



# The Elusive Gains from International Financial Integration

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Standard theoretical arguments tell us that countries with relatively little capital benefit from financial integration as foreign capital flows in and speeds up the process of convergence. We show in a calibrated neoclassical model that conventionally measured welfare gains from this type of convergence appear relatively limited for the typical emerging market country. The welfare gain from switching from financial autarky to perfect capital mobility is roughly equivalent to a 1% permanent increase in domestic consumption for the typical non-OECD country. This is negligible relative to the welfare gain from a take-off in domestic productivity of the magnitude observed in some of these countries.

## 1. INTRODUCTION

Ask an economist about the benefits of international financial integration, and what first comes to his or her mind is likely to involve, in one way or another, the efficiency of laissez-faire. A growth economist, in particular, will point to the impact of capital flows from developed (capital-abundant) to less developed (capital-scarce) countries on economic growth and convergence. Indeed, one of the main motivations behind the push towards the international financial integration of developing countries has been to accelerate their growth by attracting foreign capital.<sup>1</sup>

International financial integration was often viewed, in the policy-making circles of the early 1990's, as a new engine of growth which, together with international trade, would help to lift the standard of livings in "emerging market" countries. This optimism was in part justified by the experience of the countries that participated in the wave of financial liberalization of the late 1980's. The surge in capital inflows, investment, and real gross domestic product (GDP) that followed stock market liberalizations is consistent with the predictions of the textbook model of a capital-scarce economy opening itself to foreign capital.<sup>2</sup>

We understand the benefits of capital mobility well enough in theory, but how large are they in practice? It is, perhaps, surprising that the welfare gains that capital-scarce countries receive from capital inflows have not been estimated in the literature. The main purpose of this paper is to fill this gap by providing benchmark estimates based on the calibration of standard neoclassical

1. See Eichengreen and Mussa (1998, p. 12): "The classic case for international capital mobility is well known but worth restating. Flows from capital-abundant to capital-scarce countries raise welfare in the sending and receiving countries alike on the assumption that the marginal product of capital is higher in the latter than in the former. Free capital movements thus permit a more efficient global allocation of savings and direct resources towards their most productive uses". According to Fischer (1998, p. 2): "Put abstractly, free capital movements facilitate an efficient global allocation of savings and help channel resources to their most productive uses, thus increasing economic growth and welfare".

2. See Gourinchas and Jeanne (2005*b*) for some empirical evidence.

growth models. There is an extensive literature measuring the welfare benefits of international financial integration in calibrated models, but so far it has focused on the benefits in terms of risk sharing.<sup>3</sup> To the best of our knowledge, this paper is the first one to estimate the benefits of international financial integration coming from the capital scarcity of developing countries.<sup>4</sup>

We present two versions of the neoclassical model. The first—and simplest—one is a variant of the Ramsey–Cass–Koopman model where countries accumulate physical capital only. It serves to motivate and provide some intuition for our results. The second one proposes a higher level of detail and realism by introducing human-capital accumulation in a “Macro-Mincer” framework with realistic levels of distortions on the accumulation of physical and human capital. Our main finding is that while financial openness increases domestic welfare, and while this benefit can be significant for some countries, it is not very large on average. For the typical non-OECD country, the welfare gain from switching from complete financial autarky to perfect capital mobility is equivalent to a permanent increase in consumption of about 1%. This benefit is of an order of magnitude smaller than the gains that development economists and policy-makers seek to achieve. For example, we show that it is negligible relative to the welfare gain from a take-off in domestic productivity of the magnitude observed in some countries.

Interestingly, we find that the gains from international financial integration may be relatively small even for countries that stand to receive a lot of capital inflows. In the simple Ramsey model, for example, a country gains only 1.7% of current consumption from capital inflows that more than double its capital stock. This apparent disconnect comes from the essentially transitory nature of the distortion induced by imperfect capital mobility. A capital-scarce country that restricts the entry of foreign capital bears a distortion that is proportional to the wedge between the domestic and foreign returns on investment. Even if the capital account restriction remains in place forever, the distortion endogenously vanishes over time as the country accumulates capital domestically. The average distortion, as a result, is much lower than the initial distortion—and the initial capital inflows, might suggest.

We believe that our findings have important implications for the research agenda on financial globalization. This paper suggests that *if* the benefits of international financial integration are large, they must occur through channels that are not in the textbook neoclassical growth model. Moreover, these channels can explain large gains (in our metric) only if international financial integration raises the level of productivity or reduces the level of distortion in developing countries.<sup>5</sup> For example, our calibrations suggest that international financial integration would yield a welfare benefit about 50 times larger than the benchmark neoclassical gain if it eliminated 25% of the productivity gap with the U.S.<sup>6</sup> However, most of this benefit would occur because of the *indirect* effects of integration, not because of the increase in the size of capital flows *per se*.

This paper contributes to a growing literature on the benefits of capital account liberalization for developing countries. A number of papers have attempted to answer the same question as we do, but on the basis of cross-country regressions. The results are heterogeneous, ranging

3. See Athanasoulis and van Wincoop (2000) for a discussion of this literature.

4. Some papers have estimated the same type of benefit as we do here, but with a focus on developed economies. For example, Mendoza and Tesar (1998) find that the welfare benefit of integration is relatively small for the U.S.—less than 0.5% of permanent consumption.

5. There is a superficial analogy between our results and some conclusions of the literature on trade liberalization. In calibrated neoclassical models the gains from trade liberalization typically amount to less than 1% of GDP (de Melo and Tarr, 1992). This has led some authors to conclude that if free trade yields large welfare gains, it must be because of its indirect impact on productivity (Rutherford and Tarr, 2002).

6. This could occur, for example, because of technological spillovers associated with foreign direct investment (FDI) or an improvement in the allocation of domestic saving induced by financial liberalization. These and other channels are discussed in more detail in the concluding section.

from no impact of capital account opening on growth to a more or less significant positive impact (see Edison, Levine, Ricci and Sloek, 2002 for a review). At the optimistic end of the spectrum, Bekaert, Harvey and Lundblad (2005) and Henry (2003) find that opening the stock market to foreign investors boosts growth by 1–2% for five years in a row. Such a result, however, is not obvious to translate in terms of domestic welfare. How persistent is the impact of capital account opening on growth? What share of the output increase is transferred to foreign investors? These questions are crucial in assessing the welfare impact of capital account opening and can be addressed only by looking at the data through the lenses of a model.

Our results are consistent with the recent developments in the literature on growth and convergence in international perspective. In contrast with early papers that stressed factor accumulation as a source of growth (Mankiw, Romer and Weil, 1992; Barro, Mankiw and Sala-i-Martin, 1995), the literature has moved towards the view that total factor productivity accounts for most of income differences across countries (Hall and Jones, 1999; Easterly and Levine, 2001).

This literature has not looked at the impact of international financial integration on growth and convergence. Our contribution here is twofold. First, our approach captures the different sources of cross-country inequality that have been discussed in the literature and combines them in the context of a single optimizing framework in which the rates of factor accumulation are endogenous. This endogeneity is crucial for our purpose, since the main role of financial integration here is to accelerate the accumulation of physical capital. Second, we present a “development accounting exercise” that highlights the relative contributions of factor accumulation, productivity, and a conditional convergence gap that financial integration eliminates. We show that although countries may be far from their steady state, conditional convergence plays a minor role compared to differences in distortions and productivity in explaining the development gap between poor and rich countries. One implication is that international financial integration can equalize the marginal return of capital across countries without closing the large gaps in productivity and income *per capita* between poor and rich nations.

The theoretical literature has pointed to other reasons that international financial integration might fail to have large, or even positive, welfare effects. Matsuyama (2004) shows that in a world where countries’ ability to borrow abroad is constrained by their domestic collateral, financial globalization might make some countries richer only at the expense of making the rest of the world poorer and could slow down the growth process of middle-income countries. Other papers in which the gains from integration are limited by financial friction include Gertler and Rogoff (1990), Barro *et al.* (1995), and Boyd and Smith (1997). The gains from integration would obviously be smaller than those we estimate if financial frictions were introduced into the model.

On the other hand, our model does not include some channels that may boost the impact of international financial integration on growth. In Obstfeld (1994) and Acemoglu and Zilibotti (1997) the risk diversification allowed by international financial integration improves the overall efficiency of investment, leading, in Obstfeld’s endogenous growth model, to a permanent increase in the rate of growth and large welfare gains. Tornell and Velasco (1992) present a model in which capital mobility raises growth and welfare by ameliorating the tragedy of the commons on a common pool of resources. In Borenzstein, de Gregorio and Lee (1998) foreign direct investment increases the rate of growth by enhancing the variety of the capital goods used in domestic production.

The paper is structured as follows. Section 2 presents results based on a very stylized neo-classical model. Section 3 presents an extension of the model with endogenous human-capital accumulation and various distortions and interprets our results in the context of a decomposition of world inequality in output *per capita*. Section 4 concludes with a discussion of the implications of this paper for future research.

## 2. A SIMPLE EXPERIMENT

Consider a small Ramsey–Cass–Koopmans economy that can accumulate physical capital using the savings of its residents and/or by attracting capital from abroad. The country is small relative to the rest of the world in the sense that the capital account regime has no impact on the world return on capital. Our “experiment” assesses the benefits of international financial integration for this economy by comparing two extreme cases: a state of *complete financial autarky* in which the country has to rely purely on domestic savings and a state of *perfect financial integration* in which the country can import or export capital at the (given) world interest rate.

We assume that there are no impediments to financial flows under financial integration. This maximizes the welfare benefits from integration, since capital movements will fully and immediately arbitrage away any difference in marginal returns to capital. While the associated dynamics are trivial, this represents, we believe, a simple and transparent case where the gains from international financial integration are potentially large.

Because of its theoretical simplicity, this experiment provides a useful benchmark to start with. The next section will incorporate the insights of the recent literature on convergence and growth in an international perspective to obtain a more realistic measure of the benefits of international financial integration for a large sample of emerging economies. As we will see, our results are surprisingly robust to these extensions.

2.1. *The model*

We consider a world with one homogeneous good and a number of countries. In this world, we focus on a subset of small developing countries that may or not open their capital account. Time is discrete, and there is no uncertainty. The population  $N_t$  grows at an exogenous rate  $n$  that is country specific:  $N_t = n^t N_0$ . The population of each country can be viewed as a large family that maximizes the welfare function

$$U_t = \sum_{s=0}^{\infty} \beta^s N_{t+s} u(c_{t+s}), \quad (2.1)$$

where  $c_t$  is consumption *per capita*, and  $u(c) \equiv c^{1-\gamma}/(1-\gamma)$  is a constant relative risk aversion instantaneous utility function with coefficient  $\gamma > 0$ . In the case where  $\gamma = 1$ , the utility function is  $u(c) = \ln(c)$ .

