

# Capital Flows to Developing Countries: The Allocation Puzzle\*

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## Abstract

According to the consensus view in growth and development economics, cross country differences in per-capita income largely reflect differences in countries' total factor productivity. We argue that this view has powerful implications for patterns of capital flows: everything else equal, countries with faster productivity growth should invest more, and attract more foreign capital. We then show that the pattern of net capital flows across developing countries is not consistent with this prediction. If anything, capital seems to flow more to countries that invest and grow less. We argue that this result—which we call the *allocation puzzle*—constitutes an important challenge for economic research, and discuss some possible research avenues to solve the puzzle.

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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—has spurred a large literature, and is receiving renewed interest now that capital seems to be flowing “upstream” from developing countries to the U.S.<sup>1</sup>

This paper takes a fresh look at the pattern of capital flows to developing countries through the lenses of the neoclassical growth model. We innovate by taking advantage of the advances made in the recent “development accounting” literature. Two conclusions from this literature will be especially relevant for our analysis. First, a substantial share of the cross-country inequality in income per capita comes from cross-country differences in Total Factor Productivity (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 do not seem to encounter serious or persistent difficulties in accumulating 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.

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 key difference between these countries is that some are more successful than others at catching up relative to the world technology frontier (the TFP level of advanced economies). What does this imply for capital flows? We show that a textbook model delivers a simple answer to this question: capital should flow *into* the developing countries whose TFP catches up relative to advanced economies, and should flow *out* of the countries whose TFP falls behind. This is not a surprising result: international

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

capital markets should allocate capital to the countries where it becomes more productive relative to the rest of the world.

Although simple and intuitive, this result provides us with a new theoretical benchmark to assess the Lucas puzzle. We would expect large flows of capital from rich to poor countries only if the productivity of the latter were catching up to the level of the former. But the estimates from the development accounting literature suggest that this not the case. In fact, we find that the productivity of the average non-OECD country slightly *declined* relative to advanced economies between 1980 and 2000. So the textbook model, taken literally, predicts that the average non-OECD country should have *exported* capital to the rest of the world. Our resolution of the Lucas puzzle is merely a confirmation of Lucas' original conjecture that the low volume of capital flows to poor countries is due primarily to low productivity in those countries, rather than to international financial frictions.<sup>2</sup>

We also show (and this is the main point of our paper) that this resolution of the Lucas puzzle comes at the cost of a new puzzle. We call it the *allocation puzzle* because it relates to the allocation of capital flows *across* developing countries rather than their aggregate volume. As mentioned above, the textbook model predicts that developing countries with higher productivity growth should receive more capital inflows. But the data suggest that the opposite is true. This is shown by Figure 1, which plots average productivity growth against the average ratio of capital inflows to GDP for 69 developing countries over the period 1980-2000.<sup>3</sup> Although the variables are averaged over two decades, there is substantial cross-country variation both in the direction and in the volume of capital inflows, with some countries receiving about 10 percent of their GDP in capital inflows on average (Mozambique, Jordan), whereas others export about 10 percent of their GDP in capital outflows (Singapore, Hong Kong). More strikingly, the correlation between the two variables is negative, the opposite of the theoretical prediction. To illustrate with two countries that are typical of

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<sup>2</sup>Lucas emphasized differences in the quality of human capital, as well as human capital externalities. The development accounting literature suggests that human capital should be given less weight, as a determinant of productivity, than Lucas thought.

<sup>3</sup>Capital inflows are measured as the ratio of a country's PPP-adjusted 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.

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, received almost no net capital inflows, whereas Madagascar, whose TFP fell by 1.5 percent a year, received 6 percent of its GDP in capital inflows on average.

As we show in this paper, patterns such as Figure 1 are 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.

The main purpose of this paper being to establish the allocation puzzle, we run a number of robustness exercises. First, our main measure of capital inflows is very aggregate (as the textbook model without friction suggests it should be), but it includes some components, such as aid flows, that may influence the results. However, we do not find that our results are accounted for by aid flows: the correlation shown in Figure 1 does not become positive if one looks at capital flows net of aid, even though there still is a substantial degree of cross-country variation in the direction and volume of capital flows. We look at other ways of making the model more realistic but these changes do not help explain the allocation puzzle. Lack of perfect foresight or international financial frictions may mute the volume of international capital flows, but should not change their direction or their allocation across countries. Our results are also robust to the introduction of non-reproducible capital (land) into the model, an extension which Caselli and Feyrer (2007) have shown to be potentially important in estimating international differences in the return to capital.

What can, then, explain the puzzling allocation of capital flows across developing countries? Although the main purpose of this paper is to establish the allocation puzzle rather than solve it, we offer some thoughts on possible explanations at the end of the paper. We distinguish three possible approaches, which put the spotlight respectively on the link between savings and growth, the link between financial development and growth, and the link between trade and growth. No attempt is made to discriminate empirically between these

explanations in this paper—the objective being merely to propose a road map to think about future research rather than establishing new 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.<sup>4</sup> [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.

This paper is also related to the literature on 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 [Aguir and Gopinath \(2007\)](#)). We show in this paper that the correlation between growth and the current account is the opposite when it is considered in a larger sample of countries and over a long time period. 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 model. 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 paper is also related to the literature on savings, growth, and investment. The literature on savings and growth has established a positive correlation between these variables, which is puzzling from the point of view of the permanent income hypothesis since high-

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<sup>4</sup>Like us, [Prasad et al. \(2007\)](#) find this correlation to be very 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).

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, which means that savings not only has to be positively correlated with productivity growth, but the correlation must be stronger than that between investment and productivity growth.

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). As noted above, 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. But they do not look at the contribution of capital flows in equalizing returns. One implication of Caselli and Feyrer (2007)’s results, furthermore, 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. 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. 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.

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 looks at the robustness of the allocation

puzzle, and section 5 speculates on possible explanations.

## 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 abstract from global general equilibrium effects and 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 The model

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

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

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,

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

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

where  $I_t$  is investment,  $\delta$  is the depreciation rate,  $R^*$  is the world gross interest rate, and  $D_t$  is external debt. The country pays the riskless interest rate on its debt because there is no default risk. Capital inflows in period  $t$ ,  $D_{t+1} - D_t$ , are 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.

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 relax it later. It is also not an implausible assumption to make in the neoclassical model, 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:

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

where  $k_t$  denotes capital per capita (more generally, lower case variables are normalized by population). In line with [Gourinchas and Jeanne \(2006\)](#), we account for cross country differences in investment rates, by assuming that investors receive only a fraction  $(1 - \tau)$  of the gross return  $R_t$ . We call  $\tau$  the ‘capital wedge’. It is a short hand for the gap between the gross social return to capital  $R_t$  and the private return. One can interpret  $\tau$  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:

$$(1 - \tau) R_t = R^*. \quad (4)$$

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:

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

(‘tilde-variables’ will denote per capita variables in efficiency units:  $\tilde{x} = X/AN$ ). Equation

(5) makes clear that the capital wedge  $\tau$  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  $\tilde{k}^*$ . Perfect integration implies that for any given country, the domestic stock of capital increases one for one with domestic productivity. However the coefficient of proportionality may not be the same across countries because of domestic distortions summarized by  $\tau$ .

The country has an exogenous, deterministic productivity path  $(A_t)_{t=0,\dots,+\infty}$ , 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  $g^*$ . 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,

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

We assume that  $\pi = \lim_{t \rightarrow \infty} \pi_t$  is well defined. The limit  $\pi$  measures the country's long run technological catch-up relative to the world frontier. If  $\pi = 0$ , the country's productivity remains unchanged relative to the world frontier. When  $\pi > 0$ , the country catches up relative to the frontier. When  $\pi < 0$ , 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  $g^*$ .<sup>5</sup>

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  $n$ :  $N_t = n^t N_0$ .

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<sup>5</sup>That countries have the same long-run growth rate is a standard assumption. Models of idea flows such as [Parente and Prescott \(2000\)](#) or [Eaton and Kortum \(1999\)](#) imply a common long-run growth rate of productivity.

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:

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

where  $u(c) \equiv (c^{1-\gamma} - 1) / (1 - \gamma)$  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.

Given our assumptions, the budget constraint of the representative family is:

$$N_t c_t + N_{t+1} k_{t+1} + R^* N_t d_t = (1 - \tau) R_t N_t k_t + N_{t+1} d_{t+1} + N_t w_t + N_t z_t, \quad (7)$$

where  $w_t$  is the wage, equal to the marginal product of labor  $(1 - \alpha) k_t^\alpha A_t^{1-\alpha}$ . In order to focus on the distortive aspects, we assume that the revenue per capita  $z_t = \tau R_t k_t$  generated by the capital wedge are rebated to households in a lump sum fashion.

The representative resident maximizes the welfare function (6) under the budget constraint (7). The Euler equation,

$$c_t^{-\gamma} = \beta R^* c_{t+1}^{-\gamma}, \quad (8)$$

implies that consumption per capita grows at the constant rate  $(\beta R^*)^{1/\gamma}$ . We assume that the world interest rate is given by,

$$R^* = g^{*\gamma} / \beta, \quad (9)$$

so that the Euler equation (8) implies that domestic consumption per capita grows at rate  $g^* : c_{t+1} = g^* c_t$ . Although not crucial for our results, this assumption simplifies the analysis by ensuring that the domestic economy converges toward a steady-growth path in which consumption and output per capita grow at the same rate. 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, but 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  $d_0$ , population growth rate  $n$ , a productivity path  $\{A_t\}_0^\infty$ , and a capital wedge  $\tau$ . 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 will compare the predictions of the model with the data observed over a finite period of time  $[0, T]$ . Thus it makes sense to focus on cross-country differences in the determinants of capital flows that are observable in the time interval  $[0, T]$ . We abstract from unobserved future developments in productivity by assuming that all countries have the same productivity growth rate,  $g^*$ , after time  $T$ .

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

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,

$$\frac{\Delta D}{Y_0} = \frac{D_T - D_0}{Y_0}. \quad (10)$$

The normalization by initial GDP ensures that the measure is comparable across countries of different sizes.<sup>6</sup>

We obtain the following proposition.

**Proposition 1** *Under assumption 1, the ratio of cumulated capital inflows to initial output is given by:*

$$\frac{\Delta D}{Y_0} = \frac{\tilde{k}^* - \tilde{k}_0}{\tilde{k}_0^\alpha} (ng^*)^T + \frac{\tilde{d}_0}{\tilde{k}_0^\alpha} \left[ (ng^*)^T - 1 \right] + \pi \left[ \tilde{k}^* + \frac{\tilde{w} + \tilde{z}}{R^*} \sum_{t=0}^{T-1} \left( \frac{ng^*}{R^*} \right)^t (1 - \pi_t/\pi) \right] \frac{(ng^*)^T}{\tilde{k}_0^\alpha} \quad (11)$$

where  $\tilde{w} = (1 - \alpha) \tilde{k}^{*\alpha}$  and  $\tilde{z} = \tau / (1 - \tau) R^* \tilde{k}^*$ .

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<sup>6</sup>Our conclusions are robust to using alternate measures of foreign borrowing. For example, capital inflows could be measured as the average ratio of net capital inflows to GDP or as the change in the ratio of net foreign liabilities to GDP. Appendix A.2 shows that the predictions of the model are qualitatively the same for the three measures of capital flows. Moreover, we show in the appendix 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.

**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 ( $\pi_t = \pi = 0$ ) has zero capital flows. Consider now each term on the right-hand side of equation (11) in turn. The first term,

$$\frac{\Delta D^c}{Y_0} = \frac{\tilde{k}^* - \tilde{k}_0}{\tilde{y}_0} (ng^*)^T, \quad (12)$$

results from the initial 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,

$$\frac{\Delta D^t}{Y_0} = \frac{\tilde{d}_0}{\tilde{y}_0} \left[ (ng^*)^T - 1 \right], \quad (13)$$

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 steady growth path in which external debt remains a constant fraction of output. Expression (13) corresponds to the cumulated debt inflows that are required to keep the debt-to-output ratio constant.

