# What Drives Long-term Capital Flows?
# A Theoretical and Empirical Investigation

Comments welcome

Geneviève Verdier *

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**Abstract**

What drives capital inflows in the long run? Do they follow the predictions of neoclassical theory, or are other forces at work? The purpose of this paper is to illustrate how long-term capital movements conform surprisingly well to the predictions of a simple neoclassical model with credit constraints. The most surprising prediction of this class of models is that, contrary to a pure neoclassical model, domestic savings should act as a complement rather than a substitute to capital inflows. Nevertheless, this class of models keeps the neoclassical prediction that, ceteris paribus, capital should flow to the countries where it is most scarce. Using data on net foreign liabilities over the 1970 to 1997 period, I find evidence that supports these predictions.

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* Department of Economics, 3035 Academic Building - West - 4228 Texas A&M University, College Station, TX 77843-4228, e-mail: gverdier@econmail.tamu.edu. I would like to thank Paul Beaudry, Fabrice Collard, Michael Devereux, Francisco González, Patrick Francois, Angela Redish, Lilia Karnizova, Ana Ferrer, Stephanie McWhinnie and participants of the macroeconomics lunch seminar at UBC for helpful comments and suggestions. Special thanks to Luis Servén for sharing his data on capital controls. Any errors or omissions are my own.

# 1 Introduction

Why do growing economies borrow? Are the neoclassical forces that drive accumulation the main impulse behind long-term cross-country movements in capital? A standard view of capital flows is that they are driven by scarcity, and act as a substitute to domestic savings. Countries borrow to accumulate capital, and by using international capital markets, can increase investment with no cost in current consumption: foreign financing replaces domestic savings. An alternative view is that factors other than the domestic scarcity of capital may also drive inflows from abroad. In particular, countries that are willing to cut current consumption to accumulate domestic capital may be rewarded by additional inflows, i.e. capital inflows may complement domestic savings. The objective of this paper is to illustrate how well this latter view fits the long-term movements in external debt. More specifically, the evidence presented here suggests that the cross-country variations in net foreign liabilities conform rather well to the qualitative predictions of a simple neoclassical model with collateral constraints in which countries with high savings rates tend to accumulate debt faster.

Surprisingly, little is known about the role of savings, convergence or imperfect capital markets in driving cross-country variations in external debt [1]. The limited research on long-term cross-sectional variation in external positions stems in part from the paucity of consistent data on net foreign debt. A newly constructed database by Lane and Milesi-Ferretti [1999] now allows the investigation of these questions. This paper exploits these new data to estimate a reduced form for debt accumulation derived from a neoclassical model with credit constraints.

The predictions of neoclassical growth models for movements in capital are well known. In the benchmark neoclassical model with labour-augmenting technological progress, growth is driven by accumulation, the returns to which decline with development. With perfect capital markets, convergence accelerates: less developed economies can use international markets to finance capital accumulation, while richer countries lend them the necessary funds thereby earning higher returns on their savings. Poor countries borrow and rich countries lend to equalise the marginal products of capital. As a starting point to address questions about long-term debt accumulation, the paper focuses on this class of models with decreasing returns, which predicts convergence — a standard and well-understood phenomenon.

These models however, tend to predict infinite rates of convergence when capital is allowed to

[1] Throughout this paper , the terms 'net foreign liabilities', 'net external debt' and 'debt' are used interchangeably.

flow freely. Observed rates of convergence are not only finite, but fairly low, around 2 per cent a year (e.g. Mankiw, Romer and Weil [1992], MRW hereafter). In addition, there is evidence that the ability to borrow is somewhat limited by capital market imperfections (see Obstfeld and Rogoff [2000]). This suggests that for a neoclassical model to help us understand variations in borrowing behaviour, some type of imperfection in capital markets is needed. What form should this imperfection take? This paper suggests that a modelled imperfection that allows for the possible complementary role of domestic savings is an appropriate choice. The analysis is undertaken with a two-sector neoclassical model developed by Barro, Mankiw and Sala-i-Martin [1995] (BMS hereafter). In the framework developed by BMS, there are two types of capital, foreign and domestic. Constrained countries can borrow freely on world markets for their foreign capital needs, but must save in order to accumulate domestic capital. Nevertheless, this framework retains the feature that, everything else being equal, capital flows to where it is most scarce. Since foreign and domestic capital are complementary in production, the collateral constraint slows down the rate of income convergence compared to the standard model. Perhaps more importantly, this complementarity in production leads to a complementarity between savings in domestic capital and foreign financing of capital. This model offers a natural way to examine cross-country long-run debt accumulation and is the starting point of the empirical work presented here.

Previous empirical work in the field of international finance has focused on short run determinants of capital flows with emphasis on current account movements (e.g. Obstfeld and Rogoff [1996], Glick and Rogoff [1995]). Other studies have focused on the long-term flows of savings (Edwards [1996], Masson, Bayoumi and Samiei [1998]) and the current account (Chinn and Prasad [2000]) while another branch of the literature has shed some light on the long term determinants of debt within countries and across time (Masson, Kremers and Horne [1994], Calderon, Loayza and Serven [1999]). Yet these studies, do not explicitly allow for the forces of convergence to explain long-run dynamics either because they do not specify a model in particular or because they do not attempt to explain cross-sectional variation.

There exists some evidence of quantity constraints in international capital markets directly from measures of debt. One early example is Eaton and Gersovitz [1981] who develop a model of sovereign debt in which countries that default are excluded from world markets. The possibility of default leads lenders to establish a credit ceiling which is a function of the cost of exclusion from capital markets for the borrower. Using this model and data on gross public debt, they find that a number of low-income countries are constrained. Similarly, Adda and Eaton [1998] develop a methodology for estimating the level of expenditure of a credit-constrained country and infer the level of the credit ceiling. They find that GDP, openness and investment are significant determinants of constraints. More recent papers also include Lane [2000] and Lane and Milesi-Ferretti [2001] who report a positive relationship between debt and income. Lane [2001] also develops a version of the BMS model. In his version of the model, a small open economy can only use capital from the tradable sector as collateral for borrowing on international capital markets. His study however, focuses on the determinants of the steady state debt-output ratio, not on the cross-country dynamics of debt.

This paper will exploit the net foreign assets data constructed by Lane and Milesi-Ferretti [1999] in order to offer an empirical assessment of the role of savings as well as convergence within the context of a growth model. The vast literature on economic growth has mainly focused on the determinants of income across countries in a closed-economy framework. When the assumption of capital immobility is inappropriate, studies have relied instead on partial openness. For example, the application of the Solow model to US states [2] relies on the results of the BMS model which suggests that a neoclassical model with partial capital mobility will mimic the behaviour of a closed economy Ramsey model. This paper makes use of this feature of the model. Specifically, convergence equations for debt, similar to equations from the convergence literature, are derived from the model, and estimated using the Lane and Milesi-Ferretti database. Results give some qualitative support to the idea of convergence. Countries with low levels of initial debt did increase their borrowing over the sample period, at a rate of about 2 per cent per year, an estimate surprisingly close to those of income convergence found in the literature. In addition, the model predicts a positive correlation between domestic savings and debt accumulation which results from the combination of the technological complementarity between the two types of capital and the collateral constraint. This is supported by the data and is robust to the econometric specification, the sample countries considered as well as assumptions about technology and the measurement of domestic savings. However, the tight relationship between debt and income implied by the model only seems to be partially borne out by the data. In particular, in the samples considered here income exhibits low conditional convergence, implying that the convergence observed in debt is not entirely a consequence of decreasing returns. These results suggest that to successfully explain cross-country variations in levels of debt, a model should exhibit the convergence property, as well as a complementarity between domestic savings and foreign financing. In addition, it should allow for a more complex and flexible relationship between debt and output.

[2] See Sala-i-Martin [1996].

The paper is organized as follows. Section 2 describes the framework based on the BMS growth model and derives empirically-testable convergence equations. Section 3 presents the results of estimation. Section 4 concludes.

## 2 The Model

In order to study the long-term determinants of debt accumulation, this paper makes use of a neoclassical open-economy growth model with credit constraints developed by BMS. This choice deserves some justification. First, the use of a model with decreasing returns allows us to determine how far we can go in explaining cross-country variations in debt accumulation using the standard and well-understood mechanism of convergence. Second, to derive an empirically implementable reduced form for external debt, we must consider a model with some form of imperfection on international capital markets since the predictions of the open-economy version of the Ramsey model with perfect capital mobility for net foreign assets are problematic. In particular, for constant consumption, the value of net foreign assets is indeterminate in the steady state (it depends on initial conditions), or is excessively large for declining consumptions paths (a small open economy ends up mortgaging all of its wealth). In addition, a neoclassical open-economy model with perfect capital markets exhibits infinite speeds of convergence for capital and output. Assuming a debt-elastic interest rate, an endogenous discount factor or portfolio adjustment costs are ways to solve for the indeterminacy of debt in these models [3] (see Schmitt-Grohé and Uribe [2001]). An alternative is to have a quantity constraint as in the BMS model. This is the avenue pursued here. Furthermore, as will become apparent, the presence of the collateral constraint — as opposed to these other imperfections — leads to a role for domestic savings that is rarely emphasised. We discuss this point further below.

The BMS model is one in which credit-constrained small-open economies can use foreign financing to accumulate part of their capital and must save in order to finance the remaining fraction. Technology takes the form of a Cobb-Douglas production function over three inputs — two types of capital, $K$ and $Z$, and raw labour $L$, so that

$$Y_t = K_t^{\alpha} Z_t^{\eta} (\theta_t L_t)^{1-\alpha-\eta} \tag{1}$$

where $\alpha, \eta > 0$, $\alpha + \eta < 1$. $\theta_t$ is the exogenous source of technology and grows at rate $g$ while

[3] In Verdier [2003b] , I explore the implications for the role of savings of a model that features a debt-elastic interest rate.

raw labour grows at rate $n$. The production function can be expressed in units of effective labour (where $x_t = \frac{X_t}{\theta_t L_t}$):

$$y_t = k_t^{\alpha} z_t^{\eta} \tag{2}$$

Profit maximization then requires that factor prices equal the marginal productivities of inputs so that

$$\begin{aligned} R_{kt} &= \alpha k_t^{\alpha-1} z_t^{\eta} = \alpha \frac{y_t}{k_t} \\ R_{zt} &= \eta k_t^{\alpha} z_t^{\eta-1} = \eta \frac{y_t}{z_t} \\ w_t &= k_t^{\alpha} z_t^{\eta} - R_{kt} k_t - R_{zt} z_t = (1-\alpha-\eta) y_t \end{aligned} \tag{3}$$

where $R_{kt}$ is the rental rate of $k$, $R_{zt}$ is the rental rate of $z$ and $w_t$ is the wage rate.

Households collect income from their labour input and from ownership of the two types of capital. This income is used to consume and accumulate capital (of both types) and debt, $d$, on which they pay the constant world interest rate, $r$. The budget constraint faced by the infinitely-lived representative consumer is

$$(1+g)(1+n)(k_{t+1} + z_{t+1} - d_{t+1}) = (1 + R_{kt} - \delta)k_t + (1 + R_{zt} - \delta)z_t - (1+r)d_t + w_t - c_t \tag{4}$$

where we have assumed that foreign and domestic capital depreciate at the same rate, $\delta$. Under the small-open-economy assumption, $r = R_k - \delta$.

What distinguishes the two types of capital? In this model, the credit constraint takes an extreme form. Debt cannot exceed the amount of $k$ — what we will call foreign capital — i.e. $k$ can be used as collateral whereas $z$ — the domestic capital stock — cannot. In the original BMS model, $k$ corresponds to physical capital and $z$ to human capital. Yet as noted by the authors, one need not be that specific about the type of capital that can be used for collateral. All the credit constraint assumption requires is that some types of capital are easy to borrow against internationally whereas some others are not. It is reasonable to think that foreign investors would be reluctant to accept human capital as collateral, but one can think of other types of capital that are more difficult to acquire abroad. In fact, in this paper, we want to think of domestic capital as a broader concept than just human capital. Domestic firms might find it difficult to convince foreign investors to channel capital to their projects because of moral hazard problems, or risk of debt repudiation [4]. For example, foreign investors may finance machinery and equipment, which are easier to repossess, whereas domestic savers invest in building structures. Differences between

[4] Cohen and Sachs [1986] develop a model of borrowing with one capital good in which borrowers can choose to

the two types of capital may also be sectoral. In that case, foreign capital is used in the formal sector of the economy, while domestic capital operates in the informal sector: firms in the informal sector may not easily collateralise their assets. In all these examples — human vs physical capital, structures vs equipment or formal vs informal capital sectors — $k$ and $z$ can be complements in production.

Whether a country is constrained or not is determined by initial asset holdings relative to steady state domestic capital $z^*$. More specifically, if $k_0+z_0-d_0 \geq z^*$, the constraint does not bind and the model behaves as the open-economy Ramsey model with infinite speed of convergence. If $k_0+z_0-d_0 < z^*$, the constraint binds ($k_t = d_t$). In that case the combination of the credit constraint, the small-open-economy assumption and profit maximization (equation (3)) imply that

$$d_t = k_t = \frac{\alpha}{r+\delta} y_t \tag{5}$$

so that $\frac{k}{y}$ has a constant path to the steady state. The production function can therefore be written as

$$y_t = B z_t^{\varepsilon} \tag{6}$$

where $B = \left(\frac{\alpha}{r+\delta}\right)^{\frac{\alpha}{1-\alpha}}$ and $\varepsilon = \frac{\eta}{1-\alpha}$. Given profit maximisation (equation (3)) and the collapsed production function (equation(6)), market clearing implies

$$(1+n)(1+g)z_{t+1} = (1-\alpha)y_t - c_t + (1-\delta)z_t \tag{7}$$

Note that $(1-\alpha)y_t$ is the gross national product, and $-\alpha y$ is net factor income from abroad. In the original BMS paper, households chose their consumption paths optimally and the savings rate can rise or fall during the transition to the steady state. Here we choose to make the Solow-growth-model assumption of a constant savings rate for two reasons. First, we are interested in long-term phenomena for periods of time over which the savings rate does not vary much. In addition, the use of a constant exogenous savings rate will be useful for estimation [5].

Suppose that domestic consumers save a fixed fraction of income. Let $s_y$ denote the rate at which consumers save out of gross domestic product $y$ to accumulate domestic capital, i.e. $s_y y_t = y_t - c_t$.

default on their debt each period. Default however, results in loss of output (through loss of efficiency because of lost trade) and exclusion from capital markets in the future. To insure repayment, lenders ration credit and debt cannot exceed a lending limit which is a function of productive capital in the economy, i.e. in the notation used here $d_t \leq \upsilon k_t$ where $\upsilon \in [0,1]$ — a constraint similar to equation (5). When the constraint binds, debt and output grow at the same rate. Gertler and Rogoff [1990] construct a model with moral hazard where borrowers actions after the loan has been made are not observable. The optimal lending contract also involves a perfect correlation between debt and output net of investment.

