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

Comments welcome

Geneviève Verdier *

October 5, 2004

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 intriguing 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 1998 period, I find evidence that supports these predictions.

JEL classification numbers: F41, F43, O41

Keywords: Credit constraints, net external debt, capital flows, savings, convergence.

*Department of Economics, 4228 Texas A&M University, College Station, TX 77843-4228, e-mail: gverdier@econmail.tamu.edu. I would like to thank Paul Beaudry, Michael Devereux, Dror Goldberg, Francisco González, Paula Hernandez-Verme, Adi Mayer, Angela Reddish, Lilia Karnizova, Leonardo Auernheimer and seminar participants at the University of British Columbia for helpful comments and suggestions. Special thanks to Luis Servén for sharing his data on capital controls. Any errors or omissions are my own. This research was partly supported by the Social Sciences and Humanities Research Council of Canada.

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, they 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. The mechanism is straightforward and can be illustrated in a simple neoclassical growth model with a credit constraint. Although a country may need several types of capital for production, not all types of capital can be easily used as collateral and financed on international capital markets. If these different types of capital are all essential to, and complements in production, saving to accumulate the non-collateralized capital will increase the return to collateralized capital, and therefore inflows from abroad. The evidence presented here suggests that the cross-country variations in net foreign liabilities conform rather well to the qualitative predictions of such 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 observed 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 [2001b] 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 labor-augmenting technological progress, growth is driven by accumulation, the returns to which decline with higher income. 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. As a starting point to address questions about long-term debt accumulation, the paper focuses on the class of models with decreasing returns to capital, which predicts convergence — a standard and well-understood phenomenon.

These models however, tend to predict infinite rates of convergence when capital is allowed to flow freely across countries. 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]). These facts suggest that for a neoclassical model to help us understand variations in borrowing behavior, some

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

type of imperfection in capital markets is needed. What form should this imperfection take? I offer a model that features a possible complementary role of domestic savings. The analysis is undertaken within a framework inspired by Barro, Mankiw and Sala-i-Martin [1995] (BMS hereafter) in which some countries face a collateral constraint. I consider a world in which there are two types of capital, foreign and domestic. The collateral constraint takes the following form: domestic capital cannot be financed internationally. 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, i.e. where its return is highest. The presence of the collateral constraint slows down the rate of income convergence compared to the standard model. But perhaps more importantly, since foreign and domestic capital are complementary in production, the constraint leads to a complementarity between savings in domestic capital and foreign financing of capital: higher saving for domestic capital accumulation raises the return to foreign capital through the production function, and therefore the flow of financing from abroad.

Some of the 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, in the sense that they cannot borrow as much as they would like at the going world interest rate. 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. More recent papers also include Lane [2000] and Lane and Milesi-Ferretti [2001a] 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.

In this paper I will exploit the net foreign assets data constructed by Lane and Milesi-Ferretti [2001b] 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 empirical literature on economic growth has mainly focused on the determinants of income across countries in a closed-economy framework. In order to study the behavior of capital flows in an open economy, this paper relies on partial capital mobility. The contribution made here is twofold. First, I underscore an unexploited prediction of neoclassical models with credit constraints for the role of saving. Second, I estimate reduced forms from the model and present evidence in support of this prediction. Specifically, convergence equations for debt, similar to equations from the income convergence literature, are derived from the model, and estimated using the Lane and Milesi-Ferretti database. The results are consistent with the idea of convergence, or decreasing returns to accumulated capital. Countries with low levels of initial debt did increase their borrowing over the sample period, at a rate of about 2 to 4 per cent per year, an estimate remarkably close to those of income convergence found in the literature. More importantly, the model predicts a positive correlation between domestic savings and debt accumulation, an intriguing result which comes from the combination of the technological complementarity between the two types of capital and the collateral constraint. This prediction is not only supported by the data but is robust to the econometric specification, the sample countries considered as well as assumptions about technology and the measurement of domestic savings and capital inflows. The behavior of the debt-to-GDP ratio implied by the model only seems to be partially borne out by the data, but this is a drawback of many small-open-economy neoclassical models. 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, while allowing for a more complex and flexible relationship between debt and output.

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 based on work 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, I 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 unrealistic [2]. In addition, a neoclassical open-economy model with perfect capital markets exhibits infinite speeds of convergence for capital and output. One way to avoid these problems is to assume a quantity

[2] 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).

constraint [3]. This is the avenue pursued here. Furthermore, as will become apparent, the presence of the collateral constraint — as opposed to other imperfections — leads to a role for domestic savings that is rarely emphasized. I discuss this point further below.

The 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 labor L, so that

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

where $\alpha, \eta > 0$, $\alpha + \eta < 1$. θ_t is the exogenous source of technology and grows at rate g while raw labor grows at rate n. The production function can be expressed in units of effective labor (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 labor 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_t, 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, δ. Under the small-open-economy assumption, $r = R_k - \delta$.

What distinguishes the two types of capital? The credit constraint takes an extreme form. Debt cannot exceed the amount of k — what I 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, I want to think of domestic capital as a

[3] Assuming a debt-elastic interest rate, an endogenous discount factor or portfolio adjustment costs are other ways to solve for the indeterminacy of debt in these models (see Schmitt-Grohé and Uribe [2001]). Verdier [2003b] explores the implications for the role of savings of a model that features a debt-elastic interest rate.

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 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 collateralize 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 [5].

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 economy can finance its transition to the steady state. 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 maximization (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 saving rate can rise or fall during the transition to the steady state. Here however, I choose to make the Solow-growth-model assumption of

[4] Cohen and Sachs [1986] develop a model of borrowing with one capital good in which borrowers can choose to 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] As an example, consider the case where K is capital used in the formal sector and Z is capital used in the informal sector. Suppose goods produced in the formal and informal sector are both produced with Cobb-Douglas technologies using capital types K and Z, and labor so that

$$Y_F = K^{\alpha} L_F^{1-\alpha}$$

is the amount of goods produced in the formal sector and

$$Y_I = Z^{\eta} L_I^{1-\eta}$$

is the amount of goods produced in the informal sector with $L = L_F + L_I$. Further assume that formal and informal goods are complements in consumption, so that aggregate consumption C is a CES aggregator of formal and informal goods consumption C_F and C_I, i.e.

$$C = \left[C_F^{\psi} + C_I^{\psi}\right]^{\frac{1}{\psi}}$$

Then one can easily see that formal (foreign) and informal (domestic) capital will be complements in the aggregate production function of good C. Hence, the production function of the BMS model can be seen as a reduced form of a model illustrated here with this simple example.

a constant saving rate for two reasons. First, I want to focus on 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 [6]. This issue is discussed further in the next section.

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. $s_y y_t = y_t - c_t$. Domestic savings must equal investment in domestic capital $((1+n)(1+g)z_{t+1} - (1-\delta)z_t)$ minus net factor payments on debt $(\alpha B z_t^{\varepsilon})$, 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 α — 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 η 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

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

[6] See Appendix A for a derivation of the estimated equation in a version of the model with endogenous savings.

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 emphasized in the BMS 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 [7]. It is this feature of the model that makes it an appropriate choice for the exercise in this paper [8].

