

# Productivity Growth and Capital Flows: The Dynamics of Reforms

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## Abstract

Why doesn't capital flow into fast-growing countries? This paper provides a model incorporating heterogeneous producers and underdeveloped domestic financial markets to study the joint dynamics of total factor productivity (TFP) and capital flows. When a large-scale reform eliminates idiosyncratic distortions and liberalizes capital flows, the TFP of our model economy rises gradually and capital flows out of it. The rise in TFP reflects efficient reallocation of capital and entrepreneurial talent, a process drawn out by frictions in domestic financial markets. The capital outflows reflect a surge in saving—driven not only by initial interest rate differentials but also by strong self-financing motives of entrepreneurs—and a stagnation in investment following the reform, the latter being another ramification of the domestic financial frictions. Our welfare analysis finds that most individuals in the economy, except for entrepreneurs and the wealthy, are worse off with capital account liberalization.

*Keywords:* Productivity growth, capital flows, financial frictions

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Standard economic theory predicts that capital should flow into countries experiencing a sustained increase in total factor productivity (TFP). The evidence from developing countries over the last three decades contradicts this prediction. If anything, capital tends to flow out of countries with fast-growing productivity (Prasad et al., 2007; Gourinchas and Jeanne, 2007). Upon closer inspection, we observe that many spells of sustained productivity accelerations follow large-scale economic reforms. In these episodes, the acceleration of TFP is accompanied by a surge in aggregate saving and a more muted response of aggregate investment—that is, capital outflows.

A successful explanation of these phenomena requires both a theory of TFP dynamics and a model of international factor reallocation. This is the goal of our paper. We develop and analyze a quantitative framework where large-scale growth-enhancing reforms generate endogenous joint dynamics of TFP and capital flows. The nature of this joint dynamics is shown to depend primarily on the degree of frictions in the local financial markets.

There are three features that distinguish our model from others in the literature. First, individuals in our model choose whether to operate an individual-specific technology or to supply labor for a wage. This occupational choice allows for endogenous entry and exit of individual producers, an important channel of resource reallocation. Second, based on the growth acceleration experiences of some developing countries, we model large-scale economic reforms as the elimination of idiosyncratic distortions.<sup>1</sup> Such reforms result in efficient reallocation of production factors. Third, we incorporate financial frictions in the form of collateral constraints on capital rental. Financial frictions are not only a source of misallocation themselves, but they also slow down the resource reallocation after a reform.

These three features are responsible for the endogenous TFP dynamics. In our model, aggregate output is a function of the entire joint distribution of wealth and entrepreneurial ability: An economy with more misallocation of capital and talent—holding other things constant—will produce less, and hence its aggregate productivity measures will be lower. As the initial misallocation is unwound over time, the imputed TFP rises.

We use our model to study the transitional dynamics following a reform that eliminates idiosyncratic distortions and liberalizes capital flows. The initial condition for the transition is the stationary equilibrium of the pre-reform economy that (1) has idiosyncratic distortions—e.g. sector-specific and/or size-dependent taxes and subsidies, (2) is closed to goods and capital flows, and (3) has poorly-functioning domestic financial markets. This initial condition is characterized by gross misallocation of resources and by an equilibrium

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<sup>1</sup>The importance of idiosyncratic distortions in understanding the low TFP of developing countries is discussed by Hsieh and Klenow (2009) and Bartelsman et al. (2009). Earlier theoretical contributions include Hopenhayn and Rogerson (1993), Guner et al. (2008), and Restuccia and Rogerson (2008).

interest rate lower than the world interest rate.

Once the reform is implemented, aggregate productivity measures rise fast, mirroring the more efficient reallocation of economic resources in the absence of idiosyncratic distortions. More important, capital flows out of this small opening economy, driven by distinctive dynamics in aggregate investment and saving. After the reform, investment initially falls, and then rises sluggishly. This results from the downsizing and exit of entrepreneurs who lose their subsidy, and from the capital market frictions constraining—and slowing down—the entry and expansion of productive entrepreneurs. On the other hand, aggregate saving increases strongly throughout the post-reform transition. This increase in saving is an end product of three disparate underlying forces. First, the new, higher interest rate causes domestic residents to save more, holding other things constant. Second, most individuals' future income rises with the reform, and the permanent-income theory dictates lower saving rates. Third, productive entrepreneurs who are not too wealthy choose very high saving rates, so that they can overcome the collateral constraints over time and self-finance their profitable business. It turns out that the first and the third forces prevail over the second. In summary, our model generates a strong positive correlation between TFP and saving, and a much weaker one between TFP and investment, consistent with the empirical patterns during growth acceleration episodes.

The initial interest rate differential between the closed economy and the rest of the world is the key mechanism in the “global imbalances” literature (Caballero et al., 2008; Mendoza et al., 2009), which has shown that capital will flow from financially underdeveloped countries to those with better domestic financial markets.<sup>2</sup> However, this literature has not addressed the joint dynamics of TFP growth and capital flows, partly because it does not provide a theory of TFP. It would be erroneous to conjecture that one can extrapolate the models in this literature to generate a positive co-movement in TFP and capital outflows over time. Indeed, in these models, once exogenous TFP growth is introduced, capital flows into the country with the higher TFP growth rates, even when no borrowing is allowed for consumers (Section 4): Higher TFP spurs investment and results in dis-saving by individuals, who start consuming according to a higher permanent income. That is, these models generate a strong positive correlation between TFP and investment, and a strong negative one between TFP and saving, contrary to the data.

In order to explain why capital may flow out of countries with fast TFP growth, it is important to use a framework that allows for rich joint dynamics among TFP, investment, and saving. This is the main contribution of our paper.

We also consider an alternative sequencing of the reform. In the main exercise of the paper

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<sup>2</sup>Earlier contributions include Gertler and Rogoff (1990) and Boyd and Smith (1997).

so far described, the reform consists of two components: the elimination of idiosyncratic distortions and the liberalization of international capital flows. Note in particular that the local financial market frictions remain intact. We think of financial frictions as arising from imperfect enforceability of contracts, which is a component of broader institutions and is hence more inertial. Nevertheless, one can think of a farther-reaching reform package that not only removes idiosyncratic distortions and liberalizes capital flows but also improves the local financial institutions. With this broader reform, TFP will now increase for two reasons: the removal of idiosyncratic distortions, and the improved financial markets. At the same time, unlike in the main exercise above, capital now flows into this economy. This is primarily because local financial markets now function better than in the main exercise, expediting the entry and expansion of productive entrepreneurs: As a result, aggregate investment now increases strongly even in the early stages of the post-reform transition. In addition, entrepreneurs can now obtain more external financing, and have weaker self-financing motives for saving. Overall, investment outstrips saving, and capital flows in from overseas to meet this excess demand for capital.

Given the different results we obtain in the two exercises, it is natural to ask which sequencing of reforms is a more accurate description of developing economies' experiences. There is ample documentation showing the prevalence of the sequencing in our first exercise: The reduction of sector-specific or size-dependent taxes and subsidies, along with capital account liberalization, preceded domestic financial market reforms in the countries that are relevant for our analysis. In fact, the first two are often referred to as “first-generation” reforms, while domestic financial institutions belong to the domain of “second-generation” reforms (Camdessus, 1999). The reform of domestic financial institutions in emerging economies surfaced onto the center stage of international policy debates only after the East Asian and Russian financial crises of the late 1990s, with the realization that the gains from capital account liberalization remain elusive without a developed local financial sector (Mishkin, 2003; Stulz, 2005; Kaminsky and Schmukler, 2008; Obstfeld, 2008).

One additional advantage of our model is that it lends itself well to a quantitative welfare analysis. Of particular interest is the welfare consequence of capital account liberalization. Given that economists agree on the desirability of eliminating idiosyncratic distortions, we ask whether it is better to open up to international capital flows at the same time or not. We compare the results of our main exercise—removing idiosyncratic distortions while opening up—with those from a closed-economy reform—removing idiosyncratic distortions while remaining closed. Obviously, the wealthy directly benefit from the concurrent capital account liberalization, which instantaneously gives them higher returns—the world interest rate—on their financial assets. Likewise, high-ability individuals, who will choose to be

entrepreneurs and soon become wealthy, are better off with the open-economy reform. On the other hand, low-ability individuals, who will choose to be workers, are better off with the closed-economy reform, unless they start out very wealthy. This is because capital flows out of the economy following the reform with capital account liberalization: Holding other things constant, there is less capital per worker for domestic production, and the wage is lower than in the closed-economy transition, albeit temporarily. Wage eventually rises to a higher level with capital account liberalization, but the lower wage along the transition prevails on the overall welfare of low-ability individuals.

We draw the following conclusion from our exercises. To assess the full effects of the liberalization of international capital flows, it is important to first understand its interaction with other local distortions that interfere with the efficient allocation of economic resources. It is equally important to understand the scope and sequencing of reforms that will be undertaken with the capital account liberalization.

**Related Literature** The earlier literature on international capital flows focused on the Lucas puzzle—the small volume of capital flows from rich to poor countries. This fact can be explained by the overall lower productivity in poor countries (Lucas, 1990) or their higher relative cost of investment (Caselli and Feyrer, 2007). Gertler and Rogoff (1990) and Boyd and Smith (1997) developed theories demonstrating how frictions in local capital markets can interact with international capital markets and cause capital to flow from poor to rich countries.<sup>3</sup> As discussed earlier, Caballero et al. (2008) and Mendoza et al. (2009) emphasize this interaction between local and international financial markets to explain global imbalances, using models where the primary role of financial markets is to facilitate consumption smoothing. Castro et al. (2004) also analyze how domestic financial market imperfections can determine the direction of international capital flows.

The goal of this paper is to explain why capital does not flow into countries with fast-growing aggregate productivity (Prasad et al., 2007; Gourinchas and Jeanne, 2007). We show that models in the aforementioned literature cannot generate capital outflows during a spell of exogenous accelerations in TFP. Therefore, we provide a framework that allows for richer joint dynamics among endogenous TFP, investment, and saving.

More recently, a number of researchers have formulated and addressed a closely-related puzzle: Capital tends to flow out of countries fast growing in terms of *income per capita*. Carroll et al. (2000) use habit formation in preferences to explain this in an endowment-economy setup. Sandri (2009) and Song et al. (2009) use production-economy models to explain the best-known example of a country that has grown fast and amassed a huge

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<sup>3</sup>Matsuyama (2005) is a more recent contribution in this context.

amount of foreign assets during the past decade and a half: China. Sandri focuses on the market incompleteness in sharing entrepreneurial risk, and in this sense is closely related to the underlying mechanism of Caballero et al. (2008) and Mendoza et al. (2009). Song et al. capture the interaction between the private sector and the state-owned firms with privileged access to financing, a feature of the Chinese economy.