[5] See Verdier [2003a] for a derivation of the estimated equation in a version of the model with endogenous savings.

Domestic savings must equal investment in domestic capital minus net factor payments on debt ($i_t^z = (s_y - \alpha)Bz_t^{\varepsilon}$), so that

$$(1+n)(1+g)z_{t+1} = sBz_t^{\varepsilon} + (1-\delta)z_t \tag{8}$$

where $s = s_y - \alpha$. In the steady state, $z_{t+1} = z_t = z^*$ so that

$$z^* = \left[\frac{sB}{(1+n(1+g)-(1-\delta)}\right]^{\frac{1}{1-\varepsilon}} \tag{9}$$

Since $k_t = d_t = \frac{\alpha}{r+\delta}y_t$,

$$d^* = \frac{\alpha B}{r+\delta}\left(\frac{sB}{(1+n)(1+g)-(1-\delta)}\right)^{\frac{\varepsilon}{1-\varepsilon}} \tag{10}$$

Note that equation (8) will behave just like the dynamic equation in capital of a closed-economy Solow growth model with a broad capital share less than $\alpha+\eta$. Consequently, the convergence rate is higher than in a closed economy but lower than with perfect capital markets. $\frac{k}{z}$ falls during the transition: the possibility of tapping into world markets means that $k$ is relatively high initially. $k$ does not jump immediately to its steady state since domestic capital accumulation is constrained and $k$ and $z$ are complementary in production.

We can easily solve equation (8). Log-linearizing to approximate around the steady state, we have:

$$\log z_t = \lambda^t \log z_0 + (1-\lambda^t)\log z^* \tag{11}$$

where $1-\lambda$ is the convergence rate and $\lambda = \varepsilon + \frac{(1-\varepsilon)(1-\delta)}{(1+n)(1+g)}$.

In this model the rate of convergence is a function of $\varepsilon = \frac{\eta}{1-\alpha}$ which governs how fast decreasing returns set in. Individual shares however, govern the degree of capital mobility. The relative importance of the two types of capital determine the degree to which countries are constrained. As $\alpha$ — the income share of capital that can be used as collateral — rises, the degree of capital mobility increases. Foreign capital is more important in production and the economy behaves more like an open economy. On the other hand, a higher $\eta$ means that the importance of domestic savings has increased as the relative importance of domestic capital in production rises. Thus when $\alpha = 0$, the economy behaves like a closed economy, and when $\eta = 0$, it exhibits an infinite rate of convergence. By raising $\frac{\alpha}{\eta}$ for a given $\alpha+\eta$, one can increase the degree of capital mobility and therefore the rate of convergence.

Equation (11) implies that the change in net foreign debt takes the form

$$\log d_t - \log d_0 = -(1-\lambda^t)\log d_0 + (1-\lambda^t)\log d^* \tag{12}$$

Manipulating this equation yields a convergence equation for debt of the form

$$\begin{aligned}\log d_t - \log d_0 &= (1-\lambda^t)\frac{\varepsilon}{1-\varepsilon}\log B + (1-\lambda^t)\log\frac{\alpha}{\delta+r}B - (1-\lambda^t)\log d_0 \\ &+ (1-\lambda^t)\frac{\varepsilon}{1-\varepsilon}\log s - (1-\lambda^t)\frac{\varepsilon}{1-\varepsilon}\log\left((1+n)(1+g)-(1-\delta)\right)\end{aligned} \tag{13}$$

This specification with exogenous savings sheds light on one of the predictions of the model not emphasised in the BMS original paper: a positive relationship between domestic savings and debt accumulation. Typically, we think of domestic and foreign sources of finance as substitutes: one of the advantages of open economies is that they need not save in order to accumulate capital — they can borrow. In this model, domestic savings and foreign investment are complements. This is a direct consequence of the assumption about the production function, in which domestic and foreign capital are complements in production. Even though the economy has access to foreign sources of financing, domestic agents must still accumulate domestic capital. As it rises, their ability to attract foreign funds is enhanced and debt increases. Lucas [1990] has noted that the (unmodified) neoclassical model implies marginal product differentials so large that, no investment should take place in rich countries, as all capital would flow to low-income economies. Here, differences in marginal products are lowered by the combination of the credit constraint and the complementarity of savings and capital inflows [6].

It is this feature of the model that makes it an appropriate choice for the exercise in this paper. As noted above, there are alternative ways of introducing capital market imperfections in a neoclassical model. Kremer and Thompson [1998], and Duczynski [2000] and [2002] have argued in favour of models with adjustment costs. They note that this model relies on binding constraints — and is thus only relevant for a limited set of economies. Nevertheless, if we interpret the domestic capital as human capital, this may be relevant for numerous countries. In addition, although a model with adjustment costs would also predict some form of convergence in debt, it would not predict a possible complementarity between domestic savings and foreign financing. As shown in the results below, this prediction is supported by the data.

[6] In this paper, we emphasise the complementary role of savings as a source of differences in growth rates within a neoclassical setting from a technological point of view. It is also possible to consider a preference-based explanation to the role of savings. Rebelo [1992] focuses on the role of savings, but in endogenous growth models. He argues that endogenous growth models cannot explain differences in income growth in a world with perfect capital markets. In these models, liberalising capital markets leads capital to flow from poor to rich countries — where the rate of return is high — and to the equalisation of growth rates across countries. He suggests that assuming Stone-Geary preferences with subsistence-level consumption instead of the standard isoelastic preferences partly addresses this issue. Under this assumption, poor countries in which consumption is close to subsistence level, would have low savings rates, and perfect capital markets would not lead to 'capital flight'. This alternative model would also predict that savings and capital inflows are positively correlated.

# 3 Estimation

## 3.1 Empirical Approach

The empirical exercise has a qualitative flavour. That is, we ask whether we can understand the cross-country variation in net external debt observed in the data within the framework set up in the previous section. Although the exercise is empirical in nature, it is *qualitative* in the sense that we want to determine whether the data exhibit the correlations predicted by the model, without defining a metric of how far they are from it [7]. More specifically, we will estimate (13) in its average form:

$$\frac{1}{t}\left(\log\frac{D_{it}}{\theta_{it}L_{it}} - \log\frac{D_{i0}}{\theta_{i0}L_{i0}}\right) = -\frac{(1-\lambda^t)}{t}\log\frac{D_{i0}}{\theta_{i0}L_{i0}} + \frac{(1-\lambda^t)}{t}\log d^* \tag{14}$$

for each country $i$, where $d^*$ takes on the values defined in (10). In order to estimate this equation, we must address three issues. First, since we only observe debt per worker $\left(\frac{D}{L}\right)$ and not debt per efficiency units of labour $\left(\frac{D}{AL}\right)$, we must make some assumptions about how technology flows across countries. Second, we must correctly control for cross-country variations in the level of steady state net external debt, or equivalently of output. Finally, we must determine whether and how to discriminate between constrained and unconstrained countries.

One possibility to account for the fact that we do not observe the level of technology in each country $i$ is to follow MRW and assume that the level of technology is common across countries, i.e.

$$\log\theta_{i0} = c$$

with

$$\frac{\theta_{it+1}}{\theta_t} = (1+g)$$

This suggest a regression of the form

$$\frac{1}{t}\left(\log\frac{D_{it}}{L_{it}} - \log\frac{D_{i0}}{L_{i0}}\right) = k - \frac{(1-\lambda^t)}{t}\log\frac{D_{i0}}{L_{i0}} + X\beta + u_i \tag{15}$$

where $k$ is a constant, $X$ is a matrix of variables that capture differences in steady states across countries and $u_{it}$ an the error term assumed to be uncorrelated with $X$. This assumption about technology is relaxed later.

In the model, steady state differences can arise from differences in savings behaviour and technology parameters, depreciation and interest rates as well as labour force growth. What variables

[7] See Verdier [2003a] for a quantitative evaluation of the model.

should we include in $X$? We have already assumed that countries share the same production function, and implicitly, that differences in output stem from disparities in factor inputs so the common initial technology level will be included in the constant. Contrary to the previous growth literature, we cannot use average investment rates as controls for steady state output since it is endogenous to the domestic savings decisions. Equation (13) however, suggests variables that may be included in $X$ which I choose to focus on: first, the model predicts that the domestic savings rate $s$ positively affects debt accumulation; second, labour force growth which is a major force behind accumulation in all neoclassical models of growth. Low income countries, more likely to be constrained, generally have a numerous and growing population that needs to be equipped with new capital in order to produce output. Additional controls are considered in a later section.

The basic convergence regression will therefore take the form

$$\frac{1}{t}\left(\log\frac{D_{it}}{L_{it}} - \log\frac{D_{i0}}{L_{i0}}\right) = k + \beta_0\frac{1}{t}\log\frac{D_{i0}}{L_{i0}} + \beta_L\frac{1}{t}\log\left((1+n_i)(1+g)-(1-\delta)\right) + \beta_s\log s_i + u_i \quad (16)$$

A final issue concerns the determination of the countries which are credit constrained. The convergence equation for debt will be estimated on two types of samples. One possible test of the model is to consider whether the estimated reduced form holds for all countries in the sample, whether or not we consider them to be constrained. A second possibility is to discriminate between constrained and unconstrained countries. I divide the sample between countries likely to be constrained and those likely to be unconstrained. In the model, constrained countries are determined by their initial wealth relative to the steady state domestic capital stock. The data on assets are limited but income can be used as a proxy. The approach taken here is to choose income as a criterion as in Lane [2000] and [2001] where the sample consists of low and middle-income countries. First I will estimate equation (16) on the entire sample including both high and low-income countries. I will also use a sample of countries with income below the median.

## 3.2 Results

### 3.2.1 The Data

The data on net external debt are taken from Lane and Milesi-Ferretti [1999]. The authors construct data for 66 countries between 1970 and 1997 using data on current account balances supplemented by available stock data on foreign direct investment, portfolio equity and debt assets and liabilities. They justify their use of flow data by noting that changes in net foreign assets are equal to current account balances net of capital transfers (transactions that do not give rise to an asset or liabilities such as debt forgiveness) and capital gains. They can therefore construct measures of net foreign assets using an initial value and cumulating current account balances. When possible, they also use direct measures of stocks. These measures are adjusted for valuation effects such as exchange rate changes, variations in the price of capital goods and changes in the values of stock market indices [8]. In all regressions, debt per worker is computed as

$$\frac{D}{L} = \frac{-B}{pL}$$

where $B$ is a measure of net foreign assets in US dollars, $p$ is the US GDP deflator, and $L$ is working-age population from the Penn World Tables.

I consider two measures for $B$. The first, `CUMCA`, is based on cumulative current accounts. It is available for both industrial and developing countries. The second, `NFA`, is based on direct stock measures of the various assets included in debt and is available for developing countries. The main difference between these two measures is the treatment of unrecorded capital flows. As unrecorded capital flows are large — the world had a current account deficit on the order of $US70 billion in 1998 — this is of some importance. `CUMCA` implicitly assumes that unrecorded capital flows reflect accumulation of foreign debt assets by domestic residents. The second measure, `NFA`, only includes unrecorded capital flows to the extent that they are recorded in net errors and omissions. If capital flight is important and often goes unreported, `NFA` will tend to overstate external debt levels. Finally, despite the great care with which these data were constructed, they have the same measurement drawbacks as all balance-of-payments data.

Figure 1 illustrates the movements in external positions over the past 30 years. The figure shows density estimates of demeaned net debt per worker in 1970 and 1997. The last few decades have seen large increases in both levels and perhaps more strikingly, in the variance of external positions. This must reflect in part, the much publicised globalisation: countries seem to have found it much easier to access world capital markets.

The BMS model is only relevant for small-open economies with negative assets, and that may be constrained in borrowing. Thus, the model is more likely to be relevant for low-income countries. Some restrictions are therefore in order. First, estimation will be restricted to countries with positive net external debt in both beginning and end of sample. Note that this implies a sample that excludes countries that have switched from being net lenders to net borrowers, and vice versa. Countries less likely to be small-open economies such as the U.S. and Japan are also excluded. The

[8] More details on the debt measures, as well as all other data used in the paper are available in Appendix **??**.

remaining group of countries also excludes important members of the G7 countries, such as France and the U.K.

These restrictions reduce the sample size to 42 observations for the `CUMCA` measure (Sample I), 29 observations for the `NFA` measure (Sample II). A third sample corresponds to the poorest half of the `CUMCA` sample in terms of income in 1970 (Sample III). Sample compositions are described in Appendix **??**. Note that among developing nations, the samples are dominated by middle-income countries. Possibly then, the results presented here cannot be assumed to extend to much poorer economies, such as those of sub-saharan Africa. In fact, Lane and Milesi-Ferreti [2001] find that the relationship between external debt and output is non-linear, suggesting that the simple mechanisms considered here cannot explain all cross-country variation. Data limitations however, prevent the further exploration of this issue.

Figures 2 to 4 illustrate the two mechanisms emphasised in this paper: convergence and the complementarity between domestic savings and debt accumulation. On the left panel, these figures show raw correlations between the average annual growth in debt between 1970 and 1997 and initial conditions, measured by the log of debt per worker or the log of GDP per worker at the beginning of the sample period. In all three samples, the negative correlation between initial debt and subsequent accumulation is consistent with decreasing returns. The model also predicts a positive correlation between domestic savings and debt accumulation. Still, it does not specify the type of domestic savings that might exhibit this type of complementarity. In this paper, I will focus on the fraction of gross domestic product not consumed [9]. The right panel of these figures show the correlation between average annual debt growth and this savings rate. It is measured as $1 - \frac{\bar{c}}{\bar{y}}$ where $\frac{\bar{c}}{\bar{y}}$ is the average consumption-to-output ratio between 1970 and 1997 from the Penn World Tables version 6.0. Again, in all three samples, the positive raw correlations are consistent with the prediction from the model. The model relies heavily on the assumption that output and debt are tightly linked. Figures 5 to 7 show that output growth and debt accumulation do tend to move together. The correlation is higher in the samples dominated by low-income countries. The relationship between debt and output is investigated further below.