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

$$Y_t = K_t^\alpha (A_t L_t)^{1-\alpha}, \quad (2.2)$$

where  $K_t$  denotes the stock of domestic capital,  $L_t$  is labour supply, and  $A_t$  is a labour-augmenting measure of productivity. Labour supply is exogenous and proportional to population ( $L_t = N_t$ ). Factor markets are perfectly competitive. Lastly, labour productivity grows at a gross rate  $g_t \equiv A_t/A_{t-1}$ , which may differ across countries in the short run but converges towards the same value for all countries:

$$\lim_{t \rightarrow +\infty} g_t = g^*. \quad (2.3)$$

This is a common assumption in the empirical growth literature. The common asymptotic growth rate  $g^*$  reflects the advancement of knowledge, which should not be country specific in the long run. If growth rates of productivity differed permanently across countries, the world income distribution would diverge without bounds, and the country or region with the highest long-run growth rate would overtake world output. Some mechanism, such as innovation and technology transfers, must constrain the tendency towards infinite divergence.

However, countries could differ in their growth rate of productivity in the short run or in their levels of productivity  $A$  in the long run. Differences in productivity growth underlie recent “growth miracles”. Differences in productivity levels reflect, as Mankiw *et al.* (1992, p. 411) mention, “not just technology but resource endowments, climate, institutions, and so on”.

Under *financial autarky*, each country accumulates capital domestically. The neoclassical framework predicts that the economy will converge towards a balanced growth path in which capital, output, and consumption *per capita* asymptotically grow at the same rate as productivity. We denote with lower case letters and tildes the variables normalized by population and by the level of productivity, respectively, that is,  $k_t = K_t/N_t$  and  $\tilde{k}_t = k_t/A_t$ . Let  $R_{t+1}$  be the gross return on domestic investment between  $t$  and  $t + 1$ . It follows from the Euler equation for consumption,  $u'(c_t) = \beta R_{t+1} u'(c_{t+1})$  that

$$\tilde{c}_t = (\beta R_{t+1})^{-1/\gamma} g_{t+1} \tilde{c}_{t+1}, \quad (2.4)$$

so that in the long run the return on domestic saving is given by

$$R^* = g^{*\gamma} / \beta. \quad (2.5)$$

$R^*$  is the *natural* level of the gross rate of interest. It is the same for all countries.

Taking the limit of the first-order condition for capital  $R_t = \alpha \tilde{k}_t^{\alpha-1} + 1 - \delta_k$  (where  $\delta_k$  is the depreciation rate of capital) gives the asymptotic level of productivity-adjusted capital

$$\lim_{t \rightarrow +\infty} \tilde{k}_t = \tilde{k}^* = \left( \frac{\alpha}{R^* + \delta_k - 1} \right)^{1/1-\alpha}, \quad (2.6)$$

which is also the same for all countries.

Under *financial integration* domestic agents can lend or borrow at the gross world interest rate. We assume that the rest of the world is composed of developed countries that have already achieved their steady state. Under that assumption, the world interest rate is equal to the natural gross rate of interest,  $R^*$ , and financial integration does not “tilt” permanently consumption profiles.<sup>7</sup> The Euler equation  $c_t = (\beta R^*)^{-1/\gamma} c_{t+1}$  implies that domestic consumption *per capita* grows at rate  $g^*$  as soon as the country is financially integrated. The first-order equation for capital implies that  $\tilde{k}_t$  jumps immediately to its long-run level  $\tilde{k}^*$ .

The assumption that the world interest rate and the natural interest rate coincide has one important implication. The long-run levels of capital and output *per capita* are the same under autarky and financial integration. These levels may differ across countries because of persistent differences in productivity levels, but they are not affected by the capital account regime. This is a general property of the neoclassical framework: the effect of integration is to *accelerate* the country’s convergence towards a steady growth path that is the same as under autarky.<sup>8</sup>

We measure the gains from international financial integration in terms of domestic consumption. Let us denote by  $U_{\text{aut}}$  and  $U_{\text{int}}$  the domestic welfare of the representative agent at time 0 under financial autarky and financial integration, respectively. By the first welfare theorem we know that domestic welfare is higher under financial integration than under autarky. In the following discussions, we report the Hicksian equivalent variation  $\mu$ , defined as the percentage increase in the country’s consumption that brings domestic welfare under autarky up to its level under integration:

7. We are interested in measuring the benefits of international financial integration that stem from capital scarcity, not from intrinsic and permanent differences in the natural rate of interest between countries.

8. Integration makes only one difference in the long run: the level of consumption is lower under financial integration than under autarky because of the flow of interest payments to the rest of the world.

TABLE 1  
Common parameters

$\beta$	$\gamma$	$\alpha$	$\delta_k$	$g^*$	$n$
0.96	1	0.3	0.06	1.012	1.0074

$$\mu = \left( \frac{U_{\text{int}}}{U_{\text{aut}}} \right)^{1/1-\gamma} - 1, \quad (2.7)$$

if  $\gamma \neq 1$ , and  $\mu = \exp((1 - n\beta)(U_{\text{int}} - U_{\text{aut}})) - 1$  if  $\gamma = 1$ .

## 2.2. Calibration and results

In order to compute a country's welfare gains from integration in year 0, we need the path of future productivities  $(A_t)_{t \geq 0}$ . We make the simple assumption that productivity grows at the long-run rate  $g^*$  from year 0 onwards. Table 1 reports the values of the parameters of the model, calibrated by reference to the U.S. economy. We set  $g^* = 1.012$  in line with long-run multi-factor productivity growth in the U.S. and a population growth rate of 0.74% per annum, consistent with U.S. population growth. Although the assumption that the capital share is constant across countries is certainly too strong, recent estimates by Gollin (2002) suggest that the Cobb–Douglas assumption is roughly appropriate, with an estimated capital share between 0.2 and 0.4. Accordingly, we set  $\alpha = 0.3$ . We assume a rate of depreciation of physical capital equal to 6% per annum as in Summers and Heston (1991). With these assumptions, the world real interest rate is equal to  $R^* = 1.0542$ , and the (common) steady-state capital–output ratio  $k^*/y^* = \tilde{k}^{*1-\alpha}$  is equal to 2.63.

In our simple model, the initial conditions can be characterized either in terms of the capital ratio,  $k_0/k^*$  measuring the distance of a country to its steady state or in terms of the capital–output ratio  $k_0/y_0 = \tilde{k}_0^{1-\alpha}$ .<sup>9</sup>

Figure 1 reports the welfare gains  $\mu$  as a function of the initial capital–output ratio, along with a vertical line at the steady-state capital–output ratio. The figure delivers a stark message: since the curve is very flat around  $k^*/y^*$ , a country must have a very low or a very high capital–output ratio to significantly benefit from international financial integration. The capital–output ratio must fall below 1.29 or exceed 4.38 for the gains from integration to exceed 2% of annual consumption. In order to get a rough order of magnitude, we use the Heston, Summers and Aten (2002) Penn World Tables Mark 6.1 (PWT) to construct capital stocks in 1995 for 82 non-OECD countries.<sup>10</sup> We find a population-weighted average capital–output ratio equal to 1.40, with a top and bottom deciles equal to 1.0 and 2.1, respectively. According to Figure 1, the potential welfare gain associated with this sample average is equal to 1.74% of annual consumption.

As a first point of comparison, we note that this welfare gain is of the same order of magnitude as the quantitative estimates of the benefits of international financial integration in terms of risk sharing. These estimates, like ours, are based on calibrated models and are expressed in terms of consumption. Most papers find gains from international risk sharing smaller than 0.5% of consumption for developed economies, with somewhat larger gains when the model is calibrated with reference to the more volatile developing economies (see Pallage and Robe, 2003). Another point of comparison is the empirical public finance literature establishing the incidence of taxes (Mendoza and Tesar, 1998). This literature typically finds welfare effects that are a fraction of 1%.

9. The two ratios are related by the equation  $(k_0/y_0)/(k^*/y^*) = (k_0/k^*)^{1-\alpha}$ . The next section will present more detailed estimates of the distance of a country from its steady state.

10. See next section and the appendix for more details on how we construct capital stocks.

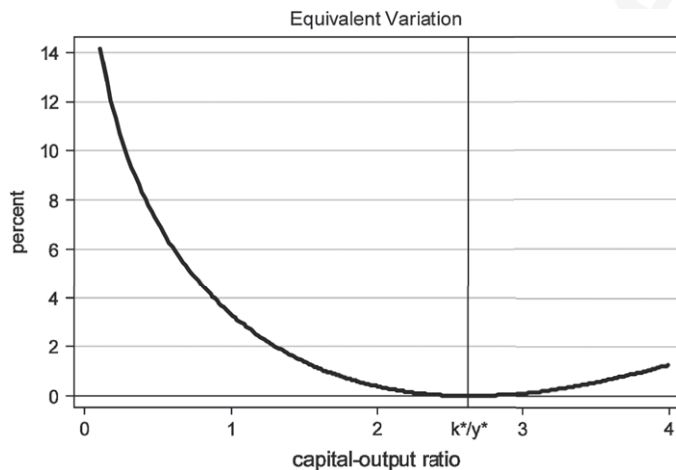


FIGURE 1

International Financial Integration, benchmark case. The solid line corresponds to the theoretical gains from international financial integration as a function of the capital–output ratio  $k/y$ . Parameters defined in Table 1

TABLE 2

*Change in output growth*

Capital–Output ratio	Horizon (years)		
	1	5	10
1.0	42.60	3.92	0.89
1.4	27.65	2.78	0.66
2.1	10.18	1.13	0.28

The table reports the change in domestic output growth following financial integration (per cent, per annum).

As mentioned in the introduction, the empirical literature on the benefits of capital account liberalization often focuses on domestic output growth. We can use our model to revisit this issue. Table 2 reports the increase in output growth predicted by the model at various horizons and for values of the capital–output ratio between 1.0 and 2.1 that comprise 80% of our sample. The large increase in output growth at a one-year horizon reflects the absence of any friction in the capital market. More realistically, the table shows that at the 5-year horizon the gain in output growth can be substantial, in excess of 2.7% per year on average for capital–output ratios below 1.4. The empirical literature reports somewhat smaller gains. For instance, Bekaert *et al.* (2005) find that the GDP growth rate increases by 1% over five years following an equity market liberalization. This is comparable to the increase in growth that would result from integration starting from a capital–output ratio slightly higher than 2.0 in our model. In light of our calculations, such a growth improvement is associated with a very small benefit in terms of domestic welfare (0.29%, see Table 3).