Our paper complements this literature by addressing the experiences of a broader set of developing countries, where the impact of large-scale economic reforms was intermediated through underdeveloped local financial markets. Our model is uniquely capable of illuminating the disparate forces driving the post-reform transition dynamics of endogenous TFP, investment, and saving.<sup>4</sup>

Our work also relates to the recent papers by Aoki et al. (2007, 2009), who study theoretically how the adjustment to liberalization of international financial transactions depends upon the degree of domestic financial development.<sup>5</sup> In our framework, the liberalization of capital flows unaccompanied by other reforms only generates inconsequential TFP dynamics. In order to account for the joint dynamics of capital flows and TFP growth, one needs to consider the broader set of reforms implemented in many developing economies.

## 1 Motivating Facts

In this section we discuss the empirical evidence on capital flows and productivity growth. First, we review an empirical literature documenting that capital tends to flow out of countries whose output and TFP grow fast. Second, we study in detail the joint dynamics of saving and investment—and hence capital flows—for a group of countries where large-scale reforms led to a prolonged period of output and TFP accelerations.

Two papers have recently documented a positive correlation between capital outflows and economic growth for developing economies. Prasad et al. (2007) show that the countries whose output per worker grew the fastest between 1970 and 2004 tended to run current account surpluses over the same period. Gourinchas and Jeanne (2007) establish a similar pattern between capital outflows and TFP growth. Both studies further show that the capital flows and the resulting accumulation of net foreign assets are accounted for by a strong positive correlation between growth and aggregate saving, together with a relatively weaker one between growth and aggregate investment.<sup>6</sup>

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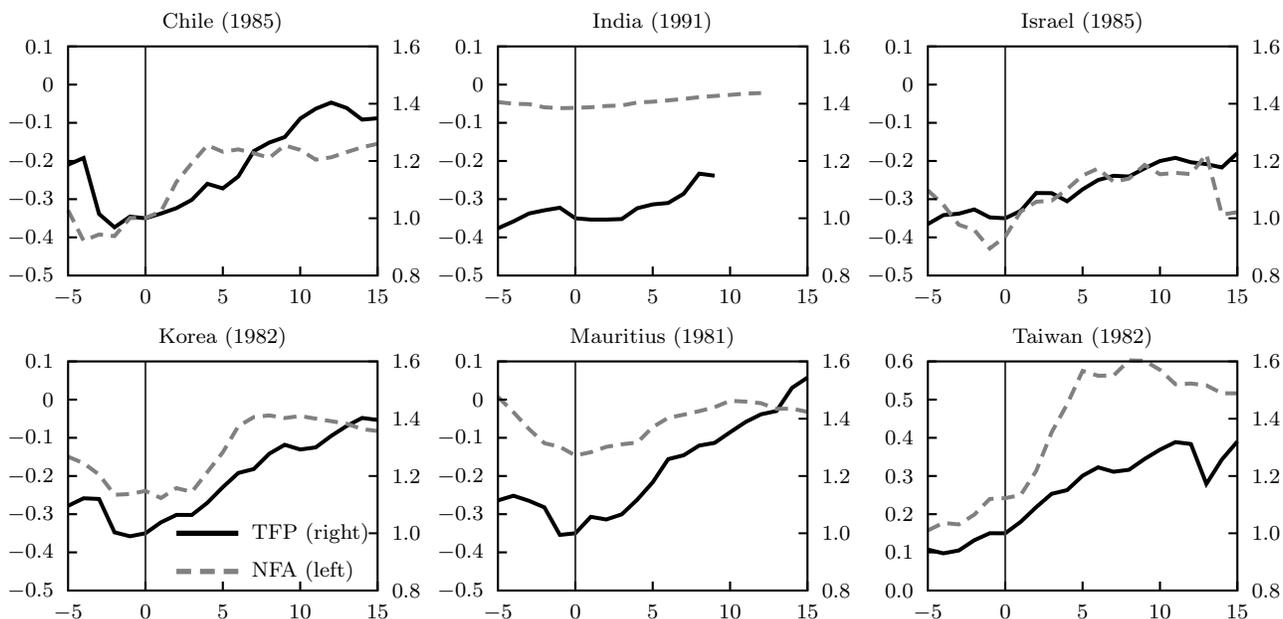
<sup>4</sup>As we describe in Section 1, we look at a different time period, 1980–1995. Notably, little capital flowed out of China during this period.

<sup>5</sup>Compared to Aoki et al. (2007, 2009), our model has richer heterogeneity across entrepreneurs, an extensive margin allowing unproductive entrepreneurs to become workers, and decreasing-returns-to-scale technologies at the level of production units.

<sup>6</sup>Gourinchas and Jeanne (2007) provide a more systematic interpretation of this evidence by showing that

This relationship between growth and capital flows is also present in individual countries' time series. Indeed, when analyzing the evolution of saving and investment during the sustained growth acceleration episodes identified by Hausmann et al. (2005), one sees strong growth in saving precede the more gradual increments in investment. See Prasad et al. (2007), especially their Figure 9. An important finding of Hausmann et al. is that the beginning of many such acceleration episodes coincides with large-scale economic reforms.

Building on these studies, we take a closer look at the developing countries with large-scale economic reforms between 1980 and 1995. For six of them, we can identify and date large-scale economic reforms that coincide with the onset of TFP accelerations. They are Chile, India, Israel, Korea, Mauritius, and Taiwan, and include all the sustained growth accelerations identified by Hausmann et al..<sup>7</sup>



**Fig. 1:** TFP and Net Foreign Asset Positions. Year 0 on the horizontal axis is the year of reform implementation, which is shown in parentheses next to the country name. Net foreign asset position as a fraction of PPP GDP is measured on the left scale, and aggregate TFP can be read off the right scale. TFP is normalized by its value in year 0.

one needs to introduce saving wedges into the neoclassical growth model to explain the correlation between TFP and capital flows in the data.

<sup>7</sup>We focus on the 1980–1995 period for three reasons. Firstly, the 1980s witnessed the first wave of capital account liberalization in emerging economies. Secondly, during the 1990s, innovations in international financial markets (e.g. derivatives and off-balance sheet transactions) made it harder to closely keep track of cross-border capital flows, substantially amplifying measurement problems (Lane and Milesi-Ferretti, 2007). Lastly, we abstract from the developments in the aftermath of the East Asian and Russian financial crises of the late 1990s, when many emerging economies espoused an explicit policy of improving their net foreign asset positions as a precautionary measure, e.g. the Guidotti-Greenspan rule and the proposals by Feldstein (1999). Note that our sample period precedes the massive acquisition of foreign assets by China, which is the subject of Sandri (2009) and Song et al. (2009).

Figure 1 shows the evolution of net foreign asset positions (dashed lines) and aggregate productivity (solid lines) before and after major economic reforms. The year of the reform is set to zero, and the two variables are plotted for the surrounding 20 years. Net foreign asset positions are measured relative to PPP GDP (left scale), and TFP is relative to the year-zero level (right scale). The dates of the reforms are 1981 for Mauritius, 1982 for Korea and Taiwan, 1985 for Chile and Israel, and 1991 for India. See the appendix for a description of these reform episodes. In all six cases, the large-scale reforms ushered in a period of sustained productivity growth. At the same time, capital flowed out of these countries.

Later in the paper, in the right panel of Figure 3 to be precise, we show the evolution of saving and investment rates before and after the reforms in these six countries. Consistent with the evidence in Prasad et al. (2007), the rise in net foreign assets that accompany the TFP acceleration is accounted for by a surge in aggregate saving that precede gradual increments in investment.

To summarize, three robust conclusions can be drawn from the data. First, capital tends to flow out of countries experiencing fast growth in output and TFP, contrary to the predictions of the standard neoclassical model. Second, the pace of the capital outflows and hence net foreign asset accumulation are faster in the early stages of the growth acceleration episodes, many of which are triggered by large-scale reforms. Last, the capital outflows reflect a surge in aggregate saving that precede the delayed reaction of aggregate investment to the reform. In the rest of the paper, we provide a quantitative theory that will explain these phenomena.

## 2 Model

The above empirical observations call for a model of TFP dynamics and capital flows. We propose a model with individual-specific technologies and imperfect credit markets.

In each period, individuals choose either to operate an individual-specific technology—i.e. to become entrepreneurs, or to work for a wage. This occupation choice allows for endogenous entry and exit in and out of the production sector, which are an important channel of resource allocation. Individuals are heterogeneous with respect to their entrepreneurial ability and wealth. Our model generates endogenous dynamics for the joint distribution of ability and wealth, which turns out to be crucial for understanding macroeconomic transitions.

Imperfection in credit markets is modeled with a collateral constraint on capital rental that is proportional to an individual’s financial wealth. This rental limit applies equally to all individuals in the economy.<sup>8</sup>

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<sup>8</sup>In this section, we do not consider idiosyncratic distortions such as idiosyncratic taxes/subsidies and

We consider both an economy that is closed to capital flows and a small open economy facing a constant world interest rate.

**Heterogeneity and Demographics** Individuals live indefinitely, and are heterogeneous with respect to their wealth  $a$  and their entrepreneurial ability  $e \in \mathcal{E}$ , with the former being chosen endogenously by forward-looking saving decisions. An individual’s ability follows a stochastic process. In particular, individuals retain their ability from one period to the next with probability  $\psi$ . With probability  $1 - \psi$ , an individual loses the current ability and has to draw a new entrepreneurial ability. The new draw is from a time-invariant ability distribution, and is independent of one’s previous ability level. One can think of the ability shock as an arrival of a new technology making existing production processes obsolete or less profitable. In Section 3.1.1 we will calibrate this shock to be of a relatively low frequency—an average duration of ten years—to match the rate of establishment turnovers in the US data.

We denote by  $\mu(e)$  the mass of type- $e$  individuals in the invariant distribution, with  $e$  being assumed to be a discrete random variable. We denote by  $G_t(e, a)$  the cumulative density function for the joint distribution of ability and wealth at the beginning of period  $t$ . For notational convenience,  $G_t(a|e)$  is the associated c.d.f. of wealth for a given ability type  $e$ . The population size of the economy is normalized to one, and there is no population growth.

**Preferences** Individuals discount their future utility using the same discount factor  $\beta$ . The preferences over the consumption sequence from the point of view of an individual in period  $t$  are represented by the following expected utility:

$$\mathbb{E}_t \sum_{s=t}^{\infty} \beta^{s-t} u(c_s).$$

**Technologies** In any given period, individuals can choose either to work for a wage or to operate an individual-specific technology. We label the latter option as entrepreneurship. We assume that an entrepreneur with talent  $e$  who uses  $k$  units of capital and hires  $l$  units of labor produces according to a production function  $f(e, k, l)$ , which is assumed to be strictly increasing in all arguments, and strictly concave in capital and labor, with  $f(0, k, l) = 0$ .

