Capital Flows to Developing Countries: The Allocation Puzzle[*]

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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 seems to flow more to countries that invest and grow less. We then introduce wedges into the neoclassical growth model and find that one needs a saving wedge in order to explain the correlation between growth and capital flows observed in the data. We conclude with a discussion of some possible avenues for research to resolve the contradiction between the model predictions and the data.

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1 Introduction

The role of international capital flows in economic development raises important open questions. In particular, the question asked by Robert Lucas almost twenty years ago—why so little capital flows from rich to poor countries—received renewed interest 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 capital flows to developing countries through the lenses of the neoclassical growth model.

Our contribution is twofold. First, we show that there is a significant discrepancy between the predictions of the textbook neo-classical growth model for the distribution of capital flows across developing countries and the behavior of capital flows 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 negative. The non-OECD countries that have grown at a higher rate over 1980-2000 have tended to export (not import) more capital. The international capital market, thus, does not allocate capital across developing countries in the way predicted by textbook theory—a fact that we call here the "allocation puzzle".

Our second contribution is to delineate the respective roles of investment and saving in explaining this puzzle. We augment the neoclassical growth model with two "wedges": one 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 so capital flows). We find that the augmented model can explain the data with investment and saving wedges of a plausible order of magnitude. Furthermore we find that the investment wedge cannot, by itself, explain the allocation puzzle. Solving the allocation puzzle requires a saving wedge that is strongly negatively correlated with productivity growth. That is, the

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

allocation puzzle is a saving puzzle.

The 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, Rep. of Congo), 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, 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: standard models have a hard time accounting for the *allocation* of international capital flows across developing countries. Capital flows from rich to poor countries are not only low (as argued by Lucas (1990)), but their allocation across developing countries seems to be the opposite of the predictions of the standard textbook model. This is the allocation puzzle.

What can, then, explain the puzzling allocation of capital flows across developing countries? Although the main purpose of this paper is to establish and characterize the allocation puzzle rather than solve it, we offer some thoughts on possible explanations at the end of the paper. Our wedge analysis shows that the explanation must involve the relationship between savings and growth. We argue that the discrepancy between the predictions of a standard model and the data might be explained by non-standard preferences, financial frictions or international trade. No attempt is made to discriminate empirically between

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[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 -0.78 (p-value of 1%).

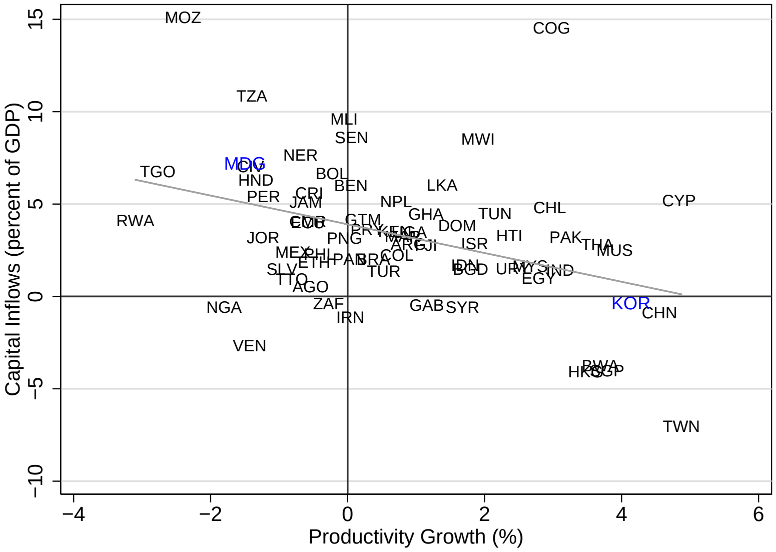

Figure 1: Average productivity growth and average capital inflows between 1980 and 2000.

these explanations in this paper—the objective being merely to demonstrate the robustness of our empirical finding and propose a road map to think about future research rather than to establish new theoretical results.

This paper lies at the confluence of different lines of literature. First, it is related to other papers 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.[4] 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.

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[4] Like us, Prasad et al. (2007) find this correlation to be robust. In particular, it remains statistically significant if one excludes the countries receiving a large amount of foreign aid (averaging more than 10 percent of their GDP).

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, which seems difficult to reconcile with free capital mobility. 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: savings not only has to be positively correlated with productivity growth, but the correlation must be stronger than that between investment and 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 (1993) 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.

The methodology in our paper is similar to Chari, McGrattan and Kehoe (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 that paper looks 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 (2004). 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.[5] 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 to the data.[6]

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

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[5] Caselli and Feyrer (2007) do not look at the contribution of capital flows in equalizing returns. One implication of their results is that observed returns to capital are not a good predictor of capital flows (since those returns are equal across countries, plus or minus a measurement error). Here, we look instead at the underlying determinant of capital flows in a world of perfect capital mobility, i.e., cross-country differences in productivity paths.

[6] 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.

section 5 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:

$$Y_t = K_t^{\alpha} \left(A_t L_t\right)^{1-\alpha}, \ 0 < \alpha < 1, \tag{1}$$

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 budget 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.[7]

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 (more generally, lower case variables are normalized by population). 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 R_t. We call τ_k the 'capital wedge'. Like in the "business cycle accounting" literature, this wedge is introduced in order to allow us to characterize the discrepancy between the model predictions and the data on investment rates. 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.

