovation lacks access to finance. In this respect, innovative start-ups could be one target group as e.g. agency problems can prevent even those with the best prospects from getting access to necessary finance.

The financial crisis has shown that complicated financial products are probably not essential for own innovation. Own innovation should be enhanced by means other than finance as well. For future research, better indicators for financial development should be constructed to obtain more precise results. Indicators such as private credit to GDP used here and in many other studies may not be optimal since they are also correlated with over-indebtedness, which hampers economic growth. Indicators of venture capital finance may be valuable as they are unlikely to be correlated with over-indebtedness. Additionally, the factors affecting own innovation deserve greater investigation. Research and development expenditures, although important, do not necessarily say anything about how effective R&D activities actually are. While human capital obviously plays an important role, explanations beyond traditional education-based measures of human capital are needed. While tertiary education was used as a measure in all the regressions of this study, such standard measures of education are perhaps too broad. It might be more efficient to construct measures of education that clearly relate to own innovation such as natural sciences, technology, or novel problem-solving. Other explanations to check could be own innovation fostering institutional, historical, or cultural factors.

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Appendix

Table 1. **Variable names and explanations**

Variable Name	Explanation
GDPGROWTHOC	Real Per-Capita GDP Growth
DOMESTICCREDOC	Domestic Credit to Private Sector / GDP
LOANSPERGDP	Loans to Non-Financial Corporations / GDP
FRONTIERGAP(-1)	Frontier Gap
DOMESTICCREDOC*FRONTIERGAP(-1)	(Frontier Gap)*(Domestic Credit to Private Sector / GDP)
LOANSPERGDP*FRONTIERGAP(-1)	(Frontier Gap)*(Loans to Non-Financial Corporations / GDP)
OWNINNOD	PCT Applications Per Capita
MORIGINALPERPOP	Average Aggregated Originality Per Capita
ORIGINALPERPOP	Aggregated Originality Per Capita
DOMESTICCREDOC*OWNINNOD	(PCT Applications Per Capita)*(Domestic Credit to Private Sector / GDP)
DOMESTICCREDOC*MORIGINALPERPOP	(Average Aggregated Originality Per Capita)*(Domestic Credit to Private Sector / GDP)
DOMESTICCREDOC*ORIGINALPERPOP	(Aggregated Originality Per Capita)*(Domestic Credit to Private Sector / GDP)
LOANSPERGDP*OWNINNOD	(PCT Applications Per Capita)*(Loans to Non-Financial Corporations / GDP)
LOANSPERGDP*MORIGINALPERPOP	(Average Aggregated Originality Per Capita)*(Loans to Non-Financial Corporations / GDP)
IMITATIOND	National Patent Applications / PCT Applications
MWIPOPERORI	Average National Patent Applications / Aggregated Originality
WIPOPERORI	National Patent Applications / Aggregated Originality
DOMESTICCREDOC*IMITATIOND	(National Patent Applications / PCT Applications)*(Domestic Credit to Private Sector / GDP)
DOMESTICCREDOC*MWIPOPERORI	(Average National Patent Applications / Aggregated Originality)*(Domestic Credit to Private Sector / GDP)
DOMESTICCREDOC*WIPOPERORI	(National Patent Applications / Aggregated Originality)*(Domestic Credit to Private Sector / GDP)

Variable Name	Explanation
LOANSPERGDP*IMITATIOND	(National Patent Applications / PCT Applications)*(Loans to Non-Financial Corporations / GDP)
LOANSPERGDP*MWIPOPERORI	(Average National Patent Applications / Aggregated Originality)*(Loans to Non-Financial Corporations / GDP)
KGROWTHOC	Per-Capita Physical Capital Growth
DOMESTICCREDOC*KGROWTHOC	(Per-Capita Physical Capital Growth)*(Domestic Credit to Private Sector / GDP)
LOANSPERGDP*KGROWTHOC	(Per-Capita Physical Capital Growth)*(Loans to Non-Financial Corporations / GDP)
HUMAN	Human Capital
GOVCONSGDP	Government Consumption / GDP
DOMESTICCREDOCF	Domestic Credit to Private Sector / Trend GDP
LOANSPERGDPF	Loans to Non-Financial Corporations / Trend GDP

7 Effect of venture capital investment in driving economic growth

7.1 Introduction

The ratio of venture capital investment to GDP likely correlates with financial depth.[37] Thus, models of the finance-growth nexus can, in principle, be applied to studies of the effects of venture capital on growth. The use of the venture-capital-investment-to-GDP ratio in measuring financial development may overcome some of the shortcomings of the usual measures: M3 to GDP and private credit to GDP. Even though venture capital investment to GDP is not immune to those problems, it suffers less from such factors as over-indebtedness. Further, analyzing how growth is affected by venture capital allows the study of the effects of a particular form of financial intermediation.

7.1.1 Theoretical considerations and previous studies on venture capital

Modigliani and Miller (1958) propose that financial structure (choice between debt and equity) has no material effect on the value of the firm or the cost or availability of capital. Taxes, bankruptcy costs, agency costs, or asymmetrical information alter this result.

Although activities of banks reduce agency costs and information asymmetries, however, this may not be sufficient for technologically innovative start-ups or small firms where human capital is the main asset. Such firm characteristics are likely to create large information asymmetries and agency costs. Under these circumstances, venture capital (VC) could play a crucial role in financing small firms – a role that banks cannot perform. The relationship between entrepreneur and venture capitalist is essential as it affects the structure of venture financing (Hasan and Wang, 2008).

There is a large body of literature on how venture capital reduces agency problems through e.g. intensive monitoring, phased investment,

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[37] I thank the participants in the 2012 Annual Meeting of the Finnish Economic Association in Vaasa and participants in the Bank of Finland research workshop for their useful comments.

and effective control mechanisms that lower capital constraints. Notable studies include Sahlman (1990), Admati and Pfleiderer (1994), Gompers (1995), Neher (1999), Hamilton (2000), Moskowitz and Vissing-Jorgensen (2002), Kaplan and Stromberg (2001, 2003, and 2004), Gompers and Lerner (2004), as well as Kaplan et al. (2009). Hellman and Puri (2002) find that venture capitalists also participate in managerial services, adopting schemes for stock options, HR policy planning, communication proficiency, strategy planning, etc. Hasan and Wang (2008) find that supply of venture capital is related to US bankruptcy law with company and state level data.

Venture capital necessarily focuses on small and innovative growth companies, and thereby may have an independent role in enhancing total factor productivity. Samila and Sorenson (2011) mention three factors as possible mechanisms through which venture capital can affect economic growth: selection and substitution of companies, positive expectation of success on the part of potential entrepreneurs (demonstration effect), and facilitation of spin-offs (training effect). Additionally, fierce competition from small innovative companies may provoke incumbent corporations to innovate themselves.

There is also a considerable amount of literature on the effect of VC on innovation. Hellman and Puri (2000) compare VC-financed and non-VC-financed companies in Silicon Valley. They find that innovator firms obtain venture capital with higher probability than imitator firms and their results indicate that start-up strategies and success at product marketing are linked to VC. Their study may suffer from causality problems because of unobserved heterogeneity over entrepreneurs such as skills and ambition. Such talent influences the firm's ability to grow and innovate, and simultaneously attract venture capital. (See Kerr, Lerner, and Schoar, 2010.) The same effect might also be caused by the arrival of technological opportunities (Gompers and Lerner, 2001).

Kerr, Lerner and Schoar (2010) control for unobserved heterogeneity of angel-financed and non-angel-financed companies by applying regression discontinuity analysis. In practice, they make comparisons between companies slightly exceeding and companies slightly falling behind the criteria that determine whether a firm obtains funding. They reveal that the growth and survival of startups (measured as website traffic growth) is benefitted by angel financing.

Popov and Roosenboom, (2009b) study how private equity affects the rate of firm entry with data on European firms. They find that private equity investment benefits new business incorporation, especially in industries with naturally higher entry rates and R&D intensity. Data for legislation regulating the private equity investment of pension funds is used as an instrument for private equity.

Popov and Roosenboom (2009a) also consider how private equity finance affects patent applications and patent grants with European cross-country panel data. Using the empirical methodology in Kortum and Lerner (2000), who find venture capital to be associated with an ample increase in the number of patented innovations in US industry-level data, Popov and Roosenboom (2009a) use as instrument for private equity finance the laws regulating investment behavior of pension funds and insurance companies across countries and over time. They conclude that while private equity investment accounts for 8% of aggregate industrial spending, it accounts 12% of industrial innovation.

The results of Kortum and Lerner (2000) showed VC-per-research-and-development-expenditure ratio being less than 3% in the average 1983–1992, but venture capital accounting for 8% of industrial innovation during the same period. Other papers include Lerner et al. (2011), Bernstein et al. (2011), and Seru (2012).

Given the importance of venture capital in financing innovative growth companies and its advantages compared to other indicators of financial development, the paucity of literature on how venture capital affects growth remains is surprising, especially regarding cross-country studies.

In a cross-regional study, Samila and Sorensen (2011) find that venture capital exerts an advantageous influence on firm starts, employment, and aggregate income in a panel of US metropolitan areas using returns to the portfolios of limited partners as instruments. Expectation and spin-off mechanisms from VC to economic growth are consistent with their results.

Ueda and Hirukawa (2011) assess the causality of VC and innovation in the US manufacturing industry by using both total factor productivity and patent counts as measures of innovation. According to their findings, total factor productivity frequently remains positively and significantly linked to future venture capital investments, but not vice versa, indicating that innovations induce VC investment.

Tang and Chyi (2008) find the development of VC industry to significantly enhance TFP growth of Taiwanese industry. A measure for changes in VC-related legislation serves as an instrumental variable for VC development.

Romain and van Pottelsberghe de la Potterie (2004) evaluate VC effects on TFP in a panel of 16 OECD countries during the period 1990–2001. They find that the impact of VC remains larger in comparison to private or public R&D, and conclude that VC affects TFP through the channels of innovation and absorptive capacity.

7.1.2 Purpose and structure of study

This study aims at examining whether venture capital investments (or venture capital investments representing financial development) positively affect growth. It builds on the frame-breaking work of Aghion, Howitt, and Mayer-Foulkes (2005), and the previous stand-alone essay in this thesis on how financial development affects growth through promoting more efficient utilization of technological innovations. The study considers the specific role of venture capital in promoting growth and the use of VC as a measure of financial development. The most important variable is the interaction term between the measure of innovation and venture capital investments. The joint impact related to VC with its interactions is examined as well.

The rest of this study is structured as follows. Section 7.2 describes the data and analyzes stationarity and multicollinearity issues. The section on estimation provides the specification and addresses some methodological issues. The next section presents the results and implements robustness checks. The final section concludes.

7.2 Data

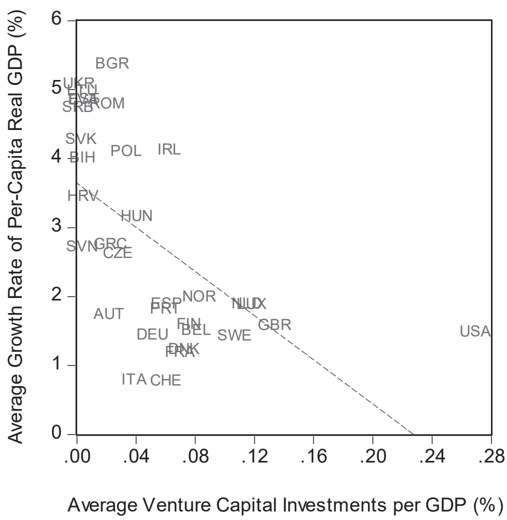
The data consist of panel data on financial, macroeconomic and other indicators. Availability of data on venture capital investments restricts data sample's dimensions in terms of time periods and cross-sectional units. For venture capital investment, the available panel consists of data for the United States and a set of European countries from the turn of the 1990s to 2009. However, the available time period varies by country. Altogether, data has been gathered for 32 countries over the period from 1989 to 2009. The panel includes: Austria, Estonia, Latvia, Lithuania, Belgium, Bulgaria, Czech Republic, Denmark, Bosnia and Herzegovina, Croatia, Serbia, Slovak Republic, Slovenia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland, Ukraine, United Kingdom, and United States. The main data sources are the FVCA,[38] EVCA,[39] and NVCA[40] for venture capital investments; the World Bank WDI for growth of per capita real GDP, real GDP per capita, population, general government final consumption

[38] Finnish Venture Capital Association.
[39] European Private Equity & Venture Capital Association.
[40] National Venture Capital Association.

expenditure, gross investment, and domestic credit to private sector;[41] the OECD for PCT applications filed by domestic resident inventors; Nehru and Dhareshwar (1993) for initial levels of physical capital stock; and Barro and Lee (2010) for average number of years at school. The dataset draws on the original data of the data sources, augmented with author's own calculations where needed.

Mean real GDP per capita growth versus average venture capital investment per GDP in European countries and the United States is laid out in Figure 1. The scatter plot shows an inverse relationship between the variables. There seems to be a positive relationship among developed economies. One reason for this dichotomy could be the fact that growth rates have been high in emerging Europe, where venture capital investments play no significant role in financial intermediation. In western Europe and the US, venture capital investment may generate economic activity that could not have been financed by bank credit. Further, the time period over which the averages are taken varies by country due to data availability. Figure 1 does not control for the effects of other variables on a country's growth process and ignores the possible endogeneity of venture capital investment.

Figure 1. **Venture capital investments and growth in Europe and the US, 1989–2009**



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[41] World Development Indicators.

In the series, with the exception of domestic credit to private sector per GDP and its interaction terms with other variables, the hypothesis for unit root is generally rejected by panel unit root tests. This variable is not central in the study as it is only employed in approximately half of the regressions. Additionally, the hypothesis of unit root is accepted for frontier gap by some tests. In this study, regressions with annual data have a significant number of time periods, but this number is clearly smaller than the number of cross-sections. In regressions with averages over the whole period there is just one time period, implying that time-series properties are unimportant in these specifications.

Overall, non-stationarity may not crucially affect the results in this study. This becomes at least partly verified by the fact that the results of regressions for averages over the full time period are largely in harmony with those for annual observations. Moreover, regressions with first differences are run as robustness checks to control for non-stationarity and whether the relationship is strong enough to stand differencing.

All indicators point to a multicollinearity problem, i.e. the correlation tables, variance inflation factor (VIF), and the condition number of **X’X**. Both indicators revealing contributing variables (correlation tables and VIF) give the same message: correlation exceeds 0.90 and even approaches unity between some variables. These results are hardly surprising as the interaction terms are likely to be correlated with variables that are part of them. However, if coefficients and their standard errors appear plausible and relatively stable across different specifications, multicollinearity is not likely to affect the results here.

7.3 Estimation

7.3.1 Regression equation

Estimation follows the approach adopted in the first essay of this thesis. Basically, the model is Aghion, Howitt and Mayer-Foulkes (2005) in which finance is replaced by venture capital investment to GDP and which is extended by a measure for innovation and its interaction term with venture capital investments to GDP, as well as other variables theoretically and empirically relevant to growth (growth of physical capital stock per capita, log of human capital stock, and government expenditure to GDP). For Aghion, Howitt and Mayer-Foulkes (2005), the catching-up or convergence effect is dependent on financial development, which implies that the technological frontier can be reached by fostering innovation with adequate financial development. An innovation variable is added here to control for differences in innovation rates for reasons other than finance. The interaction term between innovation and venture capital is supposed to capture the effect that venture capital (or financial development) is needed to convert innovations to products and businesses.

The regression equation takes the following form:

$$g_{it} = \beta_0+\beta_1\left(y_{i(t-1)} - y_{1(t-1)}\right)+\beta_2 V_{it}+\beta_3\left(y_{i(t-1)} - y_{1(t-1)}\right)V_{it} +\beta_4 N_{it}+\beta_5 V_{it}N_{it}+\beta_6 k_{it}+\beta_7 h_{it}+\beta_8 G_{it}+\varepsilon_{it} \qquad (11)$$

where

g_{it} is country i's real GDP per capita growth at time t,

$(y_{i(t-1)}-y_{1(t-1)})$ denotes period t–1's gap to the technological frontier (frontier gap) in country i, i.e. logarithmic real GDP per capita – logarithmic real GDP per capita in the United States (assumed technological frontier),

V_{it} is venture capital investments per GDP at time t in country i,

N_{it} is the log of innovation (stock of PCT applications filed by domestic resident inventors per capita) at time t in country i,

k_{it} is growth of per capita physical capital stock (physical capital stock in Nehru and Dhareshwar (1993) extended by the Harberger (1978) method for missing countries, and extended for subsequent periods by adding gross fixed capital formation and subtracting depreciation (normally assumed to be 4% of the physical capital stock)) at time t in country i,

h_{it} is the log of human capital stock (average years of schooling, period of coverage is extended by linear interpolation) at time t in country i,

G_{it} is government expenditure as a percentage of GDP at time t in country i, and

ε_{it} is a disturbance term at time t in country i.

The most important variable is the interaction term between the measure of innovation and venture capital investment to GDP. In addition, the direct effect of venture capital and its interaction with the gap to the technological frontier is of particular interest as the total effect of venture capital on growth is determined by all three variables. Different measures for innovation derived from PCT applications are considered. Private credit per GDP (the traditional financial development measure) and its interactions in some estimations allows for indicative assessment of the relative importance of venture capital with respect to domestic credit to private sector. The regression equation is also estimated with total factor productivity instead of growth of real per capita GDP.

As data on venture capital investments are only available for developed countries, some variables that appear in the first essay but are not relevant for developed countries are omitted here (e.g. the measure of imitation and its interaction term). Interaction of physical capital with financial development has been omitted as it was already established in the first essay to be mostly insignificant. Both studies exclude trade openness as it would have made the sample smaller and did not seem to affect the results of the first essay.

This study aims at examining whether venture capital investment (or venture capital investment representing financial development) positively affects growth. The main hypothesis presumes total impact of venture capital investment per GDP to be positive. The most important component of the total effect is the interaction term of venture capital investment with innovation, which measures venture capital's effect on growth through more efficient utilization of technological innovations. The main hypothesis implies that this term should have a positive and significant sign.

7.3.2 Methodology

In addition to pure cross-sectional analysis, this study utilizes data panels. Panel estimation is implemented with annual observations. The log (average) stock of PCT applications per capita serves as the innovation measure in annual panel analysis, while growth of stock of PCT applications per capita is used in the average-value regressions. Although the latter is probably a better proxy for rate of innovation, it is not used in annual panel-data analysis as its relatively large short-term variance is likely unrelated to economic growth. An average over a longer period makes more sense as changes in actual innovation rate can be quite sticky. As this choice for the innovation-related variable may at least partly make cross-sectional fixed effects unnecessary, cross-sectional and period fixed effects are added only as robustness tests.

The regressions are run with and without private credit per GDP and its interactions. It is useful to consider results with and without them since venture capital investments and domestic credit to private sector are both measures of financial development. Domestic credit to private sector may blur the effect of venture capital investments.

The names of methods follow EViews conventions and their descriptions are obtained from EViews (2013). OLS, GLS, and GMM are used for each regression group. In this study GMM equals two-stage least squares and is used to control for possible endogeneity of venture capital investment and domestic credit to private sector. The variation in GLS and GMM specifications depends on whether annual panel or one cross-section (country averages) is used. With panel data, GLS is estimated with cross-section weights using White period standard errors, and GLS with period weights is estimated with White cross-section standard errors. GMM IV is estimated with no GLS weights, GLS cross-section weights using White period standard errors, and GLS period weights using White cross-section standard errors. With country averages, GLS is estimated with cross-section weights. White diagonal standard errors are also used in addition to regular standard errors. GMM IV is estimated with no GLS weights, GLS cross-section weights and by additionally using White diagonal standard errors. With GLS (cross-section or period weights), the data are first transformed to eliminate cross-sectional or period-wise heteroscedasticity in the error term. White diagonal standard errors preserve consistency under heteroscedastic errors, White cross-section standard errors preserve consistency under heteroscedasticity and contemporaneous correlation, and White period standard errors preserve consistency under heteroscedasticity and autocorrelation.

In panel regressions, the most appropriate specifications are those with White period standard errors and GLS cross-section weights. In cross-sectional regression, those with GLS cross-section weights are most important. Even so, it is also useful in assessing robustness to compare results obtained using different standard errors and GLS transformations.

In another dimension, the most appropriate specifications are those with instrumental variables as they control for endogeneity. With IV estimation of the annual panel, a once-lagged value of venture capital investment is used as instrument for venture capital investment and once-lagged private credit as instrument for private credit. For pure cross-sectional analysis, the role of instruments is played by the initial values of the two variables. Even the interaction terms of the two variables with other variables are instrumented. Instruments for the interaction terms are generated by replacing venture capital investment or domestic credit to private sector by its lagged or initial value in the original interaction term. Arellano-Bond-type regressions (Arellano and Bond, 1991) are run as the robustness test. The instruments based on lagged or initial values of venture capital investment and domestic credit to private sector should be relevant since they are strongly correlated with the original variables.

The validity (exogeneity) of instruments is controlled with a Sargan/Hansen J-test (p-value of J-statistic). As the J-test requires that the number of instruments exceeds the number of variables, the set of instruments is augmented with lagged log human capital in the annual panels and with initial log human capital in the cross-sectional regressions. In case of annual panels, other reported results than the J-test are for regressions that do not include the lagged log human capital as instrument. These results do not materially differ from the non-reported results of regressions that include the additional instrument. In case of cross-sectional analysis, all the reported results (for specifications where the J-test is reported) are for regressions that include initial log human capital as instrument. The reason for reporting the results of specifications including initial log human capital as instrument is that this inclusion tends to decrease standard errors, particularly for specifications where domestic credit to private sector is included as an explanatory variable.

A Wu-Hausman test is used to check whether regressions could have been run with least squares in the first place. An interpretation of financial development as a manifestation of cumulative money supply growth in excess of nominal GDP growth reduces the risk of endogeneity. However, since GDP per capita forms part of the dependent variable and lagged GDP per capita forms part of the explanatory variable frontier gap, it is possible that this, combined with autocorrelation in disturbances, could render the least squares estimator biased and inconsistent. Autocorrelation is measured by the reported Durbin-Watson statistic and the Ljung-Box Q-statistic. Since the Q-statistic is calculated for several lags, these results are not reported in the tables.

7.4 Results

7.4.1 General

The first six columns of Table 1 show results of regressions that include only a constant, venture capital investment to GDP, and initial frontier gap. The coefficient for venture capital investment to GDP gains significance only in GMM specifications with GLS cross-section weights. These two specifications are the most important. The two other variables are highly significant across all specifications and R^2 is very high, especially with efficient estimation. The J-test cannot be applied because the number of available instruments does not exceed the number of variables. As this regression equation is quite simple, serious caution is needed reaching any conclusions.

The remaining columns of Table 1 show results of regressions similar to those of Aghion, Howitt, and Mayer-Foulkes (2005). Here, private credit per GDP and its interaction with the initial frontier gap is replaced by venture capital investment to GDP and its interaction with the initial frontier gap. In the same table, results of these regressions complemented with the substituted Aghion, Howitt, and Mayer-Foulkes (2005) variables are also presented. These analyses exclude innovation and its interactions, as well as control variables. The estimation is carried out in a cross-section where variables are averages and initial values are used as instruments. The time period over which the averages are taken varies somewhat by country because of data availability. In GMM specifications including domestic credit to private sector, no variables are statistically significant due to high standard errors. This may be caused by multicollinearity, suggesting further analysis would be unreasonable.

Regarding the remaining columns of Table 1, the direct effect of venture capital investment to GDP is positive and significant in efficient estimation specifications in all cases except in one non-IV specification. The initial frontier gap is always negative and highly significant. The interaction of these variables usually shows a positive sign. It is significant only with efficient non-IV estimation in specifications that include domestic credit to private sector. Except in one non-IV specification, the total effect of venture capital investment to GDP is always positive with efficient estimation. It is computed as the sum of products of statistically significant coefficients including venture capital investment to GDP with sample means of corresponding variables. The coefficient for private credit per GDP remains negative and significant when efficient estimation is applied. Its interaction with the initial frontier gap behaves in the same way. R^2 is quite high, especially with efficient estimation.

