Financial Development and the Patterns of International Capital Flows*

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Abstract

We develop a tractable two-country overlapping-generations model and show that cross-country differences in financial development can explain three recent empirical patterns of international capital flows: Financial capital flows from relatively poor to relatively rich countries while foreign direct investment flows in the opposite direction; net capital flows go from poor to rich countries; despite of its negative net international investment positions, the United States receives a positive net investment income. We also explore the welfare and distributional effects of international capital flows and show that the patterns of capital flows may reverse along the convergence process of a developing country.

Keywords: Capital account liberalization, financial development, foreign direct investment, symmetry breaking
JEL Classification: E44, F41

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1 Introduction

Standard international macroeconomics predicts that capital flows from capital-rich countries, where the marginal return on investment is low, to capital-poor countries, where the marginal return is high. Furthermore, there should be no difference between gross and net capital flows, as capital movements are unidirectional.

The patterns of international capital flows observed in the past 20 years, however, stand in stark contrast to these predictions (Lane and Milesi-Ferretti, 2001, 2007a,b). First, since 1998, the average per-capita income of countries running current account surpluses has been below that of the deficit countries, i.e., net capital flows have been "uphill" from poor to rich countries (Prasad, Rajan, and Subramanian, 2006, 2007). Second, many developing economies, including China, Malaysia, and South Africa, are net importers of foreign direct investment (hereafter, FDI) and net exporters of financial capital at the same time, while developed countries such as France, the United Kingdom, and the United States exhibit the opposite pattern (Ju and Wei, 2010). Third, despite its negative net international investment position since 1986, the U.S. has been receiving a positive net investment income until 2005 (Gourinchas and Rey, 2007; Hausmann and Sturzenegger, 2007; Higgins, Klitgaard, and Tille, 2007).

Recent research offers two main explanations to these empirical facts. Devereux and Sutherland (2009) and Tille and van Wincoop (2010) focus on the cross-country risk-sharing investors can achieve by diversifying their portfolios globally. International portfolio investment is determined by the cross-correlation patterns of aggregate shocks at the country level. These models do not distinguish between FDI and portfolio equity investment and, therefore, offer no explanation for the second pattern.

The other strand of literature focuses on domestic financial market imperfections (Aoki, Benigno, and Kiyotaki, 2009; Caballero, Farhi, and Gourinchas, 2008; Smith and Valderrama, 2008). Matsuyama (2004) shows that, in the presence of credit market imperfections, financial market globalization may lead to a steady-state equilibrium in which fundamentally identical countries end up with different levels of per capita output, a result he calls "symmetry breaking". Furthermore, financial capital flows from poor to rich countries in the steady state. However, Matsuyama (2004) does not address FDI flows. Mendoza, Quadrini, and Rios-Rull (2009) analyze the joint determination of financial capital flows and FDI in a heterogeneous-agent model with uninsurable idiosyncratic endowment and investment risks. The precautionary savings motive plays the crucial role. Ju and Wei (2010) show in a static model that, when both FDI and financial capital flows are allowed, all financial capital leaves the country where credit market imperfections are more severe, while FDI flows into this country. Thus, capital mobility allows investors to fully *bypass* the underdeveloped financial system.

We extend the second strand of literature and develop an overlapping-generations model to explain three recent empirical facts. Our model builds on the notion that individuals in an economy differ in the productivity (Kiyotaki and Moore, 1997). In the frictionless case, all capital would be operated by the most productive individuals and, the rates of return on loan and equity capital would be equal to the marginal return on investment. Due to financial frictions, however, individuals are subject to borrowing constraints. The constraint on the aggregate credit demand has a general equilibrium effect, keeping the rate of return on loans (hereafter, the loan rate) lower and the rate of return on equity capital (hereafter, the equity rate) higher than the marginal return on investment.[1] Thus, financial frictions distort the two interest rates and generate an equity premium in this deterministic model.

Following Matsuyama (2004), we take the tightness of the borrowing constraints as a measure of a country's level of financial development. In a more financially developed country, credit contracts can be enforced and borrowers can be monitored more effectively. Thus, the individuals can borrow more from financial institutions. The two countries in our model differ fundamentally only in the level of financial development. Under international financial autarky (hereafter, IFA), interest rates depend on two factors. First, a lower aggregate capital-labor ratio implies a higher marginal return on investment and a higher equity and loan rate. We call this the *neoclassical* effect, because it arises from the concavity of the neoclassical production function with respect to the capital-labor ratio. Second, for a given capital-labor ratio, a lower level of financial development implies a lower aggregate credit demand, which leads to a lower loan rate and a higher equity rate. We call this the *credit-demand* effect of financial development. In the steady state, financial development affects the interest rates only via the credit-demand channel but not the neoclassical channel in our model.[2] That is, the loan rate is higher while the equity rate is lower in the more financially developed country.

Under full international capital mobility, since the more financially developed country has a larger credit market, it receives net capital inflows and becomes richer in the steady state , and the opposite applies to the less financially developed country. In other words, net capital flows are "uphill" from the poor to the rich country in the steady state. Due to the initial cross-country interest rate differentials, financial capital flows from the poor to

[1] The overlapping-generations framework together with certain assumptions ensures that the aggregate credit supply is perfectly inelastic to the loan rate. Thus, we can isolate the effect of financial frictions on the aggregate credit demand and on the interest rates. Caballero, Farhi, and Gourinchas (2008) assume that agents have a constant probability of death, which has the similar effect.

[2] This is due to the assumption that the less productive users of capital do not have an alternative production technology except inelastically lending to the productive individuals. von Hagen and Zhang (2010b) relax this assumption and, as a result, financial frictions distort production efficiency as well as interest rates. The qualitative results still hold.

the rich country, while FDI flows in the opposite direction. Since the rich country receives a higher return on its FDI than it pays on its foreign debts, it gets a positive net investment income despite its negative net position of international investment. Essentially, the more financially developed country "exports" its financial services in the form of two-way capital flows and receives a positive net reward. This way, we show that cross-country differences in financial development can explain the three empirical facts.

The static model of Ju and Wei (2010) is useful for analyzing the immediate impacts of capital account liberalization, while our OLG model facilitates the short-run and the long-run analysis. In the absence of uncertainty, international capital flows vanish in Devereux and Sutherland (2009); Mendoza, Quadrini, and Rios-Rull (2009); Tille and van Wincoop (2010). In contrast, international capital flows exist in our deterministic model. Thus, differences in financial development rather than uncertainty are the fundamental factor driving the recent patterns of international capital flows.[3] In this sense, our model shares the similar feature as Caballero, Farhi, and Gourinchas (2008). However, Caballero, Farhi, and Gourinchas (2008) assume that foreign direct investors from the more financially developed country have the advantage in capitalizing the investment revenue in the host country, while we do not need this extra assumption.

We also analyze a scenario where one country is more financially developed and in its steady state, while the other country is less financially developed and below its steady state before capital account liberalization. In so doing, we study the interactions of capital flows and the economic convergence of the second country. In particular, we show that the pattern of international capital flows may change or even reverse along the convergence process of the less financially developed country. Additionally, countries with a higher level of financial development are more likely to have financial capital inflows.

Financial capital flows affect the owners of credit capital and equity capital in the opposite way and so do FDI flows. Due to transitional effects, capital flows also affect the intergenerational income distribution. Our model points out such distributional effects of capital flows and offers an explanation for why capital account liberalization often encounters both support and opposition in a given country.

We assume that the mass of individuals who can produce is fixed in each country, while the size of each production project is endogenously determined. Thus, investment occurs on the intensive margin instead of the extensive margin as in Matsuyama (2004). We show that, under various forms of capital mobility, countries with identical fundamentals have the same, unique, and stable steady state. This way, we show that Matsuyama's *symmetry-breaking* property depends critically on the assumption of a fixed size of individual projects and thus, investment occurs on the extensive margin. In our model,

[3]Aggregate or idiosyncratic uncertainty is important for the quantitative purpose in Devereux and Sutherland (2009); Mendoza, Quadrini, and Rios-Rull (2009); Tille and van Wincoop (2010).

countries with identical fundamentals except the level of financial development have the same steady-state output level under IFA, but they have different steady-state levels of output under capital mobility. Thus, capital mobility also breaks the symmetry in our model, but it does so for the reason different from that in Matsuyama (2004).

The rest of the paper is structured as follows. Section 2 sets up the model and shows the distortions of financial frictions on interest rates under IFA. Section 3 analyzes the long-run and short-run patterns of international capital flows. Section 4 concludes with some remarks. Appendix collects the technical proofs and relevant discussions.