Finally, the third term in (11) reflects the impact of the productivity catch-up. It can be decomposed into two terms, each with an intuitive interpretation. The first term,

$$\frac{\Delta D^i}{Y_0} = \pi \frac{\tilde{k}^*}{\tilde{y}_0} (ng^*)^T, \quad (14)$$

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 the right-hand side of (14).

The second term,

$$\frac{\Delta D^s}{Y_0} = \pi \frac{\tilde{w} + \tilde{z}}{R^* \tilde{y}_0} (ng^*)^T \sum_{t=0}^T \left( \frac{ng^*}{R^*} \right)^t \left( 1 - \frac{\pi_t}{\pi} \right), \quad (15)$$

represents the change in external debt brought about by changes in *domestic saving*. It is tied to the time path of disposable income  $w_t + z_t$ . In general, this term depends on the whole productivity path  $\pi_1, \pi_2, \dots, \pi_T$ . For simplicity we assume that the path for the ratio  $\pi_t/\pi$  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  $\lim_{t \rightarrow \infty} f(t) = 1$ .

Under assumption 2, we can rewrite equation (15) as,

$$\frac{\Delta D^s}{Y_0} = \pi \frac{\tilde{w} + \tilde{z}}{R^* \tilde{y}_0} (ng^*)^T \sum_{t=0}^T \left( \frac{ng^*}{R^*} \right)^t (1 - f(t)),$$

which is proportional to the long-run productivity catch-up  $\pi$ . Faster relative productivity growth implies higher future income, leading to an increase in consumption and a decrease in savings.<sup>7</sup> Since current income is unchanged, the representative domestic consumer borrows on the international markets.

This results in the following corollary.

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

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

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:*

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

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<sup>7</sup>Obviously, savings can decrease at the same time as investment increases because of capital inflows. 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.

To summarize, the investment and consumption channels lead to the same prediction—that countries growing faster should borrow more.

The simplicity of the relationship between productivity and capital flows is in part driven by the assumptions of the model. First, we assume perfect international financial integration. 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. This ceiling is likely to increase 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 not binding, nothing is changed and the previous results apply. Consider instead what happens when the constraint is binding. Countries with higher productivity growth have higher output and accumulate more capital. They can borrow more capital 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.<sup>8</sup> Hence, Corollary 1 remains true. International financial frictions can reduce the predicted size of capital inflows, but cannot make capital flow more towards the countries that invest less—or flow less toward the countries that invest more.

Second, equation (15) assumes perfect foresight: the path of future productivity is known with certainty as of time  $t = 0$ . Uncertainty about the future path of productivity would dampen the willingness of the domestic household to borrow against future income. We will consider a variant of the model with stochastic productivity in section 4.2. Again, while this may affect the magnitude of capital flows, it should still be the case that countries that grow more should borrow more.

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<sup>8</sup>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.

Lastly, the assumption that the economy is populated by infinitely-lived consumers removes demographic effects from the model. Models with overlapping generations could deliver different predictions for the aggregate relationship between saving and growth, and thus modify the implications of the model for capital flows. For instance, in Modigliani's original life cycle model, faster growth may increase aggregate savings by raising the saving of richer younger cohorts relative to the dissaving of poorer older cohorts. As we have mentioned in the introduction, other models have been developed to explain the positive association between faster growth and national saving that is observed in the data. We will discuss that literature in section 5. Let us simply note, for now, that when looking at the quantitative predictions of the model, we should take the savings component (15) less seriously than the investment component (14).

### 3 Capital Flow Accounting and Calibration

We look in this section whether the data support the model's prediction concerning capital flows. To be more specific, we investigate whether developing countries with faster productivity growth and larger initial capital scarcity receive more capital inflows. This requires, for each country, estimates for the levels of initial capital scarcity and for productivity growth.

We focus on the period 1980-2000. This choice of period is motivated by two considerations. First, we 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.<sup>9</sup> 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 financial crisis or by fluctuations in the world business cycle. Our final sample consists of 69 developing countries: 66 non-OECD countries, as well as Korea, Mexico and Turkey.<sup>10</sup>

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<sup>9</sup>The index is normalized to run from 0 (most closed) to 100 (most open).

<sup>10</sup>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.

A certain number of model parameters are common across countries. We assume that a period is a year. We adopt logarithmic preferences ( $\gamma = 1$ ) and set the discount factor  $\beta$  to 0.96.<sup>11</sup> Next, we set the depreciation rate  $\delta$  to 6 percent, and the capital share of output  $\alpha$  equal to 0.3.<sup>12</sup> Lastly, the growth rate of world productivity  $g^*$  is set to 1.017, the annual multifactor productivity growth observed on average in the U.S. between 1980 and 2000. Given these parameter values, the world real interest rate is equal to  $R^* - 1 = 5.94$  percent per year.

The 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).<sup>13</sup> From (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  $(k_t/y_t)^{1/(1-\alpha)}$ .<sup>14</sup>

We measure  $n$  as the annual growth rate of the working-age population. Under assumption 1, we can measure  $\pi$  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.<sup>15</sup>

The next step consists in constructing the steady state capital level  $\tilde{k}^*$ . From equation (5), this is equivalent to constructing the capital wedge  $\tau$ . Our approach is to calibrate the capital wedge so as to match exactly investment rates in the data. The next proposition characterizes the average investment rate between 1980 and 2000.

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

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<sup>11</sup>The value of  $\gamma$  matters only for the level of  $R^*$ , given in equation (9). Conditional on  $R^*$ ,  $\gamma$  does not matter for the direction and size of capital flows.

<sup>12</sup>This assumption will be relaxed in section 4. Recent estimates by Gollin (2002) suggest that the capital share is roughly constant within countries, and varies between 0.2 and 0.4.

<sup>13</sup>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.

<sup>14</sup>We measure output and capital per working-age capita using data on the fraction of the population of working age (typically ages 15 to 64) from the World Bank.

<sup>15</sup>Consistent with this approach,  $g^*$  is equal to  $(\bar{A}_{2000}^{US}/\bar{A}_{1980}^{US})^{1/20}$ .

the following three terms:

$$\bar{s}_k = \frac{1}{T} \frac{\tilde{k}^*(\tau) - \tilde{k}_0}{\tilde{k}_0^\alpha} + \frac{\pi}{T} \tilde{k}^*(\tau)^{1-\alpha} g^* n + \tilde{k}^*(\tau)^{1-\alpha} (g^* n + \delta - 1). \quad (16)$$

**Proof.** See appendix A. ■

Equation (16) 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.<sup>16</sup>

Solving numerically (16), we obtain the capital wedge  $\tau$  as a function of the observed average investment rate  $\bar{s}_k$ , productivity catch-up  $\pi$  and population growth  $n$ . Appendix C reports the values of  $\bar{s}_k$ ,  $\pi$ ,  $n$  and  $\tau$  for each country in our sample. Everything else equal, our calibration approach assigns a high capital wedge to countries with low average investment rate.

Our approach to constructing  $\tau$  assumes that countries are perfectly integrated. Although international financial frictions could bias our estimates of  $\tau$ , 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  $\tau$  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 the capital outflows. The important point is that while there is a downward bias in the *size* of capital flows, the model still predicts accurately their direction and relative magnitude.

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<sup>16</sup>Observe that when  $g^* = n = 1$ , this last term simplifies to  $\delta \tilde{k}^{*(1-\alpha)} = \delta \tilde{k}^* / \tilde{y}^*$ .

### 3.1 Capital accumulation

With these caveats in mind, Table 1 decomposes the observed investment rate  $\bar{s}_k$  into the three components of equation (16). This decomposition yields a number of interesting results. First, as is well known, investment rates vary widely across regions. They also vary with income levels, increasing from 8.6 percent for low income countries to 28.5 percent for high-income non-OECD countries. By construction, the model accounts exactly for observed differences in average investment rates. We view this as a strength of our approach: since the model is designed to reproduce the change in the capital stock over the long run for a large number of countries, we can assess precisely whether the drivers of capital accumulation are also the drivers of observed capital flows.

Table 1 also contains interesting information on the factors driving capital accumulation across countries. First, the table 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  $\tau$  (reported in column 5). The average capital wedge is relatively large, at 11.6 percent, and decreases with income levels from 18.8 percent to 1.6 percent. To a first order of approximation, the countries with a high investment rate are those that maintain a high capital-to-output ratio because of a low capital wedge.

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 ( $k_0/k^* = 1.07$ ). 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 half of the difference in the investment rate between the two regions.

Last but not least, the estimates of  $\pi$  reported in column 6 show that there is no overall productivity catch-up with advanced countries ( $\pi$  is negative on average). Yet, closer inspection reveals an interesting geographical pattern. There is some productivity catch-up in Asia, while Latin America and Africa fell behind.<sup>17</sup> Accordingly, the contribution of productivity to investment is positive for Asia (1.6 percent), but negative for Africa and Latin America (-1.2 percent and -2.7 percent respectively).

### 3.2 Capital flows

We now compute, for each country, the level of capital inflows predicted by the model—the right-hand side of equation (11)—and compare the model predictions with the data. There is one measurement difficulty to solve, however, before we can proceed with this comparison. The Penn-World Tables do not provide PPP-adjusted estimates of capital flows and external liabilities that are comparable to the output and capital data that we have used to calibrate the model.

The reader is referred to Appendix B for a detailed explanation of how we constructed PPP-adjusted measures of capital flows. We measure net capital inflows in current US dollars using International Financial Statistics data on current account deficits, keeping with the usual practice that considers errors and omissions as unreported capital flows. The main point is the choice of an appropriate price index to convert this measure into constant international dollars, the unit used in the Penn World Tables for real variables. 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 such price indices. We chose instead the price of investment goods 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 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)).

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<sup>17</sup>This pattern does not apply to all countries in a region. For instance, we find  $\pi = -0.34$  for the Philippines, 0.28 for Chile and 0.47 for Botswana. See appendix C.

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. The deflator chosen for the PPP-adjustment of capital flows affects the volume but not the direction of capital flows.<sup>18</sup> The theory can be tested using various measures of capital flows, which all deliver the same broad message as the results presented in this section.

We present our estimates of observed and predicted net capital inflows in Table 2. Column 1 reports observed net capital inflows, as a fraction of initial output,  $\Delta D/Y_0$ . The size of cumulated capital inflows is small, around 33 percent of 1980 output.

Column 2 reports the total predicted net capital inflows based on equation (11). The estimates for the predicted capital flows are constructed under the assumption that the productivity catch-up follows a linear path:  $f(t) = \min(t/T, 1)$ . Predicted capital flows are often an order of magnitude larger than realized flows. More importantly, they often have the wrong sign. For instance, the model predicts that the average developing country in our sample should have *exported* a quantity of capital amounting to 2.5 times its initial output. This results from the fact that with a negative  $\pi$ , the typical developing country did not catch up relative to the world technology frontier. While Lucas (1990) argued that the volume of capital flowing from rich to poor countries seemed puzzlingly low, our results rather suggest that given the absence of productivity catch-up and high level of distortions, capital should have flown *out* of the average developing country in our sample.<sup>19</sup>

Why is there such a discrepancy between the model and the data? The answer lies in columns 3-6, which report the various components of (11). Column 3 indicates that developing countries should have borrowed 7 percent of initial output on average to equate domestic and foreign private returns on capital at the beginning of the sample period. This

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<sup>18</sup>We used the price of output as a deflator for current account balances in a previous version of this paper, and obtained similar results.

<sup>19</sup>The results for average cumulated capital flows are different if the cross-country averages are weighted by GDP or population. Then, we find that the average developing country should receive capital inflows, because of the large weights of China and India. Whereas the predictions of the model for average capital flows are sensitive to outliers, we found that the allocation puzzle is robust to the different weighting schemes. The results are also qualitatively unchanged if we use the median instead of weighted averages.

is a small amount, less than one fourth of the observed capital inflows. Likewise, the trend component reported in column 6 is also relatively small and similar in magnitude to observed flows.

Most of the difference between the model-predicted and the observed capital flows come from the investment and savings components reported in columns 4 and 5. As discussed earlier, both terms increase with the productivity catch-up parameter  $\pi$ . The model implies that, everything else equal, capital should flow to the countries that catch up relative to the world technology frontier ( $\pi > 0$ ), and flow out of the countries that fall behind ( $\pi < 0$ ). As noted above, the average developing country in our sample falls in the second category ( $\pi = -0.1$ ) and thus should have *exported* capital. The capital outflows coming from lower investment are sizeable (29 percent of initial output) and those that come from lower savings are very large (2.6 times initial output), reflecting the high sensitivity of consumption-savings choices to future income in a perfect foresight model.