3 Estimation

3.1 Empirical Approach

In this empirical exercise, I 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. More specifically, I will estimate (13) in its time-averaged form:

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

[7] In this paper, I emphasize 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, liberalizing capital markets leads capital to flow from poor to rich countries — where the rate of return is high — and to the equalization 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.

[8] 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 favor 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.

for each country i, where $D_{it} = d_{it}\theta_t L_{it}$ is total debt and d^* takes on the values defined in (10). t is the period of time over which the average is taken.

In order to estimate this equation, I must address three issues. First, since we only observe debt per worker $\left(\frac{D}{L}\right)$ and not debt per efficiency units of labor $\left(\frac{D}{\theta L}\right)$, I must make some assumptions about how technology flows across countries. Second, I must correctly control for cross-country variations in the level of steady state net external debt, or equivalently of output. Finally, I 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. $\log \theta_{i0} = c + u_i$ with $\frac{\theta_{it+1}}{\theta_t} = (1+g)$. c is a constant representing the technology level which is common across countries and u_i is a country-specific shock which should capture endowments, geography, climate, etc. 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 behavior and technology parameters, depreciation and interest rates as well as labor force growth. What variables should we include in X? I 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, I cannot use average investment rates as controls for steady state output since it is endogenous to the domestic saving 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, labor 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. These variables are all assumed to be constant over time. Of course saving rates vary over time — as do population growth rates. Barro and Sala-i-Martin [1995] note that saving rates tend to rise moderately as a country grows richer. To assume that they are constant means that I am ignoring the time-series variation in saving rates to focus on the long-term cross-sectional information contained in the data. Debt, output and saving rates may tend to move together over time, but it is possible to deal with these co-movements with instrumental variables. This empirical assumption of constant steady state variables is in line with the growth literature where investment rates are assumed to be constant over time (see for example MRW). Finally, note that an alternative is to assume the consumption decision is endogenous, and to include saving rates as a control for varying discount rates across countries [9].

The basic convergence regression will therefore take the form

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

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. Given that data on assets are limited, income can be used as a proxy. Thus I 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 [2001b]. The authors construct net foreign assets time-series for 66 countries for the period between 1970 and 1998 using data on current account balances. They supplement the latter source with stock data (whenever available) on foreign direct investment, portfolio equity and debt assets and liabilities. They justify their use of flow data by first noting that direct stock data is not available for most years and most countries. Second, 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 stocks 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 [10]. In all regressions, I computed debt per worker 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 first consider two measures for B [11]. The first, `ACUMCA`, is based on cumulative current accounts. It is available for both industrial and developing countries. The second, `ACUMFL`, 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

[9] See Appendix A for an illustration of this point.

[10] More details on the debt measures, as well as all the measurement and source of all other data used in the paper are available in Appendix B.

[11] In the robustness section, I consider a an additional measure which only includes private capital flows.

large — the world had a current account deficit on the order of \$US70 billion in 1998 — this is of some importance. `ACUMCA` implicitly assumes that unrecorded capital flows reflect accumulation of foreign debt assets by domestic residents. The second measure, `ACUMFL`, 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, `ACUMFL` 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.

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 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 `ACUMCA` measure (Sample I), and 30 observations for the `ACUMFL` measure (Sample II). A third sample corresponds to the poorest half of the `ACUMCA` sample in terms of income in 1970 (Sample III). The full Sample I includes both rich and poor countries, all likely to be small open economies in the sense that they cannot affect the rate at which they borrow and lend on international capital markets. Sample compositions are described in Appendix B. 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-Ferretti [2001a] 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.

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

In all regressions, the dependent variable is the average annual log change in real net debt per worker between 1970 and 1998 for most countries. In this paper, I focus on the cross-sectional variation in the dynamics of debt and do not explore the time-series variation. The BMS model is not appropriate for explaining business cycles variation since it is deterministic. By averaging out short-term variations, I hope to abstract from movements due to temporary shocks. The objective is to understand the direction and role of capital inflows over *long* periods of time. Explaining time-series variation in the context of a model with a complementary role for savings is left for future research. [12]

Since there are missing data for some countries, the sample period for each country varies between seventeen and twenty-seven years [13]. 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 1998. As in MRW, I assume that the exogenous rate of technological progress g is 2 percent and the depreciation rate δ is 3 percent. 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 $s = 1 - \frac{c}{y}$ [14].

Table 1 shows some descriptive statistics for the three samples used in estimation. In Sample I, which includes both rich and poor countries, average income at the beginning of the sample is \$15,276 in real PWT dollars per worker, and drops to \$10,735 and \$7,751 in Samples II and III. As noted before, the countries shown here are therefore relatively well-off compared to some growth disasters in sub-saharan Africa. On average these countries have received capital inflows ($\log d_t - \log d_0$ is positive on average) in all three samples. The saving rate s is on average over 30 per cent, where s 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 1998 from the Penn World Tables version 6.0 [15].

Table 2 illustrates the two mechanisms emphasized in this paper: decreasing returns to capital through debt convergence and the complementarity between domestic savings and debt accumulation. It presents raw correlations between the main variable used in estimation, in particular the average annual growth in debt between 1970 and 1998 and initial conditions, measured by debt per worker. In all three samples, the negative correlation between initial debt and subsequent accumulation is consistent with decreasing returns to capital. The table also shows the correlation between average annual debt growth and the savings rate. 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. 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.

Table 3 presents the results for ordinary least squares. As in the tables below, all variables are in logs.

[12] See Lane and Milesi-Ferretti [2001a] and Calderon, Loayza and Serven [1999] for results on shorter time spans.

[13] The starting date varies between 1970 and 1980 and the end date between 1988 and 1998.

[14] A measure of government saving is not available in the Penn World Tables. However, I add a measure of government spending as a control in the robustness section. An alternative measure of saving for human capital accumulation is also considered below. Finally, the results are robust to using $s = 1 - \frac{c}{y} - \frac{G}{y}$ where G is government spending. The estimation with $s = 1 - \frac{c}{y} - \frac{G}{y}$ is not shown here due to space constraints but is available from the author upon request.

[15] The model suggests that a better measure of savings would be the fraction of GNP 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. 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.

In addition, both asymptotic and bootstrap p-values are shown [16]. These bootstrap statistics are robust to the presence of heteroscedasticity.

First, in all three samples, the estimated convergence rate is about 2-3 percent per year and is statistically significant. This is curiously close to the estimates of income convergence in the literature since these are two different sources for the estimation of convergence. Second, in this model, labor force growth lowers output-per-worker through the usual neoclassical channel: new entrants in the labor force must be equipped with capital. Consequently, because of the credit constraint, countries with higher labor-force growth rates should have low output, and thus low net external debt. The labor force variable however, fails to significantly affect debt accumulation, particularly in Sample III which excludes high-income countries [17]. Third, saving seems to increase debt accumulation, particularly in Samples I and II. This positive association may be surprising to readers used to thinking about foreign sources of finance as substitutes for domestic ones. In fact, economists 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 [18]. Saving 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 saving rate. Table 4 shows the results of estimation by instrumental variables where I have instrumented for both n and s. The instruments are the average labor force growth and saving rate between 1960 and 1969 [19]. The savings rate is now significant in all samples.