2 The Model under International Financial Autarky

The world economy consists of two countries, Home (H) and Foreign (F). There are a final good and a capital good. The final good is internationally tradable and serves as the numeraire, while the capital good is non-tradable and its price in country $i \in \{H, F\}$ and period t is denoted by v_t^i. In the following, variables in country i are denoted with the superscript i. The final good can be either consumed or transformed into capital goods. At the beginning of each period, final goods Y_t^i are produced with capital goods K_t^i and labor L_t^i in a Cobb-Douglas fashion. Capital goods fully depreciate after production. Capital goods and labor are priced at their respective marginal products. To summarize,

$$Y_t^i = \left(\frac{K_t^i}{\alpha}\right)^{\alpha}\left(\frac{L_t^i}{1-\alpha}\right)^{1-\alpha}, \qquad \text{where} \qquad \alpha \in (0,1), \tag{1}$$

$$v_t^i K_t^i = \alpha Y_t^i \qquad \text{and} \qquad w_t^i L_t^i = (1-\alpha) Y_t^i. \tag{2}$$

w_t^i denotes the wage rate. There is no uncertainty in the economy. In this section, we assume that capital flows are not allowed between the two countries.

The population in each country consists of two generations, the old and the young, which live for two periods each. There is no population growth and the population size of each generation in each country is normalized to one. Agents consume only when old. Agents when young are endowed with a unit of labor which they supply inelastically to the production of final goods $L_t^i = 1$. Each generation consists of two types of agents, *entrepreneurs* and *workers*, of mass η and $1-\eta$, respectively. Only young entrepreneurs can produce capital goods one-to-one from final goods and the production takes a period.

Consider any particular worker born in country i and period t. With no other investment opportunity available to him[4], the worker lends his entire labor income at the gross interest rate R_t^i in period t to finance his consumption in period $t+1$,

$$c_{t+1}^{i,w} = w_t^i R_t^i. \tag{3}$$

[4]Excluding workers from other saving alternatives significantly simplifies the analysis. von Hagen and Zhang (2010b,c) show that relaxing this assumption does not change our qualitative results.

Consider any particular entrepreneur born in country i and period t. In period t, he invests i_t^i units of final goods into the project which produces i_t^i units of capital goods in period $t+1$. Given the gross loan rate R_t^i, he finances the investment with the debt $z_t^i = i_t^i - w_t^i$ and the equity capital, w_t^i. Due to limited commitment problems, however, he can borrow only against a fraction of the project revenues,

$$R_t^i z_t^i = R_t^i (i_t^i - w_t^i) \leq \theta^i i_t^i v_{t+1}^i. \tag{4}$$

As in Matsuyama (2004, 2007, 2008), the level of financial development in country i is measured by $\theta^i \in (0, 1]$. θ^i is higher in countries with more sophisticated financial and legal systems, better creditor protection, and more liquid asset market. Thus, θ^i captures a wide range of institutional factors. We assume that the two countries differ only in the level of financial development, i.e., $0 < \theta^H < \theta^F \leq 1$.

After repaying his debt in period $t+1$, the entrepreneur gets $v_{t+1}^i i_t^i - R_t^i z_t^i$ as the net return. The equity rate is defined as the rate of return on equity capital,

$$\Gamma_t^i \equiv \frac{v_{t+1}^i i_t^i - R_t^i z_t^i}{w_t^i} = v_{t+1}^i + (v_{t+1}^i - R_t^i)(\lambda_t^i - 1) \geq R_t^i, \tag{5}$$

where $\lambda_t^i \equiv \frac{i_t^i}{w_t^i}$ denotes the investment-equity ratio. For each unit of equity capital invested in the project, the entrepreneur gets v_{t+1}^i as the marginal return. Additionally, he can borrow $(\lambda_t^i - 1)$ units of debt which gives him an extra rate of return, $v_{t+1}^i - R_t^i$. The term $(v_{t+1}^i - R_t^i)(\lambda_t^i - 1)$ captures the *leverage* effect. In equilibrium, the equity rate should be no less than the loan rate; otherwise, he would rather lend than borrow. The inequality in (5) is equivalent to $R_t^i \leq v_{t+1}^i$ and can be considered as his participation constraint.

If $R_t^i < v_{t+1}^i$, the entrepreneur borrows to the limit, i.e., he finances the investment i_t^i using $z_t^i = \frac{\theta^i v_{t+1}^i i_t^i}{R_t^i}$ units of debt and w_t^i units of equity capital in period t. After repaying the debt in period $t+1$, he gets $(1-\theta^i) v_{t+1} i_t^i$ as the project return. If $R_t^i = v_{t+1}^i$, the entrepreneur does not borrow to the limit. According to equation (5), the equity rate is equal to the loan rate, $\Gamma_t^i = v_{t+1}^i$. To summarize,

$$\Gamma_t^i = \begin{cases} \frac{(1-\theta^i) v_{t+1}^i i_t^i}{w_t^i} = \frac{(1-\theta^i) v_{t+1}^i}{1 - \frac{\theta^i v_{t+1}^i}{R_t^i}}, & \text{if } R_t^i < v_{t+1}^{i,B}, \\ v_{t+1}^i & \text{if } R_t^i = v_{t+1}^i. \end{cases} \tag{6}$$

The entrepreneur chooses the project investment i_t^i in period t to maximize his consumption in period $t+1$,

$$c_{t+1}^{i,e} = v_{t+1}^i i_t^i - R_t^i z_t^i = w_t^i \Gamma_t^i, \tag{7}$$

subject to the borrowing constraint (4) and the participation constraint (5). Note that only one of the two constraints can be strictly binding in equilibrium.

Let K_{t+1}^i denotes aggregate capital stock in country i and period $t+1$. The credit market equilibrium implies that aggregate labor income is fully invested by entrepreneurs,

$$\eta(i_t^i - w_t^i) = (1-\eta)w_t^i, \quad \Rightarrow \quad K_{t+1}^i = I_t^i \equiv \eta i_t^i = w_t^i. \tag{8}$$

The market-clearing condition for final goods in period t is

$$C_t^i + I_t^i = Y_t^i, \quad \text{where} \quad C_t^i = \eta c_t^{i,e} + (1-\eta)c_t^{i,w}. \tag{9}$$

The social welfare of the generation born in period t and country i is measured by its aggregate consumption when old, C_{t+1}^i.

Definition 1. *Given the level of financial development θ^i, a market equilibrium in country $i \in \{H, F\}$ under IFA is a set of allocations of workers, $\{c_t^{i,w}\}$, entrepreneurs, $\{i_t^i, z_t^i, c_t^{i,e}\}$, and aggregate variables, $\{Y_t^i, K_t^i, I_t^i, w_t^i, v_t^i, R_t^i, \Gamma_t^i\}$, satisfying equations* (1)-(5) *and* (7)-(8).

Let X_{IFA} denote the steady-state value of variable X under IFA. The revenue of capital goods in period $t+1$ is $v_{t+1}^i K_{t+1}^i = \rho w_{t+1}^i$, where $\rho \equiv \frac{\alpha}{1-\alpha}$. Let $\Psi_t^i \equiv \frac{v_{t+1}^i K_{t+1}^i}{I_t^i} = \frac{\rho w_{t+1}^i}{w_t^i} = v_{t+1}^i$ define the social rate of return to aggregate investment, which is constant at $\Psi_{IFA}^i = \rho$ in the steady state. The loan rate R_t^i and the price of capital good v_{t+1}^i are essentially the intertemporal prices of final good for workers and for country i as a whole, respectively. Let $\psi_{t+1}^i \equiv \frac{R_t^i}{v_{t+1}^i}$ denote the intertemporal relative price.

Lemma 1. *The model dynamics are characterized by the dynamic equation of wages, $w_{t+1}^i = \left(\frac{w_t^i}{\rho}\right)^\alpha$. There exists an unique and stable steady state with $w_{IFA}^i = \left(\frac{1}{\rho}\right)^\rho$.*

Let $\bar{\theta} \equiv 1-\eta$. For $\theta^i \in (\bar{\theta}, 1]$, the borrowing constraints are slack, $\psi_t^i = \psi_{IFA}^i = 1$, and $R_t^i = \Gamma_t^i = \Psi_t^i$. For $\theta^i \in (0, \bar{\theta})$, the borrowing constraints are binding, $\psi_t^i = \psi_{IFA}^i = \frac{\theta^i}{1-\eta} < 1$, and $R_t^i = \Psi_t^i \psi_{IFA}^i < \Psi_t^i < \Gamma_t^i = \Psi_t^i \left[1 + \frac{1-\eta}{\eta}(1-\psi_{IFA}^i)\right]$.