### 2.3. Intuition

It may come as a surprise that the gains from international financial integration are so low, even for countries that stand to receive large capital flows. For instance, the capital ratio is only 0.4 in our benchmark estimate. Domestic welfare increases by only 1.74% of annual consumption, even though the stock of domestic capital more than doubles at the time of financial integration.

*Query 1*

TABLE 3

*Robustness checks: the table reports the equivalent variation  $\mu$  for various parameter configurations*

$k/y$	Benchmark	EIS ( $1/\gamma$ )			$\sigma$		$n$	$\alpha$
		1/3	1/5	1/10	0.5	1.5	2.3	0.6
1.0	3.46	5.34	4.69	1.32	18.23	2.21	2.01	76.75
1.4	1.74	1.88	0.99	0.09	4.74	1.18	1.02	54.71
2.1	0.29	0.01	0.27	4.78	0.52	0.22	0.18	30.85
$r^*$ (%)	5.42	7.96	10.57	17.36	5.42	5.42	5.42	5.42

EIS, Elasticity of inter-temporal substitution.

In order to understand this result, one has to bear in mind the essentially transitory nature of the distortion induced by imperfect capital mobility. A capital-scarce country that restricts the entry of foreign capital bears a distortion that is proportional to the wedge between the domestic and foreign returns on investment. Even if the capital account restriction remains in place forever, the distortion endogenously vanishes over time as the country accumulates capital domestically. The average distortion, as a result, is much lower than the initial distortion—and the initial capital inflows—might suggest.<sup>11</sup>

From that point of view, there is a significant difference between our results and those of the calibrated literature on the welfare effects of trade liberalization. The small welfare gains in that literature—sometimes referred to as the “Harberger constant”—arise from the elimination of a small but permanent “triangular” distortionary loss. By contrast, the distortionary loss induced by imperfect capital mobility is initially large but converges to 0 over time, as countries converge towards the same steady-state level of capital under autarky as under integration. The distortionary loss is small *in average* even though it could be initially much larger.

To make this point more formally, we derive a simple expression for the welfare gain from a *marginal* increase in international financial integration. Let us assume that in a capital-scarce country, a central planner authorizes the entry of a marginal amount of foreign capital  $d\kappa_{t+1}$  at time  $t$  (by relaxing quantitative capital controls, say). This increases the equilibrium real wage and decreases the return on domestic savings. By the envelope theorem, we know that the net welfare gain from the marginal capital inflow is the same as if  $d\kappa_{t+1}$  were invested at time  $t$ , and the resulting increase in domestic net income were consumed in period  $t + 1$ . The welfare gain at time  $t + 1$  can be written as<sup>12</sup>

$$dU_{t+1} = u'(c_{t+1})(R_{t+1} - R^*)d\kappa_{t+1}. \quad (2.8)$$

This is equal to the marginal utility of consumption times the marginal increase in domestic income,  $dy_{t+1} - R^*d\kappa_{t+1} = (R_{t+1} - R^*)d\kappa_{t+1}$ . The welfare gain from a small capital inflow in terms of current consumption is equal to the return differential between the country and the rest of the world times the capital inflow.

One can view financial integration at time 0 as the result of an incremental process in which the social planner continuously relaxes the capital controls in all periods. Assume that at time 0 the authorized capital inflows are increased by a small fraction of consumption in all periods,  $d\kappa_{t+1} = c_{t+1}dc/c$  ( $t \geq 0$ ). With log-preferences, the equivalent variation is approximately:<sup>13</sup>

11. Assuming that a family with infinitely lived agents yields a welfare criterion that averages the short-term and the long-term impact of financial integration. The welfare analysis would be more ambiguous with overlapping generations—the early and late generations would be affected in different ways by integration.

12. Population growth is assumed away for simplicity.

13. See Gourinchas and Jeanne (2005b) for a derivation.

$$\mu \approx \beta(\hat{R} - R^*) \frac{dc}{c}, \quad (2.9)$$

where  $\hat{R} \equiv (1 - \beta) \sum_0^\infty \beta^t R_{t+1}$  represents the *permanent value* of the domestic interest rate.

For example, starting from a capital–output ratio of 1.4, the initial domestic return on capital is 15%, which is 10% above the world interest rate.<sup>14</sup> But the domestic return converges towards the world interest rate, and the permanent value  $\hat{R}$ , at 6.88%, is only 1.46% higher than the world interest rate. Equation (2.9) then implies that starting from autarky, a marginal capital inflow equal to 1% of domestic consumption yields a welfare benefit equivalent to 0.014% of consumption ( $0.96 * 0.0146$ ). Thus, the welfare gain from a capital inflow is a very small fraction of its face value.

The small size of the gains comes in part from the speed at which the return differential decreases over time, which is directly related to the conditional speed of convergence towards the steady state. As is well-known, the convergence speed in the benchmark Ramsey model is excessively high. With our parameters, the speed of convergence—measured as the fraction of the output gap that is eliminated every year—is 11.49%.<sup>15</sup> This is much larger than the 2–3% reported by Barro and Sala-i-Martin (1992), although inside the 8–13% range estimated by Caselli, Esquivel and Lefort (1996), who correct some biases in earlier estimation methods. Given that the model's speed of convergence is close to the highest estimates obtained in the literature, we will test the robustness of our results to modifications of the model that reduce the speed of convergence. This will also be one of the motivations for introducing human capital in the model of the next section.

#### 2.4. Robustness

How sensitive are our estimates to parameter assumptions? For instance, our results are derived under log preferences. One could argue that lower elasticities of inter-temporal substitution would increase the gains from financial integration by lowering welfare under autarky. A smaller elasticity of inter-temporal substitution, however, also makes households more reluctant to accumulate capital. This increases the long-run natural world interest rate  $R^* = g^{*\gamma} / \beta$ , lowers our estimates of the capital gap for a given initial capital stock and, consequently, lowers the potential gains from financial integration. We report in Table 3 the welfare gains as we vary the Elasticity of inter-temporal substitution (EIS)  $1/\gamma$  between 1 (our benchmark) and 1/10. As expected, lower values of the EIS are associated with higher equilibrium interest rates and smaller capital gaps.<sup>16</sup> Overall, the gains do not decrease monotonically with the elasticity of inter-temporal substitution. In fact, for an initial capital–output ratio of 1.4, the welfare gains decline for an EIS smaller than 1/3.

The gains may also vary with the elasticity of substitution between capital and labour. Suppose output is now given by

$$Y_t = \left( \eta K_t^{1-1/\sigma} + (1 - \eta) L_t^{1-1/\sigma} \right)^{\sigma/(\sigma-1)}. \quad (2.10)$$

14. This seems consistent with some estimates of the return to investment in developing countries. For example, Isham and Kaufman (1999) find that the average economic rate of return on private projects financed by the World Bank is 14%.

15. The speed of convergence defined locally around the steady state is equal to  $(\delta_k + ng^* - 1)(1 - \alpha)$  or 5.56% with the parameters in Table 1. This measure is not appropriate, however, since we want to consider potentially large deviations from steady state. The figure of 11.49% reported in the text is computed numerically from the non-linear system, assuming an initial capital–output ratio of 1.4.

16. This puts some discipline on which elasticity of inter-temporal substitution one should choose. For instance, with  $\gamma = 10$ , we find an implausible natural interest rate of 17%.

Table 3 shows our estimates for two values of the elasticity of substitution between capital and labour,  $\sigma = 0.5$  and  $\sigma = 1.5$ . The value of  $\eta$  is chosen so as to keep the share of capital income equal to 0.3 in steady state. Unsurprisingly, making capital and labour less substitutable increases the welfare gains from international capital flows. This effect is larger at lower initial capital–output ratios: the welfare gains reach 18% when  $k/y = 1.0$  and  $\sigma = 0.5$ . This reflects the fact that given  $k/y$ , a lower  $\sigma$  is associated with a lower estimate of the capital ratio  $k/k^*$  (0.1 vs. 0.25 in our benchmark).<sup>17</sup> A capital ratio of only 0.1 seems implausibly low.

The next column of Table 3 shows the impact of changing the population growth rate. Our benchmark analysis assumes the same population growth rate as in the U.S. Yet, many industrializing countries have significantly faster population growth rates. Using the World Bank development indicators, we estimate an average population growth rate of 2.32% for non-OECD economies between 1985 and 1995. As Table 3 shows, the welfare gains are roughly one-third smaller, as population growth dilutes the gains from capital accumulation.

The capital share plays an important role in our calculations. It influences the speed of convergence of the economy towards its steady state as well as the equilibrium level of output *per capita*. Mankiw *et al.* (1992) argue that the neoclassical model performs relatively well if one adopts a broad definition of capital. They suggest that the appropriate capital share may be closer to 0.6 than 0.3. With  $\alpha = 0.6$ , the convergence speed drops to 4.61%, much closer to the empirical estimates. Table 3 reports welfare estimates for that value of the capital share. We find much larger estimates for the welfare gains from integration. The gains increase from 3.5% to 77% of annual consumption when the capital–output ratio is as low as 1.0. This reflects, however, the fact that a higher  $\alpha$  is associated with a much lower capital ratio  $k/k^*$  (0.03 vs. 0.25 in our benchmark). Again, a capital ratio of only 3% seems implausibly small. Furthermore, given the evidence on factor shares reported by Gollin (2002), it is somewhat unsatisfactory to simply assume that the share of physical capital is as high as 0.6 on average. Instead, in the next section we present a model where both physical and human capital can be accumulated, yielding smaller convergence rates.

### 3. EXTENDING THE BASIC MODEL

We now augment the model of Section 2 in two ways. First, we introduce human-capital accumulation. Second, we allow for domestic distortions in the accumulation of physical and human capital.

Human capital is a basic element in growth theory. Differences in educational attainment or schooling rates translate into a more or less productive labour force and have long been described as a key element in cross-country income differences. Second, human capital makes the transition dynamics more realistic, both under financial integration, where the dynamics are no longer trivial and under autarky, where the accumulation of human capital slows down the convergence towards the steady state. Finally, human-capital accumulation is a channel through which domestic labour productivity is *endogenous* to the capital account regime. Faster accumulation of physical capital could induce faster accumulation of human capital, in particular by increasing the real wage.

