Financial Development, Technological Change in Emerging Countries and Global Imbalances*

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Abstract

The paper shows that in a general equilibrium model with two countries, characterized by different levels of financial development, and two technologies, one more productive and more financially demanding than the other, the following stylized facts can be replicated: 1) the persistent US current account deficits since the beginning of the 90's; 2) growth of output per worker in developing countries in relative terms with the US during the same period; 3) relative capital accumulation and 4) TFP growth in these countries, also relative to the US. The more productive technology takes more time to implement and is subject to liquidity shocks, while the less productive one, along with external bond assets, can be used as a hoard to finance those liquidity shocks. As a result, after financial globalization, if the emerging economy is capital scarce and if its financial market is sufficiently incomplete, it experiences an increase in net foreign assets that coincides with a fall in the less productive investment and a rise in the more productive one. Convergence towards the steady state implies then both a better allocation of capital that generates endogenous aggregate TFP gains and a rise in aggregate investment that translates into higher growth.

Key Words: Growth, Capital flows, Credit constraints, financial globalization, technological change.

JEL codes: F36, F43, O16, O33.

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1 Introduction

This paper tries to explain four stylized facts. The first one has fueled heated debates among economists: 1) *the US have run a persistent current account deficit since the beginning of the 1990's.* Figure 1 (a) shows that the aggregate deficit of the US, Australia and the UK (U) is no longer compensated by surpluses in Europe and Japan (J), but rather by surpluses elsewhere, notably in emerging countries (EM)[1]. I confront this fact to another one, illustrated in Figure 1 (b): 2) *labor productivity increased in the EM relatively to U between the early 1990's and the mid-2000's.* Namely, Figure 1 (b) shows that the relative output per worker increased steadily during the period, and in 2003 the gains reached 25% as compared to 1990. Figure 2 analyzes the sources of the relative growth of emerging markets by presenting the relative evolution of their capital per worker and total factor productivity (TFP)[2]. It appears that 3) *the relative level of capital per worker increased during the period and is 21% higher in 2003 than in 1990.* In the meantime, 4) *the relative TFP surged during the period and was 12% higher in 2003 than in 1990.* Therefore, the strong growth of emerging markets is partly due to TFP growth, and not only to capital accumulation. TFP growth even explains two thirds of the relative growth of EM.[3]

On the one hand, the first fact has drawn a lot of attention in the literature, but the second one is at best ignored or taken as exogenous, at worst contradicted. On the other hand, the study of productivity catch-up has given birth to a huge strand of literature, but, except some exceptions, ignore the first fact. This paper aims at fueling this gap by providing a general equilibrium framework to explain these two facts as the endogenous outcome of financial integration. I focus on the interaction between U and EM since, according to Figure 1 (a), the current account surpluses in the EM constitute most of the counterpart of the U deficits. When explaining Facts 1 and 2, I will also be attentive at taking into account Facts 3 and 4, that is: relative growth in emerging countries is originated in both capital accumulation and TFP growth.

Consider the conjunction of labor productivity growth and current account surpluses in

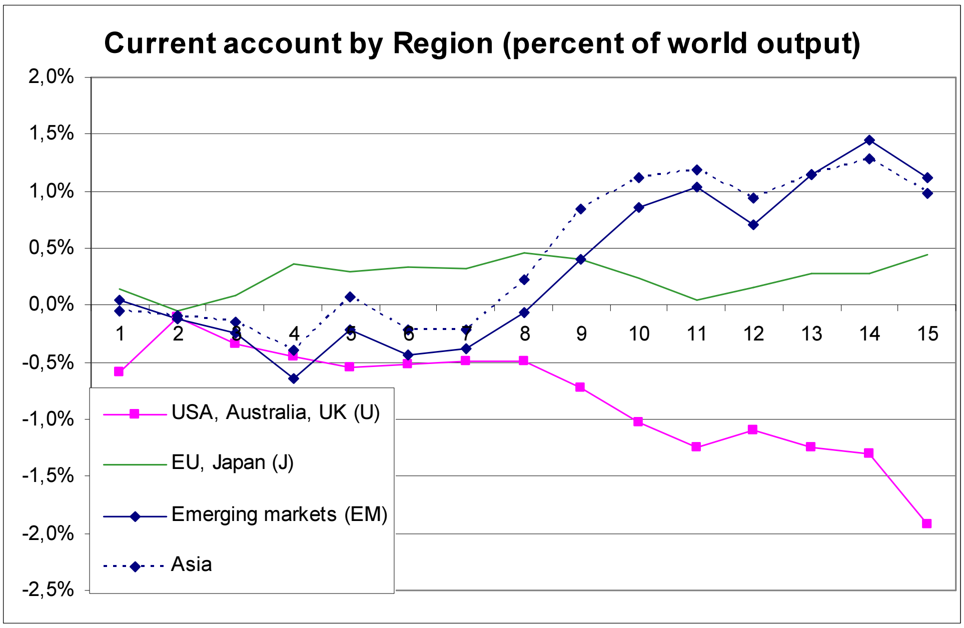
[1] I follow Caballero et al. (2008) in defining the country groups.

[2] Capital stocks in EM and U are estimated with the perpetual inventory method, using the procedure of Caselli (2004). In order to calculate TFP, I start from the following definition of production per worker: $y = Ax^{\alpha}$, where x is the level of capital per worker. TFP values in EM and U are then estimated as $y^i/(x^i)^{\alpha}$, $i \in \{EM, U\}$, where $\alpha = 0.36$.

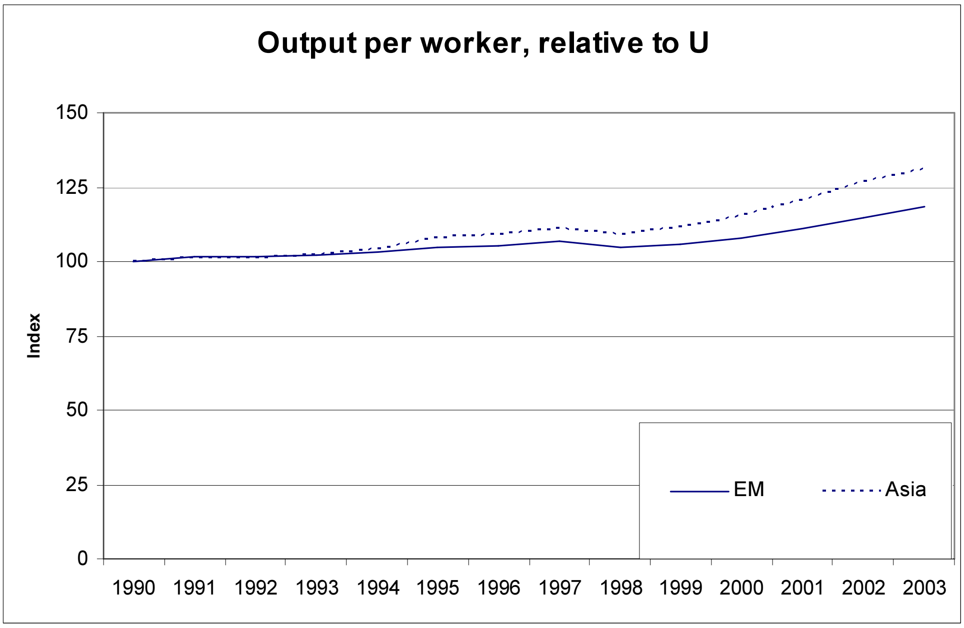
[3] The share of relative growth in EM due to TFP is calculated as $\ln\left(\frac{A^{EM}_{2003}/A^{U}_{2003}}{A^{EM}_{1990}/A^{U}_{1990}}\right) / \ln\left(\frac{y^{EM}_{2003}/y^{U}_{2003}}{y^{EM}_{1990}/y^{U}_{1990}}\right)$. Indeed, the relative growth in EM can be decomposed as follows: $\ln\left(\frac{y^{EM}_{2003}/y^{U}_{2003}}{y^{EM}_{1990}/y^{U}_{1990}}\right) = \ln\left(\frac{A^{EM}_{2003}/A^{U}_{2003}}{A^{EM}_{1990}/A^{U}_{1990}}\right) + \alpha \ln\left(\frac{x^{EM}_{2003}/x^{U}_{2003}}{x^{EM}_{1990}/x^{U}_{1990}}\right)$.

Figure 1: Stylized facts - Global imbalances and relative growth in emerging countries

(a) Global imbalances



(b) Productivity growth in emerging markets



Source: World Bank (World Development Indicators) and Penn World Tables 6.2 (Heston et al., 2006).

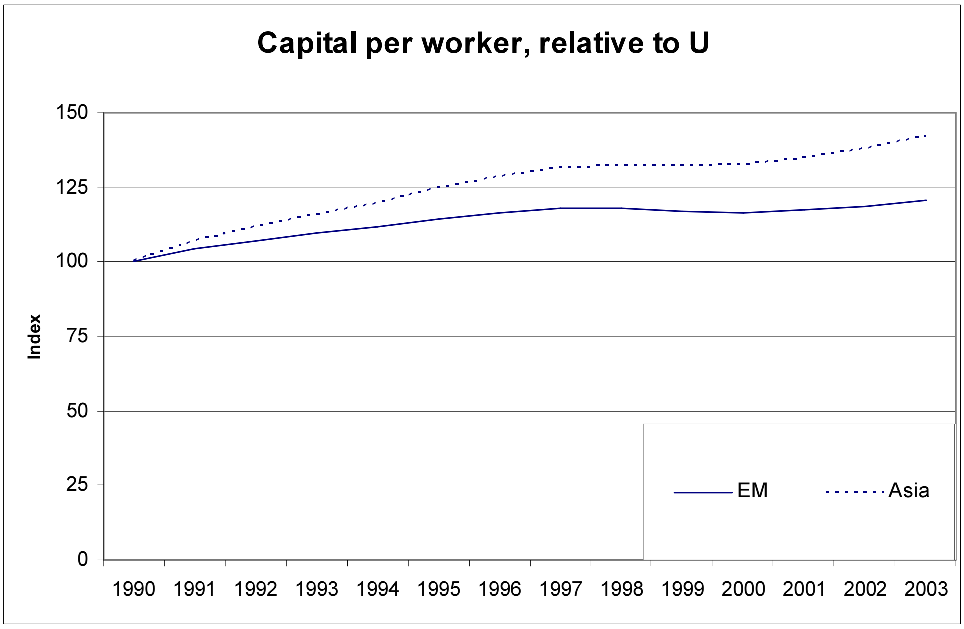
U: United States, Australia, United Kingdom.

J: Japan, Eurozone.

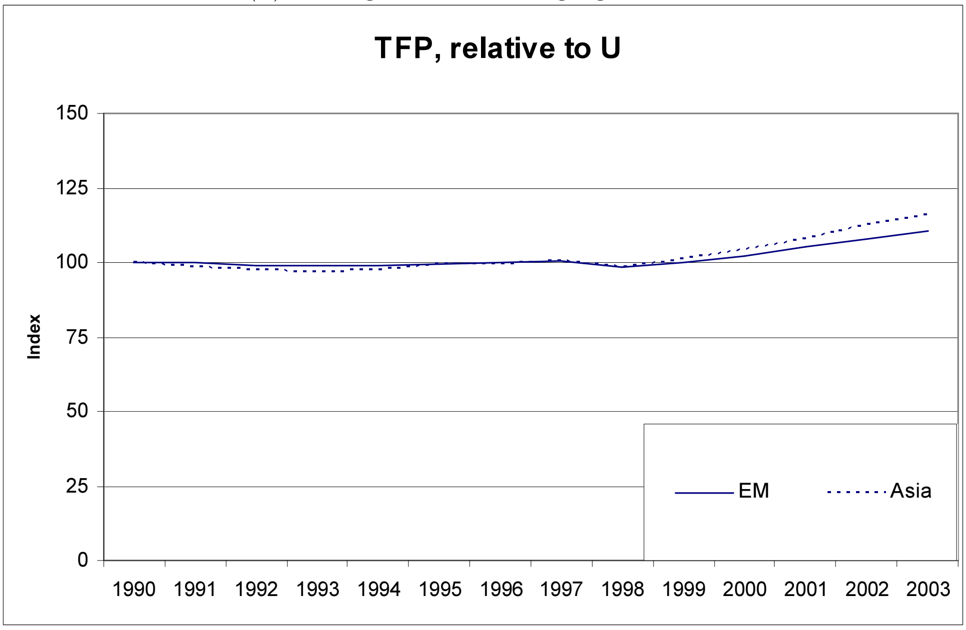
EM: Argentina, Brazil, Chile, China, Colombia, Costa Rica, Ecuador, Egypt, Hong Kong, India, Indonesia, Korea, Malaysia, Mexico, Nigeria, Panama, Peru, Philippines, Poland, Russia, Singapore, Thailand and Venezuela.

Figure 2: Stylized facts - Sources of growth

(a) Capital accumulation in emerging markets



(b) TFP growth in emerging markets



Source: Penn World Tables 6.2 (Heston et al., 2006).

U: United States, Australia, United Kingdom.

J: Japan, Eurozone.

EM: Argentina, Brazil, Chile, China, Colombia, Costa Rica, Ecuador, Egypt, Hong Kong, India, Indonesia, Korea, Malaysia, Mexico, Nigeria, Panama, Peru, Philippines, Poland, Russia, Singapore, Thailand and Venezuela.

Capital stocks in EM and U are estimated with the perpetual inventory method, using the procedure of Caselli (2004). TFP values in EM and U are estimated as $y^i/(x^i)^\alpha$, $i \in \{EM, U\}$, where $\alpha = 0.36$, y^i and x^i are respectively output per worker and capital per worker in i.

emerging markets (Facts 1 and 2). The main challenge of the study is to generate a model where financial globalization triggers both a rise in the current account and in labor productivity. The key feature of the framework is the interaction between financial development, financial globalization and technological change. The focus on technological change can be motivated as follows. Consider the definition of the current account surplus (CA):

$$CA = S - I$$

where S denotes savings and I investment. For a given amount of savings, a higher current account surplus means less investment. Therefore, to be consistent with the facts (that is a positive current account and growth in EM), savings should increase more than investment in the emerging economies. Some theories[4] that link savings to growth can account for the positive comovement between S and I but, as Gourinchas and Jeanne (2007) argue, it is not clear why S should move more than I. Trade-related growth theory (Dooley et al., 2004, 2005; Rodrik, 2006, 2007) is also a potential candidate to explain the correlation between CA and I, since the current account is the financial counterpart of the trade balance. However, these theories are in general concerned with the structure of trade in terms of exports and imports, and not with trade balance.

The focus of this paper is not on the correlation between CA and I itself. A different route is taken: the idea is that it is not the *quantity* but the *composition* of investment that matters. When there are different technologies, a positive correlation between CA and productivity does not suppose necessarily that CA and I are positively related at the aggregate level. Rather, CA should be related to the *right* type of investments, that is the most productive. This idea is rendered by introducing two technologies, one more productive than the other but submitted to idiosyncratic liquidity risk and credit constraints, as in Aghion et al. (2005). In this framework, the composition of investment depends on the availability of liquid assets used for self-insurance purposes. Since international markets are more developed financially, they provide a better access to these assets. Therefore, financial globalization can trigger a better allocation of investment in the developing economy by enabling domestic agents to hold more liquid assets in the industrial economy. This translates into higher productivity and a positive current account, even with given savings S.