For reasons discussed earlier, we should not expect the model to predict very precisely the volume of capital flows to specific countries. Sovereign risk, financial frictions or uncertainty about future productivity will limit the extent to which countries rely on foreign capital. However, the neoclassical growth model should do a good job of predicting the broad *direction* of capital flows. This is where the model fails in a systematic and interesting way. The observed allocation of capital flows *across developing countries* is the opposite of the one predicted by the model. Consider first the allocation of capital across regions. We would expect net capital inflows to Asia, the only region that catches up in terms of productivity. Indeed, Table 2 reports that the investment component of capital inflows to the average Asian developing country should represent 81 percent of its initial output. Yet Asia borrowed, over that period, only 12.5 percent of its initial output (col. 1).

By contrast, consider Africa. With an initial abundance of capital and a relative productivity decline, the model predicts large capital outflows. Indeed, Table 2 indicates that the outflows related to the investment and convergence components amount to 42 percent and 28 percent of initial output respectively (columns 4 and 3). Yet Africa received more 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.

The same pattern is evident if we group countries by income levels rather than regions. According to Table 1, poorer countries experienced lower productivity growth and so should export more capital. Indeed, Table 2 shows that predicted capital inflows increase with income level from -492 percent of output for low income countries to 828 percent of output for high-income non-OECD countries. Observed capital inflows run in the exact opposite direction: actual capital flows *decrease* with income per capita, from 58 percent of output for low income countries to -54 percent for high-income non-OECD countries.

Figure 2 summarizes the puzzle. It reports actual against predicted capital flows. One observes immediately that most countries are located in the ‘wrong’ quadrants of the figure, with predicted capital outflows and observed capital inflows, or vice versa. Figure 3 plots observed capital flows against the three determinants identified in Proposition 1: the capital gap  $(k^* - k_0)/k_0$ , initial debt  $d_0/y_0$ , and productivity catch-up  $\pi$ . While observed capital flows are positively (although weakly) correlated with the first two components, we find strong evidence against the predictions of the model regarding productivity: countries with faster productivity growth attract less capital inflows.<sup>20</sup> This is the *allocation puzzle*.

We ran a number of straightforward robustness checks.<sup>21</sup> First, we checked that our results were robust to the exclusion of African countries (which arguably 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 pattern of capital flows is very 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.

To summarize, standard growth theory can account for cross-country differences in capital accumulation, once we take into account cross-country differences in productivity and capital

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<sup>20</sup>The figure reports the fitted values from an OLS regression. The regression coefficients are significantly negative for the productivity catch-up. They are not significant for the capital gap or the initial debt.

<sup>21</sup>Results are available upon request. The following section presents additional robustness checks.

markets distortions. The same theory makes a strong and counterfactual prediction about the direction of capital flows: the countries that grow faster should rely more on foreign financing. In fact, the countries that grow faster tend to receive less capital flows. The puzzle here is not that developing countries receive little capital from advanced countries, as Lucas argued. Rather, it is the *allocation of capital across developing countries* that contradicts the theory in a fundamental way.

## 4 Robustness

Can the textbook model be rescued in a simple way? This section explore some alternatives: controlling for international aid flows, and introducing uncertainty about future productivity, or non-reproducible capital, in the model. The upshot is that our central result survives these extensions.

### 4.1 Official aid

The basic neoclassical framework may not be appropriate to predict official aid flows because aid is not necessarily allocated to the countries with the highest expected returns on capital. 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, as the countries that have received aid flows over long periods of time are often 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 \(2005\)](#)).

That the neoclassical growth model does not capture well the determinants of aid flows does not necessarily invalidate its predictions 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 given the lack of domestic investment opportunities. Because of the fungibility of aid

this would be true even if aid were earmarked to finance certain class of expenditures, such as investment. The aid inflow would be offset by an outflow, and the predictions of the model would remain valid for *net* capital flows. Indeed, it is easy to think of episodes where external borrowing or official aid go hand-in-hand with the commensurate overseas enrichment of a few government officials.<sup>22</sup> 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.

Things might be different in the presence of financial frictions. Then, aid could be used to relax some financial constraints and to finance an increase in domestic expenditures above and beyond what could be financed by private capital flows. Or 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 the level of net capital flows should be examined.

To see how far aid flows can go in explaining the puzzle, 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, perhaps in the form of illicit capital flight. Our measure of official aid flows is the net overseas development assistance (net ODA) from the Development Assistance Committee (DAC). 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’).<sup>23</sup> 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 is equivalent to assume that in the absence of aid flows the counterfactual net capital flows would have been equal to the observed cumulated net capital flows  $\Delta D$  minus the cumulated aid flows  $\Delta B$ ,

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

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<sup>22</sup>For a recent discussion of a number of well-known cases and an analysis along these lines, see [Jayachandran and Kremer \(2006\)](#).

<sup>23</sup>Our results are remain unchanged if we use instead [Roodman’s \(2006\)](#) Net Aid Transfer measure.

Table 3 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  $\Delta D$ . As a result, the average developing country is found to *export* capital net of aid flows (23 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 broad pattern 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 correlations between aid-adjusted capital flows and the determinants of capital flows are reported in Figure 4. The correlation becomes negative for capital scarcity and remains negative for productivity growth, although no longer significantly different from zero for the latter.

We conclude that official aid flows play a role in explaining why the correlation between capital inflows and productivity growth is negative: many countries with poor productivity performance are also net official aid recipients. However, aid flows per-se do not resolve the allocation puzzle. The cross-country variation in capital inflows remains significant after the adjustment for aid, and 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.

## 4.2 Uncertainty and permanent productivity shocks

We emphasized earlier the importance of the assumption of perfect foresight for the saving side of the model. Under perfect foresight, agents tend to borrow or lend heavily against a certain future income. Uncertainty about the path of future productivity should dampen the willingness of the domestic representative agent to borrow or lend.

We now consider what happens when 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. 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 3** *If agents always expect productivity to grow at rate  $g^*$  the ratio of cumulated capital inflows to initial output,  $\Delta D^n/Y_0 = [D_T - D_0]/Y_0$ , is given by:*

$$\frac{\Delta D^n}{Y_0} = \frac{\tilde{k}^* - \tilde{k}_0}{\tilde{k}_0^\alpha} (g^*n)^T + \frac{\tilde{d}_0}{\tilde{k}_0^\alpha} [(ng^*)^T - 1] + \pi \tilde{k}^* \frac{(g^*n)^T}{\tilde{k}_0^\alpha}. \quad (17)$$

**Proof.** See appendix A. ■

The only difference between (17) and (11) is that the consumption smoothing term 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 steady growth path with no productivity catch-up. Productivity influences capital flows only through the investment term.

Column 7 in Table 2 reports estimates of  $\Delta D^n/Y_0$ , as the sum of columns 3, 4 and 6. The orders of magnitude are closer to the data. Another difference with our previous results is that the average developing country is now predicted to receive capital inflows (although significantly less than the actual amount): given  $\pi < 0$  for the average country, the investment term is negative, but it is more than offset by the convergence and trend terms. However, the allocation puzzle still stands. As shown in Figure 5, the predicted and actual net capital inflows remain negatively correlated.

### 4.3 Non-reproducible capital

In a recent paper, Caselli and Feyrer (2007) 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 non-reproducible capital and in the relative price of investment and consumption goods. This adjustment is especially important for developing countries that have a larger share of natural capital (in

particular land) in total capital. Their result offers another resolution to the Lucas puzzle: if substantial differences in capital-output ratio coexist with marginal product equalization, then we should expect little, if any, capital flows between countries.

This paper adopts a different approach, based on the wedge between the private and social marginal returns to capital. The cross country distribution of the private marginal return to capital is compressed by the wedge  $\tau$ . To illustrate, the top panels of Figure 6 report the naive estimate of private returns (left), defined as  $RN = \alpha Y/K - \delta$ , and the wedge-adjusted return (right),  $RW = (1 - \tau)(1 + RN) - 1$ , against 2000 income per capita. The left-hand side top panel indicates enormous variation in the naive estimate, between 3.6 percent (Singapore) and 104 percent (Uganda), with a mean of 17.5 percent. By contrast, the wedge-adjusted return varies between -2.5 percent (Nigeria) and 14 percent (Malawi) with a mean of 4.7 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.

We now check the robustness of our results to allowing for non-reproducible capital.<sup>24</sup> We start by modifying the production function (1) as follows:

$$Y_t = K_t^{\alpha_k} X^{\alpha_l} L^{1-\alpha_k-\alpha_l} A_t^{1-\alpha_k},$$

where  $X$  represents non-reproducible capital (assumed to be constant) and  $\alpha_l$  denotes the share of non-reproducible capital in output. Notice that this production technology is isomorphic to (1) if we define a composite factor  $Z_t = (X^{\alpha_l} L^{1-\alpha_k-\alpha_l})^{1/(1-\alpha_k)}$  and write output as  $Y_t = K_t^{\alpha_k} (A_t Z_t)^{1-\alpha_k}$ . Non-reproducible capital matters, however, for estimating the capital share  $\alpha_k$ .

The production function is calibrated as follows. Like Caselli and Feyrer (2007), we obtain an estimate of  $\alpha_w = \alpha_k + \alpha_l$ , the total share of capital (reproducible and non-reproducible), from Gollin (2002) supplemented by Bernanke and Gürkaynak (2001), as one minus the labor share. The private return to reproducible capital is  $(1 - \tau)(1 + \alpha_k Y_t/K_t - \delta)$  while the

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<sup>24</sup>In this paper, we do not consider systematic variation across countries in the price of investment goods. See Chatterjee and Naknoi (2007) for an analysis of capital flows along this line.

private return to non-reproducible capital is  $(1 - \tau)(\alpha_l Y_t / X_t + P_t^x) / P_{t-1}^x$  where  $P_t^x$  denotes the price of non-reproducible capital in terms of the final good.<sup>25</sup>

In steady state, both returns must be equal and the rate of price appreciation must equal the rate of growth of real output:  $P_t^x / P_{t-1}^x = g_y$ . Solving for  $\alpha_k$ , we obtain:

$$\alpha_k = \left[ \alpha_w - (1 - g_y - \delta) \frac{P^x X}{Y} \right] \cdot \frac{K}{W}, \quad (18)$$

where  $W = P^x X + K$  denotes total wealth (natural and reproducible). This formula has a simple interpretation. If there is no natural capital ( $X = 0$  and  $W = K$ ), it boils down to  $\alpha_k = \alpha_w$ . With non-reproducible capital, two adjustments take place. First, only a fraction  $K/W$  of total capital income  $\alpha_w Y$  goes to reproducible capital. This is the first term in brackets. Second, a faster growth rate  $g_y$  or higher depreciation rate  $\delta$  mean a faster price appreciation and a larger private return on non-reproducible capital relative to reproducible capital. In both cases, returns on both types of capital can only be equated if the reproducible capital share  $\alpha_k$  increases. This is the second term in brackets.<sup>26</sup> We follow [Caselli and Feyrer \(2007\)](#) and obtain estimates of  $P^x X$  from [World Bank \(2006\)](#). Our estimated adjusted capital shares are reported in appendix C.

The bottom two panels of Figure 6 report the estimate of private returns to capital once we adjust the share of reproducible capital. The bottom left panel reports estimates of private returns without the capital wedge. We find returns varying between 4.4 percent (Thailand) and 29.5 percent (El Salvador), with a mean of 10.08 percent. Once we take into account the capital wedge, the returns are further compressed.<sup>27</sup> We find returns varying between 0.7 percent (Nigeria) and 11.5 percent (Malawi), with a mean of 4.9 percent.

Adjusting for non-reproducible capital does not change the essence of our results. Table 4 reports the predicted and actual capital flows in the adjusted model.<sup>28</sup> The predicted capital

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<sup>25</sup>We assume that the capital wedge applies equally to all forms of capital and that non-reproducible capital does not depreciate.