[9] The model suggests that a better measure of savings would be the fraction of gross national product not consumed (see equation (8)). Yet, the use of GNP presents certain problems — other than the obvious measurement issues. First, GNP is not available in PWT 6.0. It is available in PWT 5.6 but only between 1970 and 1992. This means that a measure of savings from this source can only span part of the period considered. In addition, in the remainder of the paper, savings out of GDP are often instrumented using the value of the savings rate before 1970 — an option clearly unavailable for GNP. The measure of savings based on GDP however, may not be inappropriate. First, GNP and GDP are highly correlated. Second, the results are fairly robust to the use of the GNP measure. The results are more fragile in Sample II, but this is driven by one country, Jordan. Once it is excluded, the results are similar to those found using the GDP measure.

The presentation of the empirical results will proceed as follows. I will first present the basic convergence results. Second, the robustness of the results to assumptions about technology, the measurement of savings and other steady state controls will be examined. Finally, the relationship between debt and output will be studied.

#### 3.2.2 Basic Convergence Results

Tables 1 to 2 present the basic reference convergence equations for debt. In all regressions, the dependent variable is the average annual log change in real net debt per worker between 1970 and 1997 for most countries. Since there are missing data for some countries, the sample period for each country varies between fifteen and twenty eight years. The coefficient on initial debt is thus an estimate of the average annual convergence rate. Data on population and national accounts are from the Penn World Table 6.0. $n$ is the average annual growth rate of the working-age population between 1970 and 1997. As in MRW, $g = 0.02$ and $\delta = 0.03$. In the model, $s$ corresponds to the fraction of income that goes into domestic capital investment. This domestic capital can represent human capital, as well as any other type of capital that cannot be funded by foreign sources. This type of savings is first measured by the private domestic savings rate as measured by $s = 1 - \frac{c}{y}$, where $\frac{c}{y}$ is the average consumption to output ratio between 1970 and 1997. In the tables below, all variables are in logs. In addition, both asymptotic and bootstrap $p$-values are shown [10]. These bootstrap statistics are robust to the presence of heteroscedasticity.

Table 1 presents the results for ordinary least squares. In all three samples, the estimated convergence rate is about 2 percent per year and is significant. This is surprisingly close to the estimates of income convergence in the literature. In this model, labour force growth lowers output-per-worker through the usual neoclassical channel: new entrants in the labour force must be equipped with capital. Consequently, because of the credit constraint, countries with high labour force growth should have low output, and thus low net external debt. The labour force variable however, fails to significantly affect debt accumulation, except in Sample I which includes high-income countries [11]. Savings seems to increase debt accumulation, particularly in samples I and II. This positive association may be surprising to one used to thinking about foreign sources of finance as substitutes

[10] See Appendix **??** for details on bootstrap estimation.

[11] Labour force growth could be endogenous. In the model, faster debt accumulation is synonymous with higher output growth. The model abstracts from the effect of higher output growth on fertility choices and hence on labour force growth. If fertility choices are endogenous, labour force growth and debt accumulation could be simultaneously determined. However, instrumenting with the average labour force between 1960 and 1969 does not significantly change the results.

for domestic ones. In fact, we often think of the benefits of open borders as resulting from the consumption gain capital flows create by reducing the need for saving. In the model, capital flows do not eliminate domestic savings. Countries with a high savings rate also have higher domestic capital. Since domestic and foreign capital are complementary, this leads to higher debt accumulation [12]. Savings rates however, are also likely to be partly endogenous. A positive shock on income — through terms of trade for example — could lead consumers to increase both consumption and savings, possibly their savings rate. Table 2 shows the results of estimation by instrumental variables. The instruments are average labour force growth and savings rate between 1960 and 1969. The savings rate is now significant in all samples.

#### 3.2.3 Controlling for Productivity

So far, we have assumed that $\log\theta_{i0} = c$ so that initial technology levels are identical across countries. This is not a prediction of the model. If initial technology levels vary across countries and are excluded from the matrix of explanatory variables, their resulting inclusion in the error term would bias the estimate of the convergence rate and of the effect of savings. Klenow and Rodriguez-Clare [1997] have criticised the income growth literature for failing to recognise the importance of productivity differences. If feasible then, one would like to account for the possibility that $\theta_{i0}$ varies across countries. In the literature on output convergence, this seems difficult: any measure of initial TFP — obtained by growth accounting for example — is likely to be highly correlated with initial output, a variable already included in the regression to capture convergence. This is less of a concern when dealing with debt. Suppose we allow $\theta_0$ to vary across countries so that

$$\log\theta_{i0} = c + \log A_{i0}$$

with

$$A_{it} = (1+g)^t A_{i0}$$

Our estimating equation now takes the form

$$\begin{aligned}\frac{1}{t}\left(\log\frac{D_{it}}{L_{it}} - \log\frac{D_{i0}}{L_{i0}}\right) &= k - \frac{(1-\lambda^t)}{t}\log\frac{D_{i0}}{L_{i0}} + \frac{(1-\lambda^t)}{t}\log A_{i0} + \frac{(1-\lambda^t)}{t}\frac{\varepsilon}{1-\varepsilon}\log s_i \\ &- \frac{(1-\lambda^t)}{t}\frac{\varepsilon}{1-\varepsilon}\log\left((1+n_i)(1+g)-(1-\delta)\right) + u_i \qquad (17)\end{aligned}$$

[12] The model implies that domestic savings should be substitutes to capital inflows for countries that are net creditors. When the convergence equation for debt is estimated for creditors countries at the beginning and end of sample, we find that the coefficient on the savings rate is negative, but insignificant. The results on creditor countries is thus consistent with the model, though the sample of countries with positive assets is small.

Our measure of $A_{i0}$ is obtained by standard growth accounting methods. Initial physical capital stocks are computed from Penn World Tables investment data using the perpetual inventory method. A TFP measure is computed under the assumption that $\alpha = 0.3$ [13]. The results, shown in the top panel of Table 3, are robust to alternative assumptions about capital shares [14]. The addition of $A_{i0}$ does not alter the results. Both the estimated coefficient on initial debt and savings are still individually significant. This suggests that the savings variable was not controlling for differences in technology levels in Tables 1 and 2. As before the labour force variable does not seem to matter for debt accumulation.

When using samples of these sizes, it is useful to adopt a more parsimonious specification. Recall from equation (17) that the model offers two restrictions on the parameters of the model. First, the coefficients on the labour force variable and the savings rate should be equal in magnitude but with opposite signs. In the empirical income growth literature, a similar prediction from the Solow growth model is often imposed on the estimated coefficients. From equation (8), we know that this corresponds to the domestic capital-to-output ratio in the steady state,

$$\frac{z}{(1-\alpha)y} = \frac{s}{(1+n)(1+g)-(1-\delta)}$$

This measures each country's long-run domestic capital intensity. In addition, the coefficient on initial debt and technology level should be equal in absolute value. Imposing these restrictions allows us to obtain more precise estimates, and the potential inclusion of other additional controls.

The bottom panel of Table 3 shows the result of estimation when these restrictions are imposed. First note that the fit of the regression is greatly improved by imposing these restrictions. The estimate of the convergence rate remains higher than when initial technology levels are assumed to be the same across countries. The complementary effect of savings however, is more precisely estimated. Somewhat surprisingly, the estimated least squares coefficients are very close in magnitude across samples. In addition, the null hypothesis that the restrictions are true cannot be rejected as shown by the $F$-statistic at the bottom of the table.

Are these results driven by the average behaviour of debt accumulation across countries, or are they the result of a few outliers? One way to answer this question graphically is by looking at the correlation between debt accumulation and our accumulation variable once the effect of convergence has been removed. This is easily achieved by regressing both $\log d_t - \log d_0$ and $\frac{s}{(1+n)(1+g)-(1-\delta)}$ on a constant and $\frac{d_0}{A_0}$ and graphing the resulting residuals. The residuals from these regressions

[13] See Appendix **??** for details.

[14] The results are robust to assuming $\alpha = 0.5$.

correspond to $\log d_t - \log d_0$ and $\frac{s}{(1+n)(1+g)-(1-\delta)}$ once the effect of convergence has been removed. These residuals are plotted in Figures 8 to 10. The right panel of these figures shows the residual correlation once the outliers have been removed. In all three samples, the correlation is positive, though this seems to be partly driven by Egypt and Syria, which both have very low savings and have accumulated little debt on average compared to the rest of the sample. Nonetheless, once these countries are removed, the correlation still appears strong and positive in all three samples. These results do not seem to be driven by outliers.

## 3.3 Robustness

The basic convergence results suggest that debt does converge at a rate similar to that observed in output. In addition, savings seem to play a role that is not explained by endogenous movements. These results however, are obtained under several assumptions: first, that investment in domestic capital is appropriately measured by savings out of gross domestic product; second, that other steady state controls cannot improve the fit of the regression. In addition, although the results seem to support the model, we have implicitly assumed that movements in debt were mirrored in output. We turn to each of these issues in turn.

### 3.3.1 The measurement of savings: human capital

So far we have ignored the potential role of human capital. Yet, education could be important in several ways within the framework of the BMS model. First, as noted in the original paper by BMS, human capital is likely to be the type of capital that cannot be borrowed against. Consequently, a measure of human capital investment may be an alternative to $s$, the fraction of income not consumed. If $s$ measures savings in domestic physical capital, adding human capital investment to the estimation of the convergence equation for debt may add another dimension to the results. In that case, a convergence equation for debt would be

$$\begin{aligned}\frac{1}{t}\left(\log\frac{D_{it}}{L_{it}}-\log\frac{D_{i0}}{L_{i0}}\right) &= k-\frac{(1-\lambda^t)}{t}\log\frac{D_{i0}}{L_{i0}}+\frac{(1-\lambda^t)}{t}\log A_{i0} \\ &+ (1-\lambda^t)\frac{\varepsilon}{1-\varepsilon}\log s_i^z+\frac{(1-\lambda^t)}{t}\frac{\varepsilon}{1-\varepsilon}\log s_i^h \\ &- \frac{(1-\lambda^t)}{t}\frac{\varepsilon}{1-\varepsilon}\log\left((1+n_i)(1+g)-(1-\delta)\right)+u_i\end{aligned} \tag{18}$$

where $s^z$ is savings in domestic physical capital and $s^h$ is savings in human capital [15].

[15] Alternatively, human capital may affect technology growth, through learning-by-doing for example. This would require a modification to our assumption about technology. The relationship between technology and human capital

The measurement of human capital investment is difficult. MRW construct a measure based on secondary enrollment rates. The focus on secondary schooling however, has been criticised by Klenow and Rodriguez-Clare [1997]. They note that cross-sectional variation in non-secondary school enrollment is much less than that of secondary school. This would tend to lower the effect of human capital investment on output. I use a measure that is more in line with what these authors propose. It is a weighted average of primary, secondary and higher schooling enrolment rates, $e = \log \frac{6\times P+6\times S+4\times H}{16}$ where P, S and H denote primary, secondary and higher schooling enrolment rates. The data are from Barro and Lee [1993].

The results are shown in Tables 4 and 5. In both tables, we have used the accumulation formulation for human capital, $\frac{e}{(1+n)(1+g)-(1-\delta)}$ (in logs), a restriction that is not rejected. The estimate of the convergence rate is robust to the inclusion of measures of human capital investment, but the results on savings vary. Table 4 shows the results of estimation by ordinary least squares. The measure of human capital seems to capture part of the complementarity of domestic savings when included on its own: it is precisely estimated in Sample I, and very marginally significant in Samples II and III in the top half of Table 4. Figure 11 shows the residual correlation between the education variable and the the average debt accumulation once the effect of convergence has been removed as in Figures 8 to 10. It is a positive correlation, though much lower than when $s$ is used as a measure of savings. When both measures of savings are included, private savings seem to be robust to the addition of human capital investment, whereas the reverse is not true.

These measures of investment in education however, have notorious measurement problems. In order to address this measurement issue, we instrument $e$ with the average years of schooling in the population over 15 between 1960 and 1969. Table 5 shows the results of estimation by two-

investment is potentially complicated, and has certainly given rise to a large literature on endogenous growth. One possibility is to is to assume that human capital affects technology in log-linear fashion, i.e.

$$\log \theta_{it} = c + \log A_{it} + \mu \log h_{it}$$

with

$$A_{it} = (1+g)^t A_{i0}$$

Technology levels are still partly exogenous through $A$; the rate of change of $\theta$ however, is now partially driven by human capital accumulation. In this case the convergence equation is modified as follows

$$\begin{aligned} \frac{1}{t}\left(\log \frac{D_{it}}{L_{it}} - \log \frac{D_{i0}}{L_{i0}}\right) &= k - \frac{(1-\lambda^t)}{t}\log \frac{D_{i0}}{L_{i0}} + \frac{(1-\lambda^t)}{t}\log A_{i0} + \frac{(1-\lambda^t)}{t}\frac{\varepsilon}{1-\varepsilon}\log s_i^{k^d} \\ &+ \log h_{it} - \frac{\lambda^t}{t}\log h_{i0} - \frac{(1-\lambda^t)}{t}\frac{\varepsilon}{1-\varepsilon}\log\left((1+n_i)(1+g)-(1-\delta)\right) + u_i \end{aligned}$$

Note that this view of human capital as a determinant of technology, and the alternative, human capital investment as a complement to foreign financing, are observationally equivalent. Both involve including a measure of the change in the stock of human capital in the convergence equation for debt.

stage least squares, where the private savings rate is also instrumented. Private savings remain significant in Sample I only. It seems difficult to discriminate between the types of savings that have a complementary role.

This may be due to measurement problems in $e$, though we have addressed this issue by using instrumental variable estimation. But note that private savings and human capital investment measure similar things. Presumably, part of the income not consumed is used to finance education, i.e. $e$ may contain no additional information than that already contained in $s$. On the other hand, part of human capital investment is often attributed to consumption in the national accounts (books, tuition, uniforms, part of government spending on schools, etc). In this latter case, $s$ would understate savings, and a measure of human capital would contain additional information. Finally, if a large fraction of human capital investment is financed by governments through taxes $s$ may or may not capture human capital investment depending on whether these education expenditures are financed by consumption or income taxes. As a result, even if investment in knowledge were properly measured by $e$, private savings and human capital investment may not be independent sources of information.

Nevertheless, the results from these estimations are consistent with the predictions of the model. The results from Table 4 are strongest in the largest Sample I, which also includes higher income countries. We do not tend to think of wealthier countries as constrained, but it is reasonable to think they may not be able to borrow human capital from abroad. Measurement problems however, make it difficult to go further in investigating the role of human capital.