3.2.3 Controlling for Productivity

So far, we have assumed that $\log \theta_{i0} = c + u_i$ so that initial technology levels are identical across countries up to a country-specific shock. 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 criticized the income growth literature for failing to recognisee the importance of productivity differences. If feasible then, one would like to account for the possibility that θ_{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. Let θ_0 vary across

[16] See Appendix B for details on bootstrap estimation.

[17] Labor 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 labor force growth. If fertility choices are endogenous, labor force growth and debt accumulation could be simultaneously determined. However, instrumenting with the average labor force between 1960 and 1969 does not significantly change the results.

[18] 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 saving 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.

[19] These instruments are significant in the first-stage regressions.

countries so that $\log \theta_{i0} = c + \log A_{i0} + u_i$ with $A_{it} = (1+g)^t A_{i0}$. The estimating equation now takes the form

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

My 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 the income share of foreign capital α is 30 per cent [20]. The results, shown in the top panel of Table 5, are robust to alternative assumptions about capital shares [21]. The addition of A_{i0} does not alter the results on saving qualitatively. Both the estimated coefficient on initial debt and savings are individually significant. In fact, the saving rate — which was only marginally significant in Sample III when A_0 was not controlled for — now has a bootstrapped p-value of less than 4 percent. This suggests that the savings variable was not controlling for differences in technology levels in Tables 3 and 4. The labor force variable however, does not seem to matter for debt accumulation.

When using small samples, 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 labor 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. I can therefore collapse the saving and labor force variables into one regressor, $\frac{s}{(1+n)(1+g)-(1-\delta)}$. From equation (8), this corresponds to the domestic-capital-to-output ratio in the steady state, $\frac{s}{(1+n)(1+g)-(1-\delta)} = \frac{z}{(1-\alpha)y}$, and measures each country's long-run domestic capital intensity. Second, again from equation (17), the coefficients 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 5 shows the result of estimation when these restrictions are imposed. First note that the precision of the point estimates 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. 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 behavior 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 the change in debt, $\log d_t - \log d_0$, and the accumulation variable, $\frac{s}{(1+n)(1+g)-(1-\delta)}$, once the effect of

[20] See Appendix B for details.

[21] The results are robust to assuming $\alpha = 0.5$. This is not shown here due to space constraints.

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 plotting the resulting residuals. The residuals from these regressions 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 1 to 3. 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, which has very low savings and has accumulated little debt on average compared to the rest of the sample. Nonetheless, once the outliers 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 GDP; second, that other steady state controls cannot improve the fit of the regression; third that a measure of capital flows which includes both public and private flows is appropriate. In addition, although the results seem to support the model, I have implicitly assumed that movements in debt were mirrored in output. I now turn to each of these issues in turn.

3.3.1 The measurement of savings: human capital

So far I have not explicitly considered 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 or a complement 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 [22].

[22] 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 investment is potentially complicated, and has certainly given rise to a large literature on endogenous growth. One possibility 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 θ however, is now partially driven by human capital accumulation.

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 criticized 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. P, S and H are from Barro and Lee [1993].

The results are shown in Tables 6 and 7. In both tables, I have used the accumulation formulation for human capital, $\frac{e}{(1+n)(1+g)-(1-\delta)}$ (in logs), a restriction that is not rejected as shown by the F-test. The estimate of the convergence rate is robust to the inclusion of measures of human capital investment, but the results on savings vary. Table 6 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 Samples I and II, but not in Sample III in the top half of Table 6. When both measures of savings are included, private savings seem to be robust to the addition of human capital investment (at least according to the bootstrapped p-values), whereas the reverse is not true.

These data for education however, have notorious measurement problems. In order to address this measurement issue, I instrument e with the average years of schooling in the population over 15 between 1960 and 1969. Table 7 shows the results of estimation by two-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

In this case the convergence equation is modified as follows

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

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.

results from Table 7 are strongest in the largest Sample I, which also includes higher income countries. Even if one does not tend to think of wealthier countries as constrained, 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 labor 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 8 and 9. In general, these variables fail to improve the fit of the data appreciably. Capital controls, the Sachs and Warner measure of openness and the measure of institutional performance, do not add to the fit of the regression [23]. In fact, what is interesting is how robust both the estimates of convergence and the savings effect are robust to the addition of other steady state controls [24].

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.

[23] The insignificance of institutional variables may seem surprising. Recently, Alfaro, Kalemli-Ozcan and Volosovych [2003] have attempted to explain capital flows using measures of institutional quality. They find that once variations in institutional structure are controlled for, the Lucas [1990] Paradox disappears, that is, institutional quality can explain why capital does not flow from rich to poor countries. Their sample countries however, include both debtors and creditors, as well as large open economies such as the U.S., thereby allowing much more variation in institutional quality than is possible here. In addition, their paper focuses on inflows of equity and excludes debt flows. Finally, their results are probably complementary to those in this paper. This paper does not provide an explanation for saving. The saving rate is plausibly determined by institutional quality. But the mechanism emphasized here is that, if institutions matter, they do so through the complementary role of savings.

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

3.3.3 Private Capital Flows

The `ACUMCA` and `ACUMFL` variables used to measure net foreign assets include both private and public capital flows. Thus measured, variation in capital inflows to poor countries may heavily consist of debt flows to governments. Often these debt flows may correspond to financing awarded by international development agencies according to criteria other than the domestic return to capital. The BMS model cannot explain these flows. In order to check the robustness of the data to the exclusion of debt flows, I construct a measure of assets which more closely corresponds to the notion of private capital flows. Private capital flows are defined as the sum of foreign direct investment, portfolio equity and net errors and omissions. As mis-measured capital flows, net errors and omissions are highly likely to correspond to private capital flows, particularly for low-income countries in which they may coincide with capital flight.

Table 10 presents the results with private capital flows. Once again, the results are robust to this new measure of capital flows. The estimated convergence rate is still in the 2 per cent range. In addition, the complementarity of saving is evident both with private saving and human capital investment. Both $\frac{s}{(1+n)(1+g)-(1-\delta)}$ and $\frac{e}{(1+n)(1+g)-(1-\delta)}$ enter significantly, the latter with a higher coefficient than estimated in previous tables for the size of the complementarity effect. Finally, the inclusion of a measure of institutional quality does not alter the results. Table 10 is perhaps more striking than the robustness of the previous results using an all-encompassing measure of debt. This measure of capital flows is perhaps better suited to estimate the reduced form from the model since private flows are more likely to respond to the return to capital. Yet the complementarity of saving appears again, as predicted by the model.

So far, the robustness section supports the mechanism emphasized in the model for the direction of capital flows. The results of the estimated reduced form equation are not only consistent with, but support the idea of a complementary role for saving. What is remarkable is that such a simple mechanism — the combination of a credit constraint and a technological complementarity between foreign and domestic capital — could help in understanding international capital flows. The following section however, presents one caveat of the model: the relationship between debt and output.

3.3.4 Debt and Output

The model also predicts a tight link between net liabilities and output. The convergence rate for debt, estimated to be around 2-4 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 Table 2, 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, labor force growth seems to only have at best a marginally significant individual effect on debt accumulation. This is curious since previous empirical work suggests that labor force growth has a negative effect on output growth [25]. Since debt is proportional to output in this model, we should expect the same 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

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

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

Since output and debt 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 in Table 11 [26]. 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 than on debt accumulation.

