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Capital Flows to Developing Countries: the Allocation Puzzle

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Abstract

This paper looks at the pattern of capital flows to developing countries over the last 20 years. We show that this pattern is not consistent with the predictions of the textbook neoclassical model of growth. Capital seems to flow upstream: it goes more to the countries that invest less. We argue that this result -which we call the 'allocation puzzle'- constitutes and important challenge for economic research.

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1 Introduction

Between the years 1980 and 2000, the investment to GDP ratio averaged 32 percent in Korea and only 2.8 percent in Madagascar. Over the same period, Korea experienced an economic miracle, with a growth rate of output per worker of 5.4 percent p.a.. Madagascar was less lucky: output per worker declined by 1.3 percent p.a.. By 2000, PPP-adjusted output per worker reached $22,022 in Korea and only $1,599 in Madagascar. Modern growth theory teaches us how to interpret such enormous differences in economic performance. Hall and Jones (1999) and the subsequent literature on development accounting (see Caselli (2005)) argue conclusively that a substantial share of the differences in output per worker can be attributed to productivity. Indeed, standard growth decomposition exercises tell us that total factor productivity growth averaged 4.48 percent p.a. in Korea and -1.11 percent p.a. in Madagascar.

What does this imply for international capital flows. The standard growth model delivers an unambiguous prediction. High productivity growth in countries like Korea increases the marginal product of capital, which attracts foreign capital. Korea should have borrowed to finance its rapidly growing capital stock. Madagascar, facing no or little upward prospects, should not have accumulated much net international debt. Consider what happened instead. Between 1980 and 2000, both countries had a fairly open capital account. Yet Korea received almost no net capital inflows. In Madagascar, by contrast, net capital inflows averaged 6 percent of output. Figure 1 documents the same pattern across a large number of developing countries. It shows that the average share of net capital inflows in GDP between 1980 and 2000 (on the vertical axis) seems to be, if anything, negatively correlated with the investment-to-GDP ratio (on the horizontal axis). Far from being outliers, Korea and Madagascar are typical of the cross-country correlation between investment and capital inflows shown in Figure 1. Both countries are close to the regression line. If investment and capital flows were driven primarily by changes in domestic productivity, as suggested by the development accounting literature, countries that invest more should receive more capital from abroad. We observe the exact opposite.

Patterns such as Figure 1 are just one illustration of a range of results that point in the same direction: standard models cannot account for the *allocation* of international capital flows across developing countries. Capital flows from rich to poor countries are not only low (as argued by Lucas (1990)), but their allocation across developing countries is the opposite of the predictions of standard textbook models: capital does not flow more to the countries that invest more or have a higher marginal product of capital, in the way that standard open economy growth models would predict. In the terminology of Martin Wolf (2006), capital flows 'upstream'!

We argue that the pattern of capital flows across developing countries constitutes a major puzzle and its resolution will be an important challenge of economics. We call it the *allocation* puzzle. This paper's main objective is to document and establish this puzzle in the behavior of international capital flows. The allocation puzzle is different from the Lucas puzzle (Lucas (1990)), which is about the small size of capital flows from rich to poor countries. In fact, our results are not inconsistent with the Lucas puzzle: as Figure 1 shows, capital inflows amount to a much smaller share of GDP than investment on average (3.9 percent against 15.4 percent in our sample). We would argue that the small size of aggregate capital flows toward developing countries as a whole is not especially puzzling given the overall lack of productivity catch-up in these countries. Indeed, we will show that a calibrated model can predict the order of magnitude of capital flows to developing countries pretty well without assuming any international financial friction. Our explanation is consistent with Lucas' original guess: capital flows to poor countries are low because these countries are not very productive and face domestic distortions in the return to capital. It is also important to observe that introducing an external credit constraint into the model can reduce the predicted size of capital inflows, but cannot make capital flow more towards the countries that invest less (it cannot make capital flow upstream!). Thus, explaining the puzzle requires more than a neoclassical growth model with credit frictions.

Our puzzle is related to the *allocation* of the capital flows across developing countries rather than their overall level. Our calibrated open economy growth model predicts capital inflows to Asia that are much larger than those we observe in the data. Conversely, it predicts relative large capital *outflows* from Latin America and Africa. This rather provocative result reflects a straightforward implication of a standard open economy growth model: the countries whose productivity declines relative to the rest of the world should export, not import capital.

Our empirical approach consists in calibrating a *simple* neoclassical growth model. Our model and calibration methods are closely related to the recent literature on "development accounting" (although in this version of the paper we do not consider human capital explicitly). This literature has emphasized productivity growth as the main proximate cause of economic development (Hall and Jones, 1999; Caselli, others). This view has implications for the behavior of capital flows that have not been systematically explored in the literature (by contrast with investment, whose relationship with productivity is well understood and documented). Whether the observed pattern of capital flows to developing countries is consistent with the dominant theory of growth is an interesting question in its own right, and might teach us one lesson or two on the determinants of growth themselves. Our paper is the first, to our knowledge, to quantify the level of capital flows to developing countries in a calibrated open economy growth model and compare it to the data.

Section 2 begins with a simple frictionless small open economy model in the tradition of Ramsey, Cass and Koopmans. The model assumes a common technology frontier: in the long run, all countries grow at the same rate. This can result from the diffusion of ideas and technology across countries, as in Parente and Prescott, or Eaton and Kortum. Given this common long run growth, countries can experience two sorts of transitions. First, capital-scarce countries can converge to their conditional steady state. These *convergence dynamics* have been widely studied in the literature and are by now well understood (see Mankiw, Romer and Weil (1991)): countries further from their conditional steady state tend to grow faster. The implications for international capital flows are also straightforward, although their quantitative importance have been less explored (see King and Rebelo (1993) for an important exception).

Second, countries can experience a productivity catch-up towards the productivity frontier. We take this *productivity catch-up* as exogenous, although, following Hall and Jones (1999) one could interpret it as the result of a permanent increase in a country's social infrastructure, i.e. 'the set of institutions and government policies that determine the environment within which individuals accumulate skills, and firms accumulate capital and produce output' (Hall and Jones, p84). As our discussion of the relative experience of Korea and Madagascar illustrates, these productivity catch-up are essential to the process by which countries experience economic development. We calibrate the model using Penn World Table (PWT) data on investment and output as well as IMF data on currrent account (under balance of payment accounting, the opposite of net capital inflows). Because the models predictions in terms of capital flows can be quite sensitive to the 'saving' side of the model and preferences of households, we show that our results also obtain in a Solow model where the saving rate is constant, and in a model where international borrowing requires domestic capital as collateral (thus preventing consumption smoothing).

Some recent papers have focused on the determinants of capital inflows to developing countries. Aizenmann et al (2004) construct a self-financing ratio indicating what would have been the stock of capital in the absence of capital inflows. They find that 90 percent of the stock of capital in developing countries is self-financed, and that countries with higher self-financing ratios grew faster in the 1990s. Manzocchi and Martin (1996) empirically test an equation for capital inflows derived from an open-economy growth model on cross-section data for 33 developing countries—and find relatively weak support. Our approach is different: we use the theory to help us estimate the size and direction of international capital flows for developing countries. This allows us to estimate separately the contribution of convergence dynamics and productivity catch-up to observed capital flows. We do so under a number of different scenarios.

Section 3 presents our main empirical findings. Using the model of section 2, we compare estimates of actual and predicted capital flows to and from a large number of developing economies between 1980 and 2000. We find that the pattern of capital flows is always opposite to that predicted by the theory. Section 4 studies in greater detail the composition of net capital inflows. Using data from the World Bank (Global Development Finance), it proposes a decomposition of net and gross capital inflows into public and private components, reserve accumulation, etc....

[STILL PRELIMINARY]
DISCUSSION TO BE ADDED

2 Net Capital Inflows Accounting

Our analysis begins with a simple quantitative account of the pattern of capital flows to developing countries. Our starting point is the standard Ramsey-Cass Koopmans growth model. In that model, we identify a measure of capital flows associated with either initial capital scarcity, or with a productivity catch-up. The focus is on long term capital flows, so the model abstracts from short term financial frictions and adjustment costs of physical capital that would influence the dynamics of capital accumulation but not the ultimate level of the capital stock.

We consider a world with one homogeneous good and a number of countries. In this world, we focus on a subset of small and developing countries. Time is discrete and there is no uncertainty. The population N_t grows at an exogenous rate n that is country specific: $N_t = n^t N_0$. The population of each country can be viewed as a large family whose stand-in representative maximizes the welfare function:

$$U_t = \sum_{s=0}^{\infty} \beta^s \ N_{t+s} \ u\left(c_{t+s}\right). \tag{1}$$

c_t denotes consumption *per capita* (more generally, lower case variables are normalized by population) and $u\left(c\right) \equiv c^{1-\gamma}/\left(1-\gamma\right)$ is a constant relative risk aversion (CRRA) instantaneous utility function with coefficient $\gamma > 0$. In the case where $\gamma = 1$, the utility function is $u\left(c\right) = \ln\left(c\right)$.

The domestic economy produces the homogeneous good according to the Cobb-Douglas production function:

$$Y_t = K_t^{\alpha} \left(A_t L_t\right)^{1-\alpha},$$

where K_t denotes the stock of domestic physical capital, L_t is the labor supply and A_t is a labor-augmenting measure of productivity. We assume that the labor supply is exogenous and equal to the population ($L_t = N_t$) and that factor markets are perfectly competitive. Labor productivity grows at a gross rate $g_t \equiv A_t/A_{t-1}$, which may differ across countries in the short run but converges towards the same value for all countries,[1]

$$\lim_{t\to+\infty} g_t = g^*. \tag{2}$$

g^* represents the growth rate of the world productivity frontier A_t^*. It reflects the advancement of knowledge, which is not country specific. Models of idea flows such as Parente and Prescott or Eaton and Kortum imply a common long run growth rate of productivity. This assumption guarantees that no country's share of world GDP converges to 0 or 100 percent. However, it does not presume any convergence in the level of GDP per capita since country differences in the level of A could persist for ever.