#### 3.3.2 Other Steady State Controls

The growth literature has explored a plethora of variables that could control for the steady state beyond the savings rate and labour force growth. Sala-i-Martin [1997] provides a list of robust regressors. Among them are variables that capture market distortions and market performance, openness and institutions. As suggested by this author, I include three variables along these lines: (i) a measure of capital controls taken from Calderón *et al* [2000] that accounts for the presence of current and capital account restrictions, multiple exchange rate practices and mandatory surrender of export proceeds; (ii) an index of openness constructed by Sachs and Warner [1995] that measures the fraction of years between 1950 and 1994 that a country has been open to trade; (iii) a measure of institutional performance from Hall and Jones [1999] that captures the extent of corruption, bureaucracy, risk of expropriation, and the ability of government to maintain law and order. A higher value of the index indicates institutions that support growth. In addition, a measure of government spending — the ratio of spending to GDP from the Penn World Tables — is added to the list of controls. Results are shown in Tables 6 and 7. In general, these variables fail to improve the fit of the data appreciably. Capital controls seem to affect debt accumulation, but mostly in Sample II. Other variables, such as the Sachs and Warner measure of openness and the measure of institutional performance, do not add to the fit of the regression. In fact, what is surprising is how robust both the estimates of convergence and the savings effect are robust to the addition of other steady state controls [16].

The marginal significance of government spending is intriguing. There are ways to explain the negative correlation between $\frac{G}{Y}$ and the change in debt within the context of the model. If government spending is wasteful and distorts domestic savings and capital accumulation, it may reduce the marginal product of foreign capital, discouraging flows of capital. On the other hand, $\frac{G}{Y}$ may be highly correlated with government borrowing abroad. A negative correlation between $\frac{G}{Y}$ and debt accumulation could then arise because foreign funds serve as a substitute for government savings. Both possibilities are consistent with this result.

#### 3.3.3 Debt and Output

So far, we have found that predictions of the model about the complementary role of domestic savings as well as the presence of decreasing returns are consistent with the data. The model also predicts a tight link between net liabilities and output. The convergence rate for debt, estimated to be around 2 per cent, is robust to specifications with different assumptions about technology and savings, and consistent with the results from the income convergence literature. This seems to indicate a strong relationship between debt and output. There is however, evidence that this relationship is not as close as the one predicted by the model. Debt accumulation and output growth are correlated across countries as shown in Figures 5 to 7, but this correlation is much lower than the one-for-one relation predicted by the model (recall that in the model $d_t = \frac{\alpha}{r+\delta} y_t$). In addition, labour force growth seems to have no individual effect on debt accumulation. This is surprising since previous empirical work suggests that labour force growth has a negative effect on output growth [17]. Since debt is proportional to output in this model, we should expect the same

[16] Other variables such as the terms of trade also fail to to improve the fit of the regression.

[17] See MRW and more recently Beaudry, Collard and Green [2002]. Theoretically, insignificance of the coefficient on labour force growth is not inconsistent with the model. By endogenising savings and choosing a utility function that weighs each generation equally, we can eliminate the effect of labour force growth on output, and consequently on debt. The effect of labour force growth can thus be negative or zero, but it must be the same on for output and

qualitative impact on debt as on output. It is easy to determine whether debt and output follow the same dynamics. For output, the BMS model predicts a convergence equation of the form

$$\begin{aligned} \frac{1}{t}\left(\log y_t - \log y_0\right) &= \frac{(1-\lambda^t)}{t}\frac{1-2\varepsilon}{1-\varepsilon}\log B + -\frac{(1-\lambda^t)}{t}\log y_0 \\ &+ \frac{(1-\lambda^t)}{t}\frac{\varepsilon}{1-\varepsilon}\log s - \frac{(1-\lambda^t)}{t}\frac{\varepsilon}{1-\varepsilon}\log\left((1+n)(1+g)-(1-\delta)\right) \end{aligned} \tag{19}$$

when savings are exogenous, assuming technology is identical across countries.

Table 8 shows the convergence estimates for output per worker in the samples used here. A few results are worth noting. First, the estimated convergence rate appears much lower than that from the debt data, closer to 1 per cent. Second, the savings rate has a smaller estimated effect on output growth in this sample, and it is not completely robust to IV estimation.

Output and debt however, may be subject to similar shocks. It may be useful to take advantage of this empirically in order to gain efficiency by using systems methods. The debt and output convergence equations are estimated by SUR and three-stage least squares in Tables 9 and 10. The coefficient on initial debt is slightly lower than before, though if anything the effect of the savings rate on debt is a bit higher in the debt equation. On the output side, the estimated convergence rate is still fairly low. As in Table 8, the effect of the savings rate in Table 10 on output is much lower than that on debt.

What can we conclude from these results? The dynamics and predictions of the model depend crucially on the assumed perfect correlation between debt and output. As a result, convergence in debt is a direct consequence of convergence in output in the model. We know that debt accumulation is associated with output growth (Figures 5, 6 and 7). But these output regressions indicate that the convergence observed in debt can only partially be attributed to movements in output. This also means that the debt-to-GDP ratio cannot be constant as predicted by the model [18].

# 4 Conclusion

This paper has emphasized an important mechanism for the long-term dynamics of net external debt across countries: the complementary role of savings. Theoretically, we can allow for two roles for foreign capital flows. In many models, foreign funds are substitutes for domestic savings: borrowing from abroad allows an economy to increase investment with no cost in consumption. Alternatively,

debt.

[18] In fact it converges at a rate of about 2 percent per year.

foreign financing may act as a complement to domestic savings: countries with higher savings are rewarded with higher flows of capital. The framework developed by BMS allows for this possibility by specifying two types of capital, one that is accumulated domestically and one that comes from abroad. These capital inputs are complementary in production. When an economy increases its savings, and thereby its domestic capital stock, this increases the marginal product of the foreign capital. This will tend to raise output, and the closely-linked stock of net external debt. This model also allows for the standard convergence story: low-income countries borrow in order to accumulate capital. The incentive to borrow diminishes with development as the economy hits diminishing returns.

The original BMS paper mostly focused on the ability of the model to reproduce estimates of convergence found in the data. This simple model however, also allows us to determine how domestic savings and capital flows are linked. To address this question, a simple convergence equation for debt is derived from the model. It predicts that debt accumulation should exhibit convergence, and should be positively correlated to measures of domestic savings. The results are consistent with both of these mechanisms: Debt per worker converged at a rate between 2 and 2.5 per cent per year, and savings consistently increased debt accumulation. These results were robust to the econometric specification, the measure of debt, and the sample of countries. It was more difficult to discriminate between the types of domestic savings that could act as complements to foreign financing.

These results suggest that this model is clearly useful in explaining cross-country variation in debt accumulation. Even so, it may not be quantitatively sufficient. First, in the samples considered here, the convergence found in debt was not mirrored in output. In fact, convergence in output was consistently lower than that of debt. This suggests that the debt-to-GDP ratio exhibits some convergence, and is far from constant as assumed in the model.

Does this evidence support a model with decreasing returns and limited access to credit markets quantitatively? To match long-term observed movements in debt, it appears a model must exhibit some decreasing returns, but also allow for a mechanism that permits foreign financing to complement domestic savings. Nevertheless, this is not enough to explain all cross-country variations in borrowing behaviour. The model partly fails because the assumption about capital flow restrictions is too rigid. The tight relationship between income, human and physical capital stemming from the assumption about capital markets leaves little room for a more complex and independent relationship between debt accumulation and other assets. In Verdier [2003a] , I attempt to address the quantitative relevance of this model.

Despite its obvious flaws, the model does predict the importance of convergence and the complementary role of savings in explaining cross-country debt data. The policy implications are potentially important. If capital inflows are substitutes for domestic savings, policies that affect savings will be of little importance for capital accumulation and growth in open economies. On the oher hand, if savings raises the marginal product of capital from abroad as suggested by the results presented here, domestic consumption and accumulation decisions are no longer segmented. Within the framework developed here, the positive correlation between domestic savings and investment first observed by Feldstein and Horioka [1980] is interpreted naturally, in a context in which at least a fraction of capital flows freely [19]. Feldstein [1994] argues that the capital mobility is not inconsistent with this observed correlation. Countries in which investors are risk averse or uninformed will also show high savings retention. The alternative suggested in this paper, is that some types of capital are difficult to obtain from abroad and must be accumulated domestically through domestic savings even in a world with (some) capital mobility. The consequences for policy however, are similar to those advanced by Feldstein. Policies that affect national savings may potentially be important for capital accumulation and growth.

[19]Coakley, Kulasi and Smith [1998] for a review of the literature on the Feldstein-Horioka puzzle.

