Capital Flows to Developing Countries: The Allocation Puzzle*

Pierre-Olivier Gourinchas†
University of California at Berkeley

Olivier Jeanne‡
Johns Hopkins University

October 2011

Abstract

The textbook neoclassical growth model predicts that countries with faster productivity growth should invest more and attract more foreign capital. We show that the allocation of capital flows *across* developing countries is the opposite of this prediction: capital does not flow more to countries that invest and grow more. We call this puzzle the "allocation puzzle." Using a wedge analysis, we find that the pattern of capital flows is driven by national saving: the allocation puzzle is a saving puzzle. Further disaggregation of capital flows reveals that the allocation puzzle is also related to the pattern of accumulation of international reserves. The solution to the "allocation puzzle", thus, lies at the nexus between growth, saving and international reserve accumulation. We conclude with a discussion of some possible avenues for research.

JEL codes: F36, F43
Keywords: capital flows, productivity, growth

*We would like to thank Philippe Bacchetta, Chris Carroll, Francesco Caselli, Kerstin Gerling, Peter Henry, Sebnem Kalemli-Ozcan, Pete Klenow, Alberto Martin, Romain Rancière, Assaf Razin, Damiano Sandri, Federico Sturzenegger for useful comments and especially Chang-Tai Hsieh and Chad Jones for insightful discussions. We also thank seminar participants at Stanford University, MIT, Brown University and Johns Hopkins University, the 2006 NBER-IFM summer institute (Cambridge), 2007 AEA meetings (Chicago) and 2007 CEPR meeting on Global Interdependence (Dublin), the 2007 European Summer Symposium in International Macroeconomics (ESSIM), the First Paris School of Economics Workshop in International Finance. Pierre-Olivier Gourinchas thanks the NSF for financial support (grants SES-0519217 and SES-0519242).

†Also affiliated with the National Bureau of Economic Research (Cambridge), and the Center for Economic Policy Research (London). Contact address: UC Berkeley, Department of Economics, 691A Evans Hall #3880, Berkeley, CA 94720-3880. email: pog@berkeley.edu.

‡Also affiliated with the Peterson Institute for International Economics (Washington DC) National Bureau of Economic Research (Cambridge), and the Center for Economic Policy Research (London). Contact address: Department of Economics, Johns Hopkins University, Mergenthaler Hall 454, 3400 N. Charles Street, Baltimore MD 21218. Email: ojeanne@jhu.edu. A first draft of this paper was completed while the author was visiting the Department of Economics of Princeton University, whose hospitality is gratefully acknowledged.

1 Introduction

The role of international capital flows in economic development raises important open questions. In particular, the question asked by Robert Lucas twenty years ago—why so little capital flows from rich to poor countries—received renewed interest in recent years as capital has been flowing "upstream" from developing countries to the U.S. since 2000.[1]

This paper takes a fresh look at the pattern of net capital flows to developing countries through the lenses of the neoclassical growth model. We show that there is a significant discrepancy between the predictions of the textbook neoclassical growth model and the distribution of capital flows *across* developing countries observed in the data. The basic framework predicts that countries that enjoy higher productivity growth should receive more net capital inflows. We look at net capital inflows for a large sample of non-OECD countries over the period 1980-2000 and find that this is not true. In fact the cross-country correlation between productivity growth and net capital inflows is often negative and at best zero. The non-OECD countries that have grown at a higher rate over 1980-2000 have not imported more capital. This finding is robust to many controls.

The benchmark allocation puzzle is illustrated by Figure 1, which plots the average growth rate of total factor productivity (TFP) against the average ratio of net capital inflows to GDP for 68 developing countries over the period 1980-2000.[2] Although the variables are averaged over two decades, there is substantial cross-country variation both in the direction and in the volume of net capital inflows, with some countries receiving more than 10 percent of their GDP in capital inflows on average (Mozambique, Tanzania), whereas others export about 7 percent of their GDP in capital outflows (Taiwan). More strikingly, the correlation between the two variables is *negative*, the opposite of the theoretical prediction.[3] To illustrate with two countries that are typical of this relationship (i.e., close to the regression line), Korea, a development success story with an average TFP growth of 4.1 percent per year and an average annual investment rate of 34 percent between 1980 and 2000, received almost no net capital inflows, whereas Madagascar, whose TFP fell by 1.5 percent a year and average annual investment rate barely reached 3 percent, received 7 percent of its GDP in capital inflows each year, on average.

As we show in this paper, the pattern observed in Figure 1 is just one illustration of a range of results that point in the same direction. Capital flows from rich to poor countries are not only low (as argued by Lucas (1990)), but their allocation across developing countries is –at best– uncorrelated with the predictions of the standard textbook model. This is the "allocation puzzle".

We provide a more detailed characterization of the allocation puzzle by looking at different breakdowns (decompositions) of capital flows. First, we delineate the respective roles of investment and saving. We augment the neoclassical growth model with two "*wedges*": one

[1]See Lucas (1990) for the seminal article and Prasad, Rajan and Subramanian (2007) on the upstream flows of capital.

[2]Net capital inflows are measured as the ratio of a country's current account deficit over its GDP, averaged over the period 1980-2000. The construction of the data is explained in more detail in section 3.

[3]The regression line on figure 1 has a slope -0.72 (p-value of 0.1%).

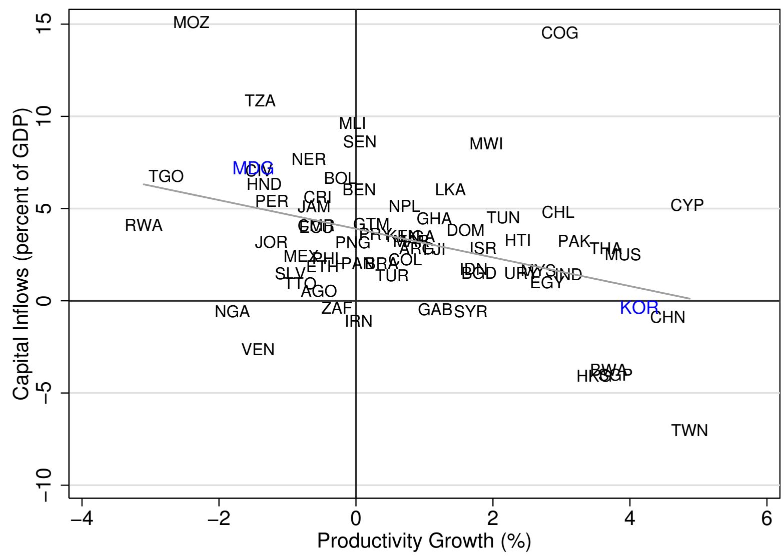


Figure 1: Average productivity growth and average capital inflows between 1980 and 2000.

wedge that distorts investment decisions, and one wedge that distorts saving decisions. It is then possible, for each country in our sample, to estimate the saving and investment wedges that are required to explain the observed levels of savings and investment (and therefore of net capital flows). We find that the investment wedge cannot, by itself, explain the allocation puzzle, and that solving the allocation puzzle requires a saving wedge that is strongly negatively correlated with productivity growth. That is, the allocation puzzle is a *saving puzzle*.

We then look at a decomposition of international capital flows into public and private flows, similar to Aguiar and Amador (2011). We confirm that paper's finding that the allocation puzzle is mostly a feature of public flows, and in addition find that the accumulation of international reserves plays a role in generating the puzzle. However, we do not find robust evidence that private flows conform to the predictions of theory.

What can explain this puzzling allocation of capital flows across developing countries? Our wedge analysis shows that the explanation must involve the relationship between savings and growth, and our flow decomposition suggests that reserve accumulation plays an important role. This suggests to us that the solution to the allocation puzzle should be looked for at the nexus between growth, saving, and reserve accumulation. Why do countries that grow more also accumulate more reserves, and why is this reserve accumulation not offset by capital inflows to the private sector? We discuss possible explanations at the end of the paper—some of which were developed since the first version of this paper was circulated. No attempt is made to discriminate empirically between these explanations —the objective of the last section of the paper being to propose a road map for future research rather than to establish new results.

This paper lies at the confluence of different lines of literature. First, it is related to the literature on the determinants of capital inflows to developing countries, and on their role in economic development. Aizenman, Pinto and Radziwill (2004) construct a self-financing ratio indicating what would have been the counterfactual 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. Prasad et al. (2007) also document a negative cross-country correlation between the ratio of capital inflows to GDP and growth, and discuss possible explanations for this finding. Manzocchi and Martin (1997) 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.

The paper is also related to the literature on savings, growth, and investment. That literature has established a positive correlation between savings and growth, a puzzling fact from the point of view of the permanent income hypothesis since high-growth countries should borrow abroad against future income to finance a higher level of consumption (Carroll and Summers (1991), Carroll and Weil (1994)). Starting with Feldstein and Horioka (1980), the literature has also established a strongly positive correlation between savings and investment. The allocation puzzle presented in this paper is related to both puzzles, but it is stronger. Our finding is that the *difference between savings and investment* (capital outflows) is positively correlated with productivity growth.

This paper is also related to the literature on the relationship between growth and the current account in developing countries. Emerging market business cycles exhibit counter cyclical current accounts, i.e., the current account balance tends to decrease when growth picks up (see Aguiar and Gopinath (2007)). We show in this paper that the cross-country correlation between growth and the current account is the opposite. Because of the very low frequency at which we look at the data, a more natural benchmark of comparison is the literature on transitional growth dynamics pioneered by Mankiw, Romer and Weil (1992). King and Rebelo (1993b) also examine transition dynamics in a variety of neoclassical growth models. Unlike these papers, we allow countries to catch-up or fall behind relative to the world technology frontier and focus on the implications of the theory for international capital flows.

Our wedge analysis is similar to Chari, Kehoe and McGrattan (2007)'s "business cycle accounting." Those authors show that a large class of dynamic stochastic general equilibrium models are observationally equivalent to a benchmark real business cycle model with correlated "wedges" in their first-order conditions. The main difference is that while Chari et al. (2007) look at real business fluctuations, we focus here on long-term growth. In a more closely related contribution, Chari, Kehoe and McGrattan (1996) show that a neoclassical growth model with investment distortions does fairly well in accounting for the observed distribution of income and the patterns of investment across countries.

Finally, this paper belongs to a small set of contributions that look at the implications of the recent "development accounting" literature for international economics. Development accounting 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). Two conclusions from this literature are especially relevant for our analysis. First, a substantial share of the cross-country inequality in income per capita comes from cross-country differences in TFP —see Hall and Jones (1999) and the subsequent literature on development accounting reviewed in Caselli (2005). The economic take-off of a poor country, therefore, results from a convergence of its TFP toward the level of advanced economies. Second, developing countries are able to accumulate the level of productive capital that is warranted by their level of TFP. Caselli and Feyrer (2007) show that the return to capital, once properly measured in a development accounting framework, is very similar in advanced and developing countries.[4] If we accept these conclusions, then an open economy version of the basic neoclassical growth model should be a reasonable theoretical benchmark to think about the behavior of capital flows toward developing countries. The present 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 with the data.[5]

The paper is structured as follows. Section 2 presents the model that we use to predict the volume and allocation of capital flows to developing countries. Section 3 then calibrates the model using Penn World Table (PWT) data on a large sample of developing countries, and establishes the allocation puzzle. Section 4 introduces the wedges into the model, and section 6 concludes by speculating on possible explanations for the allocation puzzle.

2 Capital Flows in the Neoclassical Growth Model

The neoclassical growth framework postulates that the dynamics of growth are driven by an exogenous productivity path. In this section we derive the implications of this view for capital flows, i.e., we show how the capital flows to developing countries are determined by their productivity paths relative to the world technology frontier. For simplicity, we assume that each developing country can be viewed as a small open economy taking the world interest rate as given. Thus, the model features only one country and the rest of the world.

2.1 Assumptions

Consider a small open economy that can borrow and lend at an exogenously given world gross real interest rate R^*. Time is discrete and there is no uncertainty. The economy produces a single homogeneous good using two inputs, capital and labor, according to a Cobb-Douglas production function:

$$Y_t = K_t^{\alpha} (A_t L_t)^{1-\alpha}, \; 0 < \alpha < 1, \qquad (1)$$

[4] Caselli and Feyrer (2007) consider a neoclassical growth framework similar to the model used here but do not look at the channels through which the returns to capital are equalized. By contrast, we look at the capital flows that are required to equalize those returns in the neoclassical framework.

[5] In Gourinchas and Jeanne (2006) we use a development accounting framework similar to that in this paper to quantify the welfare gains from capital mobility, and find them to be relatively small. We do not compare the predictions of the model with the observed capital flows to developing countries as we do here.

where K_t is the stock of domestic physical capital, L_t the labor supply, and A_t the level of productivity. The labor supply is exogenous and equal to the population ($L_t = N_t$). Factor markets are perfectly competitive so each factor is paid its marginal product.

We assume that the country can issue external debt or accumulate foreign bonds. Thus capital flows will take the form of debt flows (this is without restriction of generality since there is no uncertainty). The economy's aggregate resource constraint can be written,

$$C_t + I_t + R^* D_t = Y_t + D_{t+1}, \tag{2}$$

$$I_t = K_{t+1} - (1-\delta)K_t,$$

where I_t is investment, δ is the depreciation rate, R^* is the world gross interest rate, and D_t is the country's external debt. The capital K_t is owned by residents. The country pays the riskless interest rate on its debt because there is no default risk. The volume of capital inflows in period t, $D_{t+1} - D_t$, is equal to domestic investment, I_t, minus domestic savings, $Y_t - (R^* - 1)D_t - C_t$, with both terms playing an important role in the analysis.[6]

For simplicity, we assume perfect financial integration, i.e., the level of D_t is unconstrained. This assumption makes sense as a theoretical benchmark—we will discuss the implications of relaxing it in section 2.2. It is also not an implausible assumption to make in light of Caselli and Feyrer (2007)'s finding that the real returns to capital are equalized across the world.

Denote by R_t the marginal product of capital, net of depreciation:

$$R_t = \alpha \left(k_t/A_t\right)^{\alpha-1} + 1 - \delta, \tag{3}$$

where k_t denotes capital per capita and more generally, lower case variables are normalized by population. Capital mobility implies that the private return on domestic capital and the world real interest rate are equal: $R_t = R^*$. Substituting this into the expression for the gross return on capital (3), we obtain that the capital stock per efficient unit of labor $\tilde{k} = k_t/A_t$ is constant and equal to:

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

where 'tilde-variables' denote per capita variables in efficiency units: $\tilde{x} = X/AN$.

The country has an exogenous, deterministic productivity path $(A_t)_{t=0}^{\infty}$, which is bounded from above by the world productivity frontier,

$$A_t \leq A_t^* = A_0^* g^{*t}.$$

[6]Obviously, there can be a discrepancy between savings and investment because of capital flows. The Fisherian separation of savings and investment is at the core of the economics of capital flows in the neoclassical growth model. By contrast, in a closed economy, faster productivity growth leads to additional investment only if it successfully mobilizes national savings through higher interest rates.

The world productivity frontier reflects the advancement of knowledge, which is not country specific, and is assumed to grow at a constant rate g^*.

Domestic productivity could grow at a rate that is higher or lower than g^* for a finite period of time. In order to describe how domestic productivity evolves relative to the world frontier, it is convenient to define π_t as the gap between domestic productivity and the productivity in the absence of technological catch-up,

$$\pi_t \equiv \frac{A_t}{A_0 g^{*t}} - 1.$$

We assume that $\pi = \lim_{t\to\infty} \pi_t$ is well defined. Domestic productivity converges to a fraction of the world frontier, and the limit π measures the country's long-run technological catch-up relative to that frontier. If $\pi = 0$, the country's long-run productivity remains unchanged relative to the world frontier. If $\pi > 0$, the country catches up relative to the frontier, and if $\pi < 0$, the country falls further behind. The country's productivity growth rate always converges to g^*.[7]

Next, we need to make some assumptions about the determination of domestic consumption and savings. Here, we adopt the textbook Cass-Ramsey model extended to accommodate a growing population. The population N_t grows at an exogenous rate n: $N_t = n^t N_0$. Like in Barro and Sala-i-Martin (1995) we assume that the population can be viewed as a continuum of identical families whose representative member maximizes the welfare function:

$$U_t = \sum_{s=0}^{\infty} \beta^s \; N_{t+s} \; u\left(c_{t+s}\right), \tag{5}$$

where $u\left(c\right) \equiv \left(c^{1-\gamma} - 1\right) / \left(1-\gamma\right)$ is a constant relative risk aversion (CRRA) utility function with coefficient $\gamma > 0$. The number of families is normalized to 1, so that per family and aggregate variables are the same.