Overall, the results indicate that venture capital investments are beneficial for growth and there is conditional convergence as far as direct effects of these variables are concerned. In general, the results seem to be somewhat different from those obtained by Aghion, Howitt and Mayer-Foulkes (2005), who found the direct impact of private credit per GDP to be insignificant, initial frontier gap mostly positive and insignificant, and the interaction of the two variables to be negative and significant in about half of their specifications. Here, the interaction between domestic credit to private sector and initial frontier gap is also negative and significant (with efficient estimation). The differences could be the result of differences in the data, sets of variables used, or estimation methods.

Table 2 presents results of regressions augmented with innovation, its interactions, and some control variables. Table 3 shows coefficients from regressions as in Table 2, but in annual panels and with lagged values as instruments. In Table 4, real GDP per capita growth is replaced by total factor productivity in the role of dependent variable, and frontier gap refers to productivity gap. Corresponding total-factor-productivity regressions are run for the cross-section of average values. These results are not reported, but are quite similar to those with per capita real GDP growth. Estimations in Table 2 use growth of PCT applications per capita as innovation, and Tables 3 and 4 apply the log average stock of PCT applications per capita. Substituting the log stock of PCT applications per capita in Tables 3 and 4 has little impact on the results, so those results are not reported here. The log stock of PCT applications per capita is used in some robustness tests.

In general, R^2 is quite high across different specifications. It is higher in GLS than OLS specifications, and usually higher with country averages than annual panel observations. The results of regressions with total factor productivity as dependent variable are close to those with per capita real GDP growth.

The Durbin-Watson statistic indicates that some first-order autocorrelation is present in the annual panel specifications. The Ljung-Box Q-statistic also provides an indication of autocorrelation. Since the Q-statistic is calculated for several lags, these results are not reported in the tables. Convincingly, the signs of the coefficients for venture capital investments to GDP and its interaction with innovation obtained by pure cross-sectional analysis that do not suffer from autocorrelation are always the same as those obtained by the annual panel estimation. While these coefficients are always statistically significant in annual panels, they are also usually significant in cross-sectional analysis with efficient estimation. In all specifications, J-tests accept the validity of the instruments used. The only specifications where the Wu-Hausman test does not reject the use of OLS are the country-average regressions (Table 2). In the sections 7.4.2 and 7.4.3, the results presented in Tables 2, 3, and 4 are further analyzed.

7.4.2 Venture capital and its interaction terms with other variables

The sign of interaction term between venture capital investments to GDP and innovation is positive. It should be positive if venture capital investments affect growth through more efficient utilization of technological innovations. In the average-value regressions (Table 2), its coefficient is statistically significant in all efficient-estimation specifications (although in one IV specification with regular standard errors only at the 10% level). In the panel data analysis (Tables 3 and 4), its coefficient is statistically significant in all regressions. It appears that the magnitude of the coefficient is usually somewhat larger with IV estimation. It is roughly double in comparison to non-IV in average-value GLS specifications where domestic credit to private sector and its interactions are included. Further, inclusion of these variables makes the non-IV GLS coefficients roughly double in average-value regressions. In the panel data estimation, inclusion of domestic credit to private sector and its interactions does not seem to have a material effect on the coefficients, which is not that surprising considering that they are always statistically insignificant. In average-value specifications, the efficient-estimation interactions are always negative and statistically significant. In general, the coefficients are quite similar in all panel data specifications across econometric techniques. Their magnitudes cannot be directly compared to those obtained from average-value regressions as the own innovation variables are different.

Table 1. Average-value regressions with Growth Rate of Per Capita Real GDP as dependent variable

	Dependent Variable: Average Growth Rate of Per-Capita Real GDP, 1989–2009																	
	OLS	GLS, cross-section weights	GLS, cross-section weights White diagonal s.e.	GMM, IV	GMM, IV, GLS cross-section weights	GMM, IV, GLS cross-section weights, White diagonal s.e.	OLS	GLS, cross-section weights	GLS, cross-section weights, White diagonal s.e.	GMM, IV	GMM, IV, GLS cross-section weights	GMM, IV, GLS cross-section weights, White diagonal s.e.	OLS	GLS, cross-section weights	GLS, cross-section weights, White diagonal s.e.	GMM, IV	GMM, IV, GLS cross-section weights	GMM, IV, GLS cross-section weights, White diagonal s.e.
Constant	1.35***	1.26***	1.26***	1.26**	1.25***	1.25***	1.38***	1.22***	1.22***	1.25**	1.25***	1.25***	1.68**	1.67***	1.67***	5.24	59.70	59.70
	(0.35)	(0.05)	(0.02)	(0.48)	(0.01)	(0.01)	(0.36)	(0.07)	(0.04)	(0.47)	(0.01)	(0.00)	(0.65)	(0.24)	(0.23)	(4.28)	(1211.11)	(2058.74)
Venture Capital Investments / GDP	-0.25	0.27	0.27	0.71	0.85***	0.85***	-0.14	0.78	0.78**	0.93	0.85***	0.85***	3.11	3.48***	3.48***	20.92	-219.22	-219.22
	(3.10)	(0.50)	(0.40)	(4.76)	(0.11)	(0.03)	(3.17)	(0.60)	(0.29)	(4.41)	(0.11)	(0.04)	(4.58)	(0.63)	(0.46)	(22.54)	(5156.40)	(8840.24)
Initial Frontier Gap	-1.10***	-1.15***	-1.15***	-1.13***	-1.14***	-1.14***	-1.11***	-1.18***	-1.18***	-1.14***	-1.14***	-1.14***	-0.84***	-0.78***	-0.78***	-1.15	-16.42	-16.42
	(0.14)	(0.03)	(0.02)	(0.18)	(0.02)	(0.01)	(0.15)	(0.05)	(0.04)	(0.18)	(0.02)	(0.02)	(0.28)	(0.13)	(0.15)	(0.91)	(332.00)	(566.87)
(Venture Capital Investments / GDP)*(Initial Frontier Gap)							1.69	2.06	2.06	0.56	-0.10	-0.10	4.27	6.12**	6.12**	19.39	-113.97	-113.97
							(5.17)	(1.65)	(1.36)	(6.56)	(1.22)	(0.94)	(5.74)	(2.24)	(2.22)	(22.70)	(2925.74)	(5058.43)
Domestic Credit to Private Sector / GDP													-0.01	-0.01***	-0.01***	-0.04	-0.21	-0.21
													(0.01)	(0.00)	(0.00)	(0.04)	(3.86)	(6.40)
(Domestic Credit to Private Sector / GDP)*(Initial Frontier Gap)													-0.01	-0.01**	-0.01**	0.02	0.91	0.91
													(0.01)	(0.00)	(0.00)	(0.04)	(19.54)	(33.35)
Total Effect of Venture Capital Investments / GDP							0.00	0.00	0.04	0.00	0.04	0.04	0.00	0.01	0.01	0.00	0.00	0.00
R-squared	0.79	0.98	0.98	0.78	0.99	0.99	0.79	0.97	0.97	0.79	0.99	0.99	0.80	0.94	0.94	0.12	-66.10	-66.10
Periods	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cross-sections	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
Total observations	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32

Notes: *** significant at 1% level, ** significant at 5% level, * significant at 10% level, (standard errors in parentheses).
Independent variables excluding initial frontier gap are averages. The time period over which the averages are taken varies somewhat by country because of data availability.
Initial value for venture capital investments / GDP and domestic credit to private sector / GDP used as instruments.
Total effect of venture capital investments / GDP is computed as the sum of products of statistically significant coefficients including venture capital investments / GDP with sample means of corresponding variables.

Table 2. **Average-value regressions with Growth Rate of Per Capita Real GDP as dependent variable and Growth of PCT Applications Per Capita as innovation variable**

	Dependent Variable: Average Growth Rate of Per-Capita Real GDP, 1989-2009											
	OLS	GLS, cross-section weights	GLS, cross-section weights, White diagonal s.e.	GMM, IV	GMM, IV, GLS cross-section weights	GMM, IV, GLS cross-section weights, White diagonal s.e.	OLS	GLS, cross-section weights	GLS, cross-section weights, White diagonal s.e.	GMM, IV	GMM, IV, GLS cross-section weights	GMM, IV, GLS cross-section weights, White diagonal s.e.
Constant	-4.01**	-3.86***	-3.86***	-3.30*	-2.12***	-2.12***	-3.64*	-3.27***	-3.27***	-1.30	-0.80	-0.80
	(1.59)	(0.67)	(0.77)	(1.71)	(0.70)	(0.60)	(2.06)	(0.80)	(0.70)	(5.36)	(1.36)	(1.23)
Venture Capital Investments / GDP	-6.06	-8.32***	-8.32***	-6.46	-3.18	-3.18	-8.93	-13.96***	-13.96***	-26.70	-24.89**	-24.89***
	(7.69)	(2.43)	(1.75)	(11.24)	(4.21)	(3.72)	(10.45)	(3.64)	(2.88)	(21.73)	(10.10)	(7.99)
Initial Frontier Gap	-0.41**	-0.41***	-0.41***	-0.50***	-0.48***	-0.48***	-0.16	-0.02	-0.02	0.86	0.60**	0.60***
	(0.15)	(0.02)	(0.03)	(0.16)	(0.04)	(0.03)	(0.31)	(0.11)	(0.09)	(0.91)	(0.25)	(0.20)
(Venture Capital Investments / GDP)*(Initial Frontier Gap)	0.12	0.05	0.05	3.46	2.10	2.10	3.53	3.95	3.95*	18.05	18.92***	18.92***
	(4.70)	(1.65)	(1.28)	(5.85)	(2.05)	(1.69)	(6.19)	(2.32)	(1.96)	(12.23)	(5.54)	(5.34)
Growth of PCT Applications Per Capita	-0.02	-0.02***	-0.02***	-0.02	-0.02***	-0.02***	-0.01	0.02	0.02	0.09	0.06	0.06*
	(0.02)	(0.00)	(0.00)	(0.02)	(0.01)	(0.01)	(0.03)	(0.02)	(0.01)	(0.09)	(0.04)	(0.03)
(Venture Capital Investments / GDP)*(Growth of PCT Applications Per Capita)	0.28	0.37**	0.37***	0.48	0.31*	0.31**	0.60	0.96***	0.96***	2.48	2.36***	2.36***
	(0.47)	(0.13)	(0.10)	(0.67)	(0.17)	(0.15)	(0.71)	(0.26)	(0.20)	(1.53)	(0.77)	(0.62)
Domestic Credit to Private Sector / GDP							0.00	0.01	0.01	0.03	0.02*	0.02**
							(0.01)	(0.01)	(0.00)	(0.03)	(0.01)	(0.01)
(Domestic Credit to Private Sector / GDP)*(Initial Frontier Gap)							-0.01	-0.01***	-0.01***	-0.03	-0.03***	-0.03***
							(0.01)	(0.00)	(0.00)	(0.02)	(0.01)	(0.01)
(Domestic Credit to Private Sector / GDP)*(Growth of PCT Applications Per Capita)							0.00	0.00**	0.00***	0.00	0.00***	0.00***
							(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Dependent Variable: Average Growth Rate of Per-Capita Real GDP, 1989-2009

	OLS	GLS, cross-section weights	GLS, cross-section weights, White diagonal s.e.	GMM, IV	GMM, IV, GLS cross-section weights	GMM, IV, GLS cross-section weights, White diagonal s.e.	OLS	GLS, cross-section weights	GLS, cross-section weights, White diagonal s.e.	GMM, IV	GMM, IV, GLS cross-section weights	GMM, IV, GLS cross-section weights, White diagonal s.e.
Growth of Physical Capital Per Capita	0.43***	0.44***	0.44***	0.44***	0.47***	0.47***	0.43***	0.42***	0.42***	0.51***	0.52***	0.52***
	(0.07)	(0.02)	(0.02)	(0.07)	(0.02)	(0.01)	(0.08)	(0.03)	(0.02)	(0.12)	(0.03)	(0.03)
Log Human Capital	2.05***	2.00***	2.00***	1.69**	1.12***	1.12***	2.03**	1.83***	1.83***	1.26	1.07**	1.07***
	(0.64)	(0.26)	(0.34)	(0.69)	(0.25)	(0.16)	(0.72)	(0.25)	(0.20)	(1.56)	(0.40)	(0.35)
Government Consumption / GDP	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.02	-0.02*	-0.08	-0.07***	-0.07***
	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.03)	(0.01)	(0.01)	(0.06)	(0.02)	(0.02)
Total Effect of Venture Capital Investments / GDP	0.00	-0.10	-0.10	0.00	0.00	0.28	0.00	0.15	0.15	0.00	0.33	0.33
R-squared	0.94	1.00	1.00	0.93	0.99	0.99	0.94	1.00	1.00	0.88	1.00	1.00
Periods	1	1	1	1	1	1	1	1	1	1	1	1
Cross-sections	32	32	32	32	32	32	32	32	32	32	32	32
Total observations	32	32	32	32	32	32	32	32	32	32	32	32
J-statistic				0.46	1.85	1.85				0.05	0.06	0.06
P-value				0.50	0.17	0.17				0.83	0.81	0.81
Wu-Hausman statistic				2.02						0.82		
P-value				0.14						0.57		

Notes: *** significant at 1% level, ** significant at 5% level, * significant at 10% level, (standard errors in parentheses).
Independent variables excluding initial frontier gap are averages. The time period over which the averages are taken varies somewhat by country because of data availability.
Initial value of venture capital investments / GDP and domestic credit to private sector / GDP used as instruments for these variables. Initial log human capital is included in the set of instruments.
Total effect of venture capital investments / GDP is computed as the sum of products of statistically significant coefficients including venture capital investments / GDP with sample means of corresponding variables.

Table 3. **Annual-frequency regressions with Growth Rate of Per Capita Real GDP as dependent variable and Log Average PCT Applications Per Capita as innovation variable**

Dependent Variable: Annual Growth Rate of Per-Capita Real GDP, 1989-2009												
	OLS	GLS, cross-section weights, White period s.e.	GLS, period weights, White cross-section s.e.	GMM, IV	GMM, IV, GLS cross-section weights, White period s.e.	GMM, IV, GLS period weights, White cross-section s.e.	OLS	GLS, cross-section weights, White period s.e.	GLS, period weights, White cross-section s.e.	GMM, IV	GMM, IV, GLS cross-section weights, White period s.e.	GMM, IV, GLS period weights, White cross-section s.e.
Constant	0.01	1.71	-1.81**	0.30	1.73	-0.50	-1.09	0.69	-3.16**	-0.67	1.10	-1.54
	(1.46)	(1.55)	(0.87)	(1.72)	(1.26)	(1.10)	(2.24)	(1.66)	(1.59)	(2.36)	(2.01)	(1.27)
Venture Capital Investments / GDP	-54.83***	-54.40***	-43.70***	-71.21***	-70.03***	-59.40***	-50.80***	-59.68***	-41.50***	-70.45***	-79.55***	-59.28***
	(17.93)	(12.93)	(10.95)	(23.50)	(15.26)	(14.41)	(18.22)	(14.59)	(10.49)	(24.46)	(18.10)	(16.10)
Frontier Gap (-1)	0.60***	0.72***	0.35**	0.79***	0.88***	0.48**	0.53*	0.70***	0.20	0.78**	0.93***	0.46**
	(0.17)	(0.19)	(0.15)	(0.20)	(0.12)	(0.19)	(0.29)	(0.24)	(0.23)	(0.31)	(0.28)	(0.18)
(Venture Capital Investments / GDP)*(Frontier Gap (-1))	-9.81***	-8.18***	-7.58***	-10.49***	-7.83***	-6.21*	-8.59***	-8.25***	-7.01***	-9.63***	-8.79***	-5.73
	(2.36)	(1.41)	(1.76)	(3.46)	(2.20)	(3.49)	(2.37)	(1.66)	(1.59)	(3.51)	(2.70)	(3.68)
Log Average PCT Applications Per Capita	-0.12	-0.20*	-0.03	-0.23**	-0.30***	-0.10	-0.01	-0.13	0.11	-0.13	-0.25*	0.00
	(0.09)	(0.11)	(0.07)	(0.10)	(0.08)	(0.08)	(0.14)	(0.12)	(0.11)	(0.14)	(0.14)	(0.08)
(Venture Capital Investments / GDP)*(Log Average PCT Applications Per Capita)	3.35***	3.33***	2.67***	4.34***	4.27***	3.63***	3.15***	3.69***	2.57***	4.36***	4.89***	3.68***
	(1.11)	(0.81)	(0.68)	(1.45)	(0.95)	(0.88)	(1.12)	(0.91)	(0.65)	(1.51)	(1.14)	(0.98)
Domestic Credit to Private Sector / GDP							0.02	0.01	0.02	0.02	0.01	0.01
							(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.01)
(Domestic Credit to Private Sector / GDP)*(Frontier Gap (-1))							0.00	0.00	0.00	0.00	0.00	0.00
							(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Dependent Variable: Annual Growth Rate of Per-Capita Real GDP, 1989-2009												
	OLS	GLS, cross-section weights, White period s.e.	GLS, period weights, White cross-section s.e.	GMM, IV	GMM, IV, GLS cross-section weights, White period s.e.	GMM, IV, GLS period weights, White cross-section s.e.	OLS	GLS, cross-section weights, White period s.e.	GLS, period weights, White cross-section s.e.	GMM, IV	GMM, IV, GLS cross-section weights, White period s.e.	GMM, IV, GLS period weights, White cross-section s.e.
(Domestic Credit to Private Sector / GDP)*(Log Average PCT Applications Per Capita)							0.00	0.00	0.00	0.00	0.00	0.00
							(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Growth of Physical Capital Per Capita	0.81***	0.83***	0.81***	0.82***	0.83***	0.82***	0.80***	0.82***	0.80***	0.81***	0.83***	0.81***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
Log Human Capital	0.77**	0.51	0.75***	1.35***	1.16***	0.70*	0.85**	0.64*	0.67**	1.39***	1.28***	0.69**
	(0.36)	(0.40)	(0.28)	(0.37)	(0.33)	(0.37)	(0.36)	(0.38)	(0.27)	(0.38)	(0.38)	(0.34)
Government Consumption / GDP	-0.03**	-0.02	-0.01	-0.02*	-0.02	0.00	-0.04**	-0.02	-0.02**	-0.03**	-0.02	-0.02**
	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Total Effect of Venture Capital Investments / GDP	0.08	0.05	0.06	0.03	-0.03	-0.21	0.11	0.07	0.09	0.08	0.00	-0.15
R-squared	0.92	0.92	0.92	0.93	0.93	0.94	0.92	0.94	0.95	0.93	0.96	0.95
Periods	21	21	21	20	20	20	21	21	21	20	20	20
Cross-sections	32	32	32	32	32	32	32	32	32	32	32	32
Total observations	440	440	440	408	408	408	434	434	434	402	402	402
Durbin-Watson	0.81	0.89	0.63	0.91	0.99	0.67	0.86	0.90	0.70	0.95	1.03	0.72
J-statistic				0.04	0.09	0.30				0.78	1.18	2.26
P-value				0.83	0.76	0.58				0.38	0.28	0.13
Wu-Hausman statistic				13.19						7.04		
P-value				0.00						0.00		

Notes: *** significant at 1% level, ** significant at 5% level, * significant at 10% level, (standard errors in parentheses).
Lagged value of venture capital investments / GDP and domestic credit to private sector / GDP used as instruments for these variables.
Total effect of venture capital investments / GDP is computed as the sum of products of statistically significant coefficients including venture capital investments / GDP with sample means of corresponding variables.
Reported J-statistics and their p-values are obtained by augmenting the set of instruments with lagged log human capital. Other results of these augmented regressions are not reported, but they do not materially differ from the results reported in this table.

Table 4. **Annual-frequency regressions with Growth Rate of Total Factor Productivity as dependent variable and Log Average PCT Applications Per Capita as innovation variable**

	Dependent Variable: Annual Growth Rate of Total Factor Productivity, 1989-2009											
	OLS	GLS, cross-section weights, White period s.e.	GLS, period weights, White cross-section s.e.	GMM, IV	GMM, IV, GLS cross-section weights, White period s.e.	GMM, IV, GLS period weights, White cross-section s.e.	OLS	GLS, cross-section weights, White period s.e.	GLS, period weights, White cross-section s.e.	GMM, IV	GMM, IV, GLS cross-section weights, White period s.e.	GMM, IV, GLS period weights, White cross-section s.e.
Constant	-0.87	0.77	-2.17**	-0.78	1.28	-1.12	-2.21	-0.57	-3.34**	-1.82	-0.39	-1.87
	(1.47)	(1.82)	(0.85)	(1.71)	(1.60)	(1.08)	(2.25)	(2.14)	(1.57)	(2.37)	(2.24)	(1.36)
Venture Capital Investments / GDP	-42.96**	-43.48***	-35.88***	-56.14**	-60.34***	-49.07***	-41.28**	-51.24***	-33.56***	-57.34**	-74.18***	-47.49***
	(17.47)	(12.89)	(9.36)	(22.58)	(15.64)	(12.29)	(17.80)	(14.30)	(8.84)	(23.73)	(19.96)	(13.19)
Frontier Gap (-1)	0.81***	0.95***	0.46*	1.10***	1.40***	0.63**	0.62	0.83*	0.21	1.04**	1.23**	0.61**
	(0.26)	(0.35)	(0.24)	(0.30)	(0.30)	(0.28)	(0.44)	(0.49)	(0.36)	(0.47)	(0.48)	(0.29)
(Venture Capital Investments / GDP)*(Frontier Gap (-1))	-13.87***	-11.33***	-10.45***	-15.59***	-12.11***	-8.87**	-12.70***	-12.04***	-9.75***	-14.83***	-14.00***	-7.85*
	(3.36)	(1.82)	(2.33)	(4.82)	(2.72)	(4.31)	(3.39)	(2.09)	(2.13)	(4.96)	(3.81)	(4.47)
Log Average PCT Applications Per Capita	-0.03	-0.11	0.03	-0.13	-0.24**	-0.04	0.10	-0.01	0.16	-0.03	-0.13	0.05
	(0.09)	(0.12)	(0.06)	(0.10)	(0.11)	(0.07)	(0.14)	(0.15)	(0.10)	(0.14)	(0.15)	(0.08)
(Venture Capital Investments / GDP)*(Log Average PCT Applications Per Capita)	2.60**	2.66***	2.18***	3.40**	3.67***	2.99***	2.54**	3.17***	2.08***	3.53**	4.55***	2.95***
	(1.08)	(0.80)	(0.58)	(1.39)	(0.97)	(0.75)	(1.10)	(0.89)	(0.55)	(1.46)	(1.25)	(0.80)
Domestic Credit to Private Sector / GDP							0.02	0.02	0.02	0.02	0.03	0.01
							(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.01)
(Domestic Credit to Private Sector / GDP)*(Frontier Gap (-1))							0.01	0.00	0.01	0.00	0.00	0.00
							(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)
(Domestic Credit to Private Sector / GDP)*(Log Average PCT Applications Per Capita)							0.00	0.00	0.00	0.00	0.00	0.00
							(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Dependent Variable: Annual Growth Rate of Total Factor Productivity, 1989-2009

	OLS	GLS, cross-section weights, White period s.e.	GLS, period weights, White cross-section s.e.	GMM, IV	GMM, IV, GLS cross-section weights, White period s.e.	GMM, IV, GLS period weights, White cross-section s.e.	OLS	GLS, cross-section weights, White period s.e.	GLS, period weights, White cross-section s.e.	GMM, IV	GMM, IV, GLS cross-section weights, White period s.e.	GMM, IV, GLS period weights, White cross-section s.e.
Growth of Physical Capital Per Capita	0.49***	0.50***	0.46***	0.49***	0.51***	0.47***	0.47***	0.48***	0.45***	0.48***	0.50***	0.46***
	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
Log Human Capital	0.51	0.22	0.52*	1.10***	0.93***	0.50	0.54	0.36	0.39	1.10***	1.02**	0.47
	(0.35)	(0.40)	(0.27)	(0.37)	(0.34)	(0.34)	(0.37)	(0.42)	(0.25)	(0.38)	(0.40)	(0.31)
Government Consumption / GDP	-0.03**	-0.02	-0.01	-0.02	-0.01	0.00	-0.04**	-0.02*	-0.02**	-0.03**	-0.02	-0.01**
	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Total Effect of Venture Capital Investments / GDP	0.22	0.17	0.16	0.22	0.11	0.07	0.24	0.20	0.19	0.26	0.16	-0.12
R-squared	0.80	0.84	0.84	0.83	0.87	0.84	0.81	0.85	0.84	0.83	0.87	0.85
Periods	21	21	21	20	20	20	21	21	21	20	20	20
Cross-sections	32	32	32	32	32	32	32	32	32	32	32	32
Total observations	440	440	440	408	408	408	434	434	434	402	402	402
Durbin-Watson	0.75	0.84	0.59	0.83	0.94	0.62	0.80	0.85	0.66	0.87	0.99	0.67
J-statistic				0.00	0.01	0.07				0.34	0.50	1.38
P-value				0.97	0.93	0.79				0.56	0.48	0.24
Wu-Hausman statistic				5.90						4.91		
P-value				0.00						0.00		

Notes: *** significant at 1% level, ** significant at 5% level, * significant at 10% level, (standard errors in parentheses).
Lagged value of venture capital investments / GDP and domestic credit to private sector / GDP used as instruments for these variables.
Total effect of venture capital investments / GDP is computed as the sum of products of statistically significant coefficients including venture capital investments / GDP with sample means of corresponding variables.
Reported J-statistics and their p-values are obtained by augmenting the set of instruments with lagged log human capital. Other results of these augmented regressions are not reported, but they do not materially differ from the results reported in this table.