The motivation for introducing distortions in the accumulation of physical and human capital is to give a better account of observed cross-country differences in investment rates. The previous section assumed that differences between countries are summarized by their initial level of productivity  $A_0$  and the growth rate of population  $n$ . This implies relatively small cross-country

17. The capital ratio is given by  $k/k^* = \left( \frac{((k/y)/(k^*/y^*))^{1-\sigma/\sigma-\alpha}}{1-\alpha} \right)^{\sigma/1-\sigma}$  where the steady-state capital–output ratio  $k^*/y^*$  is invariant to the elasticity  $\sigma$  and is equal to  $\alpha/(R^* + \delta_k - 1)$ .

differences in investment rates. For instance, the model of the previous section predicts steady-state physical investment rates between 20.8% and 29% for non-OECD countries. This is at odds with the data, where average investment rates from 1985 to 1995 range from 2.8% (Madagascar) to 41.4% (Singapore). Similarly, distortions in the accumulation of human capital allow us to account for observed educational attainments ranging from 0.7 years (Mali) to 10.1 years (South Korea).

### 3.1. Model

We introduce human capital into the model by using the same basic equations as in the empirical literature measuring human-capital stocks (*e.g.* Barro and Lee, 1993). We assume that the labour employed in production  $L_t$  is homogenous and has been trained with  $E_t$  years of schooling, which we will interpret as educational attainment. As a result, the domestic economy produces, according to a “Macro-Mincer” Cobb–Douglas production function,

$$Y_t = K_t^\alpha (A'_t H_t)^{1-\alpha}, \tag{3.11}$$

where  $A'_t$  reflects the exogenous, non-human-capital-related determinants of productivity, and  $H_t$  denotes the amount of human-capital augmented labour used in production:

$$H_t = e^{\phi(E_t)} L_t. \tag{3.12}$$

Function  $\phi'(E)$  represents the marginal return to schooling estimated in a Mincerian wage regression. It is assumed to be decreasing with the educational attainment  $E$ .

Human-capital accumulation depends upon the fraction of time devoted to education,  $s_t$ , according to

$$E_{t+1} = (1 - \delta_e) E_t + \theta f(s_t). \tag{3.13}$$

$\delta_e$  is the depreciation rate for human capital,  $f(\cdot)$  is an increasing concave function, and  $\theta$  captures the *efficiency of the domestic schooling* technology and accounts for steady-state cross-country differences in educational attainment. This perpetual inventory specification is consistent with existing empirical work on human-capital stocks (see Barro and Lee, 1993). The concavity of  $f(\cdot)$  captures the idea that there are decreasing returns to the time invested into education, because of constraints on the educational technology or on the number of young individuals who can be educated. Finally, labour market clearing implies  $L_t = (1 - s_t) N_t$ .

Investment in domestic capital is implicitly distorted at rate  $\tau$ , so that the private return to domestic capital is  $(1 - \tau)R_t$ . We refer to  $\tau$  as the *capital wedge*. This parameter allows us to match the observed disparity in saving rates across countries.  $\tau$  is a shorthand for all the distortions that potentially affect the return to domestic capital: credit market imperfections, taxation, expropriation, bureaucracy, bribery, and corruption. Different models would have different implications for the implicit rents generated by the distortion,  $z_t \equiv \tau R_t k_t$ . For simplicity, we assume that they are rebated in a lump-sum fashion to the representative agent. In this manner, we focus exclusively on the distortive aspects of the capital wedge.

The normalized flow budget constraint of the household is

$$ng_{t+1}(\tilde{k}_{t+1} + \tilde{b}_{t+1}) + \tilde{c}_t = R^* \tilde{b}_t + (1 - \tau)R_t \tilde{k}_t + w_t h_t + \tilde{z}_t, \tag{3.14}$$

where  $w_t$  denote the normalized wage per efficiency unit of labour  $h_t = H_t/N_t = (1 - s_t)e^{\phi(E_t)}$ , and  $\tilde{b}_t$  denotes net foreign assets when the capital account is open. Current labour income, transfers, and income from domestic and foreign capital are allocated between current consumption and holdings of domestic and foreign capital.

The model with human capital is solved in our companion working paper (Gourinchas and Jeanne, 2005b) in the case where catch-up is limited to human capital ( $A'_t = A'_0 g^{*t}$ ). We summarize here the main features of the equilibrium. First, whether the capital account is open or closed, the economy converges towards the same steady growth path with a constant level of human capital *per capita* and a level of physical capital *per capita* that grows at rate  $g^*$ .

In the long run, the fraction of time devoted to education satisfies the first-order condition

$$(1 - s^*)f'(s^*) = \frac{\frac{R^*}{ng^*} + \delta_e - 1}{\theta\phi'(E^*)}. \quad (3.15)$$

Given the concavity of  $f$ ,  $s^*$  increases with the efficiency of the domestic schooling technology,  $\theta$ , and the marginal return on education,  $\phi'(E^*)$ . The steady-state level educational achievement follows from (3.13),

$$E^* = \frac{\theta}{\delta_e} f(s^*). \quad (3.16)$$

Equations (3.15) and (3.16) form a system of two equations with two unknowns,  $s^*$  and  $E^*$ . It is easy to verify that the long-run level of educational attainment,  $E^*$ , is increasing with the schooling efficiency parameter  $\theta$ .

Given  $E^*$  and  $s^*$ , the steady-state level of human capital *per capita* follows from (3.12),  $h^* = (1 - s^*)e^{\phi(E^*)}$ . The asymptotic level of productivity-adjusted capital *per capita*,  $\tilde{k}^* = \lim_{t \rightarrow +\infty} (K_t/A'_t N_t)$  is given by

$$\tilde{k}^* = \left( \frac{s_k(\tau)}{\delta_k + n \cdot g^* - 1} \right)^{1/1-\alpha} h^*, \quad (3.17)$$

where:

$$s_k(\tau) = \alpha \frac{\delta_k + n \cdot g^* - 1}{\delta_k + R^*/(1 - \tau) - 1}, \quad (3.18)$$

is the domestic steady-state investment rate, decreasing with the capital wedge  $\tau$ . Physical capital *per capita*  $k$  is proportional to productivity  $A'$  and to human capital *per capita*  $h^*$ .

Under financial autarky, the equilibrium conditions for consumption, and education can be written (for an interior solution) as

$$\tilde{c}_t^{-\gamma} = \frac{(1 - \tau)R_{t+1}}{R^*} \tilde{c}_{t+1}^{-\gamma} \quad (3.19)$$

$$\tilde{c}_t^{-\gamma} w_t e^{\phi(E_t)} = \frac{ng^*}{R^*} \tilde{c}_{t+1}^{-\gamma} w_{t+1} e^{\phi(E_{t+1})} f'(s_t) \left[ \phi'(E_{t+1})(1 - s_{t+1})\theta + \frac{1 - \delta_e}{f'(s_{t+1})} \right]. \quad (3.20)$$

The first equation is the familiar Euler equation for consumption and is identical to equation (2.4). The second equation is the novel element of the analysis. It characterizes the optimal intertemporal allocation of education. To understand the intuition behind this equilibrium condition, consider the following experiment. Suppose that at time  $t$  the household decides to increase the fraction of time devoted to education by a small amount  $\Delta s_t$ . At time  $t + 1$ , it adjusts education to revert to the optimal plan by time  $t + 2$ . The increase in education today reduces efficient labour supply by  $e^{\phi(E_t)} \Delta s_t$ . This implies a decline in current income of  $w_t e^{\phi(E_t)} \Delta s_t$  and a marginal utility loss of  $\tilde{c}_t^{-\gamma} w_t e^{\phi(E_t)} \Delta s_t$ . This is the L.H.S. of the equilibrium condition. At time  $t + 1$ , educational attainment has increased by  $\theta f'(s_t) \Delta s_t$ . This increases efficient labour supply by  $e^{\phi(E_{t+1})} (1 - s_{t+1}) \phi'(E_{t+1}) f'(s_t) \theta \Delta s_t$ . To revert to the optimal plan by  $t + 2$ , education needs to be adjusted by  $-(1 - \delta_e) f'(s_t) / f'(s_{t+1}) \Delta s_t$ . This increases current hours by  $e^{\phi(E_{t+1})} (1 - \delta_e) f'(s_t) / f'(s_{t+1}) \Delta s_t$ . Adding these two terms, multiplying by the wage  $w_{t+1}$  and the marginal

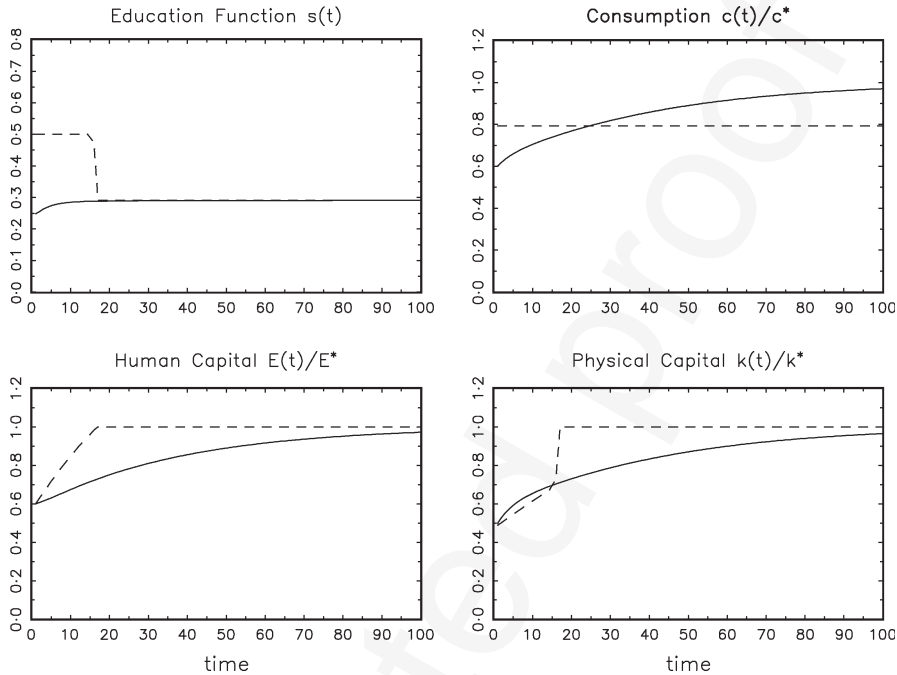


FIGURE 2

Sample convergence trajectories: thick line, autarky; dashed line, financial integration.  $k_0 = 0.5k^*$  and  $E_0 = 0.6E^*$ . Calibrated to the U.S. economy. See footnote 18 for parameter values

utility of wealth  $\tilde{c}_{t+1}^{-\gamma}$ , and discounting back to time  $t$  at rate  $ng^*/R^*$ , gives the marginal utility gain on the R.H.S. of the equilibrium condition.