[1] We assume further that $\beta n g^{*(1-\gamma)} < 1$ so that the utility is well defined.

We assume that there is a distortion τ in the return to capital. Investors receive a fraction $(1-\tau)$ of the gross return on capital R_t, equal to $\alpha\,(k_t/A_t)^{\alpha-1}+1-\delta$, where δ measures the depreciation rate. We call τ the 'capital wedge'. It is a short hand for the gap between the gross social return to capital R_t (the marginal product adjusted for depreciation) and the private return. On can interpret τ as a tax on gross capital income, but other interpretations are also possible: credit market imperfections, expropriation, bureaucracy, bribery, and corruption would also introduce such a 'wedge' between social and private returns. Importantly, this wedge allows us to account for long-run cross country differences in investment rates.[2]

The stand-in representative resident issues external debt and owns all the domestic capital. Given the previous discussion, the country's budget constraint is:

$$n\ k_{t+1}+R^{*}d_t = nd_{t+1}+(1-\tau)\,R_t k_t + w_t A_t + z_t + (1-\delta)k_t - c_t, \tag{3}$$

where d_t and k_t denote respectively external debt and physical capital per capita at time t, and w_t is the wage per efficient unit of labor $(1-\alpha)\,(k_t/A_t)^{\alpha}$.

We assume that all countries open their capital account at time $t=0$, so that $d_0=0$. A country, then, is characterized by an initial capital stock per capita k_0, a population growth rate n, an initial productivity A_0 together with a productivity path $\{A_t\}_0^{\infty}$ that satisfies (2), and a capital wedge τ. We use the model to estimate the size and the direction of capital flows from time 0 onward.

Financial liberalization means that domestic investors can borrow and lend at the world interest rate R^{*} (recall that each country we consider is small). We assume that the rest of the world is composed of developed countries that have already achieved their steady state. Then, the world interest rate R^{*} coincides with the long-run growth adjusted discount factor $g^{*\gamma}/\beta$. This implies that financial integration does not 'tilt' consumption profiles in developing countries in the long run. From time 0 onwards, capital mobility ensures that the net domestic return on capital equals the world real interest rate:

$$(1-\tau)\,R_{t+1}=R^{*}.$$

Substituting the expression for the gross return on capital, this implies that the capital stock per efficient unit of labor $\tilde{k}=k/A$ is constant:

$$\tilde{k}_{t+1}=\tilde{k}^{*}\equiv\left(\frac{\alpha}{R^{*}/\,(1-\tau)+\delta-1}\right)^{1/1-\alpha}. \tag{4}$$

The steady state capital stock per efficient unit of labor varies across countries because of the capital wedge τ. A higher wedge depresses domestic capital accumulation and yields a lower $\tilde{k}^{*}$.

[2] In order to focus on the distortive aspects of this wedge, we assume that the 'revenue per capita' $z_t=\tau R_t k_t$ is rebated in a lump sum fashion.

Given our assumption on the world interest rate, the Euler equation for consumption $c_t^{-\gamma} = \beta R^* c_{t+1}^{-\gamma}$ implies that consumption per capita grows at the constant rate g^*. Finally, the initial level of consumption per capita c_0 is determined so as to satisfy the intertemporal budget constraint of the representative household.

2.1 Convergence flows

Consider now the simple scenario where a country starts with an initial level of capital $\tilde{k}_0$ below the steady state level $\tilde{k}^*$, while productivity growth is constant and equal to g^*. That country is initially capital scarce. Under financial autarky, the country would accumulate capital domestically, asymptotically reaching $\tilde{k}^*$. Under financial integration, and in the absence of financial frictions, the country will optimally borrow the amount $\tilde{k}^* - \tilde{k}_0$, in order to fill the capital gap. Denote $\tilde{d}^c$ the amount of external debt (per efficient unit of labor) incurred to finance this convergence. It follows that:

$$\tilde{d}^c = \tilde{k}^* - \tilde{k}_0. \tag{5}$$

The model's prediction is extremely simple:capital inflows serve to close any initial capital scarcity. Notice that in this simple case, saving does not change since consumption adjusts immediately to its new permanent income level.

2.2 Productivity flows in the Ramsey-Cass-Koopmans model

Consider now a situation where the country is initially in steady state, so that $\tilde{k}_0 = \tilde{k}^*$, but experiences a productivity catch-up relative to the world productivity frontier A_t^* between time 0 and time T. To be more precise, suppose that productivity evolves according to:

$$\frac{A_t}{A_t^*} = \frac{A_0}{A_0^*} + x\frac{t}{T}\left(1 - \frac{A_0}{A_0^*}\right),$$

for $t \leq T$, after which the growth rate of domestic productivity goes back to g^*. The parameter x represents the fraction of the gap between A_0 and A_0^* that is eliminated in T years. When $x = 0$, the country maintains the same relative productivity. When $x = 1$, the country catches up to the world frontier in T years. Finally, when $x < 0$, the country experiences a relative productivity decline.

Define $\pi_t = A_t/A_0 g^{*t}$ as the ratio of the domestic productivity to the trend productivity without catch-up. π_t summarizes the relevant catch-up dynamics. It satisfies:

$$\begin{aligned}
\pi_t &= \frac{A_t}{A_0 g^{*t}} = 1 + \frac{t}{T}(\pi - 1) \ \text{ for } t \leq T, \\
\pi_t &= \pi \qquad\qquad\qquad\qquad\quad \text{for } t > T,
\end{aligned}$$

where $\pi = 1 + x(A_0^*/A_0 - 1)$ is the long-term level of π_t. $\pi > 1$ (resp. < 1) for countries that move closer to (resp. further away from) the world technology frontier.

Given a path for $\{\pi_t\}_{t=0}^{\infty}$, the fact that consumption per capita grows at rate g^*, while the capital stock per efficient unit of labor $\tilde{k}_t$ remains constant at $\tilde{k}^*$, it is immediate to solve for the initial consumption level and the path of external debt per efficient unit $\tilde{d}_t$. Appendix A shows that $\tilde{d}_t$ stabilizes in period T at the level:

$$\widetilde{d^p} = \frac{\pi - 1}{\pi}\widetilde{k}^* + \frac{\chi}{R^* \pi} \sum_{t=0}^{T} \left(\frac{n g^*}{R^*} \right)^t (\pi - \pi_t), \tag{6}$$

where $\chi = (1-\alpha)\,\tilde{k}^{*\alpha} + \tau \tilde{k}^* R > 0$ represents the steady state after-transfer labor income per efficient unit of labor.

$\widetilde{d^p}$ represents the net cumulated capital inflows and provides us with our second measure of predicted capital flows, associated this time with a productivity catch-up. Equation (6) indicates that it has two components, each with an intuitive economic interpretation.

Consider the first term on the right hand side of (6). If there is some productivity catch-up ($\pi > 1$), it is positive and equal to:

$$\widetilde{d^i} \equiv \frac{\pi - 1}{\pi}\widetilde{k}^*. \tag{7}$$

$\widetilde{d^i}$ represents the external borrowing that goes toward financing domestic *investment*. To see this, observe that since capital *per efficient unit of labor* remains constant at $\tilde{k}^*$, capital *per capita* needs to increase more when there is a productivity catch-up. Without productivity catch-up, capital per capita at time T would be $\tilde{k}^* A_0 g^{*T}$. Instead, it is $\tilde{k}^* A_T$. The difference, $(\pi - 1)\,\tilde{k}^* A_0 g^{*T}$, normalized by productivity A_T, equals $\widetilde{d^i}$. This expression makes clear that capital should flow in ($\widetilde{d^i} > 0$) for countries that get closer to the world productivity frontier ($\pi > 1$) and flow out ($\widetilde{d^i} < 0$) for countries that fall further away from the productivity frontier ($\pi < 1$).

The second term on the right-hand-side of (6),

$$\widetilde{d^s} \equiv \frac{\chi}{R^*} \sum_{t=0}^{T} \left(\frac{n g^*}{R^*} \right)^t \frac{\pi - \pi_t}{\pi}, \tag{8}$$

represents the change in external debt brought about by changes in *domestic saving.* Faster relative productivity growth ($\pi > 1$) increases consumption today and so decreases saving. The stand-in representative domestic agent borrows on the international markets in order to sustain a higher level of consumption. Conversely, when a country experiences a relative productivity decline ($\pi < \pi_t < 1$), it will tend to export capital because of consumption smoothing. This investment abroad mitigates the relative decline in future consumption. Equation (8) also makes clear that the time preference parameter β and the intertemporal elasticity of substitution $1/\gamma$ enter this expression only via their impact on the world interest rate $R^* = g^{*\gamma}/\beta$. A higher world interest rate (either because of a lower discount factor β or a lower elasticity of substitution $1/\gamma$) reduces $\tilde{d}^s$.

In the neoclassical growth model, both $\tilde{d}^i$ and $\tilde{d}^s$ have the same sign and are nonzero only if the country's productivity does not grow at the same rate as the world technology frontier. Faster productivity growth tends to depress savings for consumption smoothing reasons ($\tilde{d}^s > 0$). With higher investment ($\tilde{d}^i > 0$), the implication is an unambiguous increase in net capital inflows ($\tilde{d}^a > 0$). Hence, the standard neoclassical model makes the strong prediction that countries experiencing faster relative productivity growth should borrow more.

This raises two important issues. First, international financial frictions may limit -perhaps eliminate altogether- the ability of developing countries to borrow in order to smooth consumption profiles. We want to argue that, while financial frictions are certainly important, they are unlikely to reverse the direction of capital flows, nor the relative ranking predicted by the model. In the presence of international financial frictions, countries will be able to borrow less, much less perhaps. But countries with brighter prospects, as measured by π, should still be able to borrow more, not less, than countries facing little or no prospects for productivity improvements ($\pi \leq 1$). Financial frictions can reduce the predicted size of capital inflows, but cannot make capital flow more towards the countries that invest less (it cannot make capital flow upstream!).