The coefficient of the interaction variable between venture capital investment to GDP and frontier gap is always positive in average-value specifications, but statistically significant only in efficient IV-specifications when domestic credit to private sector and its interactions are included. In annual panel analysis, the coefficient is always negative and almost always statistically significant. Aghion, Howitt, and Mayer-Foulkes (2005) argue that the coefficient should be negative so that financial development strengthens the convergence probability. They find its sign significantly negative. Further, the sign of venture capital investment to GDP (direct effect) is always negative. The coefficient is statistically significant with efficient estimation in average-value regressions, except with instrumental variables when domestic credit to private sector and its interactions are not included. In annual panel regressions it is always significant. Aghion, Howitt and Mayer-Foulkes (2005) argue that this sign should be zero since long-term growth is no longer affected by financial development in the leading economy (or economies). However, their coefficients also have a negative sign, but are all insignificant.

To get a view of the magnitude of the effect on growth of venture capital investment to GDP, the joint effect of it and its interactions with frontier gap and innovation should be considered. The total effect of venture capital investment to GDP reported in the tables gives insight into this joint effect. It is computed as the sum of products of statistically significant coefficients including venture capital investments per GDP with sample means of corresponding variables.

In Table 2, the only negative total effects are obtained without instrumental variables with efficient estimation excluding private credit per GDP and its interactions. Using instrumental variables in efficient specifications, the corresponding total effect becomes positive with robust standard errors. The total effect becomes zero in the efficient regular standard error specification with instrumental variables that excludes domestic credit to private sector and its interactions. In that case, the interaction between venture capital investment to GDP and innovation is significant only at the 10% level. In the specifications including domestic credit to private sector to GDP and its interactions, the total effect is always positive with efficient estimation in average-value regressions.

In Table 4, all the total effects are positive except in the last column. In this specification, the coefficient for interaction term between venture capital investments to GDP and frontier gap is not statistically significant at 5% level and thus is dropped out in computing the total effect, which makes it turn negative. The only serious conflicting evidence is Table 3, where efficient IV estimation produces negative signs for the total effect. Yet it can be concluded that the joint effect of venture capital investments and its interactions remains positive in most specifications.

The total effects in Table 2 are considerably larger with efficient IV estimation than without. The total effects are zero without efficient estimation. Inclusion of domestic credit and its interactions makes the total effect always positive with efficient estimation. On the other hand, there is not much difference in Tables 3 and 4 between positive total effects produced by IV and non-IV estimation or by efficient and non-efficient estimation. Further, inclusion of domestic credit and its interactions does not seem to influence the total effect much. The magnitude of the joint effect on economic growth in Table 2 varies from 0.15 to 0.33 (0.28–0.33 in efficient IV with standard errors robust to heteroscedasticity) and in Table 3 from 0.03 to 0.11 where positive. Further, the joint impact on total factor productivity growth in Table 4 varies from 0.07 to 0.26 (0.11–0.16 in efficient IV with standard errors robust to heteroscedasticity and autocorrelation) where positive. The effect on total factor productivity seems to be somewhat larger than on GDP growth if judged by annual panels. However, some larger values for the effect on GDP growth are obtained by average-value regressions. Thus, assuming sample means of frontier gap and innovation, beginning at zero and going to sample mean of venture capital investment to GDP implies an increase of 0.03–0.33 percentage points (0.28–0.33 according to the most important specifications) in growth rate per capita real GDP or 0.07–0.26 percentage points (0.11–0.16 according to the most important specifications) in growth rate of total factor productivity. Despite some differences in magnitudes across different specifications, the in-most-specifications-positive total effect of venture capital is unlikely to be a result of potential estimation problems.

7.4.3 Other variables

The sign of innovation variable (direct effect) varies but it is usually negative when domestic credit to private sector and its interactions are not included. When they are, the number of positive signs increases. In average-value regressions, the coefficient is statistically significant in efficient estimation without domestic credit to private sector and its interactions. In panel data analysis, the coefficient is significant only without domestic credit to private sector and its interactions in efficient IV estimation using standard errors robust to heteroscedasticity and autocorrelation (even in regular IV if GDP growth per capita is the dependent variable). Countries in the sample are either developed (less growth) or catching-up (more growth), but not high-poverty countries with slow growth. Thus, the sign of the innovation variable could be a victim of the fact that a high rate of innovation is usually a feature of developed economies with less growth than that observed in catching-up countries. In average-value regressions, the coefficient of the frontier gap is negative in other cases than in IV estimation with domestic credit to private sector and its interactions, where it is positive. Without domestic credit to private sector, it is always significant; with them, only in efficient IV. In the annual panel regressions, the sign is always positive. It is insignificant only in the non-IV estimation with domestic credit to private sector, but even there it is significant in efficient estimation using standard errors robust to heteroscedasticity and autocorrelation if GDP growth per capita is the dependent variable. A negative sign indicates a direct convergence effect. A positive sign indicates a direct non-convergence effect, i.e. an economy will increasingly lag behind other countries over time if its starting point was lower than its long-term relative GDP.

The coefficient for growth of physical capital per capita is always positive and significant. Human capital remains always positive. This variable always attains significance in regressions with country averages (except in regular IV with domestic credit to private sector). In panel data analysis, the coefficient is significant in regular IV and efficient IV using standard errors robust to heteroscedasticity and autocorrelation. It is also significant in several other cases where GDP growth per capita is the dependent variable. The sign for the government consumption variable is always negative, but approximately zero in average-value regressions without domestic credit to private sector and its interactions. It is significant in average-value regressions only if these variables are included in efficient IV. In panel data analysis, the coefficient is never significant in efficient estimation using standard errors robust to heteroscedasticity and autocorrelation, but is significant in some other cases. The notions that private sector is more efficient in many instances and that higher taxes hamper growth (by reducing incentives) are in harmony with these negative signs.

In average-value regressions, the coefficient of domestic credit to private sector per GDP is positive but only significant with efficient estimation using robust standard errors when instrumental variables are applied. Further, its interactions are negative and statistically significant with efficient estimation. This gives some support to the results of Aghion, Howitt, and Mayer-Foulkes (2005). All three variables are always insignificant in the annual panel regressions.

7.4.4 Robustness checks

To assess robustness of results on venture capital investment, several checks are implemented. These include recursive least squares, regressions with differenced variables, and regressions including cross-section or period fixed effects, or both, as well as Arellano-Bond-type regressions (Arellano and Bond, 1991). The results are not reported. As these checks require time dimension, they are applied only to panel specifications. The log average PCT applications per capita is replaced by the log PCT applications per capita where necessary. Outliers have been previously removed from the data when estimating the basic results. Coefficients estimated by recursive least squares seem to converge. It is encouraging that even the endogeneity-prone frontier gap shows some stability as the number of years increases. Differencing the variables does not change the estimation results dramatically, with the exception of the expected loss of significance, although interactions of venture capital between innovation and frontier gap change signs in some specifications. In these cases, however, the direct effect of venture capital turns positive. Adding cross-section fixed effects, period fixed effects, or both, has only a modest impact on the results. Interaction between venture capital and innovation stays positive. It is even significant as long as only cross-section or period fixed effects are included. In many cases, fixed effects render **X'X** nearly singular, which makes many specifications impossible to estimate. Arellano-Bond-type estimations suffer from the same problem to some extent, but preserve the results where estimation is feasible. Here, the lagged dependent variable typical for Arellano-Bond specifications is omitted as its role is assumed to be taken by the frontier gap. If even period fixed effects are included in the Arellano-Bond-type regressions, interaction between venture capital and innovation loses significance. Overall, the robustness tests confirm the results.

7.5 Conclusions

The findings demonstrate that venture capital interacted with innovation has a positive and statistically significant coefficient. Further, the joint impact related to VC with its interactions is positive in most specifications. Thus, it appears that venture capital investment might have an effect on growth by fostering conversion of innovations to marketable products and businesses.

The results suggest that venture capital can be a relevant factor for growth and can have an independent role. As a policy implication, venture capital investments should be encouraged, e.g. for start-ups that may not always get the necessary finance due to agency problems. The results can even be interpreted as evidence of the benefits for growth from financial depth.

This study also affirms the results of Aghion, Howitt, and Mayer-Foulkes (2005) that private credit per GDP interacted with frontier gap is statistically significant and negative. From this result, it follows that domestic credit to private sector is likely to be an important factor in facilitating innovation in the context of a catching-up process.

Defying intuition, the direct impact of venture capital investment on growth remains negative, even though the innovation channel (the interaction term of VC investment with innovation) remains positive, thereby making the overall impact of VC investment on growth positive in most specifications. A possible reason for this could be that growth rates have been high in emerging Europe, where VC investment has yet to play any significant role in financial intermediation. In western Europe and the US, VC investment seems to generate economic activity that could not have been financed by bank credit. Thus, it seems prudent that VC research concentrate on developed economies in the near term.

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8 Effect of government debt and external government debt as constraints on growth

8.1 Introduction

While the current focus on rising government debt in advanced economies has arisen as part of the political debate after the global financial crisis, the trend originates in the 1980s and is not limited to public debt.[42] Figure 1 (see thesis introduction) presents historical development of public and private debt per GDP along with real GDP growth in the US. Public and private debt have been constantly rising since early 1980s. When one type of debt has been constant or slightly declining, the other has shown a commensurate rise.

Revisiting Figure 1, there is a clear inverse relationship of growth with public debt starting in the 1990s. This association becomes more pronounced on this side of the millennium, with government debt rising and the growth rate of real GDP decreasing. Even so, this association does not necessarily implicate causality from debt to growth. Lower growth is likely to make government debt levels rise. This mundane phenomenon reflects an identity: when growth is weak, the denominator in the debt-to-GDP ratio increases only modestly or decreases while government revenues decrease and expenditure increases in the numerator. The deficit can also increase, however, due to expansive fiscal policy. Thus, this study focuses on the effect from debt to growth.

In the short run, fiscal deficits and rising government debt can be a rational instrument of counter-cyclical fiscal policy in recessions to stimulate aggregate demand. However, rising debt in the long-run is hardly a sign of counter-cyclical fiscal policies. Accumulating debt by using it as engine of growth may be feasible the short or medium term, but ultimately becomes unsustainable. Sooner or later debt will trigger a sovereign debt crisis that affects growth negatively.

Even while debt accumulation is still feasible, it can cause negative structural effects on the economy as high government debt hampers

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economic growth in the long run. Boskin (2012) notes large general government deficits (large increases in debt) crowd out private investments because debt displaces financial assets issued by the non-government sector in private portfolios. Reduced fixed investment lowers future income. The impact will be amplified if low investment slows development and dissemination of new technology. Future taxes must rise to cover the higher interest expenditure caused by larger debt stock if future spending is not cut. The resulting higher taxes and uncertainty about future fiscal policy hurt growth. They also increase the probability of higher inflation and a financial crisis, which raises risk premia and interest rates.

According to Feldstein (2013), other costs generated by government debt include increased economic vulnerability to interest rate shocks and reduction in the room to maneuver e.g. for countercyclical fiscal policy. Reviews for studies analyzing how government indebtedness affects growth are provided by Elmendorf and Mankiw (1999) and Panizza and Presbitero (2013).

Based on the discussion above, the growth of debt is a fairly intractable problem, but empirically, how large is it? How growth is affected by government debt is the focus of many research papers written during recent years and this study belongs to this family of studies. Earlier studies like Kumar and Woo (2010) find a negative effect from government debt to growth, but many recent studies cast doubt on this result. For example, Panizza and Presbitero (2014) no longer find any association between debt and growth with a correction for endogeneity. Although the effect of debt on growth has been examined *ad nauseum*, the studies have usually put their emphasis on specific details (e.g. a single concept of debt or threshold values). This study aims to be an encompassing presentation on the subject of how real GDP growth is affected by public debt.

The study contributes to the previous literature by complementing previous studies and including new perspectives such as general government external debt and meta-regression analysis.

Specifically, it tackles:

- The endogeneity problem,
- Other relevant concepts of debt than general government total debt,
- The recurring issue of whether threshold values for government debt ratio exist, and
- Effect of debt on GDP components and structure.

To accomplish this purpose, it uses:

- Timely and extensive data,
- Extensive robustness analysis, and
- Result summarization by meta-regression (Stanley and Jarrell, 1989).

Panizza and Presbitero (2014) argue that there are plenty of papers that show a negative correlation between growth and debt in advanced economies – but no convincing paper on a *causal* effect. They find negative correlation between debt and growth with OLS, but the correlation turns positive with IV estimation. They criticize approaches that address endogeneity problem adopted by previous literature. Specifically, they reference the use of lagged values of the debt ratio as instrumental variables by Cecchetti, Mohanty and Zampolli (2011), system GMM in Kumar and Woo (2010), and average debt of another sample as instruments in Checherita-Westphal and Rother (2012). However, they recognize problems of relevance with their own instruments, where foreign-currency-denominated debt plays a crucial role. Specifically, the OECD countries that constitute their sample have only a limited amount of foreign-currency debt. This same problem is also referred to in Salotti and Trecroci (2016).

Even though using lagged values of debt cannot generate direct reverse causality, Panizza and Presbitero (2014) argue that using lagged values of debt may be problematic because growth and debt tend to be "persistent." Cecchetti, Mohanty, and Zampolli (2011) use only short lags. In this study, fifth lags of government debt are used as direct regressors or as instruments. If persistence of growth and debt is due to business cycles, fifth annual lags as instruments for the government debt ratio should be enough to ensure that growth and the instrument of government debt ratio do not belong to the same cyclical phase, i.e. the error term is not correlated with the instrument of government debt ratio. To the best of my knowledge, a fifth-annual-lags approach has not been pursued in the existing literature on the effect of government debt on growth.

Panizza and Presbitero (2014) seem to trust the results (and hence sufficient controlling for endogeneity) of Kourtellos, Stengos, and Tan (2013), who use lagged values as instruments in ten-year-period-average regressions. This is criticized by Salotti and Trecroci (2016), who argue that their results are driven by country heterogeneity as only three ten-year periods are included. In any case, this study includes cross-sectional regressions that cover a single cross-section (e.g. an eleven-year-period average and averages over a longer period), where government debt is represented by average or initial values, as well as resemble the cross-sectional specifications of Kumar and Woo (2010). Specifications for initial government debt, in particular, are likely to suffer less from endogeneity problems as there cannot be direct reverse causality and the long period should smooth out business cycles.

Could longer lags capture the effect of some third variable that would be correlated with both growth and debt? One possibility is that longer lags of the debt ratio could be a proxy for a country's level of development as more developed countries tolerate higher debt-to-GDP ratios. In such case, however, the bias would be toward debt having a positive effect on growth (see section 6.2.6). Another possibility is that high debt could be a symptom of structural problems caused by excessive regulation and government size (see Kourtellos et al., 2013). This is controlled for by adding the government-consumption-to-GDP ratio into the regression equation as it is a measure of government size and typically related to the amount of regulation.

Many other control variables are also added to reduce the risk of an omitted third variable that might be correlated with both growth and debt. Thus, with these assumptions the results should capture a causal effect of debt on growth and not the reverse. In contrast to Panizza and Presbitero (2014), this study finds some evidence for a significant and negative growth impact for government debt even with a correction for endogeneity. However, the evidence is not robust across samples and specifications, and the results are weaker than e.g. those obtained by Cecchetti, Mohanty, and Zampolli (2011) or Kumar and Woo (2010).

In addition to general government total debt, this study includes other relevant concepts of debt highlighted by Reinhart, Reinhart, and Rogoff (2012): general government external debt (i.e. debt held by non-residents), private debt and total external debt, the last two of which enter as control variables into the analysis. Private debt is also included in many other studies on the effect of government debt on growth (see. e.g. Cecchetti, Mohanty, and Zampolli, 2011; Kumar and Woo, 2010) while external debt is not, although the effect of total external debt on growth has been examined in the existing literature. Again, to the best of my knowledge, no existing empirical study examines the effect of general government external debt on growth.

This distinction between government external debt and government total debt is important. Tobin (1965) argues that internal and foreign debt are *essentially* different. Panizza and Presbitero (2014) argue that a higher share of external debt could hamper growth for such reasons as transfer of resources to foreigners, reduced tax base, and higher interest rates. Feldstein (2012) maintains that servicing an increased external debt in the future will require an increase in net exports. This, in turn, will require a currency depreciated in real terms, which will raise the cost of imports and thus, reduce real incomes. Further, high government external debt can make countries especially vulnerable to sovereign debt crises as international capital flows can be relatively unstable as recently seen in the euro area. On the other hand, domestic investors can be more patient as shown in Japan, where a sovereign debt crisis has not emerged despite extremely high public debt as the bulk of the debt is held by domestic residents. Reinhart, Reinhart, and Rogoff (2012) observe that external debt levels are difficult to cut. Governments cannot affect inflation rates in other countries and financial repression of other countries is problematic. Even with a correction for endogeneity, this study finds some evidence for a significant and negative growth impact for government external debt for the sample of developed economies.

Earlier studies (see e.g. Reinhart, Reinhart, and Rogoff, 2012; Cecchetti, Mohanty, and Zampolli, 2011; and Reinhart and Rogoff, 2010) find a debt threshold after which debt starts to be a drag on growth. Other studies where threshold effects or debt turning points (i.e. low levels of government debt may boost growth and stability, while high levels do just the opposite) include Salotti and Trecroci (2016), Baum, Checherita-Westphal, and Rother (2013), and Checherita-Westphal and Rother (2012).

Many recent studies dispute this view. For example, Panizza and Presbitero (2013, 2014) cast doubt on the existence of threshold effects or other non-linearities of government debt. Although Eberhardt and Presbitero (2013) find some proof of a nonlinear debt-growth association over economies, they do not find any universal threshold value for individual economies. Further, Pescatori, Sandri, and Simon (2014) conclude against finding a specific threshold above which government debt seriously hampers growth in the medium run. This study appears to confirm the results of more recent papers that suggest there may be no universal threshold value of government debt ratio across countries.

This study also includes disaggregation of GDP growth into components. Specifically, the effect of government debt on growth of private investments, public investments, household consumption, government consumption, and government transfers is examined in a simple framework. This study also analyzes the effect of government debt on GDP structure, i.e. GDP ratios of the GDP components. The existing panel-econometric literature on public debt's growth impact has, to the best of my knowledge, yet to consider the effect of government debt on household consumption, government consumption, or government transfers.[43] The results of the effect of debt on growth rates of GDP components are not particularly strong. However, results are stronger for GDP ratios of GDP components. This study's results suggest that the GDP ratio of private investment decreases as government debt increases. This result is in harmony with Kumar and Woo (2010) and Salotti and Trecroci (2016). The GDP ratio of household consumption, in contrast, seems to increase when government debt increases. The GDP ratios of both government consumption and transfers seem to be negatively correlated with government debt.

Some existing literature applying econometric analysis covers time periods that capture early years of the Great Recession. The years leading up to 2008 are covered by Checherita-Westphal and Rother (2012), as well as Panizza and Presbitero (2014). The years up to 2009 are covered by Kourtellos, Stengos, and Tan (2013), Salotti and Trecroci (2016), and Eberhardt and Presbitero (2013). Some literature uses data from before the Great Recession, e.g. Teles and Mussolini (2014), Cecchetti, Mohanty, and Zampolli (2011), and Kumar and Woo (2010). This study's observation period captures the years up to 2011 depending on the specification.

The country sets in existing literature differ greatly. Some studies consider a wide cross-section of developed and developing countries, including various subsets, while some concentrate solely on developed economies. Salotti and Trecroci (2016) argue there is considerable proof that the association of growth with debt varies between developed and emerging economies. Kourtellos et al. (2013) find that larger government debt implies weaker growth with small values of a democracy indicator. According to Panizza and Presbitero (2013) debt-growth relationship involves cross-country and possibly even cross-period heterogeneity. While they find no evidence on an adverse growth impact of debt in industrialized countries, Panizza and Presbitero (2014) maintain that this might not hold for developing countries, where a large share of debt is external and the debt overhang more relevant. This study covers the full set of countries included in the World Bank World Development Indicators (WDI), although the actual sample depends on data availability that varies according to specification. Two subsets are considered: emerging and developed economies, and developed economies by themselves.

This study applies an extensive robustness analysis. For example, different time intervals are considered, different panel estimation

[43] Ricardian equivalence implies that government debt should negatively affect private consumption as households anticipate higher taxes in the future to pay the debt.

techniques applied, and the results of meta-regressions based on this study cover over 2,000 specifications.

The results are summarized by meta-regressions (see Stanley and Jarrell, 1989) and these results are compared to those of corresponding meta-regressions on a set of existing literature. Meta-regressions show how different features of specifications affect the results. The framework of meta-regressions is applied as both this study and other studies have produced divergent results depending on estimation methods, set of countries, time periods, data etc. To the best of my knowledge, meta-regressions have not been run on studies of the growth impacts of government debt. Broadly speaking, the results of meta-regressions on this study and corresponding analysis on other studies are consistent with each other and with direct analysis of the results. The results of meta-regressions show that the coefficient of government debt becomes increasingly negative as: a larger cross-section of countries and emerging markets are included, cross-section fixed effects are excluded, the time point of measurement for government debt is set closer to the time point of measurement for economic growth, and external government debt is substituted for government total debt.

The rest of the essay is structured as follows. The second section describes the data. Section 3 deals with estimation methodology. Section 4 presents the results, including those from the meta-regressions. The final section concludes.