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 (Table 2). 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 [27].

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, 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 foreign capital. This will tend to raise output, and the closely-linked stock of net

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

[26] The results are similar when three-stage least squares methods are used.

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

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 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 converges at a rate between 2 and 4 per cent per year, and the savings rate consistently increases debt accumulation. These results are robust to the econometric specification, steady-state and technology controls, the sample of countries and the measure of debt. In particular, the estimated effect of saving complementarity is apparent in private measures of capital flows. It is 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.

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. In Verdier [2003a] , I examine the quantitative implications of the BMS model and find that it can match the dynamics of debt for a foreign capital income share of 20 percent and a domestic capital income share of 50 percent. These shares however, imply large debt-to-GDP ratios. This caveat of the model is apparent here in the tendency for debt to converge at a faster rate than output. Many small-open-economy models however, are unable to match observed debt-to-GDP ratio [28]. The inability of this model to match movements in the debt-to-GDP ratio cannot be used as a sufficient reason to discard it, given its performance in terms of saving complementarity.

The striking result is that we can gain a better understanding of the direction and role of capital flows using two very simple mechanisms — decreasing returns and inflows-complementary savings. 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 other 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 [29]. Feldstein [1994] argues that 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

[28] See Verdier [2003b] in which I show that standard neoclassical open-economy models fail on that account

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

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.

Table 1: Descriptive statistics - 1970-1998

	min	mean	max	stand. dev.
Sample I:	42 obs.			
$\log d_t - \log d_0$	-0.11	0.03	0.18	0.05
s	0.14	0.35	0.52	0.09
$\frac{d_0}{y_0}$	0.01	0.29	1.15	0.24
n	-0.00	0.02	0.04	0.01
$\frac{Y_0}{L_0}$	2465.00	15275.69	35100.00	9273.31
Sample II:	30 obs.			
$\log d_t - \log d_0$	-0.06	0.03	0.13	0.04
s	0.14	0.32	0.46	0.09
$\frac{d_0}{y_0}$	0.05	0.37	1.33	0.28
n	-0.00	0.02	0.04	0.01
$\frac{Y_0}{L_0}$	2465.00	10735.23	24096.00	5147.37
Sample III:	21 obs.			
$\log d_t - \log d_0$	-0.04	0.05	0.11	0.03
s	0.14	0.33	0.48	0.10
$\frac{d_0}{y_0}$	0.01	0.11	0.78	0.16
n	0.01	0.03	0.04	0.01
$\frac{Y_0}{L_0}$	2465.00	7751.75	11298.00	2813.83

The table shows cross-sectional averages. For each country, $\log d_t - \log d_0$ is the average change in debt per worker and s is the average saving rate between the beginning and end of sample. $\frac{d_0}{y_0}$ is the average debt-to-GDP ratio and $\frac{Y_0}{L_0}$ the average output per worker at the beginning of the sample.

Table 2: Correlation Matrix - 1970-1998

	$\log d_t - \log d_0$	s	d_0	n	$\log y_t - \log y_0$
Sample I:	42 obs.				
$\log d_t - \log d_0$	1.00	0.31	-0.64	-0.18	0.32
s	0.31	1.00	0.07	-0.27	0.24
d_0	-0.64	0.07	1.00	-0.09	-0.44
n	-0.18	-0.27	-0.09	1.00	-0.48
$\log y_t - \log y_0$	0.32	0.24	-0.44	-0.48	1.00
Sample II:	30 obs.				
$\log d_t - \log d_0$	1.00	0.44	-0.66	-0.32	0.62
s	0.44	1.00	-0.17	-0.11	0.28
d_0	-0.66	-0.17	1.00	0.13	-0.61
n	-0.32	-0.11	0.13	1.00	-0.54
$\log y_t - \log y_0$	0.62	0.28	-0.61	-0.54	1.00
Sample III:	21 obs.				
$\log d_t - \log d_0$	1.00	0.17	-0.69	-0.26	0.53
s	0.17	1.00	-0.12	-0.07	0.43
d_0	-0.69	-0.12	1.00	0.30	-0.52
n	-0.26	-0.07	0.30	1.00	-0.27
$\log y_t - \log y_0$	0.53	0.43	-0.52	-0.27	1.00

The table shows the cross-country correlations. For each country, $\log d_t - \log d_0$ is the average change in debt per worker, $\log y_t - \log y_0$ is the average change in output per worker, s is the average saving rate, and n is the average population growth rate between the beginning and end of sample. d_0 is debt per worker at the beginning of the sample.

Table 3: Basic Convergence - OLS estimation

Dependent variable: $\log d_t - \log d_0$	Sample I	Sample II	Sample III
constant	0.035	0.016	0.169
	(0.753)	(0.907)	(0.316)
	[0.736]	[0.823]	[0.109]
d_0	-0.024	-0.022	-0.033
	(0.000)	(0.000)	(0.000)
	[0.001]	[0.001]	[0.000]
$(1+n)(1+g)-(1-\delta)$	-0.084	-0.081	-0.059
	(0.042)	(0.099)	(0.332)
	[0.015]	[0.015]	[0.149]
$\overline{R}^2$	0.440	0.449	0.595
number of obs.	42	30	21

Dependent variable: $\log d_t - \log d_0$	Sample I	Sample II	Sample III
constant	0.169	0.066	0.182
	(0.137)	(0.602)	(0.260)
	[0.107]	[0.454]	[0.183]
d_0	-0.024	-0.020	-0.030
	(0.000)	(0.000)	(0.000)
	[0.000]	[0.000]	[0.004]
$(1+n)(1+g)-(1-\delta)$	-0.057	-0.075	-0.060
	(0.143)	(0.098)	(0.308)
	[0.069]	[0.031]	[0.241]
s	0.053	0.041	0.040
	(0.008)	(0.018)	(0.113)
	[0.050]	[0.046]	[0.352]
$\overline{R}^2$	0.524	0.541	0.631
number of obs.	42	30	21

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

Table 4: Basic Convergence - IV estimation

Dependent variable: $\log d_t - \log d_0$	Sample I	Sample II	Sample III
constant	0.235	0.084	0.186
	(0.050)	(0.519)	(0.253)
	[0.046]	[0.483]	[0.237]
d_0	-0.025	-0.019	-0.028
	(0.000)	(0.000)	(0.000)
	[0.000]	[0.001]	[0.006]
$(1+n)(1+g)-(1-\delta)$	-0.043	-0.072	-0.060
	(0.274)	(0.115)	(0.310)
	[0.258]	[0.124]	[0.276]
s	0.079	0.056	0.051
	(0.001)	(0.012)	(0.056)
	[0.000]	[0.013]	[0.088]
$\overline{R}^2$	0.608	0.560	0.663
number of obs.	42	30	21