The budget constraint of the representative family is given by:

$$C_t + K_{t+1} = R^*(K_t - D_t) + D_{t+1} + N_t w_t, \tag{6}$$

where w_t is the wage, equal to the marginal product of labor $\left(1-\alpha\right) k_t^{\alpha} A_t^{1-\alpha}$.

The representative resident maximizes the welfare function (5) under the budget constraint (6). The Euler equation for the small open economy is,

$$c_t^{-\gamma} = \beta R^* c_{t+1}^{-\gamma}. \tag{7}$$

[7] That countries have the same growth rate in the long run is a standard assumption, often justified by the fact that no country should have a share of world GDP converging to 0 or 100 percent. Models of idea flows such as Parente and Prescott (2000) or Eaton and Kortum (1999) imply a common long-run growth rate of productivity.

We assume that the world interest factor is given by,

$$R^* = g^{*\gamma}/\beta. \tag{8}$$

Equation (8) holds if the rest of the world is composed of advanced economies that have the same preferences as the small economy under consideration, and have already achieved their steady state. This is a natural assumption to make, given that we look at the impact on capital flows of cross-country differences in productivity, rather than preferences.

A country is characterized by an initial capital stock per capita k_0, debt per capita d_0, population growth rate n, and a productivity path $\{A_t\}_{t=0}^{\infty}$. We assume that all countries are financially open at time $t = 0$ and use the model to estimate the size and the direction of capital flows from $t = 0$ onward.

2.2 Productivity and capital flows

We compare the predictions of the model with the data observed over a finite period of time denoted $[0, T]$. We abstract from unobserved future developments in productivity by assuming that all countries have the same productivity growth rate, g^*, after time T. We further assume that the path for the ratio π_t/π is the same for all countries and satisfies $\pi_t \leq \pi$:

$$\pi_t = \pi f(t), \tag{9}$$

where $f(\cdot)$ is common across countries and satisfies $f(t) \leq 1$ and $f(t) = 1$ for $t \geq T$. This assumption allows us to characterize the productivity differences between countries with a single parameter, the long-run productivity catch-up coefficient π.

Next, we need to define an appropriate measure of capital inflows during the time interval $[0, T]$. A natural measure, in our model, is the change in external debt between 0 and T normalized by initial GDP,

$$\frac{\Delta D}{Y_0} = \frac{D_T - D_0}{Y_0}. \tag{10}$$

The normalization by initial GDP ensures that the measure is comparable across countries of different sizes.[8]

The following proposition characterizes how the direction and volume of capital flows depend on the exogenous parameters of the model.

[8] We also looked at other possible measures of capital inflows and found our main conclusions to be robust. For example, capital inflows could be measured as the average ratio of net capital inflows to GDP (like in Figure 1) or as the change in the ratio of net foreign liabilities to GDP. In Gourinchas and Jeanne (2007) we show that the predictions of the model are qualitatively the same for the three measures of capital flows. Moreover, we show that if the allocation puzzle is observed with measure (10) then it must also hold with the two other measures. This is another reason to use measure (10) as a benchmark when we look at the data.

Proposition 1 (A Decomposition of Capital Flows) *Under assumptions (1), (2), (5), (8) and (9), the ratio of cumulated net capital inflows to initial output between $t = 0$ and $t = T$ is given by:*

$$\frac{\Delta D}{Y_0} = \overbrace{\frac{\tilde{k}^* - \tilde{k}_0}{\tilde{y}_0} (ng^*)^T}^{\Delta D^c/Y_0} + \overbrace{\frac{\tilde{d}_0}{\tilde{y}_0} \left[(ng^*)^T - 1 \right]}^{\Delta D^t/Y_0} + \overbrace{\pi \frac{\tilde{k}^*}{\tilde{y}_0} (ng^*)^T}^{\Delta D^i/Y_0} + \overbrace{\pi \frac{\tilde{w}}{R^* \tilde{y}_0} (ng^*)^T \sum_{t=0}^{T-1} \left(\frac{ng^*}{R^*} \right)^t [1 - f(t)]}^{\Delta D^s/Y_0} . \tag{11}$$

Net capital inflows are increasing in the productivity catch-up parameter (π), decreasing in the initial level of capital ($\tilde{k}_0$) and, when trend growth is positive ($ng^* > 1$), increasing in the initial level of debt ($\tilde{d}_0$).

Proof. See appendix A ■

Equation (11) implies that a country without capital scarcity ($\tilde{k}_0 = \tilde{k}^*$), without initial debt ($\tilde{d}_0 = 0$) and without productivity catch-up ($\pi = 0$) has no net capital flows. Consider now each term on the right-hand side of equation (11) in turn.

The first term, $\Delta D^c/Y_0$, results from the initial level of capital scarcity $\tilde{k}^* - \tilde{k}_0$. Under financial integration, and in the absence of financial frictions or adjustment cost of capital, the country instantly borrows and invests precisely the amount $\tilde{k}^* - \tilde{k}_0$. We call this term the *convergence* term.

The second term, $\Delta D^t/Y_0$, reflects the impact of initial debt. In the absence of productivity catch-up the economy follows a balanced growth path in which external debt remains a constant fraction of output. The cumulated debt inflows that are required to keep the debt-to-output ratio constant are equal to ΔD^t and increase with debt when trend growth is positive ($ng^* > 1$). We call this term the *trend* term.

The third and fourth terms in (11) reflect the impact of the productivity catch-up. The third term, $\Delta D^i/Y_0$, 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* $k = \tilde{k}A$ needs to increase more when there is a productivity catch-up. Without productivity catch-up, capital at time T would be $\tilde{k}^* N_T A_0 g^{*T}$. Instead, it is $\tilde{k}^* N_T A_T$. The difference, $\pi \tilde{k}^* N_T A_0 g^{*T}$, normalized by output $\tilde{y}_0 A_0 N_0$, is equal to $\Delta D^i/Y_0$. This is the *investment* term.

Finally, the fourth term, $\Delta D^s/Y_0$, represents the change in external debt brought about by changes in *domestic saving*. It is proportional to normalized labor income (here the wage $\tilde{w}$) and to the long-run productivity catch-up π. Faster relative productivity growth implies higher future income, leading to an increase in consumption and a decrease in savings. Since current income is unchanged, the representative domestic consumer borrows on the international markets. This is the *saving* term.

The proposition immediately implies the following corollary .

Corollary 1 (Capital Flows and Productivity Catch-Up) *Under the assumptions of proposition 1,*

1. *Consider a country without initial capital scarcity ($\tilde{k}_0 = \tilde{k}^*$) or initial debt ($\tilde{d}_0 = 0$). Then the country receives a positive level of capital inflows if and only if its productivity catches up relative to the world technology frontier:*

$$\Delta D/Y_0 > 0 \text{ if and only if } \pi > 0.$$

2. *Consider two countries A and B, identical except for their long-run productivity catch-up. Then country A receives more capital inflows than country B if and only if A catches up more than B toward the world technology frontier:*

$$\Delta D^A/Y_0^A > \Delta D^B/Y_0^B \text{ if and only if } \pi^A > \pi^B.$$

The first part of the corollary says that capital should flow *into* the developing countries whose TFP catches up relative to the world frontier, and should flow *out* of the countries whose TFP falls behind. This is not a surprising result: international capital markets should allocate capital to the countries where it becomes more productive relative to the rest of the world. The second part of the corollary says that other things equal, the countries that grow faster should receive more capital flows.

Our results rely on a set of simple assumptions (perfect capital mobility, perfect foresight, infinitely-lived agents). However, the comparative static results stated in Proposition 1 —and in particular, the positive correlation between productivity catch-up and net capital inflows— hold in a much larger set of models. First, consider the assumption of perfect capital mobility. One could argue that in reality, the ability of developing countries to borrow is reduced by financial frictions.[9] Yet, we would argue that even if international financial frictions were important, it would remain true that net capital inflows are positively correlated with productivity growth. International financial frictions can reduce the predicted size of capital inflows, but there is no reason that they should change the sign of the correlation between π and ΔD.[10] The same would be true if we introduced an adjustment cost in the accumulation of capital.

Similarly, the behavior of aggregate saving would be different if the economy were populated by overlapping generations instead of infinitely-lived consumers. In particular, aggre-

[9] As noted before, we think that a high degree of capital mobility is a reasonable assumption given Caselli and Feyrer (2007)'s finding that the real returns to capital are not very different across the world.

[10] This point is easy to see if we augment our model with a constraint stipulating that external debt cannot exceed a certain ceiling that is itself increasing with domestic output or domestic capital. Then capital flows to capital-scarce countries are lower than in the absence of constraint but it remains true that a country without initial debt or capital scarcity receives a positive level of capital inflows if and only if it catches up relative to the world technology frontier, and that the volume of capital inflows is increasing with productivity growth.

gate saving would be less responsive to growth, as current generations would not be able to borrow against the income of future generations. However, it remains true, in plausibly calibrated OLG models, that aggregate saving is decreasing with the level of economic growth, so that higher growth would still be associated with a larger volume capital inflows.[11]

Another restrictive assumption behind our results is perfect foresight. Other things equal, making the representative consumer's income risky should increase the level of savings by adding a precautionary motive, especially if there is also an external credit constraint. This would not change the fact, however, that the representative household is willing to borrow against future income, and so the model would still predict a negative (positive) correlation between saving (capital inflows) and expected trend growth.[12]

Thus, the neoclassical growth framework makes a very robust prediction for the sign of the correlation between productivity growth and capital inflows. Countries that grow at a higher rate should receive more capital inflows. We now proceed to look at this correlation in the data.

3 The Allocation Puzzle

Do developing countries with faster productivity growth, larger initial capital scarcity, or larger initial debt level receive more capital flows? We answer this question by comparing, for each country in our sample, the model predictions with the observed net capital flows.

3.1 Measuring productivity growth and capital flows

We focus on the period 1980-2000. This choice of period is motivated by two considerations. First, we want to consider a period where countries were financially open. Indicators of financial openness show a sharp increase starting in the late 1980s and early 1990s. For instance, the Chinn and Ito (2008) index indicates an average increase in financial openness from -0.38 in 1980 to 0 in 2000 for the countries in our sample.[13] Second, we want as long a sample as possible, since the focus is on long-term capital flows. Results over shorter periods may be disproportionately affected by a financial crisis in some countries or by fluctuations in the world business cycle. Our final sample consists of 68 developing countries: 65 non-OECD countries, as well as Korea, Mexico and Turkey.[14]

We measure productivity growth following the method that has become standard in the development accounting literature. First we estimate n for each country as the annual

[11] This is why the models developed to account for the positive correlation between saving and growth that is observed in the data had to rely on other explanations, such as consumption habit (see Carroll, Overland and Weil (2000)). We will discuss whether such models can explain the allocation puzzle in section 6.

[12] Things could be different if higher growth is associated with higher risk—we will come back to that point in section 6.

[13] The index is normalized to run from -2.6 (most closed) to 2.6 (most open).

[14] We will sometimes refer to the countries in our sample simply as non-OECD countries. For a small set of countries, the sample period starts later and/or end earlier, due to data availability. The list of countries and sample period are reported in appendix D.

growth rate of the working-age population.[15] The other country-specific data are the paths for output, capital and productivity. Those data come from Version 6.1 of the Penn World Tables (Heston, Summers and Aten (2004)). The capital stock K_t is constructed with the perpetual inventory method from time series data on real investment (also from the Penn World Tables), assuming a capital share α of 0.3 and a depreciation rate δ of 6 percent.[16] From equation (1), we obtain the level of productivity A_t as $(y_t/k_t^{\alpha})^{1/(1-\alpha)}$, and the level of capital stock per efficient unit of labor $\tilde{k}_t$ as $(k_t/y_t)^{1/(1-\alpha)}$. The growth rate of world productivity g^* is set to 1.017, the annual TFP growth observed on average in the U.S. between 1980 and 2000. The productivity catch-up parameter, π, is then measured as $\bar{A}_{2000}/(g^{*20}\bar{A}_{1980}) - 1$, where $\bar{A}_t$ is obtained as the trend component of the Hodrick-Prescott filter of A_t.[17]

We then construct, for each country, the volume of capital inflows between 1980 and 2000 in terms of initial GDP,

$$\frac{\Delta D}{Y_0} = \frac{D_{2000} - D_{1980}}{Y_{1980}}.$$

The estimate of the initial net external debt in U.S. dollar (D_0) is obtained from Lane and Milesi-Ferretti (2007)'s External Wealth of Nations Mark II database (EWN), as the difference between (the opposite of) the reported net international investment position (NIIP) and the errors and omissions (EO) cumulated between 1970 and 1980. We measure net capital inflows in current U.S. dollars using IMF's International Financial Statistics data on current account deficits, keeping with the usual practice that considers errors and omissions as unreported capital flows. We need an appropriate price index to convert both measures into constant international dollars, the unit used in the Penn World Tables for real variables such as output and capital stocks. In principle, the trade and current account balances should be deflated by the price of traded goods, but the Penn World Tables do not report this price index. We use instead the price of investment goods which is reported in the Penn World Tables. This seems to be a good proxy because investment goods are mostly tradable—as suggested by the fact that their price vary less across countries than that of consumption goods. The PPP adjustment tends to reduce the estimated size of capital flows relative to output in poor countries, because those countries have a lower price of output (see Hsieh and Klenow (2007)). Appendix B provides additional details.

One advantage of our PPP-adjusted estimates of cumulated capital flows is that they can be compared to the measures of output or capital accumulation used in the development accounting literature. The allocation puzzle, however, does not hinge on the particular assumptions that we make in constructing those estimates. We tried other deflators, which

[15] Working-age population (typically ages 15-64) is constructed using United Nations data on World Population Prospects.

[16] See Caselli (2005) for details. Following standard practice, we set initial capital to $I/(g_i + \delta)$ where I is the initial investment level from the Penn World Tables and g_i is the rate of growth of real investment for the first 10 years of available data. Recent estimates by Gollin (2002) suggest that the capital share is roughly constant within countries, and varies between 0.2 and 0.4 across countries.

[17] We keep the smoothing parameter equal to 1600. With annual data, this filters out more than 70% of cycles of periodicity lower than 32 years ensuring a very smooth trend productivity. See King and Rebelo (1993a).

did not affect the thrust of our results.[18]

3.2 Correlation between productivity growth and capital flows

Table 1 presents estimates for the productivity catch-up parameters and capital flows for the whole sample as well as regional and income groups. The estimates of π reported in column (1) show that there is no overall productivity catch-up with advanced countries: π is slightly negative on average. Thus we should not expect a lot of capital to flow from advanced to developing countries. Yet, closer inspection reveals an interesting geographical pattern. There was a sizeable productivity catch-up in Asia ($\pi = 0.19$), while Latin America and Africa fell behind ($\pi = -0.24$ and -0.17 respectively).[19] So while we should not expect substantial capital inflows into developing countries as a whole, we should expect international capital to flow *out of* Africa and Latin America, and *into* Asia.

This does not seem to be the case in the data. Column (2) of Table 1 reports observed net capital inflows as a fraction of initial output, $\Delta D/Y_0$. Africa received slightly less than 40 percent of its initial output in capital flows. Similarly, capital flows to Latin America amounted to 37 percent of its initial output, in spite of a significant relative productivity decline. By contrast, Asia, whose productivity grew at the highest rate, borrowed over that period only 11 percent of its initial output.

The same pattern is evident if we group countries by income levels rather than regions. According to Table 1, poorer countries experienced lower productivity catch-up and so should export more capital according to Corollary 1. Observed capital inflows run in the exact opposite direction: actual capital flows *decrease* with income per capita, from 56 percent of output for low income countries to -58 percent for high-income non-OECD countries.