For pedagogical issues and in order to convey the main intuition, the model is first developed with a constant level of savings S. The mechanism can be summed up as follows. Under autarky,

[4]Namely, Modigliani's OLG model (Modigliani, 1986) and the infinite horizon model with habit formation proposed by Carroll et al. (2000).

the liquidity risk cannot be perfectly insured in the emerging economy and the agents invest in the less productive technology for precautionary purposes. There is an overaccumulation of the less productive capital and the autarky interest rate is low relative to the industrial economy. As a result, when financial globalization occurs, the emerging economy experiences an interest rate rise. This has two effects on the emerging economy: on the one hand, it triggers a substitution between foreign assets and the less productive capital, which was in excess; on the other hand, it lowers the cost of self-insurance and thus allows the agents to invest more in the productive technology. In the developing country, CA increases and I decreases, but the composition of I changes in favor of the more productive technology. If the productivity differential between the two technologies is high, the country is poor and financial development is low, then the economy experiences a productivity surge. Therefore, production and foreign assets can rise simultaneously in the emerging market while maintaining the level of savings constant. As a corollary, the industrial economy experiences a decline in its external position. This framework therefore can fit the two stylized facts highlighted above (Facts 1 and 2). In particular, growth in the emerging country is due to TFP (Fact 4). These results still hold when the savings rate is made endogenous in a dynamic Ramsey growth model. Besides, in the calibration analysis, the relative capital accumulation in the emerging country (Fact 3) can be replicated when it is capital-scarce before financial integration.

The remainder of the paper is organized as follows: Section 2 reviews in more details the related literature; Section 3 lays down a static model to convey the main intuitions while section 4 extends it to a dynamic Ramsey model; finally, Section 5 considers the outcome of the Ramsey model in terms of medium-run dynamics and uses a calibration approach to confront the results to the four facts.

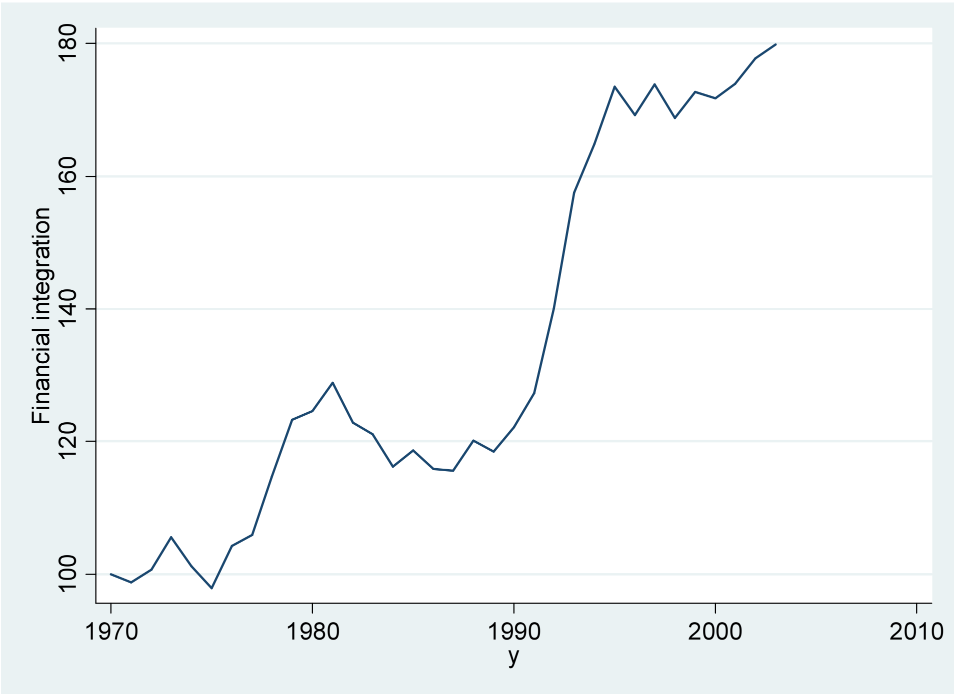
2 Related literature

This paper is related to the literature on capital composition and capital misallocation. Economists have highlighted the importance of capital quality in explaining the differences in TFP across countries (Caselli and Wilson, 2004; Caselli, 2004). Others (Banerjee and Duflo, 2005; Hsieh and Klenow, 2007; Restuccia and Rogerson, 2007) have stressed the potential gains associated with a better allocation of capital to more productive uses. In particular, some have highlighted the role of financial development in the composition of investment and technology adoption. In Obstfeld (1994), more productive technologies are riskier. As a consequence, the economy benefits from financial globalization through a greater access to insurance. Other notable contributions in that field are Matsuyama (2007), Aghion et al. (2005) and Aghion et al. (2007). A common assumption is that more productive investments are also more financially demanding. They show that endogenous changes in investment technologies can occur along the business cycle and on the equilibrium growth path. Here, I study the implication of this approach in terms of comovement of growth and current account, using the framework of Aghion et al. (2005). This approach based on capital misallocation is supported by the two last facts, illustrated in Figure 2: 3) relative capital accumulation and 4) relative TFP growth in emerging countries. In this paper's approach, growth in emerging markets is due to the convergence of the level of capital per head to its steady state, but also to the endogenous reallocation of capital to the more productive technology, which translates into a higher aggregate TFP. In the calibration analysis, I will keep track of these two additional facts.

This study is also related to the recent and rich debate on the "saving glut", concerned with the first stylized fact, that is the decline in the US current account and the matching rise in emerging countries. Some argue that the main reason is the twin deficits led by the rise in the US public deficit (Chinn and Ito, 2005); others that the origin lies in emerging markets excess savings. The latter point to the poor financial markets in emerging countries as the origin of global imbalances, but this explanation has been interpreted in different manners. First, for some, the main aspect is the incapacity of developing economies to protect themselves from episodic financial crises. Among them, Bernanke (2005) points to the role of the credit crunch that took place in the mid-90's in emerging markets and aroused the will to build reserve war-chests against future turmoils. This view has been also explored by Gruber and Kamin (2007), Obstfeld et al. (2008) and Rancière and Jeanne (2006). Others, as Caballero et al. (2008), view the financial crises as affecting the financial intermediation system itself, which increases the demand of emerging markets investors for foreign assets. Second, for others, it is the last wave of financial liberalization that revealed the flaws of the financial system of emerging markets. Mendoza et al. (2007*a*) and Mendoza et al. (2007*b*) focus on the financial integration of countries with a high demand for assets due to thin domestic financial markets. Matsuyama (2005) and Ju and Wei (2006, 2007) rely on a similar argument to explain the "uphill flows" phenomenon.

This last approach is the closest to mine. It presupposes that financial crises episodes are not at the core of the stylized facts. To back that view, consider again Figures 1 and 2. The general picture remains unaffected when excluding the countries that were primarily affected by the Asian crisis (Thailand, Korea, Indonesia and the Philippines). We also go further by excluding other countries that went through financial crises during the period (Brazil, Argentina and Russia). The main trends are unchanged. The reason is that China, which accounts for most of the stylized facts, did not suffer a crisis. In support of my approach, consider also Figure 3. This graph is constructed using the data on current account liberalization from Chinn and Ito (2007). Their index of financial openness is averaged across the U, J and EM countries (the average is weighted by GDP) and rescaled in order to be equal to 100 in 1970. Compared to the 1970's, the 1980's are more integrated financially, but the 1990's globalization surge is way more marked. The previous stylized facts could therefore be related to financial globalization. My approach is also backed by the empirical results of Forbes (2008): she finds that financial development and capital controls are the main determinants of investment in US assets.

Figure 3: Financial integration



Source: Chinn and Ito (2007) and Lane and Milesi-Ferretti (2006).

Figures are the GDP-weighted average across a sample including the countries in U, J and EM whose data are available for the whole period.

Some of the papers I review could be confronted to the above stylized facts. The common idea is that the low degree of financial development in emerging markets introduces a wedge between the social and private return to capital. This wedge induces domestic investors to turn to foreign financial markets. In Mendoza et al. (2007*a*) and Mendoza et al. (2007*b*), this wedge is due to the risk premium created by precautionary savings. In Matsuyama (2005), it comes from the presence of credit constraints among entrepreneurs. In Ju and Wei (2006, 2007), it comes from informational rents. These approaches are successful in explaining the first fact. However, they miss the second one, that is the relative TFP growth in developing countries. Others are more successful. In Caballero et al. (2008), high growth economies can still export capital if their level of development is sufficiently low. In Aghion et al. (2006), foreign investment has positive externalities on growth and is favored by domestic savings because it constitutes a collateral. However, both studies respectively take the growth rate and the savings rate as exogenous, whereas empirical evidence suggests that they cause one another (Attanasio et al., 2000). It is also doubtful that growth is constant during long periods and that savings do not react to growth perspectives. The strength of my approach is that growth, savings and investment behaviors are determined endogenously.

3 Static model

This section focuses on the impact of financial globalization on portfolio choices for one period, taking the whole amount invested as given. This helps grasping the main intuition before switching to the dynamic environment with endogenous savings. This analysis is applied to an economy with two countries in which the bond market integrates.

3.1 Economic environment

There are two countries indexed by $i \in \{I, E\}$, I denoting the industrial country and E the emerging one. For the moment, the countries' index is neglected since we are interested first in their individual behavior. Each country is populated by a continuum of identical entrepreneurs of length one who live one period. Each entrepreneur is endowed with wealth w. He makes his portfolio decisions at the beginning of the period and consumes the yield of his portfolio at the end of the period. As in Aghion et al. (2005), he can invest in three different types of assets: the bond b, the short-term investment k and the long-term investment z.

Timing : The detailed timing is the following:

- Morning: the entrepreneur invests his wealth w in b, k and z.
- Noon: the bond yields Rb, the short-term investment yields $f(k)$, with $f' > 0$ and $f'' < 0$.
- Evening: the production activity in which the long-term investment z is involved is compromised by a transitory liquidity cost shock. With probability $\frac{1}{2}$, the liquidity shock is

equal to $\Phi > 0$ and the entrepreneur has to pay Φ (bad shock). If the cost is paid, then the long-term investment yields $g(z) + \Phi$, with $g' > 0$, $g'' < 0$ and $g > f$. If not, then the whole production is lost. With probability $\frac{1}{2}$, the entrepreneur receives Φ and the long-term investment yields $g(z) - \Phi$ (good shock).

- Night: the entrepreneur consumes the return of his portfolio: either $Rb + f(k) + g(z)$ or $Rb + f(k)$, depending on the nature of the shock that occurred in the evening and on the decision to finance it.

The distribution of the liquidity cost implies that there is no aggregate risk: $\frac{1}{2}\Phi - \frac{1}{2}\Phi = 0$. The fact that the entrepreneur recovers the liquidity cost at the end of the period ensures that the shock is transitory and that the liquidity shock is neutral regarding ex post profits. In other words, Φ affects the decision to invest only through the possibility to lose $g(z)$.

z can be viewed as a long-term investment, involving more time than the short-term investment k. It is more productive than k, but it is also more risky and submitted to possible hazards. This kind of investment can be interpreted as R&D expenses, or as the cost of adopting a new technology which has to be adapted or a technology which involves more human capital. The liquidity cost can be viewed as a shock threatening the completion of the investment process. For example, the new machines have to be adapted to a new legislation or the entrepreneur that has acquired new skills falls ill. In either case, all the investment expenditure can be lost if the liquidity shock is not overcome.

Insurance : Since there is no aggregate risk, the liquidity shock can be perfectly hedged. But, because of imperfect financial markets, only a fraction $1-\rho \leq 1$ can be insured. The entrepreneur thus faces a liquidity shock $\phi = \rho\Phi$ with probability $\frac{1}{2}$ and receives ϕ with probability $\frac{1}{2}$. ϕ is therefore the resulting perceived liquidity shock. It summarizes the level of financial markets incompleteness.

Financing constraints : At noon, there are no credit markets, so the entrepreneurs who suffer from the liquidity cost cannot pay except if:

$$\phi \leq f(k) + Rb$$

The other entrepreneurs receive ϕ so they do not face any financing constraint.

Therefore, because it is more risky, the long-term investment is more financially-demanding and more vulnerable than the short-term one. On the contrary, $f(k)$ and the yield from b can be used to secure the long-term production. (k, b) can therefore be viewed as the "liquid portfolio", because it can be liquidated without cost in order to pay for the transitory shock.

3.2 Individual decisions

Entrepreneurs maximize their end-of-period expected consumption:

$$\max_{\{k,b,z\}} Rb + f(k) + \frac{1}{2}g(z) + \mathbf{1}_{\{f(k)+Rb\geq\phi\}}\frac{1}{2}g(z) \tag{1}$$

$$\text{s.t } b + k + z \leq w$$

With probability $\frac{1}{2}$, entrepreneurs face the good shock and consume $Rb + f(k) + g(z)$. With probability $\frac{1}{2}$, they face the bad shock and consume $Rb+f(k)+g(z)$ if they can pay ϕ ($f(k)+Rb \geq \phi$). If they cannot ($f(k) + Rb < \phi$), then they consume $Rb + f(k)$. If ϕ is small, then the entrepreneur would choose the first best portfolio maximizing $Rb + f(k) + g(z)$. But if ϕ is high, then the first best portfolio would violate the financing constraint. The entrepreneur would have to choose whether to satisfy the constraint and get $g(z)$ or to violate the constraint and get $g(z)$ only with probability $\frac{1}{2}$. Indeed, if z is sufficiently productive with regards to the liquid portfolio, it can be profitable to choose not to satisfy the constraint, even at the expense of the risk of losing $g(z)$. This program is therefore not standard. To understand individual decisions, I consider first the case in which the entrepreneurs want to overcome the bad shock. In that case, they have to satisfy the financing constraint. The corresponding program can be written as:

$$max_{\{k,b,z\}} Rb + f(k) + g(z) \tag{2}$$

$$\text{s.t.} \begin{cases} b + k + z \leq w & (\lambda \geq 0) \quad \text{(BC)} \\ \phi \leq f(k) + Rb & (\gamma \geq 0) \quad \text{(FC)} \end{cases}$$

(BC) and (FC) are respectively the budget and financing constraints and λ and γ are the corresponding Lagrange multipliers. The first-order conditions associated with this program yield the following results:

$$f'(k) = R$$

$$g'(z) = R(1 + \gamma)$$

The marginal productivity of the short-term investment must be equal to the return of the bond, which determines k, whether (FC) is binding or not. This comes from the fact that (FC) does not interfere with the arbitrage between k and b. In other words, the return of the liquid portfolio (k, b) must be maximized, either to optimize the entrepreneur's consumption or to satisfy the financing constraint (FC).

Either (FC) is not binding ($\gamma = 0$) and $g'(z) = R$, or (FC) is binding ($\gamma > 0$) and $\phi = f(k) + Rb$. In that case, $g'(z) > R$: the entrepreneur cannot invest as much as he would like in the long-term investment z.

There are two possible solutions:

- If $f(k^*) + Rb^* \geq \phi$, (FC) is not binding and the solution is the first best one, labeled (k^*, z^*, b^*):

$$k^* = f'^{-1}(R), \qquad z^* = g'^{-1}(R), \qquad b^* = w - k^* - z^*$$

- If $f(k^*) + Rb^* < \phi$, the first best allocation is not implementable so (FC) is binding. The solution is the constrained one, labeled $(\bar{k}, \bar{z}, \bar{b})$:

$$\bar{k} = k^*, \qquad \bar{b} = \tfrac{\phi - f(k^*)}{R}, \qquad \bar{z} = w - k^* - \bar{b}$$

For a given R, if the entrepreneur is constrained, we have $\bar{b} > b^*$ and $\bar{z} < z^*$. The entrepreneur under-invests in the more productive technology as compared to the first-best solution because he has to hold an additional amount of bonds in order to satisfy the financing constraint.