Capital mobility implies that the private return on domestic capital and the world real interest rate are equal:

$$\left(1 - \tau_k\right) R_t = R^*. \tag{4}$$

Substituting this into the expression for the gross return on capital (3), we obtain that

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[7] 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. This is the main reason our results are different from Chen, Imrohoroglu and Imrohoroglu (2006) who study the Japanese saving rate from the perspective of a closed economy.

the capital stock per efficient unit of labor $\tilde{k} = k_t/A_t$ is constant and equal to:

$$\tilde{k}_t = \tilde{k}^* \equiv \left(\frac{\alpha}{R^*/\left(1-\tau_k\right)+\delta-1} \right)^{1/1-\alpha}, \tag{5}$$

('tilde-variables' will denote per capita variables in efficiency units: $\tilde{x} = X/AN$). Equation (5) makes clear that the capital wedge τ_k is the only source of variation in the steady state capital stock per efficient unit of labor across countries. A higher wedge, equivalent to a higher implicit tax on capital, depresses domestic capital accumulation and lowers $\tilde{k}^*$.

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

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

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 the difference between domestic productivity and the productivity conditional on no 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. The limit π measures the country's long-run technological catch-up relative to the world 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. Domestic productivity converges to a fraction $(1+\pi)A_0/A_0^*$ of the world frontier, and the growth rate of domestic productivity converges to g^*.[8]

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[8] 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.

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:

$$U_t = \sum_{s=0}^{\infty} \beta^s \; N_{t+s} \; u\left(c_{t+s}\right), \tag{6}$$

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.

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

$$C_t + K_{t+1} = (1 - \tau_s) R^* (K_t - D_t) + D_{t+1} + N_t (w_t + z_t), \tag{7}$$

where w_t is the wage, equal to the marginal product of labor $\left(1 - \alpha\right) k_t^{\alpha} A_t^{1-\alpha}$, z_t is a lump-sum transfer and τ_s is the "saving wedge." When positive, this wedge functions like a tax on capital income. 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.

The representative resident maximizes the welfare function (6) under the budget constraint (7). The Euler equation for the small open economy is,

$$c_t^{-\gamma} = \beta R^* (1 - \tau_s) c_{t+1}^{-\gamma}. \tag{8}$$

We assume that the world interest factor is given by,

$$R^* = g^{*\gamma} / \beta. \tag{9}$$

Equation (9) holds if the rest of the world is composed of advanced economies that have the same preferences as the small economy under consideration, no saving wedge 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. We will also assume that $\tau_s = 0$ in the long run, ensuring that the small open economy ends up with the same consumption growth rate as the rest of the world.

A country is characterized by an initial capital stock per capita k_0, debt per capita d_0, population growth rate n, productivity path $\{A_t\}_0^\infty$, and capital and savings wedges, τ_k and τ_s. 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, and that the saving wedge is zero after time T.

Assumption 1 $\pi_t = \pi$ *and* $\tau_s = 0$ *for* $t \geq T$.

For simplicity we further assume that the path for the ratio π_t/π is the same for all countries and satisfies $\pi_t \leq \pi$.

Assumption 2 $\pi_t = \pi f(t)$ *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 by one single parameter, the long-run productivity catch-up 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.[9]

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[9] 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

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

Proposition 1 *The ratio of cumulated capital inflows to initial output is given by a function:*

$$\frac{\Delta D}{Y_0} = \mathcal{D}\left(\widetilde{k}_0, \widetilde{d}_0, \pi, \tau_k, \tau_s\right). \tag{11}$$

Under general conditions, this function is increasing in the initial level of debt ($\widetilde{d}_0$), the productivity catch-up parameter (π) and the saving wedge (τ_s), and decreasing in the initial level of capital ($\widetilde{k}_0$) and the capital wedge (τ_k).

Proof. See appendix A ■

A closed-form expression for $\Delta D/Y_0$ is derived in appendix A. Here, we provide intuition for proposition 1 by looking at the case without saving wedge ($\tau_s = 0$). Then, cumulated capital inflows are given by,

$$\frac{\Delta D}{Y_0} = \overbrace{\frac{\tilde{k}^* - \tilde{k}_0}{\widetilde{y}_0}(ng^*)^T}^{\Delta D^c/Y_0} + \overbrace{\frac{\tilde{d}_0}{\widetilde{y}_0}\left[(ng^*)^T - 1\right]}^{\Delta D^t/Y_0} + \overbrace{\pi\frac{\tilde{k}^*}{\widetilde{y}_0}(ng^*)^T}^{\Delta D^i/Y_0} + \overbrace{\pi\frac{\widetilde{w} + \tilde{z}_k}{R^*\widetilde{y}_0}(ng^*)^T \sum_{t=0}^{T-1}\left(\frac{ng^*}{R^*}\right)^t [1 - f(t)]}^{\Delta D^s/Y_0}, \tag{12}$$

where $\widetilde{w}$ is the normalized real wage and $\tilde{z}_k$ is the normalized lump-sum transfer financed by the capital wedge. Equation (12) 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 zero capital flows. Consider now each term on the right-hand side of equation (12) 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 presence of *trend* growth ($ng^* > 1$). In the absence of productivity catch-up the economy follows a balanced

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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.

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.

The third and fourth terms in (12) 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* 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 $\Delta D^i/Y_0$.

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 after-transfer labor income $\tilde{w} + \tilde{z}$ 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.

As shown in Appendix A, introducing saving wedges slightly complicates expression (12), but the impact of the wedges on capital inflows is intuitive. The investment wedge reduces the predicted level of capital inflows by lowering initial capital scarcity as well as the impact of productivity catch-up on investment. By contrast, the saving wedge lowers domestic savings between time 0 and time T and so increases the predicted level of capital inflows.

It is then easy to show the following corollary.

Corollary 1 *Capital flows and productivity catch-up.*

1. *Consider a country without initial capital scarcity, initial debt, or saving wedge. Then the country receives a positive level of capital inflows if and only if its productivity catches up relative to the world technology frontier:*

$$\Delta D > 0 \textit{ if and only if } \pi > 0.$$

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:

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

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 capital inflows—hold in a much larger set of models. First, consider the assumption of perfect capital mobility. In reality, financial frictions may limit severely—perhaps eliminate altogether—the ability of developing countries to borrow in order to smooth consumption profiles. Yet, we would argue that, while international financial frictions may be important, they are unlikely to reverse the direction of capital flows, or the sign of their correlation with productivity growth.