Figure 2 gives a broader cross-country perspective on the discrepancy between the model predictions and the data by plotting observed capital inflows against observed productivity catch-up for the full country sample, together with the relationship that should have been observed (according to the model) based on the investment term $\Delta D^i/Y_0$ (solid line with triangles) and the saving term $\Delta D^s/Y_0$ (dashed line with circles). The model predictions are computed assuming that there is no initial debt or capital scarcity ($\tilde{d}_0 = 0$ and $\tilde{k}_0 = \tilde{k}^*$) and using the average growth rate of working-age population in our sample: $\bar{n} = 1.0214$. Under these assumptions, predicted total net inflows is the sum of the investment and saving terms in equation (11) where each term is linear in the productivity catch-up coefficient.[20]

One observes immediately that most countries are located in the 'wrong' quadrant of the figure, with negative productivity catch-up but positive capital inflows. Indeed, the empirical correlation between productivity catch-up and capital inflows is negative and statistically

[18] For instance, results are similar when using the price of output as a deflator. The results are available from the authors upon request.

[19] This pattern does not apply uniformly to all countries within a region. For instance, $\pi = -0.34$ for the Philippines, 0.28 for Chile and 0.47 for Botswana.

[20] For simplicity, we assume that the productivity catch-up follows a linear path: $f(t) = \min(t/T, 1)$. The world interest rate is set to $R^* - 1$=5.94 percent per year, the level that results from (8) if $\beta = 0.96$, and preferences are logarithmic.

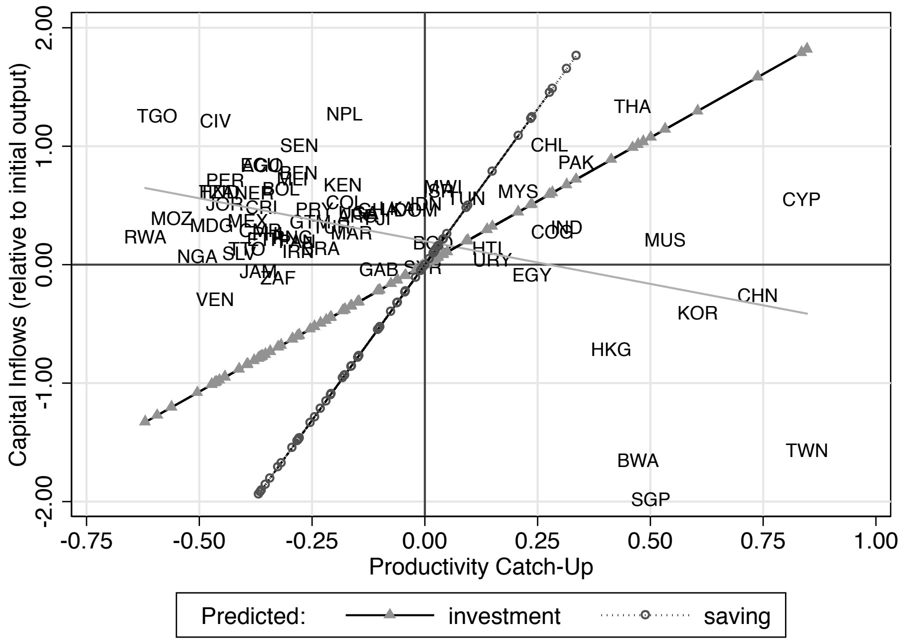


Figure 2: Productivity catch-up (π) and change in external debt ($\Delta D/Y_0$) together with predicted investment $\left(\Delta D^I/Y_0\right)$ and predicted saving $\left(\Delta D^S/Y_0\right)$ terms.

significant at the 1 percent level.[21]

In addition to confirming, with different measures, the basic correlation already shown in Figure 1, Figure 2 compares the data to the prediction of the basic neoclassical growth framework. We observe that capital flows are not only negatively correlated with the model predictions but also tend to be smaller in absolute value. This is especially true if we look at the saving component, which implies that a one percentage point increase in the productivity catch-up variable π should raise capital inflows by 5.25 percent of initial output.[22] For a country such as Korea, with a productivity catch up π equal to 0.61, the model predicts investment and saving components of net capital *inflows* each in excess of 130 percent of initial output. Conversely, for Madagascar, with a relative productivity decline π equal to -0.47, the model predicts investment and saving components of net capital *outflows* each in excess of 100 percent of initial output!

As noted at the end of section 2, the saving component is very responsive to growth in the model because of the assumption that consumers are infinitely-lived and can perfectly smooth consumption. Introducing financial frictions or assuming different preference structures could reduce significantly the importance of the saving component.[23] By contrast, observed flows

[21]The slope of the regression line in figure 2 is -0.68 with a s.e. of 0.18 (p-value smaller than 0.01).

[22]The slope of the investment term $\Delta D^i/Y_0$ is $(\bar{n}g^*)^{20} = 2.14$ while the slope of the saving term $\Delta D^s/Y_0$ is $(1+(1-\alpha)\tilde{k}^{*(\alpha-1)}/R^* \sum_{t=0}^{19} (\bar{n}g^*)^t (1-t/20) (\bar{n}g^*)^{20} = 5.25$.

[23]In the limit case where households cannot access financial markets, the saving component would equal zero.

are of the same order of magnitude as the investment component of predicted flows. The ratio of the sum of the absolute value of the observed net inflows amounts to 76 percent of the model prediction based on the investment component. We conclude that the model is able to reproduce the magnitude of capital flows (the range on the vertical axis in Figure 2) much better than their allocation across countries (the slope on Figure 2).

This finding is robust to controlling for determinants of capital flows other than productivity. One problem with the correlation reported in Figure 2 is that it does not control for cross-country differences in initial capital scarcity, initial debt, or population growth rates. The negative correlation between the productivity growth rate and capital inflows could be due to the fact that countries with lower productivity growth also tend to have higher initial capital scarcity or debt. Is it true in the data? We answer this question by regressing observed capital inflows $\Delta D/Y_0$ on the predictors identified in Proposition 1: initial capital abundance k_0/y_0, initial debt d_0/y_0, working-age population growth n, as well as productivity catch-up π. The results are reported in the first column of Table 2. Observed capital flows are still significantly negatively correlated with productivity catch-up. The other variables do not enter significantly, except initial debt, which has a positive coefficient as predicted by theory but much smaller in magnitude.[24]

The remaining two columns of Table 2 report the results of the same regression when the Chinn-Ito measure of capital controls is added as a regressor, either additively (second column) or interacted with the productivity catch-up (third column). One would *a priori* expect a better fit between the model and the data for more financially open countries. Yet we find the opposite to be true: the coefficient on productivity catch-up remains strongly negative, the more so for more financially open economies.[25]

We ran a number of other robustness checks whose results are not reported here.[26] We controlled for initial capital scarcity and initial debt by constraining the coefficient on those variable to be those coming from equation (11). We also found our results to be robust to the exclusion of African countries (where arguably many countries may be too poor to export capital while maintaining subsistence levels of consumption). We also started the analysis in 1970 instead of 1980. While the sample is much smaller (30 countries instead of 68), and many developing countries had closed financial accounts in the early part of the sample, the results are broadly similar. We also controlled capital flows for official aid (those results are reported in section 5).[27]

It may be useful at this point to emphasize the difference between the allocation puzzle and the Lucas puzzle. The Lucas puzzle states that the volume of capital flows to the average developing country is surprisingly small. We find instead that the model has little to say about that. Since the average country fell modestly behind the world technology between

[24] The predicted coefficient according to proposition 1 would be equal to $(ng^*)^T - 1 = 1.14$. The estimated coefficient is 0.006.

[25] Given the range of variation of the Chinn-Ito index from -2.6 (least open) to 2.6 (most open), for more open economies a 1% increase in productivity catch-up reduces significantly net capital inflows by -0.697-2.6*0.455=1.88 % of initial capital.

[26] These results are available upon request.

[27] We also used as an alternate measure of net capital inflows ΔD the change in net investment position constructed by Lane and Milesi-Ferretti (2007). The results were unchanged.

1980 and 2000 ($\pi = -0.1$ in Table 1), the model predicts modest net capital outflows of at most 0.7 percent of initial output. Instead, observed capital inflows averaged 30 percent of initial output (column (2)). As we will show in section 5, observed average net capital inflows using aid-adjusted flows equal -20 percent of initial output. In other words, the range of plausible observed capital flows (from -20 to +30 percent) dwarfs the average model-based predictions flows in either direction and it is hard to conclude from this whether there is too much or too little capital flowing to developing countries on average.

The allocation puzzle is instead about the allocation of capital inflows *across countries*, and how this allocation is correlated with cross-country differences in productivity growth —it is the Lucas puzzle, but in first differences. A very robust and intuitive prediction of the neoclassical growth framework is that countries that have higher productivity growth over long periods of time should receive more capital inflows than countries with lower productivity growth. We find that this is not the case in the data.[28]

4 Wedges

Net capital inflows are the difference between investment and savings. Is the allocation puzzle driven more by the behavior of investment or by that of savings? We answer this question by introducing in the model two wedges, one that affect capital accumulation and one that affects savings decisions. By construction, it is possible to determine, for each country, the levels of the wedges that are required so as to achieve a perfect match with the data. Therefore, we should not interpret these wedges as an *explanation* for the allocation puzzle, but rather as a diagnosis tool, a metric that points to the first-order conditions that exhibit the largest discrepancies with the data—and may then guide us toward the type of changes to the model that may explain the puzzle.[29]

The first wedge that we introduce into the model distorts investment decisions: we assume that investors receive only a fraction $(1 - \tau_k)$ of the gross return to capital R_t. We call τ_k the 'capital wedge'. It can be interpreted as a tax on gross capital income, or as the result of other distortions—credit market imperfections, expropriation risk, bureaucracy, bribery, and corruption—that would also introduce a 'wedge' between social and private returns to physical capital.[30] With perfect capital mobility, capital accumulation will adjust so that

[28]We focus on non-OECD countries because the main motivation of the paper is related to the role of international capital flows in economic development, and because this country group exhibits considerable heterogeneity in productivity growth. Running the same type of exercise with OECD countries yields different results (available on request). We do find that the allocation puzzle in the weak form applies also to OECD countries: there is little to no correlation between capital flows and productivity growth. However, this result is not very robust. First, noise and mis-measurement are more likely to be an issue are for advanced economies because of the smaller cross-country differences in productivity growth. Second, we find that increased financial openness significantly raises the impact of productivity growth on capital inflows for these countries, in line with theory.

[29]A quick and incomplete list of potential distortions that could influence observed wedges would include demographics, interest rate risk, natural resources, fiscal policy etc...

[30]This capital wedge could also come from inefficiencies in producing investment goods that affect the relative price of capital goods as in Hsieh and Klenow (2007).

the wedge adjusted return $(1-\tau_k)R_t$ equals the world interest rate R^*.

We introduce our second wedge into the budget constraint of the representative family:

$$C_t + K_{t+1} = (1-\tau_s)(R_t(1-\tau_k)K_t - R^* D_t) + D_{t+1} + N_t(w_t + z_t), \tag{12}$$

where τ_s is the "saving wedge" and z_t is a lump-sum transfer. When positive, this wedge functions like a tax on capital income that reduces current consumption relative to future consumption. The Euler equation for the small open economy becomes $c_t^{-\gamma} = \beta R^*(1-\tau_s)c_{t+1}^{-\gamma}$. In order to focus solely on the distortion induced by the wedges, we assume that the revenue per capita that they generate, $z_t = \tau_k R_t k_t + \tau_s R^*(k_t - d_t)$, is rebated to households in a lump-sum fashion. Lastly, we assume that $\tau_s = 0$ for $t \leq T$, in order to ensure that the small open economy ends up with the same consumption growth rate as the rest of the world.[31]

The model with wedges can be solved in closed form (see Appendix C for details). The model-predicted level of net capital inflows $\Delta D/Y_0$ is now also a function of the wedges, $\mathcal{D}\left(\widetilde{k}_0, \widetilde{d}_0, \pi, \tau_k, \tau_s\right)$. Moreover, because of perfect capital mobility, there is a Fisherian separability between the two wedges, in the sense that the capital wedge required to explain the observed investment rate can be computed independently of the saving wedge required to explain the observed level of savings. We now turn to the calibration of the wedges, starting with the capital wedge.

4.1 The capital wedge

Our approach is to calibrate the capital wedge so as to match exactly the investment rates observed in the data, using the same calibration as in section 2. The capital wedge τ_k can be estimated to match the observed investment rates, as shown in the following proposition.

Proposition 2 *Given an initial capital stock $\tilde{k}_0$, productivity catch-up π, and capital wedge τ_k, the average investment-output ratio between $t=0$ and $t=T-1$ can be decomposed into the following three terms:*

$$i_k = \frac{1}{T}\frac{\tilde{k}^*(\tau_k) - \tilde{k}_0}{\tilde{k}_0^{\alpha}} + \frac{\pi}{T}\tilde{k}^*\left(\tau_k\right)^{1-\alpha} g^* n + \tilde{k}^*\left(\tau_k\right)^{1-\alpha}(g^* n + \delta - 1). \tag{13}$$

where $\tilde{k}^*(\tau_k) = \left(\frac{\alpha}{R^*/(1-\tau_k)+\delta-1}\right)^{1/1-\alpha}$ *is the level of capital per efficient unit of labor.*

Proof. See appendix A. ■

Equation (13) has a simple interpretation. The first term on the right-hand side corresponds to the investment at time $t=0$ that is required to put capital at its equilibrium

[31] If we relaxed that assumption (for example, if we assumed that the wedge were constant), the inferred values for τ_s would be different but this would not affect the thrust of our results.

level. This is the *convergence* component. The second term reflects the additional investment required by the productivity catch-up. The last term is simply the usual formula for the investment rate in steady state, with productivity growth g^*. It corresponds to the investment required to offset capital depreciation, adjusted for productivity and population growth.[32]

Equation (13) implicitly determines the capital wedge τ_k as a function of the observed average investment rate i_k, productivity catch-up π and population growth n. Appendix D reports the values of i_k, π, n and τ_k for each country in our sample. Everything else equal, our calibration approach assigns high capital wedges to countries with low average investment rates.

Table 3 reports information on the investment rate, the capital wedge, and the decomposition of the observed investment rate i_k into the three components of equation (13). First, as is well known, investment rates vary widely across regions. They also vary with income levels, increasing from 8.5 percent for low income countries to 28.5 percent for high-income non-OECD countries. Table 3 indicates that most of the variation in the investment rate is accounted for by the trend component, which itself is strongly correlated with the capital wedge τ_k (reported in column (5)). To a first order of approximation, countries with a high investment rate are those that are able to maintain a high capital-to-output ratio because of a low distortion on capital accumulation.

The convergence and productivity growth components (columns (2) and (3)) account for a relatively small share of the investment rates on average. The small contribution of the convergence component is explained by the fact that the initial capital gap was relatively small on average at the beginning of the sample period ($k_0/k^* = 0.98$). But this average masks significant regional disparities between Asia and Latin America, which were capital scarce ($k_0/k^* = 0.87$ and 0.94 respectively), and Africa, which was capital abundant ($k_0/k^* = 1.09$).

The estimated capital wedge (column (5)) varies between 51.4 percent for Uganda and -2.5 percent for Singapore, with an average of 11.5 percent. It is negatively correlated with both the level of economic development and the productivity catch-up parameter (see Figure 3)—consistent with the idea that economic development is associated with better institutions and lower distortions on capital accumulation. The negative correlation between the capital wedge and the productivity catch-up magnifies the positive correlation between the productivity catch-up and capital inflows predicted by the model —which tends, if anything, to aggravate the allocation puzzle.

That the capital wedge does not help to explain the allocation puzzle is made clear by Figure 4. This figure plots the volume of capital inflows predicted by the model with capital wedges against the productivity catch-up π. The correlation is positive and statistically very significant: according to the model countries with productivity catch-up should be net recipients of foreign capital, and countries falling behind should be net lenders.[33]

[32] Observe that when $g^* = n = 1$, this last term simplifies to $\delta\tilde{k}^{*(1-\alpha)} = \delta\tilde{k}^*/\tilde{y}^*$.

[33] We estimate a slope coefficient of 19.06, with a s.e. of 0.74 (p-value$<$0.01). Excluding the saving term would reduce the slope from 19.06 to 3.34 but not change its positive and significant sign.