Figure 1: Distribution of net external debt

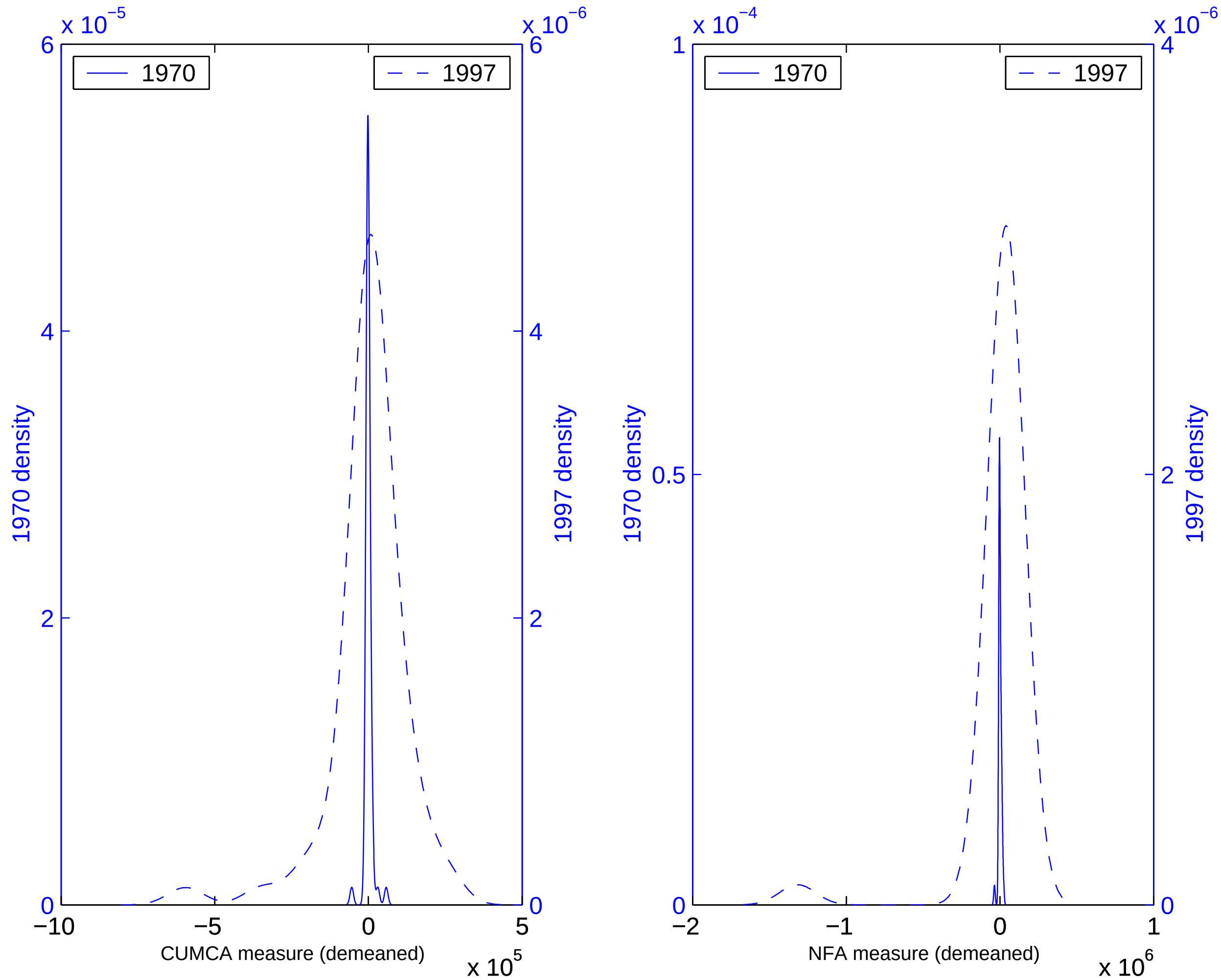

Figure 2: Debt accumulation, initial conditions and savings - Sample I

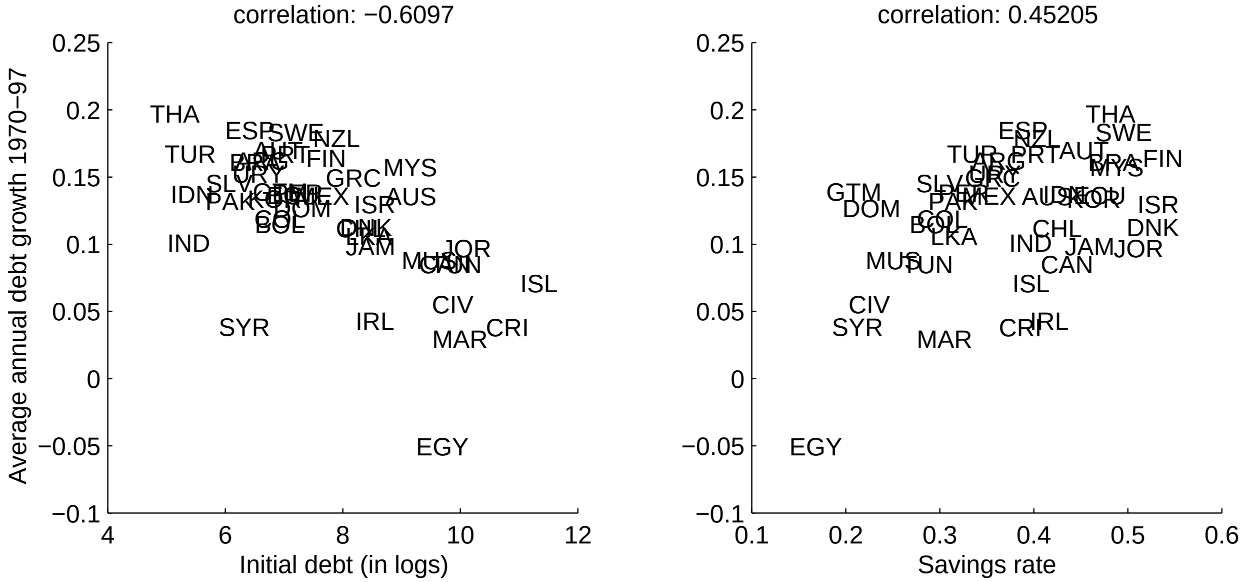


Figure 3: Debt accumulation, initial conditions and savings- Sample II

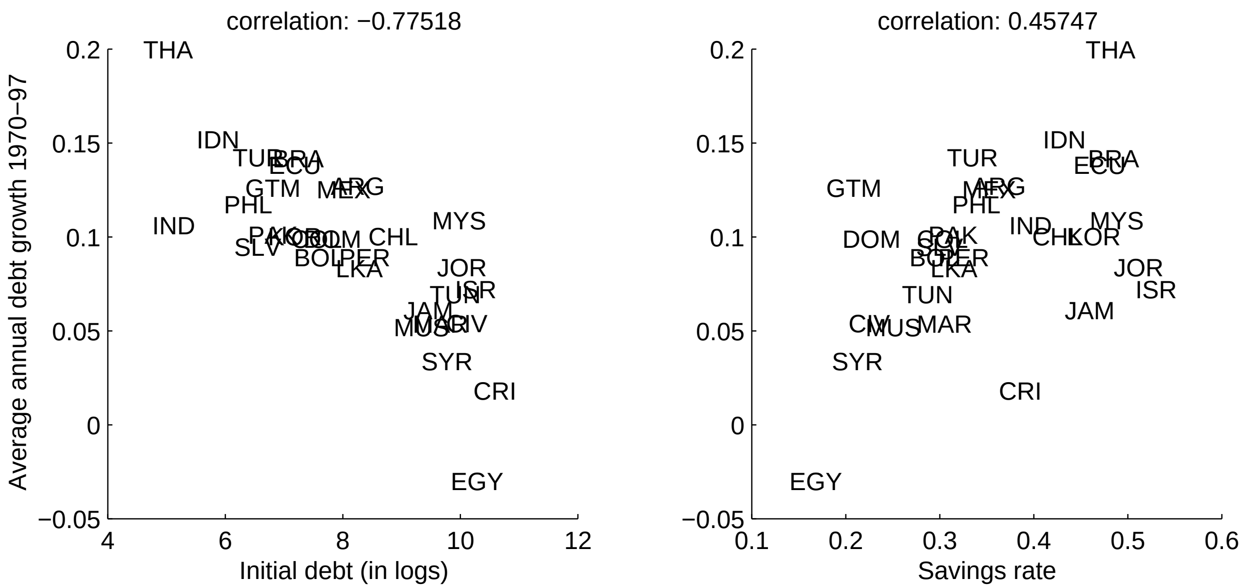

Figure 4: Debt accumulation, initial conditions and savings- Sample III

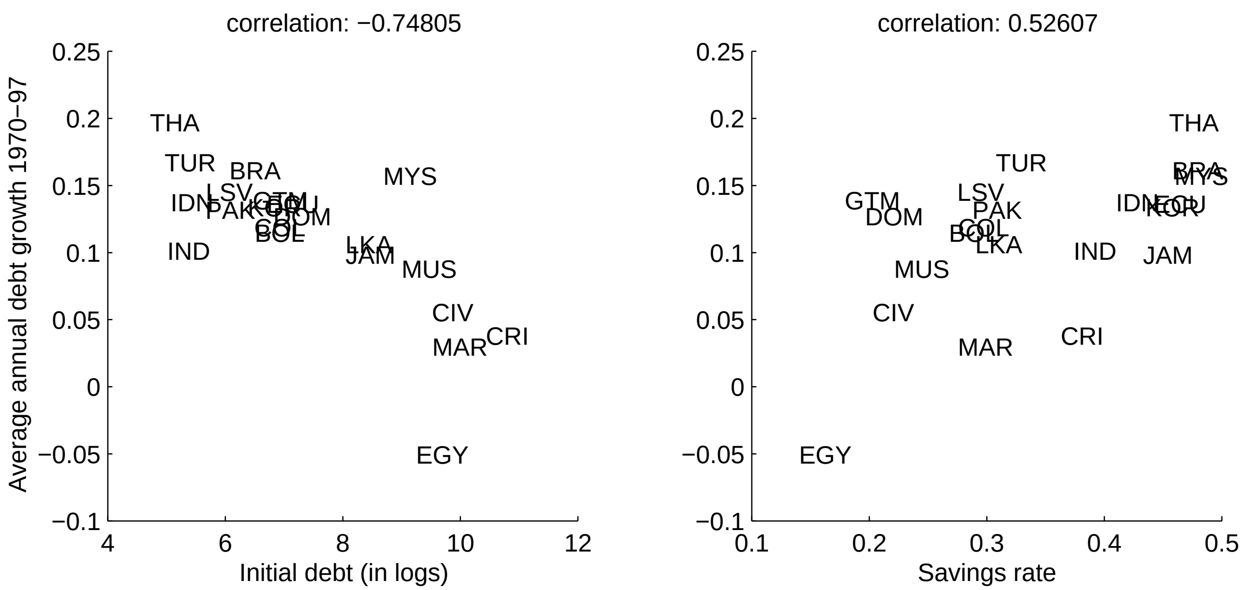

Figure 5: Debt accumulation and output growth - Sample I

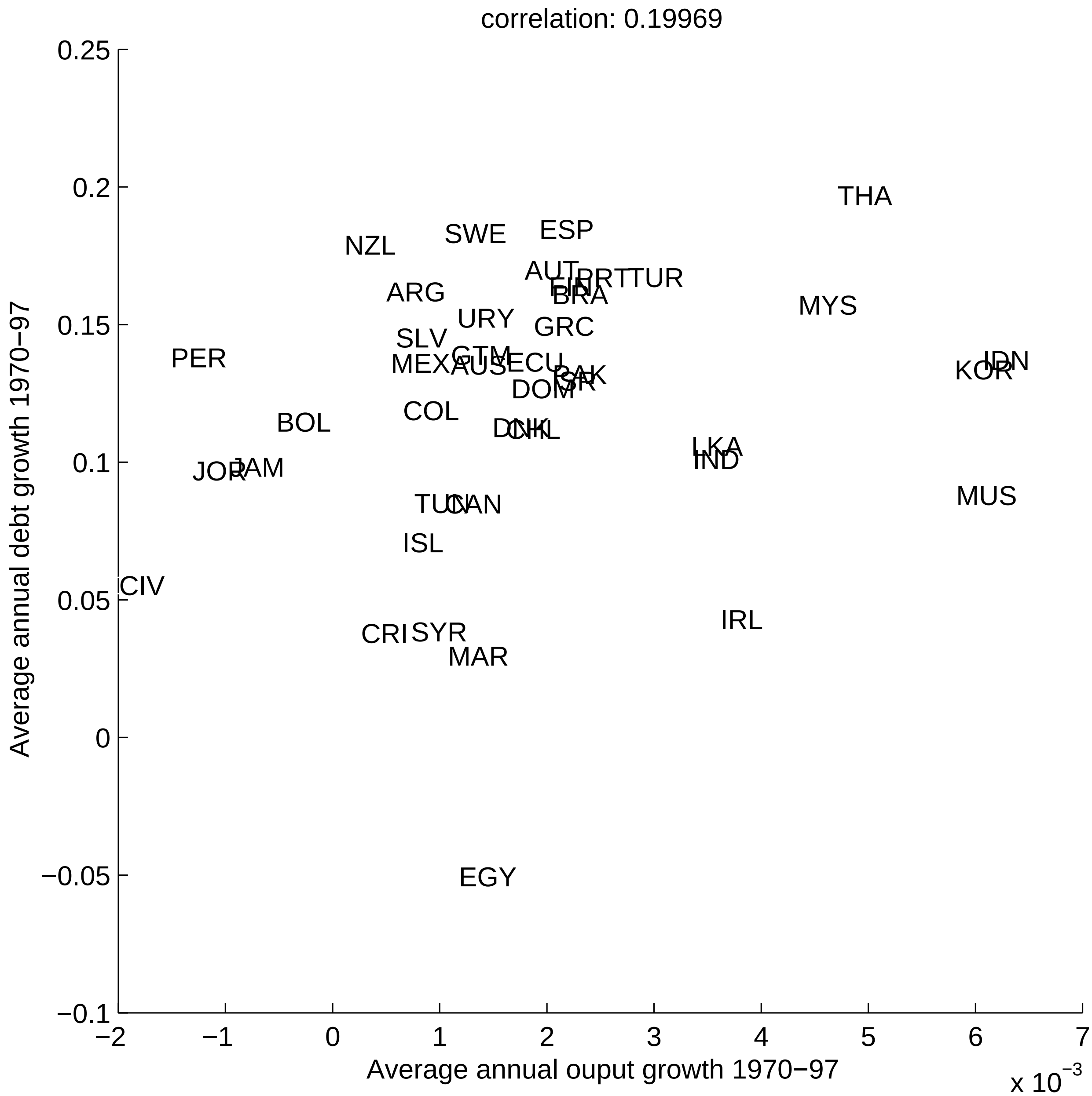

Figure 6: Debt accumulation and output growth - Sample II

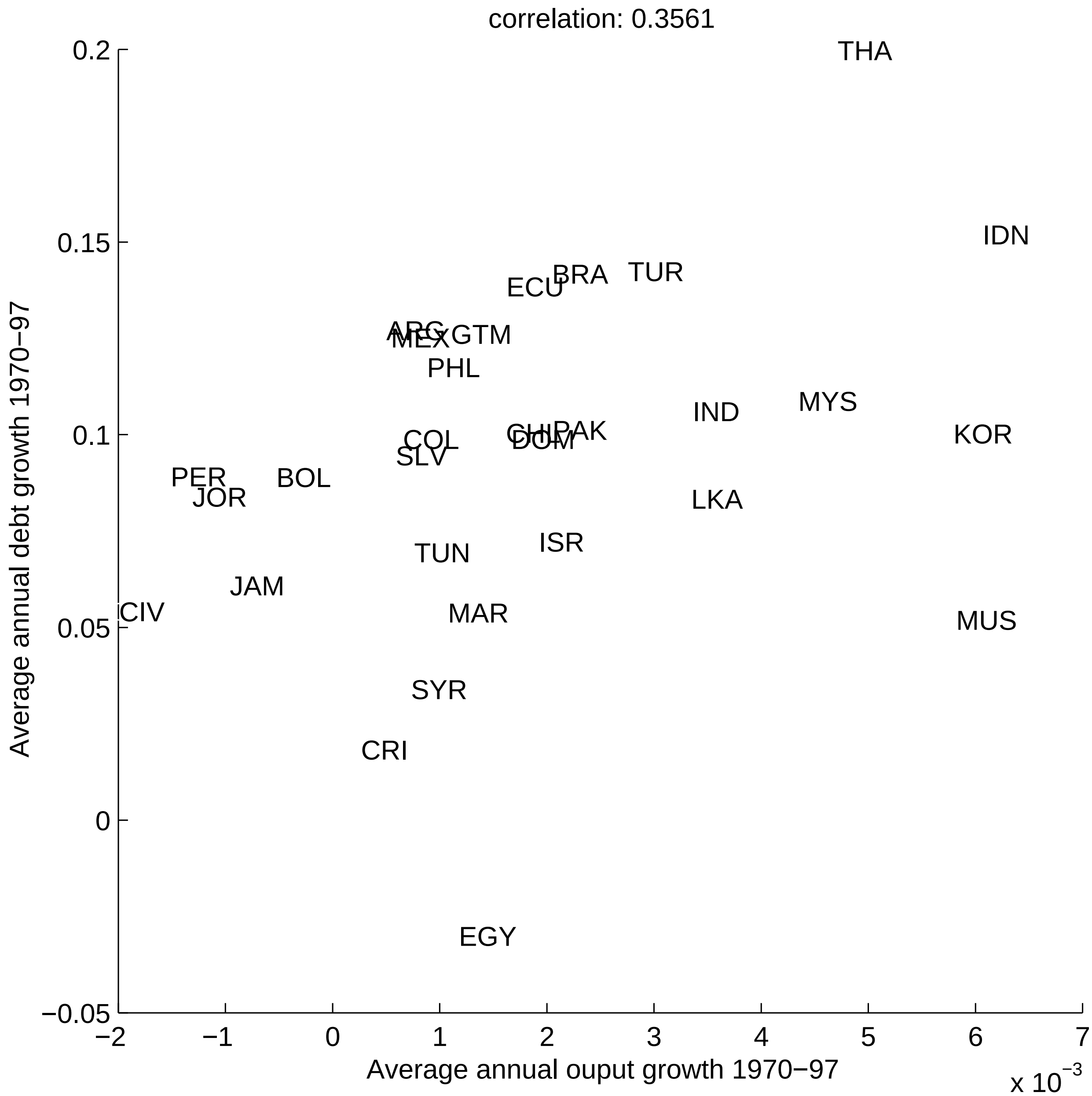

Figure 7: Debt accumulation and output growth - Sample III

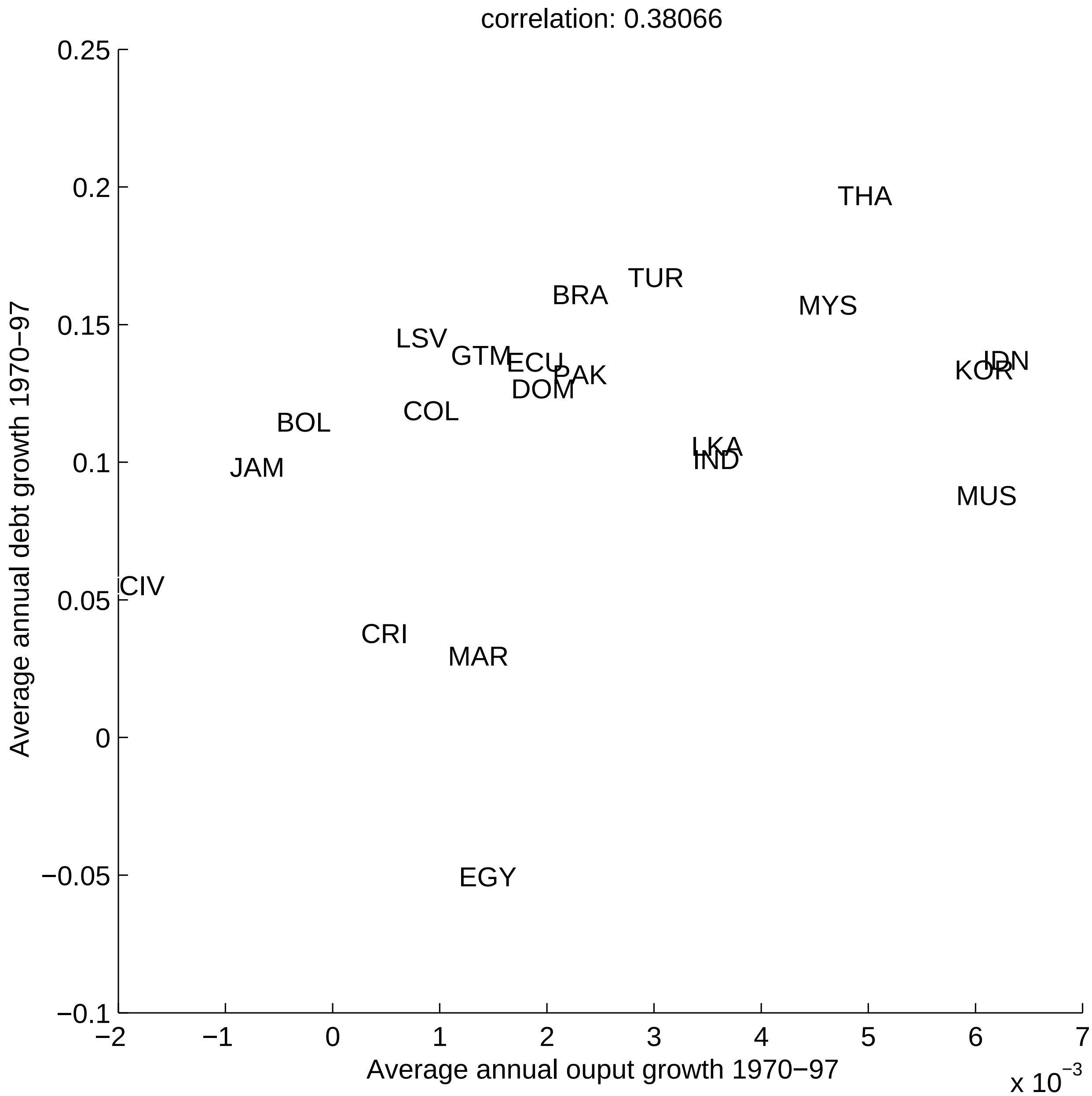

Table 1: Basic Convergence - OLS estimation

| Dependent variable: $\log d_t - \log d_0$ | Sample I | Sample II | Sample III |
|---|---|---|---|
| constant | 0.040 | 0.297 | 0.102 |
| | (0.738) | (0.019) | (0.571) |
| | [0.736] | [0.009] | [0.400] |
| $d_0$ | -0.019 | -0.021 | -0.024 |
| | (0.000) | (0.000) | (0.000) |
| | [0.000] | [0.001] | [0.001] |
| $(1+n)(1+g)-(1-\delta)$ | -0.083 | 0.015 | -0.069 |
| | (0.058) | (0.737) | (0.319) |
| | [0.052] | [0.604] | [0.237] |
| $\overline{R}^2$ | 0.398 | 0.573 | 0.538 |
| number of obs. | 42.000 | 30.000 | 21.000 |

| Dependent variable: $\log d_t - \log d_0$ | Sample I | Sample II | Sample III |
|---|---|---|---|
| constant | 0.200 | 0.317 | 0.153 |
| | (0.064) | (0.003) | (0.347) |
| | [0.011] | [0.000] | [0.075] |
| $d_0$ | -0.019 | -0.019 | -0.021 |
| | (0.000) | (0.000) | (0.000) |
| | [0.000] | [0.000] | [0.001] |
| $(1+n)(1+g)-(1-\delta)$ | -0.050 | 0.005 | -0.064 |
| | (0.173) | (0.887) | (0.293) |
| | [0.068] | [0.806] | [0.133] |
| s | 0.071 | 0.051 | 0.055 |
| | (0.000) | (0.001) | (0.026) |
| | [0.005] | [0.001] | [0.140] |
| $\overline{R}^2$ | 0.584 | 0.716 | 0.637 |
| number of obs. | 42.000 | 30.000 | 21.000 |

Note: Asymptotic $p$-values are in parenthesis. Bootstrap $p$-values are in brackets.

Table 2: Basic Convergence - IV estimation

| Dependent variable: $\log d_t - \log d_0$ | Sample I | Sample II | Sample III |
|---|---|---|---|
| constant | 0.208 | 0.319 | 0.156 |
| | (0.063) | (0.003) | (0.340) |
| | [0.065] | [0.006] | [0.313] |
| $d_0$ | -0.019 | -0.019 | -0.020 |
| | (0.000) | (0.000) | (0.000) |
| | [0.000] | [0.000] | [0.004] |
| $(1+n)(1+g)-(1-\delta)$ | -0.049 | 0.004 | -0.064 |
| | (0.192) | (0.903) | (0.294) |
| | [0.175] | [0.898] | [0.291] |
| s | 0.074 | 0.055 | 0.058 |
| | (0.001) | (0.003) | (0.030) |
| | [0.002] | [0.005] | [0.047] |
| $\overline{R}^2$ | 0.528 | 0.675 | 0.631 |
| number of obs. | 42.000 | 30.000 | 21.000 |

Note: Asymptotic $p$-values are in parenthesis. Bootstrap $p$-values are in brackets. The savings rate is instrumented using the average savings rate between 1960-69.

Table 3: Controlling for $A_0$

| Dependent variable: $\log d_t - \log d_0$ | Sample I | Sample II | Sample III |
|---|---|---|---|
| constant | 0.194 | 0.185 | -0.072 |
| | (0.262) | (0.757) | (0.734) |
| | [0.235] | [0.602] | [0.712] |
| $d_0$ | -0.023 | -0.022 | -0.023 |
| | (0.000) | (0.000) | (0.000) |
| | [0.000] | [0.001] | [0.000] |
| $(1+n)(1+g)-(1-\delta)$ | 0.024 | -0.010 | -0.074 |
| | (0.692) | (0.958) | (0.212) |
| | [0.675] | [0.927] | [0.218] |