To see this, suppose that external debt cannot exceed a certain ceiling that is increasing with domestic output and domestic capital. This type of constraint arises in models in which the country can pledge only up to a fraction of domestic capital or output to foreign creditors. If the constraint is binding, countries with higher productivity growth have higher output and capital, and so can borrow more from abroad as their collateral constraint is relaxed. It also 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 frontier.[10] Hence, Corollary 1 remains true. International financial frictions can reduce the predicted size of capital inflows, but does not change the correlation between π and ΔD.

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[10] Such a country accumulates foreign assets if $\pi < 0$. If $\pi > 0$, the country wants to borrow and the only impact of the debt ceiling is to constrain the volume of borrowing.

Second, there are several reasons to take the savings component $\Delta D^s/Y_0$ less seriously than the other components when looking at the quantitative predictions of the model. The implications of the textbook neoclassical growth model for savings are not especially robust. For example, the behavior of aggregate saving would be different if the economy were populated by overlapping generations instead of infinitely-lived consumers. Furthermore, the predictions of the textbook model for savings have already been found to be at odds with the data in the literature. As we have mentioned in the introduction, other models have been developed to explain the positive association between growth and national saving that is observed in the data.

Thus, one might want to look at the implications of the model when the the savings component $\Delta D^s/Y_0$ is omitted. In fact, omitting this component is exactly what one should do if the perfect foresight assumption were relaxed in a plausible way. So far we have assumed that the path of future productivity is known with certainty as of time $t = 0$. Instead, let us assume that agents expect future productivity growth to remain constant and equal to g^*. This is a reasonable approximation, in light of Easterly, Kremer, Pritchett and Summers (1993) finding that output growth rates are unpredictable, and uncorrelated across decades. Ex-ante, households might be unsure about how long a period of high or low growth will last. In order to abstract from the complications associated with precautionary savings, we solve the model under certainty equivalence and assume that agents always expect productivity to grow at rate g^* with certainty. Under this assumption we obtain the following result.

Proposition 2 *If agents always expect productivity to grow at rate g^* and there is no savings wedge, the ratio of cumulated capital inflows to initial output, $\Delta D^n/Y_0 = [D_T - D_0]/Y_0$, is given by:*

$$\frac{\Delta D^n}{Y_0} = \overbrace{\frac{\tilde{k}^* - \tilde{k}_0}{\tilde{y}_0}(ng^*)^T}^{\Delta D^c/Y_0} + \overbrace{\frac{\tilde{d}_0}{\tilde{y}_0}\left[(ng^*)^T - 1\right]}^{\Delta D^t/Y_0} + \overbrace{\pi\tilde{k}^*\frac{(ng^*)^T}{\tilde{y}_0}}^{\Delta D^i/Y_0}. \tag{13}$$

Proof. See appendix A. ■

The only difference between equations (13) and (12) is that the consumption smoothing term, $\Delta D^s/Y$, has disappeared. The intuition is straightforward: when productivity is expected to grow at rate g^*, the consumption-savings choices are the same as in the balanced growth path with no productivity catch-up. Productivity influences capital flows only through the investment term.

However, whether or not we take the savings component $\Delta D^s/Y_0$ into account does not change the model's prediction about 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

Are the model's predictions concerning capital flows supported by the empirical evidence? To be more specific, do developing countries with faster productivity growth and larger initial capital scarcity receive more capital flows? We answer this question by estimating, for each country, their initial capital scarcity and productivity growth, then comparing the actual and predicted 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, the sample period cannot start too early because countries need to be financially open over most of the period under study. Indicators of financial openness indicate a sharp increase starting in the late 1980s and early 1990s. For instance, the Chinn and Ito (2007) index indicates an average increase in financial openness from 31.3 in 1980 to 42.5 in 2000 for the countries in our sample.[11] 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.[12]

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[11] The index is normalized to run from 0 (most closed) to 100 (most open).

[12] 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 C.

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 growth rate of the working-age population.[13] 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 PWT), assuming a capital share α of 0.3 and a depreciation rate δ of 6 percent.[14] 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. This detrending removes short term fluctuations in productivity due to mismeasurement or business cycle factors.

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

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

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 this measure 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 used instead the price of investment goods reported in the Penn World Tables. This seems to be a good proxy because investment goods are mostly

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

[14] See Caselli (2004) for details. Following standard practice, we set initial capital to $I/(g_i + \delta)$ where I is the initial investment level from the PWT 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.

tradable—as suggested by the fact that their price vary less across countries than that of consumption goods. The PPP adjustment will tend 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 did not affect the thrust of our results.[15]

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 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, while Latin America and Africa fell behind.[16] So 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 about 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

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

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

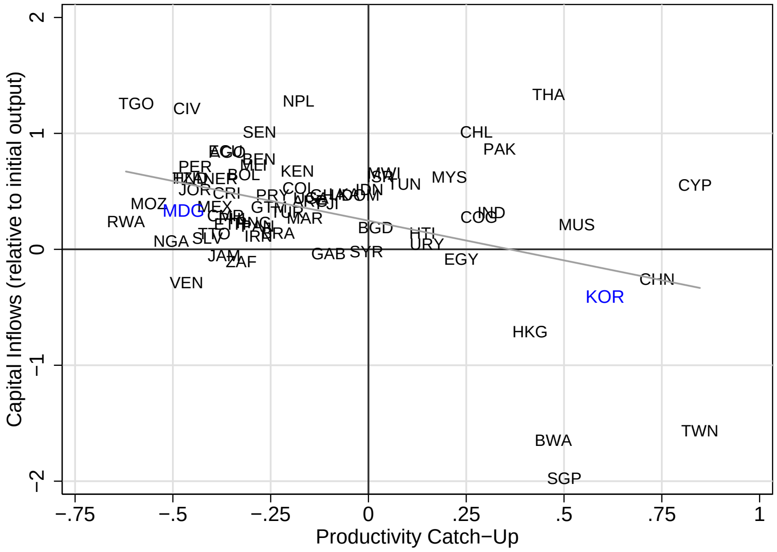

Figure 2: Productivity catch-up (π) and change in external debt $\left(\frac{\Delta D}{Y_0}\right)$.

export more capital. 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 correlation between productivity catch-up and capital inflows by plotting those variables for the full country sample. 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 significant at the 1 percent level.[17] Figure 2 confirms, with different measures, the basic correlation already shown in Figure 1.