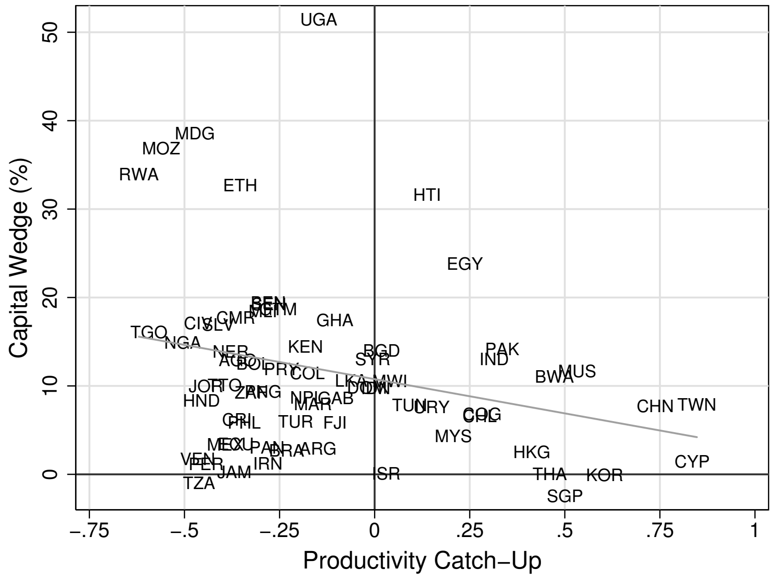


Figure 3: Productivity catch-up (π) and capital wedge (τ_k).

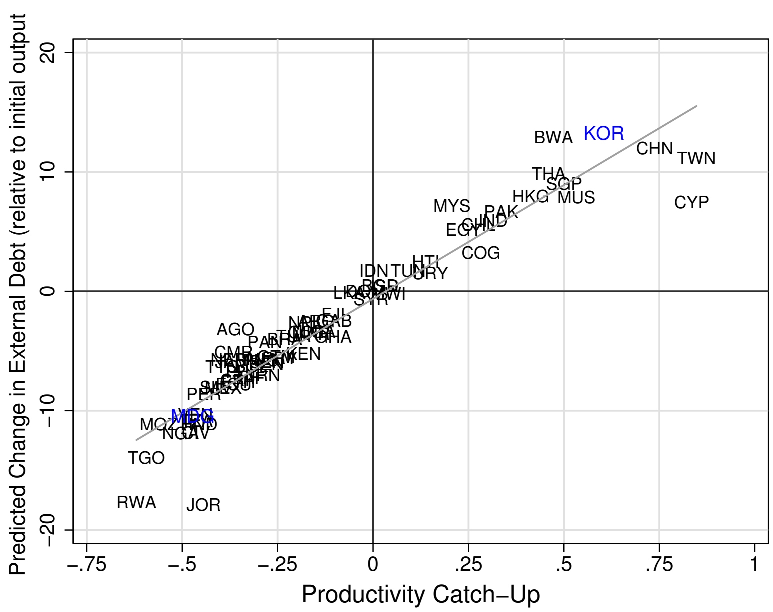


Figure 4: Productivity catch-up (π) and capital inflows $\left(\frac{\Delta D}{Y_0}\right)$ predicted by the model with capital wedges.

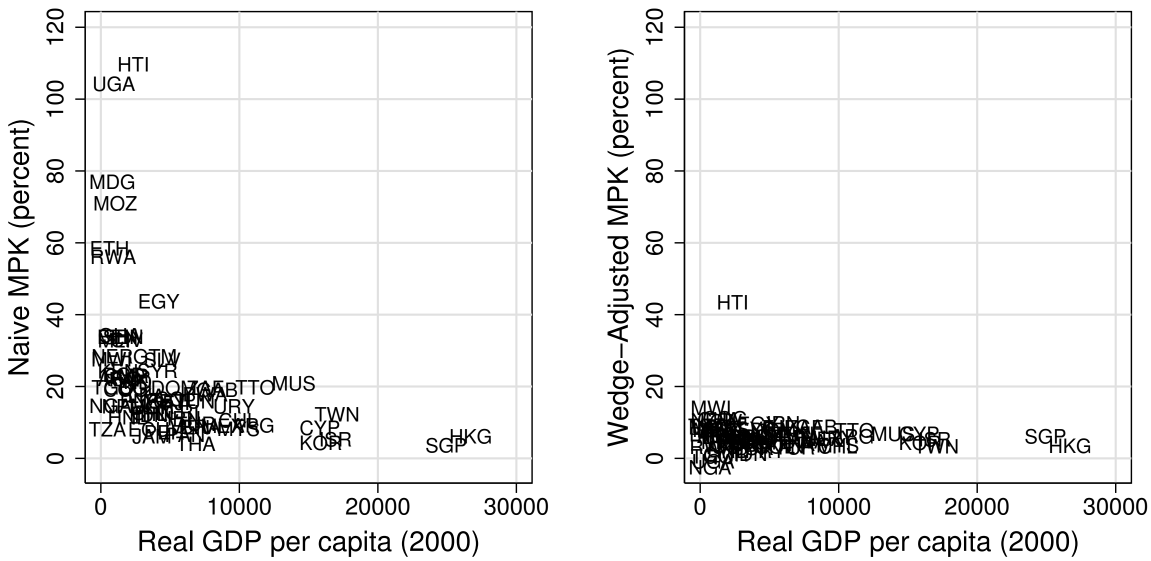


Figure 5: Naïve and Wedge-adjusted Marginal Product of Capital in year 2000.

As a final comment, it is interesting to note that the capital wedge plays a similar role as adjusting for non-reproducible capital and relative price effects discussed in Caselli and Feyrer (2007). Those authors argue that, while naïve estimates of the marginal product of capital vary enormously across countries, the returns to capital are essentially the same once the estimates are adjusted for cross-country differences in the share of non-reproducible capital in total capital and in the price of reproducible capital in terms of output, which are both higher in less advanced countries. Our approach leads to the same cross-country compression in the estimates of the returns on capital, but this is achieved by the capital wedge τ_k.

To illustrate this point, Figure 5 compares the naive estimate of private returns (left panel), defined as $RN = \alpha Y/K - \delta$, and the wedge-adjusted return (right panel), $RW = (1 - \tau_k)(1 + RN) - 1$, against 2000 income per capita. The left panel indicates enormous variation in the naïve estimate, between 3.6 percent (Singapore) and 110 percent (Haiti), with a mean of 22.3 percent. By contrast, the wedge-adjusted return varies between -2.5 percent (Nigeria) and 43 percent (Haiti, a clear outlier), with a mean of 6.3 percent. The amount of compression is remarkable, given that the capital wedge is not calibrated to ensure private returns equalization. Our results thus parallel those of Caselli and Feyrer (2007): private returns to capital appear remarkably similar across countries.[34]

To summarize, introducing investment wedges to match observed investment rates into the model does not help to solve the allocation puzzle, but is consistent with the equalization of private returns to capital across countries. We now turn to the saving wedges.

[34] In Gourinchas and Jeanne (2007) we also look at the correlation between productivity growth and capital inflows when productivity is measured based on the model with non-reproducible capital of Caselli and Feyrer (2007). We find the same negative correlation.

4.2 The saving wedge

We now estimate the saving wedges that are required to explain the level of capital flows observed in the data. Having estimated the capital wedge using observed investment rate, we compute for each country the saving wedge τ_s such that the model-predicted level of net capital inflows is equal to the observed level,

$$\mathcal{D}\left(\widetilde{k}_0, \widetilde{d}_0, \pi, \tau_k, \tau_s\right) = \frac{\Delta D}{Y_0}.$$

With both capital and saving wedges, the model replicates perfectly, but trivially, the observed capital flows. In order to compute the left-hand side of the equation above, we need to make further assumptions about preferences. First, we assume logarithmic preferences ($\gamma = 1$) and set the discount factor β to 0.96 (which implies $R^* - 1 = 5.94$ percent per year, as indicated before).[35]

Figure 6 reports the calibrated saving wedge against the productivity catch-up π. A number of salient facts stand out. First, we observe that the saving wedge needed to account for aggregate saving ranges from -6 percent for countries such as Taiwan or Singapore, to 6 percent for countries such as Rwanda or Angola, with an average of 1 percent. This may seem relatively small but the cumulative impact on initial consumption of such annual wedges applied for twenty years is large.

Second, the pattern of saving wedges across countries is far from random. We observe a strong negative correlation between the saving wedge and productivity catch-up: countries whose productivity catches up ($\pi > 0$) are also countries that "subsidize"saving ($\tau_s < 0$) while countries that fall behind ($\pi < 0$) are countries that "tax" saving ($\tau_s > 0$). The linearity and intercept (close to 0) of this relationship imply that on average, countries that catch-up twice as much in terms of productivity "subsidize" their saving twice as much. Given the sensitivity of capital flows to the saving wedge, this translates into significant capital outflows.

Explaining the allocation puzzle requires explaining the correlation shown in Figure 6. To some extent, the saving wedge can be interpreted as a distortion. This is for example the case if a negative wedge (a saving subsidy) reflects domestic financial repression that prevents residents from borrowing against their future income.[36]

We conclude this section by showing the decomposition of the observed levels of capital flows into the same four terms as in equation (11).[37] The wedges are now included, so that the model predicts exactly the observed capital flows for each country. Table 4 presents the decomposition together with the calibrated saving wedge τ_s.

We observe first that the convergence (column (2)) and investment (column (3)) components are independent from the saving wedge τ_s. They reflect simply initial capital scarcity,

[35] The coefficient or relative risk aversion γ matters for the size of the estimated saving wedge but not for its correlation with the productivity catch-up.

[36] But note that the distortion would need to be *positively* correlated with productivity growth to account for Figure 6.

[37] See appendix C for details.

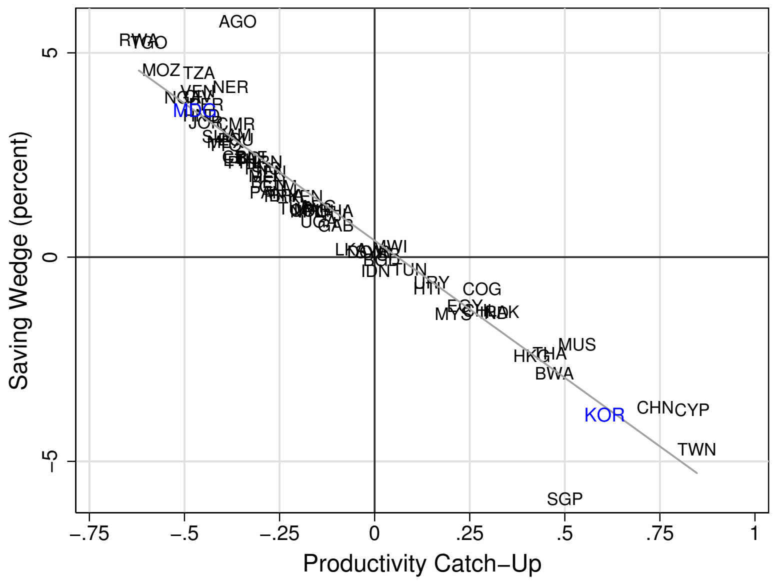


Figure 6: Productivity catch-up (π) and saving wedges (τ_s).

productivity catch-up and distortions in the accumulation of domestic capital summarized by the capital wedge τ_k. Not surprisingly, the convergence component is positive for Asia and Latin America (capital scarce regions) and negative for Africa (capital abundant), while the investment component is positive for Asia (productivity catch-up) and negative for Latin America and Africa (productivity decline). The sum of these two terms is negatively correlated with observed capital inflows.

This illustrates the extent to which the allocation puzzle is a *saving* puzzle: adjusting investment rates to account for physical capital accumulation is not enough to account for patterns of capital flows across countries. The saving wedge is essential to account for the observed pattern of net capital flows across developing countries. Our wedge analysis indicates that Asia subsidizes saving ($\tau_s = -1.14$ percent) whereas Latin America and Africa tax savings similarly ($\tau_s = 1.8$ percent). Similarly, the saving tax decreases with levels of development.

5 Public vs. private flows

Having established that the allocation puzzle is a saving puzzle, we now offer a different cut of the data. This section documents differences between the behavior of public capital flows (defined as flows that go to or emanates from the public sector) and that of private flows (defined as the residual). We look first at official aid flows, and then at broader measures of public flows.[38] One could argue that the basic neoclassical framework may not be appropriate

[38] Our results on aid flows were reported in previous versions of this paper. The analysis was extended to public flows as defined by Aguiar and Amador (2011) following a suggestion of the editor and referees.

to predict public flows because those flows are not necessarily allocated to the countries with the highest expected returns on capital.[39] This objection does not invalidate, per se, the predictions of the basic model for net capital flows. For example if we assumed that aid flows or public external debt were financing a lump-sum transfer to the domestic consumer in the model of section 2, then an increase in public flows would be offset one-for-one by a decrease in the private sector's external borrowing, and the predictions of the model would remain valid for *net* capital flows.[40]

However, things might be different if private capital flows are constrained by financial frictions that do not affect public flows to the same extent. Then, public flows could finance an increase in domestic expenditures above and beyond what could be financed by private capital flows. In addition, capital controls could prevent changes in public flows from being completely offset by private flows. Whether public flows are neutral in a Barro-Ricardian sense is an empirical question.

To see how far public flows can go in explaining the puzzles, we make the extreme assumption that those flows are *not* offset by any other type of capital flows. That is, we ask whether the allocation puzzle applies to the counterfactual volume of net capital flows equal to the observed cumulated net capital flows ΔD *minus* the cumulated public flows ΔD^{pub},

$$\frac{\Delta D'}{Y_0} = \frac{\Delta D - \Delta D^{pub}}{Y_0}.$$

This is an extreme assumption since, as argued above, a change in public flows should be offset, at least partially, by a counterveiling change in private flows.

First, let us look at the impact of official aid flows. Our measure of official aid flows is the net overseas development assistance (net ODA) from the Development Assistance Committee (DAC).[41] As shown in Appendix B, it is possible to compute the PPP-adjusted cumulated net ODA flows normalized by initial GDP using the same method as for net capital flows.

Column (2) of Table 6 reports aid-adjusted net capital inflows. Since net ODA flows are always positive in our sample (all developing countries are net recipients), $\Delta D'$ is always *smaller* than ΔD reported in Table 1. As a result, the average developing country is found

[39]On the one hand, public flows should be positively correlated with productivity growth if they finance forms of public investment that are associated with economic development. On the other hand, there is a selection bias if the countries that have been receiving public flows over long periods of time are those that have failed to develop (as would be the case for humanitarian aid flows). The large literature on development aid has generally failed to find a significant relationship between aid and growth (see Rajan and Subramanian (2008)).

[40]Indeed, one may think of cases where external borrowing or official aid go hand-in-hand with the commensurate overseas enrichment of a few government officials who place their savings abroad. For a discussion of a number of well-known cases and an analysis along these lines, see Jayachandran and Kremer (2006). Our approach is robust to these unrecorded financial transactions, since we measure net capital inflows using data on current account deficits, and treat errors and omissions as unrecorded capital flows.

[41]This measure is available for all countries in our sample, except Taiwan. According to Roodman (2006), DAC counts total grants and concessional development loans and subtracts principle repayments on these loans (hence the 'net'). Our results remain unchanged if we use instead Roodman's (2006) Net Aid Transfer measure.