| $A_0$ | 0.036 | 0.018 | 0.038 |
| | (0.013) | (0.404) | (0.143) |
| | [0.010] | [0.196] | [0.181] |
| s | 0.063 | 0.052 | 0.066 |
| | (0.003) | (0.009) | (0.018) |
| | [0.005] | [0.005] | [0.030] |
| $\overline{R}^2$ | 0.523 | 0.674 | 0.633 |
| number of obs. | 41.000 | 29.000 | 21.000 |

| Dependent variable: $\log d_t - \log d_0$ | Sample I | Sample II | Sample III |
|---|---|---|---|
| constant | 0.055 | 0.050 | 0.044 |
| | (0.046) | (0.064) | (0.190) |
| | [0.043] | [0.045] | [0.160] |
| $\frac{d_0}{A_0}$ | -0.022 | -0.022 | -0.023 |
| | (0.000) | (0.000) | (0.000) |
| | [0.000] | [0.000] | [0.000] |
| $\frac{s}{(1+n)(1+g)-(1-\delta)}$ | 0.055 | 0.054 | 0.063 |
| | (0.001) | (0.004) | (0.008) |
| | [0.001] | [0.004] | [0.016] |
| $\overline{R}^2$ | 0.528 | 0.683 | 0.655 |
| number of obs. | 41.000 | 29.000 | 21.000 |
| $F$-test | 0.931 | 0.735 | 0.040 |
| | (0.403) | (0.490) | (0.961) |

Note: $\frac{s}{(1+n)(1+g)-(1-\delta)}$ is instrumented with average labour force and the average savings rate between 1960 and 1969. $A_0$ is measured as $\log y_0 - 0.3 \log k_0$. The line denoted $F$-test shows the $F$ statistic for testing the null that the restricted model is true. The last line shows the $p$-value for this test.

Figure 8: Savings and Debt Accumulation, Residual Correlation (convergence removed): Sample I

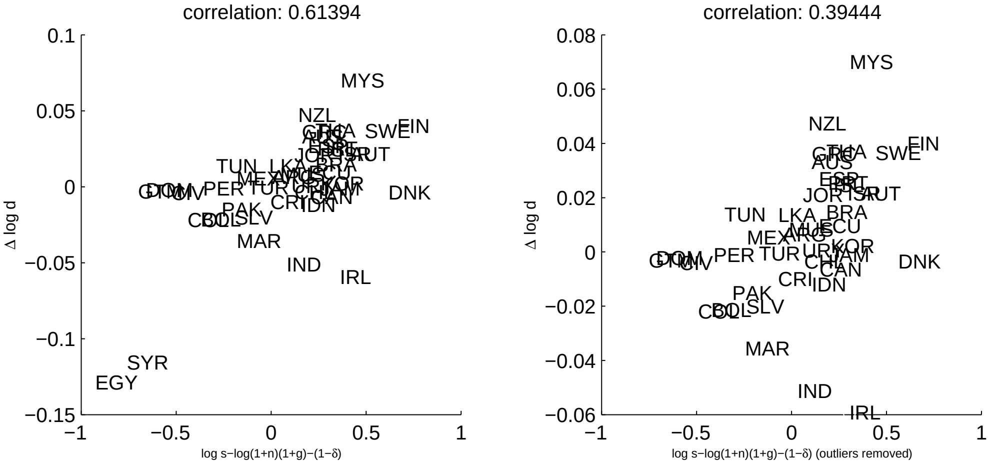


Figure 9: Savings and Debt Accumulation, Residual Correlation (convergence removed): Sample II

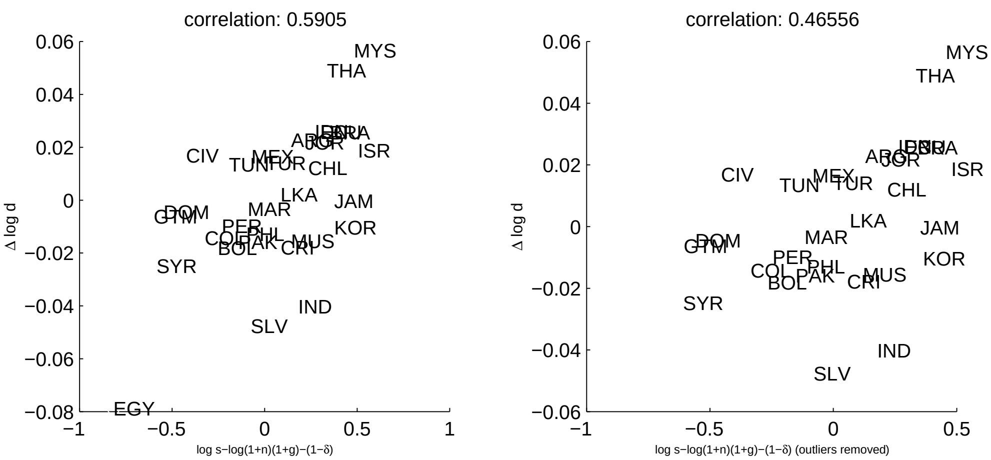


Figure 10: Savings and Debt Accumulation, Residual Correlation (convergence removed): Sample III

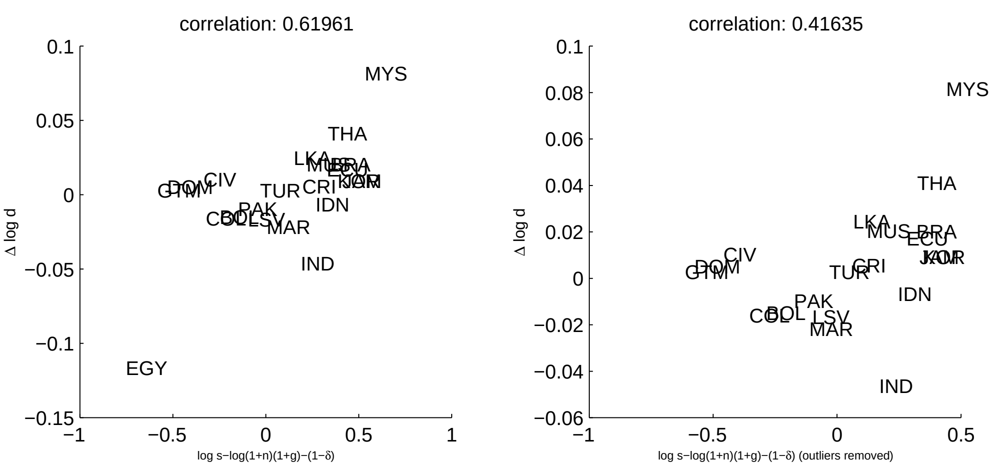

Table 4: Controlling for human capital I

| Dependent variable: $\log d_t - \log d_0$ | Sample I | Sample II | Sample III |
|---|---|---|---|
| constant | 0.064 | 0.092 | 0.071 |
| | (0.083) | (0.020) | (0.210) |
| | [0.077] | [0.003] | [0.151] |
| $\frac{d_0}{A_0}$ | -0.023 | -0.025 | -0.027 |
| | (0.000) | (0.000) | (0.000) |
| | [0.001] | [0.000] | [0.002] |
| $\frac{e}{(1+n)(1+g)-(1-\delta)}$ | 0.044 | 0.024 | 0.042 |
| | (0.030) | (0.294) | (0.235) |
| | [0.027] | [0.131] | [0.162] |
| $\overline{R}^2$ | 0.469 | 0.590 | 0.519 |
| number of obs. | 41.000 | 29.000 | 20.000 |
| $F$-test | 0.250 | 0.159 | 0.503 |
| | (0.620) | (0.693) | (0.488) |

| Dependent variable: $\log d_t - \log d_0$ | Sample I | Sample II | Sample III |
|---|---|---|---|
| constant | 0.049 | 0.060 | 0.032 |
| | (0.114) | (0.065) | (0.500) |
| | [0.142] | [0.038] | [0.527] |
| $\frac{d_0}{A_0}$ | -0.022 | -0.023 | -0.024 |
| | (0.000) | (0.000) | (0.000) |
| | [0.000] | [0.000] | [0.000] |
| $\frac{s}{(1+n)(1+g)-(1-\delta)}$ | 0.070 | 0.053 | 0.067 |
| | (0.000) | (0.001) | (0.007) |
| | [0.023] | [0.001] | [0.121] |
| $\frac{e}{(1+n)(1+g)-(1-\delta)}$ | -0.010 | -0.005 | 0.003 |
| | (0.638) | (0.796) | (0.915) |
| | [0.639] | [0.732] | [0.886] |
| $\overline{R}^2$ | 0.627 | 0.736 | 0.683 |
| number of obs. | 41.000 | 29.000 | 20.000 |
| $F$-test | 0.262 | 1.636 | 0.043 |
| | (0.612) | (0.213) | (0.839) |

Note: OLS estimation. $e$ is measured as $\log \frac{6\times P+6\times S+4\times H}{16}$. The line denoted $F$-test shows the $F$ statistic for testing the null that the restricted model is true. The last line shows the $p$-value for this test.