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 5: Controlling for A_0

Dependent variable: $\log d_t - \log d_0$	Sample I	Sample II	Sample III
constant	0.204	0.000	-0.156
	(0.235)	(1.000)	(0.459)
	[0.183]	[1.000]	[0.474]
d_0	-0.038	-0.029	-0.037
	(0.000)	(0.000)	(0.000)
	[0.000]	[0.000]	[0.003]
$(1+n)(1+g)-(1-\delta)$	0.053	-0.041	-0.074
	(0.437)	(0.903)	(0.170)
	[0.388]	[0.816]	[0.207]
A_0	0.065	0.042	0.068
	(0.001)	(0.077)	(0.037)
	[0.000]	[0.014]	[0.066]
s	0.079	0.057	0.071
	(0.000)	(0.011)	(0.013)
	[0.002]	[0.001]	[0.045]
$\overline{R}^2$	0.698	0.510	0.709
number of obs.	41	29	21
Dependent variable: $\log d_t - \log d_0$	**Sample I**	**Sample II**	**Sample III**
constant	0.034	0.031	0.046
	(0.197)	(0.365)	(0.235)
	[0.198]	[0.368]	[0.227]
$\frac{d_0}{A_0}$	-0.034	-0.027	-0.035
	(0.000)	(0.000)	(0.000)
	[0.000]	[0.001]	[0.001]
$\frac{s}{(1+n)(1+g)-(1-\delta)}$	0.065	0.057	0.058
	(0.000)	(0.006)	(0.012)
	[0.000]	[0.007]	[0.031]
$\overline{R}^2$	0.674	0.547	0.702
number of obs.	41	29	21
F-test	1.926	0.034	0.091
	(0.160)	(0.967)	(0.913)

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. The number of observations may vary across tables since data are not always available for all countries in all years.

Figure 1: Savings and Debt Accumulation, Residual Correlation (convergence removed): Sample I

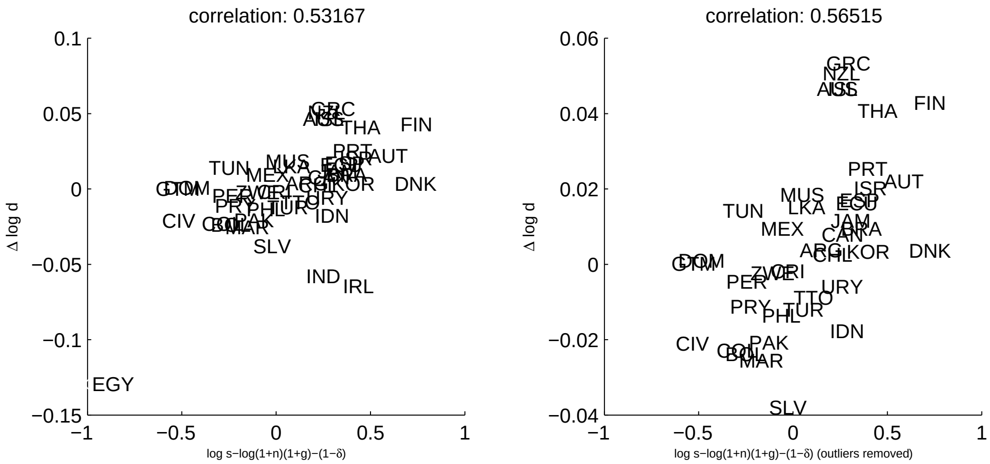

Figure 2: Savings and Debt Accumulation, Residual Correlation (convergence removed): Sample II

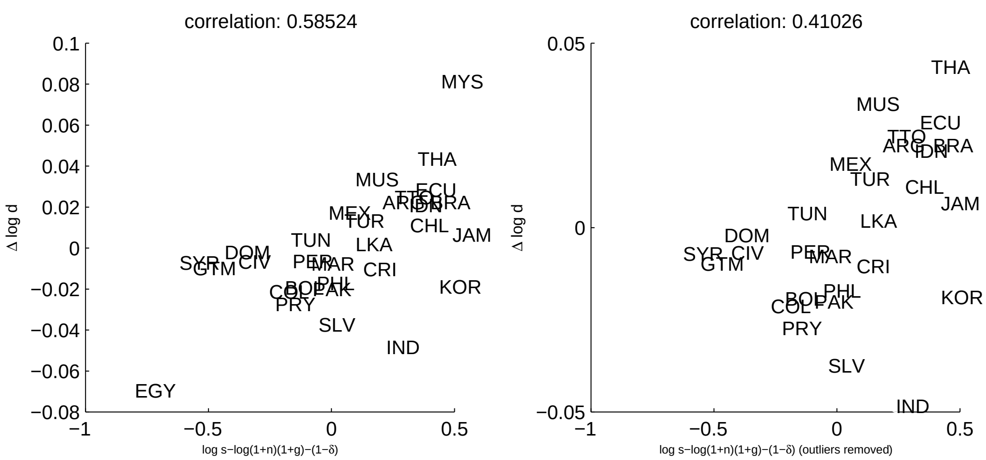

Figure 3: Savings and Debt Accumulation, Residual Correlation (convergence removed): Sample III

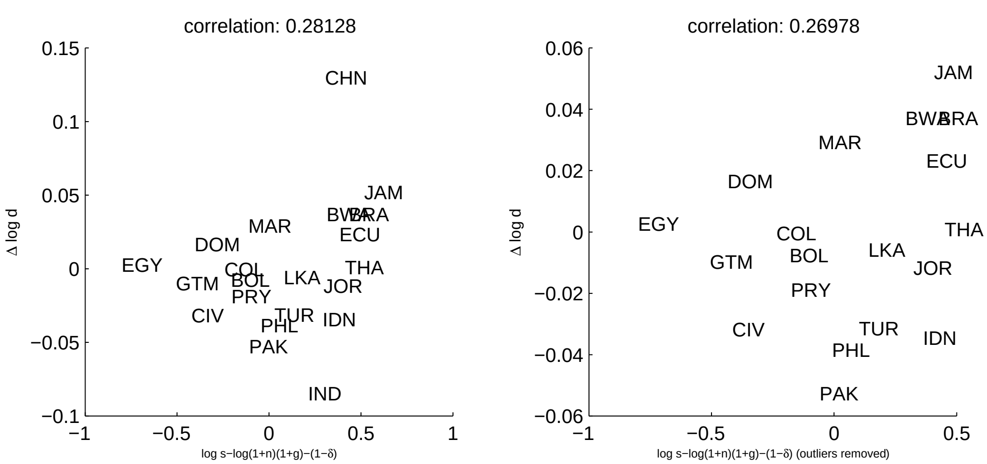

Table 6: Controlling for human capital I

Dependent variable: $\log d_t - \log d_0$	Sample I	Sample II	Sample III
constant	0.053	0.050	0.088
	(0.093)	(0.227)	(0.101)
	[0.114]	[0.129]	[0.070]
$\frac{d_0}{A_0}$	-0.034	-0.030	-0.039
	(0.000)	(0.000)	(0.000)
	[0.000]	[0.000]	[0.001]
$\frac{e}{(1+n)(1+g)-(1-\delta)}$	0.048	0.043	0.031
	(0.007)	(0.075)	(0.292)
	[0.005]	[0.024]	[0.124]
$\overline{R}^2$	0.572	0.463	0.576
number of obs.	41	29	20
F-test	0.001	1.650	0.462
	(0.977)	(0.211)	(0.506)

Dependent variable: $\log d_t - \log d_0$	Sample I	Sample II	Sample III
constant	0.042	0.018	0.043
	(0.162)	(0.626)	(0.373)
	[0.222]	[0.575]	[0.426]
$\frac{d_0}{A_0}$	-0.034	-0.028	-0.036
	(0.000)	(0.000)	(0.000)
	[0.000]	[0.000]	[0.000]
$\frac{s}{(1+n)(1+g)-(1-\delta)}$	0.044	0.047	0.056
	(0.020)	(0.004)	(0.020)
	[0.173]	[0.025]	[0.233]
$\frac{e}{(1+n)(1+g)-(1-\delta)}$	0.015	0.018	0.006
	(0.486)	(0.411)	(0.834)
	[0.475]	[0.229]	[0.834]
$\overline{R}^2$	0.621	0.599	0.683
number of obs.	41	29	20
F-test	0.618	0.243	0.035
	(0.437)	(0.626)	(0.854)

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, shown in the table, is true. The last line shows the p-value for this test. The unrestricted model does not impose that the coefficients on s and $(1+n)(1+g)-(1-\delta)$, and e and $(1+n)(1+g)-(1-\delta)$ be equal. The number of observations may vary across tables since data are not always available for all countries in all years.

