

# Financial reforms and capital flows: insights from general equilibrium

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**Abstract:** As a result of debt enforcement problems, many high-productivity firms in emerging economies are unable to pledge enough future profits to their creditors and this constrains the financing they can raise. Many have argued that, by relaxing these credit constraints, reforms that strengthen enforcement institutions would increase capital flows to emerging economies. This argument is based on a partial equilibrium intuition though, which does not take into account the origin of any additional resources that flow to high-productivity firms after the reforms. We show that some of these resources do not come from abroad, but instead from domestic low-productivity firms that are driven out of business as a result of the reforms. Indeed, the resources released by these low-productivity firms could exceed those absorbed by high-productivity ones so that capital flows to emerging economies might actually decrease following successful reforms. This result provides a new perspective on some recent patterns of capital flows in industrial and emerging economies.

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# 1 Introduction

How are capital flows affected by financial reforms that relax credit constraints and raise the ability of domestic firms to borrow? At first sight, one might be tempted to dismiss this question as trivial. If some domestic firms are credit constrained (which we assume to be the case!), relaxing their constraints will allow them to borrow more and increase their investment. If domestic savings are not affected by this relaxation of credit constraints (which we also assume to be the case!), this increased investment must be financed with foreign savings. This line of reasoning leads naturally to the conclusion that financial reforms raise capital inflows. Indeed, this reasoning has led many to argue that emerging economies should reform their financial systems if they want to absorb more foreign savings and speed up investment and economic growth.

Of course, things are never so simple. The first point of this paper is to show that this line of reasoning is at best incomplete and, possibly, misleading. The reason is that it does not take into account that any additional borrowing and investment by some domestic firms crowds-out investment by other domestic firms. This is far from an innocent oversight, as we prove here. The second point of this paper is that recognizing this crowding-out effect might shed light on some real-world questions regarding capital flows into and out of emerging economies. For instance, it might be the case that financial reforms in emerging economies raise rather than reduce global imbalances.

Let us start by revisiting the line of reasoning above and consider the effects of a financial reform that relaxes credit constraints and allows domestic firms to borrow more. In a closed economy, this newfound ability to borrow leads high-productivity firms to expand their investments. The resources needed for this expansion come from low-productivity firms, which are no longer able to compete and are forced to shut down. Although the savings and labor available within the economy might both be fixed in the short run, the relaxation of credit constraints leads to a better allocation of these scarce resources. In the short run, the reform does not affect the quantity of investment, but it still raises its quality. In the long run, the reform raises the capital stock, wages and savings and it therefore also raises the quantity of investment.

It is useful to think more carefully about the role of the domestic interest rate in this process. A key observation is that, if the reform is successful in raising the quality of investment, future wages will be high and this reduces the return to all types of investment today. This reduction in profitability leads marginal or low-productivity firms to close and stop investing, releasing some

domestic savings that can be used by high-productivity firms. Are these savings large enough to accommodate the increased investment demand by high-productivity firms? The answer depends on the distribution of firm productivities within the economy. If there is only a small pool of marginal or low-productivity firms, the reduction in their investments does not free enough savings and the interest rate must increase to equilibrate domestic savings and investment. If, instead, there is a large pool of marginal or low-productivity firms, the reduction in their investments frees savings in excess of those demanded by high-productivity firms and the interest rate must fall. Somewhat surprisingly, then, the effects of a financial reform that relaxes credit constraints and directly raises investment demand does not necessarily lead to an increase in the interest rate. There is a countervailing general equilibrium effect that works through wages and indirectly reduces investment demand. The size of this effect depends on the distribution of firm productivities, and it is pivotal in determining whether aggregate investment increases or decreases after a financial reform.

How does this picture change in the open economy? Consider, for simplicity, the case of the small open economy in which the interest rate is not affected by changes in the domestic demand for credit. If the domestic demand for credit increases, the reform leads to capital inflows. This is what one would expect if there is only a small pool of marginal or low-productivity firms in the economy. If instead this pool is large, the reform reduces the domestic demand for credit and leads to capital outflows. Moving away from the small open economy and allowing the financial reform to have effects on the world interest rate does not affect this result.

This theoretical insight has important implications for two real-world developments that have attracted substantial interest from academics and policymakers alike: the appearance of large global imbalances in the world economy and the puzzling observation that capital tends to flow to those emerging economies that exhibit lowest growth in productivity and output. We discuss each of these developments in turn.

A first striking development of the past two decades has been the emergence of large and persistent current account surpluses and deficits in the world economy, a phenomenon referred to as “global imbalances”. The lion’s share of these deficits has been concentrated in the United States, which began experiencing an increasing current account deficit in the mid 1990s. This deficit exceeded 1% of world GDP after 1999, and it peaked at more than 1.5% of world GDP in 2006. In the late 1990s, the main counterparts to this deficit were surpluses in emerging Asia (excluding China) and Japan. In the 2000s, however, the largest surpluses became those of China and of

the oil-producing countries. These current account deficits and surpluses have had a tremendous influence on the evolution of international asset positions. The net foreign liabilities of the United States quadrupled in size between 1998 and 2008, for instance, rising to \$3.5 trillion in 2008. In the same period, Chinese net foreign assets rose to \$1.5 trillion, which represented a third of the country's GDP in 2008.<sup>1</sup>

There is one aspect of global imbalances that has drawn the attention of economists: the deficits have been largely concentrated in industrial economies while the surpluses have been concentrated in emerging economies. This is contrary to the prediction of conventional economic theory that capital should flow towards emerging economies, where it is relatively scarce. This discrepancy between facts and theory has prompted a substantial amount of research that, broadly speaking, can be grouped into one of two categories. The first category views global imbalances as the result of unsustainable behavior by economic agents (particularly governments), which must therefore be eventually reversed. We do not comment on this view here, except for noting that no formal models of it have yet been developed. A second, and more interesting, category views global imbalances as the result of equilibrium behavior by rational agents, which might therefore persist far into the future. This literature has largely adopted the view that underdeveloped financial markets prevent capital to flow towards fast-growing, capital-scarce emerging economies. This is the narrative that, details aside, emerges from the theories recently laid forth in Caballero et al. (2008) and Song et al. (2011).<sup>2</sup> This view has also been in the mind of some important policymakers.<sup>3</sup>

The theoretical results in this paper indicate that this view needs to be qualified, since financial sector reform might increase rather than decrease global imbalances. This seems especially likely if, as Song et al. (2011) argue, the Chinese economy is characterized by a large pool of low-productivity public enterprises that are not credit constrained. These firms coexist with a smaller

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<sup>1</sup>Since the onset of the financial crisis, the magnitude of global imbalances has been reduced. At the time of writing, it is unclear whether this reduction is temporary or permanent. See Blanchard and Milesi-Ferretti (2009) and Servén and Nguyen (2010) for a discussion of this point.

<sup>2</sup>Mendoza et al. (2007) also portray global imbalances as the result of financial underdevelopment in emerging economies. In their view, it is the lack of insurance markets in emerging economies that fosters precautionary savings, lowering domestic interest rates and causing capital to flow out of these economies.

<sup>3</sup>In a well-known speech of 2005, Federal Reserve Chairman Ben Bernanke concluded that "... (S)ome of the key reasons for the large U.S. current account deficit are external to the United States, implying that purely inward-looking policies are unlikely to resolve this issue. Thus a more direct approach is to help and encourage developing countries to re-enter international capital markets in their more natural role as borrowers, rather than as lenders ... Providing assistance to developing countries in strengthening their financial institutions ... could ... increase both the willingness of those countries to accept capital inflows and the willingness of foreigners to invest there." Raghuram Rajan expressed himself in a similar vein in 2006 when, as Economic Counselor and Director of Research at the IMF, he noted that: "I will focus on a familiar issue, the problem of global current account imbalances, and will describe how financial sector reform can help narrow them ...".

pool of high-productivity private firms that are severely constrained. Under these circumstances, the model developed in this paper suggests that financial reform is likely to reduce the demand for credit in China, leading to larger global imbalances and even lower interest rates around the world.