One may still want to use the model to evaluate the size of capital inflows. There, the nature and importance of financial frictions would matter greatly to our final estimates. To address this question, we consider additional benchmark estimates of $\tilde{d}^s$, under different specifications. First, we consider an environement where $\tilde{d}^s = 0$ when $\pi > 0$. This would be the case if, for instance, there is a collateral constraint on international borrowing stipulating that capital inflows cannot exceed physical investment: $D_t - D_{t-1} \leq K_t - (1-\delta) K_{t-1}$. In that environment, non-secured loans to increase consumption would not be available when $\pi > 1$ (it would still be possible, however, for countries with $\pi < 1$ to invest abroad). As an alternate specification, we consider in the next subsection a Solow model where agents save a constant fraction s of their income every period.

Second, it is important to realize that richer environments could deliver different predictions for the aggregate relationship between saving and growth. For instance, in Modigliani's original life cycle model, it is well known that faster growth increases aggregate savings by increasing the saving of richer young cohorts relative to the dissaving of poorer older cohorts. Indeed, the empirical literature tends to find that faster growth is associated with more national saving, and the consensus view is that the causality runs from growth to saving and not from saving to growth (see Carroll and Weil). Can this reverse our theoretical results? For this to be the case, the increase in savings generated by a more rapid productivity growth would need to *exceed* the associated increase in investment. In other words, it would require that $\tilde{d}^s$ be opposite in sign and *larger* in absolute value than $\tilde{d}^i$. In that case faster relative productivity growth would be associated with *smaller* net capital inflows.

If this were the case, we would expect countries with faster relative productivity growth to experience smaller net capital inflows. We view this as unlikely

2.3 Productivity flows in the Solow model

Define national income per capita as $q_t = y_t - R^* d_t$. Solow (1956) assumes that the stand-in representative agent consumes a constant fraction of national income:

$$c_t = (1 - s)\, q_t$$

where s is the -now constant- saving rate.

Substituting this expression into the budget constraint, we obtain after a few manipulations:

$$n k_{t+1} + s R^* d_t = n d_{t+1} + s k_t^{\alpha} + (1 - \delta)\, k_t$$

As before, assume that the economy is initially in steady state, so that $\tilde{k}_0 = \tilde{k}^*$, but experiences a productivity catch-up relative to the world productivity frontier A_t^* between time 0 and time T, summarized by π. Capital mobility ensures that $\tilde{k}_t = \tilde{k}^*$ at all times, so the above equation implies a difference equation in $\tilde{d}_t$, the debt per efficient unit of labor:

$$\tilde{d}_{t+1} = \frac{1}{n g_{t+1}} \left[s R^* \tilde{d}_t - s \tilde{k}^{*\alpha} - (1 - \delta)\, \tilde{k}^* \right] + \tilde{k}^*$$

This difference equation is stable provided that $sR^*/ng^* < 1$ which we assume to be satisfied.

Eventually, external debt converges towards a long run level:

$$\tilde{d}^* = \frac{(n g^* + \delta - 1)\, \tilde{k}^* - s \tilde{k}^{*\alpha}}{n g^*}, \tag{9}$$

The level of external debt decreases with the saving rate, and increases with productivity growth.

How should we choose the saving rate s? Observe that the long run level of external debt is independent of the productivity catch-up. In particular, (9) characterizes the path of debt accumulation even when there is no productivity catch-up ($\pi = 1$). By analogy with the Ramsey model, we impose that the saving rate is such that the economy does not accumulate foreign debt when there is no catch-up. Inspecting (9), this is equivalent to assuming a saving rate:

$$s = (\delta + n g^* - 1)\, \tilde{k}^{*(1-\alpha)}. \tag{10}$$

The same condition holds in the Ramsey model: it must be the case that in equilibrium flow saving $s \tilde{k}^{*\alpha}$ just cover depreciation, adjusted for productivity an population growth $(\delta + n g^* - 1)\, \tilde{k}^*$.

We can now solve for the entire path of debt accumulation under a productivity catch-up. In light of the previous discussion, observe first that eventually, the debt disappears, since $\tilde{d}^* = 0$. We are interested here in the *maximum* debt accumulated, which will be realized at time T. Appendix A shows that the maximum external debt in the Solow model satisfies:

$$\tilde{d}_T = \tilde{k}^* \frac{\pi - 1}{\pi} \frac{1}{T} \left(\frac{1 - \rho^T}{1 - \rho} \right)$$

We can decompose this total external debt into and investment and saving component as follows:

$$\begin{aligned} \tilde{d}_T &= \tilde{d}^i + \tilde{d}^{solow} \\ \tilde{d}^i &= \tilde{k}^* \frac{\pi - 1}{\pi} \\ \tilde{d}^{solow} &= \tilde{k}^* \frac{\pi - 1}{\pi} \left[\frac{1}{T} \left(\frac{1 - \rho^T}{1 - \rho} \right) - 1 \right] \end{aligned} \tag{11}$$

where $\tilde{d}^i$ represents as before the external borrowing that goes toward financing domestic *investment* while $\tilde{d}^{solow}$ represents the maximum net capital inflows brought about by changes in *domestic saving*. Equations (11) makes clear that the investment and saving terms $\tilde{d}^i$ and $\tilde{d}^{solow}$ have opposite signs: in the Solow model, countries with rapid productivity growth save *more*, since saving increases mechanically with output. This effect is never strong enough, however, to offset the increase in investment $\tilde{d}^i$. Hence countries with faster productivity growth still end up borrowing more from international capital market.

3 Predicted versus Actual Net Capital Inflows

The previous section discusses four components of predicted cumulated capital inflows: $\tilde{d}^c$ in response to initial capital scarcity, $\tilde{d}^i$, $\tilde{d}^s$ and $\tilde{d}^{solow}$ in response to productivity improvements. $\tilde{d}^i$ reflects the contribution of capital flows towards an increase in domestic capital stocks. $\tilde{d}^s$ and $\tilde{d}^{solow}$ represent the response of capital flows to changes in savings, in the Ramsey-Cass-Koopmans and in the Solow model respectively. This section quantifies each component separately, for the year 1980, using data from the Penn World tables (PWT). We then compare predicted capital flows to observed capital flows between 1980 and 2000.

Table 1 reports the values of the parameters of the model. We assume that the U.S. economy remains on the world productivity frontier. Accordingly, we set $g^* = 1.0168$. This corresponds to the U.S. multifactor productivity growth between 1980 and 2000. We also assume that the capital share is constant across countries, and equal to 0.3.[3] We assume a

[3]Recent estimates by **?** suggest that the capital share is roughly constant within countries, and varies between 0.2 and 0.4 across countries.

β	γ	α	δ_k	g^*
0.96	1	0.3	0.06	1.0168

Table 1: Common parameters

rate of depreciation of physical capital equal to 6 percent per annum as in **?**. We also assume logarithmic preferences ($\gamma = 1$), with a discount factor of 0.96 (the period is a year). Given these parameter values, the world real interest rate is equal to $R^* - 1 = 5.92$ percent p.a..

Our sample consists of an unbalanced panel of 92 non OECD countries between the years 1950 and 2000. We first construct estimates of the capital stock per capita k_t using investment rates from PWT and a perpetual inventory method as in Bernanke and Gűrkaynak (2001). Given estimates of output per capita y_t, also from PWT, we infer the productivity level as a residual from the Cobb Douglas technology: $A_t = (y_t/k_t^{\alpha})^{1/(1-\alpha)}$. Our measure of the catch-up in productivity π is then constructed as $\exp(\ln \bar{A}_T - \ln \bar{A}_0)/g^{*T}$ where $\ln \bar{A}_t$ is obtained from a Hodrick-Prescott filter of $\ln A_t$. This filtering removes short term fluctuations in productivity due to mismeasurement or business cycle factors.

The next step consist in constructing the steady state capital level $\tilde{k}^*$ from equation (4). The only unknown quantity in this equation is the capital wedge τ. We obtain an estimate of τ by observing that under perfect financial integration, the average investment rate to GDP is given by:

$$\bar{s}_k = \frac{\alpha\,(\delta + n\bar{g} - 1)}{R^*/\,(1-\tau) + \delta - 1},$$

where $\bar{g}$ is the average growth rate of productivity over the period. When productivity growth is constant at g^*, this reduces to the usual formula for the investment rate in steady state: $s_k^* = (\delta + ng^* - 1)\,\tilde{k}^{1-\alpha}$. In our model, faster productivity growth increases the investment rate above s_k^*. Inverting this expression, we obtain the capital wedge as a function of the average investment rate, the average productivity growth rate and the growth rate of the population:

$$\tau = 1 - \frac{R^*}{\alpha\,(\delta + n\bar{g} - 1)\,/\bar{s}_k + 1 - \delta} \tag{12}$$

We measure $\bar{s}_k$ as the average investment rate between 1980 and 2000, and $\bar{g}$ and n respectively as the average gross growth rate of the Solow residual $\bar{A}_t$ and the growth rate of the working age population over the same period (Appendix C reports the values of $\bar{s}_k$, $\bar{g}$, n and τ for each country in our sample). At the average growth rate of working age population in our sample of developing countries (2.32 percent p.a.), (12) implies a capital wedge of zero when the investment rate $\bar{s}_k$ equals 25 percent of GDP. The average investment rate in our sample is only 15.6 percent and the associated capital wedge on the gross capital return is 9.52 percent.