Table 7: Controlling for human capital II

Dependent variable: $\log d_t - \log d_0$	Sample I	Sample II	Sample III
constant	0.026	-0.173	-0.020
	(0.548)	(0.326)	(0.894)
	[0.525]	[0.378]	[0.864]
$\frac{d_0}{A_0}$	-0.036	-0.035	-0.038
	(0.000)	(0.007)	(0.001)
	[0.000]	[0.016]	[0.008]
$\frac{e}{(1+n)(1+g)-(1-\delta)}$	0.065	0.189	0.097
	(0.014)	(0.103)	(0.297)
	[0.018]	[0.224]	[0.260]
$\overline{R}^2$	0.553	0.553	0.619
number of obs.	37	24	18
F-test	1.654	0.016	0.315
	(0.207)	(0.901)	(0.583)

Dependent variable: $\log d_t - \log d_0$	Sample I	Sample II	Sample III
constant	0.033	-0.216	-0.003
	(0.439)	(0.525)	(0.983)
	[0.382]	[0.731]	[0.977]
$\frac{d_0}{A_0}$	-0.034	-0.038	-0.036
	(0.000)	(0.082)	(0.000)
	[0.000]	[0.205]	[0.008]
$\frac{s}{(1+n)(1+g)-(1-\delta)}$	0.085	-0.036	0.054
	(0.016)	(0.785)	(0.189)
	[0.010]	[0.830]	[0.140]
$\frac{e}{(1+n)(1+g)-(1-\delta)}$	-0.017	0.254	0.035
	(0.710)	(0.459)	(0.736)
	[0.702]	[0.715]	[0.748]
$\overline{R}^2$	0.689	0.586	0.736
number of obs.	37	24	18
F-test	2.531	0.000	0.990
	(0.121)	(0.986)	(0.338)

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, shown in the table, is true. The last line shows the p-value for this test. The unrestricted model does not impose that the coefficients on s and $(1+n)(1+g)-(1-\delta)$, and e and $(1+n)(1+g)-(1-\delta)$ be equal. The number of observations may vary across tables since data are not always available for all countries in all years.

Table 8: Controlling for the steady state I

Dependent variable: $\log d_t - \log d_0$	Sample I	Sample II	Sample III
constant	0.037	0.053	0.046
	(0.353)	(0.202)	(0.337)
	[0.336]	[0.213]	[0.337]
$\frac{d_0}{A_0}$	-0.034	-0.026	-0.034
	(0.000)	(0.000)	(0.000)
	[0.000]	[0.000]	[0.004]
$\frac{s}{(1+n)(1+g)-(1-\delta)}$	0.065	0.056	0.060
	(0.001)	(0.007)	(0.013)
	[0.004]	[0.013]	[0.046]
capital controls	-0.001	-0.009	-0.002
	(0.871)	(0.156)	(0.858)
	[0.855]	[0.192]	[0.837]
$\overline{R}^2$	0.682	0.656	0.704
number of obs.	41	29	21

Dependent variable: $\log d_t - \log d_0$	Sample I	Sample II	Sample III
constant	0.037	0.028	0.042
	(0.178)	(0.370)	(0.254)
	[0.163]	[0.340]	[0.236]
$\frac{d_0}{A_0}$	-0.033	-0.025	-0.033
	(0.000)	(0.000)	(0.000)
	[0.000]	[0.001]	[0.002]
$\frac{s}{(1+n)(1+g)-(1-\delta)}$	0.059	0.046	0.051
	(0.003)	(0.030)	(0.037)
	[0.008]	[0.021]	[0.055]
openness	0.015	0.032	0.025
	(0.405)	(0.070)	(0.260)
	[0.377]	[0.059]	[0.305]
$\overline{R}^2$	0.696	0.650	0.742
number of obs.	41	29	21

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 9: Controlling for the steady state II

Dependent variable: $\log d_t - \log d_0$	Sample I	Sample II	Sample III
constant	0.033	0.016	0.060
	(0.220)	(0.612)	(0.186)
	[0.205]	[0.611]	[0.195]
$\frac{d_0}{A_0}$	-0.034	-0.028	-0.035
	(0.000)	(0.000)	(0.000)
	[0.000]	[0.000]	[0.002]
$\frac{s}{(1+n)(1+g)-(1-\delta)}$	0.064	0.051	0.056
	(0.007)	(0.033)	(0.029)
	[0.010]	[0.026]	[0.066]
pol. inst.	0.005	0.047	-0.020
	(0.911)	(0.436)	(0.783)
	[0.908]	[0.389]	[0.755]
$\overline{R}^2$	0.688	0.610	0.672
number of obs.	41	29	21

Dependent variable: $\log d_t - \log d_0$	Sample I	Sample II	Sample III
constant	-0.076	-0.004	-0.107
	(0.170)	(0.943)	(0.248)
	[0.178]	[0.948]	[0.250]
$\frac{d_0}{A_0}$	-0.033	-0.027	-0.032
	(0.000)	(0.000)	(0.000)
	[0.000]	[0.000]	[0.004]
$\frac{s}{(1+n)(1+g)-(1-\delta)}$	0.081	0.065	0.090
	(0.000)	(0.003)	(0.003)
	[0.001]	[0.009]	[0.018]
$\frac{G}{Y}$	-0.049	-0.013	-0.058
	(0.021)	(0.455)	(0.083)
	[0.025]	[0.390]	[0.099]
$\overline{R}^2$	0.696	0.568	0.746
number of obs.	41	29	21

Table 10: Private Capital Flows

Dependent variable: $\log d_t - \log d_0$			
constant	-0.007	-0.087	0.001
	(0.834)	(0.120)	(0.986)
	[0.815]	[0.107]	[0.988]
$\frac{d_0}{A_0}$	-0.022	-0.022	-0.021
	(0.000)	(0.000)	(0.000)
	[0.000]	[0.000]	[0.000]
$\frac{s}{(1+n)(1+g)-(1-\delta)}$	0.060	–	0.066
	(0.013)	–	(0.031)
	[0.020]	–	[0.022]
$\frac{e}{(1+n)(1+g)-(1-\delta)}$	–	0.103	–
	–	(0.005)	–
	–	[0.008]	–
pol. inst.	–	–	-0.032
	–	–	(0.612)
	–	–	[0.571]
$\overline{R}^2$	0.520	0.510	0.529
number of obs.	35	31	35

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. The number of observations may vary across tables since data are not always available for all countries in all years.