**Financial Markets** In the benchmark case, productive capital is the only asset in the economy. There is a perfectly-competitive financial intermediary that receives deposits, and rents out capital to entrepreneurs. The return on deposited assets—i.e. the interest rate in

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size-dependent policies. We show how to introduce idiosyncratic distortions into our model in Section 3.1.2.

the economy—is  $r_t$ . The zero-profit condition of the intermediary implies that the rental cost of capital is  $r_t + \delta$ , where  $\delta$  is the depreciation rate. If the economy is open to capital flows, its interest rate will be equal to the constant world interest rate  $r^*$ . The intermediary can accept deposits from foreigners as well as domestic residents at the interest rate  $r^*$ , and rent capital to foreign and domestic entrepreneurs at the world rental rate of capital  $r^* + \delta$ .

We assume that entrepreneurs' capital rental  $k$  is limited by a collateral constraint  $k \leq \lambda a$ , where  $a \geq 0$  is individual financial wealth and  $\lambda$  measures the degree of credit frictions, with  $\lambda = +\infty$  corresponding to perfect credit markets and  $\lambda = 1$  to financial autarky where all capital has to be self-financed by entrepreneurs. The same  $\lambda$  applies to everyone in a given economy.

Our specification captures the common prediction from models of limited contract enforcement: The amount of credit is limited by individuals' wealth. At the same time, its parsimoniousness enables us to analyze the quantitative effects of financial frictions on aggregate transitional dynamics without losing tractability.<sup>9</sup> This specification has been widely used in the literature on financial frictions and entrepreneurship (Evans and Jovanovic, 1989), and also in the literature on credit frictions and business cycles (Bernanke et al., 1999; Kiyotaki and Moore, 1997).

In the benchmark case, we focus on within-period credit, or capital rental, for production purposes, and do not allow borrowing for intertemporal consumption smoothing; i.e.,  $a \geq 0$ . This constraint will only bind for individuals who choose to be workers, and has no direct bearing on the behavior of entrepreneurs, who will need to hold assets to overcome the collateral constraint. In Section 3.4, we relax this constraint and allow consumption loans:  $a \geq -B$ , with  $B > 0$ . We find that our results stand, unless the consumers' borrowing limit is unrealistically generous.

**Individuals' Problem** The problem of an individual in period  $t$  can be written as:

$$\begin{aligned} \max_{\{c_s, a_{s+1}\}_{s=t}^{\infty}} \mathbb{E}_t \sum_{s=t}^{\infty} \beta^{s-t} u(c_s) \\ \text{s.t. } c_s + a_{s+1} \leq \max\{w_s, \pi(a_s; e_s, w_s, r_s)\} + (1 + r_s)a_s, \quad \forall s \geq t \end{aligned} \tag{1}$$

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<sup>9</sup>Our collateral constraint can be derived from the following limited enforcement problem. Consider an individual with financial wealth  $a \geq 0$  deposited in the financial intermediary at the beginning of a period. Assume that he rents  $k$  units of capital. Then he can abscond with fraction  $1/\lambda$  of the rented capital. The only punishment is that he will lose his financial wealth  $a$  deposited in the intermediary. In particular, he will not be excluded from any economic activity in the future. In fact, he is allowed to instantaneously deposit the stolen capital  $k/\lambda$  and continue on as a worker or an entrepreneur. Note that  $\lambda$  in this context measures the degree of capital rental contract enforcement, with  $\lambda = +\infty$  corresponding to perfect enforcement and  $\lambda = 1$  to no enforcement. In the equilibrium, the financial intermediary will rent capital only to the extent that no individual will renege on the rental contract, which implies a collateral constraint  $k/\lambda \leq a$  or  $k \leq \lambda a$ .

where  $e_t$ ,  $a_t$ , and the sequence of wages and interest rates  $\{w_s, r_s\}_{s=t}^{\infty}$  are given, and  $\pi(a; e, w, r)$  is the profit from operating an individual technology. This indirect profit function is defined as:

$$\pi(a; e, w, r) = \max_{l, k \leq \lambda a} \{f(e, k, l) - wl - (\delta + r)k\}.$$

Note that the collateral constraint  $k \leq \lambda a$  is taken into account. Similarly, we denote the input demand functions by  $l(a; e, w, r)$  and  $k(a; e, w, r)$ .

The max operator in the budget constraint stands for the occupation choice. A type- $e$  individual with current wealth  $a$  will choose to be an entrepreneur if his profit as an entrepreneur,  $\pi(a; e, w, r)$ , exceeds labor income as a wage earner,  $w$ . This occupational choice can be represented by a simple policy function. Type- $e$  individuals decide to be entrepreneurs if their current wealth  $a$  is higher than the threshold wealth  $\underline{a}(e)$ , where  $\underline{a}(e)$  solves:

$$\pi(\underline{a}(e); e, w, r) = w.$$

Intuitively, individuals of a given ability choose to become entrepreneurs only if they are wealthy enough to overcome the collateral constraint and run their businesses at a profitable scale. Similarly, individuals of a given wealth level choose to become entrepreneurs only if their ability is high enough.

**Competitive Equilibrium (Closed Economy)** Given  $G_0(e, a)$ , a competitive equilibrium in a closed economy consists of sequences of joint distribution of ability and wealth  $\{G_t(e, a)\}_{t=1}^{\infty}$ , allocations  $\{c_s(e_t, a_t), a_{s+1}(e_t, a_t), l_s(e_t, a_t), k_s(e_t, a_t)\}_{s=t}^{\infty}$  for all  $t \geq 0$ , and prices  $\{w_t, r_t\}_{t=0}^{\infty}$  such that:

1. Given  $\{w_t, r_t\}_{t=0}^{\infty}$ ,  $e_t$ , and  $a_t$ ,  $\{c_s(e_t, a_t), a_{s+1}(e_t, a_t), l_s(e_t, a_t), k_s(e_t, a_t)\}_{s=t}^{\infty}$  solve the individual's problem in (1) for all  $t \geq 0$ ;
2. The labor, capital, and goods markets clear at all  $t \geq 0$ —in particular:

$$\sum_{e \in \mathcal{E}} \mu(e) \left[ \int_{\underline{a}(e, w_t, r_t)}^{\infty} l(a; e, w_t, r_t) G_t(da|e) - G_t(\underline{a}(e, w_t, r_t)|e) \right] = 0, \quad (\text{Labor Market})$$

$$\sum_{e \in \mathcal{E}} \mu(e) \left[ \int_{\underline{a}(e, w_t, r_t)}^{\infty} k(a; e, w_t, r_t) G_t(da|e) - \int_0^{\infty} a G_t(da|e) \right] = 0; \quad (\text{Capital Market})$$

3. The joint distribution of ability and wealth  $\{G_t(e, a)\}_{t=1}^{\infty}$  evolves according to the equilibrium mapping:

$$G_{t+1}(a|e) = \psi \int_{u \leq a} \int_{a'(e, v) = u} G_t(dv|e) du + (1 - \psi) \sum_{\hat{e} \in \mathcal{E}} \mu(\hat{e}) \int_{u \leq a} \int_{a'(\hat{e}, v) = u} G_t(dv|\hat{e}) du.$$

A competitive equilibrium for a small open economy is defined similarly, given a world interest rate  $r^*$ . In this case, the domestic capital rental market and goods market do not need to clear, and the net foreign asset ( $NFA$ ) equals:

$$NFA_t = \sum_{e \in \mathcal{E}} \mu(e) \left[ \int_0^\infty a G_t(da|e) - \int_{\underline{a}(e, w_t, r^*)}^\infty k(a; e, w_t, r^*) G_t(da|e) \right].$$

### 3 Quantitative Exploration

The central objective of this paper is to construct a quantitative model of TFP dynamics and capital flows during the transition of economies from a steady state with low per-capita income to one with high per-capita income. Building upon the recent literature emphasizing the role of idiosyncratic distortions (Restuccia and Rogerson, 2008; Hsieh and Klenow, 2009; Bartelsman et al., 2009), we model transition dynamics launched by large-scale reforms that remove idiosyncratic distortions.

In order to quantify our theory, we first need to choose a set of structural parameters—preferences, technologies, distribution of entrepreneurial ability—that are invariant to the reforms. Then we choose a set of parameters that can be changed by the reforms—parameters governing idiosyncratic distortions and financial frictions. Once all these parameters are chosen, we use our model to construct the initial condition for the transition exercises,  $G_0(e, a)$ . This initial condition is a stationary equilibrium of an economy that (1) has idiosyncratic distortions, (2) is closed to goods and capital flows, and (3) has poorly-functioning domestic financial markets.

#### 3.1 Calibration

##### 3.1.1 Parameters Invariant to Reforms

We first describe the parametrization of the model, and then discuss the calibration of the parameters. For the sake of clarity, we choose a parsimonious parametrization that follows as much as possible the standard practices in the literature.

We choose a period utility function of the iso-elastic form:

$$u(c) = \frac{c^{1-\sigma} - 1}{1-\sigma}.$$

We assume that an entrepreneur with talent  $e$  who hires  $k$  units of capital and  $l$  units of labor produces according to the following production function:

$$f(e, k, l) = e (k^\alpha l^{1-\alpha})^{1-\nu}, \tag{2}$$

where  $1 - \nu$  is known as the span-of-control parameter. Accordingly,  $1 - \nu$  represents the share of output going to the variable factors. Out of this, fraction  $\alpha$  goes to capital, and  $1 - \alpha$  goes to labor.

The entrepreneurial ability  $e$  is assumed to be a truncated and discretized version of a Pareto distribution whose probability density is  $\eta e^{-(\eta+1)}$  for  $e \geq 1$ . Each period, an individual may retain his previous entrepreneurial ability with probability  $\psi$ . With probability  $1 - \psi$ , he draws a new ability realization from the distribution of  $e$  given above. Obviously,  $\psi$  controls the persistence of ability, while  $\eta$  determines the dispersion of ability in the population.

We now need to determine seven parameter values: two technological parameters,  $\alpha$  and  $\nu$ , and the depreciation rate  $\delta$ ; two parameters describing the ability process,  $\psi$  and  $\eta$ ; the reciprocal of intertemporal substitution elasticity,  $\sigma$ , and the subjective discount factor,  $\beta$ .<sup>10</sup>

We let  $\sigma = 1.5$  following the standard practice. The one-year depreciation rate is set at  $\delta = 0.06$ . We choose  $\alpha(1 - \nu) = 0.3$  to match the aggregate income share of capital. We are thus left with four parameters:  $\nu$ ,  $\eta$ ,  $\psi$ , and  $\beta$ . We calibrate them using as many relevant moments in the US data: the employment share of the top decile of establishments; the share of earnings generated by the top twentieth of the population; the exit rate of establishments; and the real interest rate. To be more specific, we calibrate the perfect-credit benchmark of our model—with no idiosyncratic distortion—to match these moments in the US, a relatively undistorted economy. We allow for the possibility that the average entrepreneurial productivity in the US is higher than in less developed economies, reflecting human capital and exogenous TFP differences.<sup>11</sup> As the primary mechanism of our model concerns the allocation of resources among heterogeneous producers, however, our calibration and results are not affected by cross-country differences in the mean.<sup>12</sup>

The first column of Table 1 shows the moments in the US data. The decile with the largest—measured by employment—establishments in the US accounts for 63 per cent of the total employment in 2000. We target the earnings share of the top twentieth of the population (0.31 in 1998), and an annual establishment exit rate of ten per cent. Finally, as

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<sup>10</sup>As is common in heterogeneous-agent models with incomplete markets, the discount rate must be jointly calibrated with the parameters governing the stochastic income process.