8.2 Data

The data cover 174 *developed, emerging,* and *other economies* over the period 1960–2011.[44] Three samples are used: *all countries* (where sufficient data is available), *emerging and developed economies*, and *developed economies*. Actual sample size depends on specification. The World Bank WDI serves as the data source for GDP and GDP per capita, investment (public and private), household consumption, general government consumption, general government transfers, domestic credit to private sector, trade openness, inflation, real interest rate, population, and age-dependency ratio.[45] Data for general government debt per GDP has been obtained from the IMF World Economic Outlook (WEO), Reinhart-Rogoff (2013) as well as Cecchetti, Mohanty, and Zampolli (2011). Data for external debt per

[44] "Other economies" refers to countries such as some countries in Eastern Europe and impoverished countries in Africa and elsewhere.
[45] World Development Indicators.

GDP are from the World Bank quarterly external debt statistics and Reinhart-Rogoff (2013). Data sources for general government external debt per GDP include the World Bank quarterly external debt statistics, World Bank quarterly public debt statistics, and IMF balance of payments. Human capital (average years of schooling) has been provided by Barro and Lee (2010).[46] The dataset draws on the original data of the data sources, augmented with author's own calculations where needed.

Names and descriptions of dependent variables, debt variables, and controls are shown in Appendix Table 1. The dependent variables can be divided into two sets. The first set consists of growth rates and the second set of GDP ratios. To eliminate outliers in dependent variables, values outside three times standard deviation on both sides of the mean are excluded. Aghion, Howitt, and Mayer-Foulkes (2005) used a criterion also based on three standard deviations in removing outliers. Additionally, growth rates exceeding 100 and falling below –100, as well as GDP ratios exceeding 100 and below 0 are removed. The debt variables include total general government debt and general government external debt. Among controls, there are two additional debt variables: domestic credit to private sector and total external debt. To remove outliers, the limit for the total-general-government-debt-to-GDP ratio is set to 400, the general-government-external-debt-to-GDP ratio to 200, and the external-debt-to-GDP ratio to 1,200. Other controls include typically applied control variables in growth regressions.

Figures 1–6 illustrate the negative correlations of growth of real GDP or its components with the general government debt ratio. The negative correlation is present in all cases. The dispersion seems much to be much larger in growth of private investment, public investment, and government transfers than in growth of real GDP, household consumption, and government consumption. This makes sense as they are more sensitive to cyclical conditions.

In general, in the series of interest, the hypothesis for unit root is rejected by at least some panel unit root tests.[47] The exceptions are private credit per GDP and external debt to GDP for which all the tests accept this hypothesis. The hypothesis for the unit root is accepted by some tests for general government consumption to GDP, general government debt to GDP, the frontier gap, nominal GDP in USD, population growth, average years of schooling, age-dependency ratio, and general government external debt to GDP. First differences of all the series are stationary by all tests except average years of schooling

[46] Period of coverage is extended by linear interpolation.

[47] Statistics are not reported here.

in some tests and the age-dependency ratio in all tests. To sum up the results for the two government debt variables, some tests indicate them to be stationary (and some non-stationary), and all tests show their first differences to be stationary.

Non-stationarity may not crucially affect the results in this panel-data study (see section 5.5). In any case, regressions with first differences are run as robustness checks to control for non-stationarity and whether the relationship is strong enough to stand differencing. Differencing is also used in the context of a difference GMM estimator. Differences are taken with respect to previous year even in the case of regressions with five-year averages.

Multicollinearity is analyzed with correlation tables, variance inflation factor (VIF), and the condition number of **X'X** (statistics not reported here). Starting with the correlation tables, the relevant correlations between variables are less than 0.80 in general. This is inapplicable, of course, to correlations between different lags of the same variable, which can be quite high. Additionally, a few correlations between cross-sectional averages of variables are high. Variance inflation factors are not large for variables in regressions with five-year averages and in annual regressions. For variables in cross-sectional regressions, they are somewhat higher. The extremely high condition number of **X'X** would seem to be problematic, but multicollinearity problems, if any, are most likely to emerge in cross-sectional regressions. If coefficients and their standard errors appear plausible and relatively stable across different specifications, multicollinearity is not likely to be a problem.

Figure 1. **General government debt to GDP versus real GDP growth**

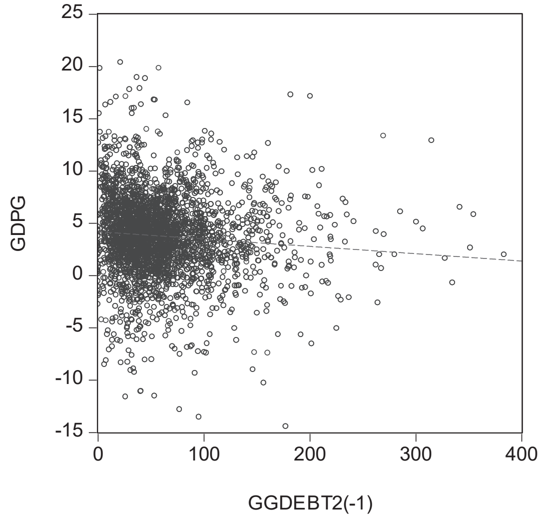


Figure 2. **Growth of private investment and general government debt to GDP**

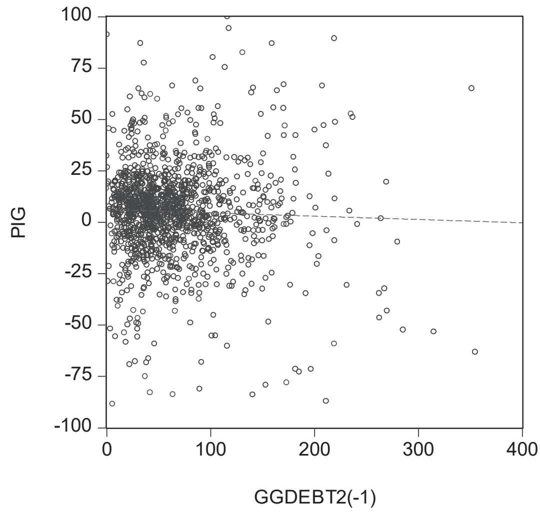


Figure 3. **Growth of public investment and general government debt to GDP**

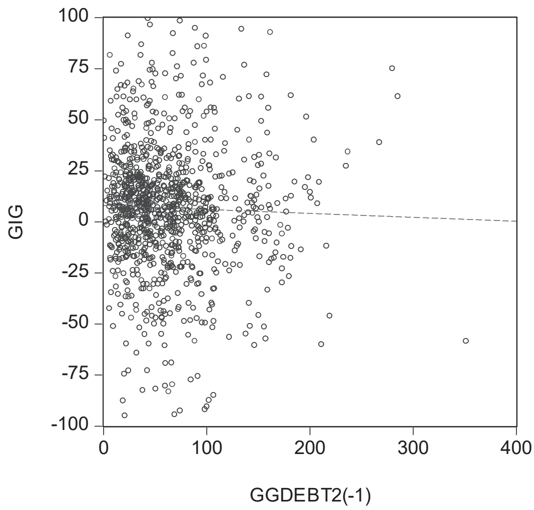


Figure 4. **Growth of household consumption and general government debt to GDP**

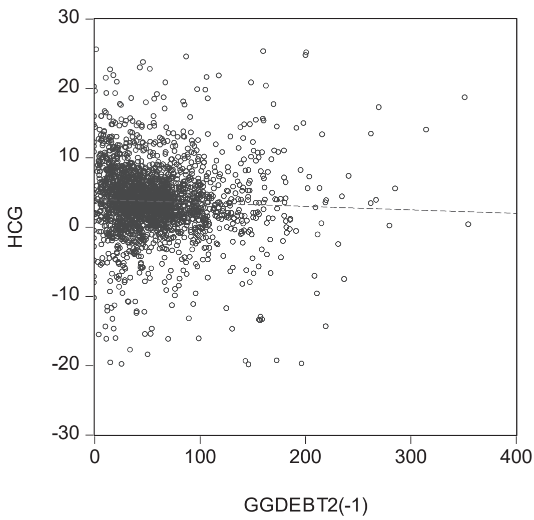


Figure 5. **Growth of government consumption and general government debt to GDP**

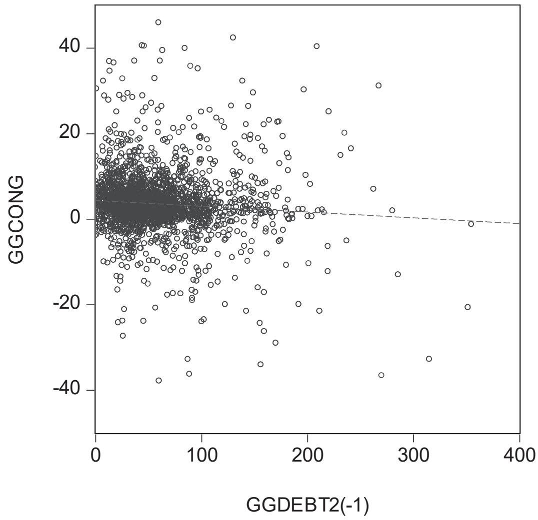
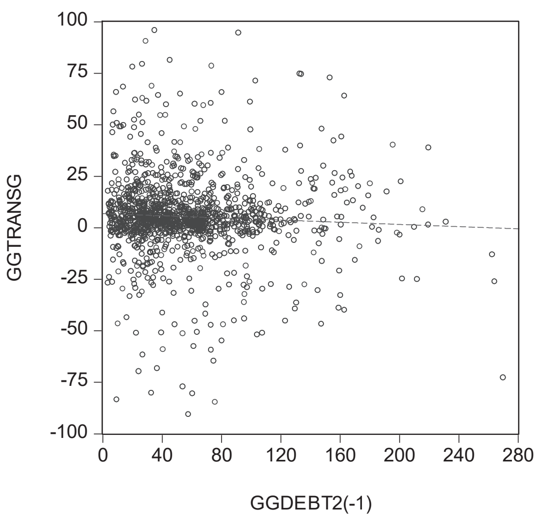


Figure 6. **Growth of government transfers and general government debt to GDP**



8.3 Estimation

A regression model consisting of a reduced-form single equation is estimated. The model includes growth of GDP or another dependent variable, government debt, and control variables. The annual baseline regression equation takes the following form:

$$g_{i,t-1,t} = \mu + \gamma_0 D_{i,t-1} + \gamma_1 d_{i,t-1} D_{i,t-1} + \mathbf{x}'_{i,t-1}\beta + \alpha_i + \delta_t + \varepsilon_{it} \qquad (12)$$

where $g_{i,t-1,t}$ denotes growth of the dependent variable to period t from t–1 in country i; μ marks a constant coefficient; $D_{i,t-1}$ is the government-debt-to-GDP ratio at time t–1 in country i; $d_{i,t-1}$ indicates the dummy variable that takes a value 1 provided that government debt ratio exceeds a threshold at time t–1 for country i, but zero otherwise; $\mathbf{x}'_{i,t-1}$ denotes a vector for controls at time t–1 in country i;[48] δ_t marks a period fixed effect; α_i a country fixed effect; and ε_{it} indicates the disturbance at time t in country i. Based on the theory discussion in Chapter 3, the main hypothesis is that γ_0 and γ_1 are negative.

Equation (12) presents the annual baseline regression equation. Annual regressions are also run using explanatory variables from period t instead of t–1.[49] In baseline regressions with five-year averages, $g_{i,t-1,t}$ is replaced by $g_{i,t-1,t+4}$, i.e. average growth of dependent variable from time period t–1 to t+4. The five-year periods are non-overlapping. They are one year longer than in Kumar and Woo (2010), who define a five-year period from t–4 to t. In cross-sectional regressions, observations in annual regressions are replaced by cross-sectional averages of variables or their initial values to obtain a single cross-section. Equation (12) and its derivatives are run as a simple regression model (i.e. a constant and government debt ratio), the model with added controls, the model with added controls and a threshold term, and by adding country- or time-specific fixed effects or both to all these models.

Appendix Table 1 presents the dependent variables. They are real GDP growth, growth of its components, and GDP ratios of the components. For growth of GDP components and their GDP ratios, only simple models with and without fixed effects are run. A universal constant coefficient is included so that fixed effects sum to zero. The central variable of interest is general government debt. Both total

[48] For population growth, the time period t is used instead of t–1. In regressions with five-year averages, average population growth from time period t–1 to t+4 is used.
[49] Frontier gap is from period t–1, even in this case.

general government debt and general government external debt are used in separate regressions.[50] The thresholds are based on results of simple regressions and are the values of general government debt from the point at which the sign of the threshold term stabilizes. The controls are listed in Appendix Table 1. They include commonly used theoretically and empirically relevant variables in growth regressions, e.g. trade openness for the relevance of which results were obtained by Levine and Renelt (1992). External debt is only included in some regressions as a major part of it is likely to be general government external debt. In cross-sectional regressions, real interest rate is excluded as there are too few observations for it especially in earlier time periods. Inflation and private credit are excluded for some cross-sectional regressions for the same reason.

The regression model is loosely based on Aghion and Howitt's (1992) growth model, which is why the regression equation includes distance to technological frontier and not lagged GDP. Distance or gap to technological frontier (frontier gap) is defined as logarithmic real GDP per capita (USD) subtracted by logarithmic real GDP per capita in the United States (USD) (the assumed technological frontier). This regression equation omits investments or growth of physical capital as the Aghion-Howitt model also omits them. In addition, investments are the major channel through which general government debt supposedly affects growth. Including them in the regression equation would mean that the coefficient of government debt would not capture the investment channel. However, real interest rates are included as a control variable, even though they are a channel through which government debt supposedly affects growth. There are two reasons for this. First, they are considered a relevant control. Second, studies often find that the effect of government debt on interest rates is weak and insignificant (see Salotti and Trecroci, 2016).

A Wu-Hausman test was applied to analyze endogeneity in some baseline regressions: the test detects endogeneity in some cases (results not reported here). As expected, the risk of endogeneity is greater when contemporaneous values for government debt to GDP are used instead of initial values in annual regressions. The risk seems to be largest in samples with emerging and developed economies, and smallest in sample with developed economies. It is important to note that Wu-Hausman is relational to the alternative, which here is equivalent to replacing the government-debt-to-GDP ratio with its fifth lag. To control for endogeneity, longer lags of government debt are used as

[50] General government external debt covers both domestic and foreign currency external debt.

regressors or as instruments in annual regressions and regressions with five-year averages.

8.4 Results

8.4.1 Simple regression models

In addition to simple baseline regressions on the effect of government debt on growth, this study also includes disaggregation of GDP growth into components. Specifically, the study examines the effects of government debt on growth of private investments, public investments, household consumption, government consumption, and government transfers. This study also analyzes the effect of government debt on GDP structure, i.e. GDP ratios of the GDP components. In these analyses, the sets of independent variables consist of the constant coefficient and government debt without effects, or the constant coefficient and government debt with cross-section fixed effects, period fixed effects, or both. Fixed effects help to reduce omitted variables bias to some extent, but control variables are not included as it is not obvious which controls should be included. In this setup, the results of the effect of government debt on GDP growth and growth rates of GDP components are not particularly strong for specifications beyond annual regressions with contemporaneous or once-lagged explanatory variables (see Appendix Table 2). This could indicate that the bias caused by omission of potentially relevant controls is not toward finding strong results. This is confirmed for GDP growth by meta-regressions on this study (see Table 6), which also shows that the bias is not large. In any case, the endogeneity bias generated by business cycles is addressed through longer lagged values of government debt.

Results are stronger for GDP ratios of GDP components (see Appendix Table 2). The results show that the GDP ratio of private investments decreases as government debt increases. This result is in line with those of Kumar and Woo (2010) and Salotti and Trecroci (2016). The coefficient of government debt remains statistically significant and negative in all annual regressions. This result for the sign holds even among five-year-average regressions. However, the significance of the coefficient disappears in these regressions if both fixed effects are included, and with longer lags even when cross-section fixed effects alone are included. Further, it seems that there is a negative association of the public investment GDP ratio with government debt, although this evidence is weaker than with private investment. This result agrees with Checherita-Westphal and Rother (2012). In annual specifications, the significance of government debt disappears when period fixed effects alone are included and with longer lags even when no fixed effects are included. With five-year-average regressions, the coefficient is significant only with just cross-section effects and only at the 10% significance level.

On the other hand, the GDP ratio of household consumption seems to increase when government debt increases. This result does not hold when cross-section fixed effects alone are included and in specifications other than annual regressions with contemporaneous or once-lagged explanatory variables even when both fixed effects are included. The coefficient of government debt turns negative with cross-section fixed effects alone and with longer lags even when both fixed effects are included in specifications other than annual regressions with contemporaneous or once-lagged explanatory variables. The GDP ratios of both government consumption and transfers seem to be negatively correlated with government debt. The results for government consumption are weak. The coefficient of government debt is negative and significant in annual regressions with the combination of initial values and cross-section fixed effects or with the combination of longer lags and no fixed effects, and in five-year average regressions with no fixed effects or with the combination of longer lags and cross-section fixed effects. The coefficient turns positive in annual regressions with longer lags and both fixed effects. Although the coefficient of government debt in regressions of government transfers is positive in annual specifications for initial values with both fixed effects and for contemporaneous values when cross-section fixed effects are included, the result for a negative and statistically significant coefficient holds in all other specifications except in five-year-average regressions with longer lags and no fixed effects.

The risk of direct reverse causality from any of these GDP ratios to the GDP ratio of government debt is not obvious. If there would be direct short-term reverse causality from government investment, consumption, and government transfers to government debt, the sign of the coefficient could be positive and not negative as higher government expenditure to GDP increases the likelihood of larger deficits. It could also be negative if it is assumed that increased government expenditure would boost growth in the short-term, and thus reduce the debt-to-GDP ratio. In the long term, higher GDP ratios of government expenditure likely harm growth (because of malignant supply-side effects), and thus increase the GDP ratio of government debt (i.e. imply a positive coefficient).

The short-term effects of GDP ratios of private investment and household consumption on government debt are also not obvious. In the long term, however, reduced GDP ratios of private (and public) investment *must* be bad for growth.

Business cycles can also cause endogeneity problems. For example, recessions can simultaneously cause a higher GDP ratio of government transfers (and assuming active fiscal policy, a higher GDP ratio of government consumption, investment, or both) and a higher debt-to-GDP ratio. Recessions are likely to lower the GDP ratio of private investments and as a residual, increase the GDP ratio of household consumption. The results are not likely generated by this endogeneity problem as the sign of the coefficient of government debt does not usually change in specifications with longer lags and the coefficient remains significant in some of them.

If government total debt is replaced by government external debt, the results for GDP ratios of private and public investment and government transfers become weaker, especially those for public investment, for which there are significant coefficients only in annual regressions with initial and contemporaneous values and for which most specifications with longer lags yield positive coefficients (see Appendix Table 3). One reason for this could be that external debt is often raised to finance significant public investments.

If government total debt is replaced by government external debt, however, the results for GDP ratios of household and government consumption become stronger, especially those of government consumption, which is now always negative and it is insignificant only in five-year-average regressions with period fixed effects. To sustain the availability of external credit, governments may need to enhance their credibility by cutting public consumption in times of high external debt. In general, the results are weak for the effect of government external debt on growth of GDP components (see Appendix Table 3).

Figure 7 illustrates coefficients of general government debt to GDP in simple baseline regressions with growth of real GDP and its components as dependent variable. This illustrates the sign and the magnitude of the coefficient, but not standard errors or significance levels. The sign of the coefficient of government debt is negative for all specifications including growth of real GDP and most specifications including growth of a component of real GDP. The magnitude of the coefficient is small in specifications that include growth of real GDP or household consumption. The notable exceptions are specifications that include public investment where the coefficient of government debt is positive (except in annual regressions without fixed effects).

This could be the result of endogeneity. Large public investments often increase pressure on public finances in ways that are likely to increase government borrowing and debt. This can be amplified if public investments are used as a tool in counter-cyclical fiscal policy. There is some evidence to back up this hypothesis. Further results on coefficients of general government debt to GDP in simple regressions are available in Appendix Table 2. Omitting period or cross-section fixed effects sometimes changes the sign. Using contemporaneous values for government debt rarely affects it. However, using fifth lags of government debt often produces positive coefficients. Running the same annual regressions as in Figure 7 for general government external debt yields results otherwise not too different results, except that now growth of public investment is reduced by debt (results not reported here). In five-year-average regressions, there are more positive coefficients but it should be kept in mind that the number of observations in these regressions is small. Further results on coefficients of general government external debt ratio for simple regressions can be found in Appendix Table 3.

Figure 7. **Coefficients of general government debt to GDP in simple baseline regressions with growth of real GDP and its components as dependent variable**

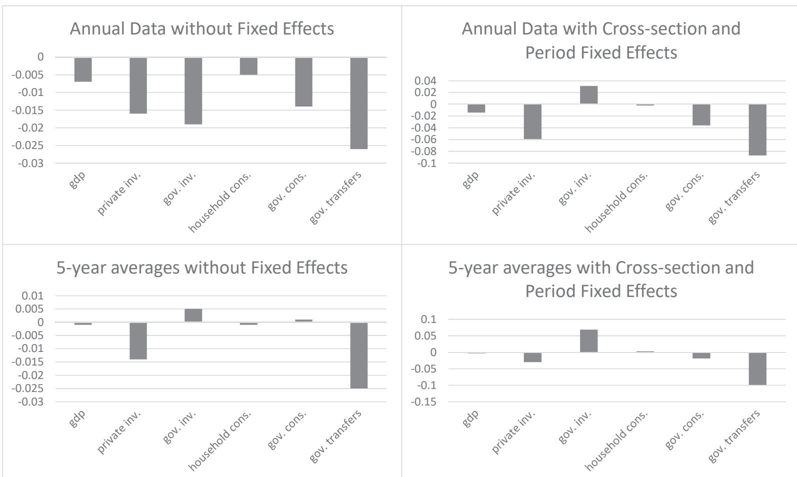


Figure 8 illustrates coefficients of general government debt to GDP in simple regressions with GDP components per GDP as dependent variable. General government debt seems to decrease other examined GDP ratios besides household consumption, which it appears to increase. It is particularly interesting that government debt decreases the share of private and public investment with respect to GDP. Omitting period or cross-section fixed effects, using contemporaneous values for government debt, or using fifth lags of government debt sometimes affects the sign (see Appendix Table 2). Results on coefficients of government external debt in simple regressions of growth rates and GDP ratios on general government external debt are available in Appendix Table 3. In comparison to regressions on total debt, negative signs for external debt are somewhat less frequent, especially among five-year-average regressions and regressions with fifth lags of debt.

Figure 8. **Coefficients of general government debt to GDP in simple regressions with GDP components per GDP as dependent variable**

Figures 9 and 10 present evolutions of the coefficients of government debt in recursive samples of annual simple baseline regressions of growth of real GDP on general government debt to GDP without or with fixed effects, respectively. These regressions start from the beginning of the data by adding one year at a time to the sample. Although standard errors are larger in the beginning, the coefficients appear relatively stable by the end. In the beginning, the number of countries is also much smaller as individual countries are included in the regressions when there is enough data for them. Adding controls barely changes the evolution of the coefficient of government debt (results not reported here).