Table 11: Convergence for debt and output — SUR Estimation

Dependent variable: $\log d_t - \log d_0$	Sample I	Sample II	Sample III
constant	0.241	0.234	0.264
	(0.000)	(0.000)	(0.000)
	[0.000]	[0.001]	[0.001]
d_0	-0.025	-0.024	-0.028
	(0.000)	(0.000)	(0.000)
	[0.000]	[0.002]	[0.002]
$\frac{s}{(1+n)(1+g)-(1-\delta)}$	0.040	0.029	0.034
	(0.000)	(0.005)	(0.000)
	[0.000]	[0.032]	[0.004]
$\overline{R}^2$	0.664	0.503	0.760
number of obs.	43	30	22

Dependent variable: $\log y_t - \log y_0$	Sample I	Sample II	Sample III
constant	0.109	0.126	0.105
	(0.002)	(0.012)	(0.190)
	[0.012]	[0.021]	[0.310]
y_0	-0.011	-0.012	-0.010
	(0.004)	(0.021)	(0.254)
	[0.019]	[0.030]	[0.380]
$\frac{s}{(1+n)(1+g)-(1-\delta)}$	0.012	0.012	0.011
	(0.001)	(0.010)	(0.052)
	[0.006]	[0.029]	[0.081]
$\overline{R}^2$	0.259	0.260	0.190
number of obs.	43	30	22

References

Adda, J., and J. Eaton (1998): "Borrowing Constraints with Unobserved Liquidity Constraints: Structural Estimation with an Application to Sovereign Debt," Working Paper 9806, CEPREMAP.

Alfaro, L., S. Kalemli-Ozcan, and V. Volosovych (2003): "Why Doesn't Capital Flow from Rich to Poor Countries? An Empirical Investigation," Mimeo.

Barro, R. J., and X. Sala-i-Martin (1995): *Economic Growth*. MIT Press.

Barro, R. J., and J.-W. Lee (1993): "International Comparisons of Educational Attainment," *Journal of Monetary Economics*, 32, 363–394.

Barro, R. J., N. G. Mankiw, and X. Sala-i-Martin (1995): "Capital Mobility in Neoclassical Models of Growth," *American Economic Review*, 85, 103–115.

Beaudry, P., F. Collard, and D. Green (2002): "Decomposing the Twin Peaks: A Study of the Changing World Distribution of Output per Worker," Mimeo.

Calderón, C., N. Loayza, and L. Servén (2000): "External Sustainability: A Stock Equilibrium Perspective," Policy Reserach Working Paper 2281, World Bank.

Chinn, M., and E. S. Prasad (2000): "Medium-term Determinants of Current Accounts in Industrial and Developing Countries: An Empirical Exploration," *Journal of International Economics*, 59, 47–76.

Coakley, J., F. Kulasi, and R. Smith (1998): "The Feldstein-Horioka Puzzle and Capital Mobility: A Review," *International Journal of Finance and Economics*, 3, 169–188.

Cohen, D., and J. Sachs (1986): "Growth and External Debt under Risk of Debt Repudiation," *European Economic Review*, 30, 529–560.

Davidson, R., and J. G. MacKinnon (1993): *Estimation and Inference in Econometrics*. Oxford University Press.

Duczynski, P. (2000a): "Adjustment Costs in a Two-Capital Growth Model," *Journal of Economic Dynamics and Control*, 26, 837–850.

——— (2000b): "Capital Mobility in Neoclassical Models of Growth: Comment," *American Economic Review*, 90, 687–694.

Eaton, J., and M. Gersovitz (1981): "Debt with Potential Repudiation: Theoretical and Empirical Analysis," *Review of Economic Stuidies*, 48, 288–309.

Edwards, S. (1996): "Why are Latin America's Savings Rates so Low? An International Comparative Analysis," *Journal of Development Economics*, 51, 5–44.

Feldstein, M. (1994): "Tax Policy and International Capital Flows," *Weltwirtschaftsliches Archiv*, 4, 675–697.

Feldstein, M., and C. Horioka (1980): "Domestic Savings and International Capital Flows," *Economic Journal*, 90, 314–329.

Gertler, M., and K. Rogoff (1990): "North-South Lending and Endogenous Capital Market Inefficiencies," *Journal of Monetary Economics*, 26, 245–266.

Glick, R., and K. Rogoff (1995): "Global versus Country-Specific Poductivity Shocks and the Current Account," *Journal of Monetary Economics*, 35, 159–192.

Hall, R. E., and C. I. Jones (1999): "Why Do Some Countries Produce So Much More Ouput per Worker than Others?," *Quarterly Journal of Economics*, 114, 83–116.

Klenow, P. J., and A. Rodríguez-Clare (1997): "The Neoclassical Revival in Growth Economics: Has it Gone too Far?," *NBER Macroeconomics Annual*, 12, 73–103, B.S. Bernanke and J. Rotenberg, editors.

Kremer, M., and J. Thompson (1998): "Why Isn't Convergenc Instantaneous? Young Workers, Old Workers, and Gradual Adjustment," *Journal of Economic Growth*, 3, 5–28.

Lane, P. R. (2000): "Empirical Perspectives on Long-Term External Debt," Mimeo.

——— (2001): "International Trade and Economic Convergence: The Credit Channel," *Oxford Economic Papers*, 53, 221–240.

Lane, P. R., and G. M. Milesi-Ferretti (2001a): "Long-Term Capital Movements," *NBER Macroeconomics Annual*, 16, 73–116.

——— (2001b): "The External Wealth of Nations: Measures of Foreign Assets and Liabilities for Industrial and Developing Countries," *Journal of International Economics*, 55, 263–294.

Lucas, R. E. (1990): "Why Doesn't Capital Flow from Rich to Poor Countries?," *American Economic Review*, 80, 92–96.

MacKinnon, J. G. (2002): "Bootstrap Inference in Econometrics," *Canadian Journal of Economics*, 35, 615–645.

Mankiw, N. G., D. Romer, and D. N. Weil (1992): "A Contribution to the Empirics of Economic Growth," *Quarterly Journal of Economics*, 107, 407–437.

Masson, P. R., T. Bayoumi, and H. Samiei (1998): "International Evidence on the Determinants of Private Savings," *World Bank Economic Review*, 12, 483–501.

Masson, P. R., J. Kremers, and J. Horne (1994): "Net Foreign Assets and International Adjustment: The United States, Japan and Germany," *Journal of International Money and Finance*, 13, 27–40.

Mooney, C. Z., and R. D. Duval (1993): "Bootstrapping: A Nonparametric Approach to Statistical Inference," Working Paper 07-095, Sage University.

Obstfeld, M., and K. Rogoff (1996): *Foundations of International Economics*. MIT Press.

——— (2000): "The Six Major Puzzles in International Economics: Is these a Common Cause?," *NBER Macroeconomics Annual*, 15, 339–390.

Rebelo, S. (1992): "Growth in Open Economies," *Carnegie-Rochester Conference Series on Public Policy*, 36, 5–36.

Sachs, J. D., and A. Warner (1995): "Economic Reform and the Process of Global Integration," *Brookings Papers on Economic Activity*, 1, 1–95.