Under financial integration, the domestic after-tax return on physical capital equates the world interest rate  $R^*$ . This pins down the ratio of physical capital to human capital augmented labour input  $\tilde{k}_t = \omega h_t$ , and the production function becomes linear in  $h$ :  $\tilde{y}_t = \omega^a h$ . Convergence in  $h$ —and hence in  $k$ —is not instantaneous, since human capital can only be accumulated domestically by sacrificing labour. Since the world interest rate is equal to the growth adjusted discount rate, consumption jumps to the constant level that is consistent with the country's inter-temporal budget constraint. Consider now human-capital accumulation. Intuitively, the country can accumulate human capital without sacrificing domestic consumption by contracting a “student loan” with the rest of the world. As a result, human-capital accumulation and convergence—although not instantaneous—are much more rapid under financial integration.

To illustrate the impact of the capital account regime on human-capital accumulation, Figure 2 reports the convergence paths to the steady state for education, consumption, and physical and human capital, for an economy calibrated to the U.S. when  $k_0 = 0.5k^*$ ,  $E_0 = 0.6E^*$ , and  $f(s) = \min(s, 0.5)$ .<sup>18</sup> In this example, the country has initially relatively more human than physical capital. Under financial autarky, it is optimal to concentrate on accumulating physical capital. Hence the schooling rate  $s$  and consumption  $c$  are low, while capital accumulates rapidly. Under financial integration, by contrast, it is optimal to accumulate human capital as rapidly as possible. The integrated economy reaches its steady state in about 15 years.

18. The parameters are set to the U.S. economy:  $\tau = 0.66\%$ ;  $\theta = 1.28$ ;  $n = 0.73\%$ ;  $\delta_e = 2.76\%$ . These values imply  $\tilde{k}^* = 9.62$ ,  $s^* = 0.29$ , and  $E^* = 13.49$ .

Figure 2 illustrates that financial opening need not be associated with large capital inflows, at least initially. In this particular example, there are no capital inflows or outflows at time 0. On the other hand, when human capital reaches its steady state, a large quantity of labour becomes available for production and attracts correspondingly large amounts of capital. The figure also illustrates that long-run consumption under integration  $c_0$  is lower than steady-state consumption under autarky  $c^*$ .

Human-capital accumulation slows down convergence towards the steady state. The speed of convergence decreases from 11.49% in the model without human capital to 3.67% and 3.21%, respectively, in the model with human capital with and without domestic distortions. These convergence speeds are reasonably close to the lower range of existing empirical estimates (Barro and Sala-i-Martin, 1992).

### 3.2. Calibration and results

Our model captures the two main sources of cross-country inequality and convergence that have been discussed in the literature: first, the accumulation of physical and human capital (Chari, Kehoe and McGrattan, 1996) and, second, total factor productivity (Klenow and Rodriguez-Clare, 1997; Hall and Jones, 1999). In addition, our model puts all these factors together in the context of a single inter-temporal optimizing framework in which the rates of factor accumulation are endogenous. The endogeneity of the rates of accumulation is crucial for our purpose since the benefit of international financial integration is to accelerate the accumulation of capital.

We can calibrate the model by combining together the different sources of evidence that have been used in the previous literature. We start by assuming that the marginal return to the time invested in education is constant up to a country-specific critical threshold  $\bar{s}$ :

$$f(s) = \min(s, \bar{s}). \quad (3.21)$$

The threshold  $\bar{s}$  is calibrated as a function of the long-run level of human-capital investment  $\bar{s} = \kappa s^*$ , where the determination of  $\kappa > 1$  is described below. With that representation of  $f(\cdot)$ , the optimal investment in education is bang-bang under financial integration.<sup>19</sup> As long as human capital has not reached its steady state, it is optimal to accumulate at the fastest possible rate,  $\bar{s}$ .<sup>20</sup>

We estimate the welfare gains of financial integration for 65 non-OECD countries with annual data in 1995.<sup>21</sup> Each country is characterized by a constant population growth rate  $n$ , an initial educational attainment  $E_0$ , level of capital *per capita*  $k_0$ , a productivity path  $(A'_t)_{t \geq 0}$ , distortion rates  $\tau$  and  $\theta$ , and depreciation rate of human capital  $\delta_e$ . The details of the calibration are presented in appendix 4 and summarized here.

The country levels of productivity and (physical and human) capital are calibrated in the same way as in the development accounting literature—see Bils and Klenow (1990); Hall and Jones (1999). The rates of distortion  $\tau$  and  $\theta$  are calibrated by matching the historical rates of accumulation of physical and human capital. In short, our approach consists in matching average investment rates in physical and human capital to their steady-state equivalent. This approach

19. See the appendix to Gourinchas and Jeanne (2005b).

20. At the suggestion of the editor and one referee, we explored two variants of the model that imply smoother human-capital dynamics under integration. In the first variant, we assumed that international borrowing needs to be collateralized by domestic physical capital as in Barro *et al.* (1995). This prevents the country from contracting a large student loan with the rest of the world. The second variant assumed that physical investment is irreversible. In both scenarios, it is optimal to devote some labour to production under financial integration. We found that the welfare gains remained close to our benchmark (1.07% and 0.90%, respectively, for the typical non-OECD country).

21. The selection is based on OECD membership at the beginning of the time period, so our sample includes three current OECD members, Mexico, Korea, and Turkey. The complete list of countries is available in Gourinchas and Jeanne (2005b).

interprets low historical accumulations rates in a given country as the results of distortions that will persist in the future.<sup>22</sup> We measure  $n$  as the average rate of growth of the working age population between 1985 and 1995, where working age is defined as 15–64 years old. Data on total population and on the fraction of the population of age 15–64 are obtained from the 2002 *World Bank Development Indicators*.

To construct  $\phi'(E)$ , we follow the literature and adopt a piecewise linear representation of the returns to schooling consistent with the empirical evidence in Psacharopoulos (1994). For educational attainment, we construct estimates of the steady-state and initial human capital by the perpetual inventory method of Barro and Lee (1993). Briefly, we construct a measure of total educational attainment for people over age 25 using data on durations and educational attainment rates of primary, secondary, and higher schooling. This provides a measure of  $E_t$  every five years from 1960 to 2000. We set the rate of depreciation of human capital  $\delta_e$  to the average fraction of the population aged 25–29.

The schooling efficiency  $\theta$  is calibrated for each country as follows. First, we construct the long-run educational attainment of each country  $E^*$  by projecting forward the schooling enrolment rates observed in the latest available data (1998–2000). Then, substituting  $s^*$  out of (3.15) using (3.16) and  $f(s^*) = s^*$ , we solve for the value of  $\theta$  given  $E^*$ ,

$$\theta = \delta_e E^* + \frac{R^*/ng^* + \delta_e - 1}{\phi'(E^*)}. \quad (3.22)$$

Given this value of  $\theta$  and the Barro–Lee measures of educational achievement ( $E_t$ ), we then derive for each country the path ( $s_t$ ), the long-run level  $s^*$ , and the implied level of human capital *per capita*  $h^* = (1 - s^*)e^{\phi(E^*)}$  from equations (3.13) and (3.16). We set the parameter  $\kappa$  to the cross-country average of the maximum observed ratio  $\max(s_t/s^*)$ , which gives  $\kappa = 1.22$ . The implied  $\bar{s}$  is equal to 0.37 on average and varies between 0.17 (Mozambique) and 0.52 (Botswana). The threshold  $\bar{s}$  inherits the properties of the steady-state investment in human capital. This appealing feature implies that  $\bar{s}$  increases with the efficiency of the schooling system  $\theta$  and the marginal return to schooling  $\phi'(E^*)$ .

Calibrating  $f(\cdot)$  in this way produces reasonable dynamics for the aggregate accumulation of human capital. We should point out that the details of the calibration of  $\bar{s}$  are relatively unimportant since our estimates of the gains from integration are not very sensitive to the value of  $\bar{s}$  we adopt. For a typical non-OECD country in the sample, the gains remain below 2% even if one set  $\bar{s}$  to its maximum level of 1.

Turning to physical capital, we construct measures of the initial capital stock  $k_0$  using investment rates from the Heston *et al.* (2002) Penn World Tables, Mark 6.1 (PWT) and a perpetual inventory method as in Bernanke and Gürkaynak (2001). For each country, we measure the average investment share  $\hat{s}_k$  in gross GDP from 1985 to 1995. We then assume that the observed average investment rate is a good approximation to the steady-state investment rate and infer the value of  $\tau$  by setting  $s_k(\tau) = \hat{s}_k$  in equation (3.18). Using equation (3.17), we construct an estimate for  $\tilde{k}^*$ .

One can then compute for each country the ratio of the capital installed in year 0 to the capital level that would prevail in the steady state,  $k_0/k_0^* = \tilde{k}_0/(A_0'\tilde{k}^*)$ . Finally, given  $y_0$ ,  $E_0$ ,  $k_0$ , and  $s_0$ , the productivity level of a given country in a given year 0 can then be derived from the Cobb–Douglas relationship  $y_0 = (A_0'h_0)^{1-a}k_0^a$ .

22. This is not the only way to estimate a country's distance to its steady state. We note however, that this approach is similar to Mankiw *et al.* (1992) who assume constant saving rates in their tests of unconditional and conditional convergence. Similarly, the literature on calibrated business cycle models often interprets historical averages as equivalent to steady-state values.

TABLE 4  
*Human-capital parameters and estimates*

	$\theta/\theta^{\text{U.S.}}$	$E^*$	$E_0/E^*$		Obs.
			D	ND	
Non-OECD countries	0.74	7.32	0.66	0.37	65
Low income	0.66	6.47	0.57	0.28	24
Lower middle income	0.75	7.34	0.75	0.42	23
Upper middle income	0.97	9.85	0.57	0.43	13
High income (non-OECD)	1.09	13.20	0.75	0.75	5
Africa	0.76	6.88	0.59	0.30	27
Latin-America	0.93	9.24	0.59	0.41	22
Asia	0.71	7.07	0.68	0.37	16
Except China and India	0.82	7.94	0.58	0.35	63
China and India	0.68	6.86	0.72	0.38	2

$\theta/\theta^{\text{U.S.}}$  measures the efficiency of the schooling system relative to the U.S.  $E^*$  denotes the steady-state educational attainment (years of schooling).  $E_0/E^*$  represents the attainment ratio with (D) and without (ND) distortions. Population-weighted averages. Year is 1995.