<sup>26</sup>These last two corrections are absent in [Caselli and Feyrer \(2007\)](#) who assume a common depreciation rate and price appreciation for reproducible and non-reproducible capital.

<sup>27</sup>The capital wedges are recomputed for the model with non-reproducible capital to match the observed investment rates. The adjustment for natural capital reduces the average level and variance of our capital wedge estimates. The mean capital wedge is now only 4.5 percent.

<sup>28</sup>The actual capital flows are not the same as in 2, because the sample of countries is slightly smaller.

inflows remain negative on average, and the model predictions for the allocation of capital flows by income levels or by regions remain at odds with the data. Figure 7 shows the same variables as Figure 3 for the model with non-reproducible capital. Again, predicted capital flows are negatively correlated with productivity growth.

## 5 Discussion

This section discusses some possible approaches to the resolution of the allocation puzzle. It is meant as a tentative road map for future research, not as an attempt to push forward a particular explanation.<sup>29</sup> We first look at the puzzle from the point of view of the literature on savings and growth. We then discuss the possible role of international trade and that of domestic financial frictions.

The allocation puzzle can be summarized in terms of the cross-country correlations between savings, investment and growth. Let us consider the following three variables in a sample of developing countries:  $g$ , the average growth rate of productivity;  $s$  the average savings rate and  $i$  the average investment rate. The net capital outflows are measured by the difference between the savings rate and the investment rate,  $s - i$ . The allocation puzzle is the finding that capital outflows are positively correlated with the growth rate of productivity across countries:

$$\text{cov}(g, s - i) > 0,$$

or equivalently, that the savings rate is *more* correlated with productivity growth than the investment rate:

$$\text{cov}(g, s) > \text{cov}(g, i). \tag{19}$$

We argued that this is a puzzle for the simple neoclassical open-economy model of growth, which predicts that the left-hand side of equation (19) is negative while the right-hand side is positive.

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<sup>29</sup>Indeed, the explanations reviewed below are not mutually exclusive, and may be complementary. Moreover, the most relevant explanation could depend on the countries or the regions.

## 5.1 Savings and growth

We already know from the literature on savings and growth that the model's first prediction,  $cov(g, s) < 0$ , is at odds with the data. Empirically, the savings rate is positively correlated with growth (see, e.g., [Mankiw et al. \(1992\)](#)), and the explanations that have been put forward in the literature for this positive correlation may help us to explain the allocation puzzle.

One such class of explanations considers the causality from savings to growth. Note that  $g$  is the growth rate in productivity, not output per capita, so the mechanism must involve some endogeneity of domestic productivity to domestic savings. This is the case in a number of 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. An example of a model with those features is [Aghion, Comin and Howitt \(2006\)](#), in which domestic savings matters for innovation because it fosters the involvement of domestic intermediaries with a superior monitoring technology.<sup>30</sup>

Another class of explanations considers the causality from growth to savings.<sup>31</sup> 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. \(2000\)](#) ).

Whether the models discussed above can explain the allocation puzzle is an open question for future research. The answer is not obvious *a priori*: those models can account for a positive correlation between savings and growth, but cannot necessarily explain why this correlation is larger than that between investment and growth.

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<sup>30</sup>However, that model does not include investment in productive physical capital.

<sup>31</sup>[Carroll, Overland and Weil \(2000\)](#) present evidence suggesting that the causality runs from growth to savings.

We can flesh out further the relationship between savings and productivity growth as follows. Suppose that, in addition to the capital wedge  $\tau$ , domestic households face a saving wedge  $\tau_s$ . When positive, this wedge functions like a tax on domestic and foreign capital income. When negative, it represents a saving subsidy. The budget constraint of the representative family is modified as follows:

$$c_t + n [k_{t+1} - d_{t+1}] = (1 - \tau_s) [(1 - \tau) R_t k_t - R^* d_t] + w_t + z_t \quad (20)$$

where  $z_t$  rebates the proceeds from both wedges back to the household. We show in appendix [A.5](#) that we can write the capital inflows as a function of the wedges:

$$\frac{\Delta D_T}{Y_0} = \mathcal{D}(\tau, \tau_s). \quad (21)$$

In other words, by varying  $\tau$  and  $\tau_s$ , it is possible to match exactly both investment and saving, hence, replicating perfectly observed capital inflows. Figures [8](#) and [9](#) report the calibrated saving wedge against the capital wedge  $\tau$  and the productivity catch-up  $\pi$  respectively.

A number of salient facts stand out. First, we observe that the saving wedge needed to account for aggregate saving is quantitatively small. It ranges from -0.9 percent for Taiwan, to 1.1 percent for Mozambique. This confirms the finding that the saving side of the model is very sensitive to parameter assumptions: a small saving distortion is enough to reverse the predictions of the model. Nevertheless, the pattern of saving wedges across countries is far from random. The two figures indicate a small but positive correlation between capital and saving wedges. More importantly, we find a strong negative correlation between the saving wedge and productivity catch-up: countries whose productivity catches up ( $\pi > 0$ ) are the countries that “subsidize” saving ( $\tau_s < 0$ ) while the countries that fall behind ( $\pi < 0$ ) are the ones that “tax” saving ( $\tau_s > 0$ ). The slope (-1) and intercept (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 saving to the saving wedge, this translates into significant capital outflows. Explaining the allocation puzzle requires

explaining the correlations shown in Figures 8 and 9.

## 5.2 Domestic financial frictions

International financial frictions that increase the cost of external finance relative to domestic finance cannot explain the puzzle: as mentioned earlier, they can mute the absolute size of capital flows, not change their direction. But *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. It would be interesting to know whether they might 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 (see Caballero, Farhi and Gourinchas (2008)). Second, it constrains their ability to insure efficiently and encourages precautionary savings (see Mendoza, Quadrini and Rios-Rull (2007)). Further, an inefficient financial intermediation system should also reduce the responsiveness of investment to productivity growth.

In terms of our previous discussion, and taking productivity growth  $g$  as an exogenous determinant of savings and investment, we would expect to find that  $cov(g, s)$  is *decreasing* with the level of financial development, while  $cov(g, i)$  is *increasing* with the level of financial development. Thus  $cov(g, s - i)$  would be decreasing with the level of financial development, and could be positive for countries with a low level of financial development. For instance, in Caballero et al. (2008), financially underdeveloped countries run larger current account surpluses if they grow faster. The explanation for the allocation puzzle, then, would be that the correlations in our sample are determined by financially underdeveloped countries. Some of these countries would have high growth in spite of their financial underdevelopment (e.g., China), whereas others would remain trapped in a path with low growth.<sup>32</sup> The allocation

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<sup>32</sup>This association may seem at odd with the fact that financial development seems good for growth (King

puzzle would result from  $cov(g, s - i) > 0$  conditional on low financial development.

This explanation takes a different angle than, but is not inconsistent with, the other two. Indeed, domestic credit constraints have been mentioned as a possible explanation in the literature trying to explain the positive correlation between saving and growth ([Carroll and Weil \(1994\)](#)), and also as a way of maintaining a competitive real exchange rate ([Jeanne \(2007\)](#)).

### 5.3 Trade

Another way of presenting the allocation puzzle is that the ratio of net exports to GDP is positively correlated with the productivity growth rate across countries. Looking at this from the perspective of international trade, the allocation puzzle is consistent with a view in development economics that emphasizes the importance of a competitive export sector as an engine of modernization and growth (see [Rodrik \(2006\)](#) for a recent exposition). This also seems consistent with the pattern of capital flows observed in the recent period, in which the developing countries that grew the fastest (the Southeast Asian emerging market countries) were also those that had the largest trade surpluses.

Developing a dynamic general equilibrium model of this view is beyond the scope of this paper, but one can speculate on the assumptions and properties that such a framework would have. For instance, suppose that productivity take-offs originate in the tradable sector before spilling over to the nontradable sector. Then, the initial phase of the take-off should be associated with a surge in net exports, and capital outflows.<sup>33</sup> One could add a “mercantilist” twist to the story by assuming that the country aims to maintain a competitive real exchange rate so as to preserve and develop its export sector during the take-off phase. This could be

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and [Levine \(1993\)](#)). However one must control for the initial level of development. The least developed countries tend to be less developed financially, but they have more scope for catching up in terms of productivity.

<sup>33</sup>In equilibrium this would happen only under some conditions. On the one hand the consumption of tradables would be held back by the low supply of nontradables. On the other hand, the consumption of tradables should be stimulated by the real exchange rate appreciation associated with the take-off. Net exports should increase if the elasticity of substitution between tradable and nontradable goods is sufficiently low relative to the elasticity of intertemporal substitution of consumption (see [Obstfeld and Rogoff \(1996, chapter 4\)](#)).

achieved by repressing domestic demand, using capital controls or other forms of domestic financial repression. Those factors would magnify the size of the capital outflows associated with the economic take-off.

To restate the argument in the terms of the previous section, developing countries with higher productivity growth  $g$  would tend to be countries in which the tradable sector is larger relative to the nontradable sector. Because domestic demand is constrained by the relative underdevelopment of the nontradable sector, these countries would also have a higher savings rate  $s$ . The allocation puzzle would be explained if savings increase more than investment during the productivity take-off.

It remains to be seen whether a calibrated model designed along those lines can explain the cross-country correlation between growth and capital flows that we observe in the data, and whether other implications of the model (e.g., for the relative sizes of the nontradable and tradable sectors, and for the real exchange rate) fit the facts.

## 6 Concluding Comments

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.

Aid flows contribute to this pattern, but this is far from the whole story. What is the main explanation for the allocation puzzle (and whether there is one main explanation, as opposed to a range of complementary causes) is an open question. We have discussed three lines of explanations that seem the most promising to us for future research: one focuses on the relationship between savings and growth, the second one emphasizes domestic financial underdevelopment, while the last one gives the key role to trade. It seems important to know more about which channels explain the puzzling behavior of capital flows to developing countries if one wants to understand how international financial integration helps economic development.

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	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Average Investment Rate (percent of output)	Total $\bar{s}_k$	Convergence	Productivity	Trend	Wedge $\tau$	Catch-up $\pi$	Obs.
Non-OECD countries	13.47	0.13	-0.93	14.27	11.58	-0.10	69
Low Income	8.56	-0.14	-1.56	10.26	18.76	-0.22	27
Lower Middle Income	14.06	0.29	-1.64	15.42	8.84	-0.15	23
Upper Middle Income	15.69	0.40	-1.35	16.64	6.13	-0.06	13
High Income (Non-OECD)	28.52	0.20	5.52	22.79	1.62	0.54	6
Africa	10.27	-0.66	-1.20	12.12	16.00	-0.17	32
Latin-America	13.40	0.39	-2.67	15.69	8.50	-0.24	20
Asia	19.59	1.34	1.61	16.64	6.90	0.19	17
except China and India	13.40	0.13	-1.05	14.33	11.62	-0.12	67
China and India	15.76	0.40	3.02	12.34	10.35	0.53	2
except Africa	16.24	0.82	-0.70	16.13	7.77	-0.04	37

Table 1: 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 of initial output)	(1) $\Delta D/Y_0$	(2) $\Delta D^p/Y_0$	(3) $\Delta D^c/Y_0$	(4) $\Delta D^i/Y_0$	(5) $\Delta D^s/Y_0$	(6) $\Delta D^t/Y_0$	(7) $\Delta D^n/Y_0$	(8) Obs.
		(3)–(6)					(3)+(4)+(6)	
Non-OECD countries	32.77	-255.21	7.13	-28.77	-260.06	26.49	4.85	69
Low Income	58.08	-491.94	-11.04	-50.47	-457.39	26.96	-34.55	27
Lower Middle Income	37.02	-358.64	17.38	-62.62	-338.16	24.76	-20.48	23
Upper Middle Income	12.94	-80.48	22.85	-40.99	-98.65	36.31	18.18	13
High Income (Non-OECD)	-54.43	827.99	15.50	225.15	577.59	9.75	250.40	6
Africa	40.97	-452.75	-28.14	-42.38	-410.36	28.14	-42.39	32
Latin-America	36.89	-478.74	20.96	-100.07	-435.02	35.40	-43.72	20
Asia	12.48	379.61	57.25	80.75	228.69	12.92	150.92	17
except China and India	33.65	-289.49	7.00	-33.85	-289.89	27.24	0.39	67
China and India	3.21	893.39	11.39	141.57	739.14	1.29	154.25	2
except Africa	25.67	-84.36	37.63	-16.99	-130.07	25.07	45.71	37

Table 2: Predicted and actual capital flows between 1980 and 2000, in percent of initial output.  $\Delta D/Y_0$  is the observed ratio. Predicted capital flows  $\Delta D^p/Y_0$  given by (11). Convergence component  $\Delta D^c/Y_0$  given by (12). Investment component  $\Delta D^i/Y_0$  given by (14). Saving component  $\Delta D^s/Y_0$  given by (15). Trend component  $\Delta D^t/Y_0$  given by (13).  $\Delta D^n/Y_0$ : predicted cumulated capital inflows in the model with permanent productivity shocks. Linear specification for  $f(\cdot)$ :  $f(t) = \min(t/T, 1)$ . Unweighted country averages.