<sup>11</sup>That is, for the US, one can use the following production function with  $A > 1$ :

$$f(e, k, l) = Ae(k^\alpha l^{1-\alpha})^{1-\nu}.$$

<sup>12</sup>Similarly, one can consider introducing exogenous differences across countries in the higher-order moments of the entrepreneurial ability distribution. The difficulty here is that the available data do not provide enough guidance or discipline on the direction and magnitude of cross-country variations in these moments. Even without such exogenous differences in the higher-order moments of the underlying entrepreneurial ability distribution, however, our model endogenously generates different distributions of productivity among active entrepreneurs for economies with different degrees of financial frictions or idiosyncratic distortions.

	US Data	Model	Parameter
Top 10% Employment	0.63	0.63	$\eta = 4.95, \nu = 0.19$
Top 5% Earnings	0.31	0.31	
Establishment Exit Rate	0.10	0.10	$\psi = 0.89$
Real Interest Rate	0.04	0.04	$\beta = 0.93$

**Table 1:** Calibration. The model quantities are from the calibrated version of our perfect-credit benchmark without idiosyncratic distortions.

the target interest rate, we pick four per cent per year.

The second column of Table 1 shows the moments simulated from the calibrated model. Even though in the model economy all four moments are jointly determined by the four parameters, each moment is primarily affected by one particular parameter. Given the span-of-control parameter  $1 - \nu$ , the tail parameter of the talent distribution  $\eta$  can be inferred from the tail of the distribution of employment. We can then infer  $\nu$  from the earnings share of the top five per cent of the population. Top earners are mostly entrepreneurs both in the data and in our model, and  $\nu$  controls the share of output going to the entrepreneurial input. These two parameters are calibrated at  $\nu = 0.19$  and  $\eta = 4.95$ . The parameter  $\psi = 0.89$  leads to an annual exit rate of ten per cent in the model. Finally, the model requires a discount factor of  $\beta = 0.93$  to attain an interest rate of four per cent.

### 3.1.2 Parameters for Idiosyncratic Distortions and Financial Frictions

We model the initial condition of our transition exercises as the joint ability-wealth distribution in a closed-economy stationary equilibrium under financial frictions *and* idiosyncratic distortions. The latter can be thought of as individual/sector/size-specific taxes/subsidies  $\tau_{yi}$  on output, that distort the static profit-maximization problem of entrepreneur  $i$  into:

$$(1 - \tau_{yi}) e_i (k_i^\alpha l_i^{1-\alpha})^{1-\nu} - wl_i - (\delta + r) k_i, \quad k_i \leq \lambda a_i.$$

The important distinction is that our financial frictions apply equally to everyone in the economy— $\lambda$  has no individual subscript—while  $\tau_{yi}$  is individual specific. We could have alternatively assumed that idiosyncratic distortions take the form of labor taxes/subsidies or capital taxes/subsidies.

For the sake of parsimoniousness, we assume that  $\tau_y$  is a random variable with only two possible outcomes:  $\tau_+ (\geq 0)$  and  $\tau_- (\leq 0)$ . Also, the probability of being taxed for a type- $e$  individual,  $\Pr\{\tau_y = \tau_+ | e\}$ , is assumed to be  $qe$ , with  $\Pr\{\tau_y = \tau_- | e\} = 1 - qe$ .<sup>13</sup> These three

<sup>13</sup>The choice of  $q$  is constrained to ensure that  $qe$  lies between 0 and 1.

parameters,  $\tau_+$ ,  $\tau_-$ , and  $q$ , are then chosen to match the following three moments. First, measured TFP increases by 40 per cent over the 15 years of post-reform transitions, averaged across the six countries we study. Second, the capital to output ratios of the six countries immediately before their respective reforms are 1.8 on average. Finally, we impose budget balance on the pre-reform stationary equilibrium: The subsidies and the taxes on active entrepreneurs must cancel each other out.

We pick  $\lambda = 1.5$ , which yields an external finance to GDP ratio of a typical developing economy, 0.6–0.8 (Beck et al., 2000), and use our model to compute the closed-economy stationary equilibrium with idiosyncratic distortions and financial frictions. The resulting joint distribution of wealth and ability is the initial condition of our transition exercises in Section 3.3.

## 3.2 Financial Frictions and Interest Rates

In our calibration, we set the annual interest rate in the no-distortion, perfect-credit economy to four per cent. We now assume that this is the world interest rate, which a small open economy will take as given. Note that our transition exercises start from an economy that (1) has idiosyncratic distortions, (2) is closed to goods and capital flows, and (3) has poorly-functioning domestic financial markets ( $\lambda = 1.5$ ). In this economy, the equilibrium interest rate turns out to be two per cent. This lower interest rate is primarily because of the financial frictions. Tight collateral constraints (i.e. low  $\lambda$ ), holding other things constant, restrict entrepreneurs’ demand for capital ( $k \leq \lambda a$ ), and at the same time increase their self-financing needs and hence saving rates (i.e., a larger supply of capital). Therefore, the equilibrium interest rate is lower with tighter collateral constraints. This prediction of our model is consistent with empirical findings and also the prevalence of “financial repression” in less developed countries (McKinnon, 1981; Ohanian and Wright, 2008).<sup>14</sup>

From this, we can foresee one force driving capital flows. When a less developed country opens up to international capital markets, the domestic interest rate will rise and be equalized with the world interest rate, which is pinned down by large countries with well-functioning financial markets. At this new, higher interest rate, there is an excess supply of capital in the domestic rental market, and this surplus capital will be rented out to overseas production units. This is the main mechanism explored in the literature to explain why capital may flow from economies with underdeveloped financial markets to those with more financial

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<sup>14</sup>This result does not contradict the fact that the cost of capital could be higher in countries with higher financial intermediation costs. Firstly, economies with higher intermediation costs tend to have a higher spread between deposit and lending rates. We could introduce this feature into our model without much difficulty, but it will not change our main results. Secondly, one can think of the quantity-constrained entrepreneurs in our model as being subject to a prohibitively high (shadow) rental rate of capital.

development. The examples include Gertler and Rogoff (1990), Boyd and Smith (1997), Matsuyama (2005), and Mendoza et al. (2009). However, the literature focuses more on steady-state comparisons, rather than dynamics, and, more important, it is not a framework for analyzing TFP. Indeed, it would be erroneous to conjecture that one can extrapolate the models in this literature to generate a positive co-movement in TFP and capital outflows over time. In these models, once exogenous TFP growth is introduced, capital flows into the country with the higher TFP growth rates (Section 4).<sup>15</sup> Here, an increase in TFP spurs investment, which easily overwhelms the capital outflows caused by the initial interest rate differential. In addition, with persistent growth in TFP, aggregate saving declines initially, as individuals consume according to the now higher permanent income.

As we now show, our model has two additional forces—forces hitherto not identified in the literature—that will result in capital outflows during the post-reform transitions. First, the downsizing and exit of those entrepreneurs who lose their subsidy will further suppress aggregate investment, especially in the early phases of the transition. Second, the accumulation of wealth by productive but financially constrained entrepreneurs for self-financing purposes will materially contribute to aggregate saving. More important, these two forces are an integral part of the endogenous TFP growth after the reforms.

### 3.3 Post-Reform Transition Dynamics

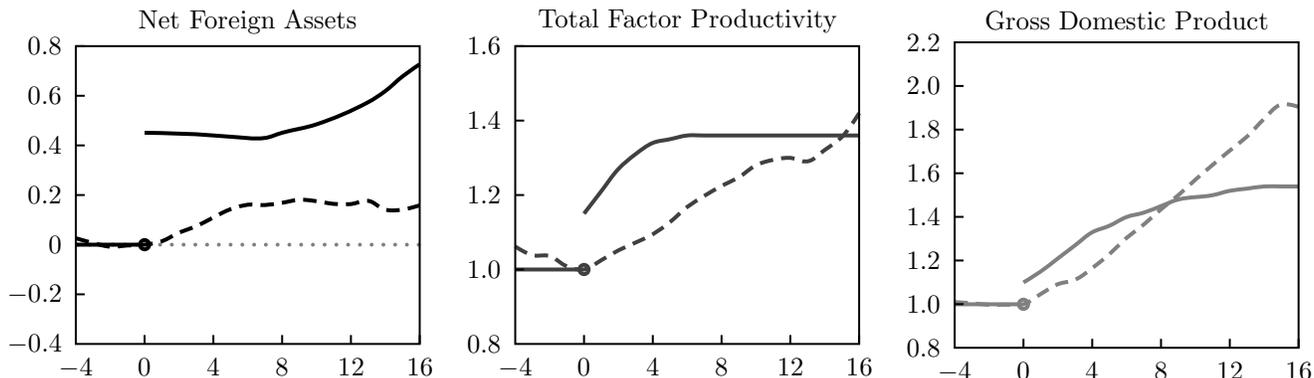
In this section, we study the co-movement of TFP and capital flows following large-scale economic reforms. We consider two main exercises. Both will start with the same initial condition constructed in Section 3.1.2: the stationary equilibrium of an economy that (1) has idiosyncratic distortions, (2) is closed to goods and capital flows, and (3) has poorly-functioning domestic financial markets.

**Exercise 1: Distortion Removal and Opening Up** The economic reform occurs in year zero. It is unexpected. Once it happens, everyone understands that it is a permanent change. In this exercise, the reform consists of two components. One is the opening up of the economy’s capital accounts, and the other is the removal of the idiosyncratic distortions. However, we assume that domestic financial frictions remain as before. We are thinking of financial frictions as arising from enforcement problems, which are a component of broader institutions and are hence more sluggish. The reform experiences of the countries we study in Section 1 are consistent with this sequencing of reforms. Measured in both de jure and de facto sense, domestic financial market reforms lagged behind the removal of size-dependent

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<sup>15</sup>In these models, there is no endogenous TFP dynamics. Therefore, one has to feed exogenous TFP dynamics into them.

or industry-specific taxes and subsidies, as well as capital account liberalization.<sup>16</sup>



**Fig. 2:** Transition Dynamics without Domestic Financial Market Reform. In year 0, a reform is implemented to remove all idiosyncratic distortions in the economy. At the same time, the economy opens up to the world capital market. Domestic financial frictions remain intact. In the left panel, net foreign assets to GDP ratios are shown. The model outcome is the solid line, and the average across the six countries in Section 1 is the dashed line, which has been shifted vertically so that it is zero on the eve of the reform. The center panel shows the TFP series before and after the reform, and the right panel shows GDP (solid for the model and dashed for the six-country average). Both TFP and GDP are normalized by their respective pre-reform levels. The unit of the horizontal axis is years.