Figure 11: Education and Debt Accumulation, Residual Correlation (convergence removed)

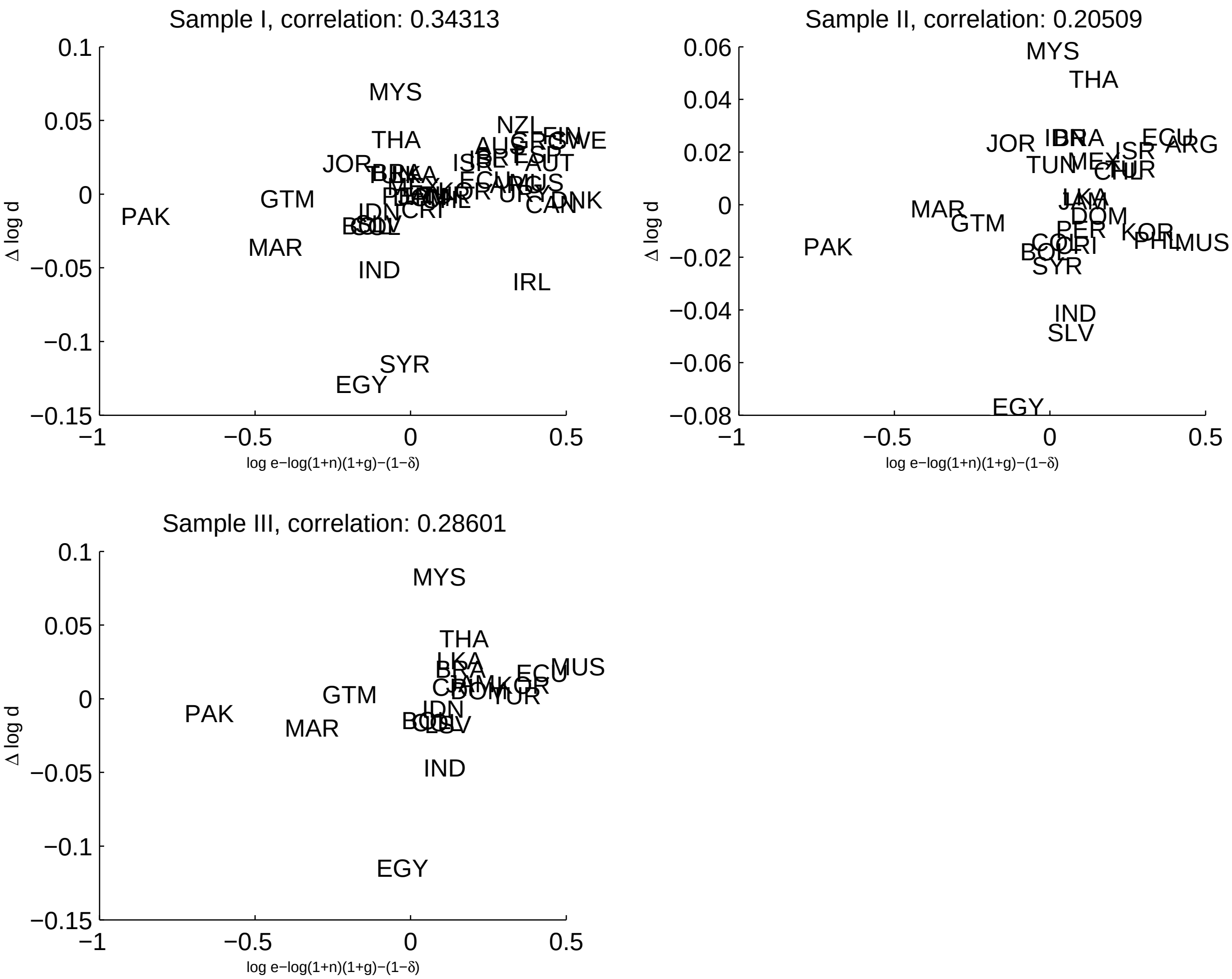

Table 5: Controlling for human capital II

| Dependent variable: $\log d_t - \log d_0$ | Sample I | Sample II | Sample III |
|---|---|---|---|
| constant | 0.066 | -0.085 | -0.327 |
| | (0.173) | (0.461) | (0.431) |
| | [0.133] | [0.444] | [0.552] |
| $\frac{d_0}{A_0}$ | -0.026 | -0.024 | -0.027 |
| | (0.000) | (0.001) | (0.103) |
| | [0.000] | [0.004] | [0.070] |
| $\frac{e}{(1+n)(1+g)-(1-\delta)}$ | 0.046 | 0.132 | 0.292 |
| | (0.085) | (0.069) | (0.269) |
| | [0.078] | [0.152] | [0.467] |
| $\overline{R}^2$ | 0.493 | 0.607 | 0.629 |
| number of obs. | 36.000 | 24.000 | 17.000 |
| $F$-test | 2.374 | 0.388 | 0.001 |
| | (0.133) | (0.540) | (0.981) |
| Dependent variable: $\log d_t - \log d_0$ | Sample I | Sample II | Sample III |
| constant | 0.070 | -0.046 | -1.046 |
| | (0.122) | (0.687) | (0.849) |
| | [0.109] | [0.662] | [0.964] |
| $\frac{d_0}{A_0}$ | -0.025 | -0.024 | -0.034 |
| | (0.000) | (0.000) | (0.599) |
| | [0.000] | [0.001] | [0.625] |
| $\frac{s}{(1+n)(1+g)-(1-\delta)}$ | 0.096 | 0.027 | -0.245 |
| | (0.008) | (0.567) | (0.880) |
| | [0.013] | [0.539] | [0.964] |
| $\frac{e}{(1+n)(1+g)-(1-\delta)}$ | -0.043 | 0.083 | 0.975 |
| | (0.347) | (0.432) | (0.844) |
| | [0.327] | [0.451] | [0.964] |
| $\overline{R}^2$ | 0.654 | 0.665 | 0.690 |
| number of obs. | 36.000 | 24.000 | 17.000 |
| $F$-test | 2.079 | 0.249 | 0.000 |
| | (0.159) | (0.624) | (0.994) |

Note: IV estimation. $e$ is measured as $\log \frac{6\times P+6\times S+4\times H}{16}$ and is instrumented using the average years of schooling in the population over 15 at the beginning of the period and average labour force growth between 1960 and 1969. $\frac{s}{(1+n)(1+g)-(1-\delta)}$ is instrumented with the average savings rate and labour force growth between 1960 and 1969. The line denoted $F$-test shows the $F$ statistic for testing the null that the restricted model is true. The last line shows the $p$-value for this test.

Table 6: Controlling for the steady state I

| Dependent variable: $\log d_t - \log d_0$ | Sample I | Sample II | Sample III |
|---|---|---|---|
| constant | 0.088 | 0.079 | 0.075 |
| | (0.038) | (0.025) | (0.113) |
| | [0.042] | [0.029] | [0.131] |
| $\frac{d_0}{A_0}$ | -0.022 | -0.022 | -0.022 |
| | (0.000) | (0.000) | (0.000) |
| | [0.000] | [0.000] | [0.001] |
| $\frac{s}{(1+n)(1+g)-(1-\delta)}$ | 0.047 | 0.052 | 0.060 |
| | (0.019) | (0.004) | (0.012) |
| | [0.020] | [0.002] | [0.041] |
| capital controls | -0.009 | -0.010 | -0.010 |
| | (0.150) | (0.071) | (0.221) |
| | [0.151] | [0.081] | [0.267] |
| $\overline{R}^2$ | 0.597 | 0.779 | 0.714 |
| number of obs. | 41.000 | 29.000 | 21.000 |

| Dependent variable: $\log d_t - \log d_0$ | Sample I | Sample II | Sample III |
|---|---|---|---|
| constant | 0.062 | 0.052 | 0.053 |
| | (0.043) | (0.067) | (0.132) |
| | [0.044] | [0.054] | [0.142] |
| $\frac{d_0}{A_0}$ | -0.023 | -0.023 | -0.024 |
| | (0.000) | (0.000) | (0.000) |
| | [0.000] | [0.000] | [0.000] |
| $\frac{s}{(1+n)(1+g)-(1-\delta)}$ | 0.044 | 0.050 | 0.049 |
| | (0.049) | (0.016) | (0.069) |
| | [0.047] | [0.011] | [0.085] |
| openness | 0.023 | 0.009 | 0.031 |
| | (0.277) | (0.591) | (0.216) |
| | [0.255] | [0.577] | [0.250] |
| $\overline{R}^2$ | 0.561 | 0.700 | 0.709 |
| number of obs. | 41.000 | 29.000 | 21.000 |

Note: $\frac{s}{(1+n(1+g)-(1-\delta)}$ is instrumented with the average savings rate and the average labour force growth rate between 1960 and 1969.

Table 7: Controlling for the steady state II

| Dependent variable: $\log d_t - \log d_0$ | Sample I | Sample II | Sample III |
|---|---|---|---|
| constant | 0.051 | 0.047 | 0.044 |
| | (0.065) | (0.076) | (0.267) |
| | [0.057] | [0.067] | [0.268] |
| $\frac{d_0}{A_0}$ | -0.023 | -0.023 | -0.023 |
| | (0.000) | (0.000) | (0.000) |
| | [0.000] | [0.000] | [0.003] |
| $\frac{s}{(1+n)(1+g)-(1-\delta)}$ | 0.055 | 0.051 | 0.060 |
| | (0.066) | (0.038) | (0.043) |
| | [0.056] | [0.025] | [0.057] |
| pol. inst. | 0.007 | 0.014 | 0.008 |
| | (0.886) | (0.826) | (0.928) |
| | [0.865] | [0.819] | [0.925] |
| $\overline{R}^2$ | 0.543 | 0.702 | 0.634 |
| number of obs. | 41.000 | 29.000 | 21.000 |

| Dependent variable: $\log d_t - \log d_0$ | Sample I | Sample II | Sample III |
|---|---|---|---|
| constant | -0.023 | 0.012 | -0.069 |
| | (0.567) | (0.793) | (0.403) |
| | [0.575] | [0.782] | [0.394] |
| $\frac{d_0}{A_0}$ | -0.022 | -0.021 | -0.023 |
| | (0.000) | (0.000) | (0.000) |
| | [0.000] | [0.000] | [0.001] |
| $\frac{s}{(1+n)(1+g)-(1-\delta)}$ | 0.070 | 0.065 | 0.086 |
| | (0.000) | (0.003) | (0.003) |
| | [0.000] | [0.005] | [0.008] |
| $\frac{G}{Y}$ | -0.033 | -0.013 | -0.046 |
| | (0.031) | (0.394) | (0.150) |
| | [0.035] | [0.356] | [0.169] |
| $\overline{R}^2$ | 0.579 | 0.695 | 0.680 |
| number of obs. | 41.000 | 29.000 | 21.000 |

Table 8: Output convergence

| Dependent variable: $\log y_t - \log y_0$ | Sample I | Sample II | Sample III |
|---|---|---|---|
| constant | 0.099 | 0.096 | 0.060 |
| | (0.003) | (0.059) | (0.468) |
| | [0.000] | [0.032] | [0.463] |
| $y_0$ | -0.013 | -0.013 | -0.009 |
| | (0.000) | (0.019) | (0.307) |
| | [0.000] | [0.004] | [0.267] |
| $\frac{s}{(1+n)(1+g)-(1-\delta)}$ | 0.025 | 0.024 | 0.027 |
| | (0.000) | (0.009) | (0.027) |
| | [0.003] | [0.027] | [0.059] |
| $\overline{R}^2$ | 0.341 | 0.309 | 0.246 |
| number of obs. | 42.000 | 30.000 | 21.000 |

| Dependent variable: $\log y_t - \log y_0$ | Sample I | Sample II | Sample III |
|---|---|---|---|
| constant | 0.098 | 0.113 | 0.091 |
| | (0.003) | (0.037) | (0.290) |
| | [0.007] | [0.029] | [0.280] |
| $y_0$ | -0.011 | -0.013 | -0.011 |
| | (0.003) | (0.019) | (0.234) |
| | [0.005] | [0.016] | [0.217] |
| $\frac{s}{(1+n)(1+g)-(1-\delta)}$ (IV) | 0.016 | 0.015 | 0.016 |
| | (0.074) | (0.211) | (0.216) |
| | [0.065] | [0.197] | [0.227] |
| $\overline{R}^2$ | 0.129 | 0.149 | 0.075 |
| number of obs. | 42.000 | 30.000 | 21.000 |

Note: The accumulation variable is instrumented using average labour force growth and the average savings rate between 1960 and 1969

Table 9: Convergence for debt and output — SUR Estimation

| Dependent variable: $\log d_t - \log d_0$ | Sample I | Sample II | Sample III |
|---|---|---|---|
| constant | 0.153 | 0.178 | 0.174 |
| | (0.000) | (0.000) | (0.001) |
| | [0.000] | [0.000] | [0.015] |
| $d_0$ | -0.019 | -0.019 | -0.020 |
| | (0.000) | (0.000) | (0.000) |
| | [0.000] | [0.001] | [0.003] |
| $\frac{s}{(1+n)(1+g)-(1-\delta)}$ | 0.066 | 0.045 | 0.056 |
| | (0.000) | (0.001) | (0.008) |
| | [0.001] | [0.002] | [0.034] |
| $\overline{R}^2$ | 0.592 | 0.702 | 0.657 |
| number of obs. | 42.000 | 30.000 | 21.000 |

| Dependent variable: $\log y_t - \log y_0$ | Sample I | Sample II | Sample III |
|---|---|---|---|
| constant | 0.092 | 0.092 | 0.067 |
| | (0.003) | (0.058) | (0.378) |
| | [0.014] | [0.099] | [0.441] |
| $y_0$ | -0.012 | -0.012 | -0.010 |
| | (0.001) | (0.017) | (0.230) |
| | [0.004] | [0.047] | [0.308] |
| $\frac{s}{(1+n)(1+g)-(1-\delta)}$ | 0.024 | 0.024 | 0.027 |
| | (0.000) | (0.006) | (0.019) |
| | [0.001] | [0.015] | [0.037] |
| $\overline{R}^2$ | 0.340 | 0.309 | 0.245 |
| number of obs. | 42.000 | 30.000 | 21.000 |

Table 10: Convergence for debt and output — 3SLS Estimation

| Dependent variable: $\log d_t - \log d_0$ | Sample I | Sample II | Sample III |
|---|---|---|---|
| constant | 0.165 | 0.173 | 0.180 |
| | (0.000) | (0.000) | (0.001) |
| | [0.001] | [0.000] | [0.011] |
| $d_0$ | -0.020 | -0.020 | -0.021 |
| | (0.000) | (0.000) | (0.000) |
| | [0.000] | [0.000] | [0.001] |
| $\frac{s}{(1+n)(1+g)-(1-\delta)}$ | 0.062 | 0.050 | 0.053 |
| | (0.001) | (0.004) | (0.019) |
| | [0.002] | [0.003] | [0.042] |
| $\overline{R}^2$ | 0.593 | 0.705 | 0.656 |
| number of obs. | 41.000 | 29.000 | 21.000 |

| Dependent variable: $\log y_t - \log y_0$ | Sample I | Sample II | Sample III |
|---|---|---|---|
| constant | 0.091 | 0.106 | 0.099 |
| | (0.005) | (0.040) | (0.212) |
| | [0.005] | [0.038] | [0.300] |
| $y_0$ | -0.011 | -0.012 | -0.012 |
| | (0.004) | (0.019) | (0.161) |
| | [0.007] | [0.023] | [0.242] |
| $\frac{s}{(1+n)(1+g)-(1-\delta)}$ | 0.016 | 0.016 | 0.016 |
| | (0.053) | (0.149) | (0.172) |
| | [0.062] | [0.094] | [0.202] |
| $\overline{R}^2$ | 0.301 | 0.279 | 0.209 |
| number of obs. | 41.000 | 29.000 | 21.000 |

Note: $\frac{s}{(1+n(1+g)-(1-\delta)}$ is instrumented with the average savings rate and the average labour force growth rate between 1960 and 1969.