To summarize, we find strong evidence against the predictions of the model regarding productivity: countries with faster productivity growth attract less capital inflows. This is the *allocation puzzle*.

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[17] 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).

3.3 Robustness

We ran a number of straightforward robustness checks. First, we checked that our results were robust to the exclusion of African countries (where arguably many countries may be too poor to export capital while maintaining subsistence levels of consumption). Second, we started the analysis in 1970 instead of 1980. The sample is much smaller (30 countries), but the results are broadly similar. Third, we split the sample according to whether Chinn and Ito's (2007) index of financial account openness is above or below the sample median. One would a priori expect a better fit between the model and the data for more financially open countries. Yet the results are similar for both groups of countries.[18]

We also looked at the potential bias induced by aid flows. The basic neoclassical framework may not be appropriate to predict official aid flows because aid is not necessarily allocated to countries with the highest expected returns on capital.[19] This objection does not invalidate, per se, the predictions of the basic model for net capital flows. If we modeled aid as a lump-sum transfer to the representative agent in the model of section 2, then aid would immediately leave the country—as the representative agent would find it optimal to invest it abroad—and the predictions of the model would remain valid for *net* capital flows. 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.[20] Our benchmark 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.

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, aid could finance an

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[18] Those results are available upon request.

[19] On the one hand, if aid has any effectiveness the flows of development aid should be positively correlated with productivity growth. On the other hand, there is a selection bias if the countries that have been receiving aid flows over long periods of time are those that have failed to develop. In addition, the components of aid that are justified by humanitarian reasons should be negatively correlated with growth. The large literature on development aid has generally failed to find a significant relationship between aid and growth (see Rajan and Subramanian (2005)).

[20] For a recent discussion of a number of well-known cases and an analysis along these lines, see Jayachandran and Kremer (2006).

increase in domestic expenditures above and beyond what could be financed by private capital flows. In addition, capital controls could prevent aid inflows from being completely offset by a capital outflow. In those cases, aid would not be neutral and its impact on our results should be examined.

To see how far aid 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. This is an extreme assumption since, as argued above, part of the official aid flows could easily find their way back outside of the country. Our measure of official aid flows is the net overseas development assistance (net ODA) from the Development Assistance Committee (DAC).[21] 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.

Our assumption that official aid flows have no offset means that in the absence of aid flows the counterfactual volume of net capital flows would have been equal to the observed cumulated net capital flows ΔD minus the cumulated aid flows ΔB,

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

Column 3 of Table 1 reports the results for the aid-adjusted capital flows. Since net ODA flows are always positive in our sample (all developing countries are net recipients), $\Delta D'$ is always *smaller* than ΔD. As a result, the average developing country is found 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 3. A large level of cross-country variation in capital flows remains. The correlation

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[21] This measure is available for all countries in our sample, except Taiwan. According to Roodman (2006), DAC counts total grants and concessionnal 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.

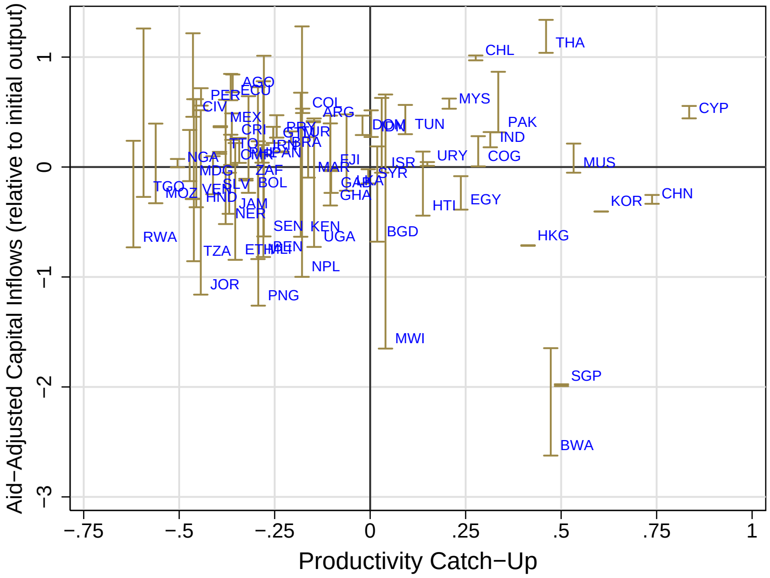

Figure 3: Productivity catch-up (π) and aid-adjusted change in external debt $\left(\frac{\Delta D'}{Y_0}\right)$. The vertical bars report the initial (top) and aid-adjusted (bottom) change in external debt for each country.

remains negative, although it is no longer significantly different from zero.[22]

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.

4 Wedges

Capital inflows are the difference between investment and savings. In this section we estimate the capital and saving wedges that allow the model to match the observed levels of investment and savings for each country in our sample. There is separability between the two wedges, in the sense that the capital wedge required to explain the observed investment rate can

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[22] 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).

be computed independently of the saving wedge required to explain the observed level of savings. We start with the capital wedge.

4.1 The capital wedge

Our approach is to calibrate the capital wedge so as to match exactly investment rates in the data. We assume for simplicity 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, which results from the assumptions made about individual preferences in the following section. The capital wedge τ_k can be estimated to match the observed investment rates, as shown in the following proposition.