Sala-i-Martin, X. (1997): "I Just Ran Two Million Regressions," *American Economic Review*, 87, 178–83.

Schmitt-Grohé, S., and M. Uribe (2003): "Closing Small Open Economy Models," *Journal of International Economics*, 61, 163–185.

Verdier, G. (2003a): "External Debt in Neoclassical Models with Collateral Constraints: A Quantitative Evaluation," Mimeo.

——— (2003b): "The Role of Capital Flows in Neoclassical Open-Economy Models with Imperfect Capital Markets," Mimeo.

Appendix

A Model with endogenous savings

Under these assumptions, the household problem takes the form:

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

The dynamics of the system are governed by the Euler equation

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

and the market-clearing condition

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

where $\beta^* = \frac{\beta}{(1+n)(1+g)}$ is the effective discount rate. 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

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

Consider the role of the effective discount factor β^*. As β^* increases, consumers put a higher weight on future consumption and more importance on current saving. It can be characterized as the 'propensity' to save. In this model, steady-state debt is a positive function of the effective discount factor, i.e. $\frac{\partial d^*}{\partial \beta^*} > 0$. Countries that have a higher propensity to save tend to have higher debt levels. In the context of a convergence equation, this also means that countries that save more during the transition will attract more capital flows, i.e. capital inflows and savings are complements.

Manipulating equations (A.5) and (A.6) yields a convergence equation for debt of the form

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

An alternative interpretation of the equation estimated in the paper is as the reduced form of a model with endogenous savings where the average savings rate is a control for cross-country variations in the discount factor.

B Data and Estimation Issues

B.1 Debt

The debt data are from Lane and Milesi-Ferretti (1999). They construct net foreign asset positions for 66 countries between 1970 and 1998. Their approach essentially consists in using 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, `ACUMCA`, corresponds to the cumulative sum of current account balances. It is available for industrial and developing countries between 1970 and 1998. The second measure `ACUMFL` corresponds to the sum of stock measures of the various assets and liabilities. These measures are either cumulative flows or direct stock measures. `ACUMFL` is available for developing countries between 1970 and 1998. 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 `ACUMCA` 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, `ACUMFL` 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 `ACUMFL` will tend to be larger than debt measured by `ACUMCA` 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 $D^m = -\texttt{ACUMCA}$ or $D^m = -\texttt{ACUMFL}$. 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.*

For private capital flows, net foreign assets are measured as the sum of net cumulative foreign direct investment (FDI assets minus FDI liabilities: `CFDIAH-CFDILH`), net cumulative portfolio equity (Equity assets minus Equity liabilities: `CEQAR-CEQLR`) net cumulative errors and omissions (`CUMEO`): $D^m = -(\texttt{CFDIAH-CFDILH+CEQAR-CEQLR-CUMEO})$.

L corresponds to the labor 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.

B.2 Output, Savings, Capital and Other Controls

The output measure is real per worker GDP from the Penn World Tables 6.0 (`RGDPW`). The labor 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 labor 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.

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 monopolize 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.

B.3 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 $\mathtt{P}$, $\mathtt{S}$ and $\mathtt{H}$ 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.

B.4 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 labor force growth as $\bar{n} = \frac{\log(\mathtt{L}_{1980})-\log(\mathtt{L}_{1970})}{10}$. The TFP measure is computed as $A_0 = \log(\mathtt{RGDPW}_0) - \alpha\log\frac{K_0}{L_0}$ with $\alpha = 0.3$.

B.5 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.

B.6 Bootstrap

The unrestricted model is

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

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 (i.e. re-sampling pairs). 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 [30].

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

B.7 Sample Composition

Sample I (`ACUMCA`)	Sample II (`ACUMFL`)	Sample III (`ACUMCA`) [a]	Private Capital Flows
Argentina (ARG)	Argentina (ARG)	Bolivia (BOL)	Argentina (ARG)
Australia (AUS)	Bolivia (BOL)	Brazil (BRA)	Australia (AUS)
Austria (AUT)	Brazil (BRA)	Colombia (COL)	Bolivia (BOL)
Bolivia (BOL)	Chile (CHL)	Dominican Republic (DOM)	Botswana (BWA)
Brazil (BRA)	Colombia (COL)	Ecuador (ECU)	Brazil (BRA)
Canada (CAN)	Costa Rica (CRI)	Egypt (EGY)	Chile (CHL)
Chile (CHL)	Dominican Republic (DOM))	Guatemala (GTM)	Colombia (COL)
Colombia (COL)	Ecuador (ECU)	India (IND)	Costa rica (CRI)
Costa rica (CRI)	Egypt (EGY)	Indonesia (IDN)	Dominican Republic (DOM)
Denmark (DNK)	El Salvador (SLV)	Ivory Coast (CIV)	Ecuador (ECU)
Dominican Republic (DOM)	Guatemala (GTM)	Jamaica (JAM)	Egypt (EGY)
Ecuador (ECU)	India (IND)	Korea (KOR)	El Salvador (SLV)
Egypt (EGY)	Indonesia (IDN)	Mauritius (MUS)	Guatemala (GTM)
El Salvador (SLV)	Ivory Coast (CIV)	Morocco (MAR)	India (IND)
Finland (FIN)	Jamaica (JAM)	Pakistan (PAK)	Indonesia (IDN)
Greece (GRC)	Korea (KOR)	Paraguay (PRY)	Israel (ISR)
Guatemala (GTM)	Malaysia (MYS)	Philippines (PHL)	Ivory Coast (CIV)
Iceland (ISL)	Mauritius (MUS)	Sri Lanka (LKA)	Jamaica (JAM)
India (IND)	Mexico (MEX)	Thailand (THA)	Korea (KOR)
Indonesia (IDN)	Morocco (MAR)	Turkey (TUR)	Malaysia (MYS)
Ireland (IRL)	Pakistan (PAK)	Zimbabwe (ZWE)	Mexico (MEX)
Israel (ISR)	Paraguay (PRY)		Morocco (MAR)
Ivory Coast (CIV)	Peru (PER)		Pakistan (PAK)
Jamaica (JAM)	Philippines (PHL)		Paraguay (PRY)
Korea (KOR)	Sri Lanka (LKA)		Peru (PER)
Mauritius (MUS)	Syria (SYR)		Philippines (PHL)
Mexico (MEX)	Thailand (THA)		South Africa (ZAF)
Morocco (MAR)	Trinidad & Tobago (TTO)		Spain (ESP)
New Zealand (NZL)	Tunisia (TUN)		Sri Lanka (LKA)
Pakistan (PAK)	Turkey (TUR)		Syria (SYR)
Paraguay (PRY)			Thailand (THA)
Peru (PER)			Trinidad & Tobago (TTO)
Philippines (PHL)			Tunisia (TUN)
Portugal (PRT)			Turkey (TUR)
Spain (ESP)			Uruguay (URY)
Sri Lanka (LKA)			Venezuela (VEN)
Thailand (THA)			
Trinidad & Tobago (TTO)			
Tunisia (TUN)			
Turkey (TUR)			
Uruguay (URY)			
Zimbabwe (ZWE)			
42 countries	30 countries	21 countries	36 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 ACUMCA sample