The result of this reform exercise is shown in Figure 2. Solid lines represent the model simulations, and the dashed lines reproduce the average across the six countries in Section 1. From year zero, as the reform is implemented, resources are reallocated more efficiently. Reallocation occurs along two margins. First, capital and labor are reallocated among existing entrepreneurs (intensive margin). In addition, more productive entrepreneurs will enter into business, while previously-subsidized incompetent entrepreneurs will exit (extensive margin). The reallocation along these two margins occurs gradually over time (the unit of the horizontal axis is years), slowed down by the frictions in the domestic financial market: It takes time for a talented-but-poor entrepreneur to save up and self-finance the capital needed for operating at a profit-maximizing scale. The increase in TFP reflects this reallocation (center panel). Following the reform, TFP jumps up and gradually increases over time: Over the first eight years, TFP increases by about 3.8 per cent per year.<sup>17</sup>

GDP per capita (right panel) also increases following the reform, largely mirroring the increase in TFP early on (first eight years) and the accumulation of capital later (10 to 20 years after the reform). TFP and GDP in the model (solid lines) increase much faster than

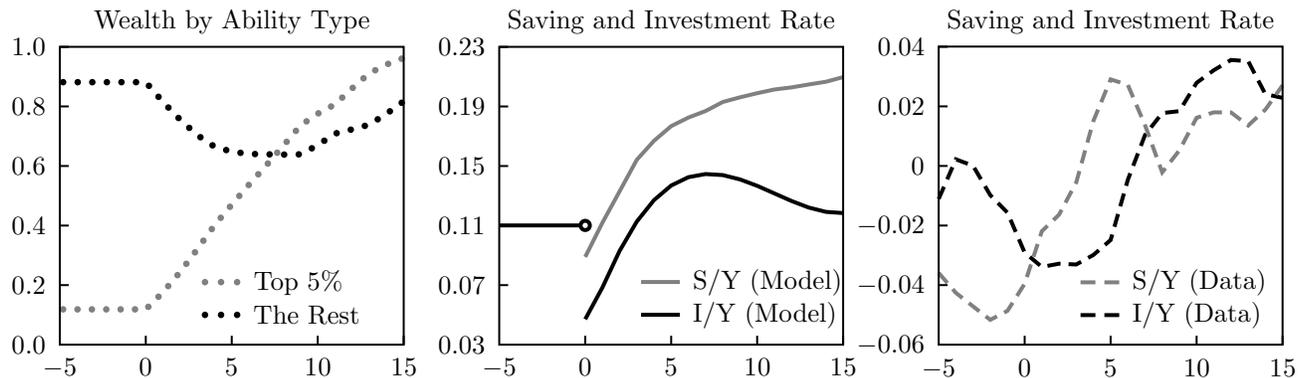
<sup>16</sup>Beim and Calomiris (2001) also document evidence of capital account liberalization preceding domestic financial market reforms in a broader set of developing economies.

<sup>17</sup>The solid line from the model and the dashed line from the six-country data cross in year 15, which was one of the target moments in our construction of the initial condition (Section 3.1.2).

in the data (dashed lines) initially, but slow down significantly after the first six years or so. This should not come as a surprise, given how we model the reform: a sudden and drastic event. Its real world counterparts are more gradual and less drastic. We decided against modeling our reform as a more gradual process, so that we can illuminate and emphasize the endogenous dynamics in our model uncontaminated by any other exogenously-imposed dynamics.

In the left panel of Figure 2, the ratio of net foreign assets to GDP jumps up and then goes further up gradually after the reform. As net foreign assets are shown relative to contemporaneous GDP, a constant ratio would mean that the two are growing at the same rate, and hence that capital is flowing out. To better illuminate the driving forces behind the capital flows, we now consider investment and saving separately in turn.

The center panel of Figure 3 shows the saving (gray solid line) and investment (black solid line) rates in our model before and after the reform. Investment not only drops much more initially but also recovers much more slowly than saving. As a result, capital keeps flowing out of the country, while its TFP increases fast during the first eight years after the reform (solid line, center panel, Figure 2).



**Fig. 3:** Saving and Investment over Time. In the left panel, we show the total wealth held by the top twentieth of the entrepreneurial ability distribution with a gray dotted line. The wealth held by the rest of the population is shown with a black dotted line. Each group’s wealth is normalized by the aggregate wealth in the pre-reform economy. In the center panel, the saving and investment rates in the model before and after the reform are traced with gray and black solid lines, respectively. In the right panel, we first compute 25-year average saving and investment rates for each of the six countries, and de-mean each series using its own (country-specific) mean. Then we show the average saving and investment rates across the six countries using gray and black dashed lines, respectively. The unit of the horizontal axis is years.

Investment exhibits a rich dynamics. Opening up capital accounts implies that the domestic rental rate of capital is equalized to the higher world level. Thus, holding other things constant, less capital is demanded for domestic production, and investment falls immediately. At the same time, some of the entrepreneurs who lose their subsidy will

begin to exit, further reducing the demand in the domestic capital rental market. However, they are not immediately replaced by productive individuals who were previously taxed out of entrepreneurial activities. These individuals are not rich enough to overcome the collateral constraints and start production immediately. They have to work as workers and save up enough collateral first. All these factors explain the initial drop in investment. Over time, productive individuals enter into entrepreneurship and increase their scales of operation, boosting domestic demand for capital and hence investment. Note that financial frictions impede the growth of entrepreneurs as well, which explains the slow recovery of investment. Furthermore, a substantial fraction of this increased investment is matched by accumulation of assets (supply of capital) by these entrepreneurs for self-financing purposes—also a consequence of domestic financial frictions.

As for saving, there are three distinct co-determinants after the reform. First, holding other things constant, the new, higher interest rate causes domestic residents to save more. Second, productive entrepreneurs who are not too wealthy choose very high saving rates, so that they can overcome the collateral constraints over time and self-finance their profitable business. Third, most individuals' future income will rise because of the reform, and the permanent-income theory dictates lower saving rates. In addition, those wealthy entrepreneurs who now lose their subsidy will run down their assets, because they no longer have a self-financing motive. This third factor in particular is responsible for the initial drop in the saving rate (gray line, center panel).

To better illustrate the interactions among these co-determinants of saving, in the left panel of Figure 3 we show the total wealth held by two distinct groups of individuals. The gray dotted line is the total wealth held by the top twentieth of the ability distribution, and the black dotted line is the wealth held by the rest of the population.<sup>18</sup> Those in the first group are either active or soon-to-be entrepreneurs, and have a strong self-financing motive. This self-financing motive is an important driver of their saving and hence wealth. Note the rapid rise of the gray dotted line. By contrast, the rest of the population are mostly workers, and hence do not have a self-financing motive. Their wealth initially declines as they consume according to a higher permanent income, and also as the previously-subsidized entrepreneurs run down their wealth.

In our benchmark exercise without intertemporal consumption loans, the first two co-determinants of saving come out stronger than the third, and the aggregate saving increases fast and persistently after the reform. This will be the case even when individuals are allowed to borrow against their higher future income, as long as the consumption loan limit is not unrealistically generous (Section 3.4). This is primarily because the individuals with

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<sup>18</sup>Obviously, with the stochastic ability process, the identities of those in either group change over time.

the steepest income trajectory—i.e., talented-but-poor entrepreneurs—choose not to borrow against their future income: To the contrary, they accumulate assets so as to overcome the collateral constraint over time. Their high future income cannot be realized without their high saving rates today.<sup>19</sup>

The above patterns of saving and investment in the model are consistent with the data. In the right panel of Figure 3, we plot the average of the de-measured saving (gray dashed line) and investment (black dashed line) rates across the six countries.<sup>20</sup> In these six countries, following the reform, saving rates go up immediately, and by much more than investment rates. Investment rates are actually stagnant for the first five years, in spite of the sustained acceleration in TFP in the data (dashed line, center panel, Figure 2).<sup>21</sup>

### **Exercise 2: Distortion Removal, Opening Up, and Domestic Financial Reform**

The difference here is that the large-scale reform in year 0 has one additional component. On top of the capital account liberalization and the removal of idiosyncratic distortions, we will also reform the domestic financial institutions, increasing its  $\lambda$  from 1.5 to 7.5. The choice of  $\lambda = 7.5$  corresponds to the equilibrium external finance to GDP ratio of about 1.5, a level that few, if any, developing countries attained before 2000. In this sense,  $\lambda = 7.5$  represents a very well-functioning financial market by the developing country standard.

The results are shown in Figure 4. The reform leads to more efficient reallocation of resources, as is reflected on the TFP series. The TFP increases faster and rises higher than in Exercise 1. So does GDP. In particular, GDP more than doubles within four years, while it grew by only 30 per cent during the same interval in Exercise 1. Both Exercises 1 and 2 have the same initial condition, and Figures 2 and 4 have the same scale for TFP and GDP, facilitating visual comparison. Here TFP—and hence GDP as well—increases for two reasons: the removal of idiosyncratic distortions and the improved domestic financial market. The latter expedites the reallocation of capital among heterogeneous producers, and facilitates the entry into entrepreneurship of talented individuals. With better financial markets, undoubtedly, the post-reform transition is now much faster. In addition, the domestic financial market reform has its own permanent effect on the long-run level of TFP and GDP.<sup>22</sup>

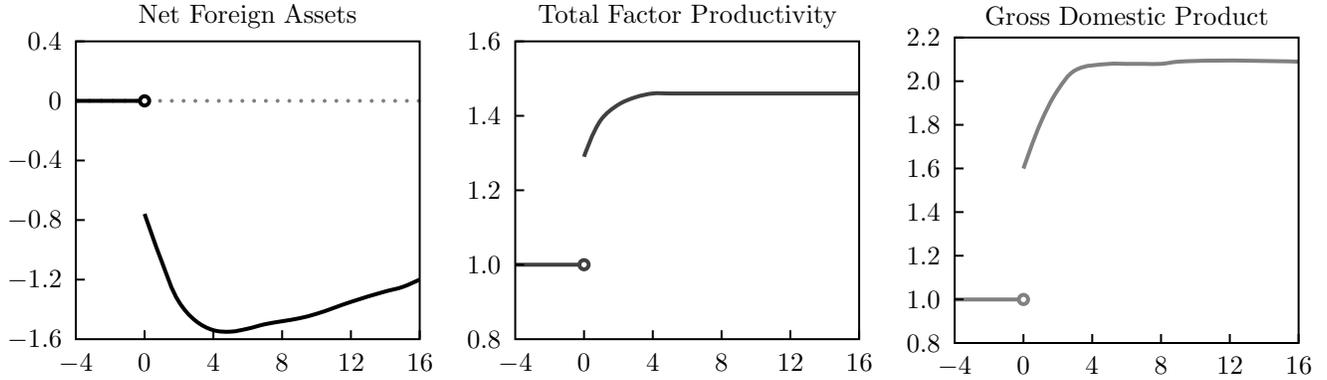
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<sup>19</sup>Not-so-talented individuals—workers—do not have a self-financing motive, and choose to dis-save and even borrow if allowed. For this reason, with an unrealistically generous borrowing limit, the aggregate saving can at least temporarily dip below investment, resulting in capital inflows.