A second striking development is that, among emerging economies, surpluses tend to be concentrated in those economies that exhibit highest growth in productivity and output. Gourinchas and Jeanne (forthcoming), for instance, examined a large sample of emerging economies and found that the cross-country correlation between productivity growth and capital inflows is negative. That is, emerging economies with high productivity growth tend to export capital, while emerging economies with low productivity growth tend to import capital. This surprising empirical regularity cannot be explained easily within standard theory and led Gourinchas and Jeanne to coin the term “the allocation puzzle” to refer to it. In a related paper, Prasad et al. (2011) examined two samples containing industrial countries and emerging economies, respectively. In the sample of industrial countries, they found a positive correlation between economic growth and capital inflows. As textbook theory suggests, in industrial countries capital flows to those countries that are capital scarce (relative to the steady state) and converge fast towards their steady state. In the sample of emerging markets, however, they found a negative correlation between economic growth and capital inflows. Contrary to textbook theory, in emerging economies capital flows to those countries that are less capital scarce (relative to the steady state) and are close to their steady states.

The theoretical results in this paper suggest that these puzzling observations could be the result of asymmetric financial development. The model developed in this paper suggests that, if there is a large pool of low-productivity firms in emerging economies, asymmetric reforms among these economies could lead to the allocation puzzle. Emerging economies that implement successful financial reforms see that many of these low-productivity firms shut down and this has two simultaneous effects: (i) increases in productivity and in the capital stock; and (ii) capital outflows. Emerging economies that implement failed financial reforms see that many of these low-productivity firms expand and this has two simultaneous effects: (i) reductions in productivity and the capital stock; and (ii) capital inflows. Thus, the allocation puzzle might be nothing but the manifestation of asymmetric financial development.<sup>4</sup>

From a modeling perspective, this paper builds on Martin and Ventura (2011), who develop a model of the macroeconomy with heterogeneous firms and credit constraints. Given its focus, the

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<sup>4</sup>There are, of course, other plausible explanations for this puzzle. Alfaro et al. (2011), for instance, argue that it is essentially driven by the behavior of public capital flows.

paper is closely related to a body of research that has studied the effects of contracting frictions on the direction and magnitude of capital flows. Gertler and Rogoff (1990) and, in dynamic contexts, Boyd and Smith (1997) and Matsuyama (2004) are some key models within this literature.<sup>5</sup> These models have been used to argue that more severe contracting frictions, by constraining credit, reduce capital inflows and sometimes even generate capital outflows in capital-scarce or high-productivity economies.

Martin and Taddei (2012) have recently challenged this view by arguing that the effects of contracting frictions on capital flows depend on the specific origin of these frictions. They build a model with two types of contracting frictions: limited pledgeability and adverse selection. While limited pledgeability tends to constrain credit and reduce capital inflows, adverse selection might do just the opposite, namely, expand credit and increase capital inflows. To some extent, the present paper also challenges the notion that more severe contracting frictions reduce capital inflows. We focus exclusively on limited pledgeability as the source of contracting frictions, but we find that: (i) the presence of contracting frictions reduces capital inflows globally, i.e. relative to the frictionless economy, and; (ii) less severe contracting frictions do not necessarily raise capital inflows locally, i.e. relative to an economy with more severe contracting frictions.

The closest paper to ours is Matsuyama (2011), which also develops a model of limited pledgeability to show that a reduction in the severity of contracting frictions has ambiguous effects on capital flows. For a given mix of investment projects, it allows entrepreneurs to borrow more, and this first effect raises capital inflows. But it also changes the equilibrium mix of investment projects. In particular, low-productivity projects with high pledgeability are replaced by high-productivity projects with low pledgeability, and this second effect tends to reduce capital inflows. Like us, Matsuyama (2011) finds that less severe contracting frictions might reduce capital inflows. But the mechanisms emphasized by both papers are different. In our model, all projects have the same pledgeability but financial reforms lead some of low-productivity ones to be abandoned because the expansion of high-productivity ones raises their costs. Thus, our results rely only on general equilibrium interactions among investment projects. In Matsuyama's model these interactions are absent since technologies are linear and the return to a given investment project is unaffected by the amount of investment in other projects.

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<sup>5</sup>Recent papers that emphasize the role of contracting frictions on different aspects of capital flows include Aoki et al. (2009), who focus on the effects of capital account liberalization; Antràs and Caballero (2009), who focus on the relationship between commodity trade and capital flows; Ju and Wei (2010), who focus on the composition of capital flows; and Buera and Shin (2011), who focus on the effects of productivity-enhancing reforms on capital flows.

The paper is organized as follows. Section two develops a world equilibrium model of economic growth and capital flows. Section three uses this model to derive the main theoretical results of the paper. Section four explores their implications for global imbalances and the allocation puzzle. Section five concludes.

## 2 A stylized model of economic growth and capital flows

This section presents a world equilibrium model of economic growth and capital flows. There are two productive resources in this world, labor and savings. The labor market is perfectly competitive but geographically segmented. The credit market is imperfect because firms cannot pledge part of their future output to their creditors. We allow countries to differ in the severity of this friction, i.e. their level of financial development. We define the world equilibrium assuming first that the credit market is geographically segmented, and then that the credit market is integrated. We refer to these opposite cases as financial autarky and financial globalization, respectively.

### 2.1 Setup

The world economy contains an infinite sequence of generations that live for two periods, youth and old age. Each generation is evenly distributed across  $C$  countries or regions, each of them containing a continuum of individuals of measure one. Each generation contains individuals with  $N + 1$  different levels of productivity. Therefore, individuals are characterized or indexed by (i) their generation:  $t = 0, 1, \dots, \infty$ ; (ii) their country:  $c = 1, \dots, C$ ; and (iii) their productivity type:  $n = 0, 1, \dots, N$ .

All individuals maximize expected old-age consumption, i.e.  $E_t \{c_{c,t+1}^n\}$ ; where  $c_{c,t+1}^n$  is the old-age consumption of type  $n$  of generation  $t$  in country  $c$ . To finance this consumption, individuals supply one unit of labor when young and receive a wage. This wage is common for all types within a generation and country. Let  $w_{c,t}$  be the wage that all types of generation  $t$  in country  $c$  receive during their youth. Since individuals only care about old age consumption, they save this wage. Since there is no risk, they invest these savings so as to maximize their return.

All individuals have access to a standard Cobb-Douglas production technology. In particular, type  $n$  of generation  $t$  in country  $c$  has access to the production function:  $F(l_{c,t+1}^n, \pi^n \cdot k_{c,t+1}^n) = (l_{c,t+1}^n)^{1-\alpha} \cdot (A_c \cdot \pi^n \cdot k_{c,t+1}^n)^\alpha$ ; where  $k_{c,t+1}^n$  is investment during youth and  $l_{c,t+1}^n$  are the workers hired in old age. Capital fully depreciates in production. As mentioned, productivity varies across

types, i.e.  $\pi^n \in \{\pi^0, \dots, \pi^N\}$ . We order types such that  $0 = \pi^0 < \dots < \pi^N = 1$ . All generations and countries have the same distribution of types. In particular, let  $\varepsilon^n \in [0, 1]$  be the fraction of individuals of type  $n$ . Thus,  $\sum_{n=0}^N \varepsilon^n = 1$ . The parameter  $A_c$  allows for differences in productivity across countries. To streamline the theoretical analysis, we assume initially that  $A_c = 1$  in all countries  $c = 1, \dots, C$ . We do allow  $A_c$  to vary across countries in Section 3.2, however, when we develop some numerical examples.