Our approach to constructing τ assumes that countries are perfectly integrated. In the presence of international financial frictions, our estimates of the contribution of capital scarcity and productivity catch-up to capital flows are likely to be biased. Can this bias upset our results? To see in which direction the bias goes, consider the extreme case where the capital account remains closed, so that the investment rate equals the saving rate. With a Cobb-Douglas production function and log preferences, the saving rate is *decreasing* with the capital stock (this is not true in the general case. See Barro and Sala-i-Martin, 1996, p77 for a discussion). So, capital scarce countries will tend to have higher saving and investment rates than in steady state. For these countries, our approach underestimates the capital wedge τ and overerestimates the steady state capital stock $\tilde{k}^*$. This implies an overestimate of the contribution to capital inflows due to both to capital scarcity and productivity catch-up while leaving $\tilde{d}^s$ unchanged ($\tilde{k}^*$ enters in both (5) and (7)). Conversely, for a capital abundant country, the observed saving rate is lower than in steady state. For these countries, our approach overestimates the capital wedge τ and underestimates the steady state capital stock $\tilde{k}^*$. Therefore, it overestimates the net capital outflows due convergence while underestimating capital flows due to productivity catch-up (a low $\tilde{k}^*$ implies a low $\tilde{d}^i$ for a given π). Hence our approach is likely to overestimate the size of capital flows due to convergence dynamics for countries that are imperfectly open. However, capital scarce countries are still predicted to borrow and capital abundant countries to lend, hence the sign of the correlation between capital scarcity and capital stock remains unaffected. As to productivity dynamics, our results could be reversed only if the low productivity countries are also the high investment countries and vice versa (so that low productivity countries face an upward bias, and high productivity countries face a downward bias). Not surprisingly, this is not the case in the data: high productivity tend to be high investment countries. Thus using the steady state investment rate is likely to give us a robust prediction as to the direction of capital flows.

We begin by reporting the increase in capital stock ($\Delta K = K_{2000} - K_{1980}$) in billions of 1996 constant international dollars. Table 2 presents estimates of ΔK together with estimates of the predicted increase in the capital stock, assuming that countries reach their steady state by year 2000. This predicted increase in the capital stock is defined as $\Delta K^p = \left[\tilde{k}^* (gn)^T - \tilde{k}_0\right] A_0 N_0$ for various geographical regions and income groups. Our sample consists of 65 non OECD countries and 20 OECD countries, covering most of the world's population and output.[4] The table also decomposes ΔK^p into a convergence and a productivity components as follows:

$$
\begin{aligned}
\Delta K^p &= \Delta K^{pc} + \Delta K^{pp} + \Delta K^{p0} \\
\Delta K^{pc} &= \tilde{k}^* \left(1 - \frac{\tilde{k}_0}{\tilde{k}^*}\right) A_0 N_0 \\
\Delta K^{pp} &= \tilde{k}^* n^T \left(g^T - g^{*T}\right) A_0 N_0 \\
\Delta K^{p0} &= \tilde{k}^* \left((g^* n)^T - 1\right) A_0 N_0
\end{aligned}
$$

[4] The list of countries by region and income group is included in appendix C.

Predicted Capital Flows (bn of 1996 intl' dollar)	(1) ΔK	(2) ΔK^{p}	(3) ΔK^{pc}	(4) ΔK^{pp}	(5) Obs.
Non-OECD countries	16,758	16,824	2,299	443	65
Low Income	3,232	3,334	505	249	23
Lower Middle Income	8,523	7,685	762	1648	23
Upper Middle Income	2,749	3,549	741	-2,404	14
High Income (Non-OECD)	2,254	2,257	291	950	5
Africa	884	948	-63	-790	30
Latin-America	2,752	3,580	796	-3,016	21
Asia	13,122	12,296	1,566	4,248	14
except China and India	9,340	10,463	1,982	-2,855	63
China and India	7,418	6,361	317	3,298	2
OECD	27,520	29,064	7,656	-720	20

Table 2: Predicted and Actual Increase in Capital Stock, between 1980 and 2000, billions of 1996 international dollars.

The term ΔK^{pc} represents the increase in the capital stock due to the closing of the capital gap. It is a function of the initial capital gap $\tilde{k}_0/\tilde{k}^*$. The second term represents the contribution of relative productivity growth. It is a function of the growth rate of productivity relative the to growth rate of the technology frontier: $g^T - g^{*T}$. The last term ΔK^{p0} accounts for the increase in the capital stock that would occur without convergence or productivity catch-up, simply as a result of the trend growth rate in productivity (g^*) and the growth rate of population (n).

Table 2 contains a number of interesting results. First, comparing ΔK and ΔK^p (columns (1) and (2)), we notice that the fit of the model is quite remarkable: the simple neoclassical growth model can account for much of the increase in the capital stock observed between 1980 and 2000. This success may not come as a surprise, given that the productivity changes have been calibrated based on the changes in the capital stock in the data, while the capital wedge has been calibrated out of the investment rate in the data. We view this as a strength of our approach: since the model is able to reproduce reasonably well the change in the capital stock over the long run for a large number of countries, we can assess precisely whether the drivers of capital accumulation are also the drivers of observed capital flows.

The table indicates that much of the capital accumulation in developing countries occurred in Asia (13tr) compared to Latin America (2.7tr) and Africa (less than one billion). Almost half of the increase in physical capital occurred in just two countries: China and India (7.4tr out of total of 16.7tr). Columns (3) and (4) indicate that convergence (ΔK^{pc}) and relative productivity growth (ΔK^{pp}) represent a small contribution to the overall capital accumulation (2.3tr and 0.4tr respectively, out of 16.7tr). Overall, this decomposition indicates relatively little productivity catch-up across developing countries. Closer inspection, however, reveals interesting geographical patterns. About a third of the capital increase in Asia, and close to half of the capital accumulation in China and India arises from faster productivity growth (4.2tr out of 12.3tr and 3.3tr out of 6.3tr respectively). Conversely, Latin America, Africa and most of the Upper Middle Income countries have experienced a relative productivity decline ($g < g^*$). Finally, only Africa experienced both negative convergence and productivity contributions to its capital accumulation.

Beyond regional averages, the fit of the model is also excellent. Figure 2 reports the predicted capital accumulation against the actual, for all 65 developing countries in the sample. With a R^2 of 0.98, the model accounts for most of the change in the stock of physical capital in all countries.

Table 3 presents our estimates of net capital inflows for the developing countries of Table 2. We construct estimates of the level of external debt, in billions of 1996 international dollars, D^c, D^i, D^s, D^{solow} and D^p using (5), (7), (8) and (11). We compare these predictions with estimates of the cumulated capital inflows between 1980 and 2000, denoted D. We construct these estimates by cumulating current account balances –measured in 1996 international dollars– between 1980 and 2000: $\hat{D} = -\sum_{s=1980}^{2000} CA_s$.[5] Constructing estimates of current account balances in 1996 international dollars requires two steps. First, we convert US dollar estimates of current account balances from the IFS (CA_t^{IFS}) into international dollars using the price index of GDP from the PWT (P_t). Second, we these current international dollars estimates into constant international dollar estimates using the ratio of the Laspeyres constant international estimate of GDP ($RGDPL_t$) to its current international dollar equivalent ($CGDPL_t$) in the PWT database. Our final estimate of CA_t is:[6]

$$CA_t = \frac{CA_t^{IFS}}{P_t}.\frac{RGDPL_t}{CGDP_t}.$$

Column (1) reports our estimate of cumulated net capital inflows, $\hat{D}$. The size of cumulated capital inflows to developing countries remains small, around 2 trillion US dollars, or about 12 percent of the capital accumulated over the period (2034/16758). Most of these capital inflows (1.3tr) went to Latin-America, with only small and roughly equivalent amounts going to Asia and Africa (300 to 400bn).

[5] This assumes that the errors and omissions terms in the Balance of Payments reflect omitted transactions in the capital and financial accounts.

[6] Given the absence of IFS estimates on current account for China and Hong-Kong, we construct CA_t directly from the PWT database as

$$CA_t = [CGNP_t - KI_t - KC_t - KG_t]\,.RGDPL_t.POP_t$$

where $CGNP_t$, KI_t, KC_t and KG_t are respectively the percentage of GNP, investment, consumption and government expenditures to GDP, and POP_t represents the population.

Column (2) to (5) report the predicted capital flows due to convergence and productivity growth. First, we observe that developing countries were predicted to borrow about 2.3 tr 1996 international dollars to eliminate their initial capital scarcity (i.e. move from $\tilde{k}_0$ to $\tilde{k}^*$). At the same time, however, their overall lack of productivity catch-up implies that they should have exported between 39bn (-1,338+1,267) of capital in the Solow model and a staggering 5.3tr (-1,338-3,989) in the Ramsey model. it follows immediately that the observed amount of capital inflows (2.0tr) stands at the *upper end* of the range of total inflows (convergence and catch-up) predicted by the model (-3.0 tr under Ramsey to 2.2tr under Solow).

The relatively small predicted capital flows to developing countries indicates that there is no Lucas puzzle, once differences in productivity levels and distortions on capital markets are accounted for. If anything, it is likely that too much capital flows to developing countries, according to our exercise! According to Table (3), poor countries do not import more capital because (a) they face significant capital wedges, that lower the return to private investors well below the marginal product of capital and (b) poor economies, on average, failed to keep up with the productivity performance of the leading economies. This implies that the capital scarcity are not as large as indicated in the original Lucas calculation and that they are perhaps more than offset by relative productivity declines.

Nevertheless, our estimates also reveal that the overall external debt projections are very sensitive to the saving side of the model. For instance, the difference between D^s and D^{solow} equals 6.6tr international dollars, more than three times the amount of observed capital flows. We emphasize again that while our approach may be quite imprecise in pinning down the actual amount of external borrowing by any single country, it should pin down the *relative structure* of external borrowing across countries quite precisely. This is what we focus on next.

We argue that the true failure of the model consists in its inability to explain the allocation of capital flows *across developing countries*. To illustrate, consider the allocation of capital across regions. According to table 2, a significant share of Asia's capital accumulation reflects productivity catch-up. Hence, we expect significant associated net capital inflows. Table 3 reveals a positive investment term (1.1tr) and a strong capital scarcity component (1.6tr). The total predicted net capital inflows stands between 1.7tr (1.6+1.1-1.0) and 7.4tr (1.6+1.1+4.7), i.e. between 13 and 56 percent of the increase in the Asian capital stock. Yet Asia borrowed 'only' about 412bn over that period, i.e. less than 25 percent of the lowest estimate, or about 4 percent of its capital accumulation over the period. By contrast, consider Africa. With an initial capital abundance and a relative productivity decline, the neoclassical model expects significant capital outflows. Indeed, Table 3 indicates predicted outflows of 36bn (convergence), 539bn (investment) and between -508bn and 3.3tr due to the saving component. The range of total capital outflows is -67bn to 3.3tr. Instead, Africa received 304bn in net capital inflows. A similar analysis for Latin America reveals a significant relative productivity decline and a small capital scarcity. Hence, we predict significant capital outflows (between 117bn and 7.8tr). Yet, Latin America received instead 1.3 tr in net capital inflows, making it the largest net recipient of international capital flows.