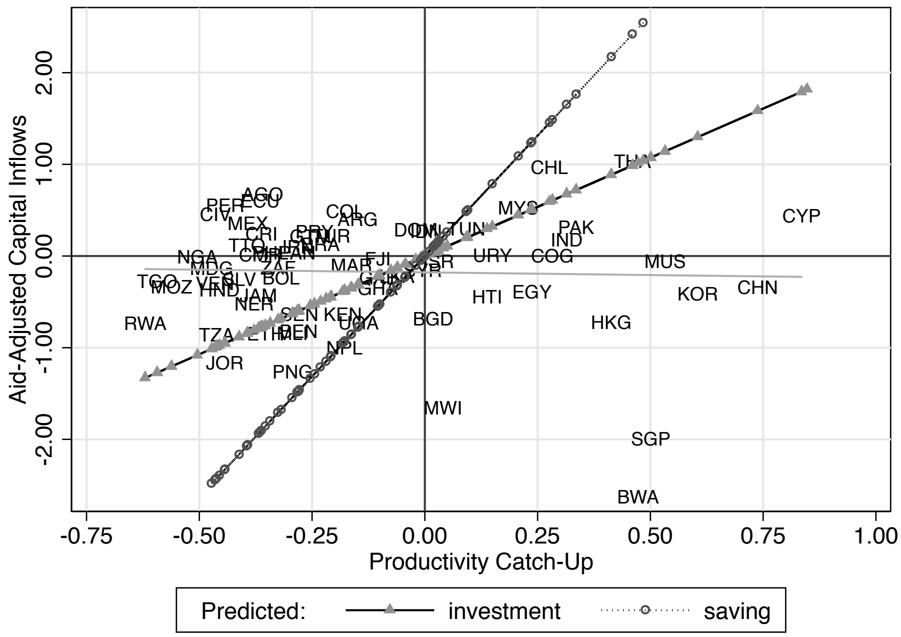


Figure 7: Productivity catch-up (π) and change in aid-adjusted external debt ($\Delta D'/Y_0$) together with predicted investment $\left(\Delta D^I/Y_0\right)$ and predicted saving $\left(\Delta D^S/Y_0\right)$ terms.

to *export* capital net of aid flows (20 percent of initial output, on average). This comes mostly from the low-income and African countries for whom gross aid inflows are twice as large as total net inflows. However, the allocation puzzle persists since higher income countries and Asian countries export relatively more capital than low income countries or Latin American countries, in contradiction with the predictions of the model. The correlation between productivity catch-up and aid-adjusted capital flows is shown in Figure 7 which is similar to Figure 2, but with our measure of aid-adjusted net capital flows. A large level of cross-country variation in capital flows remains. The correlation remains negative, although it is no longer significantly different from zero.[42]

We conclude that although official aid flows contribute to the allocation puzzle, they do not explain it. The cross-country variation in capital inflows appears to be (at best) orthogonal to its main theoretical determinant—productivity growth. Even after adjusting for aid, the only region whose productivity caught up relative to the world frontier (Asia) has been exporting capital while theory predicts substantial capital inflows.

Second, we look at a broader definition of public flows taken from Aguiar and Amador

[42]The slope of a regression of aid-adjusted capital flows on productivity catch-up is -0.07 with a s.e. equal to 0.23 (p-value 0.76). Other authors have looked at the robustness of the allocation puzzle since the first version of this paper was circulated. Alfaro and Kalemli-Ozcan (2011), for instance, have pointed out that if one removes countries such as Singapore and Bostwana from the sample, the relationship between aid-adjusted capital flows and growth becomes positive, although, as can be seen from Figure 7, it remains weak.

(2011). These authors define net *public* capital inflows as the change in public and publicly guaranteed debt minus the change in international reserves (minus gold). *Private* net capital inflows are then constructed as total net inflows minus net public inflows. Data on public and publicly guaranteed debt are available from the World Development Indicators (WDI), while data on international reserve holdings come from the International Financial Statistics of the IMF. As before, we construct PPP-adjusted cumulated public and private capital inflows relative to initial GDP, $\Delta D^{pub}/Y_0$ and $\Delta D^{priv}/Y_0$.[43] Columns (3) and (4) of Table 6 report measured average private and public flows. At first glance, there is more support for the standard model when looking at *private* flows. Net private capital inflows are now correlated with income per capita and productivity catch-up. High income non-OECD economies received 71 percent of private capital inflows, while low income countries only received 28 percent. Looking across regions, the picture is more muddled since all three regions received about the same amount of private capital (between 27 and 36 percent) despite vastly different productivity performance. As column (4) shows, the behavior of public flows is strikingly at odds with that of private flows, and almost always larger in magnitude. Figure 8 confirms these findings. It is similar to Figure 2 and reports the correlation between cumulated flows and our measure of productivity catch-up π for public flows (left panel) and private flows (right panel).[44]

The negative correlation between productivity catch-up and net capital flows is clearly present for *public* capital flows. These results are consistent with those of Aguiar and Amador (2011) who report a strong statistically significant relationship between growth and the change in government's external assets.[45] This result is robust to controlling for determinants of capital flows other than productivity. Table 5 regresses public and private net capital inflows onto our theoretically motivated set of regressors: productivity catch-up, initial capital abundance, initial debt, population growth and financial openness (interacted with productivity catch-up). As in the scatter plot, productivity catch-up is strongly negatively correlated with public net capital flows (column 1). In addition, public inflows decrease with capital abundance, population growth, and financial openness. Finally, column 2 of Table 5 indicates that more open economies experience also larger public capital outflows. The magnitude is economically large. A 10 percent increase in our measure of productivity catch-up, representing a 11 percent increase in long term productivity, on average, is associated

[43] Due to data availability, the following six countries drop from the sample: Angola, Hong Kong, Mozambique, Taiwan and South Africa.

[44] Given the large net public capital outflows of Botswana and Singapore (-248 percent and -261 percent of initial output respectively), we drop these two countries from the figure. Not that unlike in Alfaro and Kalemli-Ozcan (2011), adding them would only strengthen our results.

[45] There are several differences between Aguiar and Amador (2011) and our results. First, our measure of net capital inflows is PPP-adjusted and expressed as a fraction of initial output while they use the change in the ratio of net foreign assets to GDP. Second, our measure of the cumulated capital flows is based on current account data, while Aguiar and Amador (2011) use the change in the net investment position from Lane and Milesi-Ferretti (2007). The latter include valuation effects, to the extent that the underlying asset positions are reported at market value. Aguiar and Amador (2011) also cover a different set of countries, over a longer period (1970-2004). Finally, our explanatory variable is the productivity catchup rather than output growth.

with a decrease in public capital inflows of 30 percent of initial output.[46]

Net private capital inflows, by contrast, appear to increase with productivity catch-up, as predicted by the theory.[47] However, this correlation does not survive controlling for the other determinants of capital flows. Columns 3 and 4 of Table 5 indicate that the coefficient on productivity, while positive, is not statistically significant. We only find a positive and marginally significant correlation for the interaction term between productivity growth and capital account openness, indicating that more open economies do experience somewhat larger net private capital inflows. For a very open economy, a 10 percent increase in π is associated with an increase in private capital flows of 7.7 percent of initial output over a 20 year period. However, for the average level of openness of -0.42 in our sample, the effect is to *reduce* private capital inflows by 1.2 percent of initial output.

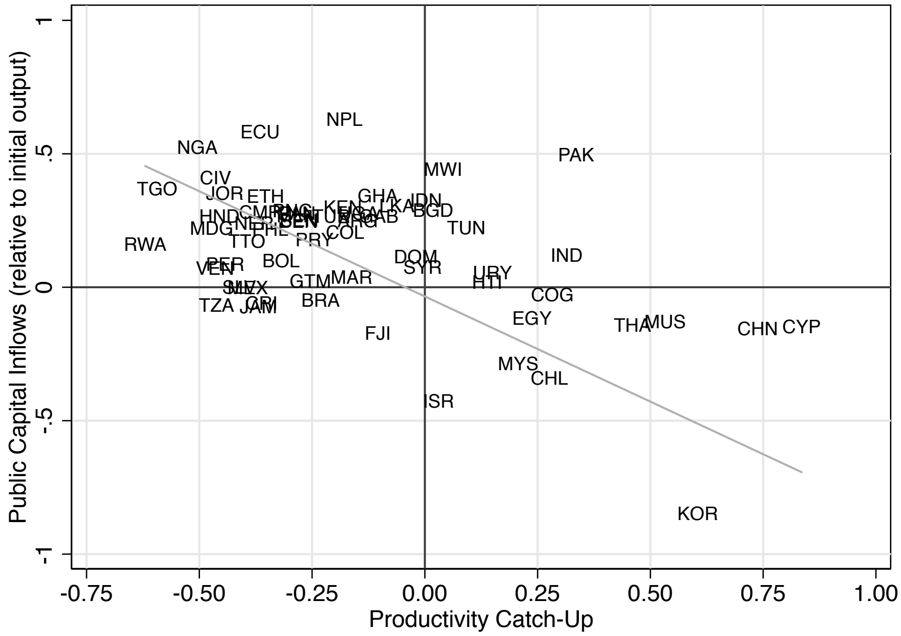
Since public capital inflows play such an important role in total inflows, our final decomposition consists in examining separately the two components of public flows: public and publicly guaranteed debt and (the opposite of) international reserves accumulation. With the method described above, we construct ΔD^{ppg} and ΔD^{res} such that $\Delta D^{pub} = \Delta D^{ppg} + \Delta D^{res}$. Figure 9 reports the scatter plot of each component (normalized by initial output Y_0) against productivity catch-up π while columns 5 and 6 of Table 5 report the regression coefficients with covariates.[48] The results indicate unambiguously that the accumulation of international reserves plays a major role in the allocation puzzle. The regression coefficients for total public flows (column 2) and for international reserves (column 6) are very similar. According to the estimates, open developing countries that experience a 10 percent increase in their productivity catch-up between 1980 and 2000 accumulated international reserves accounting for about 30 percent of their initial output. It is important to observe that these estimates are obtained on a pre-2000 sample. Therefore, they do not include the rapid rise in international reserve holdings of major emerging economies that occurred since then.

These findings indicate that, as emphasized by Aguiar and Amador (2011), public flows play a role in explaining the allocation puzzle. The consideration of public flows does not per se resolve the allocation puzzle but it leads us to reformulate the question in a more precise way. First, why do countries with higher productivity growth have larger public outflows? Second, why are those larger public flows not offset by private flows, even in developing economies with a very open financial account? As shown by Table 2, the interaction term between financial openness and productivity on total capital inflows is negative and significant, indicating that the allocation puzzle applies more strongly to financially more open economies. The reason, as shown by Table 5, is that public outflows respond more strongly than private inflows to productivity growth in more open economies. Thus,

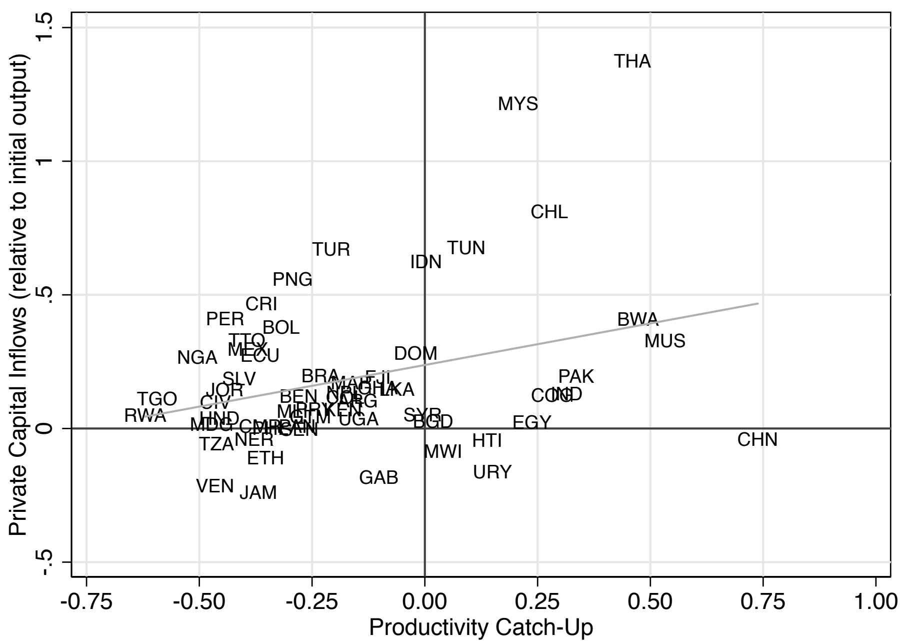
[46] We arrive at these numbers as follows. First, an increase in π by 0.1 represents a percentage increase in A_T by $0.1/(1+\pi)$. Since π equals -0.10 on average, this represents a 11 percent increase in long term productivity. Second, for the most open economies, the Chinn-Ito index is equal to 2.6, so the effect of a 11 percent productivity increase is -1.182-0.693*2.6*0.1=29.83 percent.

[47] The slope of the fitted line for public inflows is -0.79 with a p-value smaller than 1%; the slope for private inflows is 0.23 with a p-value of 8.3%.

[48] As for figure 8, we exclude Botswana and Singapore from the plot of foreign reserves. Our estimates indicate that reserve accumulation for these two countries amounted to about -260 percent of their 1980 output. Once again, adding them back would only strengthen our results.



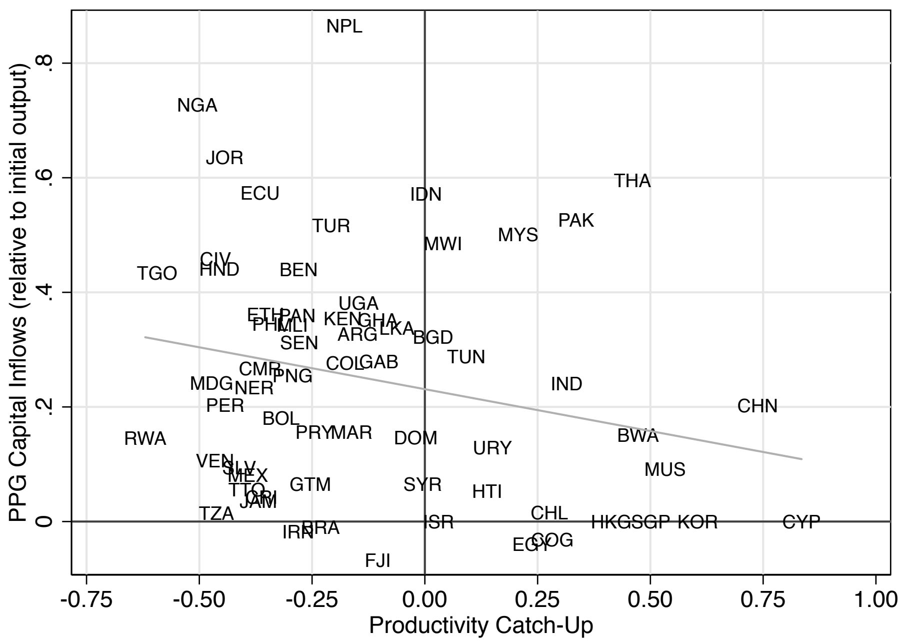
(a) Net *Public* Capital Inflows



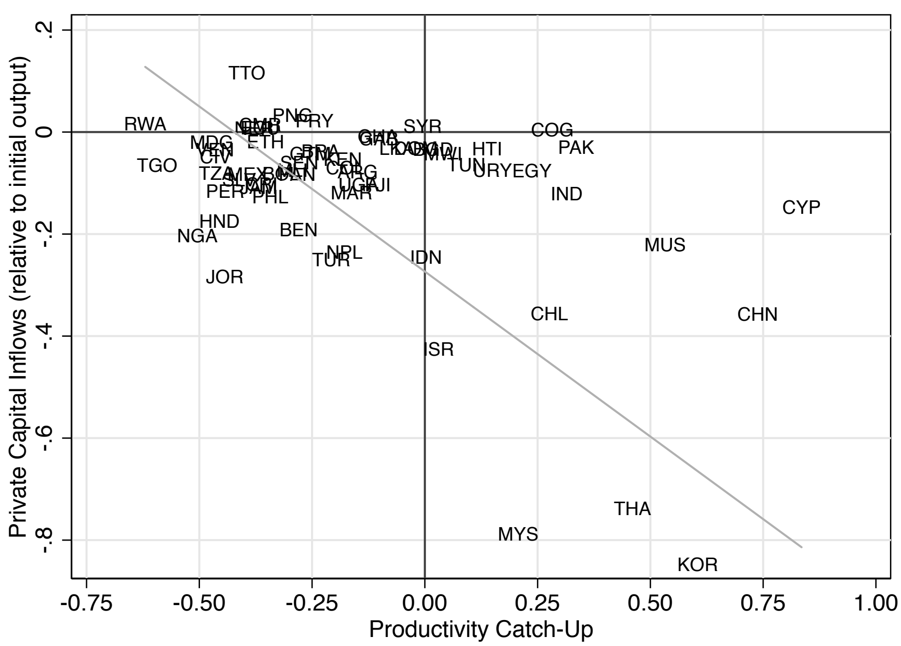
(b) Net *Private* Capital Inflows

Note: top panel reports $\Delta D^{pub}/Y_0$ against π. Bottom panel reports $\Delta D^{priv}/Y_0$ against π.