All individuals can participate in the credit market, but there is an agency cost that limits their ability to obtain credit. In particular, all types in generation  $t$  in country  $c$  can commit or pledge to their creditors only a fraction  $\phi_{c,t+1} \in [0, 1]$  of their resources in period  $t + 1$ :

$$R_{c,t+1} \cdot (k_{c,t+1}^n - w_{c,t}) \leq \phi_{c,t+1} \cdot [F(l_{c,t+1}^n, \pi^n \cdot k_{c,t+1}^n) - w_{c,t+1} \cdot l_{c,t+1}^n] \quad (1)$$

where  $R_{c,t+1}$  is the gross interest rate on credit. To capture time-series and cross-country differences in the level of financial development, we allow the friction  $\phi_{c,t+1}$  to vary across countries and over time. For simplicity, we assume that  $\phi_{c,t+1}$  is known in period  $t$ , i.e.  $E_t \phi_{c,t+1} = \phi_{c,t+1}$ .

With these assumptions and notation at hand, we can write the budget constraint of type  $n$  of generation  $t$  in country  $c$  as follows:

$$c_{c,t+1}^n = F(l_{c,t+1}^n, \pi^n \cdot k_{c,t+1}^n) - w_{c,t+1} \cdot l_{c,t+1}^n - R_{c,t+1} \cdot (k_{c,t+1}^n - w_{c,t}) \quad (2)$$

Equation (2) says that consumption consists of production minus labor and financial costs. Of course, if type  $n$  is a creditor, i.e.  $k_{c,t+1}^n < w_{c,t}$ , financial costs become negative and, in this case, we say that type  $n$  receives financial income. The problem of type  $n$  of generation  $t$  in country  $c$  consists of maximizing expected old-age consumption subject to Equations (1) and (2), taking the wage and the interest rate as given.

All transactions take place in the labor and credit markets. In the labor market, the young supply labor to the old. All young supply one unit labor, while maximization implies the following labor demands by the old:

$$l_{c,t+1}^n = \left( \frac{1 - \alpha}{w_{c,t+1}} \right)^{\frac{1}{\alpha}} \cdot \pi^n \cdot k_{c,t+1}^n \quad (3)$$

Equation (3) results from equating the wage to the marginal product of labor. Since the labor market is geographically segmented, we must match demand and supply within each of the  $C$



countries, i.e.  $1 = \sum_{n=0}^N l_{c,t+1}^n \cdot \varepsilon^n$ . This means that:

$$w_{c,t+1} = (1 - \alpha) \cdot k_{c,t+1}^\alpha, \quad (4)$$

where  $k_{c,t+1}$  is the capital-labor ratio in efficiency units, i.e.  $k_{c,t+1} \equiv \sum_{n=0}^N \pi^n \cdot k_{c,t+1}^n \cdot \varepsilon^n$ . Equation (4) simply says that the wage in country  $c$  equals the marginal product of labor evaluated at the aggregate (effective) capital-labor ratio.

In the credit market, the young borrow and lend. Let  $\bar{x}_{c,t}^n$  be the maximum amount of investment that type  $n$  can finance as a share of his/her wage or wealth. This quantity is given as follows:

$$\bar{x}_{c,t}^n = \begin{cases} \frac{R_{c,t+1}}{R_{c,t+1} - \phi_{c,t+1} \cdot \alpha \cdot \left(\frac{1-\alpha}{w_{c,t+1}}\right)^{\frac{1-\alpha}{\alpha}} \cdot A \cdot \pi^n} & \text{if } R_{c,t+1} > \phi_{c,t+1} \cdot \alpha \cdot \left(\frac{1-\alpha}{w_{c,t+1}}\right)^{\frac{1-\alpha}{\alpha}} \cdot A \cdot \pi^n \\ +\infty & \text{if } R_{c,t+1} \leq \phi_{c,t+1} \cdot \alpha \cdot \left(\frac{1-\alpha}{w_{c,t+1}}\right)^{\frac{1-\alpha}{\alpha}} \cdot A \cdot \pi^n \end{cases} \quad (5)$$

Equation (5) spells out the implications of the credit constraint in Equation (1). To understand this Equation, note that the marginal product of capital for type  $n$  is given by  $\alpha \cdot \left(\frac{1-\alpha}{w_{c,t+1}}\right)^{\frac{1-\alpha}{\alpha}} \cdot \pi^n$  and the fraction of this marginal product that can be pledged to creditors is  $\phi_{c,t+1}$ . If the interest rate is high, this fraction is insufficient guarantee and type  $n$  is credit constrained. That is, the amount this type can borrow depends on its wealth or net worth, which in this model equals the wage. If the interest rate is low, the fraction of the marginal product that can be pledged is enough to pay the interest rate and type  $n$  is not constrained.

Let  $x_{c,t}^n$  be the actual investment that type  $n$  undertakes as a share of his/her wage or wealth. Maximization implies that:

$$x_{c,t}^n \begin{cases} = 0 & \text{if } R_{c,t+1} > \alpha \cdot \left(\frac{1-\alpha}{w_{c,t+1}}\right)^{\frac{1-\alpha}{\alpha}} \cdot \pi^n \\ \in [0, \bar{x}_{c,t}^n] & \text{if } R_{c,t+1} = \alpha \cdot \left(\frac{1-\alpha}{w_{c,t+1}}\right)^{\frac{1-\alpha}{\alpha}} \cdot \pi^n \\ = \bar{x}_{c,t}^n & \text{if } R_{c,t+1} < \alpha \cdot \left(\frac{1-\alpha}{w_{c,t+1}}\right)^{\frac{1-\alpha}{\alpha}} \cdot \pi^n \end{cases} \quad (6)$$

Equation (6) describes the optimal investment policy. If the interest rate is above the marginal product of capital, type  $n$  prefers to lend. If the interest rate is equal to the marginal product of capital, type  $n$  is indifferent between investing and lending. If the interest rate is below to the

marginal product of capital, type  $n$  invests as much as possible.

Finally, we can write the law of motion of the capital stock as follows:

$$k_{c,t+1} = \left( \sum_{n=0}^N \pi^n \cdot x_{c,t}^n \cdot \varepsilon^n \right) \cdot (1 - \alpha) \cdot k_{c,t}^\alpha \quad (7)$$

Equation (7) simply says that the capital stock in efficiency units in period  $t + 1$  equals domestic investment in period  $t$  weighted by its productivity. This result follows from the assumption that capital fully depreciates and net and gross investment coincide.

Equations (4), (5), (6) and (7) describe the dynamics of the world economy as a function of the interest rates in each country, i.e.  $R_{c,t+1}$ . To complete the model, we must explain how these interest rates are determined. We consider two alternative arrangements: (i) financial autarky, in which case the credit market is geographically segmented into  $C$  local credit markets; and (ii) financial globalization, in which case there is a single global credit market.

Under financial autarky, the credit market is geographically segmented and equilibrium requires:

$$\sum_{n=0}^N (x_{c,t}^n - 1) \cdot \varepsilon^n = 0 \quad (8)$$

Equation (8) states that investment must equal savings within each country. Within a country, all types save the same but they might invest differently. If some types invest in excess of their savings and obtain credit, i.e.  $x_{c,t}^n > 1$ ; it must be because other types invest less than their savings and supply credit, i.e.  $x_{c,t}^n < 1$ . Equations (4), (5), (6), (7) and (8) provide a full description of the dynamics of the world economy under financial autarky.

Under financial globalization, there is a single integrated credit market, the interest rate is equalized across countries,

$$R_{c,t+1} = R_{t+1} \quad (9)$$

and equilibrium requires:

$$\sum_{c=1}^C \left( \sum_{n=0}^N (x_{c,t}^n - 1) \cdot \varepsilon^n \right) \cdot k_{c,t}^\alpha = 0 \quad (10)$$

Equation (10) says that world investment must equal world savings. If some countries invest in excess of their savings and obtain credit, i.e.  $\sum_{n=0}^N (x_{c,t}^n - 1) \cdot \varepsilon^n > 0$ ; it must be because other countries invest less than their savings and supply credit, i.e.  $\sum_{n=0}^N (x_{c,t}^n - 1) \cdot \varepsilon^n < 0$ . Equations (4), (5), (6), (7), (9) and (10) provide a full description of the dynamics of the world economy under

financial globalization.