Proposition 3 *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:*

$$i_k = \frac{1}{T}\frac{\tilde{k}^*(\tau_k) - \tilde{k}_0}{\tilde{k}_0^\alpha} + \frac{\pi}{T}\tilde{k}^*(\tau_k)^{1-\alpha} g^* n + \tilde{k}^*(\tau_k)^{1-\alpha}(g^* n + \delta - 1). \tag{14}$$

Proof. See appendix A. ■

Equation (14) 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 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.[23]

Solving (14) numerically, we obtain 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 C reports the values of i_k, π, n and τ_k for each country in our sample. Everything else equal, our calibration approach assigns a high capital wedge to countries with low average investment rate.

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

Our estimates of the capital wedge assume that countries are perfectly integrated. Although international financial frictions could bias our estimates of τ_k, this bias should not affect the model's predictions for the *direction* of capital flows. In the case of a capital-scarce country where financial frictions maintain the domestic interest rate above the world level, the observed investment rate will be lower than under perfect financial integration, leading us to overestimate the capital wedge τ_k and thus underestimate the level of capital inflows needed to equalize returns. Symmetrically, in the case of a capital abundant country the bias induced by financial frictions should lead us to underestimate capital outflows. The important point is that while there is a downward bias in the predicted *size* of capital flows, the model still predicts accurately their direction and relative magnitude.

With these caveats in mind, Table 2 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 (14). 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 2 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 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 ($k_0/k^* = 1.09$). Because the countries that were capital-scarce in 1980 also tended to have a higher productivity growth rate in the following two decades, the cumulated contribution of the productivity and convergence components can be significant. This is most apparent if one compares Asia and Africa—the productivity and convergence components explain more than

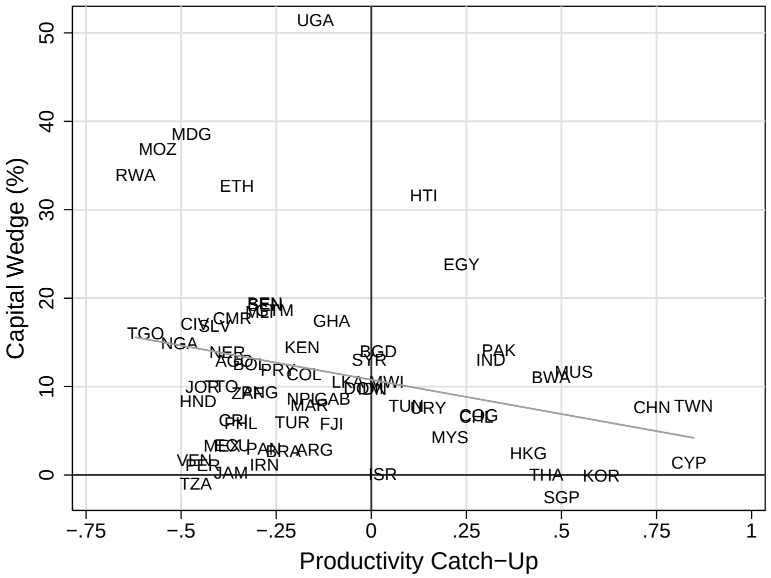

Figure 4: Productivity catch-up (π) and capital wedge (τ_k).

half of the difference in the investment rate between the two regions.

We observe that the estimated capital wedge (column 5) has a plausible order of magnitude. It 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 4)—consistent with the idea that economic development is associated with better institutions and lower distortions. 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 5. 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; countries falling behind should be net lenders.[24]

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[24] We estimate a slope coefficient of 19.06, with a s.e. of 0.74 (p-value<0.01). Excluding the consumption smoothing term would reduce the slope but not change its positive sign.

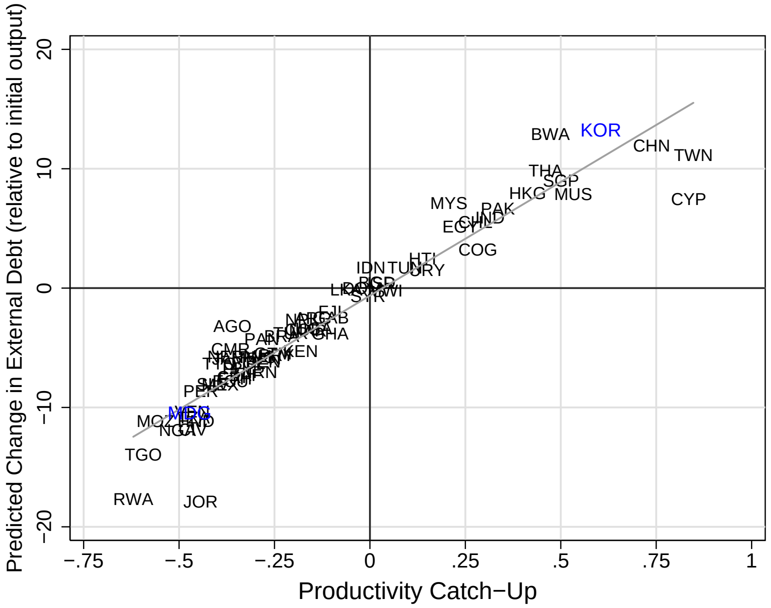

Figure 5: Productivity catch-up (π) and capital inflows $\left(\frac{\Delta D}{Y_0}\right)$ predicted by the model with capital wedges.

As a final comment, it is interesting to note that the capital wedge plays the same role as adjusting for non-reproducible capital and relative price effects discussed in Caselli and Feyrer (2007). Those authors argue that, while naive 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 it is achieved by the capital wedge τ_k.