Consider next the case where entrepreneurs anticipate that they will not be able to overcome the bad shock, which means that $\phi > f(k) + Rb$. Therefore, they anticipate that they will get $Rb + f(k) + g(z)$ with probability $\frac{1}{2}$ (good shock) and $Rb + f(k)$ with probability $\frac{1}{2}$ (bad shock). They solve the following programme:

$$max_{\{k,b,z\}} Rb + f(k) + \frac{1}{2} g(z) \tag{3}$$

$$\text{s.t. } w \geq b + k + z$$

The first order conditions lead to the following results:

$$f'(k) = R$$

$$g'(z) = 2R$$

which yields the following solution:

$$k^{**}(R) = k^*(R), \qquad z^{**}(R) = g'^{-1}(2R), \qquad b^{**}(R) = w - k^* - z^{**}$$

(k^{**}, z^{**}, b^{**}) is labeled the "risky" allocation. The production of the long term investment is less efficient so the entrepreneur invests less in z than in the first best case: $z^{**}(R) < z^*(R)$.

The following lemma shows when this risky allocation can be ruled out:

Lemma 3.1 *(General case):*

For a given R, if $g'\left(w - f'^{-1}(R) - \frac{\phi - f'^{-1}(R)}{R}\right) \leq 2R$, *then the solution to Problem (1) is the solution to Problem (2):*

$$k(R) = k^*(R), \qquad z(R) = \min(z^*(R), \bar{z}(R)), \qquad b(R) = \max(b^*(R), \bar{b}(R))$$

Proof: If $z^*(R) \leq \bar{z}(R)$, then the first best is implementable and the solution is $z^*(R)$. If $z^*(R) > \bar{z}(R)$, then the solution is either $\bar{z}(R)$ (the entrepreneur chooses to satisfy the financial constraint) or $z^{**}(R)$ (the financial constraint is violated and the entrepreneur takes into account the fact that the long-term production is less efficient).

If $\bar{z}(R) \geq z^{**}(R)$, then, since $k^*(R) = \bar{k}(R) = k^{**}(R)$, $\bar{b}(R) \leq b^{**}(R)$. As a consequence, $\phi = R\bar{b}(R) + f(k^*(R)) \leq Rb^{**}(R) + f(k^*(R))$: the financing constraint is satisfied for $z^{**}(R)$. Besides, $g'(z^{**}(R)) > R$. If $z = z^{**}(R)$, the entrepreneur could be better-off by increasing z without violating the financing constraint. Therefore, the entrepreneur would prefer $z = \bar{z}(R)$ over $z = z^{**}(R)$. Finally, according to the definitions of $z^{**}(R)$ and $\bar{z}(R)$, $\bar{z}(R) \geq z^{**}(R)$ is equivalent to $g'\left(w - f'^{-1}(R) - \frac{\phi - f'^{-1}(R)}{R}\right) \leq 2R$.[5] ■

Provided that $\bar{z}(R) \geq z^{**}(R)$, the risky allocation can be ruled out and the entrepreneurs' program can be reduced to a standard constrained maximization problem, which corresponds to Problem (2). If, besides, $z^*(R) > \bar{z}(R)$, which means that $g'(\bar{z}(R)) > R$, then the constrained allocation is chosen. Therefore, the range of w and ϕ over which the entrepreneurs choose the

[5] Note that if $\bar{z}(R) < z^{**}(R)$, the financing constraint is binding for $z^{**}(R)$. The entrepreneur has the choice between investing $\bar{z}(R)$ with a higher productivity ($g(z)$) or investing a higher amount $z^{**}(R)$ with a poorer average technology ($\frac{1}{2}g(z)$). This case is inconclusive: depending on the parameters and on R, $\bar{z}(R)$ or $z^{**}(R)$ could be chosen.

constrained allocation is defined by

$$R < g'\left(w - f'^{-1}(R) - \frac{\phi - f'^{-1}(R)}{R}\right) \leq 2R$$

On the one hand, if the entrepreneur is poor (w low) and faces large liquidity shocks (ϕ high), he might not be able to choose the first best allocation because he would not be able to overcome the bad shock. On the other hand, if the entrepreneur is too poor and faces too large liquidity shocks, then it could be too costly to satisfy the financing constraint and the entrepreneur might choose the risky allocation. For intermediary levels of w and ϕ, he chooses the constrained allocation.

3.3 Comparative statics

The approach here is to compare the investment decisions under autarky and financial globalization, defined by cross-border trade in bonds. As in Mendoza et al. (2007a), the two countries are supposed to be identical, except for the level of market incompleteness ϕ. The industrial country I is financially developed while the emerging one E is not. In order to be more specific, I define the two following cases:

- Perfect financial markets (PFM): $\phi = 0$. The entrepreneurs are perfectly insured against liquidity shocks so the first-best decisions apply.
- Imperfect financial markets (IFM): the parameters of the model are such that the PFM allocation is not implementable under autarky: $f(k^*(R^{a*})) < \phi$, where R^{a*} is the autarky interest rate that would prevail under PFM.

We assume then that the industrial country I has PFM, while the emerging country E has IFM.

Two types of equilibria are compared:

- The autarky equilibrium, defined by the zero-net demand for bonds in each country: $b^I = b^E = 0$.
  $\bar{R}^a$ denotes the autarky interest rate under IFM (that is in E) and R^{a*} the autarky interest rate under PFM (that is in I).
- The financial globalization equilibrium, defined by the ability to trade bonds between countries. It implies a world zero-net demand for bonds: $b^I + b^E = 0$.

We are interested in the way financial globalization affects the net external position b, investment in both kinds of capital k and z, and production in both countries.

3.3.1 Autarky

Consider the investment decisions under perfect and imperfect financial markets when the economy is under autarky. For any variable X, X^{a*} denotes its autarky value under PFM and $\bar{X}^a$ its autarky value under IFM. We solve first for the portfolio choices and then derive a proposition for I and E.

Under PFM:

Under autarky, $b^{a*} = 0$ so $z^{a*} = w - k^{a*}$, according to the resource constraint. The optimal allocation satisfies $g'(w - k^{a*}) = f'(k^{a*})$, which defines the level of short term investment k^{a*}. Then we can infer the level of long-term investment $z^{a*} = w - k^{a*}$ and the autarky interest rate $R^{a*} = f'(k^{a*})$.

Under IFM:

By definition of IFM, $f(k^*(R^{a*})) < \phi$. This means that the first-best portfolio cannot be implemented under autarky, so the solution is either the constrained or the risky one. Let's consider the constrained solution: under autarky, $\bar{b}^a = 0$ so, since the credit constraint is binding, $f(\bar{k}^a) = \phi$, which defines $\bar{k}^a$ as $\bar{k}^a = f^{-1}(\phi)$. Then we can infer $\bar{R}^a = f'(f^{-1}(\phi))$ and $\bar{z}^a = w - f^{-1}(\phi)$.

In order to rule out the risky allocation under autarky in E, we make the following assumption:

Assumption 3.1 *(Ruling out the risky allocation under autarky in E):* $g'(w - f^{-1}(\phi^E)) < 2f'(f^{-1}(\phi^E))$.

Assumption 3.1 insures that $\bar{z}(\bar{R}^a) \geq z^{**}(\bar{R}^a)$ in E, which is sufficient to rule out the risky allocation (Lemma 3.1) for $R = \bar{R}^a$. It requires that wealth w is not too low and that the degree of market incompleteness ϕ is not too high. Otherwise, the financing constraint could be so stringent that the entrepreneur would rather violate it, even if the long-term production is at risk. Under Assumption 3.1 and IFM, the constrained solution exists in autarky.

Proposition 3.1 *(General case): Autarky*

Under Assumption 3.1, the constrained allocation is a solution in E under autarky while the first-best allocation is chosen in I. If the constrained allocation is indeed chosen in E, the autarky *stock of k is higher, the stock of z is lower and the interest rate is lower in E than in I.*

Proof:

By definition of IFM, $f(k^*(R^{a*})) < \phi^E$, which implies that $f(k^*(R^{a*})) < f(\bar{k}(\bar{R}^a))$. This yields $k^*(R^{a*}) < \bar{k}(\bar{R}^a)$ (or, alternatively, $k^{a*} < \bar{k}^a$).

As a corollary, since $z = w - k$, $z^*(R^{a*}) > \bar{z}(\bar{R}^a)$ (or, alternatively, $z^{a*} > \bar{z}^a$). Similarly, $R = f'(k)$, so $\bar{R}^a < R^{a*}$.

Finally, I has PFM, so the first best allocation is chosen. E has IFM, and Assumption 3.1 rules out the risky allocation in E for $R = \bar{R}^a$, according to Lemma 3.1. Therefore, the constrained allocation is compatible with autarky. ■

Figure 4 illustrates the mechanism. It represents the demands for bonds and for short-term and long-term capital in a country with perfect financial markets (the industrial country) and a country with binding financing constraints (the emerging country). These countries differ only with regards to the level of financial development. The short-term investment k is decreasing in R and it is identical in both countries since it follows the same optimality rule. The bond b is increasing with R in both countries, but, for a given interest rate, the demand for bonds is higher in the constrained economy because of the precautionary hoarding motive. As a corollary, the demand for long-term investment is lower, because less resources are available. In order to equilibrate the domestic bond market, the autarky interest rate has to be lower in the constrained country than under PFM so that bond holdings are discouraged. The corresponding level of short-term capital is higher in the constrained country than in the IFM one since b and k are substitutes, while the level of long-term capital is lower.

The consequence of the binding financing constraint in the emerging country is that there is an over-accumulation of the short-term investment k. Because of financial markets imperfections, it has to be used as a store for liquidity to avoid compromising the production involving the long-term investment. As a consequence, because of the resource constraint, there is an under-accumulation of the long-term investment z.

3.3.2 Financial globalization

What is the effect of the possibility to trade bonds between countries on foreign assets, investment and production, from a comparative statics point of view? In order to answer this question, remember that Proposition 3.1 showed that $\bar{R}^a < R^{a*}$. For the world bond market to clear, the world interest rate R^o will lay between the two autarky interest rates. We will thus have: $\bar{R}^a < R^o < R^{a*}$. When capital markets integrate, the industrial country experiences a drop in its interest rate while the emerging one experiences a rise in its own rate.

Investment

Proposition 3.2 *(General case): Effect of financial integration on investment*

Under Assumption 3.1, a solution where the constrained allocation is chosen under general equilibrium in E exists and exhibits the following features:

- *When financial markets integrate, I experiences a drop in the interest rate. Besides, k and z rise and b becomes negative.*
- *When financial markets integrate, E experiences a rise in the interest rate. Besides, k falls, z rises and b becomes positive.*

The formal proof is provided in the appendix.

As for the effect of financial markets integration in the industrial country, the intuition is as follows: when financial markets integrate, the industrial economy experiences a drop in the interest rate, so the entrepreneurs take advantage of the new financing opportunities by increasing their debt and reallocating their resources in favor of the productive investments.

For the effect of financial globalization in the emerging country, the mechanisms are different. Differentiating the financing constraint (FC) with respect to R yields:

$$\frac{\partial \bar{b}}{\partial R} = \underbrace{-\frac{\partial \bar{k}}{\partial R}}_{\text{Substitution effect}>0} \underbrace{-\frac{\bar{b}}{R}}_{\text{Wealth effect }<0 \text{ or } >0}$$

The first term of the derivative represents the substitution effect and it is positive. When the bond return R rises, there is a substitution between the bond and the short-term investment in favor of the former. The second term represents the wealth effect and depends on the sign of the amount invested in the bond. If the entrepreneur is indebted, then a rise in R increases debt repayments. In order to satisfy the financing constraint, a further decrease in the debt level is therefore required (i.e. a further increase in b). The wealth effect is then positive. If, on the opposite, the entrepreneur holds positive claims, then an increase in R would stimulate his revenues. Therefore, he does not need to raise b a lot to satisfy the financing constraint. The wealth effect is then is negative. Notice that in this particular case where $\bar{b}$ starts from zero,

$\bar{b}$ becomes positive after an increase in the interest rate, since there is no wealth effect around $\bar{b} = 0$.

Similarly, differentiating the budget constraint (BC) with respect to R and replacing the derivative of b yields:

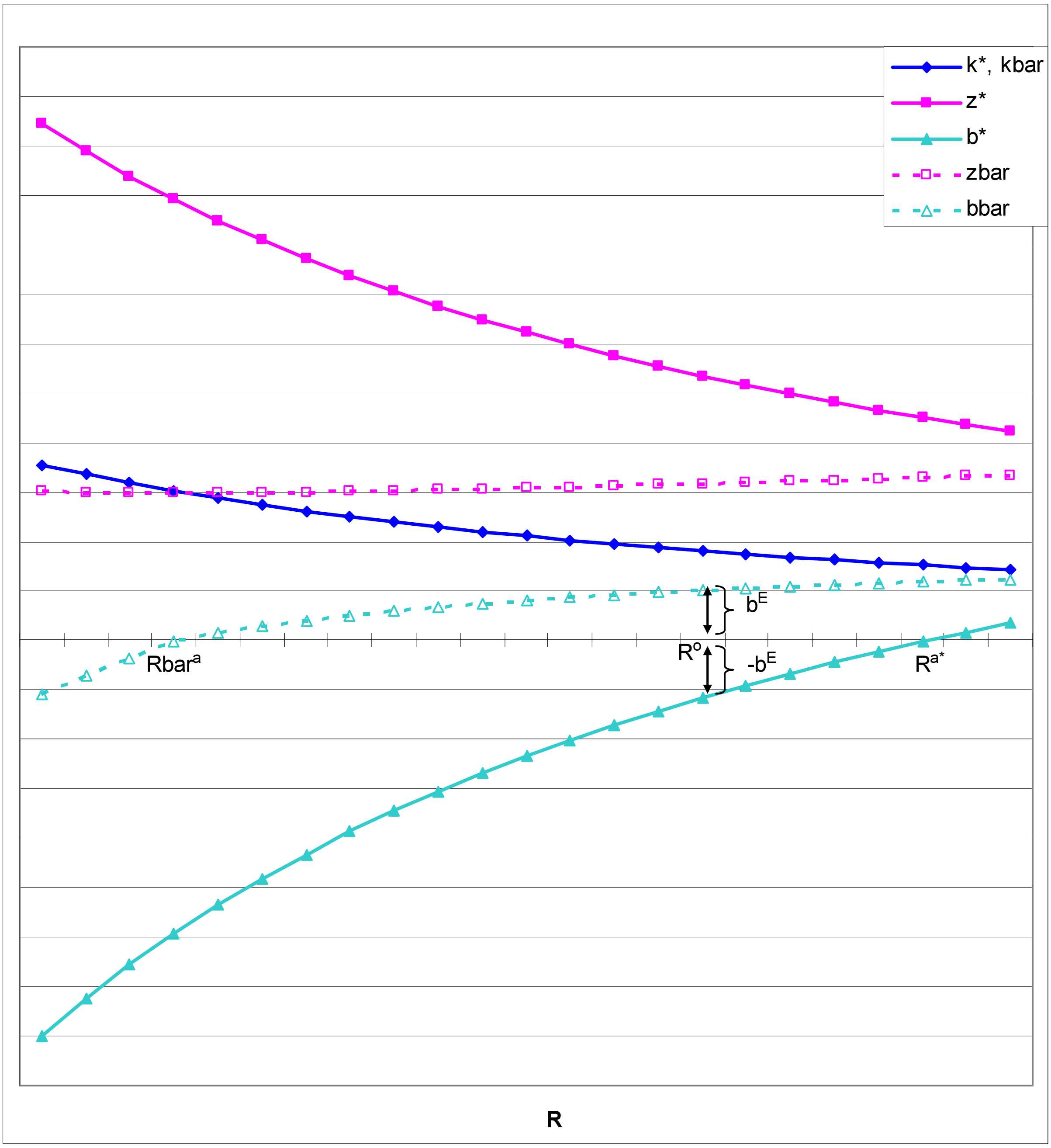
$$\frac{\partial \bar{z}}{\partial R} = -\frac{\partial \bar{k}}{\partial R} - \frac{\partial \bar{b}}{\partial R} = \frac{\bar{b}}{R}$$

The interest rate has an impact on $\bar{z}$ through a wealth effect opposite to that of $\bar{b}$. To understand, consider again the effect of a rise in R. According to what have been said above, if the entrepreneur is indebted ($\bar{b} < 0$), then he must increase $\bar{b}$ more than he must decrease $\bar{k}$ ($\partial\bar{b} + \partial\bar{k} > 0$) to keep the financing constraint satisfied, so $\bar{z}$ has to diminish ($\partial\bar{z} < 0$), according to the resource constraint. If he holds positive claims ($\bar{b} > 0$), then he can increase $\bar{b}$ less than he decreases $\bar{k}$ ($\partial\bar{b} + \partial\bar{k} < 0$), so $\bar{z}$ has room to increase ($\partial\bar{z} > 0$). In this particular experiment where the economy starts from autarky and experiences a rise in the interest rate when financial markets integrate, the bond level $\bar{b}$ increases and becomes positive so the wealth effect on $\bar{z}$ is positive.