TABLE 5  
*Capital ratio and capital wedge*

	$\tau$	$k_0/k_0^*$		Obs.
		D	ND	
Non-OECD countries	7.7	0.67	0.16	65
Low income	12.2	0.69	0.17	24
Lower middle income	4.5	0.60	0.31	23
Upper middle income	5.4	0.96	0.48	13
High income (non-OECD)	-3.2	0.52	0.84	5
Africa	19.3	1.20	0.24	27
Latin-America	7.4	0.99	0.43	22
Asia	6.2	0.55	0.26	16
Except China and India	10.0	0.90	0.33	63
China and India	6.0	0.51	0.23	2

$\tau$  measures the gross capital wedge in per cent.  $k_0/k_0^*$  denotes the capital ratio relative to steady state with (D) and without (ND) distortions. Population-weighted averages. Year is 1995.

Table 4 reports our estimates of  $E_0/E^*$ , a measure of the country's abundance in human capital relative to the long-run, as well as the projected steady-state attainment level  $E^*$  and the efficiency of the schooling system relative to the U.S. Table 5 reports our estimates of the capital ratio  $k_0/k_0^*$ , a measure of the country's capital abundance conditional on human capital being at its long-run level ( $E_0 = E^*$ ), together with the estimated capital wedge  $\tau$ . We find that non-OECD countries are below their steady state, with an educational attainment ratio of 0.66 and a capital ratio of 0.67. It is noteworthy that the capital ratio, at 0.67, remains low on average. Our results do not indicate, as is sometimes presumed, that emerging economies will not benefit from financial integration because they are very close to their steady state. However, it is interesting to note that Latin America is very close to its steady state and that Africa is above it. We find that

TABLE 6

*The benefits of international financial integration*

Equivalent variation, $\mu$ (per cent)	mean	S.D.	Obs.
Non-OECD countries	1.24	0.67	65
Low income	1.37	0.52	24
Lower middle income	1.27	0.60	23
Upper middle income	0.92	0.74	13
High income (non-OECD)	-1.19	0.93	5
Africa	0.66	0.95	27
Asia	1.38	0.56	16
Latin-America	0.82	0.71	22
Except China and India	0.88	0.91	63
China and India	1.50	0.01	2

The table reports the population-weighted average of the equivalent variation  $\mu$ . Year is 1995.

given its low productivity and its high rate of distortion, Africa is capital abundant! Most of the capital shortage of emerging market countries is located in Asia, especially in China and India.

The average relative schooling efficiency is 0.74, significantly below 1, while the capital wedge is moderate but positive, equal to 7.7%. The capital wedge is negative for the high-income non-OECD countries because our method interprets the very large average investment rates of countries like Singapore (41%) and Korea (37%) as evidence of an implicit subsidy to investment (-4.7% and -4.0%, respectively). Conversely, Mozambique and Uganda, countries with the lowest average saving rates (2.9% and 3%, respectively) are associated with a large capital wedge (40% and 46%, respectively).

Table 6 reports our calculated welfare gains. Non-OECD economies benefit, on average, to the tune of 1.24% of consumption from a switch from complete financial autarky to complete financial integration with world capital markets.<sup>23</sup> This number is our benchmark estimate of the benefit of international financial integration for non-OECD countries. This gain is larger than in the simple model without human capital, which would predict a gain of 0.39% of consumption for a capital ratio of 0.67. That human capital increases the welfare gains from integration should not come as a surprise. Integration reduces the sacrifice in terms of current consumption required to accumulate human capital. By accelerating human-capital accumulation, it increases domestic inter-temporal labour income and reduces the inter-temporal wedge between the domestic and foreign returns to capital. Indeed, we find that human capital multiplies the gains from integration by more than three.

### 3.3. *Is it large? Some comparisons*

It is important to establish relevant points of comparison. After all, a welfare gain of 1.24% of consumption would be considered as significant in the literature estimating the benefits of international portfolio diversification or those of reducing taxes. This section proposes two other points of comparison that arise naturally in our model: first, the welfare gains from removing the domestic distortions and second, the benefit of a productivity catch-up with the U.S. We find that these gains are significantly larger than those from international financial integration.

23. The number for high-income non-OECD countries is negative. This is so since the model with distortions does not satisfy the criteria of the first welfare theorem. Countries can be made worse off by international financial integration. Specifically, this happens when countries subsidize capital returns ( $\tau < 0$ ). Capital inflows mean that the subsidy goes to foreign investors.

TABLE 7  
*The benefits of eliminating domestic distortions*

Regime	Distortion						Obs.
	Both distortions				Capital wedge		
	Integration		Autarky		Integration		
	Mean	S.D.	Mean	S.D.	Mean	S.D.	
Non-OECD countries	39.6	23.0	32.1	19.3	10.34	11.12	65
Low income	56.8	23.9	46.0	20.6	16.64	12.39	24
Lower middle income	31.0	9.9	25.2	8.9	5.91	8.34	23
Upper middle income	13.1	5.4	10.3	5.4	5.44	2.16	13
High income	5.7	2.8	5.3	2.7	5.25	2.85	5
Africa	69.4	46.2	58.9	38.7	29.54	22.11	27
Asia	38.6	14.2	31.0	11.4	8.22	6.33	16
Latin-America	21.6	18.8	17.9	16.8	8.25	6.79	22
Except China and India	40.6	33.6	33.7	28.3	14.13	14.82	63
China and India	38.8	12.9	31.0	10.3	7.54	8.24	2

The table reports the population-weighted average of the equivalent variation  $\mu$  (in per cent). Year is 1995.

Table 7 reports the welfare gain from removing the distortions on physical and human-capital accumulation, that is, of setting  $\theta$  to  $\theta_{U.S.}$  and  $\tau$  to 0. Under autarky the gain amounts to 32% of permanent consumption in the average non-OECD country. Unsurprisingly, the gain is larger in poorer countries, where the distortions are larger. The gains from removing the distortions are even larger under financial integration (40% on average), since other things equal, removing the distortions magnifies the countries' initial level of capital scarcity by raising their steady-state levels of physical capital.<sup>24</sup>

Another natural benchmark of comparison is the welfare benefit of an increase in domestic productivity. Clearly, the assumption that relative productivity remains constant is extreme and unrealistic. Figure 3 reports the change in relative productivity  $A'_0/A_0^{U.S.}$  for non-OECD countries between 1960 and 1995.<sup>25</sup> While many developing countries fell behind in terms of relative productivity, a number of countries —such as Singapore, Hong Kong, Mauritius, Cyprus, Israel, and Korea experienced a drastic improvement in productivity. These countries reduced their productivity gap with the U.S. by more than 25% over that time period and by as much as 113% for Singapore. We now evaluate the welfare gains from such productivity catch-ups.

For each country, we assume that productivity converges partly towards the world technology frontier (here, the U.S.) according to

$$\frac{A'_t}{A_t^{U.S.}} = \frac{A'_0}{A_0^{U.S.}} + x \frac{t}{35} \left( 1 - \frac{A'_0}{A_0^{U.S.}} \right) \quad (3.23)$$

in the first 35 years ( $t \leq 35$ ), after which the growth rate in productivity goes back to the U.S. level. The variable  $x$  represents the convergence in productivity expressed as a fraction of the

24. The welfare difference between integration and autarky in Table 7 approximately represents the gains from financial integration when there are no distortions. Not surprisingly, perhaps, these gains are larger than those reported in Table 6. More importantly, they remain small compared to the gains from the removal of distortions or from productivity catch-up that we present in Table 8.

25. The figure only includes 60 countries. No data on human capital are available as of 1960 for Benin, China, Republic of Congo, Egypt, and Rwanda.

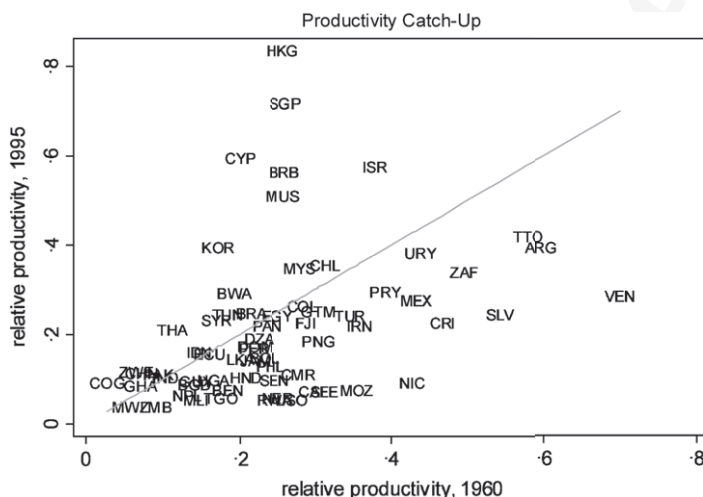


FIGURE 3

Relative productivity change,  $A'_0/A_0^{U.S.}$  for non-OECD economies, 1960–1995

TABLE 8

*The benefits of a productivity catch-up*

Regime	Productivity catch-up (%)				Obs.	$A'_0/A_0^{U.S.}$
	25		100			
	<i>I</i>	<i>A</i>	<i>I</i>	<i>A</i>		
Non-OECD countries	61.2	52.1	242.6	192.4	65	0.27
Low income	74.2	62.9	292.7	232.9	24	0.23
Lower middle income	59.4	49.9	233.6	183	23	0.26
Upper middle income	25.9	22.6	100.7	86.4	13	0.45
High income	12.4	12.9	53.3	48.8	5	0.59
Africa	64.4	58.1	255.7	219.6	27	0.34
Asia	66.1	55.3	260.4	203.2	16	0.23
Latin-America	30.4	26.8	119.0	102.1	22	0.42
Except China and India	51.2	45.0	202.1	169.5	63	0.35
China and India	69.2	57.3	272.3	209.2	2	0.21

The table reports the equivalent variation  $\mu$  (per cent) resulting from a productivity catch-up for each country under integration (*I*) or autarky (*A*).  $A'_0/A_0^{U.S.}$  denotes the productivity relative to the U.S. Year is 1995.

original productivity gap. The case  $x = 0$  corresponds to no-convergence, and  $x = 1$  corresponds to full convergence in 35 years.