Figures 3-5 explore the cross country relationship more systematically by comparing the average investment and capital flows relative to GDP (the metric we used in the introduction-see Figure 1). Figure 3 reports the relationship between predicted and realized average investment rates to GDP. As for Figure 2, the fit is quite good. Figure 4 reports the predicted against actual average capital inflows rates to GDP (using the Ramsey benchmark). Figure 5 breaks down the same information by geographic area. Both figures confirm how poorly the class of models we considered does at explaining capital inflows. The regression coefficient is not only different from 1, but it is negative (significant at the one percent level).[7] In other words, capital flows upstream: it leaves capital scarce countries with strong productivity growth moves to capital abundant countries with low prospects!!

Figures 6 and 7 shed some light on the source of the discrepancy by looking at the relationship between capital inflows and productivity growth in the model and in the data. The calibrated model predicts a strongly positive correlation between average productivity growth and the average ratio of investment to GDP (figure 6). This correlation is significantly negative in the data (figure 7). Taken together, these two findings explain the paradoxical correlation shown in Figure 1 in the introduction. Countries with higher productivity growth have both a higher investment to GDP ratio and a lower capital inflows to GDP ratio. This is the opposite of the correlation predicted by the model.

4 Gross Capital Flows Accounting

The discussion up to that point focussed exclusively on net capital inflows, measured empirically as the opposite of the current account. As a matter of accounting, the current account is a measure of the domestic savings that flow abroad. This savings flow, however, can take various and sometimes very different forms: FDI, aid and transfers, remittances, IMF loans, accumulation of reserves by the central bank, etc..

Can we identify particular flows that account for our allocation puzzle? This section proposes a methodology by which net capital inflows can be decomposed into gross capital flow components, and then applies it to the available data.

4.1 A Decomposition of net capital inflows

One distinction that we expect to be significant is whether the source and the recipient of the capital flow are public or private. We would expect the predictions of the textbook

[7] The regression coefficients (resp. standard error) are -0.047 (0.009) for the whole sample, -0.06 (0.014) for Asia, 0.03 (0.08) for Latin America, and -0.06 (0.05) for Africa.

Predicted Capital Flows (bn of 1996 intl' dollar)	(1) $\hat{D}$	(2) D^c	(3) D^i	(4) D^s	(5) D^{solow}	(6) D^p (3)+(4)	Obs.
Non-OECD countries	2,034	2,313	-1,338	-3,989	1,267	-5,328	65
Low Income	1,192	584	-187	-476	176	-663	23
Lower Middle Income	82	760	26	334	-21	360	23
Upper Middle Income	962	660	-1,490	-4,487	1399	-5,976	14
High Income (Non-OECD)	-202	309	312	640	-288	952	5
Africa	304	-36	-539	-2,791	508	-3,330	30
Latin-America	1,318	711	-1,933	-5,872	1,816	-7,804	21
Asia	412	1,638	1,133	4,673	-1,057	5,806	14
except China and India	2,217	2,008	-2,268	-8,471	2,139	-10,739	63
China and India	-183	305	929	4,482	-873	5,411	2

Table 3: Predicted and Actual Capital Flows between 1980 and 2000, billions of 1996 international dollars.

neoclassical model to apply the most to the capital flows in the private-to-private category (FDI, portfolio flows etc...).

Capital flows that involve the government are a different story. For example, one would not necessarily expect the countries that have invested the most to be also those where the government has issued the largest quantity of debt abroad. Similarly, multilateral and bilateral loans do not necessarily go in priority to the countries with the highest private return to capital. Many of these loans are meant to finance productive investment in developing countries, but often giving some priority to the very countries that have difficulties attracting funds from private investors.

We start from the Balance of Payments equation:

$$CA_t + KF_t - \Delta R_t = 0 \tag{13}$$

The change in international reserves is equal to the current account balance plus capital inflows. We can further break down capital flows into different components,

$$KF_t = \sum_i KF_t^i, \tag{14}$$

where the terms KF_t^i could be interpreted as different types of capital flows, such as FDI, debt flows (private, public), portfolio flows etc.

Table 4 below decomposes net capital flows including reserves $KF_t - \Delta R_t$ into four components according to whether the source or recipient sector is public or private. The first upper index refers to the source, with p denoting the private sector and g denoting the governmental (or public) sector. The second upper index refers to the recipient sector with similar notations. For example, KF^{pg} denotes the volume of capital flows going from foreign private investors to the domestic public sector. The change in reserves is included in the public-to-public category, since it is a change in the domestic government's (or central bank's) holdings of short-term claims on foreign governments.

Table 4.

		recipient	
		public	private
source	public	KF^{gg}	KF^{gp}
	private	KF^{pg}	KF^{pp}

To construct empirical counterparts to these flows, we use the balance-of-payments data available from the World Bank's Global Development Finance (GDF) data set. This data set covers 136 developing countries from 1970 to the present. Appendix B explains in details how we estimate the different capital flow components based on the GDF data. One problem with the GDF data is that flows are not netted of the foreign assets accumulated by the domestic public and private sectors. Hence, this data set does not provide a complete breakdown of the balance-of-payments equation (13). Nevertheless, this problem can be solved if we are willing to assume that the *only* foreign assets accumulated by the domestic public sector are foreign exchange reserves. Conditional on this assumption it is possible to construct an estimate of the net flows to the private sector $KF^p = KF^{gp} + KF^{pp}$ as a residual in the balance-of-payments equation. This gives us (by construction) an exact decomposition of the current account balance in terms of net flows to the domestic public sector and private sector. One drawback of this decomposition is that it contains no information about the source of the flows.

Table 4 presents the results. Note that, according to our decomposition,

$$\hat{D} = -CA = KF^p + KF^g$$

while

$$KF^g = KF^{pg} + KF^{gg} - RES.$$

The table also reports estimates of the cumulated FDI flows as well as cumulated reserves.

The sample of countries for which the data is available is slightly smaller (57 instead of 65). Yet the general pattern of capital flows remains largely unchanged: Latin America is the largest recipient of net capital inflows. Second, in general, the net flows to the public sector are quite small compared to the net flows towards the private sector (619bn versus 1.5tr). The exception to that pattern are low and lower middle income countries, and Africa where public flows appear similar in size to flows to the private flows.

Capital Flows Components (bn of 1996 international dollar)	$\hat{D}$	FDI	RES	KF^{pp}	KF^{pg}	KF^{gg}	KF^{g}	KF^{p}	Obs
Non-OECD countries	2,113	2,298	1,785	4,304	1,049	1,356	619	1,494	57
Low Income	1,088	137	326	413	153	649	476	612	20
Lower Middle Income	145	1,296	1,020	2,233	536	541	57	88	20
Upper Middle Income	972	796	272	1,458	353	129	210	763	16
High Income (Non-OECD)	-93	70	167	199	7	36	-124	31	1
Africa	281	69	113	185	41	244	173	108	23
Latin-America	1,263	806	232	1,455	386	201	355	908	22
Asia	569	1,423	1,440	2,664	622	910	91	477	12
except China and India	2,296	1,284	903	2,531	578	1,029	704	1,592	55
China and India	-183	1,014	882	1,773	471	326	-84	-98	2

Table 4: Predicted Capital Flows between 1970 and 2000, billions of 1996 international dollars.

Third, we observe that both net FDI and changes in reserve can be much larger than cumulated external debt. This is especially the case in Asia where the both cumulated FDI flows and changes in reserves attain 1.4tr. In fact, there is a strong positive correlation between reserve accumulation and private capital inflows such as FDI.

Figures 8-11 show that the pattern of misallocation of capital is present across the different forms of capital flows. Figure 8 and 9 report the observed public and private capital flows -relative to GDP, compared to predicted capital flows. It is immediate that both types of flows are misallocated compared to the theory: the slope of the regression line is negative and significant at 1 percent.

Some categories of capital flows, however, seem to conform better to the theory. For instance, figure 10 reports the average net FDI inflows relative to GDP. FDI flows appear positively correlated with our theoretical measure of capital inflows. While the coefficient is small –reflecting the overall low level of FDI in many of these countries, it tends to increase together witht the theoretical determinants of capital flows. Countries with faster productivity growth and larger initial capital scarcity tend to attract marginally more foreign direct investment.

Finally, figure 11 reports the change in reserves against the predicted total inflows relative to GDP. A positive change in reserves indicates and outflow of capital. The figure reveals that countries that should borrow tend to accumulate non-negligible amounts of reserves instead.

We view this joint pattern as one of the most striking feature of the global allocation of capital flows: countries with better economic prospects will attract more direct investment yet export capital, in no small part through accumulation of reserves.

5 Discussion [TO BE WRITTEN]

6 Concluding Comments

[to be completed]

APPENDIX A

Derivation of equation (6)

Using the fact that the representative resident's income $(1-\tau) R_t k_t + w_t A_t + z_t$ is equal to domestic output, $A_t \widetilde{k}^{*\alpha}$, the budget constraint (3) can be solved forward to give the country's intertemporal budget constraint,

$$\sum_{t=0}^{+\infty} \left(\frac{n}{R^*}\right)^t c_t = \sum_{t=0}^{+\infty} \left(\frac{n}{R^*}\right)^t \left(A_t \widetilde{k}^{*\alpha} + (1-\delta) A_t \widetilde{k}^* - n A_{t+1} \widetilde{k}^*\right).$$

Using $c_t = g^{*t} c_0$, $A_t = A_0 g^{*t} \pi_t$ for $t \leq T$ and $A_t = A_0 g^{*t} \pi$ for $t > T$ the intertemporal budget constraint can be solved for the initial consumption level per efficient unit of labor:

$$\tilde{c}_0 \equiv c_0 / A_0 = (R^* - n g^*)\, \tilde{k}^* + \pi\chi - \pi\chi \left(1 - \frac{n g^*}{R^*}\right) \sum_{t=0}^{T} \left(\frac{n g^*}{R^*}\right)^t \frac{\pi - \pi_t}{\pi},$$

where $\chi = \tilde{k}^{*\alpha} - (R^* + \delta - 1)\tilde{k}^* > 0$.