Figure 9. **Evolution of the coefficient of government debt in recursive samples of annual simple baseline regressions of growth of real GDP on general government debt to GDP**

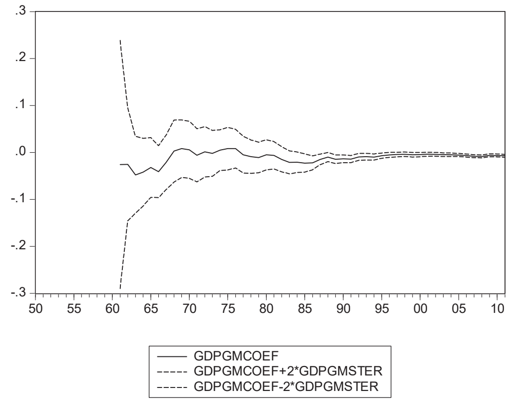
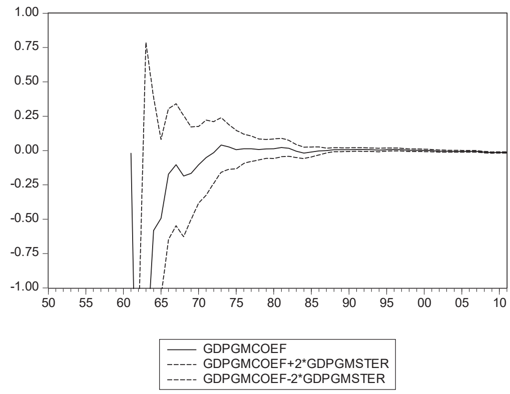


Figure 10. **Evolution of the coefficient of government debt in recursive samples of annual simple baseline regressions of growth of real GDP on general government debt to GDP with cross-section and period fixed effects**



8.4.2 Baseline regressions

Table 1 presents results of annual baseline regressions. The coefficient of government debt is negative except when cross-section fixed effects alone are included with threshold effects. In this case, the threshold effect is negative. In all other cases, it is positive. The coefficient of government debt is significant without threshold effects when cross-sectional fixed effects are not included and with threshold effects when period fixed effects are included. These are also the only cases when threshold effects are significant. The thresholds are obtained by regressing growth on a constant, government debt, and separately for each fixed-effects combination (and for each data frequency and each subsample) by increasing the government debt ratio gradually (by ten percentage points) and selecting the threshold level at which its sign stabilizes. As the threshold levels vary across fixed effects combinations, there seems to be no specific or universal threshold. Further, the varying signs, significance levels, and magnitudes of threshold effects suggest the same. Conclusions of several recent studies point in the same direction (see section 8.1). The magnitude of the coefficient of government debt seems to be smaller than in some other studies (e.g. Kumar and Woo, 2010). It is somewhat larger with threshold effects, which twist the total effect in the opposite direction. Notably, private credit always remains significant and negative. Most other controls are of expected sign and significant. Even different subsets of controls are experimented (results not reported here). When only a few controls are included, the coefficient of government debt is significant in a larger number of specifications. It appears that significance deteriorates as the number of controls increases. The reported results are for a full set of controls.

R-squared improves with inclusion of more fixed effects, but stays the same as threshold effects are included. Both Durbin-Watson and LM-statistics indicate autocorrelation. The reported standard errors are regular. Using heteroscedasticity and autocorrelation robust standard errors will not change the results dramatically – government debt and its threshold effects remain significant in the same instances, but the significance levels may be lower (results not reported here).

If the sample is restricted to emerging and developed economies (results not reported here), the sign of government debt turns positive in all specifications that include cross-section fixed effects. It is significant among other specifications only when period fixed effects are included and threshold effects not included. If the sample is restricted to developed economies only, the sign of government debt remains negative only when period fixed effects are included and threshold effects not included, and is never significant. The magnitude of (negative) coefficients is somewhat smaller. Threshold effects are not significant in either restricted sample.

If government debt is replaced by external government debt in the sample of all countries (see Appendix Table 4), the sign of external government debt is always negative, it is significant except in specifications where threshold effects are included without period effects, and the magnitude of its coefficient is bigger. When the coefficient of external government debt is not significant, the threshold effects are negative but they always remain insignificant. The results do not change much if the sample is restricted. In the sample of emerging and developed economies, the sign of external government debt remains negative except when threshold effects are included with only cross-section fixed effects and significance disappears in the specification where threshold effects are not included with only cross-section fixed effects. Threshold effects are now always negative and insignificant only when both period and country fixed effects become included.

If the sample is further restricted to developed economies, the sign of external government debt always remains negative and is significant as long as cross-section fixed effects are not included. Estimation of most specifications with threshold effects is not feasible if government external debt is used (results not reported here).

If the period frequency is stretched from one year to five years, all the results for a negative effect of government debt on growth disappear or are much weaker (see Appendix Tables 6 and 7).

Results of corresponding regressions as in Table 1 but with contemporaneous government debt are reported in Table 2. Now all coefficients of government debt are significant and their magnitude is somewhat larger. Interestingly, independent of sample, the coefficient of government debt is always negative (results not reported here). It is significant in the sample of emerging and developed economies as long as cross-section effects are not included and in the sample of developed economies with only period effects if threshold effects are not included, and if they are then only with all fixed effects. If external government debt is used instead, its sign is always negative across samples and is more often significant (see Appendix Table 5). Otherwise, the results are not different from those reported for Table 1.

Since the association of public debt with growth is weaker when government debt is lagged, the conclusion is that with contemporaneous government debt, the findings are influenced by reverse causality, that is, they are subject to an endogeneity bias. Thus, the results of Table 2 (and Appendix Table 5) illustrate the association of debt with growth that is not necessarily causal from debt to growth.

8.4.3 Longer lags as regressors and IV estimation

In Table 3, the baseline five-year-period regressions are modified by replacing the first lag of government debt with its fifth lag and first lags of all the other variables with their second lags. This is done to reduce the risk of endogeneity, i.e. the risk that results would be driven by an omitted third variable that is related to business cycles and correlated with both growth and government debt, and with other explanatory variables to a lesser extent. Now the coefficient of government debt is negative and significant in all specifications excluding cross-section fixed effects. Without them its magnitude is plausible (–0.015 to –0.016) and not much smaller than the findings of Kumar and Woo (2010).

When cross-sectional fixed effects are included, the sign changes to positive and significance disappears. This is hardly surprising as cross-section fixed effects are likely to capture variation across countries that would otherwise be allocated to government debt. In particular, this is true for countries where government debt levels have been relatively stable (i.e. resemble a fixed effect). Conclusions drawn principally from within-country variation may be flawed as government debt in many developed countries has grown around a long-term trend. Relatively high levels are attained, but not so high as to affect growth much. It is worth noting that cross-sectional fixed effects are not detrimental to results in simple regressions with fifth lag of government debt as an explanatory variable (results not reported here).

The first essay of this thesis finds cross-section fixed effects to be strongly correlated with PCT applications per capita, with the ratio generally highest for rich economies (with China the obvious outlier). This implies that cross-sectional fixed effects should be larger as a rule in richer economies, but government debt is also likely to be larger in richer countries that can sustain a higher debt ratio. This holds particularly well from 2008 on. Thus, if government debt inadvertently captured the missing cross-section fixed effects, the sign of its coefficient would be positive when cross-section fixed effects are excluded. The fact that it is negative suggests that exclusion of cross-section fixed effects does not generate omitted variable bias.

A similar indication is given by a fact established in other studies that there does not seem to be a negative association of TFP with public debt. Salotti and Trecroci (2016), for example, note the negative effect of debt on productivity disappears as productivity is measured by TFP, and suggest this could be caused by problems in measuring the Solow residual. Further, the results of Kumar and Woo (2010) on the effect of debt on growth of TFP show no significant effect (and the sign is even positive in their fixed effects specification). Finally, the results of Afonso and Jalles (2011) show that government debt ratio positively affects TFP growth. As TFP is likely to be correlated with PCT applications per capita, it is probably correlated with cross-section fixed effects as well. The fact that there seems to be no negative association of public debt with TFP suggests there may not be a negative association of public debt with cross-section fixed effects either. If there is no relationship, omitted variables bias cannot exist in the regressions. If the relationship is positive, the bias should turn the coefficient of government debt positive.

In regressions with longer lags, threshold effects remain always insignificant. The coefficient of domestic credit to private sector is close to zero and insignificant. Fewer controls have the expected sign and are significant in comparison to corresponding regressions with first lags. R-squared is higher than with first lags for regressions excluding cross-country fixed effects. Here, the LM-statistic shows no autocorrelation in specifications without cross-section fixed effects, providing further evidence that exclusion of cross-section fixed effects does not generate omitted variables bias and that their inclusion might have negative consequences.

The results do not change much even if heteroscedasticity and autocorrelation robust standard errors are used. Government debt and its threshold effects are still significant in the same instances, but the significance levels may be lower (results not reported here). Departing from previous tables, the results in Table 3 were selectively extracted from the sample of emerging and developed economies as the results are the clearest in this sample. If the sample of all countries is used, the sign of government debt turns negative in all specifications, but remains significant (at the 10% level) only without cross-section effects if threshold effects are not included, and with threshold effects with both fixed effects only (results not reported here). In the first two cases, the coefficient's magnitude remains more modest than in the sample for emerging and developed economies. In the last case, however, the coefficient has implausibly large magnitude that is related to the threshold effect of opposite sign and approximately same magnitude significant at the 10% level. If the sample is restricted to developed economies, the sign of government debt remains non-positive in all specifications, but is always insignificant.

The sign of the coefficient of general government external debt is always non-positive across all three samples (see Appendix Table 6 for results for the sample of developed economies), but it is significant in the sample of all countries with all fixed effects only. In the sample of emerging and developed economies it is significant without any fixed effects. In the sample of developed economies, it is significant without cross-section fixed effects only. In all these cases, the magnitude of the coefficient is large. The same applies to the sample of developed economies in the case of annual regressions with longer lags where the coefficient of government external debt is always negative and where, without cross-section fixed effects, it is significant and of large magnitude. Otherwise, it is insignificant and often positive in annual regressions with longer lags.

Table 4 reports results of five-year-period GMM estimations without fixed effects, with cross-section fixed effects, with equations in differences (Arellano and Bond, 1991), with equations in orthogonal deviations, and all of the above with period fixed effects. Standard errors are robust to heteroscedasticity and autocorrelation.

Table 4 presents the regressions with all "bells and whistles." The fifth lag of government debt is used as instrument for government debt, and the second lags of all other variables (except popg5) are used as instruments for all these other variables (except popg5). For the J-test to be feasible (because there must be more instruments than variables), the third lag of lavgschooling is added as an instrument when necessary. The coefficient of government debt remains significant and negative for all specifications excluding cross-sectional fixed effects. Without them the magnitude (–0.014 to –0.017) remains approximately the same as by using OLS with longer lags (Table 3). When cross-sectional fixed effects are included or eliminated with differencing, the sign changes to positive and significance disappears. If cross-sectional fixed effects are eliminated with orthogonal deviations, the sign remains negative but still loses significance. This suggests that differencing might not be the optimal way of eliminating cross-section fixed effects here, where unbalanced data are used. Including threshold effects is detrimental for significance: significance of government debt disappears in all specifications and threshold effects are never significant (results not reported here).

In estimations without fixed effects, observations are first GLS transformed and do not change much even without the transformation (results not reported here). Other specifications are not transformed as it is impossible due to restrictions of the estimation technique. The coefficient of domestic credit to private sector varies, but is insignificant. The sign of other controls also varies and their significance deteriorates heavily when any fixed effects are included. The J-test accepts the applied instruments. R-squared is similar to using OLS with longer lags (Table 3). However, without fixed effects, the R^2 results are higher than with OLS with longer lags. In the sample of all countries, the coefficient of government debt loses significance in the specification with period effects. In the sample of developed economies, it is no longer significant in any specification. In both samples, the magnitude of the coefficients is smaller than in the sample of emerging and developed economies.

8.4.4 Cross-sectional regressions

Cross-sectional regressions emphasize the long-term view, so they are less likely to suffer from endogeneity. Additionally, time-series problems (non-stationarity) and detrimental effects of cross-section fixed effects are not issues. The results of the cross-sectional regressions are reported in Table 5.

Cross-sectional regressions are run both with and without controls, with and without threshold effects, and for both initial and average values of government debt and frontier gap. Initial values are used to reduce the risk of reverse causality. When average values of government debt are used, adding controls, threshold effects, or both, does not change the findings. The coefficient of government debt remains always significant and negative, but its magnitude is about half that observed in five-year panel regressions without cross-section effects (Tables 3 and 4).

In the reported regressions, domestic credit to private sector, real interest rate, and inflation are excluded from controls as their inclusion decreases sample size significantly. If inflation and private credit are included, however, the results (not reported here) do not change. For real interest rate, there are too few observations for feasible estimation.

When initial values (instead of average values) of government debt (and frontier gap) are used, the coefficient of government debt turns positive without controls. With controls, it remains negative and loses about half its magnitude. The coefficient of government debt is always significant and adding threshold effects does not change the results.

The controls are of expected sign and significant. R-squared is extremely high when controls are included, and higher with average values when controls are excluded. GLS transformation provides higher significance levels of government debt as using OLS with initial values always yields insignificant coefficients. Using OLS with average values yields significant coefficients only without threshold effects (and even then, only at the 10% level). (The OLS results are not reported here.)

The sample time period is restricted to 2001–2011. A longer period would reduce the sample size significantly. This is because as the sample time period is extended, the sample increasingly consists only of developed economies. On the other hand, a longer time period decreases the risk of endogeneity. Using a longer time period (1991–2011 or 1981–2011) with average values, however, does not change the essential results much (not reported here). The same is true for all three periods in explicitly restricted samples (not reported here). Although significance disappears and the coefficient becomes smaller with controls and without threshold effects in the short sample period in the sample of developed economies, significance holds and the coefficient increases in corresponding specifications in longer sample periods.

Using the short sample period, replacing government debt with government external debt still yields significant and negative coefficients in the full sample and in the sample of emerging and developed economies. The magnitude of these coefficients is larger (results not reported here). In the sample of developed economies, significance still disappears and the coefficient becomes smaller with controls (no threshold effects feasible). However, in contrast to specifications with government total debt, the results in longer sample periods do not hold with controls in any of the three samples (results not reported here). It is worth noting that sample sizes are smaller for specifications with general government external debt and can be tiny for developed economies and longer periods.

Table 1. **Baseline annual regressions**

	Dependent Variable: Annual Growth Rate of Real GDP, 1971—2011, All Countries							
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects
CONSTANT	0.102	-2.98*	18.63**	43.9***	0.231	-2.753*	18.041**	41.293**
	(1.632)	(1.596)	(7.541)	(16.863)	(1.64)	(1.592)	(7.587)	(16.823)
GGDEBT2(-1)	-0.006***	-0.008***	-0.003	-0.006	-0.011	-0.012***	0.002	-0.012***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.007)	(0.002)	(0.008)	(0.004)
DOMCRED(-1)	-0.007***	-0.006***	-0.013***	-0.018***	-0.007***	-0.006***	-0.013***	-0.017***
	(0.002)	(0.002)	(0.004)	(0.004)	(0.002)	(0.002)	(0.004)	(0.004)
FRONTIERGAP(-1)	-0.665***	-0.847***	-2.874***	-1.929**	-0.665***	-0.839***	-2.941***	-2.029**
	(0.088)	(0.098)	(0.74)	(0.969)	(0.088)	(0.098)	(0.746)	(0.966)
TRADEPERGDP(-1)	0.007***	0.009***	0.011**	0.016***	0.007***	0.009***	0.011**	0.015**
	(0.001)	(0.001)	(0.006)	(0.006)	(0.001)	(0.001)	(0.006)	(0.006)
LINFLATION(-1)	-7.517***	-6.322***	-12.236***	-9.178***	-7.439***	-6.566***	-12.246***	-9.129***
	(1.107)	(1.114)	(1.372)	(1.355)	(1.112)	(1.112)	(1.373)	(1.35)
GGCONPERGDP(-1)	-0.039***	-0.04***	-0.017	-0.003	-0.04***	-0.04***	-0.017	-0.005
	(0.014)	(0.013)	(0.029)	(0.027)	(0.014)	(0.013)	(0.029)	(0.027)
LGDPCURUSD(-1)	0.117**	0.183***	-1.026***	-1.809***	0.116**	0.192***	-1.011***	-1.682***
	(0.053)	(0.051)	(0.331)	(0.619)	(0.053)	(0.051)	(0.332)	(0.618)
LREALINTRATE(-1)	-6.214***	-5.603***	-11.316***	-9.496***	-6.213***	-5.101***	-11.312***	-9.142***
	(1.108)	(1.069)	(1.342)	(1.304)	(1.109)	(1.075)	(1.342)	(1.304)
POPG	0.041	0.157	0.205	0.271*	0.042	0.145	0.21	0.224
	(0.107)	(0.102)	(0.147)	(0.139)	(0.107)	(0.102)	(0.147)	(0.139)
LAVGSCHOOLING(-1)	0.798***	1.071***	3.833***	1.926	0.804***	0.964***	3.842***	1.973
	(0.248)	(0.255)	(1.199)	(1.244)	(0.248)	(0.256)	(1.199)	(1.24)
AGEDEPENDENCY(-1)	-0.036*	-0.026	-0.107*	-0.164***	-0.035*	-0.026	-0.111*	-0.191***
	(0.02)	(0.019)	(0.063)	(0.062)	(0.02)	(0.019)	(0.063)	(0.062)
GGDEBT2(-1)*(GGDEBT2(-1)>50)					0.004			
					(0.005)			

Dependent Variable: Annual Growth Rate of Real GDP, 1971—2011, All Countries								
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects
GGDEBT2(-1)*(GGDEBT2(-1)>180)						0.011*** (0.003)		
GGDEBT2(-1)*(GGDEBT2(-1)>50)							-0.004 (0.006)	
GGDEBT2(-1)*(GGDEBT2(-1)>180)								0.011*** (0.003)
R-squared	0.16	0.28	0.37	0.48	0.16	0.28	0.37	0.48
Durbin-Watson	1.31	1.23	1.69	1.63	1.31	1.23	1.69	1.63
LM-statistic	229.94	265.74	114.38	111.76	228.66	268.23	114.32	111.84
P-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Periods	41	41	41	41	41	41	41	41
Cross-sections	112	112	112	112	112	112	112	112
Total observations	1638	1638	1638	1638	1638	1638	1638	1638

Notes: *** significant at 1% level, ** significant at 5% level, * significant at 10% level, (standard errors in parentheses).

Table 2. **Annual regressions with contemporaneous explanatory variables**

Dependent Variable: Annual Growth Rate of Real GDP, 1970—2011, All Countries								
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects
CONSTANT	-0.597	-3.31**	-32.944***	-131.008***	-0.241	-3.229**	-32.212***	-131.939***
	(1.579)	(1.56)	(6.931)	(15.8)	(1.582)	(1.561)	(6.966)	(15.803)
GGDEBT2	-0.013***	-0.014***	-0.014***	-0.01***	-0.029***	-0.016***	-0.021***	-0.013***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.006)	(0.002)	(0.007)	(0.004)
DOMCRED	-0.007***	-0.005**	-0.029***	-0.02***	-0.007***	-0.005**	-0.029***	-0.02***
	(0.002)	(0.002)	(0.004)	(0.004)	(0.002)	(0.002)	(0.004)	(0.004)
FRONTIERGAP(-1)	-0.681***	-0.892***	-5.867***	-8.95***	-0.682***	-0.889***	-5.779***	-8.983***
	(0.084)	(0.095)	(0.684)	(0.898)	(0.084)	(0.095)	(0.689)	(0.898)
TRADEPERGDP	0.008***	0.009***	0.035***	0.042***	0.008***	0.009***	0.035***	0.041***
	(0.001)	(0.001)	(0.005)	(0.006)	(0.001)	(0.001)	(0.005)	(0.006)
LINFLATION	-6.793***	-6.914***	-7.104***	-4.471***	-6.548***	-6.996***	-7.094***	-4.454***
	(1.086)	(1.098)	(1.321)	(1.319)	(1.088)	(1.1)	(1.321)	(1.318)
GGCONPERGDP	-0.057***	-0.056***	-0.148***	-0.133***	-0.06***	-0.056***	-0.149***	-0.134***
	(0.013)	(0.013)	(0.027)	(0.025)	(0.013)	(0.013)	(0.027)	(0.025)
LGDPCURUSD	0.16***	0.204***	1.501***	4.836***	0.159***	0.207***	1.482***	4.886***
	(0.051)	(0.049)	(0.303)	(0.577)	(0.051)	(0.049)	(0.304)	(0.578)
LREALINTRATE	-6.096***	-4.341***	-7.847***	-5.55***	-6.091***	-4.165***	-7.854***	-5.379***
	(1.078)	(1.046)	(1.297)	(1.263)	(1.076)	(1.056)	(1.297)	(1.267)
POPG	0.219**	0.297***	0.192	0.244*	0.224**	0.294***	0.189	0.224*
	(0.104)	(0.101)	(0.141)	(0.134)	(0.104)	(0.101)	(0.141)	(0.135)
LAVGSCHOOLING	0.522**	0.912***	-4.145***	-1.689	0.538**	0.874***	-4.157***	-1.668
	(0.242)	(0.249)	(1.133)	(1.199)	(0.241)	(0.251)	(1.133)	(1.198)
AGEDEPENDENCY	-0.004	0.000	-0.129**	0.032	-0.001	0.000	-0.123**	0.018
	(0.02)	(0.019)	(0.058)	(0.058)	(0.02)	(0.019)	(0.058)	(0.059)
GGDEBT2*(GGDEBT2>50)					0.013***			
					(0.005)			

Dependent Variable: Annual Growth Rate of Real GDP, 1970—2011, All Countries								
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects
GGDEBT2*(GGDEBT2>180)						0.004 (0.003)		
GGDEBT2*(GGDEBT2>50)							0.006 (0.006)	
GGDEBT2*(GGDEBT2>180)								0.005 (0.003)
R-squared	0.18	0.29	0.40	0.50	0.19	0.29	0.40	0.50
Durbin-Watson	1.32	1.26	1.65	1.57	1.32	1.26	1.65	1.57
LM-statistic	230.66	259.46	129.15	141.10	227.91	259.38	127.99	141.84
P-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Periods	42	42	42	42	42	42	42	42
Cross-sections	112	112	112	112	112	112	112	112
Total observations	1703	1703	1703	1703	1703	1703	1703	1703

Notes: *** significant at 1% level, ** significant at 5% level, * significant at 10% level, (standard errors in parentheses).

Table 3. **Five-year period regressions with longer lags of explanatory variables**

Dependent Variable: Five-Year Average Growth Rate of Real GDP, 1975—2009, Emerging and Developed Economies								
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects
CONSTANT	-3.769	-7.533*	24.793	49.469	-3.704	-7.373	26.43*	43.977
	(4.457)	(4.383)	(15.248)	(36.194)	(4.506)	(4.448)	(15.702)	(36.443)
GGDEBT2(-5)	-0.016***	-0.015***	0.006	0.01	-0.016**	-0.015**	0.008	0.036
	(0.006)	(0.005)	(0.009)	(0.008)	(0.007)	(0.006)	(0.009)	(0.025)
DOMCRED(-2)	0.000	0.001	0.002	0.000	0.000	0.001	0.001	-0.001
	(0.005)	(0.004)	(0.01)	(0.009)	(0.005)	(0.004)	(0.01)	(0.009)
FRONTIERGAP(-2)	-0.803***	-1.394***	-2.384	-1.558	-0.799***	-1.384***	-2.35	-2.21
	(0.209)	(0.264)	(1.488)	(2.174)	(0.212)	(0.268)	(1.498)	(2.244)
TRADEPERGDP(-2)	0.011***	0.012***	0.035***	0.042***	0.011***	0.011***	0.034**	0.042***
	(0.003)	(0.003)	(0.013)	(0.015)	(0.003)	(0.003)	(0.013)	(0.015)
LINFLATION(-2)	2.787	-2.292	-3.011	-6.035	2.809	-2.215	-3.271	-6.025
	(3.249)	(3.332)	(4.119)	(3.764)	(3.268)	(3.361)	(4.176)	(3.756)
GGCONPERGDP(-2)	0.032	0.000	0.151*	0.033	0.032	0.001	0.141	0.033
	(0.032)	(0.031)	(0.09)	(0.092)	(0.032)	(0.031)	(0.093)	(0.091)
LGDPCURUSD(-2)	0.292*	0.315**	-1.199*	-1.966	0.291*	0.312**	-1.272*	-1.802
	(0.159)	(0.147)	(0.685)	(1.328)	(0.16)	(0.148)	(0.705)	(1.333)
LREALINTRATE(-2)	6.413**	6.775**	10.958**	6.466	6.482**	6.881**	10.496**	7.384*
	(3.074)	(2.892)	(4.623)	(4.29)	(3.137)	(2.935)	(4.745)	(4.357)
POPG5	0.254	0.453	-0.172	-0.122	0.256	0.458	-0.183	-0.113
	(0.307)	(0.284)	(0.399)	(0.366)	(0.309)	(0.286)	(0.401)	(0.365)
LAVGSCHOOLING(-2)	-0.737	0.112	2.097	1.669	-0.742	0.096	2.162	1.951
	(0.6)	(0.641)	(2.595)	(2.384)	(0.603)	(0.647)	(2.612)	(2.392)
AGEDEPENDENCY(-2)	-0.07	-0.001	-0.183*	-0.224**	-0.071	-0.004	-0.159	-0.243**
	(0.045)	(0.045)	(0.105)	(0.1)	(0.046)	(0.046)	(0.117)	(0.101)

Dependent Variable: Five-Year Average Growth Rate of Real GDP, 1975—2009, Emerging and Developed Economies								
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects
GGDEBT2(-5)*(GGDEBT2(-5)>100)					0.001 (0.006)			
GGDEBT2(-5)*(GGDEBT2(-5)>100)						0.001 (0.006)		
GGDEBT2(-5)*(GGDEBT2(-5)>100)							-0.003 (0.006)	
GGDEBT2(-5)*(GGDEBT2(-5)>30)								-0.024 (0.021)
R-squared	0.56	0.65	0.84	0.89	0.56	0.65	0.84	0.89
LM-statistic	0.75	0.82	32.39	21.24	0.75	0.80	32.47	20.59
P-value	0.69	0.66	0.00	0.00	0.69	0.67	0.00	0.00
Periods	7	7	7	7	7	7	7	7
Cross-sections	39	39	39	39	39	39	39	39
Total observations	124	124	124	124	124	124	124	124

Notes: *** significant at 1% level, ** significant at 5% level, * significant at 10% level, (standard errors in parentheses).