Table 8 reports relative productivity in 1995, as well as the welfare gains from productivity catch-ups of 25% and 100% under financial integration and financial autarky. Developing countries are much less productive than the U.S., with an average relative productivity of 0.27, that increases with income. It is, thus, not surprising to find very large gains from productivity catch-ups. Under financial autarky, a 25% reduction in the productivity gap yields welfare gains of 52% of annual consumption on average. These gains jump to 192% of consumption if

the country completely catches up with the U.S. in terms of productivity. These gains are even larger under financial integration, again because the catch-up increases the capital scarcity of the country (61% and 242%, respectively).

Thus, the gains from international financial integration are dwarfed by the potential gains from policies that aim at reducing the domestic level of distortion or increasing domestic productivity. One could argue, however, that opening the capital account is one of these policies. For example, a country could “import” foreign productivity through FDI, or the discipline induced by free capital mobility could induce the government to reduce the level of domestic distortions. These indirect channels are not in the textbook of neoclassical framework, in which productivity and distortions as exogenous to international financial integration, but they might be important in the real world.

For example, assume that the wedge  $\tau$  is lower for foreign investors than for domestic ones (e.g. because the investment of foreign investors is more sensitive to taxes or extortion). Then, international financial integration will benefit developing countries also by lowering their average rates of distortion in physical investment. Consider, for instance, the extreme case where foreigners face no capital wedge ( $\tau = 0$ ). In that case, the domestic stock of capital should be entirely owned by foreigners while residents invest their funds in the undistorted foreign markets. Table 7 reports the welfare gains from financial integration when the latter eliminates the domestic distortion on credit markets (the next to last two columns of table 7). The gains are nine times larger than before (10.34% vs. 1.24%) and are especially large for African countries (29.54% vs. 0.66%). Alternatively, if financial integration results in a 25% productivity catch-up with the U.S., the welfare gains are 50 times larger (from 1.24% to 61.2%).

From this perspective, another interpretation of our results is that international financial integration *could* yield large gains *if* it reduced the gap between developing countries and advanced countries in terms of distortions and productivity through indirect channels. But most of the gains would come from these indirect channels and not from capital flows *per se*.

### 3.4. Prosperity and capital mobility: development accounting

What are the implications of our analysis for the world income distribution and for economic convergence between developing and developed countries? In principle, international financial integration could accelerate convergence in GDP *per capita* by raising the stock of physical capital and by stimulating the accumulation of human capital in developing countries. The small size of the welfare gains suggests, however, that international financial integration does not significantly reduce the very large gaps between developing and developed countries.

Consider a country like Bangladesh. According to our calculations, although Bangladesh’s output *per capita* would increase by 26% if it opened its capital account completely and foreign capital were free to rush in, it would still represent only about 7% of U.S. output *per capita*. Perhaps this should not come as a surprise, once we realize that the gross investment rate in Bangladesh has been only 9.46% from 1985 to 1995, that the implicit distortion on real returns to capital is 16%, and the education efficiency of Bangladesh relative to the U.S. stands at 0.72. In other words, financial integration would only bring Bangladesh much faster to a much impoverished steady state.

According to this interpretation, the difference between industrialized and emerging economies is *not* that the latter start with a large capital deficit that can be filled by capital inflows but rather that they are converging towards a much lower level of income. Although capital account opening can accelerate this convergence, the welfare benefit appears small when compared to the long-run inequality resulting from long-run cross-country differences in productivity or distortion levels. This interpretation does not imply that countries are close to their steady state.

Rather, their distance to the steady state, even though it might seem large in absolute, explains a relatively small part of the cross-country inequality in GDP *per capita*.

We develop this intuition by providing a decomposition of the gap in GDP *per capita* between advanced and developing countries. This decomposition is closely related to the decompositions of world inequalities that have been developed in the recent literature on “development accounting” (see Caselli, 2004). The main difference is that our decomposition is rooted in an inter-temporal optimization model that nests four sources of cross-country inequality: a distortion in the accumulation of physical capital, another distortion in the accumulation of human capital, productivity differences, and the distance to the steady state. The last factor has not been measured in the development accounting literature, which generally takes a static perspective on cross-country inequality.<sup>26</sup>

Consider then, the ratio between a country’s income *per capita* in some reference year—say 1995—and the steady-state income *per capita* in the U.S.:  $y_0/y_0^{*,U.S.}$ . We can think of economic development as a process that increases this ratio by raising the standards of living in emerging countries ( $y_0$ )s and their steady-state levels in the developed world ( $y_0^{*,U.S.}$ ).

A key question for economic development consists in identifying the sources of the gap in GDP *per capita* between developing and advanced countries. Does this gap reflect the fact that emerging countries are far away from their steady state? Does it reflect a lack of domestic saving, possibly caused by a high capital wedge? Does it reflect high distortions or low returns in the accumulation of human capital? Or does it reflect low domestic productivity? To answer these questions, we decompose the development ratio into three components as follows:

$$\ln \frac{y_0}{y_0^{*,U.S.}} = \ln \frac{\tilde{y}_0}{\tilde{y}^*} + \ln \frac{\tilde{y}^*}{\tilde{y}^{*,U.S.}} + \ln \frac{A'_0}{A_{0,U.S.}}, \quad (3.24)$$

where  $\tilde{y}$  denotes output per efficient unit ( $y/A'$ ).

The first term reflects the fact that the country has not yet converged to its steady state. We refer to this term as the *convergence ratio*. This term converges to 0 more quickly under financial integration than under autarky.

The second term reflects cross-country differences in the efficiency of (physical and human) capital accumulation. We call it the *distortion ratio*. It can be further decomposed into a physical capital and human-capital components. Countries with a small distortion ratio are poor because their domestic capital markets are distorted and/or because their human-capital accumulation technology is very inefficient.

The third term in equation (3.24), the *productivity ratio*, reflects differences in productivity between the domestic country and the U.S. that are not accounted for by human capital. Countries with a low productivity ratio are poor because they have a lower productivity than the U.S. after controlling for human capital.

Table 9 reports summary development accounting statistics for each component in equation (3.24), in 1995. The first column reports the development ratio  $y_0/y_0^{*,U.S.}$ . It is small, with non-OECD countries at only 11% of the U.S. steady-state income *per capita*. Columns 2, 5, and 6 report the share of the development ratio accounted for by the convergence, distortion, and productivity ratios, respectively.<sup>27</sup> Columns three and four further decompose the contribution

26. For example, Hall and Jones (1999) decompose relative output per worker into a relative capital, relative human capital, and relative productivity term. Implicitly, their method includes a relative convergence gap term (the ratio of the convergence gap relative to the U.S. convergence gap) that is allocated between the capital–output component and human-capital components. Jones (1997) decomposes steady-state relative output into its capital and productivity gap components. His focus on steady-state output excludes a convergence term.

27. For example, the contribution of the convergence ratio is computed as  $\ln(\tilde{y}_0/\tilde{y}^*)/\ln(y_0/y_0^{*,U.S.})$ .

TABLE 9  
*Development accounting*

	$y_0/y_0^{*,U.S.}$ (1)	$\tilde{y}_0/\tilde{y}^*$ (2)	Physical capital (3)	Human capital (4)	Total $\tilde{y}^*/\tilde{y}^{*,U.S.}$ (5)	$A'_0/A_0^{U.S.}$ (6)	Obs.
Non-OECD countries	0.11	0.15	0.08	0.20	0.28	0.58	65
Low income	0.07	0.13	0.11	0.20	0.31	0.56	24
Lower middle income	0.11	0.15	0.05	0.20	0.25	0.60	23
Upper middle income	0.24	0.15	0.11	0.19	0.29	0.56	13
High income	0.44	0.46	-0.22	0.17	-0.05	0.58	5
Africa	0.12	0.08	0.19	0.22	0.41	0.50	27
Asia	0.09	0.16	0.06	0.19	0.25	0.59	16
Latin-America	0.21	0.13	0.13	0.20	0.32	0.55	22
Except China and India	0.15	0.14	0.11	0.21	0.31	0.55	63
China and India	0.07	0.15	0.06	0.19	0.25	0.60	2

$y_0/y_0^{*,U.S.}$  represents the development ratio (output *per capita* relative to U.S. steady-state output *per capita*);  $\tilde{y}_0/\tilde{y}^*$  denotes the convergence ratio (ratio of output *per capita* to steady-state output per efficient capita);  $\tilde{y}^*/\tilde{y}^{*,U.S.}$  denotes the distortion ratio (ratio of steady-state output per efficient capita to U.S.); Finally,  $A'_0/A_0^{U.S.}$  denotes the productivity ratio. Columns (2)–(6) expressed as a share of the log-development ratio. Population-weighted averages. Year is 1995.

of the distortion ratio into its physical and human-capital components. It is immediate that while the contribution of the convergence ratio is substantial (0.15), it accounts for a small fraction of the development ratio compared with the distortion (0.28) and productivity (0.58) ratios. These numbers imply that even with full convergence—so that the convergence ratio would be equal to 0—the development ratio would still equal only 0.15 (*i.e.*  $0.11^{(1-0.15)}$ ) of the U.S. steady state. Looking at the components of the distortion ratio, it is also apparent that differences in schooling efficiency (0.20) account for a larger share than differences in investment rates (0.08).

To summarize, if capital mobility simply brings faster conditional convergence, it will not succeed in closing the gap between poor and rich countries. Differences in standards of living arise mostly from differences in productivity and human capital, especially for the poorest countries.

Figure 4 presents additional evidence on the role of the convergence gap. In each panel, the horizontal axis reports the log development ratio  $\ln(y_0/y_0^{*,U.S.})$  against each component on the R.H.S. of equation (3.24). As the figure makes clear, the convergence ratio is the only component that is not positively correlated with the development ratio. In other words, while the poorest countries in our non-OECD sample are, on average, those with the lowest productivity and the highest rates of distortion, there is no evidence that they are further away from their steady state than the richest non-OECD countries.

#### 4. CONCLUSION

This paper's main finding is that developing countries do not benefit greatly from international financial integration in a calibrated neoclassical growth model. We believe that this finding provides a useful theoretical benchmark for research on financial globalization. We conclude this paper by outlining what constitute, in our view, the most significant implications of our results for this research agenda.