### 3 Financial reforms, productivity and capital flows

This section uses the model developed above to study the effects of financial reforms on productivity and capital flows. In particular, we explore the basic mechanism through which financial reforms affect investment, the interest rate and capital flows. We first build some intuitions and then develop some concrete examples.

#### 3.1 Building intuitions

The key question that this paper addresses is how investment changes after a financial reform. Throughout, we think of a financial reform in country  $c$  as a reduction in the country-specific agency cost that limits the ability of entrepreneurs to obtain credit, i.e. as an increase in  $\phi_{c,t}$ . The main insight of our model is that such a reform has conflicting effects on investment. By relaxing credit constraints, the reform allows all entrepreneurs to expand investment. But this expansion has general equilibrium effects that reduce the return to investment, so that the reform also makes some entrepreneurs reduce their investment. The relative magnitude of these two effects, as we shall see, depends on the distribution of productivities.

To formalize the discussion, combine Equations (5) and (6) to obtain the investment of each type as a function of the interest rate and future wages:

$$i_{c,t}^n \begin{cases} = 0 & \text{if } R_{c,t+1} > \alpha \cdot \left( \frac{1-\alpha}{w_{c,t+1}} \right)^{\frac{1-\alpha}{\alpha}} \cdot \pi^n \\ \in \left[ 0, \frac{1}{1-\phi_{c,t+1}} \cdot (1-\alpha) \cdot k_{c,t}^\alpha \right] & \text{if } R_{c,t+1} = \alpha \cdot \left( \frac{1-\alpha}{w_{c,t+1}} \right)^{\frac{1-\alpha}{\alpha}} \cdot \pi^n \\ = \frac{R_{c,t+1}}{R_{c,t+1} - \phi_{c,t+1} \cdot \alpha \cdot \left( \frac{1-\alpha}{w_{c,t+1}} \right)^{\frac{1-\alpha}{\alpha}} \cdot \pi^n} \cdot (1-\alpha) \cdot k_{c,t}^\alpha & \text{if } R_{c,t+1} < \alpha \cdot \left( \frac{1-\alpha}{w_{c,t+1}} \right)^{\frac{1-\alpha}{\alpha}} \cdot \pi^n \end{cases} \quad (11)$$

We can also combine Equations (4) and (7) to express future wages as an increasing function of the current investment:

$$w_{c,t+1} = (1-\alpha) \cdot \left( \sum_{n=0}^N \pi^n \cdot i_{c,t}^n \cdot \varepsilon^n \right)^\alpha \quad (12)$$

Jointly considered, Equations (11) and (12) allow us to derive, for each interest rate  $R_{c,t+1}$ , the

equilibrium investment of each type. As usual, we refer to this relationship between investment and the interest rate as the investment demand of the corresponding type, and write it as follows:

$$i_{c,t}^n = i_c^n(R_{c,t+1}; k_{c,t}, \phi_{c,t+1}). \quad (13)$$

The individual investment demand functions in Equation (13) are always decreasing in  $R_{c,t+1}$ . To see this, consider an increase in the interest rate. Since this raises financing costs and reduces the return to investment some entrepreneurs decide to stop investing. Moreover, those entrepreneurs that still continue investing face tighter borrowing constraints and are forced to reduce their investments as well. The demand functions in Equation (13) might be increasing or decreasing in  $\phi_{c,t+1}$ . To see this, consider an increase in  $\phi_{c,t+1}$ . Holding the future wage constant, this does not affect the return to investment but it relaxes credit constraints and allows entrepreneurs to expand their investment. But this additional investment raises the future wage, and this lowers the return to investment. If a type did not invest before the increase in  $\phi_{c,t+1}$  it will not do so afterwards. Among the types that did invest before the increase in  $\phi_{c,t+1}$ , we can distinguish between those that stop investing and those that continue to invest. The former have relatively low productivity and stop investing because the return is too low with the higher wage. The latter have relatively high productivity and the relaxation of credit constraints allows them to expand their investments.<sup>6</sup>

We construct the aggregate investment demand of country  $c$  as follows:

$$i_{c,t} \equiv \sum_{n=0}^N i_c^n(R_{c,t+1}; k_{c,t}, \phi_{c,t+1}) \cdot \varepsilon^n. \quad (14)$$

The properties of this aggregate demand follow directly from the individual ones. In particular, this aggregate demand is decreasing in  $R_{c,t+1}$ . Interestingly, and this is the main insight on which we build this paper, whether this aggregate demand is increasing or decreasing in  $\phi_{c,t+1}$  depends on the distribution of types. If there is a sufficient mass of “marginal” entrepreneurs, i.e. whose return to investment is close to the interest rate, then the aggregate investment demand is decreasing in  $\phi_{c,t+1}$ . Otherwise, the aggregate investment demand is increasing in  $\phi_{c,t+1}$ .

With this observation at hand, we can trace the effect of financial reforms under financial

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<sup>6</sup>Whether the individual demand functions in Equation (13) are increasing or decreasing in  $k_{c,t}$  also depends on the type. An increase in  $k_{c,t}$  provides wealth and relaxes the credit constraint of all entrepreneurs. But since this additional investment raises the future wage and lowers the return to investment, some entrepreneurs decide to stop investing.

autarky and globalization. Under autarky, financial reforms that raise the aggregate investment demand lead to an increase in the equilibrium interest rate.<sup>7</sup> Likewise, financial reforms that lower the aggregate investment demand lead to a fall in the equilibrium interest rate. Thus, the effects of financial reforms on the domestic interest rate depend on the distribution of types. Under globalization, financial reforms that raise the aggregate investment demand lead to capital inflows and, to the extent that the country is “large”, they also raise the world interest rate. Likewise, financial reforms that lower the aggregate investment demand lead to capital outflows and they might also lower the world interest rate. Thus, the effects of financial reforms on capital flows depend on the distribution of types.

## 3.2 Examples

We consider next a series of concrete examples in which the forces described above are at work. To simplify the discussion, we consider a world economy with infinitely many small countries, i.e.  $C = +\infty$ . Our objective is to determine the effects of a financial reform in one of these countries. We model this financial reform as a one-time permanent increase in  $\phi_c$ . That is, we assume that  $\phi_{c,t} = \phi_L$  if  $t < T$  and  $\phi_{c,t} = \phi_H$  if  $t \geq T$ , with  $\phi_H > \phi_L$ . We refer to  $T$  as the reform period. In order to assess the effects of this reform, we proceed from the special to the general.

### 3.2.1 Homogenous investments

Consider first a world in which the distribution of productivities is extreme, i.e.  $N = 1$  with  $\pi^0 = 0$  and  $\pi^1 = 1$ . This world economy contains “savers” which cannot produce at all, i.e.  $\pi^0 = 0$ ; and a single type of “entrepreneurs” with high productivity, i.e.  $\pi^1 = 1$ . This is quite a popular model in international economics since it has the virtue of simplicity.

The top two panels of Figure 1 show the effects of the reform under financial autarky. The reform period is  $T = 10$ .<sup>8</sup> The top left panel shows the law of motion of the economy before and after the reform (they are the same!) and the top right panel shows the dynamics of the capital

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<sup>7</sup>Remember that, for a given capital stock, domestic savings are not affected by financial reforms. The reason is that domestic savings equal current wages and financial reforms affect only future wages.

<sup>8</sup>In the figures,  $NFA_{c,t} = \sum_{n=0}^N (x_{c,t}^n - 1) \cdot \varepsilon^n$  is defined as net capital inflows as a share of wages, and  $TFP_t$  is defined as the average productivity of investment in country  $c$ , given by

$$TFP_{c,t} = \frac{\sum_{n=0}^N \pi^n \cdot x_{c,t}^n \cdot \varepsilon^n}{\sum_{n=0}^N x_{c,t}^n \cdot \varepsilon^n}.$$

Table 1 in the appendix describes all the parameter values used in the different simulations.

stock and the interest rate. The reform has no effect on the law of motion of the economy since it affects neither the quality nor the quantity of investment. The reason is simple: both before and after the reform all the savings of the economy are invested by entrepreneurs. The reform only affects the terms at which savers and entrepreneurs trade in the credit market. By relaxing credit constraints, the reform raises the demand for credit by entrepreneurs and thus the interest rate. This raises the consumption and welfare of savers, and reduces the consumption and welfare of entrepreneurs.