From the the dynamic budget constraint (3), we can solve for the path of external debt per efficient labor unit, $\widetilde{d}_t = d_t / A_t$:

$$\widetilde{d}_{t+1} = \frac{1}{g^* n} \left[\frac{\pi_t}{\pi_{t+1}} R^* \widetilde{d}_t - \tilde{k}^{*\alpha} \frac{\pi_t}{\pi_{t+1}} - (1-\delta) \widetilde{k}^* \frac{\pi_t}{\pi_{t+1}} + \frac{\tilde{c}_0}{\pi_{t+1}}\right] + \tilde{k}^*.$$

At time T the debt per efficient unit $\widetilde{d}_t$ stabilizes at a constant level $\widetilde{d}^a$ that satisfies,

$$\widetilde{d}^a = \frac{1}{g^* n} \left[R^* \widetilde{d}^a - \tilde{k}^{*\alpha} - (1-\delta) \widetilde{k}^* + \frac{\tilde{c}_0}{\pi}\right] + \tilde{k}^*.$$

Substituting for $\tilde{c}_0$ and solving for $\widetilde{d}^a$ gives equation (6).

Derivation of (??)

The level of external debt per efficient unit of labor satisfies the following difference equation:

$$\tilde{d}_{t+1} = \frac{1}{n g_{t+1}} \left[s R^* \tilde{d}_t - s \tilde{k}^{*\alpha} - (1-\delta)\, \tilde{k}^*\right] + \tilde{k}^*$$

Substituting for the level of saving that satisfies (10) and using the fact that $g_{t+1} = g^* \pi_{t+1} / \pi_t$, we obtain:

$$\tilde{d}_{t+1} = \rho \frac{\pi_t}{\pi_{t+1}} \tilde{d}_t + \left(1 - \frac{\pi_t}{\pi_{t+1}}\right) \tilde{k}^*$$

where $\rho = s R^* / n g^* < 1$. Iterating, on this equation, one can check that

$$\tilde{d}_{t+1} = \frac{\tilde{k}^*}{\pi_{t+1}} \left[\rho^t (\pi_1 - 1) + \rho^{t-1} (\pi_2 - \pi_1) + ... + (\pi_{t+1} - \pi_t)\right]$$

Substituting $\pi_{i+1} - \pi_i = (\pi - 1)/T$, the maximum external debt in the Solow model satisfies (**??**).

APPENDIX B

The GDF data

GDF reports gross capital flows. When it calls them "net" this just means that loans are net of repayments. But this is gross in the macroeconomic sense: it reports the accumulation of claims on residents by nonresidents, but not of claims on nonresidents by residents. Also, GDF includes only long-term credit flows with a maturity longer than one year.

The capital flows can be decomposed by originators and recipients as follows,

KF^{pp} =Foreign Direct Investment + Portfolio Equity Flows + Net Flows on Private NonGuaranteed (PNG) Debt

KF^{pg} =Net Flows on Public and Publicly Guaranteed (PPG) Debt from Private Creditors

KF^{gg} =Net Flows on PPG Debt from Official Creditors+ IMF Purchases -IMF repurchases.

GDF does not report flows from foreign public lenders to the domestic private sector (KF^{gp}). This is so even though some loans from the World Bank and regional development banks go to private borrowers, because these loans are publicly guaranteed and so fall in the PPG category.

FK^{gg} is close to the GDF concept of "official net resource flows", which is equal to net flows on PPG debt (official creditors)+Grants. The difference is that FK^{gg} does not include grants but includes IMF loans. The GDF concept of "private net resource flows" corresponds to $FK^{pp} + FK^{pg}$.

One problem with this decomposition is that it refers to gross flows. So these flows do not add up to the change in reserves minus the current account. This problem can be solved if one does the breakdown by recipient sector (and not by the sources), conditional on some assumptions. Let us denote by KF^g and KF^p the *net* flows to the domestic public and private sectors respectively. If one assumes that the only foreign assets that are purchased or sold by the domestic public sector are foreign exchange reserves, then the net flows to the public sector are equal to the gross flows minus the change in reserves,

$$KF^g = KF^{pg} + KF^{gg} - \Delta R.$$

The net flows to the domestic private sector can then be derived from the balance-of-payments equation,

$$CA_t + KF_t^g + KF_t^p = 0,$$

where the change in reserves does not appear because it is counted in KF^g.This equation can be used to estimate KF_t^p, using the data for the other variables in GDF.

GDF provides data expressed in current US dollars. These data must be converted into constant international dollars in order to be comparable to the Penn World Table data. We use the same conversion factor that we used to estimate current accounts in constant international dollars. The first step is to go from dollars to international dollars. This requires a relative price assumption. If the flows clearly refers to investment—for example to compute intertemporal FDI—we could use the price of investment.

Otherwise we have used the price of GDP, P. The formula to convert current into international dollars is then $E_t^{i\$} = 100 E_t^{\$}/P_t$ in the first case.

Then current international dollars have to be converted into constant ones. Here we simply use the ratio of real to nominal GDP from the PWT. The conversion formula is,

$$E_t^{ci\$} = \frac{RGDPL_t}{CGDP_t} E_t^{i\$},$$

where $E_t^{i\$}$ is the value in current dollars, $E_t^{ci\$}$ the value in constant international dollars, and $RGDPL_t$ and $CGDP_t$ are taken from the PWT.

APPENDIX C: To be added

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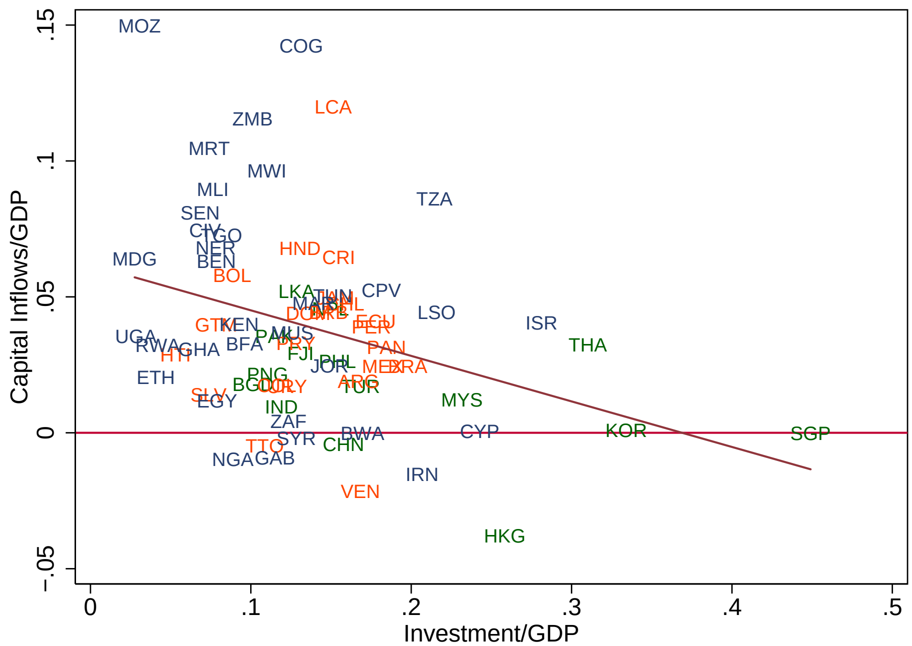

Figure 1: Capital Inflows and Investment Rates, relative to GDP, 1980-2000.

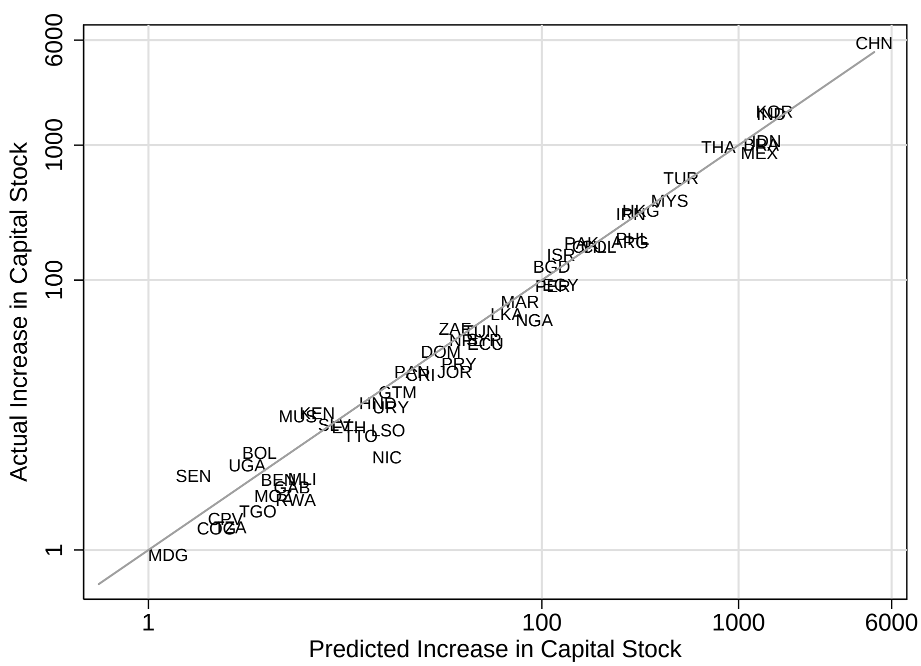

Figure 2: Predicted and Actual Capital Stock Increases between 1980 and 2000. Billions of 1996 international dollars.