First, our findings have implications for the recent debate on reforming the “international financial architecture”. A commonly held view is that capital flows to less developed economies are excessively low, and that the international financial architecture should be designed so as

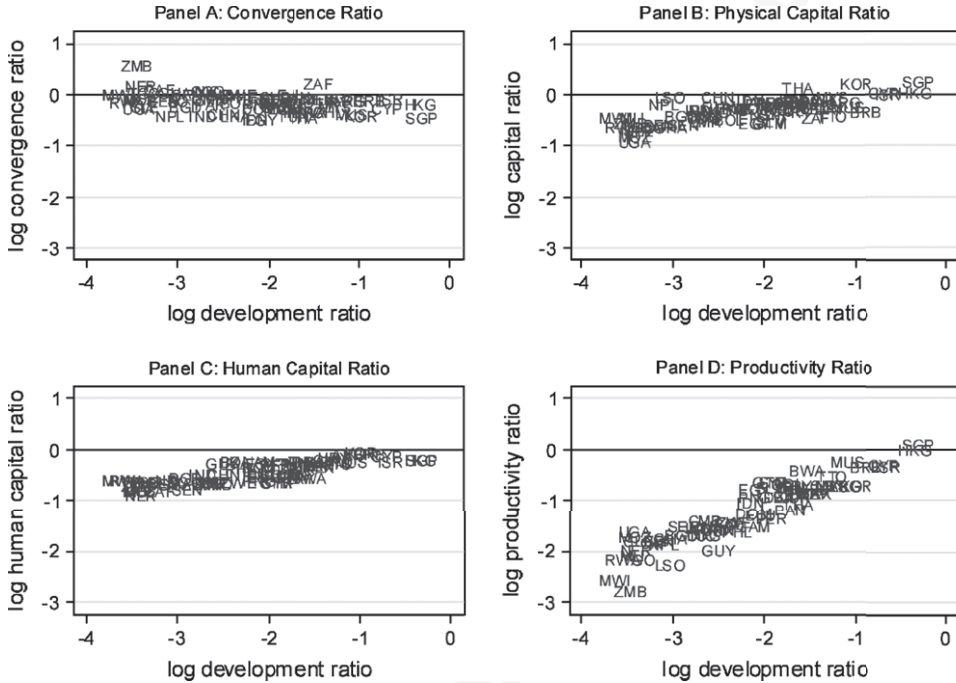


FIGURE 4

Development accounting. Year is 1995

to increase the access of developing countries to the international financial market. This paper suggests that even if capital flows were below the efficient level because of *international* credit rationing, the potential gains from mitigating this inefficiency might be quite moderate. Countries have much more to gain from upgrading their domestic engines of growth and development (*e.g.* by relaxing *domestic* credit rationing) than from attracting larger quantities of foreign capital *per se*.<sup>28</sup>

One key maintained assumption of our analysis is that total factor productivity is exogenous to the capital account regime. This assumption points to an important channel through which our results could be reversed—the endogeneity of domestic productivity to the capital account regime. The literature discusses various economic channels through which a financially open developing country could “import” foreign productivity (Prasad, Rogoff, Wei and Kose, 2003). First, international financial integration could increase the productivity of developing economies by allowing inflows of FDI in industries where foreign firms enjoy a productivity advantage.<sup>29</sup> One sector that deserves special emphasis and separate consideration in this regard, is banking. In this case, the superior efficiency of foreign banks in allocating domestic saving, or the competition they introduce in the domestic financial system, could accelerate domestic financial development and result in efficiency gains in the whole economy (Levine, 1996; Rajan and Zingales, 2003). This channel comes with important policy implications, since it would imply that the capital flows that need to be preserved are FDI and not necessarily credit flows.

28. Of course, a country that increases its productivity also makes itself more attractive to foreign investors. Our claim is that a country benefits much more from the productivity increase itself than from the resulting capital inflows.

29. See Borenstein *et al.* (1998) and Carkovic and Levine (2002) for evidence (and opposite conclusions) on the impact of FDI on growth.

There are also more indirect channels through which international financial integration could affect the policies and governance of developing countries. Opening the capital account could signal the quality of future policies (Bartolini and Drazen, 1997) or enhance the domestic government's commitment to good policies (Gourinchas and Jeanne, 2005a). International financial integration induces countries to have good governance and a high level of transparency in order to attract foreign investors *ex ante* and to maintain these good policies *ex post* in order to avoid a capital flight. On the other hand, it has been argued that far from inducing discipline, the disruption induced by volatile capital flows could have deleterious effects on domestic institutions, policies, and growth.

By construction, this paper has little to say on these channels since they are not in the textbook of neoclassical growth model. The main message of this paper, in this regard, is that *if* international financial integration has a large impact on the welfare of developing countries, this must be through channels that are not in the textbook model. This impact would occur, furthermore, mainly because of the indirect effects of integration, not because of the international reallocation of capital that the textbook model focuses on. In other words, one might have to leave the comfort of welfare theorems and open the Pandora's box of development economics in order to really understand the benefits and costs of international financial integration for developing countries.

## APPENDIX A. CALIBRATING THE MODEL

### A.1. Constructing human-capital stocks

We adopt a piecewise linear representation of the returns to schooling  $\phi'(E)$  consistent with the empirical evidence in Psacharopoulos (1994). The marginal return to education is set to 13.4% for the first four years of education, to 10.1% for the next four, and to 6.8% subsequently.

The concept of human capital we use is the average educational attainment for people over age 25, that is, the average number of years of schooling in the population older than 25. This is a stock measure, as needed for the theory. To measure  $E_t$ , we rely on the Barro and Lee (2001) updated data set (see also Jones, 1997). This data set constructs educational attainment every five years from 1960 to 2000 for a sample of 138 countries, according to the following perpetual inventory method:

$$E_t = (1 - \delta_{25,t})E_{t-5} + \delta_{25,t} \sum_j \pi_{j,t-n_j} u_j, \quad (\text{A.25})$$

where  $E_t$  represents educational attainment in year  $t$ ,  $\pi_{j,t}$  represents the educational attainment rate for cell  $j$  at time  $t$  (*i.e.* the fraction of a school-age cohort enrolled in education cell  $j$ ), and  $u_j$  represents the duration of cell  $j$  (*i.e.* the number of years of education for that cell).  $n_j$  represents the number of years necessary for someone with education level  $j$  to reach age 25.<sup>30</sup>  $\delta_{25,t}$  represents the depreciation rate for educational attainment and is equal to the fraction of the population aged 25–29 (see Barro and Lee, 1993, for a derivation). Barro and Lee provide data on six educational categories: incomplete primary, primary, incomplete secondary, secondary incomplete higher, and higher education.

Using equation A.25, steady-state educational attainment  $E^*$  is defined as

$$E^* = \sum_j \pi_j^* u_j. \quad (\text{A.26})$$

We measure steady-state enrolment rates  $\pi_j^*$  and durations  $u_j^*$  using the latest available data. Because this data is not directly available from the Barro and Lee data set, we use data from the *UNESCO World Education Report, 2003*, that reports data on duration for primary, incomplete secondary, and secondary education as well as net enrolment rates for primary and secondary education and gross enrolment rates for tertiary education for the years 1998–2000 (or the latest available year when 1998–2000 are not available). We assume, as Barro and Lee do, that incomplete cycles have a duration equal to half the full cycle and that higher education lasts four years. Gross enrolment ratios refer to the total enrolment in a given education group, regardless of age, divided by the population of the age group which officially corresponds to that education cell. The net enrolment ratio only includes enrolment for the age group corresponding to the official school age of primary education. Defining PRI, SEC, and HIGH as the UNESCO enrolment rates, we obtain:

30.  $n_j$  depends on the enrolment age for cell  $j$ . We assume that  $n_p = 15$ ,  $n_s = 10$ , and  $n_h = 5$ .

$$\pi_p^* = \text{PRI} - \text{SEC}$$

$$\pi_s^* = \text{SEC} - \text{HIGH}$$

$$\pi_h^* = \text{HIGH}.$$

We split the UNESCO enrolment rates into complete and incomplete cycles using the Barro and Lee rates of completion for primary, secondary, and higher education.

Lastly, we annualize the depreciation rate and enrolment rates as follows: define  $s_t$  the annual investment in schooling that satisfies

$$E_{t+1} = (1 - \delta_e)E_t + \theta s_t \quad (\text{A.27})$$

for  $0 \leq s_t \leq \bar{s}$ , as in the model. Assuming that  $s_t$  and  $\delta_{25,t}$  are constant between  $t - 5$  and  $t$ , it follows that

$$E_t = (1 - \delta_e)^5 E_{t-5} + \frac{\theta}{\delta_e} s_t [1 - (1 - \delta_e)^5]. \quad (\text{A.28})$$

Identifying with (A.25), we obtain

$$\delta_e = 1 - (1 - \delta_{25})^{1/5} \quad (\text{A.29})$$

$$s_t = \frac{\delta_e}{\theta} \sum_j \pi_{j,t-n_j} u_j \quad (\text{A.30})$$

$$= \frac{1}{\theta} \frac{\delta_e}{\delta_{25}} [E_t - (1 - \delta_{25})E_{t-5}] \quad (\text{A.31})$$

$$s^* = \frac{\delta_e}{\theta} \sum_j \pi_j^* u_j = \frac{\delta_e E^*}{\theta}. \quad (\text{A.32})$$

Given an estimate of  $E^*$  and  $\delta_e$ , an estimate for  $\theta$  is obtained from equation (3.15) as

$$\theta = \frac{\frac{R^*}{ng} - 1 + \delta_e [1 + E^* \phi'(E^*)]}{\phi'(E^*)}. \quad (\text{A.33})$$

## A.2. Constructing steady-state capital stocks

Using data from Heston *et al.* (2002) Mark 6.1, we measure the average investment share  $\hat{s}_k$  in gross GDP from 1985 to 1995. We then assume that the observed average investment rate is a good approximation to the investment rate that would obtain in steady state:

$$\hat{s}_k = \alpha \frac{\delta_k + n \cdot g^* - 1}{\delta_k + R^*/(1 - \tau) - 1}. \quad (\text{A.34})$$

This approach is similar to Mankiw *et al.* (1992) who assume constant saving rates in their tests of unconditional and conditional convergence. Similarly, the literature on calibrated business cycle models often interprets historical averages as equivalent to steady-state values (see Mendoza and Tesar, 1998, for an application to tax reform).<sup>31</sup>

The capital ratio then follows:

$$\ln \left( \frac{k_0}{k^*} \right) = \frac{1}{1 - \alpha} \left[ \ln \left( \frac{k_0}{y_0} \right) - \ln \left( \frac{k^*}{y^*} \right) \right] + \ln \frac{h_0}{h^*}. \quad (\text{A.35})$$

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31. It is important to emphasize that this assumption does not imply that countries are estimated to be close to their steady state. As a famous counterexample, consider the Solow model. It assumes a constant saving rate, but imposes no restrictions on the proximity of countries to their steady state.

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