Proof. See appendix A. □

Under IFA, since aggregate savings are invested entirely by entrepreneurs and the loan rate adjusts to clear the credit market, financial frictions do not affect aggregate production and the steady-state aggregate output is independent of θ^i.[5]

For $\theta \in (\bar{\theta}, 1]$, aggregate credit demand is so large as to keep the loan rate equal to the social rate of return, i.e., $\psi^i = 1$. According to equation (5), the equity rate is also equal to the social rate of return. This way, the private and the social rates of return coincide. Since the social rate of return $\Psi_t^i = \rho^{1-\alpha^2}(K_t^i)^{\alpha(\alpha-1)}$, depends negatively on K_t^i, the private rates of return are higher in the country with a lower capital-labor ratio. We

[5]von Hagen and Zhang (2010b) generalize this model by including investment composition and elastic savings. As a result, financial frictions distort aggregate production and the steady-state aggregate output is monotonically increasing in θ^i.

call it the *neoclassical* effect, as it arises from the concavity of the neoclassical aggregate production function with respect to the capital-labor ratio.

For $\theta^i \in (0, 1-\eta)$, besides the neoclassical effect, the private rates of return are also affected by θ^i. Intuitively, due to the constraint on aggregate credit demand, the loan rate falls below the social rate of return so as to clear the credit market, i.e., $0 < \psi^i < 1$. According to equation (5), due to the leverage effect, the equity rate is higher than the social rate of return. This way, financial frictions create a wedge between the private and the social rates of return, which we call the *credit-demand* effect. Such a wedge has a distributional effect on the welfare of borrowers (entrepreneurs) and lenders (workers). In the steady state, $R^i_{IFA} = \rho\psi^i_{IFA} < \rho < \Gamma^i_{IFA} = \rho\left[1 + \frac{1-\eta}{\eta}(1-\psi^i_{IFA})\right]$ implies that the loan rate is higher while the equity rate is lower in the more financially developed country.

3 International Capital Mobility

We consider three scenarios of capital mobility, *free mobility of financial capital* under which individuals are allowed to lend abroad but entrepreneurs are not allowed to make direct investments abroad, *free mobility of FDI* under which entrepreneurs are allowed to make direct investments abroad but individuals are not allowed to lend abroad, and *full capital mobility* under which individuals are allowed to lend abroad and entrepreneurs are allowed to make direct investments abroad. Without loss of generality, we study the case of $0 < \theta^H < \theta^F \leq \bar{\theta}$, where the borrowing constraints are binding in the two countries in the steady state under three scenarios of capital mobility.[6]

In subsections 3.1, 3.2, and 3.3, we assume that the two countries are initially in the steady state under IFA before capital mobility is allowed from period $t = 0$ on. We analyze capital flows in the short run and in the long run between two countries with the same initial output level. The results on the uniqueness and stability of the market equilibrium before and after capital mobility do not depend on this assumption.

In subsection 3.4, we assume that country F is in the steady state and country H is below the steady state under IFA before capital mobility is allowed from period $t = 0$ on. We study the interactions between capital flows and economic convergence of country H.

Let Φ^i_t and Ω^i_t denote the aggregate outflows of financial capital and FDI from country i in period t, respectively, with negative values indicating capital inflows. Financial capital outflows reduce the domestic credit supply, $(1-\eta)w^i_t - \Phi^i_t$, while FDI outflows reduce the aggregate equity capital available for the domestic investment, $\eta w^i_t - \Omega^i_t$. Therefore, FDI flows raise the aggregate credit demand in the host country and reduce that in the parent country.[7] With these changes, the analysis in section 2 carries through for the cases of

[6] See von Hagen and Zhang (2010a) for a general analysis for $\theta^i \in (0, 1)$ with $i \in \{H, F\}$.

[7] In the case of debt default, the project liquidation value depends on the efficiency of the legal

capital mobility, due to the linearity of preferences, projects, and borrowing constraints.

3.1 Free Mobility of Financial Capital

Financial capital flows equalize the loan rate across the border and the credit markets clear in each country as well as at the world level. To summarize,

$$R_t^H = R_t^F = R_t^*, \quad \Phi_t^H + \Phi_t^F = 0, \quad (1-\eta)w_t^i = (\lambda_t^i - 1)\eta w_t^i + \Phi_t^i.$$

Except them, the equations of market equilibrium in each country are same as under IFA. The model solutions are

$$\Gamma_t^i = \frac{w_{t+1}^i}{w_t^i}\Gamma_{IFA}^i, \tag{10}$$

$$R_t^i = \frac{w_{t+1}^i}{w_t^i}R_{IFA}^i + \frac{w_{t+1}^i}{w_t^i}\mathcal{Z}_{t+1}^i, \quad \text{where} \quad \mathcal{Z}_{t+1}^i \equiv \frac{\rho}{\eta}(\psi_{t+1}^i - \psi_{IFA}^i), \tag{11}$$

$$\Phi_t^i = (1-\eta)w_t^i\left(1 - \frac{w_{t+1}^i}{w_t^i}\frac{R_{IFA}^i}{R_t^i}\right), \tag{12}$$

$$w_{t+1}^i = \left(\frac{\Lambda_t^i}{\rho}w_t^i\right)^\alpha, \quad \text{where} \quad \Lambda_t^i \equiv \frac{\psi_{t+1}^i\eta}{\psi_{t+1}^i - \theta^i}, \tag{13}$$

$$\frac{\partial \ln \Lambda_t^i}{\partial \psi_{t+1}^i} = -\frac{\theta^i}{\psi_{t+1}^i(\psi_{t+1}^i - \theta^i)} < 0 \tag{14}$$

The solution to the equity rate (10) can be explained intuitively as follows. Given the binding borrowing constraints, entrepreneurs use $\frac{z_t^i}{i_t^i} = \frac{\theta^i v_{t+1}^i}{R_t^*}$ units of loans and $\frac{w_t^i}{i_t^i} = \frac{(1-\theta^i)v_{t+1}^i}{\Gamma_t^i}$ units of equity capital to finance a unit of investment in period t.

$$1 = \frac{z_t^i}{i_t^i} + \frac{w_t^i}{i_t^i} = \frac{\theta^i v_{t+1}^i}{R_t^*} + \frac{(1-\theta^i)v_{t+1}^i}{\Gamma_t^i} \quad \Rightarrow \quad \frac{1-\theta^i}{\Gamma_t^i} = \frac{1}{v_{t+1}^i} - \frac{\theta^i}{R_t^*}. \tag{15}$$

Given θ^i, financial capital flows affect the equity rate in two ways. Take country H as an example. First, financial capital outflows raise the loan rate and the decline in the spread tends to reduce the equity rate. Second, financial capital outflows have a general equilibrium effect, i.e., the decline in the current aggregate investment reduces aggregate output in period $t+1$ and the price of capital goods rises, which tends to raise the equity rate. Financial capital outflows in period $t=0$ reduce the labor income in period $t=1$, $w_1^i < w_0^i = w_{IFA}$, and the equity rate is lower in period $t=0$, $\Gamma_0^i = \Gamma_{IFA}^i\frac{w_1^i}{w_0^i} < \Gamma_{IFA}^i$.

institution, the law enforcement, and the asset market in the host country. Thus, we assume that entrepreneurs making FDI borrow only from the host country and are subject to the borrowing constraints there. Alternatively, we can assume that entrepreneurs may borrow only in their parent country no matter where they invest, since the financial institutions in their parent country have better information on the credit record, social network, and business activities of the entrepreneurs. The realistic case should be a hybrid of these two. Our results hold under the two alternative assumptions.

Thus, in period $t = 0$, the first effect dominates and the equity rate is lower than the steady-state level under IFA. As the economy converges to the new steady state, the general-equilibrium effect kicks in and the equity rate converges back to the initial level.

Let X_{FCF} denote the steady-state value of variable X under partial capital mobility.

Lemma 2. *Under free mobility of financial capital, there exists a unique and stable steady state with the wage rate at* $w^i_{FCF} = w_{IFA}\left[\eta + (1-\eta)\frac{R^i_{IFA}}{R^*_{FCF}}\right]^{\rho}$.