Table 4. **Five-year period regressions with GMM and instrumental variables**

	Dependent Variable: Five-Year Average Growth Rate of Real GDP, 1975—2009, Emerging and Developed Economies							
	GMM (N-Step, GLS Cross-Section Weights)	GMM (N-Step)	GMM (Arellano-Bond 2-Step)	GMM (2-Step)	GMM (N-Step)	GMM (N-Step)	GMM (2-Step)	GMM (2-Step)
	White Period GMM Weights and s.e.	Period SUR GMM Weights and s.e.	White Period GMM Weights and s.e.	White Period GMM Weights and s.e.	White Period GMM Weights and s.e.	Period SUR GMM Weights and s.e.	Period SUR GMM Weights and s.e.	Period SUR GMM Weights and s.e.
	No Fixed Effects	Cross-Section Fixed Effects	Differences	Orthogonal Deviations	Period Fixed Effects	Cross-Section and Period Fixed Effects	Differences, Period Fixed Effects	Orthogonal Deviations, Period Fixed Effects
CONSTANT	-8.047***	22.448			-8.074	54.056		
	(2.769)	(16.572)			(6.972)	(45.757)		
GGDEBT2(-1)	-0.014***	0.019	0.146	-0.025	-0.017**	0.023	0.025	-0.094
	(0.005)	(0.021)	(0.153)	(0.059)	(0.009)	(0.016)	(0.129)	(0.173)
DOMCRED(-1)	-0.004	0.003	-0.028	-0.024	0.004	0.000	-0.018	-0.006
	(0.004)	(0.01)	(0.109)	(0.042)	(0.006)	(0.009)	(0.08)	(0.098)
FRONTIERGAP(-1)	-0.636***	-2.171	14.776	-8.673	-1.364**	-0.999	5.466	-12.602
	(0.158)	(1.836)	(29.36)	(7.353)	(0.622)	(2.665)	(21.253)	(22.908)
TRADEPERGDP(-1)	0.012***	0.04***	0.229	-0.044	0.01**	0.047**	0.217	-0.117
	(0.003)	(0.015)	(0.378)	(0.11)	(0.005)	(0.019)	(0.267)	(0.237)
LINFLATION(-1)	6.832***	-4.155	-42.715	3.048	-2.905	-6.903	-23.627	13.536
	(2.4)	(5.473)	(53.04)	(9.604)	(5.354)	(5.022)	(34.78)	(34.401)
GGCONPERGDP(-1)	-0.019	0.127	-0.14	0.105	-0.006	-0.053	-0.191	0.625
	(0.023)	(0.11)	(1.705)	(0.631)	(0.033)	(0.116)	(1.287)	(1.319)
LGDPCURUSD(-1)	0.394***	-1.088	-4.256	-0.502	0.321	-2.038	-3.42	3.245
	(0.116)	(0.704)	(12.538)	(3.824)	(0.231)	(1.681)	(8.276)	(7.448)
LREALINTRATE(-1)	16.348***	13.254	70.362	-20.27	10.751*	5.17	83.443	-74.719
	(3.849)	(8.904)	(147.669)	(26.495)	(6.42)	(8.000)	(145.843)	(115.933)
POPG5	-0.061	0.159	4.68	-4.018	0.237	0.041	2.087	-7.947
	(0.205)	(0.509)	(8.169)	(2.856)	(0.343)	(0.482)	(5.504)	(11.05)

Dependent Variable: Five-Year Average Growth Rate of Real GDP, 1975—2009, Emerging and Developed Economies								
	GMM (N-Step, GLS Cross-Section Weights)	GMM (N-Step)	GMM (Arellano-Bond 2-Step)	GMM (2-Step)	GMM (N-Step)	GMM (N-Step)	GMM (2-Step)	GMM (2-Step)
	White Period GMM Weights and s.e.	Period SUR GMM Weights and s.e.	White Period GMM Weights and s.e.	White Period GMM Weights and s.e.	White Period GMM Weights and s.e.	Period SUR GMM Weights and s.e.	Period SUR GMM Weights and s.e.	Period SUR GMM Weights and s.e.
	No Fixed Effects	Cross-Section Fixed Effects	Differences	Orthogonal Deviations	Period Fixed Effects	Cross-Section and Period Fixed Effects	Differences, Period Fixed Effects	Orthogonal Deviations, Period Fixed Effects
LAVGSCHOOLING(-1)	0.303	2.232	-42.886	22.085	0.292	1.474	-24.038	35.953
	(0.537)	(2.518)	(73.113)	(14.218)	(0.869)	(2.51)	(57.372)	(55.821)
AGEDEPENDENCY(-1)	-0.064**	-0.283*	0.852	-0.694	0.002	-0.296**	1.06	-1.149
	(0.03)	(0.147)	(2.81)	(0.472)	(0.051)	(0.13)	(2.618)	(1.528)
R-squared	0.70	0.83			0.57	0.89		
Periods	7	7	7	7	7	7	7	7
Cross-sections	39	39	39	39	39	39	39	39
Total observations	123	123	122	122	123	123	122	122
J-statistic	1.55	0.06	0.05	0.20	3.67	0.26	0.23	0.01
P-value	0.21	0.81	0.82	0.65	0.06	0.61	0.63	0.91

Notes: *** significant at 1% level, ** significant at 5% level, * significant at 10% level, (standard errors in parentheses).
Instruments: fifth lag of ggdebt, popg5 and second lags of other variables. Instrumental variables are used in all specifications.
The names of methods follow EViews convention and their descriptions are obtained from EViews (2013).

Table 5. **Cross-sectional regressions**

	Dependent Variable: Average Growth Rate of Real GDP, 2001—2011, All Countries							
	GLS (Cross-Section Weights)	GLS (Cross-Section Weights)	GLS (Cross-Section Weights)	GLS (Cross-Section Weights)	GLS (Cross-Section Weights)	GLS (Cross-Section Weights)	GLS (Cross-Section Weights)	GLS (Cross-Section Weights)
CONSTANT	4.242***	4.237***	-4.111***	-4.176***	3.514***	3.492***	-7.561***	-7.397***
	(0.034)	(0.048)	(1.007)	(0.883)	(0.061)	(0.078)	(0.767)	(1.208)
MGGDEBT2(-1)	-0.009***	-0.008***	-0.008***	-0.01***				
	(0.001)	(0.001)	(0.001)	(0.002)				
GGDEBT2(-11)					0.004***	0.004***	-0.005***	-0.006***
					(0.001)	(0.001)	(0.000)	(0.001)
MFRONTIERGAP(-1)			-0.913***	-0.894***				
			(0.052)	(0.053)				
FRONTIERGAP(-11)							-1.13***	-1.134***
							(0.029)	(0.063)
MTRADEPERGDP(-1)			0.008***	0.008***			0.009***	0.009***
			(0.001)	(0.001)			(0.000)	(0.001)
MGGCONPERGDP(-1)			-0.033***	-0.03***			-0.015***	-0.011
			(0.01)	(0.009)			(0.005)	(0.006)
MLGDPCURUSD(-1)			0.219***	0.232***			0.283***	0.278***
			(0.03)	(0.026)			(0.022)	(0.032)
MPOPG			-0.074	-0.107			0.173***	0.152**
			(0.091)	(0.094)			(0.035)	(0.075)
MLAVGSCHOOLING(-1)			0.701***	0.617***			0.732***	0.75***
			(0.176)	(0.148)			(0.104)	(0.148)
MAGEDEPENDENCY(-1)			-0.062***	-0.065***			-0.037***	-0.04***
			(0.012)	(0.012)			(0.007)	(0.012)
MGGDEBT2(-1)*(MGGDEBT2(-1)>90)		0.000		0.003**				
		(0.001)		(0.001)				
GGDEBT2(-11)*(GGDEBT2(-11)>90)						0.000		0.001
						(0.001)		(0.001)

Dependent Variable: Average Growth Rate of Real GDP, 2001—2011, All Countries								
	GLS (Cross-Section Weights)	GLS (Cross-Section Weights)	GLS (Cross-Section Weights)	GLS (Cross-Section Weights)	GLS (Cross-Section Weights)	GLS (Cross-Section Weights)	GLS (Cross-Section Weights)	GLS (Cross-Section Weights)
R-squared	0.52	0.54	0.99	1.00	0.12	0.14	1.00	1.00
Periods	1	1	1	1	1	1	1	1
Cross-sections	140	140	93	93	140	140	93	93
Total observations	140	140	93	93	140	140	93	93

Notes: *** significant at 1% level, ** significant at 5% level, * significant at 10% level, (standard errors in parentheses).

Letter "M" in front of a variable denotes average. For POPG the average is of years 2001-2011; for the other variables it is of 2000–2010.

If initial values are used, significance of the coefficient of government debt disappears or weakens in a few specifications with controls using time periods longer than 2001–2011 (results not reported here). Specifically, in the samples of emerging and developed economies and developed economies alone, the significance level drops to 10% in the longest period. For the sample of all economies, the results are weaker for both longer time periods, especially the longest.

8.4.5 Meta-regressions

The results of different specifications of this study are summarized by meta-regressions (see Stanley and Jarrell, 1989). Results of meta-regressions based on the specifications of this study are reported in Table 6. These meta-regressions may shed some light on how different features of specifications affect the results. Specifically, the coefficient of government debt is regressed on a constant and dummies describing characteristics of underlying regressions.

In Table 6, the number of dummies describing regression characteristics increases in columns from left to the right. Adding dummies for all values within a category would make **X** rank deficient (i.e. having less than full rank) as a dummy for a value could be represented as a linear combination of all the other values within that particular category. The last three columns all use the same number of dummies. However, the dummy for annual panel in columns 8 and 9 is replaced by a dummy for five-year period panel in column 10. The dummy for initial government debt in columns 8 and 10 is replaced by a dummy for contemporaneous government debt in column 9. In both cases the replaced dummy has a coefficient of the same magnitude as the replacing dummy, but different sign.

The estimation method here is robust least squares (m-estimation) with corresponding standard errors (Huber type I, see EViews, 2013) as direct coefficients of government debt can relate to outlying specifications that include threshold effects. The m-estimation is robust to outliers in the dependent variable, which is the relevant issue here (see Huber, 1981). Calculating a coefficient combining both the direct and the threshold coefficient would not solve the problem, at least not in extreme cases. Results obtained by ordinary least squares and regular standard errors (heteroscedasticity and correlation of disturbances not likely) are presented in Appendix Table 8. The coefficients differ from those in Table 6, indicating that outliers are a relevant problem.

The Table 6 constants are negative and significant in all specifications. Their magnitude grows as the number of dummies increases. In columns 8 and 10, the magnitude is no different than for the coefficient of government debt obtained in specifications without cross-section fixed effects in Tables 3 and 4. Significant and negative dummies (i.e. factors that make the coefficient more negative) across columns are those for the short sample from 1990 on (significant only in columns 2, 8, 9, and 10), the short sample from 2000 on, inclusion of other countries than emerging and developed (e.g. some eastern European countries and some impoverished countries in Africa and elsewhere), threshold effects, government external debt as dependent variable, and contemporaneous government debt. The magnitude is largest for the dummy for government external debt as dependent variable, followed by contemporaneous government debt, and short sample from 2000 on. Significant and positive dummies (i.e. factors that make the coefficient more positive) are DLS, GMM, DGMM, developed economies, cross-section fixed effects, single cross-section, the "frontier gap not included in instruments" dummy variable (further lags of other explanatory variables than frontier gap replacing lagged frontier gap in the instrument matrix), initial government debt, inclusion of private credit, as well as the second lag of government debt.

It is worth noting that the dummy for cross-section fixed effects here embraces specifications where there are cross-section fixed effects, and where DGMM or OGMM are applied to deal with cross-section fixed effects by eliminating them. The magnitude is the largest for the dummy for a single cross-section, followed by DGMM, initial government debt, and DLS. The magnitude of the dummy for a single cross-section is the same as for the dummy for government external debt as dependent variable (the largest negative and significant coefficient). R-squared values are low, but increase as the number of dummies rises.

To compare results in Table 6 to other studies, corresponding meta-regressions are run for specifications in a set of other studies (Table 7). Here, the estimation technique remains OLS and standard errors regular (heteroscedasticity and correlation of disturbances not likely) as the set of values for the coefficient of government debt contains no extreme values. The results are quite consistent with those in Table 6.

Table 6. **Meta-regressions**

	Dependent Variable: Coefficient of Government Debt to GDP									
	Robust LS (M-estimation)	Robust LS (M-estimation)	Robust LS (M-estimation)	Robust LS (M-estimation)	Robust LS (M-estimation)	Robust LS (M-estimation)	Robust LS (M-estimation)	Robust LS (M-estimation)	Robust LS (M-estimation)	Robust LS (M-estimation)
CONSTANT	-0.005***	-0.004***	-0.007***	-0.007***	-0.008***	-0.01***	-0.009***	-0.015***	-0.007***	-0.016***
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
SHORT SAMPLE 1990-		-0.005***	-0.002	-0.002	-0.001	-0.001	-0.001	-0.004**	-0.004**	-0.004**
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
SHORT SAMPLE 2000-		-0.01***	-0.006***	-0.006***	-0.005***	-0.006***	-0.006***	-0.007***	-0.007***	-0.007***
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
DLS			0.008***	0.008***	0.008***	0.007***	0.007***	0.007***	0.007***	0.007***
			(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
GLS			-0.001	-0.001	0.000	0.000	0.000	0.000	0.000	0.000
			(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
GMM			0.005***	0.005***	0.005***	0.005***	0.005***	0.006***	0.006***	0.006***
			(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
DGMM			0.011***	0.012***	0.008***	0.008***	0.008***	0.009***	0.009***	0.009***
			(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
OGMM			0.004***	0.004***	0.000	0.000	0.000	0.002	0.002	0.002
			(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
INCL. OTHER ECONOMIES THAN EMERGING AND DEVELOPED				-0.002***		-0.003***	-0.003***	-0.002***	-0.002***	-0.002***
				(0.001)		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
DEVELOPED ECONOMIES				0.002***		0.002**	0.002**	0.001**	0.001**	0.001**
				(0.001)		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
CROSS-SECTIONAL FIXED EFFECTS					0.006***	0.006***	0.006***	0.005***	0.005***	0.005***
					(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
PERIOD FIXED EFFECTS					-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
					(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
INCL. CONTROL VARIABLES						0.003***	0.003***	-0.002	-0.002	-0.002
						(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
THRESHOLD EFFECTS							-0.001*	-0.001**	-0.001**	-0.001**
							(0.001)	(0.001)	(0.001)	(0.001)

	Dependent Variable: Coefficient of Government Debt to GDP									
	Robust LS (M-estimation)	Robust LS (M-estimation)	Robust LS (M-estimation)	Robust LS (M-estimation)	Robust LS (M-estimation)	Robust LS (M-estimation)	Robust LS (M-estimation)	Robust LS (M-estimation)	Robust LS (M-estimation)	Robust LS (M-estimation)
ANNUAL PANEL								-0.001	-0.001	
								(0.001)	(0.001)	
FIVE-YEAR PERIOD PANEL										0.001
										(0.001)
SINGLE CROSS SECTION								0.01***	0.01***	0.01***
								(0.002)	(0.002)	(0.002)
FRONTIERGAP NOT INCLUDED IN								0.002**	0.002**	0.002**
INSTRUMENTS								(0.001)	(0.001)	(0.001)
GGDEBT2(-5) (INSTEAD OF								-0.001	-0.001	-0.001
GGDEBT2(-2)) AS AN INSTRUMENT								(0.001)	(0.001)	(0.001)
OF GGDEBT2										
GGEXT INSTEAD OF GGDEBT2								-0.01***	-0.01***	-0.01***
								(0.001)	(0.001)	(0.001)
INITIAL GOVERNMENT DEBT								0.008***		0.008***
								(0.001)		(0.001)
CONTEMPORANEOUS									-0.008***	
GOVERNMENT DEBT									(0.001)	
5TH LAG OF GOVERNMENT DEBT								0.002	0.002	0.002
								(0.001)	(0.001)	(0.001)
2ND LAG OF GOVERNMENT DEBT								0.004**	0.004**	0.004**
								(0.002)	(0.002)	(0.002)
INCL. DOMCRED								0.005***	0.005***	0.005***
								(0.001)	(0.001)	(0.001)
INCL. EXT2								0.001	0.001	0.001
								(0.001)	(0.001)	(0.001)
R-squared	0.00	0.02	0.04	0.05	0.05	0.07	0.07	0.13	0.13	0.13
Observations	2094	2094	2094	2094	2094	2094	2094	2094	2094	2094

Notes: *** significant at 1% level, ** significant at 5% level, * significant at 10% level, (standard errors in parentheses).
Robust estimation is applied as direct coefficients of government debt can pick up outlying values in specifications that include threshold effects. Calculating a coefficient combining both the direct and the threshold coefficient would not solve the problem, at least not in extreme cases.

Table 7. **Meta-regressions on other studies**

	Dependent Variable: Coefficient of Government Debt to GDP							
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
CONSTANT	-0.004	-0.002	-0.013	-0,013	-0.057	-0.092	-0.087	-0.089
	(0.007)	(0.007)	(0.008)	(0.054)	(0.061)	(0.126)	(0.115)	(0.117)
SHORT SAMPLE 1990-		-0.019	-0.006	-0.003	-0.002	-0.003	-0.003	-0.003
		(0.023)	(0.022)	(0.027)	(0.027)	(0.03)	(0.03)	(0.03)
SHORT SAMPLE 2000-		-0.016	-0.005	-0.002	0.003	0.002	0.002	0.002
		(0.045)	(0.043)	(0.047)	(0.047)	(0.05)	(0.05)	(0.05)
2SLS			0.057***	0.06***	0.056***	0.06***	0.06***	0.06***
			(0.017)	(0.018)	(0.018)	(0.022)	(0.022)	(0.022)
GMM			-0.001	0.041	0.013	0.015	0.015	0.015
			(0.025)	(0.042)	(0.046)	(0.048)	(0.048)	(0.048)
SGMM			-0.008	-0.006	-0.011	-0.023	-0.023	-0.023
			(0.024)	(0.028)	(0.028)	(0.03)	(0.03)	(0.03)
INCL. OTHER ECONOMIES THAN EMERGING AND DEVELOPED				-0.051	-0.142*	-0.128*	-0.128*	-0.128*
				(0.038)	(0.072)	(0.076)	(0.076)	(0.076)
EMERGING ECONOMIES				-0.007	-0.009	-0.011	-0.011	-0.011
				(0.035)	(0.035)	(0.037)	(0.037)	(0.037)
DEVELOPED ECONOMIES				0.007	-0.001	0.012	0.012	0.012
				(0.025)	(0.025)	(0.032)	(0.032)	(0.032)
CROSS-SECTIONAL FIXED EFFECTS				0.001	0.008	0.02	0.02	0.02
				(0.028)	(0.028)	(0.032)	(0.032)	(0.032)
PERIOD FIXED EFFECTS				-0.002	0.005	0.01	0.01	0.01
				(0.027)	(0.027)	(0.042)	(0.042)	(0.042)
INCL. CONTROL VARIABLES				-0.003	0.035	0.059	0.059	0.059
				(0.046)	(0.052)	(0.091)	(0.091)	(0.091)
THRESHOLD EFFECTS					0.128	0.122	0.122	0.122
					(0.086)	(0.105)	(0.105)	(0.105)
OVERLAPPING FIVE-YEAR PERIODS						-0.019	-0.019	-0.019
						(0.019)	(0.019)	(0.019)

Dependent Variable: Coefficient of Government Debt to GDP								
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
ANNUAL PANEL						0.003	0.003	
						(0.048)	(0.048)	
FIVE- OR TEN-YEAR PERIOD PANEL								-0.003
								(0.048)
SINGLE CROSS SECTION						0.01	0.01	0.008
						(0.052)	(0.052)	(0.072)
INITIAL GOVERNMENT DEBT						0.005		0.005
						(0.027)		(0.027)
CONTEMPORANEOUS GOVERNMENT DEBT							-0.005	
							(0.027)	
2ND LAG OF GOVERNMENT DEBT						-0.019	-0.019	-0.019
						(0.026)	(0.026)	(0.026)
INCL. DOMCRED						-0.012	-0.012	-0.012
						(0.027)	(0.027)	(0.027)
R-squared	0.00	0.01	0.14	0.18	0.20	0.22	0.22	0.22
Observations	90	90	90	90	90	90	90	90

Notes: *** significant at 1% level, ** significant at 5% level, * significant at 10% level, (standard errors in parentheses).

Studies included: Kumar and Woo (2010), Cecchetti, Mohanty and Zampolli (2011), Panizza and Presbitero (2014), Salotti and Trecroci (2013), Checherita-Westphal and Rother (2012), Kourtellos, Stengos and Tan (2013), Teles and Mussolini (2014). Eberhardt and Presbitero (2013) is excluded since they use government debt per capita.

Table 8. **Comparison of constants in meta-regression analyses**

Dependent Variable: Coefficient of Government Debt to GDP							
1	2	3	4	5	6	7	8
Constant in a Meta-Regression on Other Studies							
-0.004	-0.002	-0.013	-0.013	-0.057	-0.092	-0.087	-0.089
(0.007)	(0.007)	(0.008)	(0.054)	(0.061)	(0.126)	(0.115)	(0.117)
Constant in the Corresponding Meta-Regression on This Study							
-0.005***	-0.004***	-0.007***	-0.01***	-0.009***	-0.015***	-0.007***	-0.016***
(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)

Notes: *** significant at 1% level, ** significant at 5% level, * significant at 10% level, (standard errors in parentheses).
Column headings 1-8 refer to columns 2-9 in Table 7 and to columns 2-4 and 7-11 in Table 6.
Other studies included: Kumar and Woo (2010), Cecchetti, Mohanty and Zampolli (2011), Panizza and Presbitero (2014), Salotti and Trecroci (2013), Checherita-Westphal and Rother (2012), Kourtellos, Stengos and Tan (2013), Teles and Mussolini (2014). Eberhardt and Presbitero (2013) is excluded since they use government debt per capita.