Official Aid	(1)	(2)	(3)	(4)	(4)
Capital Flows	$\Delta D/Y_0$	$\Delta D'/Y_0$	$\Delta B/Y_0$	$\Delta D^p/Y_0$	Obs.
(percent of initial output)					
Non-OECD countries	35.26	-23.17	58.43	-275.96	68
Low Income	-48.26	58.08	106.34	-491.94	27
Lower Middle Income	1.63	37.02	35.39	-358.64	23
Upper Middle Income	-2.94	12.94	15.88	-80.48	13
High Income (Non-OECD)	-70.74	-54.46	16.31	762.39	5
Africa	40.97	-45.16	86.13	-452.75	32
Latin-America	36.89	13.59	23.30	-478.74	20
Asia	21.76	-25.16	46.92	331.08	16
except China and India	36.22	-23.64	59.86	-311.40	66
China and India	14.17	3.21	10.96	893.39	2

Table 3: Predicted and Actual Capital Flows between 1980 and 2000, adjusted for official aid flows, percent of initial output.  $\Delta D/Y_0$  is the observed cumulated capital inflows, relative to initial GDP;  $\Delta D'/Y_0$  is the aid-adjusted ratio;  $\Delta B/Y_0$  is the ratio of cumulated aid flows to initial GDP;  $\Delta D^p/Y_0$  is the predicted cumulated capital inflow, relative to initial GDP;

Capital Flows (percent of initial output)	(1) $\Delta D/Y_0$	(2) $\Delta D^p/Y_0$	(3) $\Delta D^c/Y_0$	(4) $\Delta D^i/Y_0$	(5) $\Delta D^s/Y_0$	(6) $\Delta D^t/Y_0$	(7) $\Delta D^n/Y_0$	(8) Obs.
		(3)–(6)					(3)+(4)+(6)	
Non-OECD countries	38.79	-310.53	12.24	-39.10	-311.35	27.68	0.82	62
Low Income	61.55	-504.76	-9.72	-42.09	-478.62	25.67	-26.14	22
Lower Middle Income	43.33	-396.42	17.51	-68.68	-370.83	25.58	-25.59	23
Upper Middle Income	20.95	-130.74	24.40	-50.23	-142.43	37.51	11.69	13
High Income (Non-OECD)	-54.51	667.36	63.18	183.59	401.72	18.86	265.64	4
Africa	40.68	-511.50	-22.81	-50.09	-466.33	27.72	-45.17	28
Latin-America	47.79	-544.93	20.77	-111.53	-492.28	38.11	-52.65	19
Asia	23.86	361.53	66.85	73.15	207.14	14.40	154.39	15
except China and India	39.98	-349.95	12.27	-45.04	-345.75	28.56	-4.21	60
China and India	3.06	872.27	11.29	139.03	720.63	1.33	151.64	2

Table 4: Predicted and Actual Capital Flows between 1980 and 2000, in percent of initial output.  $\Delta D/Y_0$  is the observed ratio. Predicted capital flows  $\Delta D^p/Y_0$  given by (11). Convergence component  $\Delta D^c/Y_0$  given by (12). Investment component  $\Delta D^i/Y_0$  given by (14). Saving component  $\Delta D^s/Y_0$  given by (15). Trend component  $\Delta D^t/Y_0$  given by (13).  $\Delta D^n/Y_0$ : predicted cumulated capital inflows in the model with permanent productivity shocks. Linear specification for  $f(\cdot)$ :  $f(t) = \min(t/T, 1)$ . The predicted capital flows are computed using the model with non-reproducible capital. Unweighted country averages.

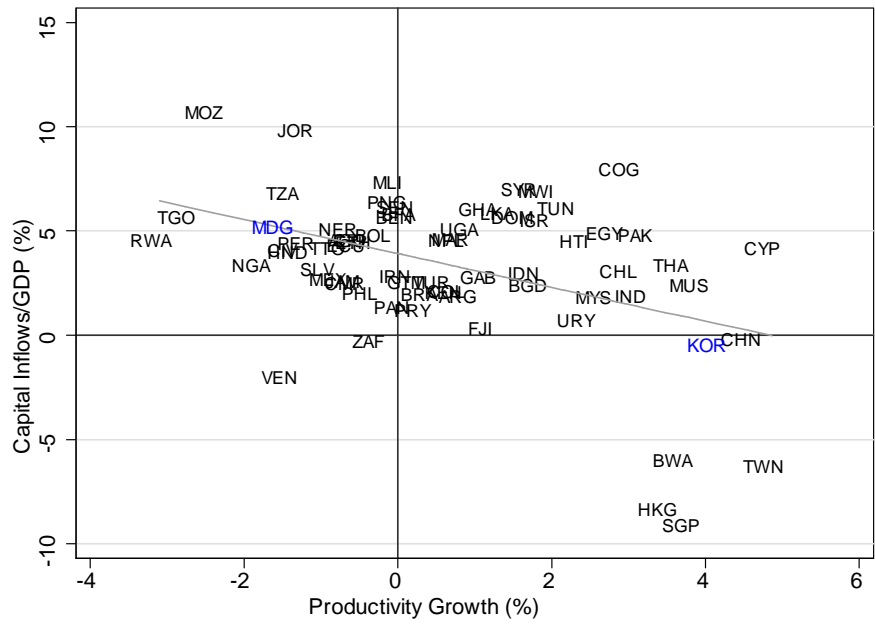


Figure 1: Average ratios of capital inflows to GDP and TFP growth rates, 1980-2000.

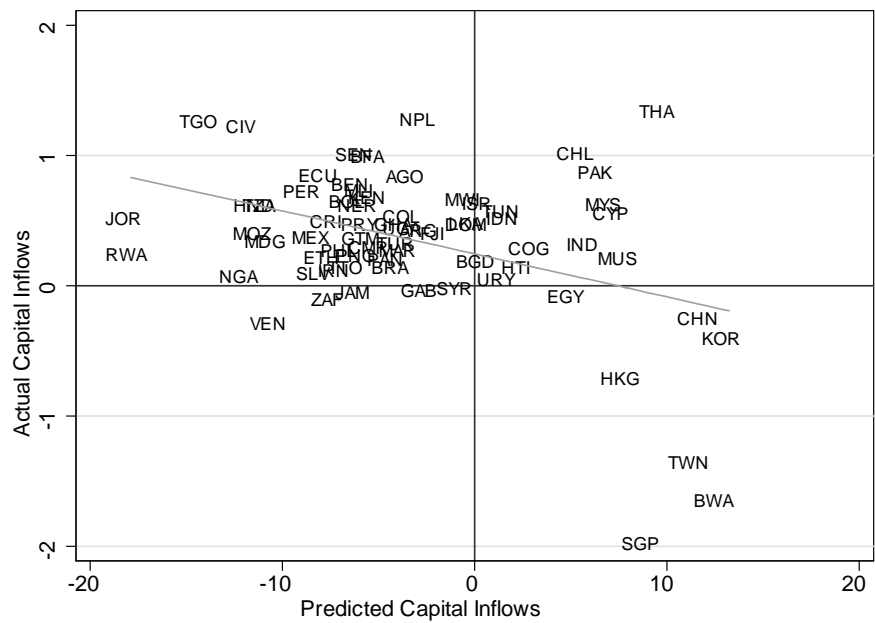


Figure 2: Predicted and actual capital inflows (as a share of initial GDP), 1980-2000.

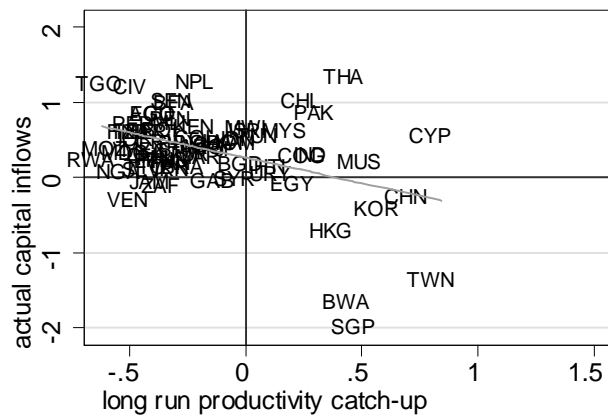
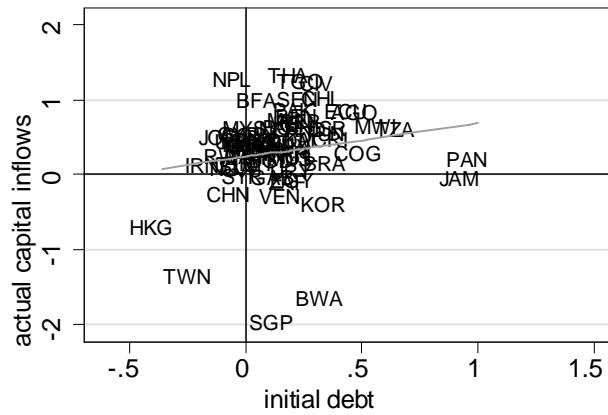
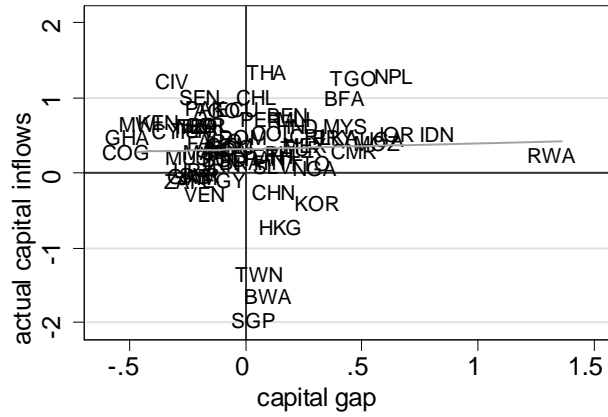


Figure 3: Actual capital inflows (as a share of initial GDP) against their determinants: capital gap  $(k^* - k_0)/k_0$ , initial debt to GDP ratio  $(d_0/y_0)$ , and productivity catch-up  $(\pi)$ , 1980-2000.