The bottom two panels of Figure 1 show the effects of the reform after financial globalization. Since the country is just one among infinitely many others of the same size, the reform has no effect on the world interest rate. We see now that the reform shifts upwards the law of motion of the economy. Almost by assumption, the reform cannot affect the quality of investment, since there is only one type of entrepreneur in the country. Thus, the shift in the law of motion does not reflect an increase in the quality of investment, but instead an increase in the quantity of investment. The relaxation of credit constraints allows domestic entrepreneurs to borrow more from abroad and invest more. These capital inflows raise the steady state capital stock and growth during the transition. Savers and entrepreneurs both enjoy higher consumption and welfare.

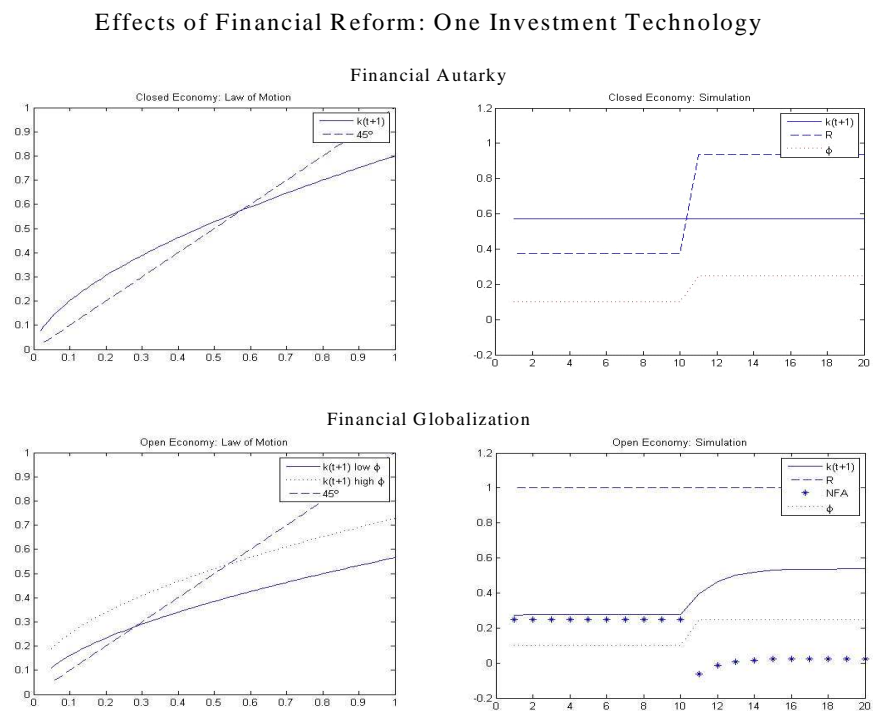


Figure 1

This first example shows a striking difference between the effects of financial reforms under financial autarky and under financial globalization. Under financial autarky, reforms do not raise average income but only change the way this income is shared. In particular, a higher share of income goes to savers relative to entrepreneurs. Under financial globalization, however, the reform raises average income and everybody wins. The key to this success is that the reform enables the economy to receive capital inflows. This story is simple and clear-cut. But it leaves out a very important aspect of financial reform: its effect on the allocation of investment and therefore the quality of investment. The next example shows this.

### 3.2.2 Heterogenous investments

Consider the possibility that country  $c$  also contains low-productivity entrepreneurs, i.e.  $N = 2$  with  $\pi^0 = 0$ ,  $\pi^1 = \pi \in (0, 1)$  and  $\pi^2 = 1$ . Thus, the country now contains “savers” and two types of “entrepreneurs”, which we refer to as low- and high-productivity. This simple extension of the previous example opens up a new role for financial reforms: improving the allocation of investment and enhancing average productivity.

The top two panels of Figure 2 show the effects of the reform under financial autarky in the extended model. Now the law of motion of the economy shifts upwards as a result of the reform. Since capital inflows are not possible, the quantity of investment is unaffected in the short run. But the reform allows the economy to improve the quality of this investment. The mechanism is quite natural: as credit constraints are relaxed, high-productivity firms borrow more and increase their investment at the expense of low-productivity firms. This raises average productivity, the steady state capital stock and growth during the transition. In the short run, only low-productivity entrepreneurs lose. In the long-run, everybody wins.

It is interesting to study the response of the interest rate to the financial reform. Since the reform raises the quality of investment, future wages are high and this reduces the return to both types of entrepreneur. This reduction in profitability leads some low-productivity entrepreneurs to stop investing, releasing domestic savings that can then be used by high-productivity entrepreneurs. Are these savings large enough to accommodate the increased credit and investment demand by high-productivity entrepreneurs? The answer depends on the proportions of low- and high-productivity entrepreneurs in the economy, i.e.  $\varepsilon^1$  and  $\varepsilon^2$ . If there is only a small pool of low-productivity entrepreneurs, the reduction in their investments does not free enough savings and the interest rate must increase. If, instead, there is a large pool of low-productivity entrepreneurs, the reduction in

their investments frees savings in excess of those demanded by high-productivity entrepreneurs and the interest rate must fall. The top right panel of Figure 2 shows a case in which this is indeed the case.

The middle and bottom panels of Figure 2 show the effects of the financial reform under financial globalization in the extended model. The law of motion has two increasing and two flat regions. When domestic savings are low (that is, the initial capital stock is so low that we are to the left of the first flat region), investment is low, the marginal product of capital is high and both types of investors are credit constrained. As domestic savings increase, all types of investment increase and the marginal product of capital declines. Eventually, this marginal product is such that low-productivity entrepreneurs are indifferent between producing or not. When this happens, we have reached the first flat region. At this point, further increases in domestic savings do not translate into higher domestic investment. High productivity entrepreneurs, who are constrained, effectively expand their investment in response to their higher savings but low-productivity entrepreneurs do not. The reason is that, if all additional savings were invested at home, the marginal product of capital would be so low that low-productivity entrepreneurs would not want to invest. But this would be inconsistent with equilibrium because high-productivity entrepreneurs are constrained and they cannot absorb these additional savings. In this flat region, then, increases in domestic savings enable high-productivity entrepreneurs to expand their investment while crowding-out low-productivity investment. The region comes to an end once all low-productivity investment has stopped. Any increases in savings beyond this point simply lead to more investment by high-productivity entrepreneurs, as their credit constraint is further relaxed. The second flat region is reached when domestic savings are so high that high-productivity entrepreneurs are no longer credit constrained.

As Figure 2 shows, the financial reform shifts the law of motion upwards, except for some parts of the flat regions. Thus, the effects of the reform crucially depend on the location of the steady state. The middle and bottom panels of the Figure display two extreme possibilities. The middle panel shows a parametrization of the model in which both steady states of the economy, before and after the reform, lie above the first flat region of the law of motion. In this case, low-productivity entrepreneurs do not invest either before or after the reform. As a result, these entrepreneurs are *de facto* savers and the reform has the same effects as in the world with only one type of investment, i.e. it affects the quantity of investment but not its quality. It leads to capital inflows that raise the steady state stock of capital and the growth rate during the transition.