However, only dummies for 2SLS and inclusion of other countries than emerging and developed (significant at 10% level) are significant. This can be partly explained by the much smaller sample size. Moreover, the magnitudes of these coefficients and the magnitude of the coefficient for the dummy for threshold effects are large. Otherwise, the magnitudes of dummy variables are comparable to those in Table 6.

Constants are still always negative but not significant. Their magnitude varies from small to large. When the dummy for threshold values is not included, the magnitude of constants is about the same as in Table 6 (see Table 8).[51] The magnitude of the coefficient increases massively with inclusion of threshold effects. The dummy for threshold effects is always large and has an opposite sign. Obviously, different studies define threshold effects differently.

With the exception of threshold effects, the dummies that were negative and significant in Table 6 (where applicable) are all still negative, with the exception of the dummy for short sample from 2000, which is only positive in specifications that include the dummy for threshold effects. Further, the dummies that were positive and significant in Table 6 (where applicable) are all still positive, except

[51] Table 8 compares the constant coefficients of Tables 6 and 7 in a single table. Negative constant coefficients can be interpreted as indicating a negative base effect of government debt on growth. The coefficients for the dummies demonstrate how much the model specification either increases or decreases this negative effect. Some model specifications even turn this negative effect positive. However, the universally negative base effect found here should be interpreted with caution as it depends on the definitions of the dummies describing model specifications. Further, meta-regressions do not differentiate between plausible and less-plausible specifications.

inclusion of domestic credit to private sector. The result for the dummy for 2SLS (positive and significant) agrees with the argument of Panizza and Presbitero (2014) that OLS is negatively biased in the presence of endogeneity. An interesting dummy variable missing in Table 6 is the one for overlapping five-year periods. It is negative although not significant. R-squared is somewhat higher as in Table 6 when there are more dummies included.

Broadly speaking, the results of meta-regressions on this study and corresponding analysis on other studies seem to be consistent with direct analysis of the results. The main result of the meta-regression analysis is that the coefficient of government debt becomes more negative as a larger cross section of countries and emerging markets are included, the cross-section fixed effects are excluded (covering even exclusion of their elimination), the time point of measurement for government debt is closer to the time point of measurement for economic growth, and external government debt is used instead of government total debt.

However, the argument for time point of measurement does not apply to the fifth lag of government debt, which seems to produce (although in a statistically insignificant way) slightly more negative coefficients of government debt than the second lag. A larger number of countries and exclusion of country fixed effects (covering even exclusion by elimination) actually imply increased cross-country variance allocated to other variables than cross-section fixed effects. Such cross-country variance can also be interpreted as a factor making the coefficient of government debt more negative.

In specifications considering a single cross-section, all variance is cross-country variance. It is worth noting that a single cross section appears to generate coefficients more in the positive direction. This is illustrated by the cross-section regressions in Table 5, where the coefficient of government debt seems to be smaller in absolute value, but still negative and significant. Thus, the results indicate that differences between countries (rather than differences between time periods in a country) are crucial for a negative effect.

8.5 Conclusions

The results imply clear evidence that general government debt is negatively associated with growth of real GDP. However, the relationship weakens when using initial values of debt, and even further in five-year periods. Restriction of sample size (i.e. removal of countries that are not developed countries) also dilutes the results. Cross-sectional regressions and exclusion of cross-section fixed effects seem to generate stronger results. With a more thorough correction for endogeneity, this study finds modest evidence of a significant and negative growth impact for government debt. This evidence is not robust across samples and specifications.

The study presents novel information or confirms the results of earlier studies. First, it finds evidence of a negative and statistically significant effect of general government external debt on growth. Second, the results comport with most recent studies that there is no universal threshold value of government debt ratio. Third, government debt appears to lower the GDP ratio of private investment and increase the GDP ratio of household consumption. Finally, the results of this and other studies seem to be broadly in line regarding how various specification features affect the estimate of the coefficient of government debt.

Even with a correction for endogeneity, this study finds some evidence for a significant and negative growth impact of government external debt for a sample of developed economies. Higher government external debt seems to be more critical for growth in developed economies. Developed economies can tolerate high government domestic debt (e.g. Japan), because there are deep financial markets. There are large domestic institutional investors with stable long-term investment policies in place and domestic investors are less inclined to spook than foreign investors. As a policy implication, it seems prudent that governments generally should avoid excessive government external debt.

This study largely confirms the results of recent papers that there is no single universal threshold value for the government debt ratio that would hold across all countries. Instead, the study finds varying threshold levels, as well as varying signs, significance levels, and magnitudes of threshold effects. If there is a threshold value of government debt, above which growth becomes seriously impeded, that value is likely to be different depending on country conditions, such as depth of financial markets and reserve currency status.

The analysis of the effect of government debt on GDP ratios of GDP components suggests, in accordance with classical theory, that the GDP ratio of private investment decreases as government debt increases. Conversely, the GDP ratio of household consumption seems to increase when government debt increases.

The results of this and other studies seem to be broadly in line regarding how different features of specifications affect the estimate of the coefficient of government debt. The results of meta-regressions on this study and corresponding analysis of other studies are broadly consistent with each other. The results of the meta-regressions also seem to be broadly consistent with direct analysis of the results. As a larger number of countries and exclusion of country fixed effects make the coefficient of government debt more negative, the results indicate that differences between countries, rather than differences between time periods in a country, are crucial for government debt to hurt growth.

As the results support somewhat the hypothesis that growth is negatively affected by government debt, the fundamental policy implication is that excessive public debt levels should be reduced. If countercyclical fiscal policy is preferred, then the right moment to reduce government debt levels is during economic booms. The IMF (2015) argues that it is common for governments to implement pro-cyclical fiscal policy measures during booms that neutralize the surplus generated by automatic stabilizers that would otherwise automatically reduce the debt. This is a reason why government debt levels only slightly decrease during booms but explode during recessions. Thus, the IMF (2015) notes that it is important to avoid pro-cyclical fiscal measures during booms and strengthen the symmetric operation of automatic stabilizers.

When is government debt excessive? There is no single figure, but intuitively there must be a limit at which government debt starts to hurt growth. The ultimate upper limit obviously is a sovereign debt crisis with the attending loss of investor confidence and capital flight. But this occurs after unsustainability of debt has been reached. While there is no well-defined method of calculating the sustainability limit, even for one country, the notion of such a point provides a useful point of departure for analysis. For example, if all measures show that public debt is unsustainable, the government would be prudent to take consolidating fiscal policy action. Conversely, as long as debt remains sustainable by various measures, the government can consider its options for expansive fiscal policy, i.e. fiscal space exists.

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Appendix

Table 1. **Variable names and explanations**

Dependent variables	
gdpg	growth of real GDP (%)
pig	growth of private investments (%)
gig	growth of general government investments (%)
hcg	growth of household consumption (%)
ggcong	growth of general government consumption (%)
ggtransg	growth of general government transfers (%)
pipergdp	private investments (% of GDP)
gipergdp	general government investments (% of GDP)
hcpergdp	household consumption (% of GDP)
ggconpergdp	general government consumption (% of GDP)
ggtranspergdp	general government transfers (% of GDP)
Government debt variables	
ggdebt2	general government debt (% of GDP)
ggext	general government external debt (% of GDP)
Controls	
domcred	domestic credit to private sector (% of GDP)
ext2	external debt (% of GDP)
frontiergap	gap to technological frontier, i.e. logarithmic real GDP per capita – logarithmic real GDP per capita in the United States
tradepergdp	trade openness (% of GDP)
linflation	inflation rate (log of (1+π))
lgdpcurusd	nominal GDP in USD (in log)
lrealintrate	real interest rate (log of (1+r))
popg	population growth (%)
lavgschooling	average years of schooling (in log)
agedependency	age-dependency ratio (population over 64 years old / working-age people, %)

Table 2. **Simple regressions of GDP components on a constant and government debt**

	Coefficients for General Government Debt, 1961—2011, All Countries											
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	No Fixed Effects	Cross-Section Fixed Effects	Period Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Cross-Section Fixed Effects	Period Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Cross-Section Fixed Effects	Period Fixed Effects	Cross-Section and Period Fixed Effects
	GGDEBT2(-1)				GGDEBT2				GGDEBT2(-5)			
Dependent Variable: Annual												
GDPG	-0.007***	-0.01***	-0.008***	-0.014***	-0.014***	-0.025***	-0.014***	-0.027***	0.000	-0.006**	-0.001	-0.009***
	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)
PIG	-0.016	-0.017	-0.022	-0.059**	-0.012	-0.019	-0.01	-0.034	-0.002	0.023	0.000	0.014
	(0.013)	(0.02)	(0.014)	(0.025)	(0.013)	(0.02)	(0.014)	(0.024)	(0.014)	(0.026)	(0.014)	(0.03)
GIG	-0.019	-0.038	0.014	0.031	-0.035*	-0.067*	0.003	-0.011	0.022	-0.012	0.029	-0.001
	(0.021)	(0.036)	(0.023)	(0.045)	(0.021)	(0.034)	(0.023)	(0.043)	(0.021)	(0.041)	(0.022)	(0.048)
HCG	-0.005**	-0.001	-0.006**	-0.002	-0.012***	-0.017***	-0.012***	-0.016***	-0.001	0.002	-0.003	0.002
	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.005)	(0.003)	(0.005)
GGCONG	-0.014***	-0.039***	-0.011***	-0.036***	-0.016***	-0.04***	-0.013***	-0.036***	0.007**	0.000	0.007**	0.007
	(0.003)	(0.005)	(0.004)	(0.006)	(0.003)	(0.005)	(0.004)	(0.006)	(0.004)	(0.006)	(0.004)	(0.007)
GGTRANSG	-0.026*	-0.067**	-0.025*	-0.087**	-0.017	-0.056*	-0.015	-0.067**	0.014	0.048	0.012	0.022
	(0.014)	(0.033)	(0.014)	(0.034)	(0.013)	(0.032)	(0.014)	(0.033)	(0.014)	(0.036)	(0.014)	(0.037)
PIPERGDP	-0.024***	-0.028***	-0.019***	-0.018***	-0.025***	-0.028***	-0.019***	-0.015***	-0.017***	-0.02***	-0.017***	-0.023***
	(0.004)	(0.004)	(0.004)	(0.005)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	(0.006)
GIPERGDP	-0.01**	-0.052***	-0.002	-0.04***	-0.009**	-0.05***	-0.001	-0.039***	-0.007	-0.047***	-0.002	-0.028***
	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)	(0.006)
HCPERGDP	0.073***	0.002	0.082***	0.016***	0.073***	0.006	0.082***	0.018***	0.065***	-0.025***	0.067***	-0.016***
	(0.007)	(0.004)	(0.007)	(0.005)	(0.007)	(0.004)	(0.007)	(0.005)	(0.007)	(0.004)	(0.008)	(0.005)
GGCONPERGDP	-0.005	-0.005***	-0.003	-0.006***	-0.002	0.000	-0.001	-0.002	-0.007**	-0.002	0.000	0.004
	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.003)
GGTRANSPERGDP	-0.019***	-0.007*	-0.019***	0.003	-0.015***	0.003	-0.015***	0.01***	-0.031***	-0.026***	-0.031***	-0.02***
	(0.006)	(0.004)	(0.006)	(0.004)	(0.006)	(0.003)	(0.006)	(0.003)	(0.006)	(0.004)	(0.006)	(0.004)

Coefficients for General Government Debt, 1961—2011, All Countries

	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	No Fixed Effects	Cross-Section Fixed Effects	Period Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Cross-Section Fixed Effects	Period Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Cross-Section Fixed Effects	Period Fixed Effects	Cross-Section and Period Fixed Effects
	GGDEBT2(-1)				GGDEBT2				GGDEBT2(-5)			
Dependent Variable: Five-Year Average												
GDPG	-0.001	-0.006*	-0.001	-0.003					0.002	-0.005	0.001	0.000
	(0.002)	(0.004)	(0.002)	(0.004)					(0.003)	(0.004)	(0.003)	(0.005)
PIG	-0.014	-0.027	-0.013	-0.03					-0.005	0.009	-0.013	-0.059
	(0.014)	(0.033)	(0.014)	(0.037)					(0.017)	(0.047)	(0.017)	(0.053)
GIG	0.005	-0.012	0.017	0.069					0.021	-0.017	0.019	-0.002
	(0.025)	(0.059)	(0.026)	(0.072)					(0.024)	(0.068)	(0.025)	(0.092)
HCG	-0.001	0.001	-0.003	0.003					0.003	0.000	0.000	0.004
	(0.003)	(0.006)	(0.003)	(0.007)					(0.004)	(0.006)	(0.004)	(0.007)
GGCONG	0.001	-0.026***	0.002	-0.019**					0.005	-0.008	0.004	0.003
	(0.004)	(0.007)	(0.004)	(0.008)					(0.005)	(0.007)	(0.005)	(0.009)
GGTRANSG	-0.025*	-0.097	-0.021	-0.099					-0.014	-0.128***	-0.011	-0.132***
	(0.015)	(0.066)	(0.015)	(0.068)					(0.016)	(0.036)	(0.016)	(0.037)
PIPERGDP	-0.019**	-0.03**	-0.017**	-0.016					-0.016*	-0.011	-0.019**	-0.022
	(0.008)	(0.013)	(0.008)	(0.015)					(0.009)	(0.02)	(0.009)	(0.022)
GIPERGDP	-0.009	-0.036*	-0.006	-0.015					-0.007	-0.045*	0.000	-0.006
	(0.009)	(0.019)	(0.009)	(0.015)					(0.011)	(0.023)	(0.01)	(0.019)
HCPERGDP	0.052***	-0.014	0.055***	0.009					0.051***	-0.028***	0.049***	-0.019*
	(0.016)	(0.01)	(0.016)	(0.011)					(0.017)	(0.008)	(0.017)	(0.01)
GGCONPERGDP	-0.014*	-0.009	-0.009	-0.009					-0.017**	-0.013**	-0.008	-0.008
	(0.007)	(0.005)	(0.007)	(0.006)					(0.008)	(0.005)	(0.008)	(0.006)
GGTRANSPERGDP	-0.028*	-0.029**	-0.027*	-0.033**					-0.028	-0.03***	-0.028*	-0.026**
	(0.015)	(0.014)	(0.016)	(0.014)					(0.017)	(0.011)	(0.017)	(0.011)

Notes: *** significant at 1% level, ** significant at 5% level, * significant at 10% level, (standard errors in parentheses).

Table 3. **Simple regressions of GDP components on a constant and government external debt**

Coefficients for General Government External Debt, 1961—2011, All Countries												
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	No Fixed Effects	Cross-Section Fixed Effects	Period Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Cross-Section Fixed Effects	Period Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Cross-Section Fixed Effects	Period Fixed Effects	Cross-Section and Period Fixed Effects
	GGEXT(-1)				GGEXT				GGEXT(-5)			
Dependent Variable: Annual												
GDPG	-0.001	-0.009	-0.008**	-0.024***	-0.011***	-0.035***	-0.015***	-0.033***	0.01***	-0.002	0.01***	0.002
	(0.003)	(0.005)	(0.003)	(0.005)	(0.003)	(0.005)	(0.003)	(0.005)	(0.003)	(0.007)	(0.003)	(0.006)
PIG	0.038*	0.071*	0.008	-0.003	0.019	0.015	-0.003	-0.009	0.036	0.109**	0.038*	0.113**
	(0.023)	(0.041)	(0.023)	(0.046)	(0.022)	(0.04)	(0.023)	(0.046)	(0.022)	(0.048)	(0.022)	(0.05)
GIG	-0.062	-0.103	-0.063	-0.097	-0.068	-0.145*	-0.069	-0.145	0.026	0.117	0.029	0.1
	(0.042)	(0.079)	(0.044)	(0.092)	(0.042)	(0.078)	(0.044)	(0.089)	(0.041)	(0.094)	(0.042)	(0.101)
HCG	-0.006	-0.003	-0.016***	-0.021***	-0.014***	-0.028***	-0.021***	-0.029***	0.003	0.000	0.000	0.00
	(0.005)	(0.008)	(0.005)	(0.008)	(0.005)	(0.008)	(0.005)	(0.008)	(0.005)	(0.01)	(0.005)	(0.01)
GGCONG	-0.008	-0.052***	-0.01	-0.051***	-0.013**	-0.059***	-0.013**	-0.052***	0.027***	-0.017	0.025***	-0.024*
	(0.006)	(0.01)	(0.006)	(0.011)	(0.006)	(0.01)	(0.006)	(0.01)	(0.006)	(0.012)	(0.007)	(0.013)
GGTRANSG	-0.004	-0.054	-0.01	-0.096*	-0.026	-0.094*	-0.02	-0.097*	0.08***	0.066	0.068**	0.022
	(0.028)	(0.049)	(0.028)	(0.051)	(0.027)	(0.049)	(0.027)	(0.051)	(0.027)	(0.058)	(0.027)	(0.062)
PIPERGDP	-0.057***	-0.031***	-0.051***	-0.011	-0.061***	-0.035***	-0.051***	-0.005	-0.039***	-0.008	-0.038***	-0.009
	(0.006)	(0.008)	(0.007)	(0.009)	(0.006)	(0.008)	(0.007)	(0.009)	(0.007)	(0.011)	(0.007)	(0.011)
GIPERGDP	-0.014**	-0.026***	-0.005	-0.014*	-0.013**	-0.02***	-0.005	-0.011	-0.001	0.003	0.001	0.01
	(0.006)	(0.007)	(0.007)	(0.008)	(0.006)	(0.007)	(0.007)	(0.008)	(0.007)	(0.01)	(0.007)	(0.01)
HCPERGDP	0.165***	0.014**	0.155***	0.013*	0.165***	0.013*	0.156***	0.011	0.158***	0.035***	0.141***	0.025***
	(0.012)	(0.007)	(0.012)	(0.007)	(0.012)	(0.007)	(0.012)	(0.007)	(0.012)	(0.009)	(0.013)	(0.009)
GGCONPERGDP	-0.026***	-0.021***	-0.013**	-0.017***	-0.023***	-0.01**	-0.011*	-0.008**	-0.031***	-0.034***	-0.017**	-0.032***
	(0.006)	(0.004)	(0.006)	(0.004)	(0.006)	(0.004)	(0.006)	(0.004)	(0.006)	(0.004)	(0.007)	(0.005)
GGTRANSPERGDP	-0.039***	-0.009	-0.033**	0.007	-0.02	-0.001	-0.017	0.01	-0.095***	-0.007	-0.089***	-0.009
	(0.013)	(0.007)	(0.013)	(0.007)	(0.013)	(0.007)	(0.013)	(0.007)	(0.013)	(0.008)	(0.013)	(0.008)

Coefficients for General Government External Debt, 1961—2011, All Countries

	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	No Fixed Effects	Cross-Section Fixed Effects	Period Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Cross-Section Fixed Effects	Period Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Cross-Section Fixed Effects	Period Fixed Effects	Cross-Section and Period Fixed Effects
	GGEXT(-1)				GGEXT				GGEXT(-5)			
Dependent Variable: Five-Year Average												
GDPG	0.011**	-0.004	0.009*	0.003					0.013**	-0.028**	0.013**	-0.021*
	(0.005)	(0.008)	(0.005)	(0.008)					(0.005)	(0.011)	(0.006)	(0.011)
PIG	0.046*	0.022	0.044*	0.028					0.028	0.008	0.018	0.007
	(0.024)	(0.044)	(0.025)	(0.045)					(0.027)	(0.052)	(0.029)	(0.057)
GIG	-0.018	0.346*	-0.008	0.335*					0.06	-0.152	0.058	-0.235
	(0.05)	(0.177)	(0.052)	(0.178)					(0.057)	(0.166)	(0.058)	(0.17)
HCG	0.001	-0.001	-0.003	-0.001					0.002	-0.044***	-0.001	-0.043***
	(0.006)	(0.011)	(0.006)	(0.012)					(0.007)	(0.014)	(0.007)	(0.015)
GGCONG	0.015*	-0.044***	0.012	-0.044***					0.043***	0.021	0.042***	0.027
	(0.008)	(0.016)	(0.008)	(0.016)					(0.008)	(0.018)	(0.009)	(0.019)
GGTRANSG	0.082***	0.107**	0.068**	0.083					0.104***	0.086	0.092**	0.055
	(0.03)	(0.052)	(0.03)	(0.054)					(0.039)	(0.1)	(0.036)	(0.102)
PIPERGDP	-0.048***	-0.021	-0.045***	-0.011					-0.019	0.02	-0.015	0.015
	(0.014)	(0.027)	(0.014)	(0.024)					(0.018)	(0.042)	(0.018)	(0.033)
GIPERGDP	0.000	-0.008	0.003	-0.02					-0.001	0.074	0.000	0.068
	(0.015)	(0.044)	(0.015)	(0.046)					(0.018)	(0.05)	(0.018)	(0.054)
HCPERGDP	0.163***	-0.012	0.148***	-0.02					0.169***	0.011	0.152***	-0.006
	(0.023)	(0.017)	(0.024)	(0.018)					(0.026)	(0.025)	(0.028)	(0.025)
GGCONPERGDP	-0.036***	-0.026***	-0.02	-0.021**					-0.029*	-0.05***	-0.011	-0.043***
	(0.013)	(0.01)	(0.014)	(0.01)					(0.017)	(0.012)	(0.018)	(0.013)
GGTRANSPERGDP	-0.068*	-0.006	-0.051	-0.014					-0.104**	-0.046*	-0.089*	-0.038
	(0.035)	(0.022)	(0.036)	(0.022)					(0.045)	(0.027)	(0.046)	(0.028)

Notes: *** significant at 1% level, ** significant at 5% level, * significant at 10% level, (standard errors in parentheses).