Proof. See appendix A. □

The solid line and the dash-dotted line in the left panel of figure 1 show the phase diagrams of wages under IFA and under free mobility of financial capital, respectively, given a fixed world loan rate at $R^*_t = R^i_{IFA}$. In both cases, wages converge monotonically and globally to a unique and stable steady state (point A).

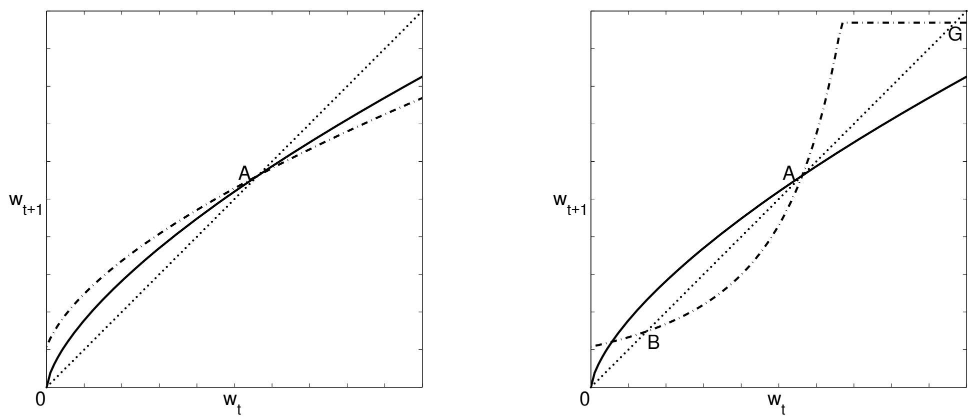

Figure 1: The Phase Diagrams of Wage

Matsuyama (2004) assumes that the size of every production project is fixed at $i^i_t = 1$, while the mass of individuals in a country who become entrepreneurs is endogenously determined. He shows that, at a given world loan rate, free mobility of financial capital may lead to an equilibrium with multiple steady states. In contrast, we assume that the mass of entrepreneurs in a country is fixed at η, while the investment size of any project i^i_t is endogenously determined. Since his model and ours differ only in this one aspect, it is straightforward to illustrate Matsuyama's result in the current framework.

The borrowing constraints, if binding, take the same form in both models,

$$R^*_t(1 - \frac{w^i_t}{i^i_t}) = \theta^i v^i_{t+1} = \theta^i (w^i_{t+1})^{-\frac{1}{\rho}}. \tag{16}$$

Lemma 3. *Given the world loan rate* R^*_t*, for* $w^i_t \in [0, 1-\theta^i]$*, the phase diagram of wages in Matsuyama (2004) described by* $R^*_t(1 - w^i_t) = \theta^i(w^i_{t+1})^{-\frac{1}{\rho}}$ *is strictly convex, and* w^i_{t+1} *increases monotonically in* w^i_t *with an intercept on the vertical axis at* $w^i_{t+1} = \left[\frac{\theta^i}{R^*_t}\right]^{\rho}$*; for* $w^i_t > 1 - \theta^i$*, the phase diagram of wages is flat with* $w^i_{t+1} = \left(\frac{1}{R^*_t}\right)^{\rho}$.

Proof. See appendix A. □

The solid line in the right panel of figure 1 shows the phase diagram of wages under IFA in Matsuyama (2004), which is the same as in our model and gives rise to the unique and stable steady state at point A. The dash-dotted line shows the phase diagram under free mobility of financial capital in his model, given a fixed world loan rate $R_t^* = R_{IFA}^i$. The phase diagram is convex for wages below a threshold value. Thus, the steady state at point A becomes unstable under free mobility of financial capital, because the slope of the phase diagram at point A is larger than one. There are two stable steady states at points B and G. This implies that countries with the identical fundamentals (including θ) and, thus, the same steady state under IFA may end up with different levels of income under free mobility of financial capital. Thus, Matsuyama (2004) claims that, in the presence of credit market imperfections, financial capital flows may result in the symmetry breaking.

According to equation (16), given a world loan rate R_t^* and a fixed size of project investment $i_t^i = 1$ as in Matsuyama (2004), a marginal increase in the current wage reduces the credit demand of each borrower, $(1 - w_t^i)$, and the debt-investment ratio, $\frac{z_t^i}{i_t^i} = (1 - \frac{w_t^i}{i_t^i}) = (1 - w_t^i)$. More domestic individuals can borrow at the prevailing world loan rate and produce. If the current wage w_t^i exceeds the level corresponding to point A, the debt-investment ratio will decrease and more individuals will become entrepreneurs. This way, although the borrowing constraints take the same form across countries, the ex post effective tightness of borrowing constraint depends essentially on the initial capital stock, due to the project indivisibility. The higher the current wage w_t^i, the larger the expansion of aggregate investment and, consequently, the larger the increase in aggregate output and the wage in the next period. This explains the convexity of the phase diagram of wages in Matsuyama's model.

In contrast, given a constant world loan rate and a fixed mass of entrepreneurs in our model, a marginal increase in the current wage enables entrepreneurs to borrow and invest more. According to equation (16), the increase in the current investment i_t^i partially offsets the negative effect of a marginal increase in the current wage w_t^i on the debt-investment ratio, $\frac{z_t^i}{i_t^i} = (1 - \frac{w_t^i}{i_t^i})$, and then on the wage in the next period, w_{t+1}^i. The higher the current wage, the smaller the investment expansion and, consequently, the smaller the increase in aggregate output and the wage in the next period. This explains the concavity of the phase diagram of wages and the uniqueness of the steady state in our model.

In the steady state, $\frac{w_{t+1}^i}{w_t^i} = 1$ and substitute it into the solutions (10)-(12). The interest rates and financial capital flows are

$$\Gamma_{FCF}^i = \Gamma_{IFA}^i, \quad R_{FCF}^i = R_{IFA}^i + \mathcal{Z}_{FCF}^i, \quad \text{where} \quad \mathcal{Z}_{FCF}^i \equiv \frac{\rho}{\eta}(\psi_{FCF}^i - \psi_{IFA}^i), \tag{17}$$

$$\Phi_{FCF}^i = w_{FCF}^i (1 - \eta) \frac{\mathcal{Z}_{FCF}^i}{R_{FCF}^*}, \tag{18}$$

Proposition 1. *In the steady state, the world loan rate is $R^*_{FCF} \in (R^H_{IFA}, R^F_{IFA}]$, implying that $\psi^H_{IFA} < \psi^H_{FCF} < \psi^F_{FCF} < \psi^F_{IFA}$; the equity rate in each country is same as under IFA, $\Gamma^i_{FCF} = \Gamma^i_{IFA}$; financial capital flows from country H to country F, $\Phi^H_{FCF} > 0 > \Phi^F_{FCF}$.*

Given $R^H_{IFA} < R^F_{IFA}$, $R^H_{FCF} = R^F_{FCF}$, and $\Phi^H_{FCF} + \Phi^F_{FCF} = 0$, Proposition 1 can be proved easily.

From period $t = 0$ on, financial capital flows reduce (raise) aggregate investment in country H (F). Thus, from period $t = 1$ on, aggregate output in country H (F) is lower (higher) than before period $t = 0$, $Y^H_t < Y_{IFA} < Y^H_t$.

Corollary 1. *From period $t = 1$ on, $Y^H_t + Y^F_t < 2Y_{IFA}$.*

Proof. See appendix A. □

Before period $t = 0$, aggregate production in the two countries is efficient and identical. From period $t = 0$ on, the cross-country resource reallocation due to financial capital flows lead the world economy away from the efficient allocation. Due to the concave aggregate production with respect to the capital-labor ratio at the country level, the world output is lower than before period $t = 0$, according to the Jensen's inequality. This also explains the world output losses in Matsuyama (2004). More generally, this is a typical result of the theory of second best. Given domestic financial frictions, capital account liberalization causes financial capital to flow to the country with the higher loan rate rather than to the country with the higher marginal product of capital.

Since financial frictions do not affect production efficiency, aggregate output in the steady state is same in the two countries under IFA, even if the two countries have the different levels of financial development. International capital flows break the initial symmetry in the two countries in our model similar as in Matsuyama (2004) but for different reasons. In particular, the levels of financial development in the two countries are same in Matsuyama (2004) but they are different in our model.