## Three Investment Technologies

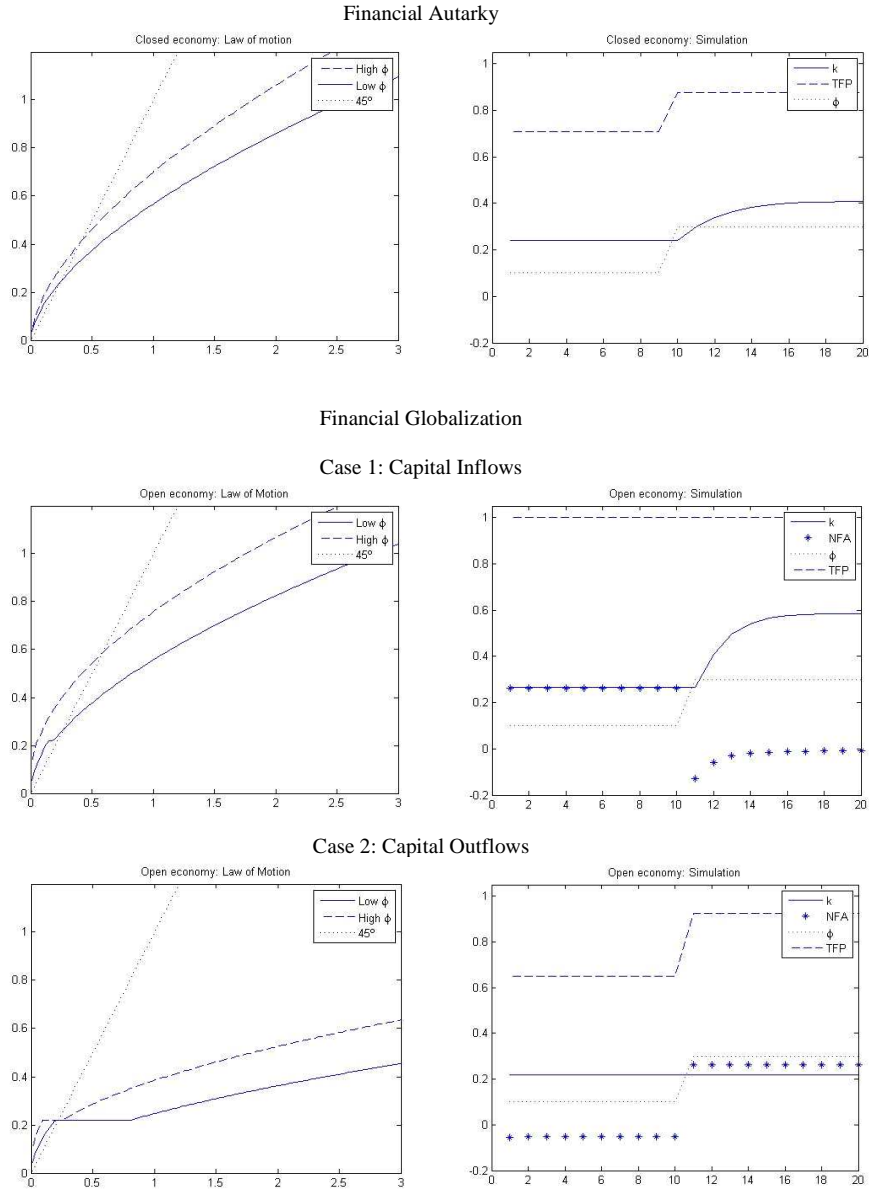


Figure 2

The bottom panel of Figure 2 shows a parametrization of the model in which the steady states before and after the financial reform both lie in the first flat region of the law of motion. In this case, the financial reform sets in motion two effects that operate simultaneously on the capital stock in efficiency units. Increased investment by high-productivity entrepreneurs raises the capital stock and wages. Increased wages, however, lower the profitability of low-productivity entrepreneurs and force some of them out of the market. How many of these entrepreneurs will stop investing? Just

enough of them to undo the effect of higher investment by high-productivity entrepreneurs on the capital stock. Only in this way will wages remain constant and allow the remaining low-productivity entrepreneurs to continue operating. This leads us to the conclusion that, in this case, the reform does not affect the capital stock. As high-productivity entrepreneurs expand and low-productivity ones contract, the average productivity of the country grows. But since the capital stock remains constant, this means that the quantity of investment falls and the reform leads to capital outflows!

The two examples in Figure 2 are revealing but, with only two types of entrepreneurs, they might strike the reader as extreme. The main message of these examples can easily be extended to the case of many technologies, i.e.  $n = N$ . This extension is shown in Figure 3. Under financial autarky, the effects of a financial reform are similar to those of the previous example. Under financial globalization, we have plotted two examples. In both of them, a reform raises average productivity and thus the quality of investment. In one of the examples, there is a small pool of marginal or low-productivity entrepreneurs and the reform leads to capital inflows. In the other example, there is a large pool of marginal or low-productivity entrepreneurs and the reform leads to capital outflows.

### N-Investment Technologies

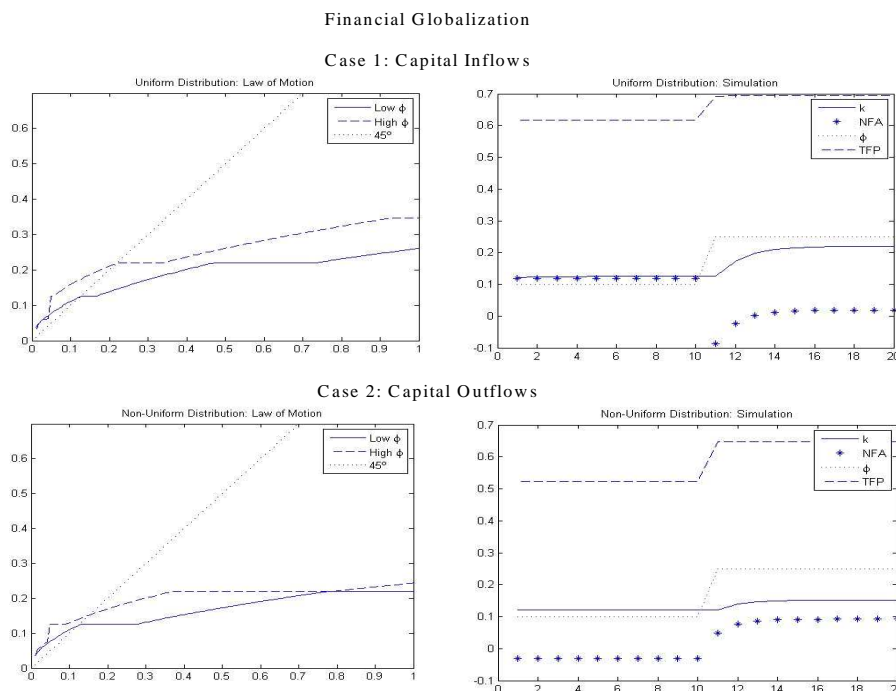


Figure 3

## 4 Potential real-world implications

The mechanisms discussed above have potentially important implications for understanding some recent trends in the world economy. We show this here by focusing on the evolution of global imbalances and the so-called “allocation puzzle”.

### 4.1 Global imbalances

A major recent development in the world economy has been the emergence of large global imbalances, i.e. large capital flows from emerging economies (mainly China) to industrial countries (mainly the United States) that have led to record-low interest rates in the latter. These global imbalances are seen as worrisome by many, since they reallocate capital from capital-scarce countries to capital-abundant ones. The efficiency at which the world economy operates cannot but decline as a result. Some also point out that these record-low interest rates create the conditions for bubbles to exist, leading to boom-bust cycles in industrial countries. Indeed, this argument has led some to blame global imbalances for the recent financial crisis of 2007-08.

What drives these global imbalances? A view shared by many academics and policymakers is that they stem from the existence of underdeveloped financial markets in China and other emerging economies. The narrative of this view is as follows: in the early 1990s, many emerging economies undertook a major process of financial liberalization. In many cases, the effects of this process were somewhat unexpected. The reason is that weak enforcement institutions did not allow entrepreneurs in emerging markets to borrow and raise investment as expected, while savers in emerging markets decided to send part of their savings abroad in search of a better risk-return combination. Contrary to the predictions of standard economic theory, financial underdevelopment thus turned some emerging market economies into capital exporters instead of capital importers. A natural corollary of this view, it seems, is that financial development in China and other emerging economies would reduce these imbalances and raise interest rates across the world.