Figure 8: Productivity catch-up (π) and change in public and private external debt.



(a) Net *Publicly and Publicly Guaranteed* Capital Inflows



(b) (opposite of) *International Reserves* Flows

Note: top panel reports $\Delta D^{ppg}/Y_0$ against π. Bottom panel reports $\Delta D^{res}/Y_0$ against π.

Figure 9: Productivity catch-up (π) and change in public and publicly guaranteed debt and international reserves.

financial openness does not reduce the allocation puzzle, it exacerbates it.

6 Discussion and Conclusion

This paper establishes a puzzling stylized fact: capital does not tend to flow more toward countries with higher productivity growth and higher investment. This is puzzling for neoclassical models of growth—in fact, this makes one wonder if the textbook neoclassical framework is the right model at all to think about the link between international financial integration and development.

We have also shown that the allocation puzzle is related to (i) saving rather than investment, and (ii) the behavior of publicly originated capital flows (and in particular, the accumulation of international reserves). The solution to the "allocation puzzle" thus lies at the nexus of between growth, saving and the accumulation of net foreign assets by the government. We conclude with a discussion of some possible approaches to understanding this nexus. This discussion is meant to review the existing research that is relevant to the allocation puzzle (some of which was motivated by earlier versions of this paper) and to provide a tentative road map for possible explanations. It is not an attempt to push forward a particular explanation.[49]

The first angle on the question is the relationship between savings and growth. That the saving rate is positively associated with growth is a well-known empirical fact. One line of explanation considers the causality from growth to savings, as suggested by Carroll et al. (2000). In Modigliani's (1970) life cycle model faster growth raises aggregate savings by increasing the saving of younger richer cohorts relative to the dissaving of older poorer cohorts. Other authors have pointed to a number of problems with the life-cycle model and put forward an alternative theory based on consumption habit (Carroll and Weil (1994), Carroll et al. (2000)). In the habit model, faster growth increases savings as households adjust their consumption levels only slowly. Whether models with consumption habit can explain the allocation puzzle (i.e., that higher growth raises saving more than investment) is an open question for future research.

Another approach emphasizes the distortions in the relationship between growth and savings induced by domestic frictions, in particular in the financial sector. International financial frictions that increase the cost of external finance relative to domestic finance cannot explain the allocation puzzle since, as mentioned earlier, they can mute the absolute size of capital flows, not change their direction. By contrast, *domestic* financial frictions might be able to do so, because of the impact they have on the relationship between savings, investment and growth. As shown by Gertler and Rogoff (1990) and Matsuyama (2004), domestic financial frictions can reverse the direction of capital flows between rich and poor countries. Can they have the same effect between high-growth and low-growth countries?

Low domestic financial development may constrain domestic demand—and increase domestic savings—in several ways. First, it constrains the residents' ability to borrow against

[49]Indeed, the explanations reviewed below are not mutually exclusive, and may be complementary. Moreover, the most relevant explanation may not be the same for different countries or regions.

future income or store value in sound financial instruments. Further, an inefficient financial intermediation system could also reduce the responsiveness of investment to productivity growth. Caballero, Farhi and Gourinchas (2008) present a model in which financially underdeveloped countries run larger current account surpluses if they grow faster for these reasons. Song, Storesletten and Zilibotti (2011) propose a model of Chinese growth in which banks channel domestic savings toward low-productivity firms and high-productivity firms must be financed out of internal savings. This friction forces a growing share of domestic savings to be invested in foreign assets, generating a foreign surplus.

Another consequence of low domestic financial development is that, together with lack of social insurance, it might encourage precautionary savings by constraining the ability of private agents to insure efficiently against income shocks (Mendoza, Quadrini and Rìos-Rull (2009)). It has been argued that some Asian emerging market countries have a high saving rate because of the rise in idiosyncratic risk that is associated with the transition to a market economy (see Chamon and Prasad (2008) for China). Some papers explore whether calibrated models of precautionary savings against idiosyncratic risk can explain a positive correlation between growth and net capital outflows. Carroll and Jeanne (2008) and Sandri (2008) present dynamic optimization models in which a positive correlation between growth and idiosyncratic risk can reverse the sign of the relationship between growth and capital flows if the country does not develop public or private mechanisms of insurance covering those risks (see also Angeletos and Panousi (2011) and Kenza (2010)). The accumulation of international reserves, however, is often justified as self-insurance against the *aggregate* risk of a crisis. It would be interesting to know if models of precautionary savings against *aggregate* income risk can also change the sign of the correlation of between growth and capital flows.[50]

Causality could also run in the opposite direction, from savings to growth. This is the case in many closed-economy models of endogenous growth, but this feature does not easily survive perfect capital mobility, which makes domestic savings a small component of the global savings pool. For domestic savings to increase growth in the open economy, there must be a friction that prevents domestic savings and foreign savings from being perfect substitutes. Aghion, Comin and Howitt (2006) present an example of a model with those features.[51]

One common feature—and a limitation—of the models discussed above is that they do not give a meaningful and distinct role to the government, and thus do not speak to the fact that the allocation puzzle seems to reflect the behavior of *public* capital flows. The only way that these models can incorporate that fact is by claiming that the public or private nature of the flows is inessential: that the international reserves accumulated by the government, for example, corresponds to a stock of foreign wealth that the private sector wishes to accumulate anyway. We now turn to lines of explanations in which government

[50] Durdu, Mendoza and Terrones (2009) present a model of precautionary savings against sudden stops, but do not look at the correlation between net capital flows and growth.

[51] In their model domestic savings matters for innovation because it fosters the involvement of domestic intermediaries with a superior monitoring technology. However, the model does not include investment in productive physical capital, and thus does not provide a realistic framework to study the allocation puzzle.

policies are instead central to the allocation puzzle.

One line of explanation is related to the "Bretton Woods 2" view of the international monetary system developed by Dooley, Folkerts-Landau and Garber (2004a). This view has not received a full-fledged theoretical treatment but could be applied to the allocation puzzle as follows. Countries with a take-off in their tradable sector (such as China) tend to resist the real appreciation of their currency through various policies, most notably the accumulation of foreign assets by the public sector combined with restrictions on capital inflows.[52] The allocation puzzle, thus, would come from the fact that developing countries with higher growth in the tradable sector would tend to have higher trade surpluses and so (as a matter of accounting) larger net capital outflows.

In addition, Dooley, Folkerts-Landau and Garber (2004b) surmise that the accumulation of international reserves can also be interpreted as a form of collateral for the FDI flows to China. This point is formalized by Aguiar and Amador (2011) in the context of a model with an interaction between political economy and contracting frictions. In their model, the domestic government has limited commitment so that foreign investors fear expropriation (on their capital holdings) and default (on their sovereign debt holdings). In the self-enforcing equilibrium of the model, growth requires that governments pay down their debt, thus reducing their external liabilities. Their model generates, along the transition path of a developing economy, the negative correlation between net public capital inflows and growth that we document in this paper.

These contributions are interesting but rely, implicitly or explicitly, on the assumption that the government can control the volume of net capital flows. This is not true in the frictionless neoclassical model, because the accumulation of reserves by the government should be offset one-for-one by higher capital inflows. This must be prevented by frictions, either natural (low financial development) or policy-induced (capital controls). In Aguiar and Amador (2011), for example, the domestic voters have no access to international capital markets. The question, then, is how to reconcile this line of explanation with our finding that the allocation puzzle is in fact stronger for the countries that are financially more integrated.

To conclude, there is no shortage of candidates but the main explanation(s) for the allocation puzzle remains in our view an open question. It seems important to know more about the underlying cause of this puzzle if one wants to understand how international financial integration helps economic development.

[52] In addition, causality could run from real undervaluation to growth, as argued by Rodrik (2008).

References

Aghion, Philippe, Diego Comin, and Peter Howitt, "When Does Domestic Saving Matter for Economic Growth?," Working Paper 12275, NBER June 2006.

Aguiar, Mark and Gita Gopinath, "Emerging Market Business Cycles: The Cycle Is the Trend," *Journal of Political Economy*, February 2007, *115* (1), 69–102.

_ **and Manuel Amador**, "Growth in the Shadow of Expropriation," *Quarterly Journal of Economics*, 2011, *126*, 651–697.

Aizenman, Joshua, Brian Pinto, and Artur Radziwill, "Sources for Financing Domestic Capital – Is Foreign Saving a Viable Option for Developing Countries?," Working Paper 10624, NBER July 2004.

Alfaro, Laura and Sebnem Kalemli-Ozcan, "Sovereigns, Upstream Capital Flows and Global Imbalances," Aug 2011. Manuscript, University of Houston.

Angeletos, G.M. and V. Panousi, "Financial integration, entrepreneurial risk and global dynamics," *Journal of Economic Theory*, 2011.

Barro, Robert J. and Xavier Sala-i-Martin, *Economic Growth*, New-York: McGraw Hill, 1995.

Caballero, Ricardo J., Emmanuel Farhi, and Pierre-Olivier Gourinchas, "An Equilibrium Model of "Global Imbalances" and Low Interest Rates," *American Economic Review*, March 2008, *98* (1), 358–93.

Carroll, Christopher and Olivier Jeanne, "A Tractable Model of Precautionary Reserves or Net Foreign Assets," Dec 2008. Manuscript, Johns Hopkins University.

Carroll, Christopher D. and David N. Weil, "Saving and Growth: A Reinterpretation," in "Carnegie-Rochester Series on Public Policy" June 1994, pp. 133–192.

_ **and Lawrence H. Summers**, "Consumption Growth Parallels Income Growth: Some New Evidence," in B.D. Bernheim and John B. Shoven, eds., *National Savings and Economic Performance*, Chicago University Press 1991.

_ **, Jody Overland, and David N. Weil**, "Saving and Growth with Habit Formation," *American Economic Review*, June 2000, *90* (3), 341–355.

Caselli, Francesco, "Accounting for Cross-Country Income Differences," in Philippe Aghion and Steven N. Durlauf, eds., *Handbook of Economic Growth*, Vol. 1, Part 1, Elsevier, 2005, pp. 679 – 741.

_ **and James Feyrer**, "The Marginal Product of Capital," *Quarterly Journal of Economics*, May 2007, *122* (2), 535–568.

Chamon, Marcos and Eswar Prasad, "Why Are Saving Rates of Urban Households in China Rising?," IMF Working Papers 08/145, International Monetary Fund 2008.

Chari, V. V., Patrick J. Kehoe, and Ellen R. McGrattan, "The Poverty of Nations: A Quantitative Exploration," NBER Working Paper 5414, National Bureau of Economic Research January 1996.

_ , _ , and _ , "Business Cycle Accounting," *Econometrica*, 05 2007, *75* (3), 781–836.

Chinn, Menzie D. and Hiro Ito, "A New Measure of Financial Openness," *Journal of Comparative Policy Analysis*, September 2008, *10*, 309–322.

Dooley, M.P., D. Folkerts-Landau, and P. Garber, "The revived bretton woods system," *International Journal of Finance & Economics*, 2004, *9* (4), 307–313.

_ , _ , and P.M. Garber, "The US current account deficit and economic development: Collateral for a total return swap," 2004.

Durdu, Ceyhun Bora, Enrique G. Mendoza, and Marco E. Terrones, "Precautionary Demand for Foreign Assets in Sudden Stop Economies: an Assessment of the New Merchantilism," *Journal of Development Economics*, 2009, *89*, 194 – 209.

Eaton, Jonathan and Samuel Kortum, "International Technology: Theory and Measurement," *International Economic Review*, 1999, *40* (3).

Feldstein, Martin and Charles Horioka, "Domestic Saving and International Capital Flows," *Economic Journal*, June 1980, *90* (358), 314–29.

Gertler, Mark J. and Kenneth Rogoff, "North-South lending and endogenous domestic capital market inefficiencies," *Journal of Monetary Economics*, 1990, *26* (2), 245–266.

Gollin, Douglas, "Getting Income Shares Right," *Journal of Political Economy*, 2002, *110* (2), 458–474.

Gourinchas, Pierre-Olivier and Olivier Jeanne, "The Elusive Gains From International Financial Integration," *Review of Economic Studies*, 2006, *73* (3), 715–741.

_ and _ , "Capital Flows to Developing Countries: the Allocation Puzzle," NBER Working Papers 13602, National Bureau of Economic Research November 2007.

Hall, Robert and Charles Jones, "Why Do Some Countries Produce So Much More Output Per Worker than Others?," *Quarterly Journal of Economics*, 1999, *114* (1), 83–116.

Heston, Alan, Robert Summers, and Bettina Aten, "Penn World Table Version 6.1," October 2004. Center for International Comparisons at the University of Pennsylvania (CICUP).

Hsieh, Chang-Tai and Peter J. Klenow, "Relative Prices and Relative Prosperity," *American Economic Review*, June 2007, *97* (3), 562–585.

Jayachandran, Seema and Michael Kremer, "Odious Debt," *American Economic Review*, March 2006, *96* (1), 82–92.

Kenza, Benhima, "A Reappraisal of the Allocation Puzzle through the Portfolio Approach," Cahiers de Recherches Economiques du Dpartement d'Economtrie et d'Economie politique (DEEP) 10.11, Universit de Lausanne, Facult des HEC, DEEP May 2010.

King, Robert and Sergio Rebelo, "Low frequency filtering and real business cycles," *Journal of Economics Dynamics and Control*, 1993, *17*, 207–231.

_ **and** _ , "Transitional Dynamics and Economic Growth in the Neoclassical Model," *American Economic Review*, September 1993, *83* (4), 908–31.

Lane, Philip and Gian Maria Milesi-Ferretti, "The external wealth of nations mark II: Revised and extended estimates of foreign assets and liabilities,1970-2004," *Journal of International Economics*, 2007, *73* (2), 223–250.

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

Mankiw, N. Gregory, David Romer, and David Weil, "A Contribution to the Empirics of Economic growth," *Quarterly Journal of Economics*, 1992, *107* (2), 407–38.

Manzocchi, Stefano and Philippe Martin, "Are Capital Flows Consistent with the Neoclassical Growth Model? Evidence from a Cross-section of Developing Countries," *Economie Internationale*, 1997, *72*, 7–24.

Matsuyama, Kiminori, "Financial Market Globalization, Symmetry-Breaking, and Endogenous Inequality of Nations," *Econometrica*, 2004, *72* (3), 853–884.

Mendoza, Enrique G., Vincenzo Quadrini, and José-Vìctor Rìos-Rull, "Financial Integration, Financial Development, and Global Imbalances," *Journal of Political Economy*, 06 2009, *117* (3), 371–416.

Modigliani, Franco, "The Life Cycle Hypothesis of Savings and Intercountry Differences in the Savings Ratio," in J.M. Volpe M. FG. Scott and W. Eltis, eds., *Induction, Growth and Trade. Essays in Honor of Sir Roy Harrod*, Oxford: Clarendon Press, 1970, pp. 197–225.

Parente, Stephen and Edward Prescott, *Barriers to Riches*, Cambridge, MA: MIT Press, 2000.

Prasad, Eswar, Raghuram Rajan, and Arvind Subramanian, "Foreign Capital and Economic Growth," *Brookings Papers on Economic Activity*, Spring 2007, pp. 153–230.

Rajan, Raghuram G. and Arvind Subramanian, "Aid and Growth: What Does the Cross-Country Evidence Really Show?," *The Review of Economics and Statistics*, 06 2008, *90* (4), 643–665.

Rodrik, Dani, "The Real Exchange Rate and Economic Growth," *Brookings Papers on Economic Activity*, 2008, *39* (2 (Fall)), 365–439.

Roodman, David, "An Index of Donor Performance," Working Paper 67, Center for Global Development November 2006.

Sandri, Damiano, "Growth and Capital Flows With Risky Entrepreneurship," Dec 2008. Manuscript, Johns Hopkins University.

Song, Z., K. Storesletten, and F. Zilibotti, "Growing like China," *The American Economic Review*, 2011, *101* (1), 196–233.