The welfare of individuals born in period t and country i is measured by their consumption in period $t + 1$. The welfare of entrepreneurs is $c^{i,e}_{t+1} = w^i_t \Gamma^i_t = w^i_{t+1} \Gamma^i_{IFA}$, reflecting the joint effects of financial capital flows on labor income and on the equity rate. From period $t = 0$ on, due to financial capital flows, the labor income falls (rises) in country H (F) in period $t + 1$, $w^H_{t+1} < w_{IFA} < w^F_{t+1}$. Thus, entrepreneurs born in country H (F) are strictly worse (better) off than before period $t = 0$ both in the short run and in the long run. It implies that entrepreneurs in the less (more) financially developed country have a strong incentive to oppose (support) policies promoting financial capital mobility.

The welfare of workers born in period t and country i is $c^{i,w}_{t+1} = w^i_t R^i_t$. Given the predetermined labor income w^i_0, workers born in country H (F) and period $t = 0$ are better (worse) off, $c^{i,w}_1 = w^i_0 R^*_0$, due to the rise (decline) in the loan rate, $R^H_{IFA} < R^*_0 < R^F_{IFA}$.

From period $t = 1$ on, financial capital flows affect workers born in country H (F) and period t, $c^{i,w}_{t+1} = w^H_t R^*_t$, negatively (positively) through labor income, $w^H_t < w_{IFA} < w^F_t$ and positively (negatively) through the loan rate, $R^H_{IFA} < R^*_t < R^F_{IFA}$. The net impact depends on the relative size of the two effects, which ultimately depends the parameters.

3.2 Free Mobility of FDI

The analysis for free mobility of FDI yields a mirror image of that for free mobility of financial capital and the main results are summarized as follows.[8]

Under free mobility of FDI, there exists a unique and stable steady state with the wage at $w^i_{FDI} = w_{IFA}\left[1 - \eta + \eta\frac{\Gamma^i_{IFA}}{\Gamma^*_{FDI}}\right]^\rho$, where a variable with subscript FDI denotes its steady-state value under free flows of FDI. In the steady state, the world equity rate is $\Gamma^*_{FDI} \in (\Gamma^F_{IFA}, \Gamma^H_{IFA})$; FDI flows from country F to country H, $\Omega^H_{FDI} < 0 < \Omega^F_{FDI}$, where $\Omega^i_{FDI} = (\Gamma^*_{FDI} - \Gamma^i_{IFA})\frac{\eta w^i_{FDI}}{\Gamma^*_{FDI}}$ and $i \in \{H, F\}$. The loan rate has a closed-form solution, $R^i_t = R^i_{IFA}\frac{w^i_{t+1}}{w^i_t}$, with the steady-state value $r^i_{FDI} = r^i_{IFA}$.

Initially, aggregate production is identical in the two countries. From period $t = 0$ on, FDI flows raise (reduce) aggregate investment in country H (F) and aggregate output in country H (F) is higher (lower). According to the Jensen's inequality, the cross-country output gap implies a lower world output under free mobility of FDI.

From period $t = 0$ on, due to FDI flows, the labor income in period $t+1$ in country H (F) is higher (lower) than its initial value, $w^H_{t+1} > w_{IFA} > w^F_{t+1}$. Workers born in country H (F) are better (worse) off than those born before period $t = 0$, $c^{i,w}_{t+1} = w^i_t R^i_t = w^i_{t+1} R^i_{IFA}$. In other words, workers in the less (more) financially developed country have a strong incentive to support (oppose) policies promoting international mobility of FDI.

Given the predetermined labor income w^i_0, entrepreneurs born in country H (F) and period $t = 0$ are worse (better) off, $c^{i,e}_1 = w^i_0 \Gamma^*_0$, due to the decline (rise) in the equity rate, $\Gamma^H_{IFA} > \Gamma^*_0 > \Gamma^F_{IFA}$. From period $t = 1$ on, FDI flows affect entrepreneurs born in country H (F), $c^{i,e}_{t+1} = w^i_t \Gamma^*_t$, positively (negatively) through labor income, $w^H_t > w_{IFA} > w^F_t$ and negatively (positively) through the equity rate, $\Gamma^H_{IFA} > \Gamma^*_t > \Gamma^F_{IFA}$. The net impact depends on the relative size of the two effects, which ultimately depends the parameters.

3.3 Full Capital Mobility

Financial capital flows equalize the loan rate across the border and the credit markets clear in each country as well as at the world level; FDI flows equalize the equity rate across the border and the world equity capital market clears; net capital flows affect aggregate

[8] See von Hagen and Zhang (2010a) for detailed proofs and analysis.

output of capital goods in each country. To summarize,

$$\Phi_t^H + \Phi_t^F = \Omega_t^H + \Omega_t^F = 0, \quad R_t^H = R_t^F = R_t^*, \quad \Gamma_t^H = \Gamma_t^F = \Gamma_t^*,$$
$$(1-\eta)w_t^i = (\lambda_t^i - 1)(\eta w_t^i - \Omega_t^i) + \Phi_t^i \;\; K_{t+1}^i = w_t^i - (\Phi_t^i + \Omega_t^i).$$

Except them, the equations of market equilibrium in each country are same as under IFA.

Let $w_t^w \equiv \frac{w_t^S + w_t^N}{2}$ denote the world-average wage in period t. The model solutions are,

$$R_t^i = \frac{w_{t+1}^w}{w_t^w} R_{IFA}^i + \frac{w_{t+1}^w}{w_t^w} \mathcal{Z}_t^i, \quad \text{where} \quad \mathcal{Z}_t^i \equiv \frac{(\psi_{t+1}^i - \psi_{IFA}^i)\Gamma_{IFA}^i}{1 + \frac{1-\eta}{\eta}(\psi_{t+1}^i - \psi_{IFA}^i)} \tag{19}$$

$$\Gamma_t^i = \frac{w_{t+1}^w}{w_t^w}\Gamma_{IFA}^i - \frac{1-\eta}{\eta}\frac{w_{t+1}^w}{w_t^w}\mathcal{Z}_t^i \tag{20}$$

$$\Phi_t^i = (1-\eta)w_t^i \left[1 - \frac{w_{t+1}^i}{w_t^i}\frac{R_{IFA}^i}{R_t^*}\right] \tag{21}$$

$$\Omega_t^i = \eta w_t^i \left[1 - \frac{w_{t+1}^i}{w_t^i}\frac{\Gamma_{IFA}^i}{\Gamma_t^*}\right] \tag{22}$$

$$\Omega_t^i + \Phi_t^i = w_t^i \left\{1 - \frac{w_{t+1}^i}{w_t^i}\left[\eta\frac{\Gamma_{IFA}^i}{\Gamma_t^*} + (1-\eta)\frac{R_{IFA}^i}{R_t^*}\right]\right\} \tag{23}$$

$$w_{t+1}^i = \left[\frac{(1-\theta^i)}{\Gamma_t^*} + \frac{\theta^i}{R_t^*}\right]^\rho. \tag{24}$$

Let X_{FCM} denotes the steady-state value of variable X under full capital mobility.

Lemma 4. *There exists a unique and stable steady state where the wage in country i is*

$$w_{FCM}^i = \left(\frac{1-\theta^i}{\Gamma_{FCM}^*} + \frac{\theta^i}{R_{FCM}^*}\right)^\rho.$$

Proof. See appendix A. □

In the steady state under full capital mobility, $\frac{w_{t+1}^i}{w_t^i} = 1$. Substituting it into equations (19)-(23), we get the steady-state patterns of interest rates and capital flows as follows,

$$R_{FCM}^i = R_{IFA}^i + \mathcal{Z}_{FCM}^i, \quad \text{where} \quad \mathcal{Z}_{FCM}^i \equiv \frac{(\psi_{FCM}^i - \psi_{IFA}^i)\Gamma_{IFA}^i}{1 + \frac{1-\eta}{\eta}(\psi_{FCM}^i - \psi_{IFA}^i)}, \tag{25}$$

$$\Gamma_{FCM}^i = \Gamma_{IFA}^i - \frac{1-\eta}{\eta}\mathcal{Z}_{FCM}^i, \tag{26}$$

$$\Phi_{FCM}^i = (1-\eta)w_{FCM}^i\left(1 - \frac{R_{IFA}^i}{R_{FCM}^*}\right) = \rho w_{FCM}^i(1-\eta)\frac{\mathcal{Z}_{FCM}^i}{R_{FCM}^*}, \tag{27}$$

$$\Omega_{FCM}^i = \eta w_{FCM}^i\left(1 - \frac{\Gamma_{IFA}^i}{\Gamma_{FCM}^*}\right) = -w_{FCM}^i(1-\eta)\frac{\mathcal{Z}_{FCM}^i}{\Gamma_{FCM}^*}, \tag{28}$$

$$\Phi_{FCM}^i + \Omega_{FCM}^i = w_{FCM}^i(1-\eta)\mathcal{Z}_{FCM}^i\frac{(\Gamma_{FCM}^* - R_{FCM}^*)}{\Gamma_{FCM}^* R_{FCM}^*}. \tag{29}$$