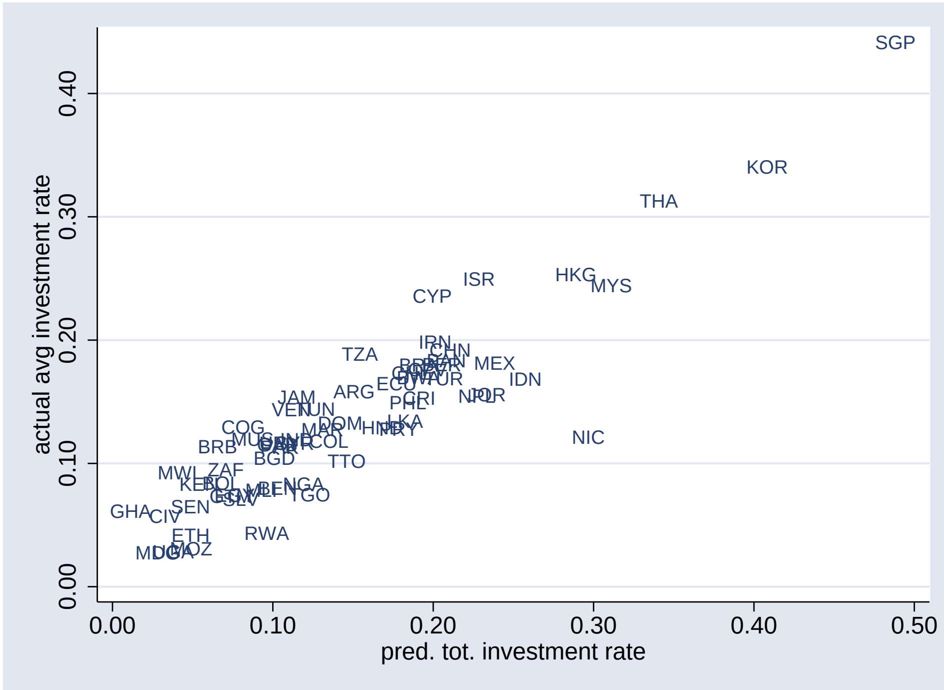

Figure 3: Actual and Predicted Total Investment/GDP rates, 1980-2000.

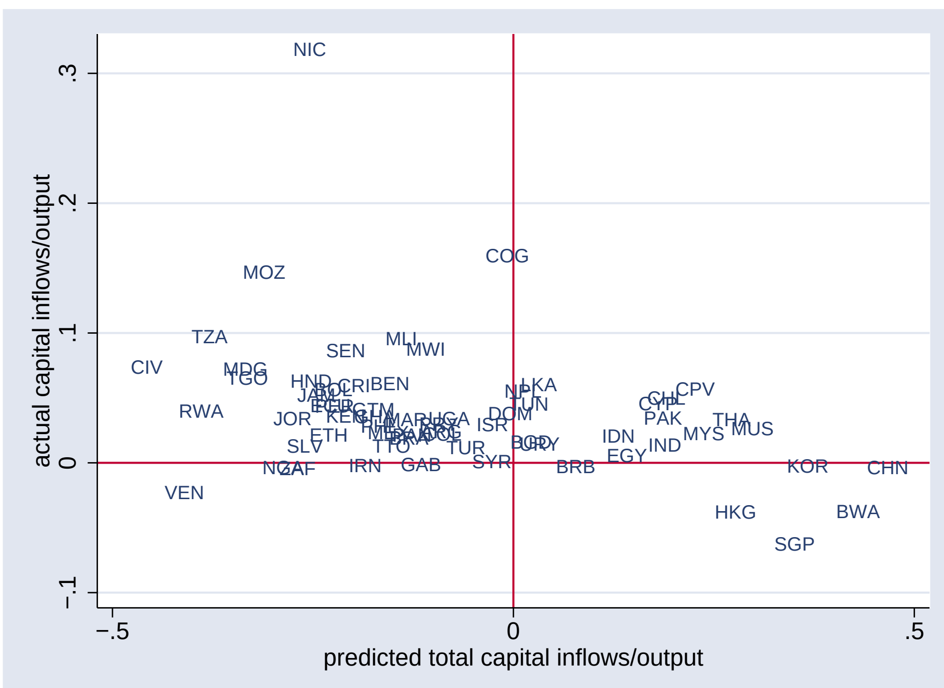

Figure 4: Actual and Predicted Capital Inflows/GDP, 1980-2000

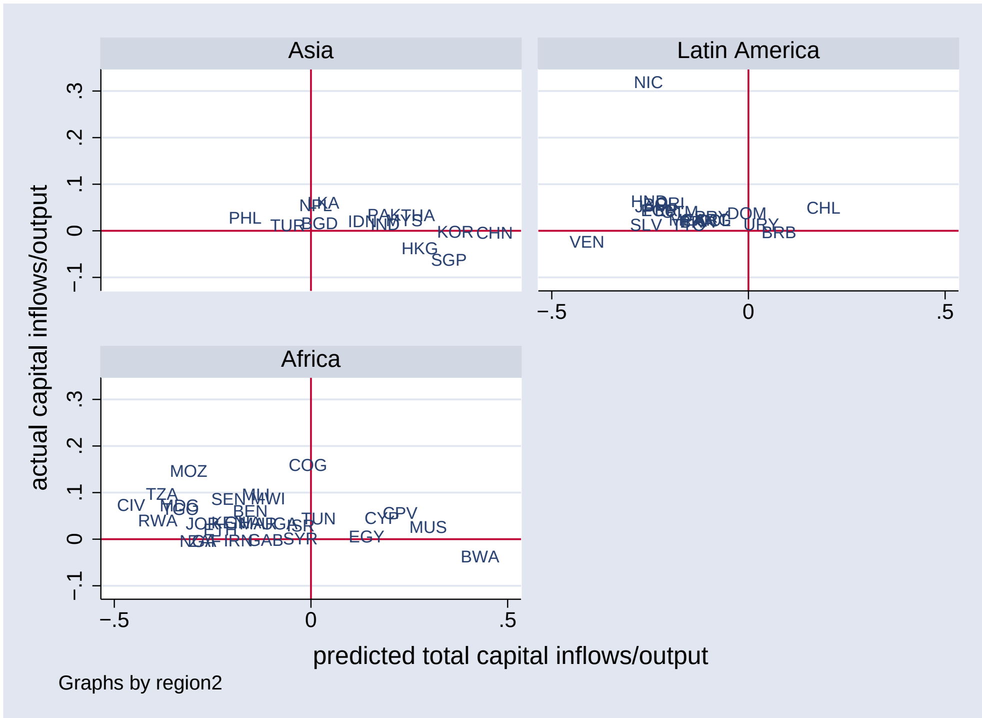

Figure 5: Actual and Predicted Capital Inflows/GDP, 1980-2000, by region.

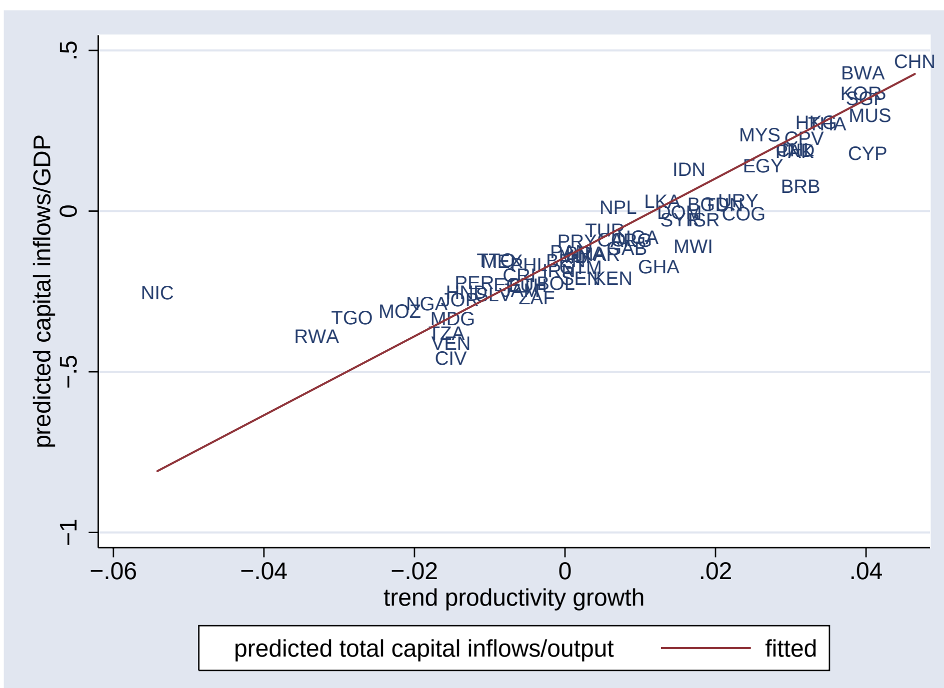

Figure 6: Predicted Capital Inflows/GDP agains Productivity Growth, 1980-2000.