	(1) Catch-up π	(2) Capital inflows $\Delta D/Y_0$	(3) Obs.
Non-OECD countries	-0.10	31.49	68
By income:			
Low Income	-0.22	56.49	26
Lower Middle Income	-0.15	37.02	23
Upper Middle Income	-0.06	12.94	13
High Income (Non-OECD)	0.54	-57.85	6
By region:			
Africa	-0.17	39.09	31
Latin-America	-0.24	36.89	20
Asia	0.19	11.28	17
China and India	0.53	3.21	2
All but China and India	-0.12	32.35	66
All but Africa	-0.04	25.12	37

Table 1: Productivity Catch-Up and Capital Inflows between 1980 and 2000. Group averages.

Variable: $\Delta D/Y_0$	(1) (Std. Err.)	(2) (Std. Err.)	(3) (Std. Err.)
Productivity catch-up (π)	-0.586***	-0.456**	-0.697***
	(0.217)	(0.209)	(0.227)
Initial capital abundance (k_0/y_0)	-0.161	-0.126	-0.081
	(0.115)	(0.109)	(0.107)
Initial debt (d_0/y_0)	0.006*	0.004	0.001
	(0.003)	(0.003)	(0.003)
Population growth (n)	-0.058	-0.098	-0.073
	(0.104)	(0.099)	(0.096)
Openness (Chinn-Ito)		-0.141**	-0.115*
		(0.063)	(0.062)
Openness x π			-0.455*
			(0.197)
Intercept	0.516	0.576	0.536
	(0.315)	(0.299)	(0.289)
Number of observations	68	67	67
Adjusted-R^2	0.174	0.157	0.214

Table 2: Estimation results : Regression of observed capital inflows $\Delta D/Y_0$ on initial conditions (capital abundance, external debt), population growth, productivity catch-up (π) and the Chinn and Ito (2008) index of capital account openness.

Average Investment Rate (percent of output)	(1) Total i_k	(2) Convergence	(3) Productivity	(4) Trend	(5) Capital Wedge τ_k	(6) Obs.
Non-OECD countries	13.52	0.11	-0.92	14.33	11.54	68
By Income Level:						
Low Income	8.49	-0.21	-1.56	10.26	18.92	26
Lower Middle Income	14.06	0.29	-1.64	15.42	8.84	23
Upper Middle Income	15.69	0.40	-1.35	16.64	6.13	13
High Income (Non-OECD)	28.52	0.17	5.54	22.82	1.55	6
By region:						
Africa	10.26	-0.74	-1.18	12.19	16.05	31
Latin-America	13.40	0.39	-2.67	15.69	8.50	20
Asia	19.59	1.32	1.62	16.65	6.88	17
China and India	15.76	0.40	3.02	12.34	10.35	2
All but China and India	13.45	0.10	-1.04	14.39	11.57	66
All but Africa	16.25	0.82	-0.70	16.13	7.76	37

Table 3: Decomposition of Average Investment Rates between 1980 and 2000, percent of GDP. Convergence: $\frac{1}{T}\frac{\tilde{k}^*-\tilde{k}_0}{\tilde{y}_0}$; Productivity: $\frac{\pi}{T}\tilde{k}^{*(1-\alpha)}g^*n$; Trend: $\tilde{k}^{*(1-\alpha)}(g^*n+\delta-1)$. Group averages.

Capital Flows (percent)	(1) Observed $\Delta D/Y_0$	(2) Convergence $\Delta D^c/Y_0$	(3) Investment $\Delta D^i/Y_0$	(4) Saving $\Delta D^s/Y_0$	(5) Trend $\Delta D^t/Y_0$	(6) Wedge τ_s	(7) Obs.
Non-OECD countries	31.49	5.95	-28.18	21.97	31.75	1.07	68
By Income:							
Low Income	56.49	-14.55	-49.76	85.39	35.42	2.11	26
Lower Middle Income	37.02	17.38	-62.62	47.96	34.30	1.28	23
Upper Middle Income	12.94	22.85	-40.99	-15.93	47.00	0.68	13
High Income (Non-OECD)	-57.85	14.37	225.12	-270.35	-26.98	-3.43	6
By Region:							
Africa	39.09	-31.64	-41.53	78.20	34.06	1.79	31
Latin-America	36.89	20.96	-100.07	62.09	53.92	1.83	20
Asia	11.28	56.84	80.74	-127.75	1.44	-1.14	17
China and India	3.21	11.39	141.57	-132.15	-17.60	-2.53	2
All but China and India	32.35	5.79	-33.32	26.64	33.24	1.18	66
All but Africa	25.12	37.45	-16.99	-25.14	29.81	0.47	37

Table 4: Decomposition of cumulated capital inflows relative to initial output between 1980 and 2000. $\Delta D/Y_0$ is the observed ratio. See appendix A for definition of the various components. Saving wedge τ_s calibrated to equate observed and predicted capital inflows. Group averages.

Variable: $\Delta D^i/Y_0$	(1)	(2)	(3)	(4)	(5)	(6)
	Public Flows		Private Flows		PPG Debt	Reserves
	(Std. Err.)	(Std. Err.)	(Std. Err.)	(Std. Err.)	(Std. Err.)	(Std. Err.)
Productivity catch-up (π)	-0.843***	-1.182***	0.218	0.072	-0.043	-1.145***
	(0.185)	(0.219)	(0.158)	(0.174)	0.094	(0.149)
Initial capital abundance (k_0/y_0)	-0.177*	-0.112	0.026	0.054	-0.106**	-0.027
	(0.103)	(0.093)	(0.088)	(0.088)	(0.045)	(0.075)
Initial debt (d_0/y_0)	-0.001	-0.002	-0.001	-0.002	0.00	-0.002
	(0.003)	(0.003)	(0.003)	(0.003)	(0.001)	(0.002)
Population growth (n)	-0.208**	-0.148*	0.002	0.028	0.071*	-0.218***
	(0.087)	(0.078)	(0.074)	(0.074)	(0.041)	(0.063)
Openness (Chinn-Ito)	-0.155**	-0.131**	-0.018	-0.007	0.025	-0.161***
	(0.060)	(0.054)	(0.051)	(0.050)	(0.026)	(0.043)
Openness x π		-0.693***		0.297*	-0.032	-0.691***
		(0.174)		(0.164)	(0.085)	(0.140)
Intercept	0.668	0.504	0.189	0.119	0.208	0.298
	(0.270)	(0.244)	(0.231)	(0.230)	(0.124)	(0.196)
Number of observations	62	62	62	62	64	62
Adjusted-R^2	0.369	0.501	-0.003	0.009	0.123	0.592

Table 5: Estimation results : Regression of observed public and private capital flows $\Delta D^{pub}/Y_0$, $\Delta D^{priv}/Y_0$, $\Delta D^{ppg}/Y_0$ and $\Delta D^{res}/Y_0$ on initial conditions (capital, debt), productivity catch-up (π) and the Chinn and Ito (2008) index of capital account openness.

	(1) Catch-up π	(2) Aid-adjusted flows $\Delta D'/Y_0$	(3) Private flows $\Delta D^{\text{priv}}/Y_0$	(4) Public flows $\Delta D^{\text{pub}}/Y_0$	(5) Obs.
Non-OECD countries	-0.10	-20.16	31.44	4.76	62
By Income:					
Low Income	-0.22	-41.46	27.73	28.32	24
Lower Middle Income	-0.15	1.63	29.01	11.50	21
Upper Middle Income	-0.06	-2.94	30.12	-17.19	13
High Income (Non-OECD)	0.54	-54.46	70.69	-100.58	4
By Region:					
Africa	-0.17	-39.36	31.80	8.48	27
Latin-America	-0.24	13.59	27.33	9.56	20
Asia	0.19	-25.16	36.26	-8.32	15
China and India	0.53	-7.75	4.76	-1.55	2
All but China and India	-0.12	-20.54	32.33	4.97	60
All but Africa	-0.04	-3.64	31.16	1.90	35

Table 6: Productivity Catch-Up and Capital Inflows between 1980 and 2000. $\Delta D'/Y_0$ reports the aid-adjusted flows, $\Delta D^{\text{priv}}/Y_0$ the private flows and $\Delta D^{\text{pub}}/Y_0$ the public flows. Group averages.

Appendices

A Proofs

A.1 Proof of Proposition 1.

The ratio of the debt increase to initial GDP is given by,

$$\frac{\Delta D}{Y_0} = \frac{D_T - D_0}{Y_0} = \frac{\tilde{d}_T A_T N_T - \tilde{d}_0 A_0 N_0}{A_0 N_0 \tilde{y}_0} = \frac{\tilde{d}_T (g^* n)^T (1+\pi) - \tilde{d}_0}{\tilde{y}_0}. \tag{A.1}$$

At the beginning of time 0 external debt jumps from $\tilde{d}_0$ to $\tilde{d}_0^+ = \tilde{d}_0 + \tilde{k}^* - \tilde{k}_0$ to finance the initial increase in capital from $\tilde{k}_0$ to $\tilde{k}^*$. Note that we normalize debt by the level of output *before* capital has jumped to $\tilde{k}^*$. Next we compute $\tilde{d}_T$. Dividing (6) by N_t gives the per capita budget constraint

$$c_t + n(k_{t+1} - d_{t+1}) = R^*(k_t - d_t) + w_t. \tag{A.2}$$

Let us denote by $g_t = A_t/A_{t-1}$ the growth rate of productivity. Then, dividing (A.2) by A_t and using $\tilde{k}_{t+1} = \tilde{k}_t = \tilde{k}^*$ gives the normalized budget constraint,

$$\tilde{c}_t + n g_{t+1}(\tilde{k}^* - \tilde{d}_{t+1}) = R^*(\tilde{k}^* - \tilde{d}_t) + \tilde{w}, \tag{A.3}$$

where the wage per efficiency unit of labor is constant and given by $\tilde{w} = (1-\alpha)\tilde{k}^{*\alpha}$.

After time T the economy is in a steady growth path with $g_{t+1} = g^*$, $\tilde{d}_t = \tilde{d}_T$ and $\tilde{c}_t = \tilde{c}_T$. Equation (A.3) implies

$$\tilde{d}_T = \tilde{k}^* + \frac{\tilde{w} - \tilde{c}_T}{R^* - n g^*}. \tag{A.4}$$

The next step is to compute $\tilde{c}_T$. Using the fact that consumption grows by the factor g^* in every period, $\tilde{c}_T$ is related to $\tilde{c}_0$ through

$$\tilde{c}_T = \frac{c_T}{A_T} = \frac{c_0 g^{*T}}{(1+\pi) A_0 g^{*T}} = \frac{\tilde{c}_0}{1+\pi}. \tag{A.5}$$

The level of net wealth per capita at the beginning of period 0 is $k^* - d_0^+ = k_0 - d_0$. The intertemporal version of the budget constraint (A.2) can be written,

$$\sum_0^{+\infty} \left(\frac{n}{R^*}\right)^t c_t = \sum_0^{+\infty} \left(\frac{n}{R^*}\right)^t w_t + R^*(k_0 - d_0). \tag{A.6}$$

Using $c_t = A_0 g^{*t} \tilde{c}_0$ and $w_t = \tilde{w} A_0 (1+\pi_t) g^{*t}$, equation (A.6) implies

$$\tilde{c}_0 = (R^* - n g^*) \left[\frac{\tilde{w}}{R^*} \sum_{t=0}^{\infty} \left(\frac{n g^*}{R^*}\right)^t (1+\pi_t) + \tilde{k}_0 - \tilde{d}_0 \right]. \tag{A.7}$$

One can then substitute $\tilde{d}_T$ out of equation (A.1) using (A.4), (A.5) and (A.7). This gives expression (11). The sign of the variations of $\Delta D/Y_0$ with $\tilde{k}_0$, $\tilde{d}_0$ and π stated in the proposition can easily be derived from that equation.

■

A.2 Proof of Proposition 2.

For $t \geq 1$ we have

$$i_t = \frac{K_{t+1} - (1-\delta)\,K_t}{Y_t} = \frac{A_{t+1}N_{t+1}\tilde{k}^* - (1-\delta)\,A_t N_t \tilde{k}^*}{A_t N_t \tilde{k}^{*\alpha}} = (g_{t+1}n + \delta - 1)\,\tilde{k}^{*(1-\alpha)}.$$

In period 0 this expression is augmented by a term reflecting that the level of capital per efficiency unit of labor jumps up from $\tilde{k}_0$ to $\tilde{k}^*$ at the beginning of the period,

$$i_0 = (g_1 n + \delta - 1)\,\tilde{k}^{*(1-\alpha)} + \frac{K_0^* - K_0}{Y_0} = (g_1 n + \delta - 1)\,\tilde{k}^{*(1-\alpha)} + \frac{\tilde{k}^* - \tilde{k}_0}{\tilde{k}_0^{\alpha}}.$$

The average investment rate between $t = 0$ and $t = T-1$ can be written,

$$\begin{aligned} i &= \frac{1}{T}\sum_{t=0}^{t=T-1} i_t = \frac{1}{T}\frac{\tilde{k}^* - \tilde{k}_0}{\tilde{k}_0^{\alpha}} + \frac{1}{T}\sum_{t=0}^{t=T-1}(g_{t+1}n + \delta - 1)\,\tilde{k}^{*(1-\alpha)}, \\ &= \frac{1}{T}\frac{\tilde{k}^* - \tilde{k}_0}{\tilde{k}_0^{\alpha}} + (\bar{g}n + \delta - 1)\,\tilde{k}^{*(1-\alpha)}, \\ &= \frac{1}{T}\frac{\tilde{k}^* - \tilde{k}_0}{\tilde{k}_0^{\alpha}} + (\bar{g} - g^*)\,n\tilde{k}^{*(1-\alpha)} + (g^* n + \delta - 1)\,\tilde{k}^{*(1-\alpha)}, \end{aligned}$$

where $\bar{g} = \frac{1}{T}\sum_{t=0}^{t=T-1} g_{t+1}$ is the average productivity growth rate. Under the additional assumption that π is small, $\bar{g}$ can be expressed as a function of π as

$$\begin{aligned} \bar{g} &= g^* \frac{1}{T}\sum_{t=0}^{t=T-1}\frac{1+\pi_{t+1}}{1+\pi_t}, \\ &\approx g^* \frac{1}{T}\sum_{t=0}^{t=T-1}(1 + \pi_{t+1} - \pi_t)\,, \\ &= g^*\left(1 + \frac{\pi}{T}\right), \end{aligned}$$

where the first line uses the definition of π_t, and the last equality uses $\pi_T = \pi$ and $\pi_0 = 0$. We can then write the average investment rate as

$$i = \frac{1}{T}\frac{\tilde{k}^* - \tilde{k}_0}{\tilde{k}_0^{\alpha}} + \frac{\pi}{T}\tilde{k}^{*(1-\alpha)}g^* n + (g^* n + \delta - 1)\,\tilde{k}^{*(1-\alpha)}.$$

■

B Measuring PPP-adjusted Capital Flows.

For a given country, data expressed in constant international dollars (the unit used in the Penn World Tables for real variables) can be converted into current U.S. dollars by multiplying them by the deflator,

$$Q_t = P_t \frac{CGDP_t}{RGDP_t},$$

where $CGDP_t$ ($RGDP_t$) is domestic GDP expressed in current (constant) international dollar and P_t is a price deflator. The ratio $CGDP/RGDP$ operates the conversion from constant international dollar into current international dollar, and P operates the conversion from current international dollar into current U.S. dollar. We define the deflator P as the price of investment goods reported in the Penn World Tables, for reasons explained in section 3. Multiplying a variable in constant international dollar, X, by the deflator Q gives its value in terms of current U.S. dollars, $X^{\$} = QX$.