Proposition 2. *In the steady state under full capital mobility, the world interest rates are* $R^*_{FCM} \in (R^H_{IFA}, R^F_{IFA})$ *and* $\Gamma^*_{FCM} \in (\Gamma^F_{IFA}, \Gamma^H_{IFA})$*, implying that* $\psi^H_{IFA} < \psi^H_{FCM} < \psi^F_{FCM} < \psi^F_{IFA}$*. The gross and net capital flows are* $\Phi^H_{FCM} > 0 > \Phi^F_{FCM}$*,* $\Omega^H_{FCM} < 0 < \Omega^F_{FCM}$*, and* $\Phi^H_{FCM} + \Omega^H_{FCM} > 0 > \Phi^F_{FCM} + \Omega^F_{FCM}$*. The gross international investment return sums up to zero in each country,* $\Phi^i_{FCM} R^*_{FCM} + \Omega^i_{FCM} \Gamma^*_{FCM} = 0$*.*

Proof. See appendix A. □

Aggregate output is initially same in the two countries under IFA. Under full capital mobility, net capital flows raise (reduce) aggregate investment in country F (H). Thus, aggregate output is higher in country F than in country H. In other words, net capital flows are uphill. Country F as a whole imports financial capital inflows and exports FDI. Since the rate of return to its foreign assets (FDI outflows) is higher than the interest rate it pays for its foreign liabilities (financial capital inflows), $\Gamma^*_{FCM} > R^*_{FCM}$, country N receives a positive net international investment income, $\Phi^N_{FCM}(R^*_{FCM} - 1) + \Omega^N_{FCM}(\Gamma^*_{FCM} - 1) = 0 - (\Phi^N_{FCM} + \Omega^N_{FCM}) > 0$, despite its negative international investment position. This way, our model shows that cross-country differences in financial development can explain the three recent empirical evidences.

Corollary 2. *The world output in the steady state is lower under full capital mobility than under IFA,* $Y^H_{FCM} + Y^F_{FCM} < 2Y_{IFA}$*.*

Due to the decline (rise) in labor income and the equity rate in country H (F), entrepreneurs in country H (F) are worse (better) off than in the steady state under IFA. In addition, country H (F) as a whole is worse (better) off.

Proof. See appendix A. □

In this model, full capital mobility is not an option for country H to make a Pareto improvement upon the steady-state allocation under IFA. In contrast, full capital mobility is a good option for country F to make a Pareto improvement, if implemented with some properly designed domestic public transfer policies. Net capital flows widen the cross-country output gap, which generates the world output losses. Thus, full capital mobility in this model cannot achieve a Pareto improvement at the world level.

3.4 Capital Mobility and Economic Convergence

We analyze here how full capital mobility affects the economic convergence of country H, if it is initially below its steady state before period $t = 0$. Figure 2 shows some threshold values with country H's capital-labor ratio and its degree of financial development on the vertical and horizontal axes, respectively. It provides an overview of the directions of capital flows during the convergence process to the steady state. The upper bound of figure 2 and the solid line represent the steady-state values of the capital-labor ratio under IFA and under full capital mobility, K_{IFA} and K^H_{FCM}, respectively.

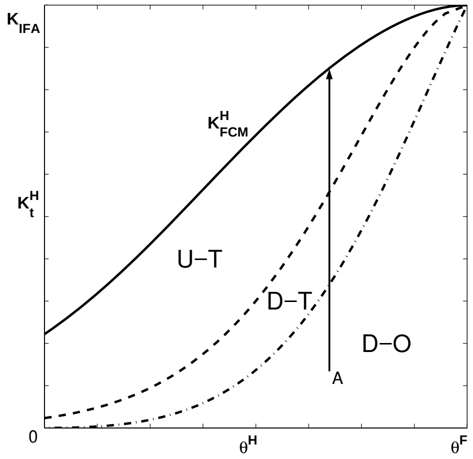

Figure 2: Full Capital Mobility between Initially Poor and Rich Countries

Suppose that the level of financial development in country H is constant over time $0 < \theta^H < \theta^F$ and that country H's initial capital-labor ratio is at point A. Lemma 1 implies that, under IFA, the equity rate is strictly higher in country H than in country F. With full capital mobility, FDI flows unambiguously "downhill" from country F to country H and the equity rates equalize. The direction of financial capital flows, however, depends on the initial capital-labor ratio, K^H_0.

Given K^H_0 at the initial level at point A, the neoclassical effect dominates the credit demand effect. Under IFA, the loan rate is higher in country H than in country F. With full capital mobility, both financial capital and FDI flow "**D**ownhill" and **O**ne-way.

Over time, the capital-labor ratio in country H rises along the arrow and eventually crosses a threshold value given by the dash-dotted line. The neoclassical effect is then dominated by the credit demand effect. Under IFA, the loan rate would be lower in country H than in country F. With full capital mobility, financial capital flows "uphill" and FDI flows "downhill". However, net capital flows are still "**D**ownhill", while gross capital flows are **T**wo-way.

As the capital-labor ratio in country H grows further, it crosses a second threshold value given by the dotted line. Financial capital still flows "uphill" and FDI flows "downhill". However, net capital flows become "**U**phill" while gross capital flows are **T**wo-way. Eventually, the capital-labor ratio reaches its steady state given by the solid line with two-way gross capital flows and "uphill" net capital flows. In this sense, the phenomenon of two-way capital flows is a feature of middle-income rather than low-income economies.

Now we may address the costs and benefits of capital account liberalization for a developing country converging to its steady state. Suppose that its initial capital-labor ratio is at point A. Without international capital flows, it would gradually converge to the level K_{IFA}. With international capital flows, both financial capital and FDI flow into this country, which speeds up its capital accumulation in the short run. As the capital-labor ratio rises over time and moves into region **D-T**, financial capital flows change the direction from "downhill" to "uphill". However, the country still receives net capital inflows and accumulates capital at a faster speed than under IFA. However, as the capital-labor ratio enters into region **U-T**, financial capital outflows exceed FDI inflows and capital accumulation is slower than under IFA. Finally, it converges to a steady state with a capital-labor ratio smaller than under IFA, $K^H_{FCM} < K_{IFA}$. Starting from a sufficiently low level of output, capital account liberalization offers a developing country the short-run benefit of faster capital accumulation but at the long-run cost of a lower level of output. Since K^H_{FCM} increases in θ^H, the developing country, when liberalizing capital account, should promote financial development so as to avoid the long-run cost.

4 Conclusion

We develop a tractable, two-country, overlapping-generations model and show that cross-country differences in financial development can explain three recent empirical characteristics of international capital flows which have been puzzling. We also show that capital account liberalization policies may offer a developing country the short-run benefit of faster capital accumulation but at the long-run cost of a lower level of output. In order to reduce the cost and exploit the benefit, the developing country should promote its level of financial development when liberalizing capital account.

We take the level of financial development as given and analyze how differences in financial development affect capital flows. An obvious and important question is how economic growth and various forms of capital flows shape the institutional infrastructures, e.g., the level of financial development. We leave this issue for future research.

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A Proofs

Proof of Lemma 1

Proof. According to equations (1), (2), and (8), the model dynamics can be characterized by a nonlinear first-order difference equation on wages, independent of θ^i,

$$w^i_{t+1} = (1-\alpha)Y^i_{t+1} = \left(\frac{K^i_{t+1}}{\rho}\right)^\alpha = \left(\frac{w^i_t}{\rho}\right)^\alpha. \tag{30}$$

Given $\alpha \in (0,1)$, the phase diagram of wages is concave and starts from the origin. Its slope, $\frac{dw^i_{t+1}}{dw^i_t} = \alpha\left(\frac{R}{\rho}\right)^\alpha (w^i_t)^{\alpha-1}$, converges to $+\infty$ for $w^i_t \to 0$ and to 0 for $w^i_t \to +\infty$. Thus, there exists a unique and stable non-zero steady state with the wage at $w^i_{IFA} = \left(\frac{1}{\rho}\right)^\rho$.