To sum up, in the emerging economy, R rises after financial globalization, because its demand for bonds is higher than in the industrial country. Since R rises, k diminishes and b rises, but not as much as k falls, so z can increase without violating the resource constraint. This comes from the fact that b is substituted to the previously excessive k inside the liquid portfolio and becomes positive. Thus, thanks to the now positive external assets, the rise in R generates a positive wealth effect that enables the entrepreneur to increase z while still satisfying the financing constraint. The overall effect of a rise is then to lower the cost of hoarding, so there is room for an increase in z. Therefore, because of the financing constraint, the external wealth b and the long-term investment are complements in the emerging economy, whereas they are substitutes in the industrial one, which has PFM.

In the appendix, it is also shown that Assumption 3.1, which rules out the risky allocation for $R = \bar{R}^a$ in the developing country, is also sufficient to rule out the risky allocation for $\bar{R}^a < R < R^{a*}$. Indeed, R rises in the emerging economy as compared to autarky, so $z^{**}(R)$ decreases. Therefore, since $\bar{z}(R)$ increases, $z^{**}(R) \leq \bar{z}(R)$ is still verified. Notice also that the definition of IFM, which rules out the first best allocation under autarky, is also sufficient to rule out the first best solution under general equilibrium, because the first-best autarky interest rate is the same as under the first-best general equilibrium. This implies that, when the bond markets integrate, the equilibrium with a constrained allocation in E, though not necessarily unique (in some cases, E could switch to the risky allocation), is a valid one.

Figure 4: Investment under PFM and IFM



Nota: This example is obtained with the following calibration: $w = 0.6$, $\alpha = 0.36$, $\phi = 0.65$ and $A = 2$.

The analysis of Figure 4 can now be complemented. Finally, while in the industrial country the long-term investment z is decreasing in R (as k), in the emerging one, it is decreasing when b is negative, but increasing when b is positive. This reflects the wealth effect described earlier. Any world interest rate between the two autarky rates would then imply a rise in debt and in both investments in I because their marginal return are higher than the world interest rate. In E, investment in k decreases and b increases because the marginal return of the short term investment is lower than the world interest rate. In the meantime, z increases because of the positive wealth effect. Finally, the general equilibrium is fixed between the two autarky interest rates in order to satisfy $b^I = -b^E$, leading to the result described in Proposition 3.2.

As a preliminary conclusion, Facts 1 and 4 are satisfied. On the one hand, the industrial country experiences a deterioration of its external position which results in a current account account deficit. On the other, the aggregate TFP increases in the emerging country, since the less productive investment diminishes while the more productive one increases. Fact 3 is not satisfied in the static framework since the aggregate level of investment diminishes. This is a consequence of the assumption that savings w are fixed: if the external position in E becomes positive after financial integration, the resource constraint implies that the aggregate level of investment $k + z$ diminishes. Fact 2 remains to be examined.

Production In the industrial country, both investments increase thanks to the decrease in the interest rate ($\partial R < 0$). As a consequence, the production increases after financial markets integration:

$$\partial y^* = f'(k^*) \underbrace{\frac{\partial k^*}{\partial R}}_{<0} \underbrace{\partial R}_{<0} + g'(z^*) \underbrace{\frac{\partial z^*}{\partial R}}_{<0} \underbrace{\partial R}_{<0} > 0$$

In the emerging country, the impact of financial markets integration on production is ambiguous, because of the rise in the interest rate ($\partial R > 0$) implies a diminution in the short-term investment and a rise in the long-term investment:

$$\partial \bar{y} = g'(\bar{z}) \underbrace{\frac{\partial \bar{z}}{\partial R}}_{>0} \underbrace{\partial R}_{>0} + f'(\bar{k}) \underbrace{\frac{\partial \bar{k}}{\partial R}}_{<0} \underbrace{\partial R}_{>0}$$

The overall effect on production depends on whether the gains from increasing z compensate for the losses from decreasing k. Notice that the evolution of production can be decomposed as follows:

$$\partial \bar{y} = \underbrace{f'(\bar{k}) \left[\frac{\partial \bar{z}}{\partial R} + \frac{\partial \bar{k}}{\partial R} \right] \partial R}_{\text{Aggregate investment effect } (<0)} + \underbrace{[g'(\bar{z}) - f'(\bar{k})] \frac{\partial \bar{z}}{\partial R} \partial R}_{\text{Investment composition effect } (>0)}$$

The impact on production of a rise in R depends both on the aggregate quantity of investment $\bar{z} + \bar{k}$, but also on the quality of investment, represented by the amount of long-term investment $\bar{z}$. The impact of the latter depends on the productivity differential between both technologies

$g'(\bar{z}) - f'(\bar{k})$, which is positive since the financing constraint is binding. As for the impact on aggregate investment, it is negative according to Proposition 3.2.

Interestingly, a certain amount of disconnection between aggregate investment and production appears. Even though the aggregate level of investment is negatively related to the external position in E, production does not necessarily respond negatively to the increase in bond holdings. It can even be positively related to the external position as long as the investment composition effect is strong enough. Indeed, this effect is proportional to the productivity differential $g'(\bar{z}) - f'(\bar{k})$, which measures the amount of investment misallocation. Fact 2 can therefore be accounted for if the parameters are such that the investment composition effect compensates for the aggregate investment effect.

To understand what happens to production under IFM, I use a Cobb-Douglas specification: $f(k) = k^{\alpha}$, $g(z) = Az^{\alpha}$, with $0 < \alpha < 1$ and $A > 1$. In order to simplify the analysis, I abstract from general equilibrium effects on the interest rate, which I consider as second-order phenomena. I focus on the impact of a given rise in the interest rate.

Proposition 3.3: *Effect of an interest rate rise on production (Cobb-Douglas case)*

If the constrained allocation holds in E, if A and ϕ^E are high, if w is small, then a rise in the interest rate has a positive effect on production in E.

Proposition 3.3 comes from the fact that A, ϕ^E and w have an impact on the amount of capital misallocation $g'(\bar{z}) - f'(\bar{k})$. When the relative productivity of the long-term investment A is high, the long-term investment is much more productive than the short-term one, so the overall impact is positive, even if the short-term investment diminishes. If the liquidity requirement ϕ^E is high, the entrepreneur accumulates more short-term capital k under autarky because he needs a higher amount of hoarding. As a consequence, the level of the long-term investment is small and its marginal productivity is high relative to the short-term one. This is also the case when the entrepreneur's wealth w is low. Consequently, the gains in terms of output from increasing the long-term investment are high and are more likely to overcome the losses from decreasing the short-term one. In other words, the higher the extent of the capital misallocation, the higher the potential gains from globalization.

Propositions 3.2 and 3.3 show that a global economy where the emerging markets are less developed financially can reproduce the stylized facts highlighted in the introduction, except Fact 3. After financial markets integrate, the industrial economy hosts capital inflows as a response to the increase in the foreign demand for bonds. This is Fact 1. On the opposite, in the emerging economy, financial globalization implies capital outflows. This increase in the external position enables the developing country to produce more by reallocating investment to the more productive technology, despite the fall in aggregate investment. In other words, the increase in production takes place through an investment composition effect, which results in an improvement in aggregate TFP and compensates for the deterioration in the total investment level. Since the composition of investment in the industrial country remains identical, there are relative TFP gains in the emerging country. This is Fact 4. However, it is unclear whether the production gains are higher in the developed or in the developing country. The quantitative section will enable us to establish Fact 2 more precisely. As for Fact 3, it is not verified since aggregate investment diminishes in the emerging country while it increases in the industrial country. However, this is because we assumed constant savings for pedagogical purposes and in order to yield the main intuitions. This is an unrealistic hypothesis that we will relax in the remainder of the paper. The next section thus extends this static model to an intertemporal Ramsey framework to take into account endogenous saving behavior and to analyze the long-term effects of financial integration. The dynamic version will also enable us to run a quantitative analysis.

4 The Ramsey framework

4.1 Economic environment

It is assumed that an entrepreneur lives infinitely and maximizes his intertemporal utility: $\sum_{s=0}^{\infty} \beta^s \log(c_{t+s})$ with c_t his consumption in period t. Each period t, he chooses how much to consume out of his wealth and how much to invest in each of the three assets described earlier: k_{t+1}, z_{t+1} and b_{t+1}. The production processes are the same as in the one period model. The continuum of entrepreneurs is of length one. We rely on the Cobb-Douglas example with partial depreciation δ: $f(k) = k^\alpha + (1-\delta)k$ and $g(z) = Az^\alpha + (1-\delta)z$, $A > 1$, $0 < \delta < 1$.

4.2 Individual decisions

4.2.1 Individual program

Let w_t denote wealth in period t. The entrepreneur solves the following program:

$$V(w_t) = \max_{\{k_{t+1}, z_{t+1}, b_{t+1}\}} \log(w_t - b_{t+1} - k_{t+1} - z_{t+1}) \tag{4}$$

$$+\beta[(\tfrac{1}{2} + \tfrac{1}{2}\mathbf{1}_{\{f(k_{t+1})+R_{t+1}b_{t+1}\geq\phi\}})V(R_{t+1}b_{t+1} + f(k_{t+1}) + g(z_{t+1})) +$$
$$\tfrac{1}{2}\mathbf{1}_{\{f(k_{t+1})+R_{t+1}b_{t+1}<\phi\}}V(R_{t+1}b_{t+1} + f(k_{t+1})]$$

In period t, w_t is given and the entrepreneur chooses how much to invest in $(k_{t+1}, z_{t+1}, b_{t+1})$. He consumes $w_t - b_{t+1} - k_{t+1} - z_{t+1}$ in period t. In period $t+1$, his wealth w_{t+1} is equal to $R_{t+1}b_{t+1} + f(k_{t+1}) + g(z_{t+1})$ if the good shock occurs (with probability $\frac{1}{2}$) or if the bad shock occurs and is overcome (with probability $\frac{1}{2}$ if $f(k_{t+1}) + R_{t+1}b_{t+1} \geq \phi$, 0 otherwise). It is equal to $R_{t+1}b_{t+1} + f(k_{t+1})$ if the bad shock occurs and is not overcome (with probability $\frac{1}{2}$ if $f(k_{t+1}) + R_{t+1}b_{t+1} < \phi$, 0 otherwise).

As in the previous section, the entrepreneur's program is not standard. Consider first the simpler program where the entrepreneur chooses to satisfy the financing constraint $f(k_{t+1}) + R_{t+1}b_{t+1} \geq \phi$. We will show afterwards the conditions under which this actually happens. In that case, the entrepreneur solves a standard constrained maximization problem:

$$V(w_t) = \max_{\{k_{t+1}, z_{t+1}, b_{t+1}\}} \log(w_t - b_{t+1} - k_{t+1} - z_{t+1}) + \beta V(R_{t+1}b_{t+1} + f(k_{t+1}) + g(z_{t+1})) \tag{5}$$

$$\text{s.t. } f(k_{t+1}) + R_{t+1}b_{t+1} \geq \phi \ (\gamma_{t+1} \geq 0)$$

where γ_{t+1} is the Lagrangian multiplier associated with the financing constraint in $t+1$.

The first-order conditions associated with this program are the following:

$$\begin{cases} /k & \frac{1}{C_t} = \frac{\beta f'(k_{t+1})}{C_{t+1}} + \gamma_{t+1} f'(k_{t+1}) \\ /z & \frac{1}{C_t} = \frac{\beta g'(z_{t+1})}{C_{t+1}} \\ /b & \frac{1}{C_t} = \frac{\beta R_{t+1}}{C_{t+1}} + \gamma_{t+1} R_{t+1} \end{cases}$$

which yields the following results:

$$f'(k_{t+1}) = R_{t+1}$$
$$g'(z_{t+1}) = R_{t+1} + \gamma_{t+1}\frac{C_{t+1}R_{t+1}}{\beta}$$

$$\frac{C_{t+1}}{C_t} = \beta g'(z_{t+1})$$

If the entrepreneur is not constrained ($\gamma_{t+1} = 0$), then $g'(z_{t+1}) = R_{t+1}$. If on the opposite he is constrained ($\gamma_{t+1} > 0$), then $f(k_{t+1}) + R_{t+1}b_{t+1} = \phi$. Besides, $g'(z_{t+1}) > R_{t+1}$ and $\frac{C_{t+1}}{C_t} > \beta R_{t+1}$, which means that, on the one hand, there is an under-accumulation of the long-term asset, and, on the other hand, the bond and the short-term asset are in excessive demand, because of their hoarding function, as in the static model.

In the remainder of the analysis, only two cases will be considered: the case where the entrepreneur is always constrained ($f(k_{t+1}) + R_{t+1}b_{t+1} = \phi$) and the case where the level of long-term investment is always optimal ($g'(z_{t+1}) = R_{t+1}$). Appropriate conditions such that these solutions exist for the particular experiment that I will conduct will be explicited later.

4.2.2 Individual dynamic system

For a given sequence of interest rates R_t, the entrepreneur faces the following dynamic system:

$$\frac{C_{t+1}}{C_t} = \beta g'(z_{t+1}) \tag{6}$$

$$C_t = g(z_t) - z_{t+1} + f(k_t) - k_{t+1} + R_t b_t - b_{t+1} \tag{7}$$

(6) is the Euler equation. Equation (7) is derived from the budget constraint.

When the entrepreneur is unconstrained, there are four variables, C_t, b_t, k_t and z_t. However, k_t and z_t can be pinned down to R_t using $f'(k_t) = g'(z_t) = R_t$, so the number of variables is reduced to two.

When the entrepreneur is constrained, there are four variables, C_t, b_t, k_t and z_t. Here, only k_t can be pinned down to R_t using the fact that $f'(k_t) = R_t$. However, we can use the fact that $b_t = [\phi - f(k_t)]/R_t$ when the financing constraint is binding, so the number of unknown variables is reduced to two.

4.3 The experiment

We focus on the impact of financial integration on the long-term external position, the interest rate, capital accumulation and growth. There are still two countries, I, with perfect financial markets, and E, with imperfect financial markets. Now, for calibration purposes, I and E not only differ with respect to their level of financial incompleteness ϕ^i, but also with regard to their initial endowment in capital per head $x_0^i = k_0^i + z_0^i$, and to their size, that is the length n^i of their continuum of entrepreneurs. It is assumed that financial globalization (i.e. trade in bonds) occurs at $t = 0$. When financial globalizzation occurs, that is when cross-border trade in bonds is allowed, the world aggregate demand for bonds must be equal to zero at each date $t > 0$: $n^I b_t^I + n^E b_t^E = 0$. We assume that I and E are in autarky before $t = 0$, which implies that $b_0^I = b_0^E = 0$.

We denote respectively z_∞ and k_∞ the values of long-term and short-term capital such that $g'(z_\infty) = f'(k_\infty) = \frac{1}{\beta}$. They correspond to the first-best steady-state levels of long-term and short-term capital. The two kinds of financial institutional environment are defined as follows:

- PFM, for which $\phi = 0$ so the first-best decisions apply.
- IFM, for which ϕ satisfies $f(k_\infty) < \phi$.[6] This condition means that the constraint is necessarily binding at steady state. We will show later that it is also a sufficient condition for the first best allocation to be ruled out for the particular experiment conducted here.