To illustrate, Figure 6 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-hand side top panel indicates enormous variation in the naive 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

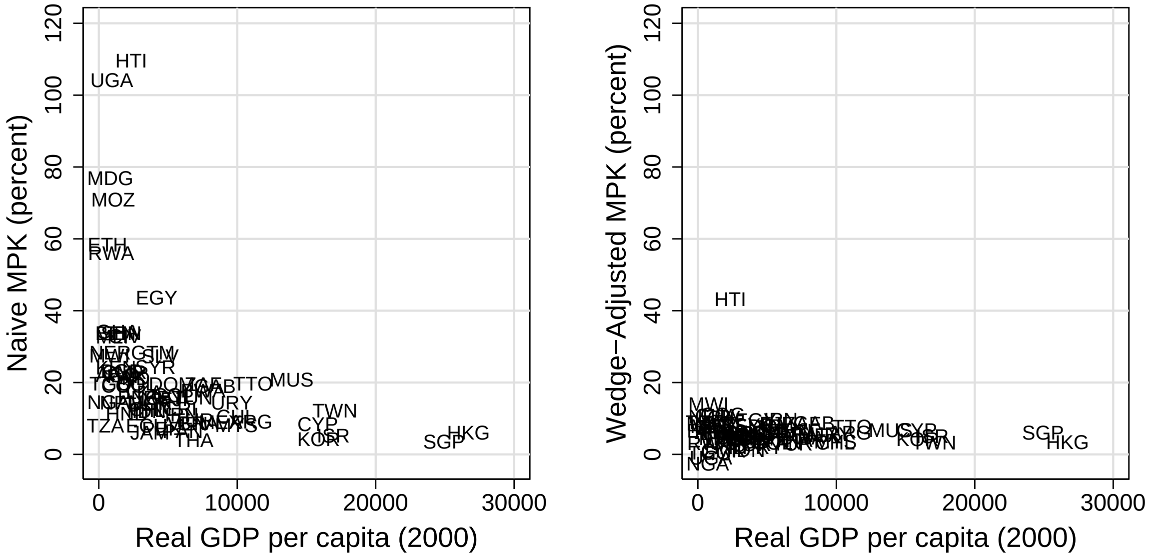

Figure 6: Naïve and Wedge-adjusted Marginal Product of Capital in year 2000.

returns equalization. Our results thus parallel those of Caselli and Feyrer (2007): private returns to capital appear remarkably similar across countries.[25]

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.

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 now 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 those capital wedges the model perfectly replicates observed capital flows. In order to compute the left-hand side of the equation above, we need to make further assumptions about

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[25] 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.

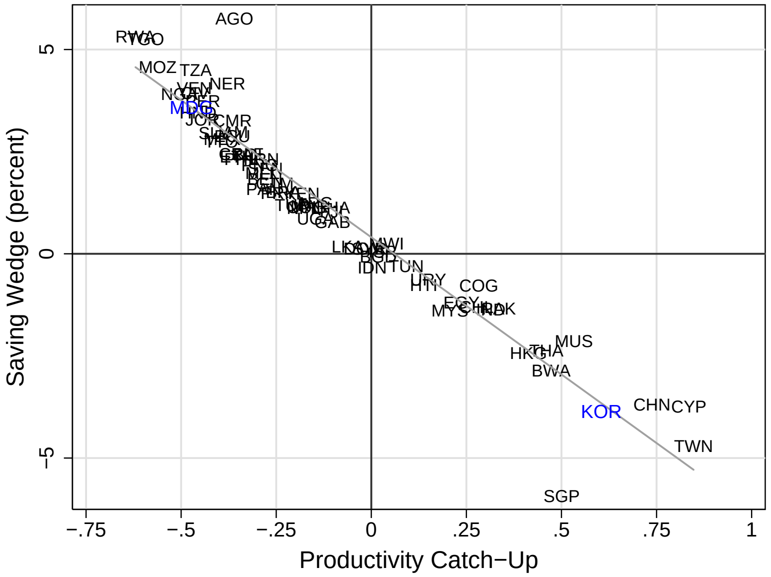

Figure 7: Productivity catch-up (π) and saving wedges (τ_s).

preferences. We assume logarithmic preferences ($\gamma = 1$) and set the discount factor β to 0.96. 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. Given these parameter values, the world real interest rate is equal to $R^* - 1 = 5.94$ percent per year.

Figure 7 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. 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 7. 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.[26] The gaps between the model and the data may also reflect the fact that the model is failing along some important and missing dimension of the real world. We discuss possible extension of the model in the next section.

We conclude this section by showing the decomposition of the observed levels of capital flows into the same four terms as in equation (12).[27] The wedges are now included, so that the model predicts exactly the observed capital flows for each country. Table 3 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, 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. This saving wedge affects the remaining two components, the saving component and the trend component.[28] Our wedge analysis indicates that Asia subsidizes saving ($\tau_s = -1.14$ percent) while Latin America and Africa tax savings similarly ($\tau_s = 1.8$ percent). Similarly, the saving tax decreases with levels of development.

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[26] But note that the distortion would need to be *positively* correlated with productivity growth to account for figure 7.

[27] See equation (24) in appendix A.

[28] The latter since a positive saving wedge makes households more impatient, so that they will run down initial wealth $k_0 - d_0$ at a faster rate, resulting in larger capital inflows.

5 Discussion and Conclusion

This paper establishes a puzzling stylized fact: capital tends to flow more toward countries with lower productivity growth and lower 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 can be "resolved" by introducing into the model a saving wedge, if this saving wedge is sufficiently negatively correlated with productivity growth. This result tells us that explaining the allocation puzzle means understanding the correlation between saving and growth in developing countries. The next question, of course, is what type of discrepancy between the undistorted neoclassical growth model and the real world is captured by our saving wedge. We conclude with a discussion of some possible approaches to answering this question. This discussion is meant as a tentative road map for future research, not as an attempt to push forward a particular explanation.[29]

A first class of explanations considers the causality from savings to growth. Note that the relevant growth rate here is the growth rate of productivity, not of output per capita, so the mechanism must involve some endogeneity of domestic productivity to domestic savings. 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.[30]

Another class of explanations considers the causality from growth to savings.[31] In

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[29] 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.