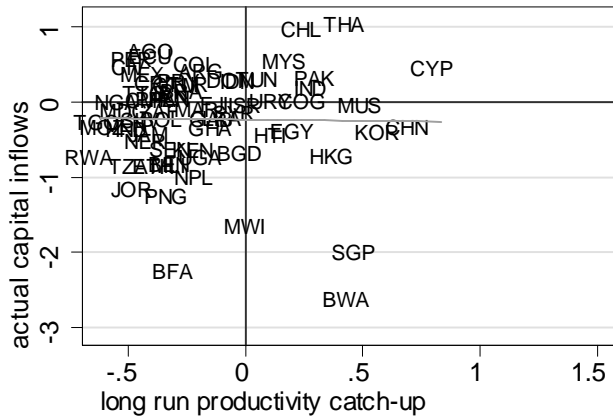
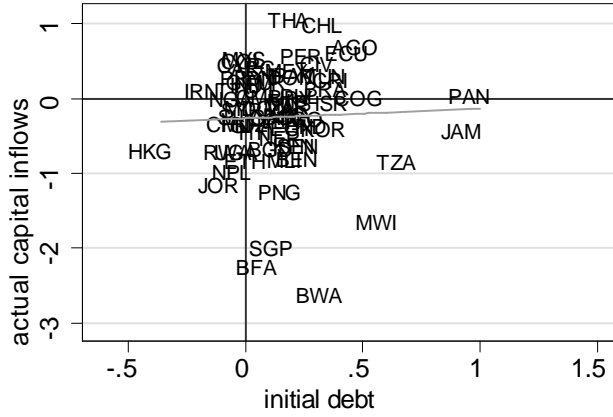
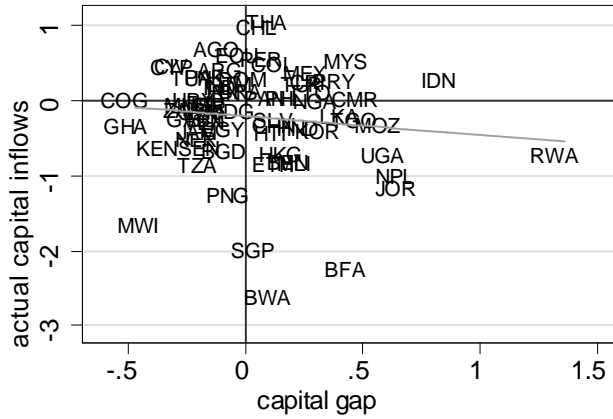


Figure 4: Observed aid-adjusted capital inflows (as a share of initial GDP) against their determinants: capital gap  $(k^* - k_0)/k_0$ , initial debt to GDP ratio  $(d_0/y_0)$ , and productivity catch-up  $(\pi)$ , 1980-2000.

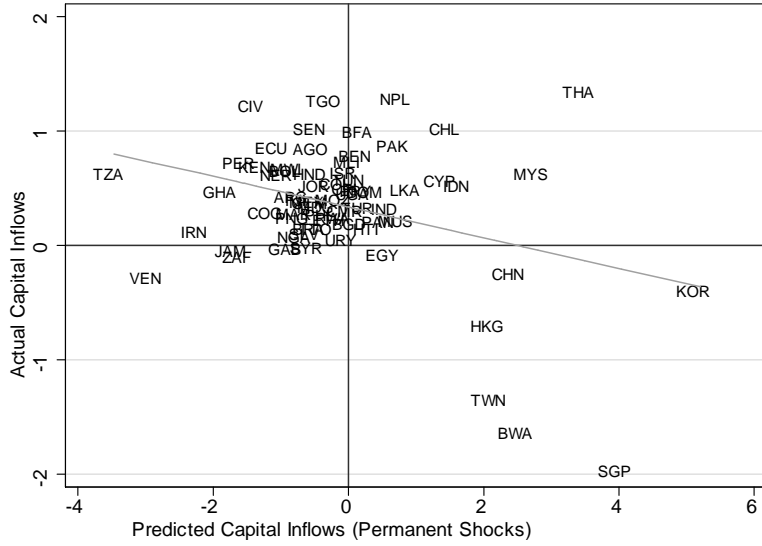


Figure 5: Predicted and actual capital inflows (as a share of initial GDP). Model with permanent productivity shocks. 1980-2000.

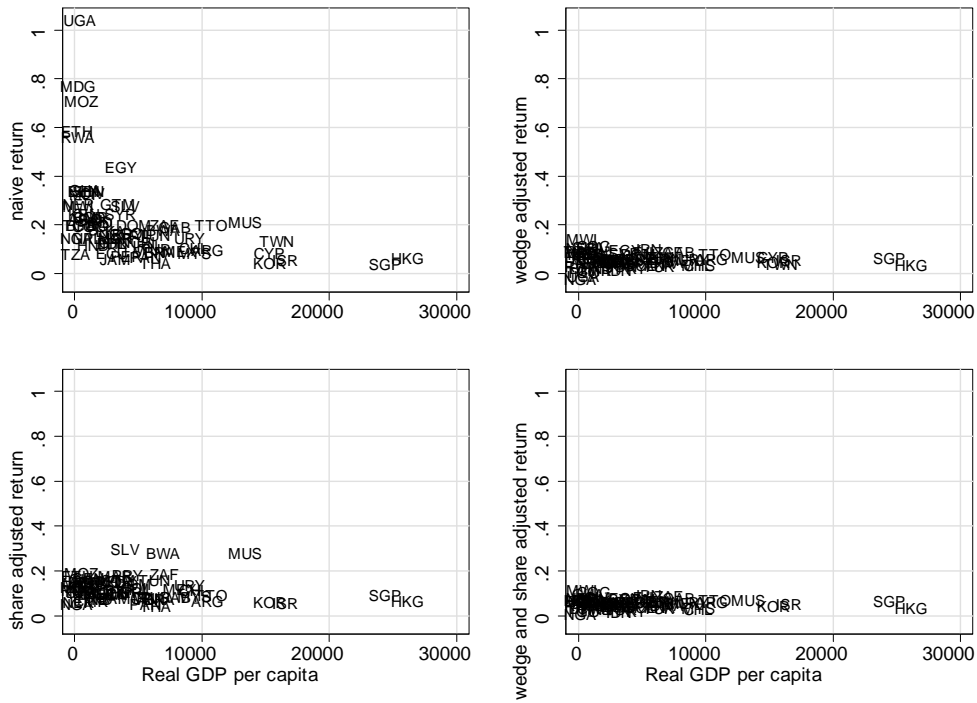


Figure 6: Various estimates of the private return on capital, 1980-2000.

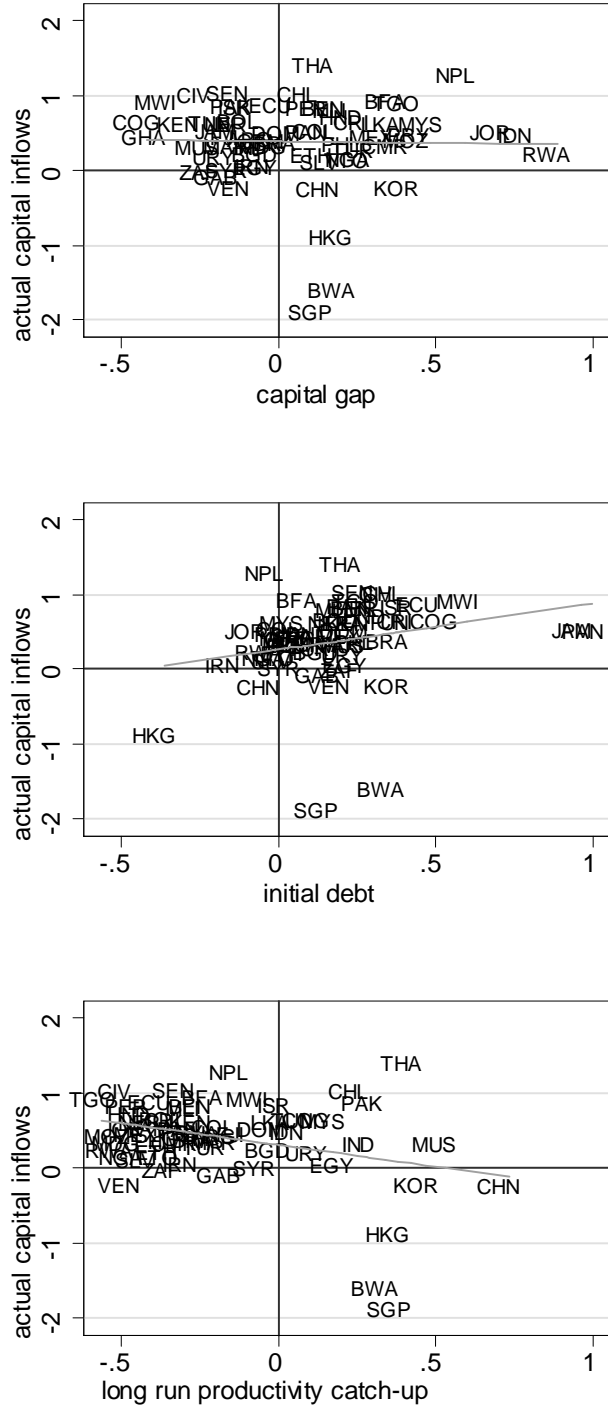


Figure 7: Actual land-adjusted capital inflows (as a share of initial GDP) against their determinants: capital gap  $(k^* - k_0)/k_0$ , initial debt to GDP ratio  $(d_0/y_0)$ , and productivity catch-up  $(\pi)$ , 1980-2000. Adjusted labor share.

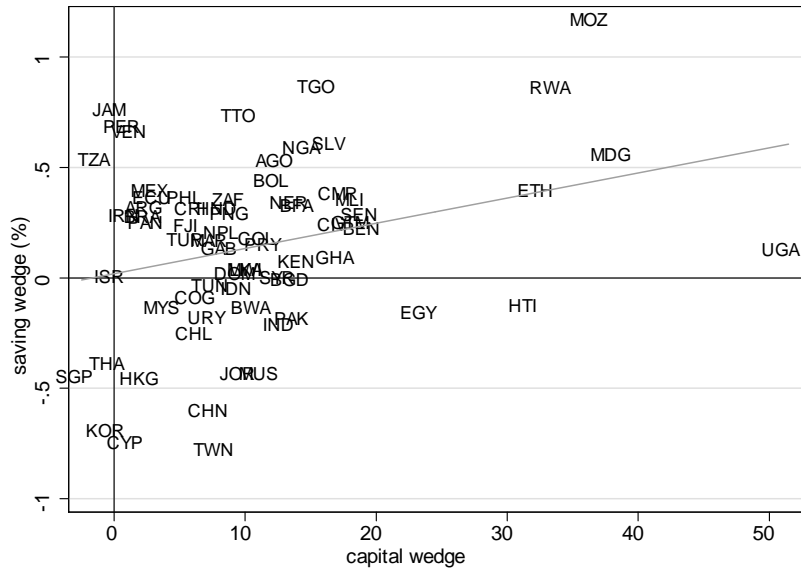


Figure 8: Saving and Capital wedges, calibrated to reproduce investment and saving.

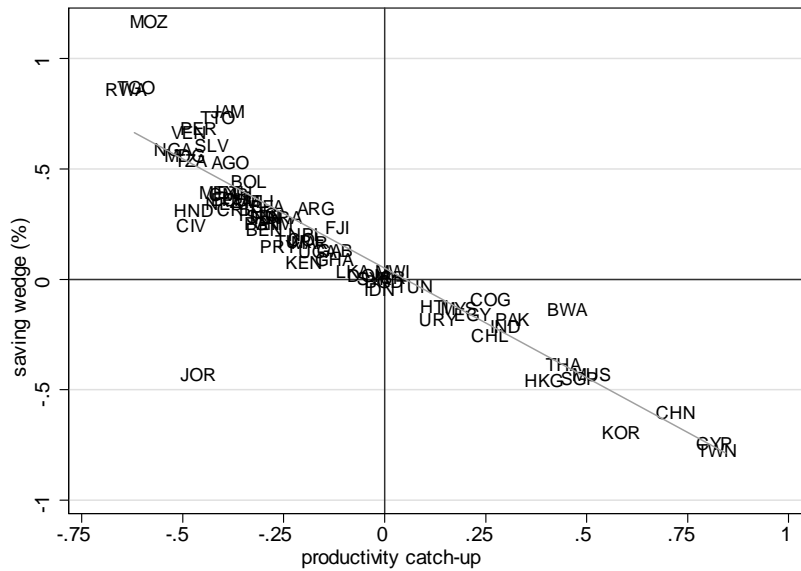


Figure 9: Saving wedge  $\tau_s$  and productivity catch-up  $\pi$ .

## A Proofs

### A.1 Proof of Proposition 1.

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

$$\frac{\Delta D}{Y_0} = \frac{D_T - D_0}{Y_0} = \frac{\tilde{d}_T A_T N_T - \tilde{d}_0 A_0 N_0}{A_0 N_0 \tilde{k}_0^\alpha} = \frac{\tilde{d}_T (g^* n)^T (1 + \pi) - \tilde{d}_0}{\tilde{k}_0^\alpha}. \quad (22)$$

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 capital gap. Note that although output is produced with the equilibrium level of capital  $\tilde{k}^*$  from period 0 onward, we normalize debt by the level of output before capital has jumped to  $\tilde{k}^*$ .