Additionally, in order to rule out the risky allocation in the emerging economy, the following assumption is made:

Assumption 4.1 *(Ruling out the risky allocation): $x_0^E > \bar{k}_0^E + g'^{-1}(f'(\bar{k}_0^E))$ where $\bar{k}_0^E$ satisfies: $f(\bar{k}_0^E) = \phi^E$*

Assumption 4.1 states that, for the given amount of capital x_0^E in E, and for the autarky interest rate that would prevail under the constrained allocation, the constrained solution for z_0^E, which is $x_0^E - \bar{k}_0^E$, is larger than the risky one, which is $g'^{-1}(f'(\bar{k}_0^E))$. This insures, for arguments similar to Lemma 3.1, that the constrained solution is a valid one at $t = 0$. As we will show, Assumption 4.1 is also a sufficient condition for the validity of binding financing constraints all along the transition path, at least for the experiment conducted here. It requires that x_0^E is not too small and that ϕ^E is not too high.

It is assumed first in what follows that the financing constraint is binding in the emerging economy, which has IFM. It will be shown later that this assumption defines a valid equilibrium under Assumption 4.1.

The industrial economy is in steady state at $t = 0$: $z_0^I = z_\infty$ and $k_0^I = k_\infty$. The emerging economy is assumed to be capital-scarce as compared to the industrial one at the date of financial

[6] That is, as a function of the parameters: $\phi > (\alpha/[1/\beta - (1-\delta)])^{\frac{\alpha}{1-\alpha}} + (1-\delta)(\alpha/[1/\beta - (1-\delta)])^{\frac{1}{1-\alpha}}$

integration. To represent this fact, I impose $x_0^E < x_\infty = k_\infty + z_\infty$. As we have additionally that $\phi^E > f(k_\infty)$, the first-best allocation is not implementable at $t = 0$. According to Assumption 4.1, the risky allocation is also ruled out in E at $t = 0$. As a consequence, the financing constraint is binding in E at $t = 0$. Therefore, the amount of short-term capital k_0^E in E is equal to $\bar{k}_0^E$ (so $f(k_0^E) = \phi^E$). We have then $k_0^E > k_\infty$, since $\phi^E > f(k_\infty)$. As a corollary, we have $z_0^E < z_\infty$, since $x_0^E < x_\infty$. Thus, E is scarce in z, but not in k: at the date of financial integration, the emerging market is over-endowed with short-term capital, because of its liquidity needs. As in the static model, the demand for liquid assets is greater in E than in I. This translates into a lower autarky interest rate in E: $f'(k_0^E) < f'(k_\infty)$.

4.4 General equilibrium dynamic system

Assume first that the financing constraints are binding in E (we will show later that this is indeed the case). Applying Equations (6) and (7) in I and E, where the entrepreneurs are not constrained, and in E, where they are, and using the fact that $R_t = g'(z_t^I)$, $f'(k_t^I) = R_t$ and $n^I b_t^I = -n^E b_t^E = -n^E \frac{1}{R_t}[\phi - f(k_t^I)]$, we find:

$$\frac{C_{t+1}^I}{C_t^I} = \beta g'(z_{t+1}^I) \text{ for } t \geq 0 \tag{8}$$

$$\begin{aligned} C_t^I &= g(z_t^I) - z_{t+1}^I + f(f'^{-1}(g'(z_t^I))) - f'^{-1}(g'(z_{t+1}^I)) \\ &- \frac{n^E}{n^I}[\phi - f(f'^{-1}(g'(z_t^I)))] + \frac{n^E}{n^I g'(z_{t+1}^I)}[\phi - f(f'^{-1}(g'(z_{t+1}^I)))] \text{ for } t > 0 \end{aligned} \tag{9}$$

and on the date of financial integration, since $b_0^I = 0$:

$$C_0^I = g(z_0^I) - z_1^I + f(f'^{-1}(g'(z_0^I))) - f'^{-1}(g'(z_1^I)) + \tfrac{n^E}{n^I g'(z_1^I)}[\phi - f(f'^{-1}(g'(z_1^I)))]$$

$$\frac{C_{t+1}^E}{C_t^E} = \beta g'(z_{t+1}^E) \text{ for } t \geq 0 \tag{10}$$

$$\begin{aligned} C_t^E &= g(z_t^E) - z_{t+1}^E + f(f'^{-1}(g'(z_{t+1}^I))) - f'^{-1}(g'(z_t^I)) \\ &+ [\phi - f(f'^{-1}(g'(z_t^I)))] - \frac{1}{g'(z_{t+1}^I)}[\phi - f(f'^{-1}(g'(z_{t+1}^I)))] \text{ for } t > 0 \end{aligned} \tag{11}$$

and on the date of financial integration, since $b_0^E = 0$:

$$C_0^E = g(z_0^E) - z_1^E + \phi - f'^{-1}(g'(z_1^I)) - \tfrac{1}{g'(z_1^I)}[\phi - f(f'^{-1}(g'(z_1^I)))]$$

Equations (8) and (9), which govern the dynamics of the developed economy, are independent from the rest of the system, since they only involve z^I and c^I. Once the dynamics of z^I and c^I is solved using this independent dynamic sub-system with 2 variables and 2 equations, the dynamics of z^E and c^E can be inferred using Equations (10) and (11).

4.5 Effect of financial globalization in the long run

Here, I examine the long-run impact of financial integration at $t = 0$.

Proposition 4.1: *Effect of financial markets globalization in the long run*

Under Assumption 4.1, the solution where the emerging economy satisfies the financing constraint at $t = 0$ *and at steady state exists and exhibits the following features:*

(i) *The emerging economy experiences in the long run an increase in the more productive investment, a decrease in the less productive investment and a positive external position. On the whole the investment level increases.*

(ii) *The industrial economy experiences no change in its investment levels in the long run, but exhibits a negative external position.*

Assume first that the financing constraint is satisfied in the emerging economy at steady state. The dynamics is characterized by Equations (8)-(11). According to Equation (8), the steady state in I is characterized by constant consumption and by a constant marginal return to z equal to $1/\beta$. Therefore, the marginal return to k converges also to $1/\beta$, and so does the interest rate. With trade in bonds, from the point of view of the emerging economy, the world interest rate converges to $\frac{1}{\beta}$. As a consequence, the emerging economy's short-term capital adjusts to $1/\beta$ in the long run. As for its long-term capital, the constancy of consumption implies that it adjusts to the inverse of the time discount factor $1/\beta$. Therefore, with trade in bonds, the steady state in both I and E is characterized by a constant interest rate equal to $1/\beta$ and by identical investment levels: $z^I_\infty = z^E_\infty = z_\infty$ and $k^I_\infty = k^E_\infty = k_\infty$. How do these steady-state outcomes compare to the initial conditions?

Consider first (i). The intuition for the emerging economy is as follows. Before financial markets integrate, the demand for liquid assets is higher in E than in I. Under autarky, the only available liquid asset is k. As a consequence, E holds excessive short-term capital ($k^E_0 > k_\infty$). However, when financial markets integrate, the financing constraint can be satisfied by holding external bonds, while k can adjust to the world interest rate. In the long run, k is equal to k_∞, since the steady-state interest rate is defined by I's discount factor, which is identical to E's. Put differently, thanks to financial integration, the steady-state level of short-term capital is equal to the first-best one, since the world interest rate is pinned down to the industrial country's, which does not suffer from any financing constraint. E then experiences a decline in the less productive investment. As for the external position of E, it is necessarily positive to satisfy the financing constraint, since the steady-state level of short-term investment is not sufficient to satisfy the liquidity requirements ($f(k_\infty) < \phi$). Besides, at $t = 0$, the country is scarce in long-term investment z, which means that $z_0^E < z_\infty$ by assumption. Therefore, the emerging market experiences a rise in the more productive investment. The rise in the investment level comes from the assumption that E is capital-scarce in $t = 0$: $x_0^E = x_\infty$.

(ii) is straightforward: the industrial country experiences no changes in its capital stocks in the long run compared to their initial levels, since they start at steady state. However, in general equilibrium, its external position should be the counterpart of the emerging country's. Since the emerging country runs a positive external position, the industrial economy is necessarily indebted in the long run.

Finally, we have to show that this solution is possible. We have shown earlier that under Assumption 4.1, the case where E satisfies the financing constraint at $t = 0$ exists. In this case, $k_0^E > k_\infty$, which implies that the steady-state interest rate is higher than the autarky interest rate in E at $t = 0$. Therefore, the risky allocation is lower at steady state than at $t = 0$. Since z_0^E is lower than z_∞, which is the value of the long-term investment in the long run when the financing constraint is satisfied, then the risky allocation is lower than the constrained one, and it is not optimal for the entrepreneurs to switch to the risky level. Thus, the steady state solution where E satisfies the financing constraint does exist.

Now these results can be confronted to the stylized facts. Fact 1 to 4 are satisfied, as long as we compare the starting point to the ending one. We note: 1) a deterioration of the external position in I, 2) an increase in individual productivity in E relative to I due to: 3) a relative increase in the aggregate level of capital per head and 4) a relative increase in TFP. This last outcome is due to the switch from the less productive technology to the more productive one in E, while the technological structure is unchanged in I. What is left is to determine whether the medium-term patterns are respected qualitatively and whether the model is able to reproduce the facts in terms of the order of magnitude. This is the object of the next section.

5 Effect of financial globalization in the medium run

In this section, I study the qualitative and quantitative implications of the model in the medium run. The goal is to apply the experiment detailed in the preceding section. In other words, I evaluate the impact of financial globalization in a world composed of two countries, one, I, which is at its stationary equilibrium on the date of financial integration and which benefits from perfect financial markets, and the other, E, which is capital-scarce and suffers from poor domestic financial markets. We should be particularly attentive to the impact of financial globalization on the external asset position, the current account, growth and its different sources: capital accumulation or TFP growth driven by capital reallocation. The purpose here is not to match the data exactly, but rather to reproduce the right patterns (qualitative fit) and check whether the magnitude of the trends are reasonable (quantitative fit).

The first country (I) is representative of the U group, mainly composed of the United States, but which includes also Australia and the United Kingdom. The second one (E) aggregates countries in the EM group, which is composed of a significant number of emerging economies: Argentina, Brazil, Chile, China, Colombia, Costa Rica, Ecuador, Egypt, Hong Kong, India, Indonesia, Korea, Malaysia, Mexico, Nigeria, Panama, Peru, Philippines, Poland, Russia, Singapore, Thailand and Venezuela. I assume that financial markets integrate in 1990 and observe the economic behavior in I and E in order to confront them to the data for the period 1990-2003.

5.1 Calibration

α is set to 0.36, β to 0.96, δ to 10%, as is common in the literature. The ratio of workers n^E/n^I is set so that the steady state share of U's GDP ($n^I y^I$) in the world GDP (defined as $n^I y^I + n^E y^E$), which is also the share of U's workers in the world population when convergence is achieved, is equal to 60%, its value in the last observed period (2003). This gives a ratio of 1.5.

The baseline value for A is set to 2. This value is in the range of firms productivities estimated by Banerjee and Duflo (2005) and Restuccia and Rogerson (2007). Besides, it yields a standard error for the logarithm of TFP equal to 0.3 at steady state, which is close to the one measured by Bartelsman et al. (2006) for the US.

The initial level of capital per head in EM in the beginning of period x_0^E is set such that the share of EM capital in the world stock ($n^E x_0^E/[n^E x_0^E + n^I x_\infty]$ according to the model) is equal to 47%, its observed value in the beginning-of-period (1990). This gives a level of capital per head in EM x_0^E equal to 60% of the level of capital per head in U x_∞. Capital stocks in EM and U are estimated with the perpetual inventory method, using the procedure of Caselli (2004).

One important parameter, EM's initial share of long-term capital in total capital z_0^E/x_0^E, remains to be defined. Two methods are used to set this value. The first method, which is the baseline one, consists in fixing this value in order to match the observed relative change in EM's TFP between 1990 and 2003 (+12%). TFP is not measured as the productivity average across technologies weighted by the investment or production shares of these technologies, but as y/x^{α}, which corresponds to the stylized facts of Figure 2. As we do not have real estimates for z and k, we must use a measure based on aggregate investment, and not on its components in order to compare the outcome of the model to the data. The resulting initial share of long-term capital in EM z_0^E/x_0^E varies with A. When $A = 2$, it represents 38% of the corresponding variable in U. For the sensitivity analysis, we also use another benchmark to set z_0^E/x_0^E: the observed end-of-period external position in U as a share of GDP (-22%). The external position in U as a share of GDP is simply given by b^I/y^I after 13 periods.

The baseline parameter set as well as the variables that were used to define them is summed up in Table 1.

Table 1: Baseline parameter set

Parameter	Value	Target	Source
α	0.36		
β	0.96		
δ	0.10		
A	2	$\sigma(\ln(TFP)) = 0.3$	Bartelsman et al. (2006)
n^E/n^I	1.5	$n^I/(n^I + n^E) = 60\%$	Penn World Tables 6.2
x_0^E/x_∞	60%	$\frac{n^E(k_0^E+z_0^E)}{n^E(k_0^E+z_0^E)+n^I(k_\infty+z_\infty)} = 90\%$	Penn World Tables 6.2
$\frac{z_0^E/x_0^E}{x_\infty/x_\infty}$	38%	$(A_T^E/A_0^E)/(A_T^I/A_0^I) = 12\%$	Penn World Tables 6.2

5.2 Qualitative fit

Here, I determine whether the medium-term patterns of Figures 1 and 2 are recovered. The results are showed analytically for the linear approximation of the dynamic system (8)-(11) and illustrated using the baseline calibration.[7]

The dynamic system (8)-(11) is linearized around the steady state. The evolution of the industrial economy boils down to a linear dynamic system of two equations and two unknown,

[7]Even if the model is solved analytically in the appendix in order to establish Propositions 5.1 and 5.2, the simulations are obtained using DYNARE (Juillard, 1996) in order to be consistent with the extension with capital installation costs.

C_t^I and z_t^I. Once the dynamics of z^I is solved using this independent dynamic sub-system with 2 variables and 2 equations, the dynamics of z^E can be inferred using the log-linearized version of Equations (10) and (11). The appendix provides the results of the log-linearization in more detail.

Proposition 5.1

If the emerging country is constrained and if $|\phi^E - f(k_\infty)|$ is sufficiently close to zero, then, after financial integration, the industrial country experiences first a drop and then progressive increase in the interest rate. It experiences a sharp increase and then a declining path for z and k. The same pattern holds for y.

The formal proof is available in the appendix.

The intuition of the dynamics is as follows. Before financial globalization, because of financial frictions and its need for liquidity, the emerging country holds excessive amounts of short-term capital. This is apparent in Figure 5, which represents the behavior of some key variables. In particular, graphs (a) and (b) show that the level of short-term capital is higher in E than in I. As a consequence, the autarky interest rate is lower, as graph (c) illustrates it. Therefore, when financial markets integrate, the world interest rate adjusts in between. From the industrial country's point of view, the interest rate falls, which stimulates investment and production. This is apparent in graphs (a) and (e). After this initial shock, the interest rate begins to rise progressively towards its long-run value. As a corollary, the investment and production levels decrease towards their steady-state after the initial rise.

Note that the hypothesis that $|\phi^E - f(k_\infty)|$ is small is made to insure that the trajectory of z^I is unique.[8]

What does this imply for capital accumulation in the developing country?