[30] 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.

[31] Carroll, Overland and Weil (2000) present evidence suggesting that the causality runs from growth to savings.

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 is an open question for future research. It requires that consumption levels increase sufficiently slowly for saving to increase faster than investment.

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 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 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.

Low domestic financial development and lack of social insurance may also constrain the ability of residents to insure efficiently and encourages precautionary savings.[32] It has often been argued that some Asian emerging market countries have accumulated reserves to deal with the aggregate risk of crisis, or the rise in idiosyncratic risk that is associ-

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[32] See Mendoza, Quadrini and Rios-Rull (2007).

ated with the transition to a market economy (see Chamon and Prasad (2008) for China). 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.

The last channel to consider is trade. Another way of presenting the allocation puzzle is that net exports are positively correlated with productivity growth across countries—consistent with a view in development economics that emphasizes the importance of exports in economic development (see Rodrik (2006) for a recent exposition). If productivity take-offs originate in the tradable sector before spilling over to the nontradable sector, the initial phase of the economic take-off could be associated with a surge in net exports, and capital outflows.

To conclude, the main explanation for the allocation puzzle is an open question. Our wedge analysis has shown that the relationship between growth and savings is key. We have discussed several channels that could help understand the discrepancy between the predictions of the basic neoclassical model of growth and the data on capital flows. It seems important to know more about those channels if one wants to understand how international financial integration helps economic development.

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	(1) Catch-up π	(2) Capital inflows $\Delta D/Y_0$	(3) Aid-adjusted cap. inf. $\Delta D'/Y_0$	(4) Obs.
Non-OECD countries	-0.10	31.49	-20.16	68
Low Income	-0.22	56.49	-41.46	26
Lower Middle Income	-0.15	37.02	1.63	23
Upper Middle Income	-0.06	12.94	-2.94	13
High Income (Non-OECD)	0.54	-57.85	-54.46	6
Africa	-0.17	39.09	-39.36	31
Latin-America	-0.24	36.89	13.59	20
Asia	0.19	11.28	-25.16	17
except China and India	-0.12	32.35	-20.54	66
China and India	0.53	3.21	-7.75	2
except Africa	-0.04	25.12	-3.64	37

Table 1: Productivity Catch-Up and Capital Inflows between 1980 and 2000. Unweighted country averages. The sample has one less observation than indicated in column (4) for the aid-adjusted capital inflows.

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
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
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
except China and India	13.45	0.10	-1.04	14.39	11.57	66
China and India	15.76	0.40	3.02	12.34	10.35	2
except Africa	16.25	0.82	-0.70	16.13	7.76	37

Table 2: 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: $\tilde{k}^{*(1-\alpha)}(g^{*}n+\delta-1)$. Unweighted country 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) Wegdge τ_s	(7) Obs.
Non-OECD countries	31.49	5.95	-28.18	21.97	31.75	1.07	68
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
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
except China and India	32.35	5.79	-33.32	26.64	33.24	1.18	66
China and India	3.21	11.39	141.57	-132.15	-17.60	-2.53	2
except Africa	25.12	37.45	-16.99	-25.14	29.81	0.47	37

Table 3: 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. Country averages (unweighted).

A Proofs

A.1 Proof of Proposition 1.

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

$$\frac{\Delta D}{Y_0} = \frac{D_T - D_0}{Y_0} = \frac{\tilde{d}_T A_T N_T - \tilde{d}_0 A_0 N_0}{A_0 N_0 \tilde{y}_0} = \frac{\tilde{d}_T (g^* n)^T (1+\pi) - \tilde{d}_0}{\tilde{y}_0}. \tag{15}$$

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 (7) by N_t gives the per capita budget constraint

$$c_t + n(k_{t+1} - d_{t+1}) = R^*(k_t - d_t) + w_t + z_{kt}, \tag{16}$$

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.

Let us denote by $g_t = A_t / A_{t-1}$ the growth rate of productivity. Then, dividing (16) by A_t and using $\tilde{k}_{t+1} = \tilde{k}_t = \tilde{k}^*$ gives the normalized budget constraint,

$$\tilde{c}_t + n g_{t+1}(\tilde{k}^* - \tilde{d}_{t+1}) = R^*(\tilde{k}^* - \tilde{d}_t) + \tilde{w} + \tilde{z}_k, \tag{17}$$

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

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 (17) implies

$$\tilde{d}_T = \tilde{k}^* + \frac{\tilde{w} + \tilde{z}_k - \tilde{c}_T}{R^* - n g^*}. \tag{18}$$

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

$$\tilde{c}_T = \frac{c_T}{A_T} = \frac{c_0 [g^* \phi(\tau_s)]^T}{(1+\pi) A_0 g^{*T}} = \frac{\tilde{c}_0 \phi(\tau_s)^T}{1+\pi}. \tag{19}$$

where $\phi(\tau_s) = (1-\tau_s)^{1/\gamma}$. 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 (16) can be written,

$$\sum_0^{+\infty} \left(\frac{n}{R^*}\right)^t c_t = \sum_0^{+\infty} \left(\frac{n}{R^*}\right)^t (w_t + z_{kt}) + R^*(k_0 - d_0). \tag{20}$$