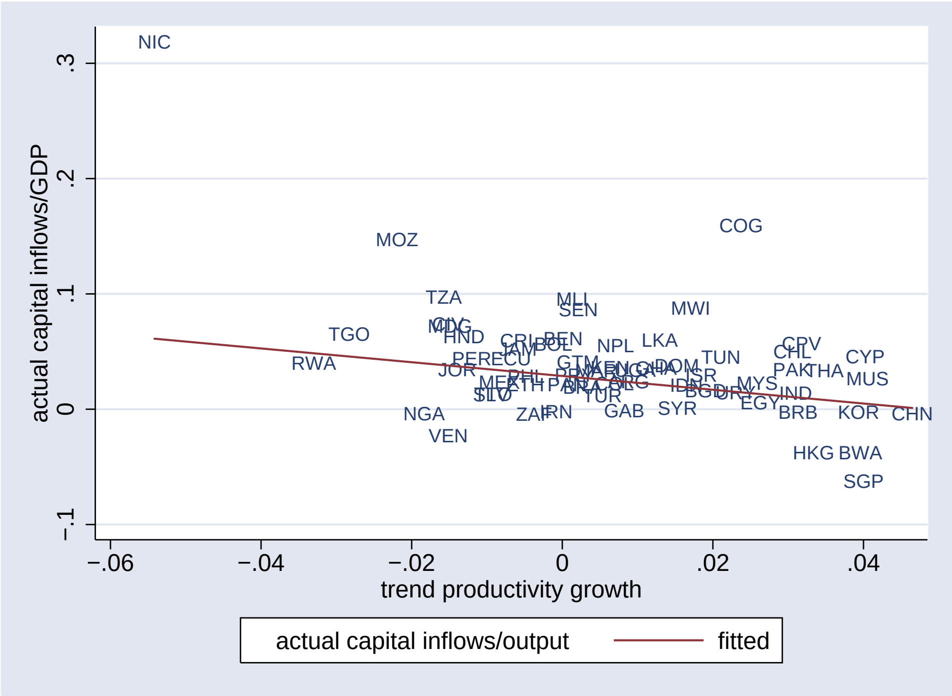

Figure 7: Actual Capital Inflows/GDP and Productivity Growth, 1980-2000

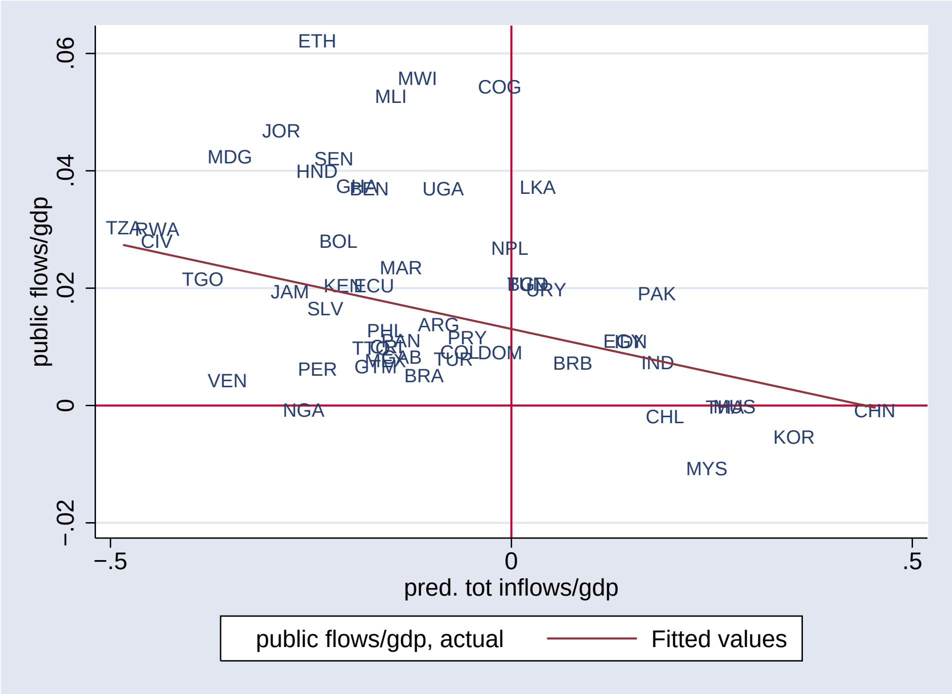

Figure 8: Actual Public Inflows/GDP and Predicted Total Flows/GDP. Years 1980-2000. Source: PWT and WDI.

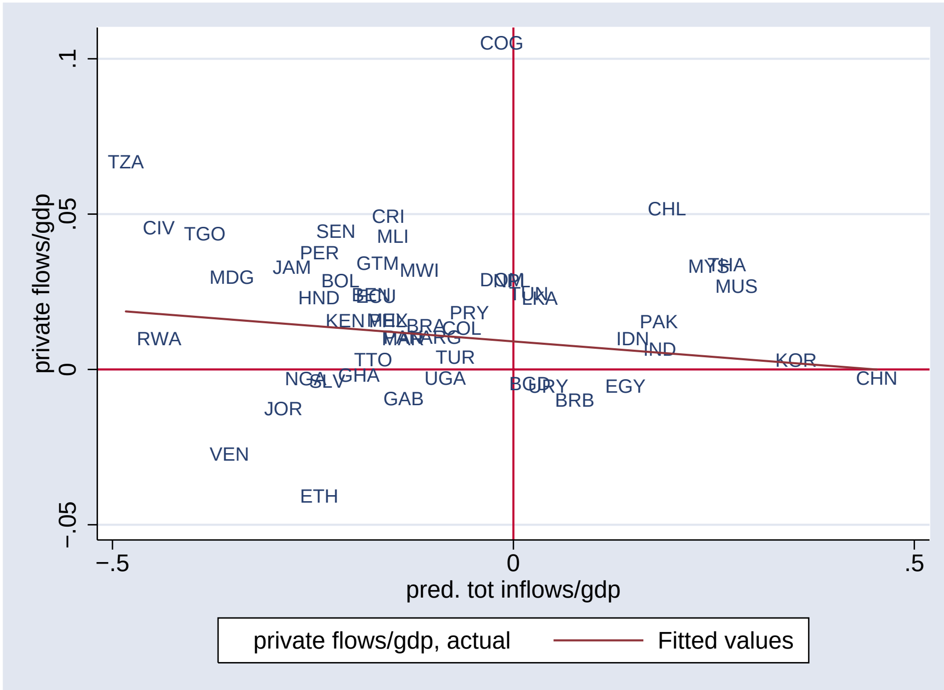

Figure 9: Actual Private Flows/GDP and Predicted Total Flows/GDP. Years: 1980-2000. Source: PWT and WDI.

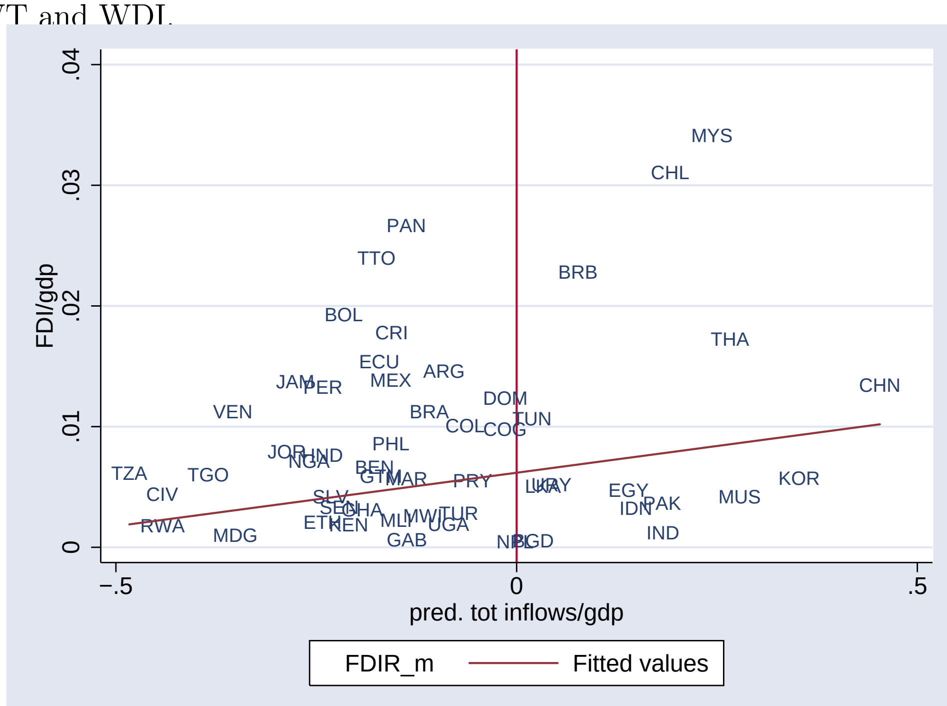

Figure 10: FDI Flows/GDP and Predicted Total Flows/GDP. Years: 1980-2000. Source: PWT and WDI.

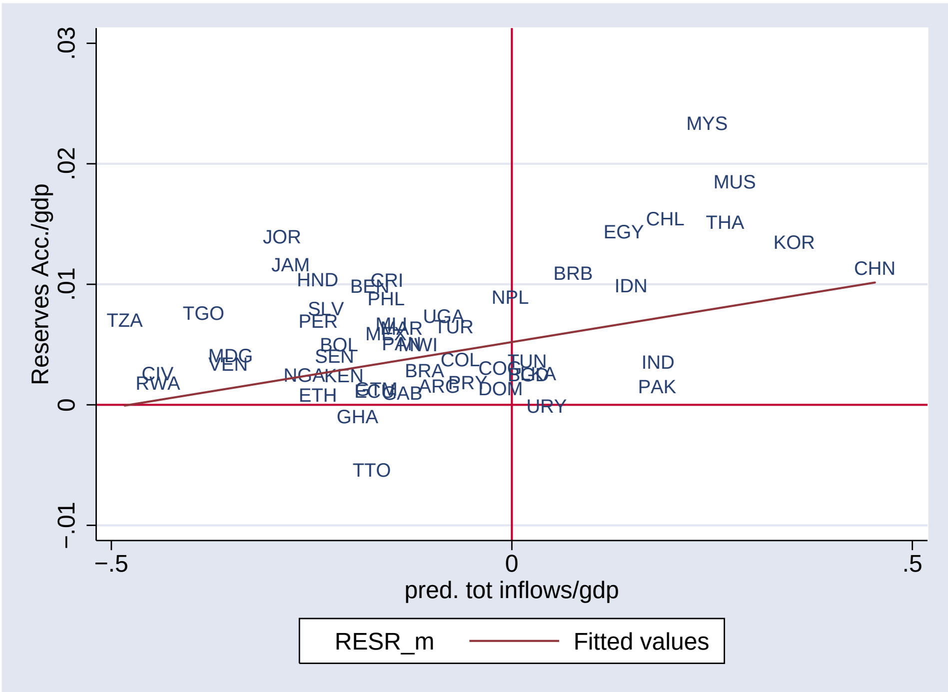

Figure 11: Actual Reserve Accumulation/GDP and Predicted Total Flows/GDP. Years: 1980-2000. Source: PWT and WDI.