Proposition 5.2

Under Assumption 4.1, if $\Delta z_0^E < 0$, if $|\phi^E - f(k_\infty)|$ and $|\phi^E - f(k_\infty)|/|\Delta z_0^E|$ are sufficiently close to zero, then, after financial integration:

(i) *The solution with permanently binding financing constraints in the emerging economy exists and is unique.*

(ii) *The emerging country experiences a sharp, then progressive increase in the interest rate. It*

[8] As in Woodford (1986), the cohabitation of two kinds of agents, one constrained and the other unconstrained, can generate instability.

experiences a growing path for b and z and a decreasing path for k. The path for y, after an initial adjustment, is increasing in the early stages of transition.

(iii) *The production in the emerging country is increasing relative to the industrial one along the transition path, after an initial adjustment.*

The formal proof is available in the appendix.

(i) derives from the fact that if the entrepreneurs anticipate the interest rate path consistent with binding financing constraints, then the constraints are actually binding, since this path is unconsistent with both the first-best and risky solutions for z^E. The argument is similar to the one for Proposition 4.1 and relies on the fact that the interest rate and the constrained z^E are increasing on the constrained path for the corresponding set of assumptions.

Consider (ii). Assume that the financing constraint is binding all along the transition path in the emerging economy: $b_t^E = [\phi^E - f(f'^{-1}(R_t))]/R_t$, where R_t is the world intrest rate. The external position in E is therefore determined exactly as in the static model, and its derivative with respect to R is the same:

$$\frac{\partial b^E}{\partial R} = \underbrace{-\frac{\partial k}{\partial R}}_{\text{Substitution effect}>0} \underbrace{-\frac{b^E}{R}}_{\text{Wealth effect } <0 \text{ or } >0}$$

The sign of the effect of the interest rate on b^E depends on the relative magnitude of the wealth and substitution effects. Wealth and substitution effects determine the impact of the variation in interest rate in exactly the same fashion as in the static model: on the one hand, if the interest rate rises, then the external bond is substituted to the short-term capital, which makes the level of bonds increase; on the other hand, if the level of bonds is positive, then the increase in the interest rate eases the liquidity requirements, so the level of bonds does not need to rise a lot. If this wealth effect is high, the level of bonds might even decrease. Therefore, since the external position is small (ϕ^E close to $f(k_\infty)$), the substitution effect dominates and the level of bonds increases with the interest rate ($\partial b^E/\partial R$). Consider now the path of the interest rate R_t from the point of view of the emerging country: as illustrated by graph (c) of Figure 5, it is set above the initial autarky interest rate after financial integration because the demand for bonds is lower in I, and then continues to increase as it converges to its steady state level. As a result, the bond level is increasing in E, as graph (b) shows. As a counterpart, the external position of the industrial country b_t^I is declining, as illustrated in graph (a). Therefore, E will exhibit current account surpluses on the transition path while I will exhibit deficits, as graph (d) indicates.

z^E follows an increasing path for two reasons: initial scarcity and wealth effects similar to the ones discussed in the static case. First, since the level of bond holdings is constrained, z^E does not adjust immediately to the world interest rate and behaves rather as under autarky. Namely, because it is in a scarce supply, it follows an increasing path towards its steady state. Second, the world interest rate is increasing steadily from the point of view of E, which eases the credit constraint more and more at each period, enabling entrepreneurs in E to invest more in the long-term capital z^E. Indeed, since the bond level is positive, an increase in the interest rate stimulates the yield of the liquid portfolio "mechanically", and the amount of resources necessary to satisfy the financing constraint diminishes. This wealth effect provides therefore additional resources which are then dedicated to the long-term investment. This last effect contributes up to 5% of the growth in he long-term investment in E. The resulting increasing path for z^E is provided in graph (b).

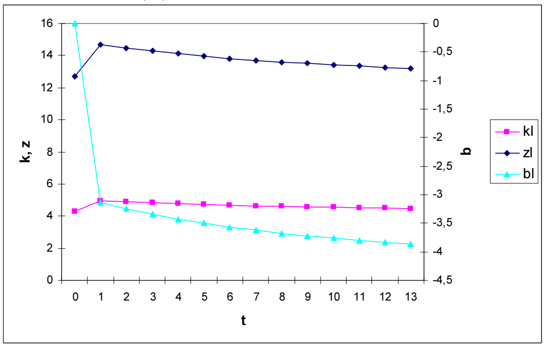
On the opposite, k^E, which adjusts to the world interest rate, follows a decreasing path, as illustrated in graph (b). The result is therefore ambiguous for y^E. However, it can be shown that when $|\phi^E - f(k_\infty)|$ is small relative to $|\Delta z_0^E|$, y^E is increasing in the early stages of transition, as illustrated in grph (e). Indeed, $|\phi^E - f(k_\infty)|$ gives the extent of the interest rate adjustment at the date of financial integration and the distance to steady state of the new world interest rate. By extension, it also gives the distance of k^E to its steady state. Therefore, the hypothesis that $|\phi^E - f(k_\infty)|$ is small relative to $|\Delta z_0^E|$ implies that z^E is further from its steady state than k^E. It thus converges more rapidly and production benefits more from the increase of the long-term capital than it suffers from the fall in short-term investment.

(iii) states that, despite the fact that y^E is not always growing, it is increasing as compared to y^I. Indeed, the growth of y^E is reversed for high ts only because of the decline in short-term investment, which affects y^I in the same way. As a consequence, E and I differ only with regards to the long-term investment, which is increasing in E and decreasing in I. Therefore, in relative terms, y^E is growing as compared to y^I, as illustrated in graph (f). However, the graph shows that this is true only at the date of financial integration, where the production in E falls relatively to I. This comes from the sharp initial adjustment in short-term capital, also visible in graph (f).

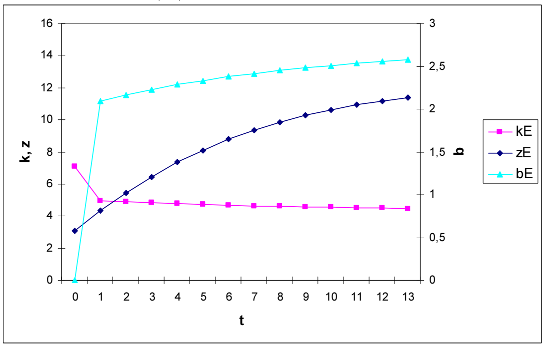
Proposition 5.2 implies that, under the specified conditions, the equilibrium with permanently binding financing constraints in the emerging market exists and that in this equilibrium, the developing country exhibits current account surpluses, which are the counterpart of deficits in the industrial one (Fact 1). Besides, the production per head (entrepreneur) is increasing in

Figure 5: Effect of financial integration at $t = 0$

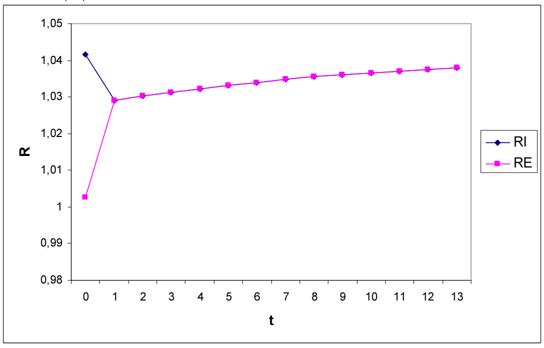
(a) On I's portfolio



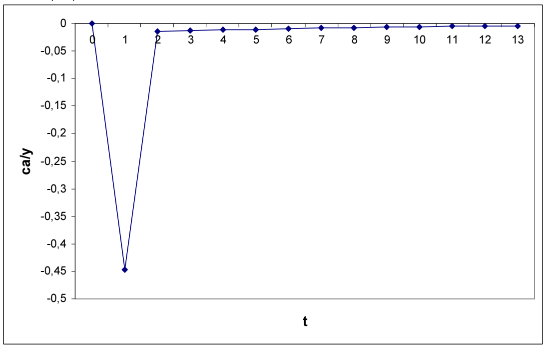
(b) On E's portfolio



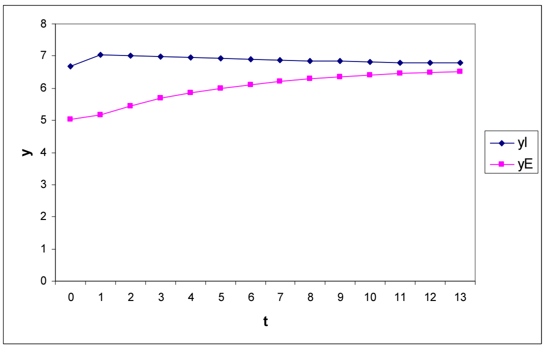
(c) On the interest rate in I and E



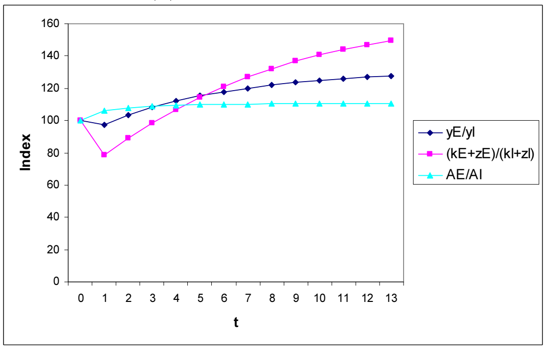
(d) On I's CA balances-GDP ratio



(e) On production per worker



(f) On relative growth



Nota: This simulation is obtained with the baseline parametrization summed up in Table 1.

the emerging country relative to the industrial one (Fact 2). This relative increase takes place thanks to capital accumulation (Fact 3), but also through aggregate TFP gains due to capital reallocation (Fact 4). Relative TFP increases smoothly in the calibration (graph (f) of Figure 5), as in the data (Figure 2), but relative aggregate capital and relative production per capita exhibit an initial fall in the simulation, while it increases steadily in the data (Figures 1 and 2). This can be explained by the fact that, in the emerging country, the adjustment in short-term capital is sharp, while the adjustment in long-term capital is smooth, as graph (b) shows. This shortcoming can be limited by adding capital installation costs.

Overall, the qualitative implications of the model in terms of qualitative adjustment of the variables of interest are globally satisfying, except for the initial adjustment. This issue will be tackled later by adding capital installation costs. Another question is whether the calibration of the model yields the adequate orders of magnitude for the stylized facts.

5.3 Quantitative fit

The results of the baseline method are reported in columns (a)-(c) of Table 2 for $A = 2$, the baseline value for A, but also for $A = 1.7$ and $A = 3$, for robustness analysis. In column (d), z_0^E/x_0^E is set such that the external debt is equal to 22% of GDP on average between 1990 and 2003, with $A = 2$. The inferred share of initial long-term capital in total capital is not shown directly, but as a ratio of U's: $\frac{z_0^E/x_0^E}{z_\infty/x_\infty}$. The following values are also reported for each calibration: TFP growth, the growth of capital per worker, the growth of production per worker in E, all relative to I; the share of growth in E attributable to growth in relative TFP; the end-of-period external position as a share of GDP and average current account as a share of GDP in I. Because of the lack of data on k and z, each calibration method uses a key stylized fact to determine z_0^E. However, it is still possible to confront the model to the other facts. For example, when z_0^E is set to match the observed TFP growth, I examine b^I/y^I and the share of growth that is due to TFP (columns (a)-(c)); when it is set to match the US's external position, I examine TFP growth and the share of growth that is due to TFP (column (d)). Last, column (e) gives the observed values of the corresponding variables. The variables that were set to their observed values in the calibration columns are presented in bold characters.

In the baseline calibration with fixed growth in relative TFP (column (a) of Table 2), the growth in relative output per worker is 1.5 times higher than in the data. This is a consequence of the fact that the model over-estimates the amount of growth in relative capital per worker by more than twice. As a result, the share of growth attributable to TFP is not as high as in the data: it is one third smaller. The amounts of end-of-period external debt and average current account deficit in I are over-estimated respectively by a factor of three and two. However, given the parsimony of the model, these are not bad results: the estimates are in the right order of magnitude. In the model, the external position and capital adjust too quickly. With appropriate installation costs on investment, the model could fit the data better. In other words, the bias of the model goes in the right direction: making it more realistic by adding adjustment costs could make it closer to the data. We check this in the extension with capital installation costs.

Table 2: Calibration results

	Baseline	Sensitivity			Data
	(a)	(b)	(c)	(d)	(e)
A	2	1,7	3	2	Unobservable
$\frac{z_0^E/x_0^E}{z_\infty/x_\infty}$	38%	34%	46%	64%	Unobservable
TFP growth of E relative to I	**12%**	**12%**	**12%**	4%	**12%**
Growth of capital per worker in E relative to I	44%	47%	38%	52%	**21%**
Growth of production per worker in E relative to I	28%	29%	26%	21%	**18%**
% of relative growth due to TFP	46%	44%	49%	19%	**68%**
End-of-period b^I/y^I	-61%	-53%	-73%	**-22%**	**-22%**
Average $\Delta b^I/y^I$	4,8%	-4,1%	-5,7%	-1.7%	**-2,6%**

Source: World Bank (World Development Indicators), Lane and Milesi-Ferretti (2006) and Penn World Tables 6.2 (Heston et al., 2006).

I corresponds to U: United States, Australia, United Kingdom.

E corresponds to EM: Argentina, Brazil, Chile, China, Colombia, Costa Rica, Ecuador, Egypt, Hong Kong, India, Indonesia, Korea, Malaysia, Mexico, Nigeria, Panama, Peru, Philippines, Poland, Russia, Singapore, Thailand and Venezuela.

Period: 1990-2003.

Capital stocks in EM and U are estimated with the perpetual inventory method, using the procedure of Caselli (2004). TFP values in EM and U are estimated as $y^i/(x^i)^\alpha$, $i \in \{EM, U\}$, where $\alpha = 0.36$, y^i and x^i are respectively output per worker and capital per worker in i.

Consider now the additional columns (b) and (c) of Table 2, which give the calibration results for different values of A. Notice that, in columns (a)-(c), the estimated share of long-term capital in total capital is increasing in A relatively to the steady state: the higher the productivity of the long-term investment compared to the short-term one, the lower the amount of misallocation needed to generate a given growth in aggregate TFP. Notice also that the higher A, the higher the growth in relative capital per worker. This is a composition effect: when A is large, the share of z in aggregate capital is higher at steady state. Since, in E, z grows while k decreases, it implies that the share of growing investment is high, which results in a higher growth in aggregate investment. I's indebtment level is increasing in A. This is because, when A is high, the steady-state level of capital is high, which implies that, to be consistent with the observed initial share of E in world's capital, the inferred initial level of aggregate capital in E is large, including k. Therefore, when financial markets integrate, the adjustment in E's external position is large. The same holds for average current account deficits. As a consequence, the results which are closer to the data, as far as the external position is concerned, are obtained with $A = 1.7$.

In the calibration with fixed external position in I, summed up in column (d) of Table 2, the better fit in terms of capital flows is compensated by a worse fit in terms of growth as compared to column (a). The average current account deficit in I corresponds quite well to the data, but growth in relative TFP is underestimated. This is intuitive: the external debt of I is an indirect measure of the initial misallocation in E, because it gives the amount of the adjutment in short-term capital in E after financial integration. In column (d), the external debt of I is smaller than in (a), which implies that the initial misallocation in E is not as strong, so the aggregate gains in TFP due to a better allocation of capital are smaller. A corollary of this limited misallocation is that the fall in short-term capital is mitigated, which leads to a higher aggregate growth in investment. As a result, the share of growth due to TFP is even lower. Still, as before, the introduction of capital installation costs could make these results closer to the data. Besides, our interpretation of the origins of TFP growth is not exclusive of others, for example knowledge transfers from North to South. Put differently, calibrating the model in order to match the external position of U gives an amount of TFP growth due to capital reallocation smaller than in the data, which is compatible with other sources of TFP growth.

5.4 Adding capital installation costs

In this section, the model is enriched with capital installation costs in order to make the model fit better the data. In particular, I check whether: (i) the initial fall in investment in E is limited, making the dynamics of relative aggregate capital stocks and productions look more like in the data; (ii) the external position and current account adjustments in I are quantitatively closer to the data when matching the parameters to account for the observed TFP growth.