<sup>20</sup>We first take 25-year average saving and investment rates for each of the six countries, and de-mean each series using its own, country-specific mean. Then we average them across the six countries. The data spans from five years before to 20 years after the reform, but we only show up to year 15.

<sup>21</sup>The right panel of Figure 3 looks strikingly similar to Figure 9 of Prasad et al. (2007).

<sup>22</sup>Even in the stationary equilibrium, there are needs for resource reallocation from previously-productive entrepreneurs who lose their high ability to newly-productive entrepreneurs. Financial frictions slow down



**Fig. 4:** Transition Dynamics with Domestic Financial Market Reform. In year 0, a reform is implemented to remove all idiosyncratic distortions in the economy. At the same time, the economy opens up to the world capital market. Unlike in Exercise 1, domestic financial frictions are partially eliminated, with  $\lambda$  being raised to 7.5 from 1.5. In the left panel, net foreign asset positions are measured relative to contemporaneous GDP. TFP is shown in the center panel, and GDP in the right panel, both normalized by their respective pre-reform levels.

However, it is the net foreign asset position that is most starkly different from Exercise 1. There is a massive inflow of capital into the economy after the reform.

On the investment side, opening up capital accounts increases the capital rental rate, and entrepreneurs who lose their subsidy downsize and exit, just like in Exercise 1. These forces pull down the demand in the domestic capital rental market and hence investment. However, as the collateral constraints are now a lot less stringent thanks to the domestic financial market reform (a higher  $\lambda$ ), productive individuals can enter entrepreneurship and start production immediately at a scale much larger than in Exercise 1, even if they do not have much collateral. This entry more than offsets the fall in investment by incumbent entrepreneurs and those who exit, and capital flows in from overseas to meet the excess demand immediately after the reform. As the new entrants expand their scale of operation at a high speed enabled by the better-functioning domestic financial market, investment rises accordingly. On the saving side, the effect of higher returns to saving is qualitatively the same as in Exercise 1. So is the effect of the higher future income that induces dis-saving, except that here it is much stronger given the larger increase in income. However, with the higher  $\lambda$ , entrepreneurs now have weaker self-financing motives given the more generous access to external financing. In summary, investment jumps up initially and then goes further up after the reform, much more so than in Exercise 1, while saving does not increase as fast as in Exercise 1, with the result that capital flows into the country during the post-reform transition.

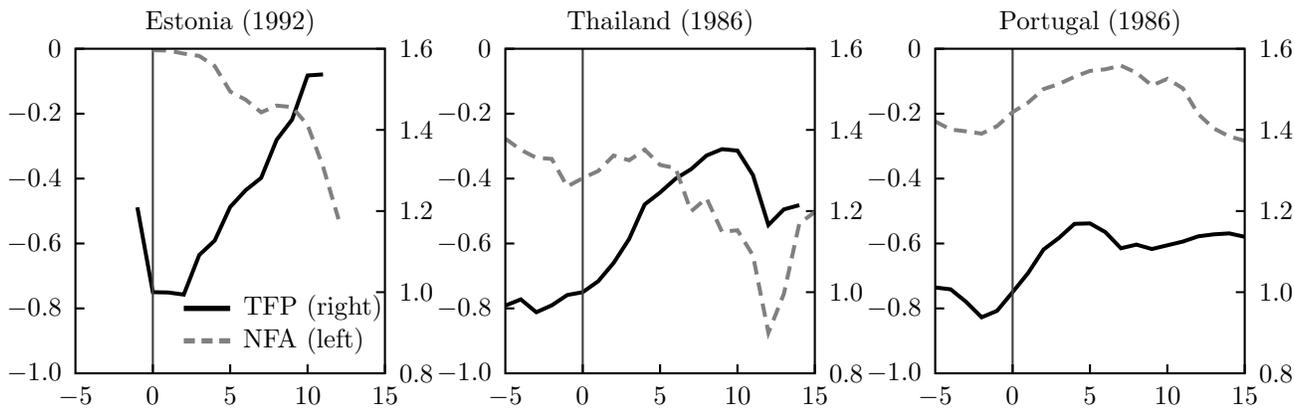
It is informative to compare Exercise 2 with the standard neoclassical growth model.

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this reallocation, and have adverse effects on the long-run output and measured TFP of the economy.

In our setup, an economy with perfect domestic credit markets ( $\lambda = \infty$ ) is isomorphic to the neoclassical growth model. If the productivity of the aggregate production function is raised in a neoclassical model, capital will flow into the small open economy and equalize the return to capital with the world level instantaneously. Although our domestic financial market reform does not take our economy all the way to the perfect-credit benchmark, we obtain results that are qualitatively similar.

Empirically, the experiences of Estonia and Thailand can be interpreted as a version of this exercise. Estonia underwent an economy-wide reform in 1992, addressing industrial policies, capital account liberalization, and the domestic banking sector (Roland, 2000). In particular, large Swedish banks set up subsidiaries in Estonia and carried out the majority of domestic financial intermediation. As can be seen in Figure 5, Estonia's experience looks similar to Figure 4. To some degree, the Thai reform of 1986 also addressed the domestic financial markets (Townsend, 2010). In particular, the fraction of bank loans coercively channeled to the government was sharply reduced. The ensuing TFP and net foreign assets series are consistent with our results in Figure 4, although the latter phase of the Thai transition is muddled by the 1997 crisis.



**Fig. 5:** TFP and Net Foreign Asset Position. Year 0 on the horizontal axis is the year of reform implementation, which is shown in parentheses next to the country name. Net foreign asset position as a fraction of PPP GDP is measured on the left scale, and aggregate TFP can be read off the right scale. TFP is normalized by its value in year 0.

Castro and Clementi (2009) also document the large-scale reform in Portugal as it joined the European Union in 1986. In addition to reducing idiosyncratic taxes and subsidies, Portugal rewrote its century-old commercial code to enhance investor protection. Castro and Clementi show that capital flowed into Portugal over the time horizon of their analysis, in response to the improved investor protection. The time-series evidence in Figure 5 is less clear-cut: TFP seems to increase the most during the first five years following the

reform, while capital inflows accelerate about five years after the reform. Such observed post-reform dynamics can be reconciled with our model if the domestic financial market reform is implemented gradually over several years.

### 3.4 Robustness to Consumer Borrowing

In all our exercises, we have not allowed consumer loans by assuming  $a \geq 0$ . Naturally, it is important to ask whether capital outflows in Exercise 1 will be reversed, once consumers are allowed to borrow against their higher future income after a reform. We have already discussed how entrepreneurs would not borrow because of their strong self-financing motive. However, those with low entrepreneurial ability will choose to be workers, and hence will want to take out consumption loans if they have little wealth. Potentially, such borrowing can pull down the aggregate saving low enough to generate a capital inflow. Recall that this is not what we observe in the data. As we discuss in Section 1 and show in Figure 3 (right panel), aggregate saving tends to increase fast together with TFP. Also, in the developing countries that we study, unsecured consumer loan markets have been almost non-existent even in the late 1990s. Nevertheless, to assess the robustness of our results to the introduction of consumer borrowing, we proceed in the following manner.

We modify the model in Section 2. In particular, we now assume that  $a \geq -B$ , with  $B \geq 0$ . That is, consumption loans are available subject to ad hoc quantity limits. Given that individuals' financial wealth can now take a negative value, we also modify the collateral constraint:

$$k_{it} \leq \max\{w_t, \lambda a_{it}\}.$$

We maintain the same linear collateral constraint on capital rental for asset holdings above a certain threshold, but then allow a small amount of rental—equivalent to a worker's annual labor income, to be exact—regardless of individuals' net worth. This specification avoids artificial delays in the entry into entrepreneurship by indebted individuals, and in effect allows more investment and borrowing than the alternative of  $k_{it} \leq \max\{0, \lambda a_{it}\}$ .

We then try different degrees of consumption loan limits  $B$ , and ask how generous the loan limit needs to be before capital flows into the small opening economy at any point during the post-reform transition of Exercise 1. We find that the economy temporarily experiences capital inflows, if  $B$  is more than seven times the pre-reform annual wage income or, equivalently, about five times the annual wage income in the post-reform steady state. If the consumption loan limits are any tighter, capital keeps flowing out of the country throughout the post-reform transition, just like in Figure 2. An unsecured consumer loan equivalent to more than seven times the annual wage income is extremely generous by any

measure, and even more so by the standard of the developing countries during the 1980s and the 1990s. We conclude that our mechanism explained in Exercise 1 is robust to the introduction of consumption loans, unless the loan limit is assumed to be unrealistically generous.

### 3.5 Welfare Consequence of Capital Account Liberalization

While economists readily agree on the merits of removing idiosyncratic distortions and reforming domestic financial institutions, there seems to be less certainty regarding the benefits of opening up to international capital flows. Our framework can be used to assess the welfare gains from capital account liberalization. In most studies in the literature, capital account liberalization improves welfare, but the magnitude is rather small.<sup>23</sup>

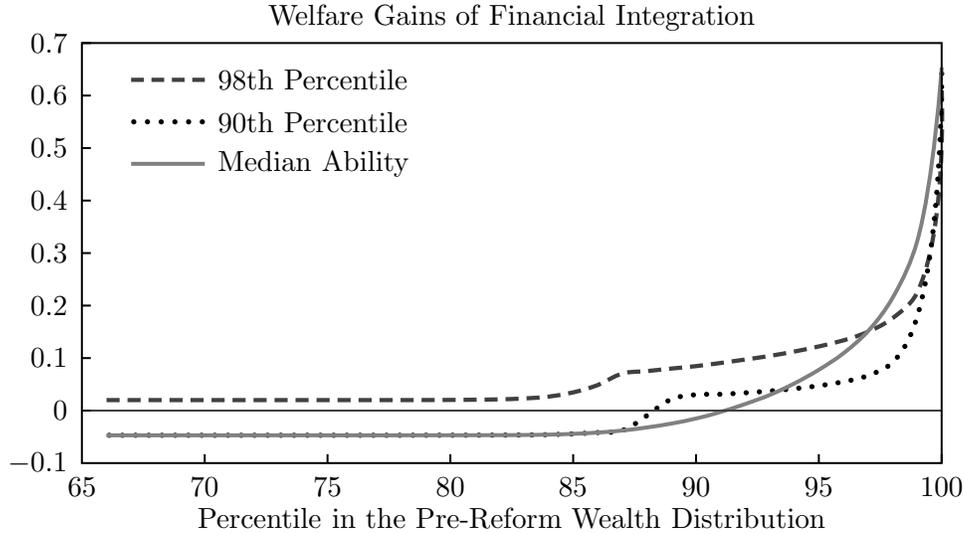
Here we focus on the interaction of capital account liberalization with other reforms. This is a very relevant question, since capital account liberalization of developing countries is typically accompanied by other reforms that remove distortions within these economies. We here analyze the marginal welfare gains from capital account liberalization by comparing the economic outcomes of removing idiosyncratic distortions while opening up (Exercise 1) with those of removing idiosyncratic distortions while remaining closed to capital flows. In either case, we assume that domestic financial markets are not affected by the reforms.