Suppose that the borrowing constraints are binding. Under IFA, the investment-equity ratio is $\lambda^i_t = \frac{i^i_t}{w^i_t} = \frac{1}{\eta}$ and the equity rate is thus $\Gamma^i_t = \frac{(1-\theta^i)v^i_{t+1}i^i_t}{w^i_t} = \frac{(1-\theta^i)}{\eta}v^i_{t+1}$. According to equation (5), $R^i_t = \frac{\theta^i}{1-\eta}v^i_{t+1}$ or $\psi^i_{t+1} = \frac{\theta^i}{1-\eta}$. It is trivial to prove that for $\theta^i \in (0, 1-\eta)$, $\Gamma^i_t > v^i_{t+1} > R^i_t$ and the borrowing constraints are binding. For $\theta^i \in (1-\eta, 1]$, the borrowing constraints are slack and $\Gamma^i_t = v^i_{t+1} = R^i_t$. □

Proof of Lemma 2

Proof. Combining equations (11) and (13), we rewrite the dynamic equation of wages,

$$\ln w^i_{t+1} = -\rho \ln R^*_t + \rho \ln\left(\frac{w^i_t}{w^i_{t+1}} R^*_t \frac{\eta}{\rho} + \theta^i\right). \tag{31}$$

The first and the second derivatives of w^i_{t+1} with respect to w^i_t are

$$\frac{\partial w^i_{t+1}}{\partial w^i_t} = \frac{w^i_{t+1}}{w^i_t}\frac{\rho}{\rho + \frac{\psi^i_{t+1}}{\psi^i_{t+1}-\theta^i}} \in \left(0, \frac{w^i_{t+1}}{w^i_t}\right)$$

$$\frac{\partial^2 w^i_{t+1}}{\partial (w^i_t)^2} = -\frac{\partial w^i_{t+1}}{\partial w^i_t}\frac{w^i_t}{(w^i_{t+1})^2}\left(\frac{w^i_{t+1}}{w^i_t} - \frac{\partial w^i_{t+1}}{\partial w^i_t}\right)\left[\frac{w^i_t}{w^i_{t+1}}(1+\rho) + \frac{\rho\theta^i}{\eta R^*_t}\right]^{-1}$$

Since $\frac{\partial w^i_{t+1}}{\partial w^i_t} \in \left(0, \frac{w^i_{t+1}}{w^i_t}\right)$, we get $\frac{\partial^2 w^i_{t+1}}{\partial (w^i_t)^2} < 0$. Thus, the phase diagram of wages is a concave function under free mobility of financial capital if the borrowing constraints are binding.

According to equation (31), for $w^i_t = 0$, the phase diagram has a positive intercept on the vertical axis at $w^i_{t+1} = (R^*_t)^{-\rho}(\theta^i)^\rho$. Define a threshold value $\bar{w}^i_t = \Gamma^i_{IFA}(R^*_t)^{-\frac{1}{1-\alpha}}$. For

$w_t^i \in (0, \bar{w}_t^i)$, the phase diagram of wages is monotonically increasing and concave. For $w_t^i > \bar{w}_t^i$, aggregate saving and investment in sector B is so high that the intratemporal relative price is equal to one, or equivalently, $R_t^i = v_{t+1}^{i,B}$. Thus, the borrowing constraints are slack and the phase diagram is flat with $w_{t+1}^i = \bar{w}_{t+1}^i = (R_t^*)^{-\rho}$. Given $R_t^* < \rho < \Gamma_{IFA}^i$, we get $\bar{w}_{t+1}^i < \bar{w}_t^i$. In other words, the kink point is below the 45 degree line.

Thus, the phase diagram of wages crosses the 45 degree line once and only once from the left, and the intersection is in its concave part. Thus, the model economy has a unique and stable steady state under partial capital mobility. □

Proof of Lemma 3

Proof. Take the world loan rate r_t^* as given. For $w_t^i \in (0, 1-\theta^i]$ and $i_t^i = 1$, take the first and second derivatives of equation (16) with respect to w_t^i,

$$\frac{dw_{t+1}^i}{dw_t^i} = \frac{\rho R^*}{\theta^i}(w_{t+1}^i)^{\frac{1}{\alpha}} > 0, \quad \text{and,} \quad \frac{dw_{t+1}^i}{d^2 w_t^i} = \frac{\rho R^*}{\theta^i}\frac{1}{\alpha}(w_{t+1}^i)^{\frac{1}{\rho}}\frac{dw_{t+1}^i}{dw_t^i} > 0. \tag{32}$$

The phase diagram of wages is convex for $w_t^i \in (0, 1-\theta^i]$. By setting $w_t^i = 0$ in equation (16), we get the vertical intercept of the phase diagram of wages at $w_{t+1}^i = \left[\frac{\theta^i}{R_t^*}\right]^\rho$. For $w_t^i > 1-\theta^i$, the marginal return on investment is equal to the world loan rate, $v_{t+1}^i = R_t^*$, and, thus, entrepreneurs do not borrow to the limit. The phase diagram of wages $w_{t+1}^i = (v_{t+1}^i)^{-\frac{1}{\rho}} = \left(\frac{1}{R_t^*}\right)^\rho$ is flat and independent of w_t^i. □

Proof of Corolarry 1

Proof. Let $a_t \equiv \frac{w_t^H + w_t^F}{2w_{IFA}}$ and $b_t \equiv \frac{w_t^F - w_t^H}{2w_{IFA}} + \frac{\Phi_t^H}{w_{IFA}}$, where $t = 0, 1, 2, 3, ...$ According to the aggregate resource constraint in country H, $0 < \Phi_t^H < w_{FCF}^H$, we get $b_t \in (0, a_t)$. In period $t \geq 0$, the aggregate project investment in country H and in country F are $I_t^H = w_t^H - \Phi_t^H = (a_t - b_t)w_{IFA}^H$ and $I_t^F = w_t^F + \Phi_t^H = (a_t + b_t)w_{IFA}^F$, respectively. Given the share of capital goods in the aggregate production, $\alpha \in (0,1)$, and $b_t \in (0, a_t)$, the world-average wage in period $t+1$ can be reformulated into a condensed form with the following property,

$$\frac{w_{t+1}^H + w_{t+1}^H}{2} = \left(\frac{1}{\rho}\right)^\alpha \left[\frac{(I_t^H)^\alpha + (I_t^F)^\alpha}{2}\right] \Leftrightarrow a_{t+1} = \frac{(a_t - b_t)^\alpha + (a_t + b_t)^\alpha}{2} < (a_t)^\alpha, \tag{33}$$

where the last inequality sign results from the Jensen's Inequality. The wage in period $t = 0$ is same in the two countries, $w_0^H = w_0^F = w_{IFA}$, and, thus, $a_0 = 1$. From period 0 on, financial capital flows are allowed. According to the inequality in equation (33), we get $a_1 < 1$. For $t = 1, 2, 3, ...$, given $b_t \in (0, a_t)$, we have $a_{t+1} < (a_t)^\alpha$ and, thus, the time series of a_t is below 1, or equivalently, $\frac{w_t^H + w_t^F}{2} < w_{IFA}$. Thus, the world output is smaller than before period $t = 0$, $Y_t^H + Y_t^F = \frac{w_t^H + w_t^F}{1-\alpha} < \frac{2w_{IFA}}{1-\alpha} = Y_{IFA}^H + Y_{IFA}^F$. □

Proof of Lemma 4

Proof. The proof consists of three steps. First, we prove that equation (21) is the solution to the equity rate under full capital mobility. If the borrowing constraints are binding, $\frac{\Gamma_t^i}{R_t^i} = \frac{(1-\theta^i)}{\psi_{t+1}^i - \theta^i}$ holds under IFA and under full capital mobility. Rewrite it into

$$\frac{\Delta\psi_{t+1}^i}{1-\theta^i} = \frac{R_t^i}{\Gamma_t^i} - \frac{R_{IFA}^i}{\Gamma_{IFA}^i}, \quad \text{where} \quad \Delta\psi_{t+1}^i \equiv \psi_{t+1}^i - \psi_{IFA}^i. \tag{34}$$

Under IFA, the total savings of households in period t, $(1-\eta)w_t^i$, have the rate of return R_t^i, while those of entrepreneurs, ηw_t^i, have the rate of return Γ_t^i. In period $t+1$, aggregate revenue of capital goods $v_{t+1}^i K_{t+1}^i = \rho w_{t+1}^i$ is distributed among them,

$$(1-\eta)w_t^i R_t^i + \eta w_t^i \Gamma_t^i = \rho w_{t+1}^i \quad \Rightarrow \quad (1-\eta)R_t^i + \eta\Gamma_t^i = \frac{w_{t+1}^i}{w_t^i}\rho. \tag{35}$$

Similarly, under full capital mobility, aggregate savings of households in the two countries in period t, $(1-\eta)(w_t^H + w_t^F)$, have the same rate of return at R_t^*, while those of entrepreneurs, $\eta(w_t^H + w_t^F)$, have the same rate of return Γ_t^*. In period $t+1$, aggregate revenue of capital goods, $v_{t+1}^H K_{t+1}^H + v_{t+1}^F K_{t+1}^F = \rho(w_{t+1}^H + w_{t+1}^F)$, is distributed among them. Let $w_t^w \equiv \frac{w_t^H + w_t^F}{2}$ denote the world average wage in period t, we get

$$(1-\eta)R_t^* + \eta\Gamma_t^* = \frac{w_{t+1}^w}{w_t^w}\rho. \tag{36}$$

According to equation (35), $(1-\eta)R_{IFA}^i + \eta\Gamma_{IFA}^i = \rho$. Substituting R_t^i and R_{IFA}^i with Γ_t^i and Γ_{IFA}^i using equation (36) and $R_{IFA}^i = \frac{1}{(1-\eta)}(\rho - \eta\Gamma_{IFA}^i)$, we solve the equity rate from equation (34). Plug in the solution to the equity rate in equation (36) for R_t^i.