Define i^k as the investment in short-term capital and i^z as the investment in long-term capital. The entrepreneur's program is modified by the introduction of capital installation costs. It can be written as follows:

$$V(k_t, z_t, b_t) =$$

$$\max_{\{k_{t+1}, z_{t+1}, b_{t+1}, i_t^k, i_t^z\}} \log\left(f(k_t) + g(z_t) + R_t b_t - b_{t+1} - k_{t+1} - z_{t+1} - k_t \Psi\left(\frac{i_t^k}{k_t}\right) - z_t \Psi\left(\frac{i_t^z}{z_t}\right)\right)$$
$$+\beta V(k_{t+1}, z_{t+1}, b_{t+1}) \tag{12}$$

$$\text{s.t.} \begin{cases} f(k_{t+1}) + R_{t+1} b_{t+1} \geq \phi \\ i_t^k = k_{t+1} - (1-\delta) k_t \\ i_t^z = z_{t+1} - (1-\delta) z_t \end{cases}$$

The installation costs per unit of capital are defined in the standard following way:

$$\Psi(x) = \frac{\psi}{2}(x - \delta)^2 \tag{13}$$

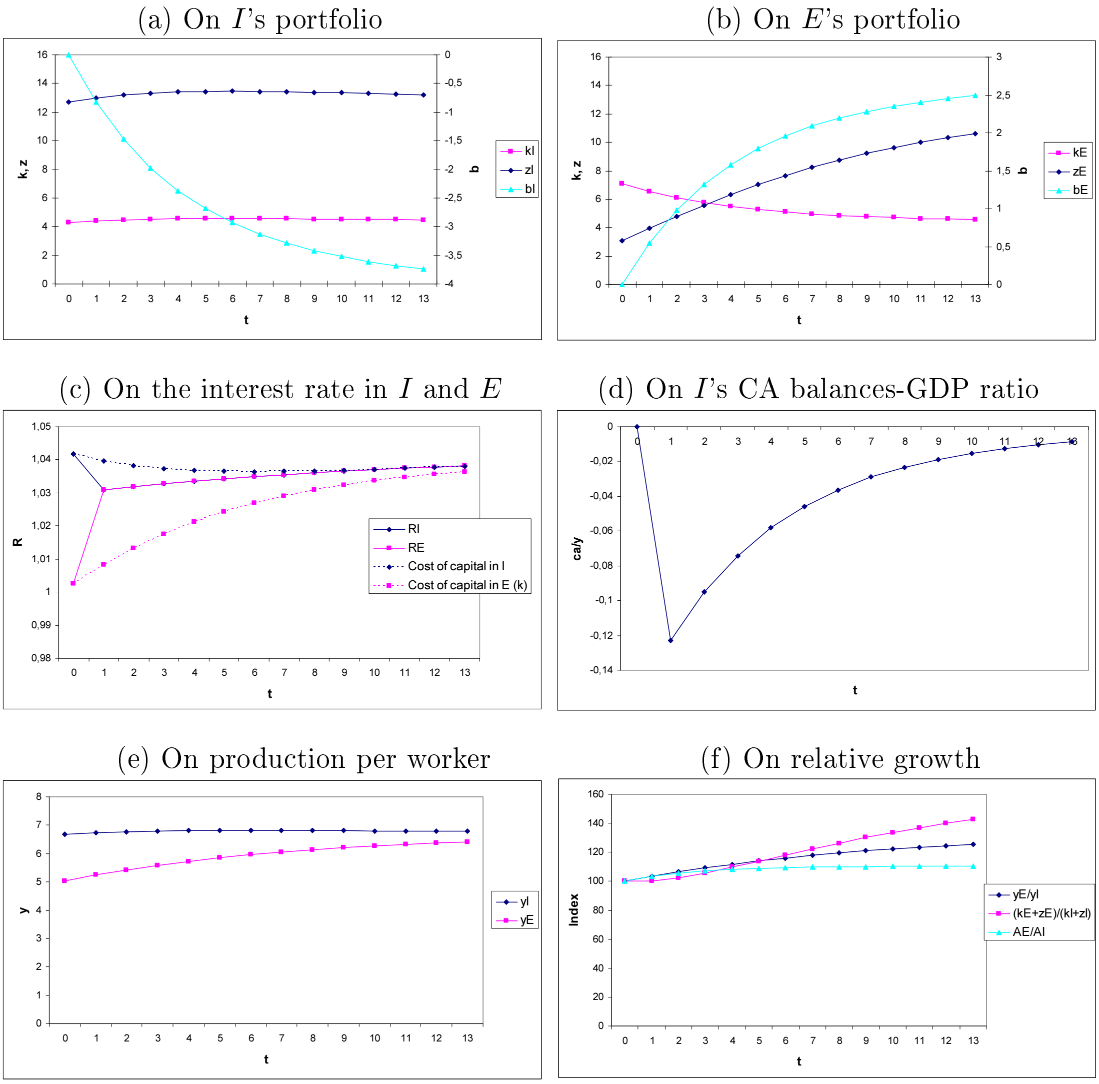
Equation (13) implies that any change in the stock of capital is costly, whether it has to be increased or decreased. It also implies that installation costs are zero when the firm's investment is at its steady state level δ. Besides, this specification entails that it is not only costly to change the stock of aggregate capital, but also to transfer capital from one technology to the other. ψ is the key parameter of the installation costs. It represents their size.

This program is solved using DYNARE (Juillard, 1996), with the baseline calibration of Table 1. Only $\frac{z_0^E / x_0^E}{z_\infty / x_\infty}$ changes slightly in order to fit the observed increase in TFP in E. For this purpose, it is set to 37%. The baseline calibration for ψ, the installation cost parameter, is set to 1. This specification is chosen to match the estimates of Gilchrist and Sim (2007) and Eberly et al. (2008) on firm-level data[9]. Gilchrist and Sim (2007) find estimates of ψ which are robustly close to 1. The estimates of Eberly et al. (2008) range between 0.8 and 1.8. For the sensitivity analysis, I also set ψ to 0.5, 2 and 5. The results are reported in Figure 6 and Table 3.

Graph (c) in Figure 6 presents both the interest rate and the cost of capital. The initial fall in the interest rate in I increases the incentives to invest for domestic agents. However, the fall in the cost of capital is limited by the increase in the installation cost. The cost of capital therefore stays temporarily above the interest rate. In E, because of the initial increase in the interest rate, the agents want to hold more short-term capital. However, the installation costs incurred by the diminution in the stock of short-term capital decrease the incentives to diminish the stock of capital. The cost of short-term capital therefore stays temporarily below the interest rate. Consequently, as graphs (a) and (b) show, the introduction of installation costs makes the

[9] Gilchrist and Sim (2007) used Korean data and Eberly et al. (2008) relied on US data.

Figure 6: Effect of financial integration at $t = 0$ - Capital installation costs



Nota: This simulation is obtained with the baseline parametrization summed up in Table 1, except for $\frac{z_0^E/x_0^E}{z_\infty/x_\infty}$, which is set to 37%.

adjustment in the capital stocks smoother. In particular, the stock of short-term capital does not fall sharply in E when financial markets integrate. Similarly, the initial adjustment in the capital stocks in I is delayed. As a consequence, the relative stock of aggregate capital is almost flat at the date of financial integration and the relative production per capita increases from the beginning to the end of the period (graph (f)).

Noticeably, graph (b) of Figure 6 shows that, as bonds are substituted to short-term capital in E's liquid portfolio, E's external position increases progressively. The progressive increase in E's assets is matched by the progressive increase in I's debt. The adjustment in the current account of I is therefore smoother than in the baseline case.

Table 3: Calibration results - Capital installation costs

	Baseline	Sensitivity			Data
	(a)	(b)	(c)	(d)	(e)
A	2	2	2	2	Unobservable
$\frac{z_0^E/(k_0^E+z_0^E)}{z_\infty/(k_\infty+z_\infty)}$	37%	37%	36%	35%	Unobservable
ψ	1	0.5	2	5	Unobservable
TFP growth of E relative to I	**12%**	**12%**	**12%**	**12%**	**12%**
Growth of capital per worker in E relative to I	37%	40%	33%	26%	**21%**
Growth of production per worker in E relative to I	25%	26%	24%	21%	**18%**
% of relative growth due to TFP	50%	49%	53%	57%	**68%**
End-of-period b^I/y^I	-60%	-61%	-57%	-49%	**-22%**
Average $\Delta b^I/y^I$	-4,7%	-4,8%	-4,5%	-3.9%	**-2,6%**

Source: World Bank (World Development Indicators), Lane and Milesi-Ferretti (2006) and Penn World Tables 6.2 (Heston et al., 2006).

I corresponds to U: United States, Australia, United Kingdom.

E corresponds to EM: Argentina, Brazil, Chile, China, Colombia, Costa Rica, Ecuador, Egypt, Hong Kong, India, Indonesia, Korea, Malaysia, Mexico, Nigeria, Panama, Peru, Philippines, Poland, Russia, Singapore, Thailand and Venezuela.

Period: 1990-2003.

Capital stocks in EM and U are estimated with the perpetual inventory method, using the procedure of Caselli (2004). TFP values in EM and U are estimated as $y^i/(x^i)^\alpha$, $i \in \{EM, U\}$, where $\alpha = 0.36$, y^i and x^i are respectively output per worker and capital per worker in i.

As for the quantitative results shown in Table 3, the end-of-period indebtment of I is only slightly decreased. Only for very high, unrealistic adjustment costs is the external position significantly affected. The results of column (d), drawn with the extreme hypothesis that $\psi = 5$, give a level of debt which is still twice as high as in the data. These disappointing results are due to the fact that the installation costs are effective only during the transition. As the level of capital converges to its steady state, the installation costs disappear. This is illustrated by the fact that the cost of capital in graph (c) of Figure 6 converges towards the interest rate. At the end of the period, given our time span, this convergence is close to be achieved. Consistently, the other quantities are also unaffected for realistic levels of installation costs.

6 Conclusion

This paper has shown that the presence of financing constraints on the more productive technology in emerging markets can account, at least qualitatively, both for their capital outflows (Fact 1) and for their relative growth since 1990 as compared to the industrial countries, in particular the US (Fact 2). This growth is due both to the convergence of the level of capital to its steady state (Fact 3), but also to TFP growth (Fact 4). The latter is due to a better allocation of capital enabled by the replacement of the less productive, short-term capital with external bonds in the portfolio of the emerging countries. Indeed, since the developed world has better financial markets, its demand for liquid assets for hoarding purposes is lower than that of the developing countries; as a result, when financial globalization occurs, the emerging economies hold US bonds in order to use it as a hoard.

Qualitatively, in particular when accounting for capital installation costs, the model fits rather well the observed trends in the US current account, relative TFP growth and capital accumulation in emerging countries (hence their relative labor productivity growth). Quantitatively, when the model is fitted on the observed relative TFP growth, the level of debt and current account deficits in the US is over-estimated as well as the share of growth due to capital accumulation. However, the order of magnitude is partly captured. Besides, when the model is fitted on the US external position, the implied TFP growth due to capital reallocation is smaller than in the data, which is compatible with other sources of TFP growth.

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7 Appendix

Proof of Proposition 3.2

First, I examine how k, z and b vary with R under PFM and IFM. Then I show how the interest rate adjusts after the financial integration of I and E. Finally, depending on how the interest rate varies from the point of view of E and I, I determine how the portfolio adjusts in both countries.

Under PFM:

$\partial k^*/\partial R = \frac{1}{f''(f'^{-1}(R))} < 0$ and $\partial z^*/\partial R = \frac{1}{g''(g'^{-1}(R))} < 0$: k^* and z^* are decreasing in R because of decreasing marginal returns. As a consequence, since $b^*(R) = w - k^*(R) - z^*(R)$, b^* is increasing in R.

Under IFM:

First, assume that the constrained allocation is chosen.

Because even for the constrained allocation the entrepreneur chooses $\bar{k}$ optimally, $\bar{k}$ is decreasing in R because it becomes relatively less efficient than $\bar{b}$: $\partial \bar{k}/\partial R = \frac{1}{f''(f'^{-1}(R))} < 0$.

Differentiating (FC) with respect to R, and using the optimality condition $f'(\bar{k}) = R$, we obtain $\partial \bar{b}/\partial R = -\partial \bar{k}/\partial R - \frac{\bar{b}}{R}$, which is positive when b small, since $\partial \bar{k}/\partial R < 0$.

Differentiating (BC) with respect to R, we find $\partial \bar{z}/\partial R = -\partial \bar{k}/\partial R - \partial \bar{b}/\partial R$. Replacing $\partial \bar{b}/\partial R$, this yields: $\partial \bar{z}/\partial R = \frac{\bar{b}}{R}$.

We have $\bar{b}(\bar{R}^a) = 0$, so when $R = \bar{R}^a$, we have $\partial \bar{b}/\partial R = -\partial \bar{k}/\partial R > 0$. Therefore, in the neighborhood of $\bar{R}^a$, if $R < \bar{R}^a$, then $\bar{b} < 0$, so $\partial \bar{b}/\partial R > 0$. $\bar{b}$ is therefore always negative when $R < \bar{R}^a$, and we have $\partial \bar{b}/\partial R > 0$ and $\partial \bar{z}/\partial R > 0$. However, when $R > \bar{R}^a$, $\partial \bar{b}/\partial R$ has an ambiguous sign. Still, for $R > \bar{R}^a$, it can be shown that $\bar{b} > 0$ and as a consequence $\partial \bar{z}/\partial R > 0$. Indeed, it can be seen that, when b is high, b can decrease with R but it never becomes negative: if b falls a lot, then $\partial \bar{k}/\partial R$ will eventually become predominant, and b would start to rise again.

Adjustment of R after financial integration:

For $R < \bar{R}^a$, both b^* and $\bar{b}$ are negative. For $R > R^{a*}$, both b^* and $\bar{b}$ are positive. For $\bar{R}^a \leq R \leq R^{a*}$, $b^* \leq 0$ and $\bar{b} \geq 0$, so, if there exists a solution R^o such that $b^*(R^o) = -\bar{b}(R^o)$, it is necessary in the $[\bar{R}^a, R^{a*}]$ interval. Such a solution exists by continuity of b^* and $\bar{b}$ since $\bar{b}(\bar{R}^a) = 0$, $\bar{b}(R^{a*}) \geq 0$, $b^*(\bar{R}^a) < 0$ and $b^*(R^{a*}) = 0$.

Now, we can show that for $R = R^o$, the credit constraint is still binding in the emerging economy by ruling out the first-best allocation and the risky one. First, a sufficient condition for ruling out the first-best allocation is $z^*(R^o) \geq \bar{z}(R^o)$. This condition is equivalent to $w - f(k*(R^o)) - b^*(R^o) \geq w - f(\bar{k}(R^o)) - \bar{b}(R^o)$, which corresponds to $b^*(R^o) \leq \bar{b}(R^o)$. We have shown that $b^*(R) \leq 0$ and $\bar{b}(R) \geq 0$ for all $R \in [\bar{R}^a, R^{a*}]$, and since $R^o \in [\bar{R}^a, R^{a*}]$, we have necessarily $b^*(R^o) \leq \bar{b}(R^o)$. Therefore, the first-best allocation is not implementable for $R = R^o$. Similarly, Assumption 3.1 implies that $\bar{z}(\bar{R}^a) > z^{**}(\bar{R}^a)$. Besides, we have shown that for $R > \bar{R}^a$, $\partial \bar{z}/\partial R > 0$. On the other hand, $\partial z^{**}/\partial R < 0$. Therefore, $\bar{z}(R^o) > z^{**}(R^o)$, which implies that the allocation for $R = R^o$ is the constrained one.