The deflator Q can be used to obtain PPP-adjusted estimates of the observed cumulated capital inflows ΔD. To do this, we start from the external accumulation equation (in current US dollars): $D_T^{\$} = D_0^{\$} - \sum_{t=0}^{T-1} CA_t^{\$}$,[53] and use the formulas $D_T = D_T^{\$}/Q_T$ and $D_0 = D_0^{\$}/Q_0$ to obtain:

$$\Delta D = \left(\frac{1}{Q_T} - \frac{1}{Q_0}\right) D_0^{\$} - \sum_{t=0}^{T-1} \frac{CA_t^{\$}}{Q_T}. \tag{B.1}$$

The estimate of the initial net external debt in U.S. dollar ($D_0^{\$}$) is obtained from Lane and Milesi-Ferretti (2007)'s External Wealth of Nations Mark II database (EWN), as the difference between (the opposite of) the reported net international investment position (NIIP) and the errors and omissions (EO) cumulated between 1970 and 1980.[54] The same approach is used to construct estimates of the initial debt output ratio d_0/y_0, which we need to compute the right-hand-side of (11).

To obtain PPP-adjusted cumulated aid flows, we compute:

$$\frac{\Delta B}{Y_0} = \sum_{t=0}^{T-1} \frac{NODA_t^{\$}}{Y_0 Q_T},$$

where $NODA_t^{\$}$ is the current U.S. dollar value of the net overseas assistance in year t from all donors. We can then construct a measure of cumulated flows, net of official aid flows:

$$\frac{\Delta D'}{Y_0} = \frac{\Delta D - \Delta B}{Y_0} = \left(\frac{1}{Q_T} - \frac{1}{Q_0}\right) \frac{D_0^{\$}}{Y_0} - \sum_{t=0}^{T-1} \frac{CA_t^{\$} + NODA_t^{\$}}{Y_0 Q_T}.$$

[53] Alternatively, one could use Lane and Milesi-Ferretti (2007)'s estimate of the net external position in year 2000. The difference between the two estimates lies in the treatment of valuation effects due to asset price and currency movements. The size and relative importance of these valuation effects has increased over time. We do not attempt to incorporate these effects in this paper.

[54] In keeping with usual practice, we interpret errors and omissions as unreported capital inflows.

C Model with wedges. (NOT FOR PUBLICATION)

Capital mobility implies that the private return on domestic capital and the world real interest rate are equal: $(1-\tau_k)\,R_t = R^*$. Substituting this into the expression for the gross return on capital (3), we obtain that (4) is replaced by:

$$\tilde{k}_t = \tilde{k}^* \equiv \left(\frac{\alpha}{R^*/\left(1-\tau_k\right)+\delta-1}\right)^{1/1-\alpha}. \tag{C.1}$$

The per capita budget constraint (A.2) becomes

$$c_t + n(k_{t+1} - d_{t+1}) = R^*(k_t - d_t) + w_t + z_{kt}, \tag{C.2}$$

where we have consolidated the terms involving the saving wedge, so that $z_{kt} = \frac{\tau_k}{1-\tau_k}R^* k_t$ is the lump-sum transfer financed by the capital wedge only. The normalized budget constraint becomes,

$$\tilde{c}_t + ng_{t+1}(\tilde{k}^* - \tilde{d}_{t+1}) = R^*(\tilde{k}^* - \tilde{d}_t) + \tilde{w} + \tilde{z}_k, \tag{C.3}$$

where the transfer per efficiency unit of labor is constant and given by $\tilde{z}_k = \frac{\tau_k}{1-\tau_k}R^*\tilde{k}^*$.

After time T, the saving wedge disappears and the economy is in a steady growth path with $g_{t+1} = g^*$, $\tilde{d}_t = \tilde{d}_T$ and $\tilde{c}_t = \tilde{c}_T$. Equation (C.3) implies

$$\tilde{d}_T = \tilde{k}^* + \frac{\tilde{w} + \tilde{z}_k - \tilde{c}_T}{R^* - ng^*}. \tag{C.4}$$

The next step is to compute $\tilde{c}_T$. It is related to $\tilde{c}_0$ through

$$\tilde{c}_T = \frac{c_T}{A_T} = \frac{c_0[g^*\phi\left(\tau_s\right)]^T}{(1+\pi)A_0 g^{*T}} = \frac{\tilde{c}_0\phi\left(\tau_s\right)^T}{1+\pi}. \tag{C.5}$$

where $\phi\left(\tau_s\right) = (1-\tau_s)^{1/\gamma}$. The intertemporal version of the budget constraint (C.2) can be written,

$$\sum_0^{+\infty}\left(\frac{n}{R^*}\right)^t c_t = \sum_0^{+\infty}\left(\frac{n}{R^*}\right)^t (w_t + z_{kt}) + R^*(k_0 - d_0). \tag{C.6}$$

Consumption grows by the factor $g^*\phi$ in every period until period T and by the factor g^* afterwards. Thus,

$$c_t = A_0\phi^{min(t,T)}g^{*t}\tilde{c}_0. \tag{C.7}$$

Using this equation we have

$$\sum_0^{+\infty}\left(\frac{n}{R^*}\right)^t c_t = \frac{A_0\tilde{c}_0}{\left(1-ng^*/R^*\right)\psi(\tau_s)} \tag{C.8}$$

where

$$\begin{aligned}\psi(\tau_s) &= \left(1-\frac{ng^*}{R^*}\right)^{-1}\left[\sum_{t=0}^{T}\left(\frac{\phi ng^*}{R^*}\right)^t+\phi^T\sum_{t=T+1}^{+\infty}\left(\frac{ng^*}{R^*}\right)^t\right]^{-1} \\ &= \frac{R^*-ng^*\phi\left(\tau_s\right)}{R^*-ng^*+\left(\frac{ng^*\phi(\tau_s)}{R^*}\right)^T ng^*\left(1-\phi\left(\tau_s\right)\right)}.\end{aligned}$$

Using (C.6), (C.8) and $w_t+z_{kt}=(\tilde{w}+\tilde{z}_k)A_0(1+\pi_t)g^{*t}$, we then have

$$\tilde{c}_0=\left(R^*-ng^*\right)\psi\left(\tau_s\right)\left[\frac{\tilde{w}+\tilde{z}_k}{R^*}\sum_{t=0}^{\infty}\left(\frac{ng^*}{R^*}\right)^t(1+\pi_t)+\tilde{k}_0-\tilde{d}_0\right]. \tag{C.9}$$

The saving wedge τ_s enters consumption choices only through the marginal propensity to consume out of wealth, $\left(R^*-ng^*\right)\psi\left(\tau_s\right)\geq 0$. One can then substitute $\tilde{d}_T$ out of equation (A.1) using (C.4), (C.5) and (C.9). This gives:

$$\begin{aligned}\frac{\Delta D}{Y_0} &= \frac{\tilde{k}^*}{\tilde{y}_0}\left(ng^*\right)^T(1+\pi)-\frac{\tilde{k}_0}{\tilde{y}_0}\psi(\tau_s)\left(ng^*\phi(\tau_s)\right)^T+\frac{\tilde{d}_0}{\tilde{y}_0}\left(\psi\left(\tau_s\right)\left(ng^*\phi\left(\tau_s\right)\right)^T-1\right) \\ &\quad+\frac{\tilde{w}+\tilde{z}_k}{\tilde{y}_0}\frac{\psi\left(\tau_s\right)}{R^*}\left(ng^*\phi\left(\tau_s\right)\right)^T\sum_{t=0}^{T-1}\left(\frac{ng^*}{R^*}\right)^t\left[\phi\left(\tau_s\right)^{t-T}(1+\pi)-(1+\pi_t)\right].\end{aligned} \tag{C.10}$$

The right-hand side is a closed-form expression for function $\mathcal{D}(\tilde{k}_0,\tilde{d}_0.\pi,\tau_k,\tau_s)$. It generalizes equation (11).

Table 4 is based on the following decomposition of expression (C.10):

- Convergence:

$$\frac{\Delta D^c}{Y_0}=\frac{\tilde{k}^*-\tilde{k}_0}{\tilde{y}_0}\left(ng^*\right)^T$$

- Trend

$$\frac{\Delta D^t}{Y_0}=\frac{\tilde{d}_0-\tilde{k}_0}{\tilde{y}_0}\psi\left(\tau_s\right)\left(ng^*\phi\left(\tau_s\right)\right)^T+\frac{\tilde{k}_0\left(ng^*\right)^T-\tilde{d}_0}{\tilde{y}_0}$$

- Investment

$$\frac{\Delta D^i}{Y_0}=\pi\frac{\tilde{k}^*}{\tilde{y}_0}\left(ng^*\right)^T$$

- Saving

$$\frac{\Delta D^s}{Y_0}=\frac{\tilde{w}+\tilde{z}_k}{R^*\tilde{y}_0}\psi\left(\tau_s\right)\left(ng^*\phi(\tau_s)\right)^T\sum_{t=0}^{T-1}\left(\frac{ng^*}{R^*}\right)^t\left[\phi(\tau_s)^{(t-T)/\gamma}(1+\pi)-(1+\pi_t)\right]$$

D Data

Table 7: Data for 65 non-OECD countries, as well as Korea, Mexico and Turkey. The table reports the sample period for each country (`Start` and `End`), the average growth rate of the

working-age population n, the average investment rate i_k, the average productivity growth rate g , the productivity catch-up parameter π, the capital wedge τ_k, the saving wedge τ_s, and the capital wedge-adjusted marginal product of capital (RW).

Country	Start	End	$n(\%)$	$i_k(\%)$	$g(\%)$	π	$\tau_k(\%)$	$\tau_s(\%)$	$RW(\%)$
Angola	1985	1996	2.85	6.16	-2.32	-0.36	12.92	5.76	6.29
Argentina	1980	2000	1.49	15.84	0.83	-0.15	2.90	1.24	6.04
Bangladesh	1980	2000	2.62	10.41	1.73	0.02	13.99	-0.07	5.92
Benin	1980	2000	3.02	8.00	-0.00	-0.28	19.41	1.83	7.77
Bolivia	1980	2000	2.46	8.38	-0.23	-0.32	12.51	2.43	4.75
Botswana	1980	1999	3.56	16.95	3.84	0.47	11.07	-2.85	4.70
Brazil	1980	2000	2.38	18.00	0.43	-0.23	2.70	1.51	5.79
Cameroon	1980	1995	2.80	8.72	-1.22	-0.37	17.74	3.26	1.06
Chile	1980	2000	1.85	17.32	2.88	0.28	6.57	-1.30	3.25
China	1982	2000	1.82	19.58	4.81	0.74	7.69	-3.68	4.00
Colombia	1980	2000	2.61	11.79	0.74	-0.18	11.42	1.15	3.23
Congo, Rep.	1980	2000	2.90	12.95	3.17	0.28	6.78	-0.78	11.10
Costa Rica	1980	2000	3.02	15.30	-0.58	-0.36	6.21	2.45	5.74
Cyprus	1980	1996	1.08	23.57	5.59	0.84	1.43	-3.74	6.84
Côte d'Ivoire	1980	2000	3.70	5.74	-1.40	-0.46	17.09	3.93	10.26
Dominican Republic	1980	2000	2.61	13.26	1.57	-0.02	9.82	0.13	7.86
Ecuador	1980	2000	3.08	16.50	-0.47	-0.37	3.40	2.88	4.35
Egypt, Arab Rep.	1980	2000	2.62	7.42	2.73	0.24	23.81	-1.19	9.50
El Salvador	1980	2000	2.28	7.10	-1.01	-0.41	16.90	2.95	5.89
Ethiopia	1980	2000	2.61	4.17	-0.50	-0.35	32.68	2.38	6.68
Fiji	1980	1999	1.65	12.64	1.10	-0.10	5.83	1.04	8.63
Gabon	1980	2000	2.44	11.53	1.14	-0.10	8.61	0.78	8.75
Ghana	1980	2000	3.40	6.11	1.14	-0.10	17.44	1.13	10.84
Guatemala	1980	2000	2.76	7.35	0.26	-0.25	18.65	1.72	4.38
Haiti	1980	1998	2.09	5.46	2.25	0.14	31.63	-0.77	43.30
Honduras	1980	2000	3.44	12.91	-1.26	-0.46	8.35	3.46	2.11
Hong Kong, China	1980	2000	1.87	25.31	3.56	0.41	2.49	-2.42	3.47
India	1980	2000	2.33	11.95	3.04	0.31	13.01	-1.37	5.46
Indonesia	1981	2000	2.46	16.91	1.74	0.00	9.75	-0.33	1.18
Iran, Islamic Rep.	1980	2000	3.10	19.84	-0.07	-0.28	1.20	2.33	9.72
Israel	1980	2000	2.72	24.97	1.88	0.03	0.09	0.06	5.17
Jamaica	1980	2000	1.80	15.39	-0.62	-0.37	0.25	2.98	5.75
Jordan	1980	2000	5.09	15.57	-1.12	-0.44	9.98	3.29	2.90
Kenya	1980	2000	3.70	8.33	0.76	-0.18	14.43	1.48	6.27
Korea, Rep.	1980	2000	1.83	34.05	4.13	0.61	-0.08	-3.86	4.33

continued on next page

Table 7 continued from previous page

Country	Start	End	$n(\%)$	$i_k(\%)$	$g(\%)$	π	$\tau_k(\%)$	$\tau_s(\%)$	$RW(\%)$
Madagascar	1980	2000	2.84	2.75	-1.50	-0.47	38.59	3.59	8.64
Malawi	1980	2000	2.64	9.24	1.84	0.04	10.56	0.26	14.05
Malaysia	1980	2000	3.07	24.42	2.65	0.21	4.31	-1.39	3.51
Mali	1980	2000	2.44	7.83	-0.08	-0.29	18.46	1.98	8.29
Mauritius	1980	2000	1.62	11.96	3.85	0.53	11.66	-2.14	6.76
Mexico	1980	2000	2.95	18.13	-0.74	-0.39	3.34	2.81	5.35
Morocco	1980	2000	2.75	12.74	0.86	-0.16	7.91	1.17	5.55
Mozambique	1980	2000	1.93	3.07	-2.52	-0.56	36.89	4.58	7.86
Nepal	1980	2000	2.29	15.45	0.64	-0.18	8.65	1.12	4.49
Niger	1980	1995	3.28	6.65	-1.58	-0.38	13.88	4.16	10.50
Nigeria	1980	2000	2.93	8.31	-1.82	-0.50	14.90	3.91	-2.51
Pakistan	1980	2000	2.57	11.34	3.20	0.34	14.14	-1.34	4.65
Panama	1980	2000	2.64	18.36	0.09	-0.28	3.00	1.58	3.35
Papua New Guinea	1980	1999	2.86	11.18	-0.19	-0.29	9.34	2.17	5.03
Paraguay	1980	2000	3.23	12.78	0.31	-0.24	11.90	1.49	2.07
Peru	1980	2000	2.63	18.02	-1.20	-0.44	1.14	3.74	5.97
Philippines	1980	2000	2.73	14.95	-0.40	-0.34	5.84	2.32	5.80
Rwanda	1980	2000	2.96	4.34	-2.99	-0.62	33.93	5.31	3.10
Senegal	1980	2000	2.88	6.50	0.03	-0.28	19.25	2.09	7.98
Singapore	1980	1996	2.94	44.14	4.29	0.50	-2.48	-5.92	6.14
South Africa	1980	2000	2.86	9.52	-0.25	-0.33	9.24	2.44	8.58
Sri Lanka	1980	2000	1.91	13.45	1.33	-0.06	10.57	0.18	4.99
Syrian Arab Republic	1980	2000	3.92	11.64	1.69	-0.00	13.04	0.13	8.12
Taiwan Province of China	1981	1998	1.46	19.10	5.43	0.85	7.86	-4.71	3.33
Tanzania	1980	2000	3.27	18.89	-1.39	-0.46	-0.96	4.50	9.05
Thailand	1980	2000	2.18	31.30	3.64	0.46	0.04	-2.36	3.96
Togo	1980	2000	2.92	7.47	-2.71	-0.59	16.06	5.26	0.46
Trinidad and Tobago	1980	2000	1.57	10.18	-0.76	-0.39	10.06	2.75	7.69
Tunisia	1980	2000	2.89	14.41	2.19	0.09	7.83	-0.30	6.70
Turkey	1980	2000	2.76	16.87	0.54	-0.21	5.96	1.19	3.07
Uganda	1980	2000	2.65	2.84	0.86	-0.15	51.47	0.87	-0.94
Uruguay	1980	2000	0.66	11.65	2.37	0.15	7.61	-0.63	5.72
Venezuela, RB	1980	2000	2.86	14.35	-1.48	-0.47	1.71	4.06	6.74