We then compute  $\tilde{d}_T$ . Let us denote by  $g_t = A_t/A_{t-1}$  the growth rate of productivity. Dividing the budget constraint (7) by  $N_t A_t$  and using  $N_{t+1}/N_t = n$ ,  $A_{t+1}/A_t = g_{t+1}$ ,  $\tilde{k}_t = \tilde{k}^*$  gives

$$\tilde{c}_t + ng_{t+1}\tilde{k}^* + R^*\tilde{d}_t = R^*\tilde{k}^* + ng_{t+1}\tilde{d}_{t+1} + \tilde{w} + \tilde{z}, \quad (23)$$

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

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 (23) implies

$$\tilde{d}_T = \tilde{k}^* + \frac{\tilde{w} + \tilde{z} - \tilde{c}_T}{R^* - ng^*}. \quad (24)$$

The next step is to compute  $\tilde{c}_T = c_T/A_T = c_0 g^{*T}/(1 + \pi)A_0 g^{*T} = \tilde{c}_0/(1 + \pi)$ . The level of net wealth per capita at the beginning of period 0 is  $k^* - d_0^+ = k_0 - d_0$ . Integrating the budget constraint (23) gives the intertemporal budget constraint,

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

Using  $c_t = A_0 \tilde{c}_0 g^{*t}$  and  $w_t + z_t = (\tilde{w} + \tilde{z})A_0(1 + \pi_t)g^{*t}$  this equation implies

$$\tilde{c}_0 = (R^* - ng^*) \left( \frac{1}{R^*} \sum_{t=0}^{+\infty} \left(\frac{ng^*}{R^*}\right)^t (1 + \pi_t)(\tilde{w} + \tilde{z}) + \tilde{k}_0 - \tilde{d}_0 \right). \quad (25)$$

Using this expression to substitute out  $\tilde{c}_T = \tilde{c}_0/(1 + \pi)$  from (24) gives

$$\tilde{d}_T = \tilde{k}^* - \frac{\tilde{k}_0 - \tilde{d}_0}{1 + \pi} + \frac{1}{1 + \pi} \frac{\tilde{w} + \tilde{z}}{R^*} \sum_{t=0}^{T-1} \left(\frac{ng^*}{R^*}\right)^t (\pi - \pi_t). \quad (26)$$

Finally, using this expression to substitute out  $\tilde{d}_T$  from (22) gives the expression in Proposition 1.

■

## A.2 Comparing different measures of capital inflows.

In the main text we measure capital inflows by the ratio of cumulated capital inflows to initial GDP:

$$m_1 = \frac{D_T - D_0}{Y_0}.$$

Our results are robust to using other measures of foreign borrowing. For example, capital inflows could be measured as the average ratio of net capital inflows to GDP over the period  $[0, T]$ ,

$$m_2 = \frac{1}{T} \sum_{t=0}^{T-1} \frac{D_{t+1} - D_t}{Y_t}. \quad (27)$$

This is the measure we used to introduce the allocation puzzle in Figure 1. Another possible measure of capital inflows is the change in the ratio of net foreign liabilities to GDP between time 0 and time  $T$ ,

$$m_3 = \frac{D_T}{Y_T} - \frac{D_0}{Y_0}. \quad (28)$$

We show that these measures are all increasing with the productivity catch-up  $\pi$ , under assumptions 1 and 2 and the additional requirement that  $f(t)$  increases with  $t$ . We have already shown this property for  $m_1$ . We now show that  $m_2$  and  $m_3$  are also increasing with  $\pi$ . First we derive a closed-form expression for  $\tilde{d}_t$  and show that it is increasing with  $\pi$  for any time  $t$ . The budget constraint (23) can be rewritten:

$$\tilde{d}_t - \tilde{k}^* = \frac{ng^*}{R^*} \frac{1 + \pi f(t+1)}{1 + \pi f(t)} (\tilde{d}_{t+1} - \tilde{k}^*) + \frac{\tilde{w} + \tilde{z} - \tilde{c}_t}{R^*}.$$

Iterating forward then gives:

$$\tilde{d}_t = \tilde{k}^* + \sum_{s=0}^{+\infty} \left( \frac{ng^*}{R^*} \right)^s \frac{1 + \pi f(t+s)}{1 + \pi f(t)} \frac{\tilde{w} + \tilde{z} - \tilde{c}_{t+s}}{R^*}.$$

Then using  $(1 + \pi f(t+s))\tilde{c}_{t+s} = \tilde{c}_0$  and expression (25), one can substitute out  $\tilde{c}_0$  from the expression above to obtain,

$$\tilde{d}_t = \tilde{k}^* + \frac{\pi}{1 + \pi f(t)} \sum_{s=0}^{+\infty} \left( \frac{ng^*}{R^*} \right)^s (f(t+s) - f(s)) \frac{\tilde{w} + \tilde{z}}{R^*} - \frac{\tilde{k}_0 - \tilde{d}_0}{1 + \pi f(t)}, \quad (29)$$

which is increasing with  $\pi$ , for any  $t$ , provided that the second term is positive and the third term is negative. The second term is positive because  $f(\cdot)$  is increasing monotonically. The third term is negative if external debt is not larger than the stock of capital at time 0 ( $\tilde{d}_0 \leq \tilde{k}_0$ ).

Next, let us show that  $m_2$  and  $m_3$  are increasing with  $\pi$ . This is very easy to show for  $m_3$  since

$$m_3 = \frac{\tilde{d}_T}{\tilde{k}^{*\alpha}} - \frac{\tilde{d}_0}{\tilde{k}_0^\alpha}.$$

The only term that depends on  $\pi$  is  $\tilde{d}_T$ , which is increasing with  $\pi$ . Measure  $m_2$  can be written

$$m_2 = \sum_{t=0}^{T-1} (g_{t+1}\tilde{d}_{t+1} - \tilde{d}_t).$$

Then using  $g_{t+1} = g^*(1 + \pi f(t + 1))/(1 + \pi f(t))$  and (29) to substitute out  $\tilde{d}_t$  and  $\tilde{d}_{t+1}$  we obtain (after some manipulations):

$$\begin{aligned} g_{t+1}\tilde{d}_{t+1} - \tilde{d}_t &= \left( g^* \frac{1 + \pi f(t + 1)}{1 + \pi f(t)} - 1 \right) \tilde{k}^* + \frac{\pi}{1 + \pi f(t)} \sum_{s=0}^{+\infty} \left( \frac{ng^*}{R^*} \right)^s (g^*(f(t + 1 + s) - f(s)) \\ &\quad - (f(t + s) - f(s)) \frac{\tilde{w} + \tilde{z}}{R^*} - (g^* - 1) \frac{\tilde{k}_0 - \tilde{d}_0}{1 + \pi f(t)}). \end{aligned}$$

One can check that all the terms on the right-hand side are increasing with  $\pi$ . Hence  $m_2$  is increasing with  $\pi$  too.

The predictions of the model, therefore, are qualitatively the same for the three measures of capital flows. However, there is a sense in which those predictions are more robust for measure (10) than for measures (27) and (28). If the allocation puzzle is observed with measure (10) then it must also hold with the two other measures. The opposite may not be true. This is another reason to use measure (10) as a benchmark when we look at the data.

We will now assume that  $m_1$ ,  $m_2$  and  $m_3$  are functions of  $\pi$  that could be different from the functions derived in the model. One could say that the puzzle is stronger with measure 1 than with measure 2 if having the puzzle for measure 1 implies that we have it for measure 2 too, i.e., if the fact that  $m_1$  is decreasing with  $\pi$  implies that  $m_2$  is also decreasing with  $\pi$ . We denote this relationship by  $m_1 \succ m_2$ . Then, under the simplifying assumption that debt accumulation is a constant fraction of GDP (that is  $D_{t+1} - D_t = m_2 Y_t$  for  $t = 0, \dots, T - 1$ ), we can establish the following ordering,

$$m_1 \succ m_2 \succ m_3.$$

Using  $Y_t = (1 + \pi f(t))n^t Y_0$  we have

$$D_T = D_0 + m_2 Y_0 \sum_{s=0}^{T-1} (1 + \pi f(s))(g^* n)^s.$$

Using the definition of  $m_1$  we have

$$m_1 = \frac{D_T - D_0}{Y_0} = m_2 \sum_{s=0}^{T-1} (1 + \pi f(s))(g^* n)^s.$$

It follows that if  $m_1$  is decreasing with  $\pi$ , so is  $m_2$ , which establishes  $m_1 \succ m_2$ . As for  $m_3$  it can

be written,

$$\begin{aligned}
m_3 &= \frac{D_0 + m_2 Y_0 \sum_{s=0}^{T-1} (1 + \pi f(s))(g^* n)^s}{(1 + \pi)(g^* n)^T Y_0} - \frac{D_0}{Y_0}, \\
&= \frac{D_0}{Y_0} \left( \frac{1}{(1 + \pi)(g^* n)^T} - 1 \right) + m_2 \sum_{s=0}^{T-1} \frac{1 + \pi f(s)}{1 + \pi} (g^* n)^{s-T}.
\end{aligned}$$

If  $m_2$  is decreasing with  $\pi$ , so is  $m_3$ , which establishes  $m_2 \succ m_3$ .

### A.3 Proof of Proposition 2.

For  $t \geq 1$  we have

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

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,

$$s_{k0} = (g_1 n + \delta - 1) \tilde{k}^{*(1-\alpha)} + \frac{K_0^* - K_0}{Y_0} = (g_1 n + \delta - 1) \tilde{k}^{*(1-\alpha)} + \frac{\tilde{k}^* - \tilde{k}_0}{\tilde{k}_0^\alpha}.$$

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

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

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  $\pi$  is small,  $\bar{g}$  can be expressed as a function of  $\pi$  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  $\pi_t$ , and the last equality uses  $\pi_T = \pi$  and  $\pi_0 = 0$ . We can

then write  $\bar{s}_k$  as

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

■

#### A.4 Proof of Proposition 3.

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 (25) with  $\pi$  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 (23) 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 (22) gives (17). ■

#### A.5 The model with saving wedges.

Since the saving wedge applies to both domestic capital and foreign debt, under capital mobility we still have  $R_t(1 - \tau) = R^*$ . This pins down the capital stock per efficiency units, as a function of  $\tau$ , as before. The budget constraint in efficient units is:

$$\tilde{c}_t + ng_{t+1} \left[ \tilde{k}_{t+1} - \tilde{d}_{t+1} \right] = (1 - \tau_s) \left[ (1 - \tau) R_t \tilde{k}_t - R^* \tilde{d}_t \right] + \tilde{w}_t + \tilde{z}_t, \quad (30)$$

where the wage per efficiency unit of labor is constant  $\tilde{w}(\tau) = (1 - \alpha) \tilde{k}^*(\tau)^\alpha$  while  $\tilde{z}_t = \tilde{z}(\tau) - \tau_s R^* (\tilde{d}_t - \tilde{k}^*(\tau))$ .

The Euler equation is now:

$$c_{t+1} = (1 - \tau_s)^{1/\gamma} g^* c_t. \quad (31)$$

This illustrates that an implicit tax on saving ( $\tau_s > 0$ ) is conceptually equivalent to a lower discount factor and depresses savings. In order to preserve the long run distribution of world income, we also assume that  $\tau_s = 0$  after  $t = T$ . Integrating forward the budget constraint and imposing the

no-ponzi and transversality conditions, we obtain:

$$\tilde{c}_0 = (R^* - ng^*) \psi(\tau_s) \left[ \frac{\tilde{w} + \tilde{z}}{R^*} \sum_{t=0}^{\infty} \left( \frac{ng^*}{R^*} \right)^t (1 + \pi_t) + \tilde{k}_0 - \tilde{d}_0 \right], \quad (32)$$

where

$$\psi(\tau_s) = \frac{R^* - ng^* (1 - \tau_s)^{1/\gamma}}{R^* - ng^* + \left( \frac{ng^*(1-\tau_s)^{1/\gamma}}{R^*} \right)^T ng^* \left( 1 - (1 - \tau_s)^{1/\gamma} \right)}$$

satisfies  $\psi(0) = 1$ .