We can use our model to evaluate these claims and, in particular, this last corollary. To do this, consider a world with two countries, i.e.  $C = 2$ . Fittingly, we refer to these countries as “East” and “West”, i.e.  $c \in \{E, W\}$ . West is richer than East and has better financial markets:  $k_{W,t} > k_{E,t}$  and  $\phi_E < \phi_W = 1$ . Once again, we model the financial reform as a one-time increase in  $\phi_E$ . That is, we assume that  $\phi_{E,t} = \phi_L$  if  $t < T$  and  $\phi_{E,t} = \phi_H$  if  $t \geq T$ , with  $\phi_H > \phi_L$ .

The first observation is that the model is broadly consistent with the views described above if

one has in mind a drastic financial reform, i.e.  $0 \approx \phi_L < \phi_H = 1$ . Before financial globalization, the interest rate in East is close to minus one. Nobody is able to borrow and average productivity is extremely low. In West, the interest rate is high and only the highest-productivity entrepreneurs invest. Financial liberalization raises the interest rate in East and lowers it in West. As a result, low-productivity entrepreneurs in East stop investing and start lending to high-productivity entrepreneurs in West. High-productivity entrepreneurs in East cannot borrow in order to raise their investment. As a result, financial globalization leads to global imbalances, i.e. capital flows that are potentially large and go from East to West.

In this scenario, a drastic reform would totally redress the picture. After the reform, high-productivity firms in East would invest the same as their counterparts in West. Since West is richer and has higher savings, this would lead to capital flows from West to East. One generation later, East would have converged to the income levels of West, just as the textbook model predicts.

Things might look quite different however if the reform is not drastic, i.e.  $0 \ll \phi_L < \phi_H \ll 1$ . What are the effects of the reform in this case? As Figure 4 shows, all of the intuitions that were developed for the small economy in the previous section carry through to this case. In the figure, the right panels show the law of motion of the relative capital stock in East, i.e.  $k_{E,t}/k_{W,t}$ , while the left panels show the evolution of  $NFA_{E,t}$  and  $TFPE_{E,t}$ . If there is a small pool of marginal or low-productivity entrepreneurs in East, the reform reduces global imbalances. Since East is large, this also leads to an increase in the world interest rate. This case, which is consistent with the corollary above, is depicted in the top panel of Figure 4. But it is also possible that there is a large pool of marginal or low-productivity entrepreneurs in East. In this case, the reform exacerbates global imbalances and leads to a reduction in the world interest rate. This case, which directly contradicts the corollary above, is depicted in the bottom panel of Figure 4.

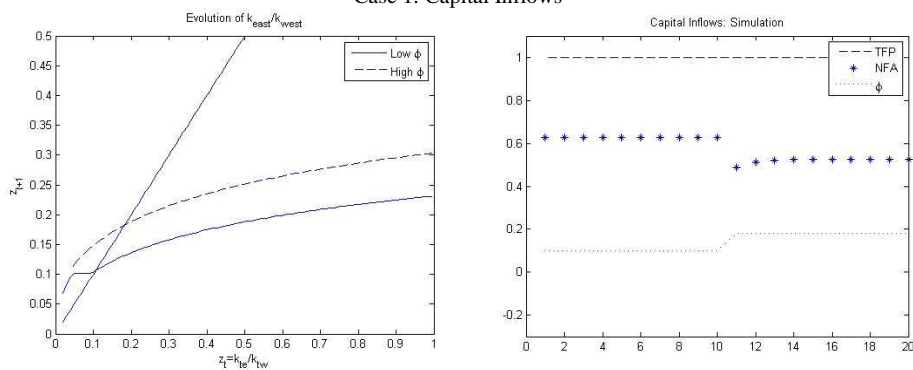
Which case is more likely to be relevant empirically? We cannot, of course, answer this question without a careful analysis of the distribution of firm productivities in China and other emerging economies. At least for the case of China, however, there is a strong presumption that there is a large pool of marginal or low-productivity companies: namely, state-owned enterprises (SOEs). Song et al. (2011) provide evidence in this regard. They study the evolution of the Chinese manufacturing sector and document how, despite losing substantial ground relative to privately enterprises (PEs) over the last two decades, SOEs still accounted for almost half of all manufacturing employment in 2007. They also document that SOEs are substantially less productive than PEs,

displaying consistently lower profitability ratios since the early 1990s.<sup>9</sup> Finally, PEs seem to be more financially constrained than SOEs, as they exhibit lower capital-labor shares and finance a lower share of their investment from bank loans and government subsidies.

## 2 Country Case: Global Imbalances

### Financial Globalization

#### Case 1: Capital Inflows



#### Case 2: Capital Outflows

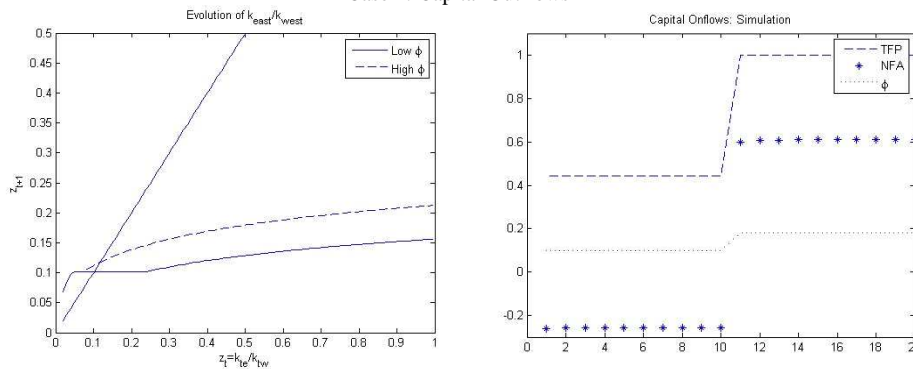


Figure 4

Viewed through the lens of our model, this evidence on Chinese manufacturing suggests that incremental financial reforms in China might actually increase capital outflows. The reason, as should be clear by now, is that financial reform enables PEs to expand at the expense of SOEs and this raises the productivity of the economy. As long as the SOEs are still operative, however, the reform does not affect the capital stock. The combination of an unchanged capital stock with a

<sup>9</sup>Song et al. (2011) define the profitability ratio as the share of total profits to fixed assets net of depreciation, and find that the differential in favor of PEs is stable around 9 percentage points. Hsieh and Klenow (2009) also find that PEs are more productive than SOEs, with a revenue TFP gap of 1.42. From a more theoretical perspective,

higher productivity of investment means that the quantity of investment must fall, and that capital outflows must increase. The question is then: how large must the reform be to ensure that wages grow enough to fully wipe out the low-productivity SOE sector? Any realistic package of financial reforms would probably fall short of this threshold and, as a consequence, it would exacerbate global imbalances and lead to even lower interest rates worldwide.

## 4.2 The allocation puzzle

The direction of capital flows within the developing world has also attracted a substantial amount of attention in recent years. Gourinchas and Jeanne (2009) examined a large sample of emerging economies and found a negative cross-country correlation between productivity growth and capital inflows. In other words, emerging economies with high productivity growth in recent decades tended to export capital, while emerging economies with low productivity growth tended to import capital. Since this empirical regularity seems to contradict standard economic theory, Gourinchas and Jeanne coined the term “allocation puzzle” to refer to it. In a related paper, Prasad et al. (2007) found a similar result when examining two samples containing industrial countries and emerging economies, respectively. In the industrial-country sample, they found a positive correlation between economic growth and capital inflows over the recent past. As textbook theory suggests, capital among industrial countries seems to have flown towards those countries that are capital scarce (relative to the steady state) and converge fast towards their steady state. In the emerging-economy sample, however, Prasad et al. found a negative correlation between economic growth and capital inflows. Contrary to the textbook theory, capital among emerging economies seems to have flown towards those countries that are less capital scarce (relative to the steady state) and are close to their steady states.