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# Appendix

## A Model with endogenous savings

Under these assumptions, the household problem takes the form:

$$\begin{aligned} \underset{\{c_t,z_{t+1}\}_{t=0}^{\infty}}{Max} \quad & \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\sigma}}{1-\sigma} \\ s.t. \quad & \\ (1+n)(1+g)z_{t+1} &= (1-\alpha)Bz_t^{\varepsilon} + (1-\delta)z_t - c_t \end{aligned} \tag{A.1}$$

The dynamics of the system are governed by the Euler equation

$$\left(\frac{c_{t+1}}{c_t}\right)^{\sigma} = \beta^* \left((1-\alpha)\varepsilon B z_{t+1}^{\varepsilon-1} + 1 - \delta\right) \tag{A.2}$$

where $\beta^* = \frac{\beta}{(1+n)(1+g)}$, and market clearing

$$(1+n)(1+g)z_{t+1} = (1-\alpha)Bz_t^{\varepsilon} + (1-\delta)z_t - c_t \tag{A.3}$$

Note that this system in $c$ and $h$ will behave just like a closed-economy neoclassical growth model with a broad capital share less than $\alpha+\eta$. Consequently, the convergence rate is higher than in a closed economy but lower than with perfect capital markets.

We can easily solve this system. Log-linearizing the system and approximating around the steady state, we have:

$$\log z_t = \lambda^t \log z_0 + (1-\lambda^t)\log z^* \tag{A.4}$$

where $1-\lambda$ is the convergence rate. This implies that the change in net foreign debt takes the form

$$\log d_t - \log d_0 = -(1-\lambda^t)\log d_0 + (1-\lambda^t)\log d^* \tag{A.5}$$

where

$$d^* = \frac{\alpha}{r+\delta} B \left[\frac{(1+n)(1+g) - \beta(1-\delta)}{B(1-\alpha)\varepsilon\beta}\right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{A.6}$$

Manipulating this equation yields a convergence equation for debt of the form

$$\begin{aligned} \log d_t - \log d_0 &= (1-\lambda^t)\log\frac{\alpha B}{r+\delta} + (1-\lambda^t)\frac{\varepsilon}{1-\varepsilon}\log B(1-\alpha)\varepsilon\beta - (1-\lambda^t)\log d_0 \\ &- (1-\lambda^t)\frac{\varepsilon}{1-\varepsilon}\log\left((1+n)(1+g) - \beta(1-\delta)\right) \end{aligned} \tag{A.7}$$

# B Data

# C Debt

The debt data are from Lane and Milesi-Ferretti (1999). They construct net foreign asset positions for 66 countries between 1970 and 1997. Their approach essentially consists in uisng available stock data and supplementing it with flows from balance-of-payments data. More specifically, they note that the balance-of-payments identity implies that the sum of the current account ($CA$), financial flows – which include foreign direct investment, portfolio equity, debt flows and capital transfers (e.g. debt forgiveness) – and the change in reserves equals zero plus net errors and omissions. The change in the value of net foreign assets thus corresponds to the sum of the current account, capital transfers and capital gains or losses on the stock of assets. The first measure used in this paper, `CUMCA`, corresponds to the cumulative sum of current account balances. It is available for industrial and developing countries between 1970 and 1997. The second measure `NFA` corresponds to the sum of stock measures of the various assets and liabilities. These measures are either cumulative flows or direct stock measures. `NFA` is available for developing countries between 1970 and 1997. Both measures are adjusted for debt reductions and forgiveness. In addition, these measures take into account valuations changes, such as exchange rate changes, and variations in the price of capital goods, as well as changes in stock market values.

The main difference between the two measures is the treatment of unrecorded capital flows. By cumulating current accounts, the `CUMCA` measure implies that unrecorded capital flows – including but over and above net errors and omissions – correspond to assets held by domestic investors abroad. On the other hand, `NFA` only reflects unrecorded capital outflows to the extent that they are recorded in net errors and omissions. In countries with periods of unrecorded capital flight, debt measured by `NFA` will tend to be larger than debt measured by `CUMCA` since the latter records a larger portion of unrecorded capital holdings. The debt per worker measure used in this paper corresponds to

$$\frac{D}{L} = \frac{D^m}{p_{US} L}$$

where $D^m = -\texttt{CUMCA}$ or $D^m = -\texttt{NFA}$. The debt data are measured in US dollars. To obtain a real value, they are divided by $p_{US}$, the US GDP deflator obtained from the IMF's *International Financial Statistics.* $L$ corresponds to the labour force. It is measured by the population between 15 and 64 computed from output and population data from the Penn World Tables, version 6.0 as

$$L = \frac{\texttt{RGDPL}}{\texttt{RGDPW}} \times \texttt{POP}$$

where `RGDPL` is real per capita chain GDP, `RGDPW` is real per worker chain GDP, and `POP` is total population. The dependent variable is the average annual growth rate of debt

$$\Delta d = \frac{\log d_T - \log d_t}{T - t}$$

where $[t; T]$ is the sample period.

# D Output, Savings, Capital and Other Controls

The output measure is real per worker GDP from the Penn World Tables 6.0 (`RGDPW`). The labour force growth rate corresponds to the average annual growth rate of $L$ computed as

$$1 + n = \left(\frac{\mathrm{L}_T}{\mathrm{L}_t}\right)^{\frac{1}{T-t}}$$

The labour force growth rate variable used in the regression is the log of $(1+n)(1+g)-(1-\delta)$. I follow Mankiw, Romer and Weil (1992) and assume a growth rate of technological progress of $g = 0.02$ and a depreciation rate $\delta = 0.03$.

The savings rate is measured as $1 - \frac{c}{y}$ where $\frac{c}{y}$ corresponds to the average value of `kc` between 1970 and 1997 in the Penn World Tables 6.0.

In Chapter **??**, initial capital is taken from the Penn World Tables 5.6. The variable used is non-residential capital stock per worker (`KAPW`).

The government variable is also taken from PWT. It is the ratio of government expenditures to GDP (`KG`). In the regressions, $\frac{G}{Y}$ corresponds to the log of the average government expenditures to GDP ratio between $t$ and $T$ divided by 100.

$\frac{p_m}{p_x}$ is the average ratio of import and export prices between $t$ and $T$. It is taken from the *IMF's International Financial Statistics*.

The capital controls variable is taken from Calderón *et al*(2000). The index constitutes of dummies that account for the presence of current and capital account restrictions, multiple exchange rate practices and mandatory surrender of export proceeds. The variable used in the regression corresponds to the average sum of these dummies between $t$ and $T$. Higher values indicate more restrictive controls.

The variable on openness corresponds to the index of trade openness from Sachs and Warner (1995). It measures the fraction of years between 1950 and 1994 that the economy has been open. An open country is defined by the following criteria: (i) non-tariff barriers cover less than 40 percent of trade, (ii) average tariff rates are less then 40 percent, (iii) any black market premium was less than 20 percent during the 1970s and 1980s, (iv) the country does not operate under a communist regime and (v) the government does not monopolise major export.

The variable on political institutions is taken from Hall and Jones (1999). The original source of the data is the *International Country Risk Guide* which ranks 130 countries according to 24 categories. The authors construct an index on a scale of zero to one between 1985 and 1995 from 5 of these categories: (i) law and order, (ii) bureaucratic quality, (iii) corruption, (iv) risk of expropriation and (v) government repudiation of contracts. A higher value of the index indicates institutions that support growth.

# E Education

The education variables are taken from Barro and Lee (1993).

The measure $e$ follows Klenow and Rodriguez-Clare (1997) and assumes that primary and secondary school has an average duration of 6 years whereas higher schooling has an average of 4 years:

$$\frac{I_H}{Y} = \log\left(\frac{6 \times P + 6 \times \mathtt{S} + 4 \times \mathtt{H}}{16}\right)$$

where `P`, `S` and `H` denote the average gross enrollment rates for primary, secondary and higher schooling between 1960 and 1970.

$e$ is instrumented by the initial stock of human capital

$$\log h_0$$

where $h_0$ is the years of education per person in the population over 15 averaged between 1960 and 1965.

# F TFP

PWT 6.0 does not provide estimates of the stock of physical capital. To compute total factor productivity at the beginning of sample, capital per worker in 1970 is estimated using the permanent inventory scheme

$$(1+\bar{n})\frac{K_{t+1}}{L_{t+1}} = \frac{I_t}{L_t} + (1-\delta)\frac{K_t}{L_t}$$

Under the assumption that capital and output per worker grow at the same rate $g$ — as they do in the model —, the initial physical capital stock is

$$\frac{K_0}{L_0} = \frac{\frac{I_0}{L_0}}{(1+\bar{n})(1+g)-(1-\delta)}$$

where we estimate initial investment per worker as

$$\frac{I_0}{L_0} = \left(\frac{1}{10}\sum_{t=1970}^{1980} \mathtt{KI}_t\right)\mathtt{RGDPW}_{1970}$$

and labour force growth as

$$\bar{n} = \frac{\log\left(\mathtt{L}_{1980}\right) - \log\left(\mathtt{L}_{1970}\right)}{10}$$

The TFP measure is computed as

$$A_0 = \log\left(\mathtt{RGDPW}_0\right) - \alpha \log \frac{K_0}{L_0}$$

with $\alpha = 0.3$.

# G Missing Values

Many variables are not available for all the years and countries in the full Lane and Milesi-Ferretti database. In order to retain the largest number of countries for estimation, the sample period differs across countries from a maximum of 28 years to a minimum of 13 years. This justifies the use of annual averages for both levels and growth rates.

# H Distribution

The distributions shown in Figure 1 is estimated using a Gaussian kernel with bandwidth $h = \frac{4}{3}^{\frac{1}{5}}\sigma n^{\frac{-1}{5}}$ where $\sigma$ is the standard deviation of the sample and $n$ is the number of observations.

# I Sample Composition

| Sample I (`CUMCA`) | Sample II (`NFA`) | Sample III (`CUMCA`) [a] |
|---|---|---|
| Argentina (ARG) | Argentina (ARG) | Bolivia (BOL) |
| Australia (AUS) | Bolivia (BOL) | Brazil (BRA) |
| Austria (AUT) | Brazil (BRA) | Colombia (COL) |
| Bolivia (BOL) | Chile (CHL) | Costa Rica (CRI) |
| Brazil (BRA) | Colombia (COL) | Dominican Republic (DOM) |
| Canada (CAN) | Costa Rica (CRI) | Ecuador (ECU) |
| Chile (CHL) | Dominican Republic (DOM) | Egypt (EGY) |
| Colombia (COL) | Ecuador (ECU) | El Salvador (LSV) |
| Costa rica (CRI) | Egypt (EGY) | Guatemala (GTM) |
| Denmark (DNK) | El Salvador (SLV) | India (IND) |
| Dominican Republic (DOM) | Guatemala (GTM) | Indonesia (IDN) |
| Ecuador (ECU) | India (IND) | Ivory Coast (CIV) |
| Egypt (EGY) | Indonesia (IDN) | Jamaica (JAM) |
| El Salvador (SLV) | Israel (ISR) | Korea (KOR) |
| Finland (FIN) | Ivory Coast (CIV) | Malaysia (MYS) |
| Greece (GRC) | Jamaica (JAM) | Mauritius (MUS) |
| Guatemala (GTM) | Jordan (JOR) | Morocco (MAR) |
| Iceland (ISL) | Korea (KOR) | Pakistan (PAK) |
| India (IND) | Malaysia (MYS) | Sri Lanka (LKA) |
| Indonesia (IDN) | Mauritius (MUS) | Thailand (THA) |
| Ireland (IRL) | Mexico (MEX) | Turkey (TUR) |
| Israel (ISR) | Morocco (MAR) | |
| Ivory Coast (CIV) | Pakistan (PAK) | |
| Jamaica (JAM) | Peru (PER) | |
| Jordan (JOR) | Philippines (PHL) | |
| Korea (KOR) | Sri Lanka (LKA) | |
| Malaysia (MYS) | Syria (SYR) | |
| Mauritius (MUS) | Thailand (THA) | |
| Mexico (MEX) | Tunisia (TUN) | |
| Morocco (MAR) | Turkey (TUR) | |
| New Zealand (NZL) | | |
| Pakistan (PAK) | | |
| Peru (PER) | | |
| Portugal (PRT) | | |
| Spain (ESP) | | |
| Sri Lanka (LKA) | | |
| Sweden (SWE) | | |
| Syria (SYR) | | |
| Thailand (THA) | | |
| Tunisia (TUN) | | |
| Turkey (TUR) | | |
| Uruguay (URY) | | |
| 42 countries | 30 countries | 24 countries |

[a]The low-income Sample III corresponds to countries whose 1970 GDP per worker is lower than the median for that variable in that year in the whole CUMCA sample

# J Bootstrap

The unrestricted model is

$$\Delta d_i = \log \frac{D_{it}}{L_{it}} - \log \frac{D_{i0}}{L_{i0}} = \gamma + \beta X \tag{J.1}$$

999 bootstrap samples are generated under the null hypothesis that the unrestricted model is true. Bootstrap samples are generated by re-sampling both regressand and regressors with replacement. The $p$-value is constructed as the proportion of test statistics (in this case, the $t$ ratio) that are more extreme than the empirical test statistics [20].

[20]See Money and Duval [1993], Davidson and Mackinnon [1993] or MacKinnon [2002] for a discussion of bootstrap methods.