In the long run, the removal of idiosyncratic distortions accompanied by capital account liberalization leads to a bigger increase in TFP, over and beyond the pure effect from the elimination of idiosyncratic distortions alone: 38 per cent (center panel, Figure 2) vs. 28 per cent (not shown). This additional impact comes from the higher returns to saving in the open economy, which enable individuals to accumulate assets more quickly for self-financing and hence partly undo the misallocation of capital caused by collateral constraints. We report the welfare differences between these two reform scenarios, correctly accounting for the transition phase.

On the horizontal axis of Figure 6, individuals are sorted according to their wealth prior to the reform. Each curve corresponds to an ability level. For example, the dashed line is for those individuals who are more talented than all but two per cent of the population. The vertical axis measures the welfare difference in units of permanent consumption. A positive number means that this particular type of individual—where type is defined as one’s wealth and ability at the time of the reform—prefers the removal of idiosyncratic distortions accompanied by opening up of capital accounts. Similarly, a negative number

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<sup>23</sup>See Gourinchas and Jeanne (2006) and the references therein. Unlike most work in the literature that assumes a small economy populated by a representative agent, our model has heterogeneous individuals within an economy and can address differential effects of capital flows on these individuals. Aoki et al. (2007, 2009) and Mendoza et al. (2009) also provide welfare analyses with heterogeneous-agent models.



**Fig. 6:** Welfare Gains from Capital Account Liberalization. The horizontal axis is the percentile in the pre-reform unconditional wealth distribution. Each curve corresponds to an ability level. The vertical axis is welfare gains in units of relative increase in permanent consumption. A positive number implies a particular individual of a given ability and wealth at the time of the reform is better off with concurrent capital account liberalization. A negative number indicates that the individual is better off when idiosyncratic distortions are removed in a closed economy.

means that the individual prefers the removal of idiosyncratic distortions implemented in a closed-economy environment.

We find that not all individuals benefit from concurrent capital account liberalization. The wealthy directly benefit from capital account liberalization, which instantaneously give them a higher return—the world interest rate—on their financial wealth. High-ability individuals, who will eventually choose to be entrepreneurs and will likely become wealthy, are also better off with the open-economy reform. Even the talented-but-poor individuals, because they get rich over time, benefit from the higher interest rate: The left tail of the dashed line lies above zero. On the other hand, lower-ability individuals, who will choose to be workers, are better off with the closed-economy reform, unless they start out very wealthy (solid line). With capital account liberalization, capital flows out of the country following the reform. Holding other things constant, this implies less capital per worker for domestic production, and the wage is lower than in the closed-economy transition, albeit temporarily. Wage eventually rises to a higher level with capital account liberalization, but the lower wage along the transition prevails on the overall welfare of lower-ability individuals.

The very wealthy and entrepreneurs are but a small fraction of the population, and the vast majority would prefer the elimination of idiosyncratic distortions with capital account controls in place.

## 4 Alternative Theories

In this section, we compare the predictions of our model—Exercise 1 in Section 3.3, to be more specific—with those from two other models that have been used to explain certain trends in capital flows, commonly known as global imbalances. This comparison will help highlight some important aspects of our model, and therefore better place our contribution relative to the literature. We will interchangeably use the terms “Exercise 1” and “our benchmark exercise.”

First, we explore a special case of our model: one with no friction in the capital rental market, or  $\lambda = \infty$ . Individuals still face idiosyncratic risk, and can only self-insure using a risk-free asset. We assume that no borrowing is allowed for consumption smoothing purposes (i.e.,  $a \geq 0$ ). We refer to this model as the incomplete-market model. As in Exercise 1, we assume that the world interest rate is determined by a large country with a more developed financial market, which in this context means a more generous consumption loan limit. Thus, the world interest rate will be higher than the equilibrium interest rate in this incomplete-market economy with no borrowing. To be more specific, we will assume that the world interest rate is one percentage point higher.<sup>24</sup> It is clear that capital will flow out of this incomplete-market economy upon capital account liberalization, holding other things—especially TFP—constant. This is the main mechanism emphasized in the global imbalances literature (Mendoza et al., 2009).

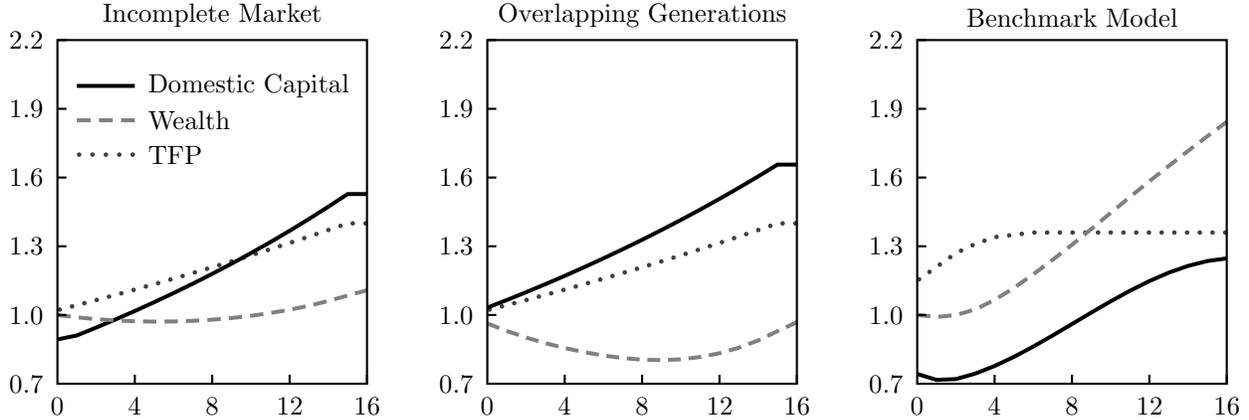
Second, we study an overlapping-generations model.<sup>25</sup> In this framework, aggregate saving is a function of exogenous TFP growth through its effect on the relative income of the young and the old, who save and dis-save for life-cycle consumption smoothing. Through this channel, this model is capable of generating a positive correlation between aggregate saving and exogenous TFP growth, when comparisons are made across balanced growth paths with different growth rates. This second model is our adaptation of the endowment economy in Chapter 3 of Obstfeld and Rogoff (1996).

Using these two models, we study the dynamics of the net foreign assets of a small economy, as it opens up to capital flows and simultaneously experiences a persistent TFP growth. Neither of the two models can generate endogenous TFP dynamics, unlike our benchmark exercise, and exogenous TFP growth needs to be imposed on them. We assume that individuals have perfect foresight about the TFP path.

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<sup>24</sup>This is the interest rate differential in the calibration of Mendoza et al. (2009).

<sup>25</sup>We choose a relatively simple overlapping-generations structure, where individuals live for 60 periods, inelastically supply labor for the first 40 periods, and then retire. We abstract from idiosyncratic risk. The discount factor is chosen so that in the closed-economy equilibrium the interest rate is four per cent, the same as the world interest rate. All other preference and technology parameters are the same as in Section 3.1.1.



**Fig. 7:** Aggregate Wealth and Aggregate Capital. The left and center panels respectively show the transition of the incomplete-market model and the overlapping-generations model, both with an exogenous TFP growth from year 0 on. The right panel reproduces Exercise 1 in Section 3.3, where a reform removes idiosyncratic distortions in year 0. The TFP in the right panel evolves endogenously. All quantities are normalized by their respective pre-reform levels, with year 0 on the horizontal axis marking the capital account liberalization.

Figure 7 shows the dynamics of aggregate capital, wealth, and exogenous TFP in these two models (left and center panels), alongside our benchmark exercise in Section 3.3 (right panel). All quantities are normalized by their respective pre-reform levels, with year zero on the horizontal axis corresponding to the capital account liberalization. For the two models, year zero also marks the beginning of the 15 years of exogenous TFP growth.

The solid lines trace the evolution of the aggregate capital used for domestic production in the incomplete-market model (left panel) and the overlapping-generations model (center panel). The production side of these two models is summarized by a standard neoclassical production function, unlike in our benchmark exercise. Therefore, following capital account liberalization, the aggregate investment in these two models is mechanically determined by the world interest rate and the exogenous TFP dynamics. Recall that aggregate investment in our benchmark exercise is determined by the evolution of the joint distribution of wealth and entrepreneurial ability.

In these two models, aggregate capital input (solid line) increases with the exogenously given rise in TFP (dotted line). Note that in the incomplete-market model there is an initial drop in aggregate capital used for domestic production. This is because domestic producers now face the higher world rental rate of capital, which is precisely the mechanism identified and exploited in the global imbalances literature. However, this effect is short-lived, and soon dominated by the effect of the rising TFP.

By contrast, the aggregate capital used for domestic production in the benchmark exercise (solid line, right panel) increases much more slowly, because of the imperfections in capital

rental markets. The corresponding investment dynamics has been shown in the center panel of Figure 3, and explained in Section 3.3. Also recall that in the benchmark exercise the TFP dynamics is endogenous, reflecting the reallocation of entrepreneurial talent and capital after the elimination of idiosyncratic distortions.