To be sure, the robustness and exact implications of these findings are still being debated.<sup>10</sup> It is nonetheless interesting to note that our model could provide a natural explanation for the allocation puzzle based on asymmetric financial development among emerging economies. To illustrate this point, we expand the example of the previous section to include a third country named “South”, i.e.  $c \in \{E, W, S\}$ . In the example, East and South are meant to respectively represent a different subset of emerging economies. We assume that, initially, East and South have the same (low) level

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<sup>10</sup>Alfaro et al. (2011) decompose capital flows into their public and private components and study their correlation with productivity growth. They claim that the puzzling pattern of capital flows among emerging economies is due to the behavior of the public component of capital flows. The private component of capital flows, according to their findings, behaves according to the predictions of standard economic theory.

of financial development, i.e.  $\phi_E = \phi_S < \phi_W = 1$ . We also assume that, initially, East and South have the same capital stock, i.e.  $k_{W,t} > k_{E,t} = k_{S,t}$ . Starting from this benchmark, we consider a financial reform in East. That is, we assume again that  $\phi_{E,t} = \phi_L$  if  $t < T$  and  $\phi_{E,t} = \phi_H$  if  $t \geq T$ , with  $\phi_H > \phi_L$ .

All previous intuition applies to this case. In particular, the reform could generate capital inflows or outflows in East. Assume that it leads to capital outflows. This is the case depicted in Figure 5. East grows faster than the world average, both in terms of average productivity and capital stock. At the same time, East exports capital. This lowers the world interest rate and leads West and South to import capital and expand their investment. Growth in East, however, is higher than in West and there is convergence between these two regions. Average productivity grows in East as low-productivity entrepreneurs stop investing and high-productivity ones expand their investments. The opposite occurs in South, which grows at the same rate as West. Its average productivity, however, declines as the low interest rate induces low-productivity entrepreneurs to raise their investment. Thus, this world exhibits not only global imbalances but also the allocation puzzle.

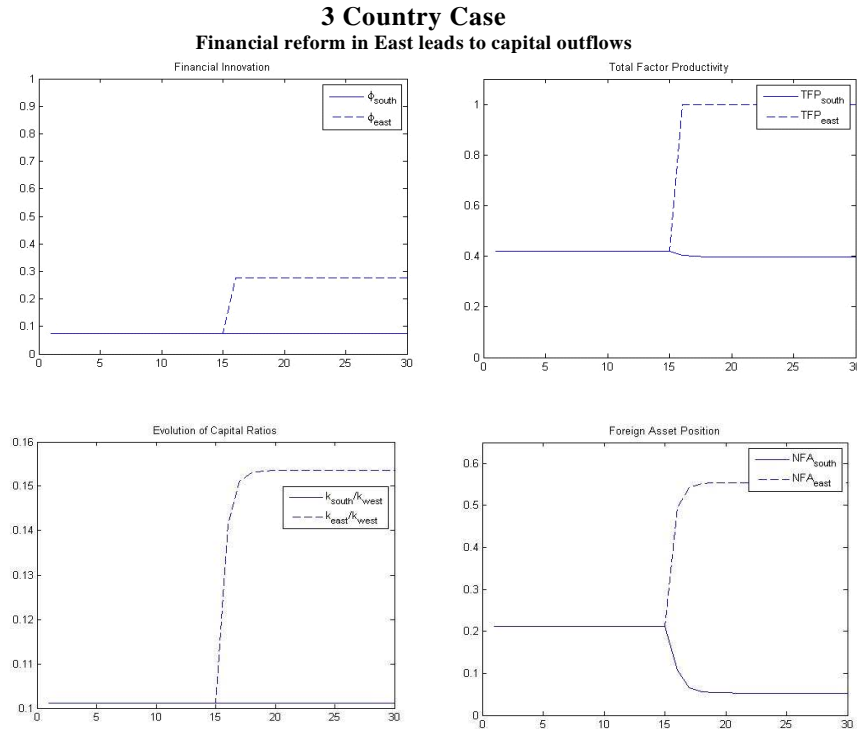


Figure 5

## 5 Concluding Remarks

This paper has developed a simple model to make a simple point: financial reforms that relax credit constraints and raise the ability of domestic firms to borrow have ambiguous effects on capital flows. The reason is that financial reforms lead to opposing effects. On the one hand, they relax credit constraints, enabling productive firms to expand their investments thereby fueling capital inflows. On the other hand, this expansion of productive firms reduces the profitability of unproductive ones and crowds-out their investment, reducing capital inflows. Which of these two effects dominates in practice depends on the distribution of firm productivities within the economy. If there is only a small pool of marginal or low-productivity firms, the reduction in their investments is small and financial reforms increase capital inflows. If, instead, there is a large pool of marginal or low-productivity firms, the reduction in their investments is large and financial reforms are more likely to increase capital outflows.

In our formal model, the only channel through which an expansion in the investments of high-productivity firms reduces the profitability of low-productivity firms is an increase in the wage. Financial reforms raise the demand for labor and, since labor markets are local, the wage increases. We have focused only on the labor market for simplicity. But our results are more general than that. In reality, firms also use many intermediate inputs that are not tradeable. Financial reforms would also raise the prices of these inputs, leading to a real appreciation and further reductions in profitability. In this regard, the results of this paper are related to the well-known Dutch-disease phenomenon.

The theoretical results of this paper are potentially important for understanding two real-world phenomena that have received a substantial amount of attention in recent years. The first such phenomenon has been the emergence of global imbalances, i.e. large and persistent capital flows from emerging economies to the developed world. These imbalances have been widely interpreted as the result of low financial development in emerging economies. This interpretation has in turn led many to argue that, in order to address global imbalances, these economies should embark in a process of financial reform. Our results cast some doubts on this implication: although large-scale financial reforms would most likely lead to lower capital outflows from emerging economies and reduce global imbalances, more gradual reforms might actually increase them. The second phenomenon has been the so called allocation puzzle, i.e. the apparently negative correlation between productivity growth and capital inflows in emerging economies. This correlation is puzzling



because it is contrary to the prediction of standard economic theory, in the sense that capital should flow to those economies where productivity growth is high. Our results provide a potential explanation for these observations, which may arise as the result of asymmetric financial reforms across the developing world.

Whether or not the mechanism that we have highlighted here is important in practice is ultimately an empirical question, the answer to which depends on the distributions of productivities within emerging economies. It thus seems crucial to further study the properties of these distributions if we are to gain a deeper understanding of the relationship between financial reforms, productivity growth and capital flows.

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## 6 Appendix: Table 1

Cases		Autarky		Financial reform leads to capital inflows		Financial reform leads to capital outflows									
A	I	O	A	I	O	A	I								
<b>Summary of Parameters used for simulation</b>															
figure	# of countries	# of industries	$\alpha$	$R^*$	$\pi_1$	$\pi_2$	$\pi_3$	$\epsilon_1$	$\epsilon_2$	$\epsilon_3$	$A_s$	$A_n$	$A_e$	$\phi_0$	$\phi_1$
A/I	1	1	2	0.6	1.1	0	-	0.4	-	0.6	2	-	-	0.1	0.3
A	2	1	3	0.6	1.1	0	0.5	0.2	0.2	0.6	2	-	-	0.1	0.3
I	2	2	3	0.6	1.1	0	0.5	0	0.75	0.25	2	-	-	0.1	0.3
O	2	2	3	0.6	-	0	0.5	0.2	0.5	0.3	2	-	-	0.1	0.3
I	3	1	6	0.6	1.1	0	3.0,4.0,5.0	0.2	=	0.2	2	-	-	0.1	0.3
O	3	1	6	0.6	1.1	0	3.0,4.0,5.0	[0.1,0.1,0.4,0.2,0.1,0.1]			2	-	-	0.1	0.3
I	4	2	3	0.6	-	0.001	0.3	0.35	0.4	0.25	1.8	1.35	-	0.1	0.18
O	4	2	3	0.6	-	0.001	0.3	0.1	0.73	0.17	1.8	1.35	-	0.1	0.18
O	5	3	3	0.6	-	0	0.3	0.1	0.8	0.1	1.8	1.35	1.8	0.075	0.275