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

$$c_t = A_0 \phi^{min(t,T)} g^{*t} \tilde{c}_0. \tag{21}$$

Using this equation we have

$$\sum_{0}^{+\infty} \left(\frac{n}{R^*}\right)^t c_t = \frac{A_0 \tilde{c}_0}{\left(1 - ng^*/R^*\right)\psi(\tau_s)} \tag{22}$$

where

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

Using (20), (22) and $w_t + z_{kt} = (\tilde{w} + \tilde{z}_k) A_0 (1 + \pi_t) g^{*t}$, we then have

$$\tilde{c}_0 = \left(R^* - ng^*\right) \psi\left(\tau_s\right) \left[\frac{\tilde{w} + \tilde{z}_k}{R^*} \sum_{t=0}^{\infty} \left(\frac{ng^*}{R^*}\right)^t (1 + \pi_t) + \tilde{k}_0 - \tilde{d}_0\right]. \tag{23}$$

The saving wedge τ_s enters consumption choices only through the marginal propensity to consume out of wealth, $\left(R^* - ng^*\right) \psi\left(\tau_s\right) \geq 0$. Using (23) it is easy to see that ψ decreases with $\phi(\tau_s)$ and so increases with τ_s. The marginal propensity to consume increases with the saving wedge. One can then substitute $\tilde{d}_T$ out of equation (15) using (18), (19) and (23). This gives:

$$\begin{aligned}
\frac{\Delta D}{Y_0} &= \frac{\tilde{k}^*}{\tilde{y}_0} \left(ng^*\right)^T (1 + \pi) - \frac{\tilde{k}_0}{\tilde{y}_0} \psi(\tau_s) \left(ng^* \phi(\tau_s)\right)^T + \frac{\tilde{d}_0}{\tilde{y}_0} \left(\psi\left(\tau_s\right) \left(ng^* \phi\left(\tau_s\right)\right)^T - 1\right) \\
&\quad + \frac{\tilde{w} + \tilde{z}_k}{\tilde{y}_0} \frac{\psi\left(\tau_s\right)}{R^*} \left(ng^* \phi\left(\tau_s\right)\right)^T \sum_{t=0}^{T-1} \left(\frac{ng^*}{R^*}\right)^t \left[\phi\left(\tau_s\right)^{t-T} (1 + \pi) - (1 + \pi_t)\right].
\end{aligned} \tag{24}$$

The right-hand side is a closed-form expression for function $\mathcal{D}$ in Proposition 1. The signs of the variations of $\Delta D / Y_0$ with the parameters can be derived from the expression above. First, $\Delta D / Y_0$ increases with $\tilde{d}_0$ if and only if $\psi(\tau_s) \left(ng^* \phi(\tau_s)\right)^T > 1$, which is true if τ_s is small enough. Second, $\Delta D / Y_0$ increases with π because $\pi_t = f(t)\pi$ with $f(t) \leq 1$ and $\phi(\tau_s)^{t-T} > 1$. Third, the variation with respect to τ_s are ambiguous in general and depend on whether $\tilde{k}_0$ is smaller or larger than $\tilde{d}_0$. In the case where $\tilde{k}_0 \geq \tilde{d}_0$, $\Delta D / Y_0$ is increasing with τ_s as indicated in the Proposition. Fourth, $\Delta D / Y_0$ unambiguously decreases with $\tilde{k}_0$. Finally, $\Delta D / Y_0$ decreases with τ_k if the consumption-saving term is positive.

Expression (24) admits the following decomposition, generalizing equation (12) in the text:

- 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

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

If there is no saving wedge ($\tau_s = 0$), then $\psi(\tau_s) = \phi(\tau_s) = 1$ and equation (24) simplifies to equation (12) in the text.

■

A.2 Proof of Proposition 2.

The proof is similar to that of Proposition 1. The only difference is that the consumption path is determined as if future productivity were growing at rate g^*. This implies that consumption at time t is given by an equation similar to (23) with π set to zero:

$$\begin{aligned} \tilde{c}_t &= (R^* - ng^*)\left(\frac{1}{R^*}\sum_{t=0}^{+\infty}\left(\frac{ng^*}{R^*}\right)^t (\tilde{w} + \tilde{z}) + \tilde{k}^* - \tilde{d}_t\right), \\ &= \tilde{w} + \tilde{z} + (R^* - ng^*)(\tilde{k}^* - \tilde{d}_t). \end{aligned}$$

Using this expression to substitute $\tilde{c}_t$ out of (17) gives,

$$\begin{aligned} \tilde{k}^* - \tilde{d}_{t+1} &= \frac{g^*}{g_{t+1}}(\tilde{k}^* - \tilde{d}_t), \\ &= \frac{1 + \pi f(t)}{1 + \pi f(t+1)}(\tilde{k}^* - \tilde{d}_t). \end{aligned}$$

Iterating from $t = 0$ to $t = T$ gives

$$\tilde{k}^* - \tilde{d}_T = \frac{1}{1+\pi}(\tilde{k}^* - \tilde{d}_0^+) = \frac{1}{1+\pi}(\tilde{k}_0 - \tilde{d}_0).$$

Using this expression to substitute out $\tilde{d}_T$ from (15) gives (13). ■

A.3 Proof of Proposition 3.

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): $D_T^{\$} = D_0^{\$} - \sum_{t=0}^{T-1} CA_t^{\$}$,[33] and use the formulas $D_T = D_T^{\$}/Q_T$ and $D_0 = D_0^{\$}/Q_0$ to obtain:

$$\Delta D = \left(\frac{1}{Q_T} - \frac{1}{Q_0}\right) D_0^{\$} - \sum_{t=0}^{T-1} \frac{CA_t^{\$}}{Q_T}. \tag{25}$$

The estimate of the initial net external debt in U.S. dollar ($D_0^{\$}$) is obtained from Lane and Milesi-Ferretti (2006)'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.[34] 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:

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

---

[33] Alternatively, one could use Lane and Milesi-Ferretti (2006)'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.

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

C Data

Table 4: 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

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Table 4 continued from previous page

`Country`	`Start`	`End`	n(%)	i_k(%)	g(%)	π	τ_k(%)	τ_s(%)	RW(%)
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
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