As a conclusion, a solution with a binding financing constraint in the emerging markets exists and is characterized by an interest rate R^o in the $[\bar{R}^a, R^{a*}]$ interval.

Adjustment of the portfolio after financial integration:

Consider the general equilibrium solution characterized by $R = R^o$.

Since the industrial economy experiences a drop in the interest rate when financial markets integrate, k^* and z^* rise and b^* decreases.

Since the emerging economy experiences a drop in the interest rate when financial markets integrate, $\bar{k}$ falls while $\bar{z}$ and $\bar{b}$ rise. ■

Proof of Proposition 3.3

We consider the solution satisfying Assumption 3.1 highlighted in Proposition 3.2, with a binding financing constraint in E. In the Cobb-Douglas case:

$$\bar{k} = \left(\tfrac{\alpha}{R}\right)^{\frac{1}{1-\alpha}}, \qquad \bar{b} = \tfrac{\Phi}{R} - \tfrac{1}{\alpha}\left(\tfrac{\alpha}{R}\right)^{\frac{1}{1-\alpha}}, \qquad \bar{z} = w - \tfrac{\Phi}{R} + \tfrac{1-\alpha}{\alpha}\left(\tfrac{\alpha}{R}\right)^{\frac{1}{1-\alpha}}$$

Then the derivatives can be inferred:

$$\partial\bar{k}/\partial R = -\tfrac{1}{1-\alpha}\frac{\alpha^{\frac{1}{1-\alpha}}}{R^{\frac{2-\alpha}{1-\alpha}}}, \qquad \partial\bar{b}/\partial R = -\tfrac{\Phi}{R^2} + \tfrac{1}{1-\alpha}\frac{\alpha^{\frac{\alpha}{1-\alpha}}}{R^{\frac{2-\alpha}{1-\alpha}}}, \qquad \partial\bar{z}/\partial R = \tfrac{\Phi}{R^2} - \frac{\alpha^{\frac{\alpha}{1-\alpha}}}{R^{\frac{2-\alpha}{1-\alpha}}}$$

Which implies:

$\partial\bar{y}/\partial R > 0$

$$\Leftrightarrow \underbrace{A\alpha\left(w - \frac{\Phi}{R} + \frac{1-\alpha}{\alpha}\left(\frac{\alpha}{R}\right)^{\frac{1}{1-\alpha}}\right)^{-(1-\alpha)}}_{g'(\bar{z})}\underbrace{\left(\frac{\Phi}{R^2} - \frac{\alpha^{\frac{\alpha}{1-\alpha}}}{R^{\frac{2-\alpha}{1-\alpha}}}\right)}_{\partial\bar{z}/\partial R} + \underbrace{R}_{f'(\bar{k})}\underbrace{\left(\frac{-1}{1-\alpha}\frac{\alpha^{\frac{1}{1-\alpha}}}{R^{\frac{2-\alpha}{1-\alpha}}}\right)}_{\partial\bar{k}/\partial R} > 0$$

$$\Leftrightarrow A\alpha\left(\underbrace{\frac{\Phi}{R^2} - \frac{\alpha^{\frac{\alpha}{1-\alpha}}}{R^{\frac{2-\alpha}{1-\alpha}}}}_{b/R(>0)}\right) > \tfrac{1}{1-\alpha}\left(\tfrac{\alpha}{R}\right)^{\frac{1}{1-\alpha}}\left(\underbrace{w - \frac{\Phi}{R} + \frac{1-\alpha}{\alpha}\left(\frac{\alpha}{R}\right)^{\frac{1}{1-\alpha}}}_{z(>0)}\right)^{(1-\alpha)}$$

Which is true if A or Φ high, or if w small.

If the above condition is satisfied, that is if A and ϕ^E high, if w small, then $\partial\bar{y}/\partial R > 0$. ■

Proof of Proposition 5.1

The (8) and (9) system that characterizes the dynamics of the industrial country is linearized around the financial globalization steady state (z_∞, C^I_∞):

$$\Delta C^I_{t+1} = \Delta C^I_t - \beta\left[\kappa + (1-\beta)\frac{n^E}{n^I}[\phi - f(k_\infty)]g''(z_\infty)\right]\Delta z^I_{t+1} \text{ for } t \geq 0 \qquad (14)$$

$$\Delta C_t^I = \frac{\chi}{\beta}\Delta z_t^I - (\chi + \beta^2 g''(z_\infty)\frac{n^E}{n^I}[\phi - f(k_\infty)])\Delta z_{t+1}^I \text{ for } t > 0 \tag{15}$$

and at $t = 0$:

$$\Delta C_0^I = -\left(\chi + \beta^2 g''(z_\infty)\frac{n^E}{n^I}[\phi - f(k_\infty)]\right)\Delta z_1^I + \frac{n^E}{n^I}[\phi - f(k_\infty)] \tag{16}$$

where $\kappa = (1 + A^{\frac{-1}{1-\alpha}})\left(\frac{1}{\beta} - [1 - \delta(1-\alpha)]\right)\left(\frac{1}{\beta} - [1 - \delta]\right)$ and $\chi = 1 + 2A^{\frac{-1}{1-\alpha}} > 1$.

Equations (14), (15) and (16), which govern the dynamics of the industrial economy, are independent from the rest of the system, since they only involve z^I and C^I. Once the dynamics of z^I is solved using this independent dynamic sub-system with 2 variables and 2 equations, the dynamics of z^E can be inferred using Equations (10) and (11).

We replace ΔC_{t+1}^I and ΔC_t^I in (14) using (15). We obtain the following second-order difference equation for Δz^I:

$$\Delta z_{t+2}^I - \left(1 + \frac{\chi}{\beta(\chi + \beta^2 g''(z_\infty)\frac{n^E}{n^I}[\phi - f(k_\infty)])} + \frac{\beta\left(\kappa + (1-\beta)\frac{n^E}{n^I}[\phi - f(k_\infty)]g''(z_\infty)\right)}{\chi + \beta^2 g''(z_\infty)\frac{n^E}{n^I}[\phi - f(k_\infty)]}\right)\Delta z_{t+1}^I + \frac{\chi}{\beta(\chi + \beta^2 g''(z_\infty)\frac{n^E}{n^I}[\phi - f(k_\infty)])}\Delta z_t^I = 0$$

The characteristic polynomial of this difference equation is:

$$P_I(x) = x^2 - \left(1 + \frac{\chi}{\beta(\chi + \beta^2 g''(z_\infty)\frac{n^E}{n^I}[\phi - f(k_\infty)])} + \frac{\beta\left(\kappa + (1-\beta)\frac{n^E}{n^I}[\phi - f(k_\infty)]g''(z_\infty)\right)}{\chi + \beta^2 g''(z_\infty)\frac{n^E}{n^I}[\phi - f(k_\infty)]}\right)x + \frac{\chi}{\beta(\chi + \beta^2 g''(z_\infty)\frac{n^E}{n^I}[\phi - f(k_\infty)])} = 0$$

Under the condition $\chi > -\beta^2 g''(z_\infty)\frac{n^E}{n^I}[\phi - f(k_\infty)]$, the above second-order polynomial has two positive roots, one above one and denoted λ_I', and the other below one and denoted λ_I. The former is irrelevant because it leads to a path for Δz_t^I that is explosive. Then we know that, for all $t > 0$:

$$\Delta z_{t+1}^I = \lambda_I \Delta z_t^I$$

with $\Delta z_1^I = \frac{n^E}{n^I}\frac{\phi - f(k_\infty)}{\lambda_I'}$ as an initial condition, derived from Equation (16). At impact, z^I thus increases in the industrial country and then slowly decreases towards its steady state.

If the emerging country is credit constrained all along the transition path, then the industrial country's dynamics is well described by the previous equations. If $\phi - f(k_\infty)$ is small, then

$\chi > -\beta^2 g''(z_\infty)\frac{n^E}{n^I}[\phi - f(k_\infty)]$. Therefore, as said before, Δz^I admits a unique trajectory towards the steady state.

Since $\phi > f(k_\infty)$ and $\lambda'_I > 1$, $\Delta z_1^I = \frac{n^E}{n^I}\frac{\phi - f(k_\infty)}{\lambda'_I} > 0$. This yields the dynamics for z^I when the emerging country is constrained, but also for k^I, y^I and the world interest rate R_t, since $\Delta k_t^I = A^{\frac{-1}{1-\alpha}}\Delta z_t^I$, $\Delta y_t^I = 1/\beta(1 + A^{\frac{-1}{1-\alpha}})\Delta z_t^I$ and $\Delta R_t = g''(z_\infty)\Delta z_t^I$. ■

Proof of Proposition 5.2

Equations (10) and (11) are log-linearized around the steady state (z_∞, C_∞^I):

$$\Delta C_{t+1}^E = \Delta C_t^E - \beta\left(\kappa - \frac{1-\beta}{\beta}g''(z_\infty)[\phi - f(k_\infty)]\right)\Delta z_{t+1}^E \text{ for } t \geq 0 \tag{17}$$

$$\Delta C_t^E = \frac{1}{\beta}\Delta z_t^E - \Delta z_{t+1}^E + \beta^2 g''(z_\infty)[\phi - f(k_\infty)]\Delta z_{t+1}^I \text{ for } t \geq 0 \tag{18}$$

Evolution of z_t^E:

Replacing ΔC_{t+1}^E and ΔC_t^E in Equation (17) using (18), we find that Δz_t^E is defined implicitly by the following second-order difference equation:

$$\Delta z_{t+2}^E - \left(\frac{1}{\beta} + \beta\left(\kappa - \frac{1-\beta}{\beta}g''(z_\infty)[\phi - f(k_\infty)]\right) + 1\right)\Delta z_{t+1}^E + \frac{1}{\beta}\Delta z_t^E$$
$$= -\beta^2 g''(z_\infty)[\phi - f(k_\infty)](1-\lambda_I)\Delta z_{t+1}^I \tag{19}$$

The characteristic polynomial of the homogeneous equation is

$$P_E(x) = x^2 - \left(\frac{1}{\beta} + \beta\left(\kappa - \frac{1-\beta}{\beta}g''(z_\infty)[\phi - f(k_\infty)]\right) + 1\right)x + \frac{1}{\beta} = 0$$

This polynomial has two positive roots, $\lambda'_E > 1$, and λ_E, which is positive and lower than one. The only relevant root is therefore λ_E. A particular solution to the general equation is of the form: $\Delta z_t^E = v\Delta z_{t+1}^I$. v must satisfy:

$$v\left[\lambda_I^2 - \left(\frac{1}{\beta} + \beta\left(\kappa - \frac{1-\beta}{\beta}g''(z_\infty)[\phi - f(k_\infty)]\right) + 1\right)\lambda_I + \frac{1}{\beta}\right]$$
$$= -\beta^2(1-\lambda_I)g''(z_\infty)[\phi - f(k_\infty)]$$

As a result: $v = \frac{-\beta^2(1-\lambda_I)g''(z_\infty)[\phi - f(k_\infty)]}{(\lambda_E - \lambda_I)(\lambda'_E - \lambda_I)}$.

The general, converging solution for Δz_t^E is then of the following form $\Delta z_t^E = \lambda_E^t \Delta z'_0 + v\Delta z_{t+1}^I$. Here, Δz_0 is given so $\Delta z'_0$ must satisfy $\Delta z_0^E = \Delta z'_0 + v\Delta z_1^I$, so we have:

$$\Delta z_t^E = \lambda_E^t(\Delta z_0^E - v\Delta z_1^I) + \lambda_I^t v\Delta z_1^I \tag{20}$$

To study the evolution of z^E, we have to determine the sign of v, which is the same as $\lambda_E - \lambda_I$. Consider the case where $\phi^E = f(k_\infty)$: $P_I(\lambda) - P_E(\lambda) = \beta\kappa(1 - 1/\chi)\lambda$. We have $\chi > 1$, so, for $\lambda > 0$, $P_I(\lambda) > P_E(\lambda)$. As a result, $P_I(\lambda_E) > P_E(\lambda_E) = 0$. Since P_I is decreasing on the $[0, 1]$ interval, and $P_I(\lambda_I) = 0$, then $\lambda_I > \lambda_E$. This is still the case by continuity when ϕ^E close to $f(k_\infty)$. Therefore, $v < 0$.

As a consequence, since Δz_1^I is of the same sign as $\phi^E - f(k_\infty)$, which is positive, the second term of the RHS is negative. Since, additionally, $\Delta z_0^E < 0$ and Δz_1^I and v are proportional to $|\phi^E - f(k_\infty)|$, which is small compared to $|\Delta z_0^E|$, the second term is also negative. Therefore, Δz_t^E is always negative and z^E is increasing in t.

Existence of the constrained solution: We now show that the solution defined by Equation (20) under the hypothesis of forever binding financing constraints does exist. We have to prove first that if z_t^E follows (20), then the entrepreneurs are indeed constrained. It is the case as long as $\Delta z_t^I > \Delta z_t^E$. $\phi^E > f(k_\infty)$ implies that $\Delta z_t^I > 0$. It has been shown also that $\Delta z_t^E < 0$. As a consequence, $\Delta z_t^I > \Delta z_t^E$ for all $t > 0$.

Second, we have to prove that under Assumption 4.1, the risky allocation is not a better choice along the transition path with binding financing constraint. First, recall that Assumption 4.1, the risky z is below the constrained one for the interest rate corresponding to the constrained allocation. When the constraint is binding on the convergence path, z^E increases. Besides, the interest rate increases, so the corresponding risky allocation decreases. The constrained allocation is still above the risky one, so the latter is ruled out along the constrained transition path.

Evolution of b_t^E: When the economy is constrained, Δb_t^E evolves according to:

$$\Delta b_t^E = \left(-\beta^2 g''(z_\infty)[\phi - f(k_\infty)] - A^{\frac{-1}{1-\alpha}}\right) \Delta z_t^I$$

When $\phi^E - f(k_\infty)$ is small, the substitution effect dominates so Δb_t^E is of the opposite sign of Δz_t^I, which is positive: b_t^E is below its steady state and is increasing in t.

Evolution of k_t^E: After the integration of financial markets, k_t^E follows the same path as k_t^I, since $f'(k_t^E)$ is equal to the world interest rate.

Evolution of y_t^E: According to Equation (20) and since $\Delta k_t^E = A^{\frac{-1}{1-\alpha}} \Delta z_t^I = A^{\frac{-1}{1-\alpha}} \lambda_I^t \Delta z_1^I / \lambda_I$, the evolution of y^E is given by the following equation:

$$\Delta y_t^E = \frac{1}{\beta} \left[\lambda_E^t (\Delta z_0^E - v \Delta z_1^I) + \lambda_I^t \left(v + \frac{A^{\frac{-1}{1-\alpha}}}{\lambda_I} \right) \Delta z_1^I \right]$$

v is proportional to $\phi^E - f(k_\infty)$. Therefore, if ϕ^E is close to $f(k_\infty)$, then the second term is positive. On the opposite, as we have already shown, the first term is negative. However, Δz_1^I is proportional to $\phi^E - f(k_\infty)$, so when $\phi^E - f(k_\infty)$ is small as compared to $|\Delta z_0^E|$, the RHS is negative and increasing in t for small values of t. However, since $\lambda_I > \lambda_E$, as we have shown, the first term becomes negligible for large values of t, and the RHS becomes positive and decreasing in t.

Evolution of y_t^E/y_t^I: Up to a linear approximation, y_t^E/y_t^I evolves in the same direction as $\Delta y_t^E - \Delta y_t^I$. Besides, we have:

$$\Delta y_t^E - \Delta y_t^I = \frac{1}{\beta}\left[\lambda_E^t(\Delta z_0^E - v\Delta z_1^I) + \lambda_I^t\left(v - \frac{1}{\lambda_I}\right)\Delta z_1^I\right]$$

All the terms of the RHS are negative and increasing in t, so $\Delta y_t^E - \Delta y_t^I$ is increasing in t. ■