Figure 7 also shows the evolution of the aggregate wealth of domestic residents (dashed line) in the incomplete-market model and the overlapping-generations model. In both models, there is an initial decline in aggregate wealth, reflecting the dis-saving by individuals who now have higher future income. Recall that we disallow consumption loans in either model, effectively stacking the deck against capital inflows in these models: If consumer borrowing were to be allowed, aggregate saving and wealth will decline by even more. Again, the wealth dynamics in these two models is starkly different from the result of the benchmark exercise (dashed line, right panel). More important, the wealth dynamics in these two models is qualitatively different from the data we reviewed in Section 1: In the data, saving reacts more promptly to TFP accelerations than investment does. As has been explained in Section 3.3, in the benchmark exercise, aggregate wealth increases monotonically after the elimination of idiosyncratic distortions and the liberalization of capital flows (dashed line, right panel). The main difference maker for the benchmark exercise during the initial phase of the transition is the strong self-financing motive of entrepreneurs, whose accumulation of financial wealth more than offsets the dis-saving by workers who consume according to their now higher permanent income (left panel, Figure 3).<sup>26</sup>

In all three cases, net foreign asset position is the aggregate wealth of domestic residents minus the aggregate capital used for domestic production. It is clear that capital flows *in* with the TFP growth—negative net foreign assets—in the incomplete-market model and the overlapping-generations model. As for the benchmark exercise, we have already shown that capital flows *out* of the small opening economy while its TFP grows fast.

The above analysis highlights the unique features of our model where entrepreneurs are subject to frictions in the domestic capital market. In our model, TFP, saving, and investment are all endogenously determined, and our model predictions are consistent with the data from the growth acceleration episodes: Aggregate saving accelerates together with TFP, while investment lags behind, resulting in capital outflows. In our model, a substantial part of the increase in saving is explained by constrained entrepreneurs' self-financing motive, which overwhelms workers' dis-saving. At the same time, the growth in investment is slowed down by the frictions in the domestic capital market. In addition, reflecting the efficient

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<sup>26</sup>In the long run, aggregate wealth rises in all three cases. In the incomplete-market model and the benchmark exercise, wealth increases in the long run because of the higher returns to saving. In the overlapping-generations model, aggregate wealth increases as the life-cycle profile of income converges to a higher level for all age groups supplying labor.

reallocation of capital and talent, TFP grows fast.

In the alternative models we examined, investment increases in lock step with the exogenously growing TFP. As for saving, there is no force countervailing the dis-saving dictated by the rise in permanent income.<sup>27</sup> We wish to conclude that our model resolves a puzzle that is stronger than what has been addressed in the global imbalances literature.

## 5 Concluding Remarks

Our quantitative framework shows that, following a reform that eliminates idiosyncratic distortions and liberalizes capital flows, there will be a rise in TFP accompanied by capital outflows. The rising TFP reflects the efficient reallocation of capital and talent, a process slowed down by frictions in domestic capital markets. Capital outflows are driven by the rise in domestic saving in response to a higher return, the accumulation of financial wealth by constrained entrepreneurs, and the sluggish response of domestic investment to the higher productivity, with the last two being the consequences of the frictions in domestic capital markets. From our analysis, we conclude that one needs to first evaluate the workings of local financial institutions when projecting the effects of capital account liberalization.<sup>28</sup> Indeed, opening up capital accounts may well have adverse welfare consequences for the majority of the population in economies with underdeveloped domestic financial markets.

While our model successfully accounts for the co-movement between TFP and capital flows, the magnitude of capital outflows predicted by the model is too large relative to the data. From this angle, now the puzzle is why capital does not flow out faster from economies with underdeveloped domestic financial markets. This can be easily addressed by modeling the reforms as a more gradual and less drastic process, and/or by incorporating the development of domestic financial markets over time. These features would clearly be a more realistic description of the actual developing country experiences, but we abstract from them because our purpose here is to illuminate the central mechanisms of the model through clean exercises.

Also, our analysis does not distinguish capital flows by type, e.g., debt contracts vs. foreign direct investment. In recent years, we have observed developing countries accumulating debt claims on foreigners while receiving foreign direct investment (Lane and Milesi-Ferretti,

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<sup>27</sup>An earlier literature developed models where income growth and saving are positively correlated (Obstfeld and Rogoff, 1996; Carroll et al., 2000). This literature used endowment-economy models, and hence has no implications on investment. As we show in this section, the real challenge is to generate a correlation between TFP and investment that is weaker than the one between TFP and saving.

<sup>28</sup>This is one of the lessons from the East Asian financial crises of the late 1990s. Afterwards, many empirical studies have found evidence that openness works better when the local financial sector is better developed. See Obstfeld (2008) and the references therein.

2007). We conjecture that an extension of our model that allows for the joint mobility of capital and entrepreneurial talent can explain such a pattern. As in the current paper, we would observe capital in the form of debt contracts flow out of economies with underdeveloped local financial markets. At the same time, there will be wealthy foreign entrepreneurs who can bring in their own capital or collateral into developing countries to take advantage of their lower factor prices. This extension will also enable us to study the migration of talented-but-undercapitalized entrepreneurs into countries with more developed local financial markets, a phenomenon resembling what is often referred to as “brain drain.”

## Appendix: Notes on Economic Reforms

We briefly describe the six large reform episodes that took place during the 1980s and the 1990s. We emphasize the three components of reforms we use in our model: reduction of idiosyncratic distortions, capital account liberalization, and domestic financial market reform.

**Chile, 1985** Following the debt and banking crisis of the early 1980s, in 1985 the Chilean government started a round of reforms (Bosworth et al., 1994). These included the privatization of state-owned enterprises and firms taken over during the 1982 financial collapse, and the reversal of protective measures imposed during the crisis. This wave of reforms not only reinforced the broad movement toward a more market-oriented allocation of resources that had started in the mid 1970s, but also remedied some shortcomings of the earlier reforms—e.g., the earlier process of privatization allowed the formation of business conglomerates through the sale of state-owned assets, which were purchased with financing provided by the state with funds obtained by abusing the implicit bank deposit insurance. The reforms of 1985 proved to be longer-lasting. We interpreted these series of reforms as more credible efforts at removing/reducing idiosyncratic distortions in the context of our model.

Controls on capital outflows that had been imposed in 1982 were removed in 1985, although restrictions on short-term capital inflows remained.

At the time of the 1985 reform, the domestic financial markets were still reeling from the financial crisis of 1982. While the financial system developed significantly in the following decade, financial intermediation remained relatively limited through the mid 1990s.

**India, 1991** Following a balance of payment crisis, in 1991 India embarked on a broad set of reforms (Kochhar et al., 2006). These reforms included the abolition of industrial licensing and the narrowing of the scope of public sector monopolies to a much smaller number of industries; trade liberalization which included elimination of import licensing and progressive reduction of non-tariff barriers; the liberalization of investment in important services, such as telecommunications; and limited financial sector reforms.

Deregulation of capital flows began in 1991, with the liberalization of inward foreign direct and portfolio investment. Exchange rates were unified in 1993, and current account convertibility was achieved by 1994.

Gradual domestic financial sector reforms started in the mid 1990s, including the removal of controls on capital issues, and freer entry for domestic and foreign private banks. However, credit control remained throughout the 1990s.

**Israel, 1985** In 1985 a successful stabilization plan was put into place. As a consequence of budget adjustments and subsequent reforms, the principal markets (capital, foreign exchange, and labor) underwent important changes (Ben-Bassat, 2002). Government interventions in production factor markets and in finances were significantly reduced. The share of government expenditure in the GDP declined by 20 percentage points in the first ten years of the reform. More important, the composition of the budget changed from an emphasis on subsidies to “priority” industries and regions, into broader investment in infrastructure. Earlier protectionist tendencies were slowly reverted. In 1985 a free-trade agreement with the US was signed, and by 1990 all non-tariff barriers on imports from “third countries” were abolished and replaced with uniform tariffs. In 1992 a process of lowering these tariffs started.

Controls on capital flows that had been imposed in 1970 began to be reversed in 1987, and the liberalization was more or less completed by 1998. The remaining restrictions pertain to overseas investment by institutional investors and forward transactions.

Distortions to domestic financial markets remained significant until the mid 1990s. Directed credit, regulated interest rate, public ownership of major banks lasted until the mid 1990s.

**Korea, 1982** In the second half of the 1970s, the Korean government embarked on a large-scale program subsidizing heavy and chemical industries. This was a form of import substitution, and the beneficiaries were steel, petrochemical, nonferrous metals, shipbuilding, electronics, and machinery industries. This experiment ceased and began to be reversed in 1981 (Leipziger, 1997). The failed industrial policy led the government to delegate the role of investment planning to the private sector. Entry of small and medium-sized firms was deregulated from the early 1980s. The sector/industry-specific taxes were replaced by flat-rate value-added taxes in the late 1970s.

Controls on capital flows were eased first in 1979 (inward), then in 1982 (inward), and then again in 1985 (inward and outward).

Rampant distortions of the financial markets remained until the mid 1990s. Directed lending and regulated interest rates—often thought of as the legacy or the “scar” from the industrial policies of the 1970s—were phased out beginning in 1995 to join the OECD, and in 1998 to meet the IMF conditionality in the aftermath of the East Asian financial crisis.

**Mauritius, 1981** Starting with the negotiation of a structural adjustment loan with the World Bank in 1980, a process of reform began that progressively removed various distortions (Gulhati and Nallari, 1990; Dabee and Greenaway, 2001). The theme of the reforms was

to move away from a focus on import substitution, which accounted for 80 per cent of manufacturing investment during 1978–81. These reforms included the elimination of price controls, quantity restrictions on imports, and export taxes on sugar. Also included was a gradual reduction of tariffs. As part of these reforms, the government eliminated the differential tax treatment for companies under various special regimes, e.g., export promotion zones and import substitution regimes. Especially in the sugar industry (a major player well into the 1980s), most size-dependent policies were abandoned, leading to consolidations and productivity gains.

Capital account liberalization began in 1981, although it was a gradual process. Exchange rates were unpegged and managed-floated since 1983.

Domestic financial market reforms began towards the end of the 1980s, with interest rate liberalization in 1988. However, pricing and allocation of funds were heavily influenced by the central bank well into the late 1990s. The government's share of domestic commercial bank credit remained at 30–35 per cent until the late 1980s, and then dropped to 25 per cent by the mid 1990s.

**Taiwan, 1982** Much like Korea during the mid 1970s, Taiwan's response to the first oil shock in 1974 was to increase the government's involvement in the economy. The government increased spending on infrastructure (railways, roads, and airports) and implemented policies to replace imported intermediate capital goods with domestically-produced materials. The beneficiaries of such import-substitution policies were petrochemical, machinery, and steel industries. At the same time, trade barriers went up, reversing the decades-long trend of trade liberalization. With their eighth four-year plan (1982–86), the emphasis of the economic policy fell again on liberalization and internationalization, removing many of the industrial policies of the late 1970s (Leipziger, 1997).

Foreign exchange rate and capital account liberalizations took place during the mid 1980s.

Throughout the second half of the twentieth century, domestic financial markets served as instruments for the government's industrial policy. Domestic financial market liberalization started in 1989, with controls on bank loan/deposit rates abolished. New entries into the banking sector were not allowed until 1992–95. Financial markets were still tightly regulated even in the late 1990s, although privatization of some financial institutions and more liberalization began in 1994–95.

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