The saving wedge  $\tau_s$  enters consumption choices only through the marginal propensity to consume out of wealth:

$$MPC = (R^* - ng^*) \psi(\tau_s) \geq 0.$$

It is easy to check that the marginal propensity to consume increases with  $\tau_s$ .

Iterate now the budget constraint between  $t = 0$  and  $t = T$ :

$$\tilde{d}_0 - \tilde{k}_0 = \frac{\tilde{w} + \tilde{z}}{R^*} \sum_t^{T-1} \left( \frac{ng^*}{R^*} \right)^t (1 + \pi_t) - \tilde{c}_0 \frac{1 - \left( \frac{ng^*\phi}{R^*} \right)^T}{R^* - ng^*\phi} + \left( \frac{ng^*}{R^*} \right)^T (\tilde{d}_T - \tilde{k}^*) (1 + \pi).$$

Solving out for  $\tilde{d}_T$ , substituting the expression for  $\tilde{c}_0$ , we obtain the final expression for the cumulated capital inflows:

$$\begin{aligned} \mathcal{D}(\tau, \tau_s) &= (ng^*)^T \frac{\tilde{k}^*(\tau) - \tilde{k}_0}{\tilde{y}_0} + \frac{\tilde{d}_0}{\tilde{y}_0} \left( \chi(\tau_s) \left( ng^* (1 - \tau_s)^{1/\gamma} \right)^T - 1 \right) \\ &+ (ng^*)^T \pi \frac{\tilde{k}^*(\tau)}{\tilde{y}_0} + \frac{\tilde{k}_0}{\tilde{y}_0} (ng^*)^T \left[ 1 - (1 - \tau_s)^{T/\gamma} \chi(\tau_s) \right] \\ &+ \frac{\tilde{w}(\tau) + \tilde{z}(\tau)}{\tilde{y}_0} \left[ \frac{1 - \left( \frac{ng^*(1-\tau_s)^{1/\gamma}}{R^*} \right)^T}{R^* - ng^*} - \frac{(1 - \tau_s)^{T/\gamma}}{R^*} \sum_t^{T-1} \left( \frac{ng^*}{R^*} \right)^t \frac{1 + \pi_t}{1 + \pi} \right] (ng^*)^T (1 + \pi) \chi(\tau_s) \end{aligned}$$

## 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 US 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 US dollar. We define the deflator  $P$  as the price of investment goods reported in the Penn World Tables, for reasons given in section 3.2. Multiplying a variable in constant international dollar,  $X$ , by the deflator  $Q$  gives its value in terms of current US dollars,  $X^{\$} = QX$ .

The deflator  $Q$  can be used to obtain PPP-adjusted estimates of the observed cumulated capital inflows  $\Delta D$ . To do this, we start from the external accumulation equation (in current US dollars):  $D_T^{\$} = D_0^{\$} - \sum_{t=0}^{T-1} CA_t^{\$}$ ,<sup>34</sup> and use the formulas  $D_T = D_T^{\$}/Q_T$  and  $D_0 = D_0^{\$}/Q_0$  to obtain:

$$\Delta D = \left( \frac{1}{Q_T} - \frac{1}{Q_0} \right) D_0^{\$} - \sum_{t=0}^{T-1} \frac{CA_t^{\$}}{Q_T}. \quad (33)$$

The estimate of the initial net external debt in US 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 cumulated errors and omissions (EO) cumulated between 1970 and 1980.<sup>35</sup> 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:

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

---

<sup>34</sup>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.

<sup>35</sup>In keeping with usual practice, we interpret errors and omissions as unreported capital inflows.

## C Data

Table 5: Data for 66 non-OECD countries, as well as Korea, Mexico and Turkey. The first five columns report the average saving rate  $s_k$ , productivity growth rate  $g$ , population growth rate  $n$ , capital wedge  $\tau$  and productivity catch-up  $\pi$  for the benchmark case of section 3. The last three columns report the share of reproducible capital income  $\alpha_k$ , the naive ( $RN$ ) and wedge-adjusted ( $RW$ ) returns for the case with non-reproducible capital described in section 4.3.

Country	Start	End	$s_k(\%)$	$g(\%)$	$n(\%)$	$\tau(\%)$	$\pi$	$\alpha_k$	$RN(\%)$	$RW(\%)$
Angola	1985	1996	6.16	-2.32	2.85	12.92	-0.36	.	.	.
Argentina	1980	2000	15.84	0.83	1.49	2.90	-0.15	0.25	6.61	6.14
Bangladesh	1980	2000	10.41	1.73	2.62	13.99	0.02	0.22	15.48	6.02
Benin	1980	2000	8.00	-0.00	3.02	19.41	-0.28	0.16	14.84	6.99
Bolivia	1980	2000	8.38	-0.23	2.46	12.51	-0.32	0.19	9.87	5.28
Botswana	1980	1999	16.95	3.84	3.56	11.07	0.47	0.43	27.71	4.79
Brazil	1980	2000	18.00	0.43	2.38	2.70	-0.23	0.28	7.50	5.88
Burkina Faso	1980	2000	10.33	0.11	2.41	14.50	-0.27	0.19	10.33	3.27
Cameroon	1980	1995	8.72	-1.22	2.80	17.74	-0.37	0.13	6.75	3.28
Chile	1980	2000	17.32	2.88	1.85	6.57	0.28	0.32	11.36	3.22
China	1982	2000	19.58	4.81	1.82	7.69	0.74	0.26	10.40	4.26
Colombia	1980	2000	11.79	0.74	2.61	11.42	-0.18	0.24	12.14	3.73
Congo, Rep.	1980	2000	12.95	3.17	2.90	6.78	0.28	0.21	11.88	10.18
Costa Rica	1980	2000	15.30	-0.58	3.02	6.21	-0.36	0.22	7.81	5.80
Cyprus	1980	1996	23.57	5.59	1.08	1.43	0.84	.	.	.
Côte d'Ivoire	1980	2000	5.74	-1.40	3.70	17.09	-0.46	0.15	13.71	8.45
Dominican Republic	1980	2000	13.26	1.57	2.61	9.82	-0.02	0.23	13.83	7.52
Ecuador	1980	2000	16.50	-0.47	3.08	3.40	-0.27	0.34	9.75	4.29
Egypt, Arab Rep.	1980	2000	7.42	2.73	2.62	23.81	0.24	0.13	15.26	7.89
El Salvador	1980	2000	7.10	-1.01	2.28	16.90	-0.41	0.32	29.54	6.03
Ethiopia	1980	2000	4.17	-0.50	2.61	32.68	-0.35	0.11	17.74	6.57
Fiji	1980	1999	12.64	1.10	1.65	5.83	-0.10	0.25	12.04	8.39
Gabon	1980	2000	11.53	1.14	2.44	8.61	-0.10	0.17	8.45	7.86
Ghana	1980	2000	6.11	1.14	3.40	17.44	-0.10	0.16	16.11	9.36
Guatemala	1980	2000	7.35	0.26	2.76	18.65	-0.25	0.19	15.88	4.89
Haiti	1980	1998	5.46	2.25	2.09	31.63	0.14	.	.	.
Honduras	1980	2000	12.91	-1.26	3.44	8.35	-0.46	0.23	7.37	2.84
Hong Kong, China	1980	2000	25.31	3.56	1.87	2.49	0.41	0.31	6.41	3.52
India	1980	2000	11.95	3.04	2.33	13.01	0.31	0.15	7.43	5.73
Indonesia	1981	2000	16.91	1.74	2.46	9.75	0.00	0.26	9.51	1.71
Iran, Islamic Rep.	1980	2000	19.84	-0.07	3.10	1.20	-0.28	0.24	7.76	9.10

*continued on next page*

Table 5 continued from previous page

Country	Start	End	$s_k(\%)$	$g(\%)$	$n(\%)$	$\tau(\%)$	$\pi$	$\alpha_k$	$RN(\%)$	$RW(\%)$
Israel	1980	2000	24.97	1.88	2.72	0.09	0.03	0.31	5.52	5.26
Jamaica	1980	2000	15.39	-0.62	1.80	0.25	-0.37	0.34	7.70	5.84
Jordan	1980	2000	15.57	-1.12	5.09	9.98	-0.44	0.31	15.22	2.91
Kenya	1980	2000	8.33	0.76	3.70	14.43	-0.18	0.19	13.22	6.39
Korea, Rep.	1980	2000	34.05	4.13	1.83	-0.08	0.61	0.35	6.12	4.32
Madagascar	1980	2000	2.75	-1.50	2.84	38.59	-0.47	0.07	12.71	6.92
Malawi	1980	2000	9.24	1.84	2.64	10.56	0.04	0.18	14.50	11.54
Malaysia	1980	2000	24.42	2.65	3.07	4.31	0.21	0.31	8.74	3.54
Mali	1980	2000	7.83	-0.08	2.44	18.46	-0.29	0.12	9.80	7.19
Mauritius	1980	2000	11.96	3.85	1.62	11.66	0.53	0.38	27.99	9.08
Mexico	1980	2000	18.13	-0.74	2.95	3.34	-0.39	0.36	11.75	5.38
Morocco	1980	2000	12.74	0.86	2.75	7.91	-0.16	0.34	17.46	5.62
Mozambique	1980	2000	3.07	-2.52	1.93	36.89	-0.56	0.10	19.16	6.81
Nepal	1980	2000	15.45	0.64	2.29	8.65	-0.18	0.24	10.31	4.65
Niger	1980	1995	6.65	-1.58	3.28	13.88	-0.38	0.11	6.19	7.89
Nigeria	1980	2000	8.31	-1.82	2.93	14.90	-0.50	0.16	4.98	0.69
Pakistan	1980	2000	11.34	3.20	2.57	14.14	0.34	0.22	14.82	5.02
Panama	1980	2000	18.36	0.09	2.64	3.00	-0.28	0.27	5.11	3.69
Papua New Guinea	1980	1999	11.18	-0.19	2.86	9.34	-0.29	.	.	.
Paraguay	1980	2000	12.78	0.31	3.23	11.90	-0.24	0.33	17.89	1.95
Peru	1980	2000	18.02	-1.20	2.63	1.14	-0.44	0.37	10.39	6.03
Philippines	1980	2000	14.95	-0.40	2.73	5.84	-0.34	0.35	15.17	5.92
Rwanda	1980	2000	4.34	-2.99	2.96	33.93	-0.62	0.08	11.55	4.54
Senegal	1980	2000	6.50	0.03	2.88	19.25	-0.28	0.17	16.68	7.31
Singapore	1980	1996	44.14	4.29	2.94	-2.48	0.50	0.47	9.05	6.54
South Africa	1980	2000	9.52	-0.25	2.86	9.24	-0.33	0.29	18.39	8.58
Sri Lanka	1980	2000	13.45	1.33	1.91	10.57	-0.06	0.20	9.41	5.19
Syrian Arab Republic	1980	2000	11.64	1.69	3.92	13.04	0.00	0.17	11.60	7.42
Taiwan	1980	1997	19.05	5.42	1.56	8.24	0.84	.	.	.
Tanzania	1980	2000	18.89	-1.39	3.27	-0.96	-0.46	.	.	.
Thailand	1980	2000	31.30	3.64	2.18	0.04	0.46	0.31	4.42	4.00
Togo	1980	2000	7.47	-2.71	2.92	16.06	-0.59	0.20	11.04	1.80
Trinidad and Tobago	1980	2000	10.18	-0.76	1.57	10.06	-0.39	0.18	9.09	7.02
Tunisia	1980	2000	14.41	2.19	2.89	7.83	0.09	0.30	15.81	6.80
Turkey	1980	2000	16.87	0.54	2.76	5.96	-0.21	0.28	8.32	3.31
Uganda	1980	2000	2.84	0.86	2.65	51.47	-0.15	.	.	.
Uruguay	1980	2000	11.65	2.37	0.66	7.61	0.15	0.29	13.46	5.85
Venezuela, RB	1980	2000	14.35	-1.48	2.86	1.71	-0.47	0.28	7.51	6.78