Table 4. **Annual regressions with government external debt**

	Dependent Variable: Annual Growth Rate of Real GDP, 1962–2011											
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	All Countries				Emerging and Developed Economies				Developed Economies			
	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects
CONSTANT	4.787**	3.16*	10.677	64.493***	4.242	-2.303	17.28***	33.54	9.73***	1.918	37.354***	16.793
	(1.906)	(1.895)	(6.638)	(18.262)	(2.77)	(3.104)	(6.591)	(20.954)	(2.904)	(2.861)	(7.288)	(20.874)
GGEXT(-1)	-0.015***	-0.025***	-0.02***	-0.04***	-0.019**	-0.031***	-0.011	-0.047***	-0.033***	-0.023***	-0.005	-0.009
	(0.005)	(0.004)	(0.007)	(0.006)	(0.008)	(0.007)	(0.012)	(0.011)	(0.009)	(0.007)	(0.012)	(0.01)
DOMCRED(-1)	-0.012***	-0.012***	-0.018***	-0.024***	-0.012***	-0.013***	-0.021***	-0.027***	-0.02***	-0.012***	-0.011**	-0.01**
	(0.002)	(0.002)	(0.004)	(0.004)	(0.003)	(0.003)	(0.005)	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)
FRONTIERGAP(-1)	-0.464***	-0.544***	-5.236***	-4.226***	-0.28*	-0.473**	-5.265***	-5.651***	-0.616	-0.976***	-6.313***	-4.889**
	(0.115)	(0.124)	(0.897)	(1.168)	(0.166)	(0.202)	(1.152)	(1.488)	(0.375)	(0.372)	(2.014)	(1.904)
TRADEPERGDP(-1)	0.002	0.004*	0.012	0.017**	0.003	0.007***	-0.002	0.025**	0.001	0.006***	0.005	0.049***
	(0.002)	(0.002)	(0.008)	(0.008)	(0.002)	(0.002)	(0.01)	(0.01)	(0.002)	(0.002)	(0.012)	(0.012)
LINFLATION(-1)	-3.305***	-2.379***	-3.504***	-2.21***	-2.391***	-1.304***	-2.806***	-1.326***	-30.305***	-20.508***	-36.604***	-31.65***
	(0.484)	(0.46)	(0.536)	(0.502)	(0.491)	(0.46)	(0.53)	(0.483)	(3.579)	(4.32)	(4.126)	(4.936)
GGCONPERGDP(-1)	-0.021	-0.007	-0.128***	-0.073**	-0.027	-0.027	-0.16***	-0.108**	-0.012	-0.025	-0.019	-0.045
	(0.016)	(0.015)	(0.04)	(0.037)	(0.021)	(0.018)	(0.058)	(0.054)	(0.02)	(0.017)	(0.07)	(0.064)
LGDPCURUSD(-1)	-0.101	-0.05	-0.863***	-2.519***	-0.017	0.165*	-0.723**	-1.167	-0.03	0.079	-0.997***	-0.247
	(0.062)	(0.058)	(0.312)	(0.655)	(0.097)	(0.092)	(0.315)	(0.748)	(0.089)	(0.073)	(0.297)	(0.749)
LREALINTRATE(-1)	-3.465***	-2.567**	-4.478***	-1.467	0.51	1.911	-1.241	0.766	-16.29***	-10.794***	-17.633***	-11.25***
	(1.115)	(1.058)	(1.345)	(1.268)	(1.45)	(1.351)	(1.841)	(1.709)	(3.209)	(3.178)	(3.325)	(3.232)
POPG	0.361***	0.444***	0.592***	0.803***	0.104	0.303	-0.505	0.111	-0.368	0.407*	-0.65**	0.685**
	(0.14)	(0.128)	(0.199)	(0.181)	(0.209)	(0.187)	(0.359)	(0.314)	(0.259)	(0.243)	(0.326)	(0.295)

Dependent Variable: Annual Growth Rate of Real GDP, 1962–2011												
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	All Countries				Emerging and Developed Economies				Developed Economies			
	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects
LAVGSCHOOLING(-1)	1.13***	0.933***	3.852***	-0.862	0.812*	1.078**	2.968*	0.055	0.649	0.913	-0.585	-3.082**
	(0.322)	(0.308)	(1.457)	(1.458)	(0.456)	(0.473)	(1.645)	(1.496)	(0.723)	(0.692)	(1.798)	(1.546)
AGEDEPENDENCY(-1)	-0.023	-0.011	-0.03	-0.16***	-0.065**	-0.031	-0.087	-0.157***	-0.159***	-0.063**	-0.237***	-0.112***
	(0.023)	(0.022)	(0.059)	(0.059)	(0.032)	(0.03)	(0.055)	(0.054)	(0.027)	(0.028)	(0.047)	(0.043)
R-squared	0.16	0.34	0.32	0.49	0.19	0.44	0.33	0.57	0.30	0.61	0.45	0.72
Durbin-Watson	1.30	1.18	1.55	1.45	1.45	1.26	1.70	1.53	1.34	1.19	1.54	1.57
LM-statistic	154.74	195.72	123.68	135.89	89.72	121.92	88.26	88.70	55.72	68.69	42.38	40.03
P-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Periods	50	50	50	50	50	50	50	50	50	50	50	50
Cross-sections	89	89	89	89	41	41	41	41	22	22	22	22
Total observations	1306	1306	1306	1306	736	736	736	736	454	454	454	454

Notes: *** significant at 1% level, ** significant at 5% level, * significant at 10% level, (standard errors in parentheses).

Table 5. **Annual regressions with contemporaneous explanatory variables and government external debt**

Dependent Variable: Annual Growth Rate of Real GDP, 1961—2011												
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	All Countries				Emerging and Developed Economies				Developed Economies			
	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects
CONSTANT	3.982**	1.815	-23.053***	-129.458***	3.372	-2.568	-4.279	-100.611***	3.278	0.374	25.513***	-69.376***
	(1.804)	(1.813)	(6.06)	(16.739)	(2.667)	(3.004)	(6.102)	(19.357)	(2.963)	(2.908)	(7.273)	(20.119)
GGEXT	-0.024***	-0.026***	-0.036***	-0.02***	-0.02***	-0.018**	-0.042***	-0.02*	-0.04***	-0.023***	-0.043***	-0.009
	(0.004)	(0.004)	(0.006)	(0.006)	(0.008)	(0.007)	(0.011)	(0.011)	(0.009)	(0.008)	(0.012)	(0.01)
DOMCRED	-0.013***	-0.012***	-0.025***	-0.017***	-0.015***	-0.012***	-0.029***	-0.018***	-0.021***	-0.012***	-0.023***	-0.013***
	(0.002)	(0.002)	(0.004)	(0.004)	(0.003)	(0.002)	(0.005)	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)
FRONTIERGAP(-1)	-0.538***	-0.64***	-7.886***	-11.552***	-0.241	-0.603***	-7.927***	-10.777***	-0.986***	-0.91**	-5.052***	-8.128***
	(0.107)	(0.118)	(0.804)	(1.033)	(0.16)	(0.193)	(1.024)	(1.304)	(0.38)	(0.376)	(1.929)	(1.871)
TRADEPERGDP	0.005**	0.005***	0.041***	0.045***	0.005**	0.006***	0.023**	0.034***	0.005***	0.007***	0.044***	0.058***
	(0.002)	(0.002)	(0.007)	(0.007)	(0.002)	(0.002)	(0.009)	(0.009)	(0.002)	(0.002)	(0.012)	(0.011)
LINFLATION	-4.298***	-4.092***	-4.393***	-3.63***	-3.71***	-3.369***	-4.404***	-3.73***	-19.02***	-11.909***	-21.796***	-18.187***
	(0.469)	(0.447)	(0.509)	(0.489)	(0.481)	(0.448)	(0.504)	(0.465)	(3.671)	(4.405)	(4.155)	(5.101)
GGCONPERGDP	-0.049***	-0.04***	-0.246***	-0.194***	-0.064***	-0.059***	-0.312***	-0.245***	-0.049**	-0.037**	-0.407***	-0.331***
	(0.015)	(0.014)	(0.036)	(0.033)	(0.02)	(0.018)	(0.05)	(0.045)	(0.021)	(0.018)	(0.069)	(0.062)
LGDPCURUSD	-0.062	-0.016	1.027***	4.576***	0.047	0.164*	0.484*	3.707***	0.104	0.114	-0.279	2.98***
	(0.059)	(0.056)	(0.285)	(0.6)	(0.093)	(0.089)	(0.292)	(0.69)	(0.091)	(0.075)	(0.293)	(0.716)
LREALINTRATE	-5.225***	-3.05***	-6.709***	-4.647***	-2.753*	-0.204	-8.539***	-5.809***	-16.73***	-10.706***	-11.058***	-9.84***
	(1.068)	(1.019)	(1.267)	(1.215)	(1.403)	(1.303)	(1.744)	(1.639)	(3.274)	(3.249)	(3.339)	(3.219)
POPG	0.554***	0.587***	0.689***	0.52***	0.337	0.431**	0.042	-0.116	-0.407	0.326	-0.018	0.495
	(0.128)	(0.118)	(0.177)	(0.163)	(0.205)	(0.184)	(0.346)	(0.307)	(0.27)	(0.261)	(0.33)	(0.301)
LAVGSCHOOLING	0.943***	1.078***	-4.382***	-1.04	0.626	1.178***	-2.341	-0.96	1.758**	1.161	-2.142	-2.709*
	(0.308)	(0.298)	(1.363)	(1.397)	(0.441)	(0.456)	(1.549)	(1.432)	(0.735)	(0.706)	(1.769)	(1.528)

Dependent Variable: Annual Growth Rate of Real GDP, 1961—2011												
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	All Countries				Emerging and Developed Economies				Developed Economies			
	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects
AGEDEPENDENCY	0.014	0.023	-0.1*	0.027	-0.036	-0.008	-0.077	0.014	-0.129***	-0.062**	-0.116**	0.019
	(0.022)	(0.021)	(0.054)	(0.055)	(0.031)	(0.029)	(0.05)	(0.05)	(0.028)	(0.029)	(0.045)	(0.042)
R-squared	0.21	0.37	0.38	0.52	0.24	0.48	0.40	0.60	0.26	0.60	0.44	0.72
Durbin-Watson	1.33	1.22	1.46	1.32	1.42	1.25	1.56	1.37	1.38	1.19	1.48	1.41
LM-statistic	156.14	194.68	123.69	168.70	76.71	107.85	77.18	106.36	52.31	67.87	44.86	41.37
P-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Periods	51	51	51	51	51	51	51	51	51	51	51	51
Cross-sections	89	89	89	89	41	41	41	41	22	22	22	22
Total observations	1352	1352	1352	1352	760	760	760	760	461	461	461	461

Notes: *** significant at 1% level, ** significant at 5% level, * significant at 10% level, (standard errors in parentheses).

Table 6. **Further regressions with government external debt for developed economies**

Dependent Variable: Growth Rate of Real GDP, 1962—2011, Developed Economies												
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	Dependent Variable: Annual				Dependent Variable: Five-Year Average				Dependent Variable: Five-Year Average			
	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects
CONSTANT	6.534**	2.138	18.222**	-0.173	9.983**	2.89	34.087***	60.991*	5.28	-1.278	36.185**	83.573
	(3.253)	(2.983)	(8.994)	(25.193)	(4.375)	(4.516)	(11.238)	(34.537)	(5.28)	(5.263)	(14.885)	(50.274)
GGEXT(-1)					-0.029*	-0.021	0.003	0.007				
					(0.015)	(0.013)	(0.019)	(0.015)				
GGEXT(-5)	-0.036***	-0.029***	-0.011	-0.012					-0.043**	-0.037**	0.000	-0.011
	(0.011)	(0.008)	(0.016)	(0.012)					(0.02)	(0.017)	(0.031)	(0.023)
DOMCRED(-1)					-0.011**	-0.006	-0.004	-0.004				
					(0.005)	(0.004)	(0.008)	(0.006)				
DOMCRED(-2)	-0.018***	-0.01***	-0.017***	-0.011***					-0.01	-0.006	0.001	-0.005
	(0.003)	(0.003)	(0.005)	(0.004)					(0.007)	(0.005)	(0.011)	(0.008)
FRONTIERGAP(-1)					-0.393	-0.903	-4.473	-6.654**				
					(0.578)	(0.596)	(3.375)	(2.94)				
FRONTIERGAP(-2)	-0.368	-0.728*	-4.132	-9.613***					-0.571	-1.102	-4.379	-7.627**
	(0.428)	(0.397)	(2.763)	(2.312)					(0.692)	(0.671)	(4.169)	(3.541)
TRADEPERGDP(-1)					-0.001	0.003	0.038	0.018				
					(0.003)	(0.003)	(0.023)	(0.026)				
TRADEPERGDP(-2)	0.000	0.005**	0.036**	0.05***					-0.003	0.005	0.044	0.014
	(0.002)	(0.002)	(0.016)	(0.016)					(0.007)	(0.006)	(0.029)	(0.033)
LINFLATION(-1)					-17.754***	-13.616*	-24.553***	-5.858				
					(6.661)	(7.908)	(7.655)	(8.514)				
LINFLATION(-2)	-26.702***	-21.12***	-29.433***	-22.912***					-8.84	-11.23	-7.731	3.577
	(4.121)	(4.911)	(5.063)	(5.978)					(7.13)	(7.578)	(8.765)	(9.425)
GGCONPERGDP(-1)					0.014	-0.009	0.214*	-0.001				
					(0.032)	(0.027)	(0.119)	(0.101)				

Dependent Variable: Growth Rate of Real GDP, 1962—2011, Developed Economies												
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	Dependent Variable: Annual				Dependent Variable: Five-Year Average				Dependent Variable: Five-Year Average			
	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects
GGCONPERGDP(-2)	0.02	0.006	0.138*	-0.012					0.028	0.02	0.172	0.032
	(0.023)	(0.019)	(0.083)	(0.071)					(0.036)	(0.031)	(0.137)	(0.115)
LGDPCURUSD(-1)					-0.126	-0.023	-1.414***	-2.144*				
					(0.134)	(0.117)	(0.497)	(1.251)				
LGDPCURUSD(-2)	-0.008	0.055	-0.656*	0.244					-0.101	-0.005	-1.837**	-3.027*
	(0.099)	(0.077)	(0.368)	(0.887)					(0.165)	(0.137)	(0.678)	(1.755)
LREALINTRATE(-1)					5.734	5.3	0.875	4.088				
					(5.435)	(5.95)	(5.673)	(6.826)				
LREALINTRATE(-2)	-9.651***	-5.892*	-6.702*	-2.822					8.055	2.271	15.752**	4.662
	(3.621)	(3.538)	(3.799)	(3.574)					(7.492)	(7.415)	(7.379)	(6.988)
POPG	-0.273	0.394	-0.953**	0.375								
	(0.285)	(0.244)	(0.385)	(0.336)								
POPG5					-0.12	0.368	-0.706	0.976*	0.02	0.289	-0.729	0.932
					(0.448)	(0.408)	(0.621)	(0.523)	(0.531)	(0.48)	(0.793)	(0.635)
LAVGSCHOOLING(-1)					0.149	0.809	1.953	-0.281				
					(1.161)	(1.125)	(2.981)	(2.336)				
LAVGSCHOOLING(-2)	1.024	0.744	2.278	-1.75					1.274	1.973	5.427	0.264
	(0.84)	(0.757)	(2.216)	(1.827)					(1.476)	(1.427)	(3.885)	(3.073)
AGEDEPENDENCY(-1)					-0.147***	-0.062	-0.254***	-0.209***				
					(0.043)	(0.043)	(0.081)	(0.066)				
AGEDEPENDENCY(-2)	-0.142***	-0.07**	-0.285***	-0.194***					-0.12**	-0.04	-0.221**	-0.234***
	(0.029)	(0.028)	(0.057)	(0.049)					(0.046)	(0.048)	(0.094)	(0.076)
R-squared	0.24	0.62	0.36	0.72	0.40	0.65	0.69	0.86	0.43	0.70	0.71	0.89
Durbin-Watson	1.46	1.24	1.71	1.61								
LM-statistic	42.56	55.37	40.33	35.56	2.51	0.08	15.80	17.11	6.55	1.72	24.21	16.93
P-value	0.00	0.00	0.00	0.00	0.29	0.96	0.00	0.00	0.04	0.42	0.00	0.00
Periods	47	47	47	47	9	9	9	9	9	9	9	9

Dependent Variable: Growth Rate of Real GDP, 1962—2011, Developed Economies												
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	Dependent Variable: Annual				Dependent Variable: Five-Year Average				Dependent Variable: Five-Year Average			
	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects
Cross-sections	22	22	22	22	22	22	22	22	20	20	20	20
Total observations	394	394	394	394	84	84	84	84	68	68	68	68

Notes: *** significant at 1% level, ** significant at 5% level, * significant at 10% level, (standard errors in parentheses).

Table 7. **Baseline five-year period regressions**

Dependent Variable: Five-Year Average Growth Rate of Real GDP, 1975—2009, All Countries								
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects
CONSTANT	-3.053	-4.416*	19.287*	34.335	-2.846	-4.26*	24.148**	23.806
	(2.512)	(2.539)	(10.004)	(26.324)	(2.519)	(2.543)	(10.471)	(25.49)
GGDEBT2(-1)	-0.004	-0.006*	0.001	-0.006	-0.001	-0.025	-0.018	-0.751***
	(0.003)	(0.003)	(0.005)	(0.006)	(0.005)	(0.018)	(0.014)	(0.219)
DOMCRED(-1)	-0.001	-0.001	-0.005	-0.008	-0.001	-0.001	-0.004	-0.009
	(0.004)	(0.004)	(0.006)	(0.007)	(0.004)	(0.004)	(0.007)	(0.006)
FRONTIERGAP(-1)	-0.745***	-0.892***	-4.335***	-3.997**	-0.746***	-0.891***	-4.014***	-6.248***
	(0.143)	(0.164)	(1.071)	(1.577)	(0.143)	(0.164)	(1.087)	(1.653)
TRADEPERGDP(-1)	0.009***	0.009***	0.018*	0.017	0.008***	0.009***	0.018**	0.016
	(0.002)	(0.002)	(0.009)	(0.01)	(0.002)	(0.002)	(0.009)	(0.01)
LINFLATION(-1)	-0.732	-1.143	-4.256**	-3.532*	-0.512	-1.006	-4.253**	-2.371
	(1.552)	(1.683)	(1.977)	(1.965)	(1.565)	(1.687)	(1.967)	(1.919)
GGCONPERGDP(-1)	-0.001	-0.006	0.04	0.031	-0.002	-0.007	0.032	0.033
	(0.023)	(0.024)	(0.046)	(0.045)	(0.023)	(0.024)	(0.046)	(0.043)
LGDPCURUSD(-1)	0.224***	0.244***	-1.296***	-1.773*	0.209**	0.244***	-1.463***	-1.506
	(0.081)	(0.081)	(0.442)	(0.965)	(0.083)	(0.081)	(0.454)	(0.931)
LREALINTRATE(-1)	1.621	0.878	-4.493*	-4.506*	1.368	0.734	-4.32*	-4.922**
	(1.894)	(1.914)	(2.442)	(2.459)	(1.907)	(1.918)	(2.434)	(2.367)
POPG5	-0.372*	-0.246	-0.193	-0.226	-0.383*	-0.23	-0.227	-0.038
	(0.204)	(0.204)	(0.333)	(0.328)	(0.204)	(0.204)	(0.332)	(0.32)
LAVGSCHOOLING(-1)	0.43	0.599	4.67***	3.988***	0.458	0.608	4.663***	3.636**
	(0.357)	(0.399)	(1.416)	(1.509)	(0.358)	(0.399)	(1.409)	(1.455)
AGEDEPENDENCY(-1)	-0.085**	-0.065*	-0.16*	-0.194**	-0.087**	-0.064*	-0.141	-0.156*
	(0.035)	(0.035)	(0.087)	(0.085)	(0.035)	(0.035)	(0.088)	(0.083)
GGDEBT2(-1)*(GGDEBT2(-1)>130)					-0.005			
					(0.004)			

Dependent Variable: Five-Year Average Growth Rate of Real GDP, 1975—2009, All Countries								
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects	No Fixed Effects	Period Fixed Effects	Cross-Section Fixed Effects	Cross-Section and Period Fixed Effects
GGDEBT2(-1)*(GGDEBT2(-1)>30)						0.018 (0.016)		
GGDEBT2(-1)*(GGDEBT2(-1)>40)							0.016 (0.011)	
GGDEBT2(-1)*(GGDEBT2(-1)>10)								0.741*** (0.217)
R-squared	0.34	0.38	0.83	0.85	0.35	0.38	0.83	0.86
LM-statistic	7.11	10.41	41.09	40.63	7.85	10.75	44.20	32.67
P-value	0.03	0.01	0.00	0.00	0.02	0.00	0.00	0.00
Periods	7	7	7	7	7	7	7	7
Cross-sections	104	104	104	104	104	104	104	104
Total observations	250	250	250	250	250	250	250	250

Notes: *** significant at 1% level, ** significant at 5% level, * significant at 10% level, (standard errors in parentheses).

Table 8. **Meta-regressions with OLS**

	Dependent Variable: Coefficient of Government Debt to GDP									
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
CONSTANT	-0.013***	-0.013***	-0.012***	-0.005	0.000	0.005	0.011	-0.005	0.001	0.025**
	(0.003)	(0.003)	(0.004)	(0.006)	(0.006)	(0.008)	(0.008)	(0.014)	(0.012)	(0.012)
SHORT SAMPLE 1990-		0.005	0.003	0.003	-0.004	-0.005	-0.005	0.000	0.000	0.000
		(0.01)	(0.011)	(0.011)	(0.012)	(0.012)	(0.012)	(0.015)	(0.015)	(0.015)
SHORT SAMPLE 2000-		-0.003	-0.005	-0.006	-0.012	-0.013	-0.013	-0.007	-0.007	-0.007
		(0.01)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.015)	(0.015)	(0.015)
DLS			0.02*	0.019*	0.021*	0.021*	0.021*	0.018	0.018	0.018
			(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.013)	(0.013)	(0.013)
GLS			0.001	0.001	-0.009	-0.009	-0.009	-0.008	-0.008	-0.008
			(0.008)	(0.008)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
GMM			0.008	0.007	0.012	0.011	0.012	0.005	0.005	0.005
			(0.007)	(0.007)	(0.008)	(0.008)	(0.008)	(0.011)	(0.011)	(0.011)
DGMM			-0.029***	-0.03***	-0.027***	-0.028***	-0.027***	-0.034***	-0.034***	-0.034***
			(0.009)	(0.009)	(0.01)	(0.01)	(0.01)	(0.013)	(0.013)	(0.013)
OGMM			-0.009	-0.009	-0.006	-0.007	-0.006	-0.013	-0.013	-0.013
			(0.009)	(0.009)	(0.01)	(0.01)	(0.01)	(0.013)	(0.013)	(0.013)
INCL. OTHER ECONOMIES THAN EMERGING AND DEVELOPED				-0.022***		-0.023***	-0.022***	-0.022***	-0.022***	-0.022***
				(0.006)		(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
DEVELOPED ECONOMIES				0.002		0.002	0.002	0.002	0.002	0.002
				(0.007)		(0.007)	(0.007)	(0.006)	(0.006)	(0.006)
CROSS-SECTIONAL FIXED EFFECTS					-0.003	-0.002	-0.002	-0.003	-0.003	-0.003
					(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
PERIOD FIXED EFFECTS					-0.025***	-0.025***	-0.025***	-0.025***	-0.025***	-0.025***
					(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
INCL. CONTROL VARIABLES						0.004	0.005	0.001	0.001	0.001
						(0.006)	(0.006)	(0.012)	(0.012)	(0.012)
THRESHOLD EFFECTS							-0.015***	-0.016***	-0.016***	-0.016***
							(0.005)	(0.005)	(0.005)	(0.005)

Dependent Variable: Coefficient of Government Debt to GDP										
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
ANNUAL PANEL								0.03***	0.03***	
								(0.007)	(0.007)	
FIVE-YEAR PERIOD PANEL										-0.03***
										(0.007)
SINGLE CROSS SECTION								0.015	0.015	-0.015
								(0.018)	(0.018)	(0.016)
FRONTIERGAP NOT INCLUDED IN INSTRUMENTS								0.027***	0.027***	0.027***
								(0.009)	(0.009)	(0.009)
GGDEBT2(-5) (INSTEAD OF GGDEBT2(-2)) AS AN INSTRUMENT OF GGDEBT2								-0.009	-0.009	-0.009
								(0.008)	(0.008)	(0.008)
GGEXT INSTEAD OF GGDEBT2								-0.013	-0.013	-0.013
								(0.009)	(0.009)	(0.009)
INITIAL GOVERNMENT DEBT								0.006		0.006
								(0.007)		(0.007)
CONTEMPORANEOUS GOVERNMENT DEBT									-0.006	
									(0.007)	
5TH LAG OF GOVERNMENT DEBT								0.009	0.009	0.009
								(0.011)	(0.011)	(0.011)
2ND LAG OF GOVERNMENT DEBT								0.002	0.002	0.002
								(0.015)	(0.015)	(0.015)
INCL. DOMCRED								-0.003	-0.003	-0.003
								(0.013)	(0.013)	(0.013)
INCL. EXT2								-0.001	-0.001	-0.001
								(0.011)	(0.011)	(0.011)
R-squared	0.00	0.00	0.01	0.02	0.02	0.03	0.03	0.04	0.04	0.04
Observations	2094	2094	2094	2094	2094	2094	2094	2094	2094	2094

Notes: *** significant at 1% level, ** significant at 5% level, * significant at 10% level, (standard errors in parentheses).

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