Second, we prove that ψ_{t+1}^i is constant under full capital mobility. Let us assume that ψ_{t+1}^i is time variant and so is the auxiliary variable Z_{t+1}^i defined in equation (19). Using equation (20), the world equity rate equalization implies that

$$\Gamma_{IFA}^H - \mathcal{Z}_{t+1}^H = \Gamma_{IFA}^F - \mathcal{Z}_{t+1}^F \tag{37}$$

$$\Delta\psi_{t+1}^H = \frac{1-\theta^H}{1-\theta^F}\Delta\psi_{t+1}^F + \frac{\eta}{1-\eta}\frac{\theta^F - \theta^H}{1-\theta^F}, \tag{38}$$

$$\frac{\partial\Delta\psi_{t+1}^H}{\partial\Delta\psi_{t+1}^F} = \frac{1-\theta^H}{1-\theta^F} > 0. \tag{39}$$

Using equations (20) and (22), we rewrite the condition, $\Omega_t^H + \Omega_t^F = 0$, into

$$\Delta\psi_{t+1}^H w_{t+1}^H + \Delta\psi_{t+1}^F w_{t+1}^F = 0. \tag{40}$$

Given the Cobb-Douglas production function, $w_{t+1}^i = (\psi_{t+1}^i)^\rho (R_t^i)^{-\rho}$. Combining it with the loan rate equalization, $R_t^i = R_t^*$, we simplify equation (40) as

$$\mathcal{K}_{t+1}^H + \mathcal{K}_{t+1}^F = 0, \quad \text{where} \quad \mathcal{K}_{t+1}^i \equiv \Delta\psi_{t+1}^i(\Delta\psi_{t+1}^i + \psi_{IFA}^i)^\rho, \tag{41}$$

$$\frac{\partial\mathcal{K}_{t+1}^i}{\partial\Delta\psi_{t+1}^i} = (\psi_{t+1}^i)^{\rho-1}(\psi_{t+1}^i + \rho\Delta\psi_{t+1}^i) > 0. \tag{42}$$

Substituting $\Delta\psi^H_{t+1}$ with $\Delta\psi^F_{t+1}$ using equations (38), the left-hand side of equation (41) becomes a monotonically increasing function of $\Delta\psi^F_{t+1}$,

$$\frac{\mathcal{K}^H_{t+1}+\mathcal{K}^F_{t+1}}{\partial\Delta\psi^F_{t+1}} = \frac{\partial\mathcal{K}^H_{t+1}}{\partial\Delta\psi^H_{t+1}}\frac{\partial\Delta\psi^H_{t+1}}{\partial\Delta\psi^F_{t+1}} + \frac{\partial\mathcal{K}^F_{t+1}}{\partial\Delta\psi^F_{t+1}} > 0. \tag{43}$$

Suppose that $\Delta\psi^F_{t+1} = 0$. Equation (38) implies that $\Delta\psi^H_{t+1} > 0$. According to the definition of $\mathcal{K}^i_{t+1}$, $\Delta\psi^i_{t+1} > 0$ implies that $\mathcal{K}^i_{t+1} > 0$. The left-hand side of equation (41) is larger zero, which contradicts condition (41). Thus, there exits a unique solution of $\Delta\psi^F_{t+1}$ smaller than zero and time-invariant. Using equation (38), we solve $\Delta\psi^H_{t+1}$.

Finally, we prove the existence of a unique and stable steady state. ψ^i_{t+1} is time-invariant and so is $\mathcal{Z}^i_{t+1}$. Let $R^i_{FCM} \equiv R^i_{IFA} + \frac{\eta}{1-\eta}\mathcal{Z}^i_{FCM}$ which is same across countries, $R^i_{FCM} = R^*_{FCM}$. Under full capital mobility, the loan rate depends on the dynamics of the world-average wages, $R^i_t = \frac{w^w_{t+1}}{w^w_t}R^*_{FCM}$, and so is the wage in country i,

$$w^i_{t+1} = \left(\frac{w^w_{t+1}}{w^w_t}R^*_{FCM}\right)^{-\rho}(\psi^i_{FCM})^\rho.$$

The dynamics of the world-average wages are

$$\begin{aligned} w^w_{t+1} &= \frac{w^H_{t+1}+w^F_{t+1}}{2} = \left(\frac{w^w_{t+1}}{w^w_t}R^*_{FCM}\right)^{-\rho}\frac{(\psi^H_{FCM})^\rho+(\psi^F_{FCM})^\rho}{2}, \\ w^w_{t+1} &= \left(\frac{w^w_t}{R^*_{FCM}}\right)^\alpha\left[\frac{(\psi^H_{FCM})^\rho+(\psi^F_{FCM})^\rho}{2}\right]^{1-\alpha} \end{aligned}$$

Given $\alpha \in (0,1)$, the phase diagram of the world-average wage is concave. Thus, there exists a unique and stable steady state. Proportional to the wage, aggregate output in country i is determined by the world output dynamics. □

Proof of Proposition 2

Proof. According to equation (27), the world credit market clearing condition, $\Phi^H_{FCM} + \Phi^F_{FCM} = 0$ implies that $\left(1-\frac{R^H_{IFA}}{R^*_{FCM}}\right)\left(1-\frac{R^F_{IFA}}{R^*_{FCM}}\right) < 0$. Given $R^H_{IFA} < R^F_{IFA}$, the world loan rate must be $R^*_{FCM} \in (R^H_{IFA}, R^F_{IFA})$. By analogy, we can prove $\Gamma^*_{FCM} \in (\Gamma^F_{IFA}, \Gamma^H_{IFA})$.

According to equation (25), $R^*_{FCM} \in (R^H_{IFA}, R^F_{IFA})$ implies $\mathcal{Z}^H_{FCM} > 0 > \mathcal{Z}^F_{FCM}$, which then implies that $\psi^H_{FCM} > \psi^H_{IFA}$ and $\psi^F_{FCM} < \psi^F_{IFA}$. The cross-country equalization of the gross equity premium $\frac{\Gamma^i_{FCM}}{R^i_{FCM}} = \frac{1-\theta^i}{\psi^i_{FCM}-\theta^i}$ implies that $\frac{1-\psi^S_{FCM}}{1-\theta^S} = \frac{1-\psi^N_{FCM}}{1-\theta^N} = \frac{\psi^N_{FCM}-\psi^S_{FCM}}{\theta^N-\theta^S} > 0$. Given $\theta^F > \theta^H$, we get $\psi^F_{FCM} > \psi^H_{FCM}$.

According to equations (27) and (28), the changes in the interest rates imply that $\Phi^H_{FCM} > 0 > \Phi^F_{FCM}$ and $\Omega^H_{FCM} < 0 < \Omega^F_{FCM}$. Since $\Gamma^*_{FCM} > R^*_{FCM}$, the steady-state net capital flows have the same sign as $\mathcal{Z}^i_{FCM}$, according to equation (29). Thus, $\mathcal{Z}^H_{FCM} > 0 > \mathcal{Z}^F_{FCM}$ implies that $\Phi^H_{FCM} + \Omega^H_{FCM} > 0 > \Phi^F_{FCM} + \Omega^F_{FCM}$.

According to equations (27) and (28), we get,

$$R^*_{FCM}\Phi^i_{FCM} + \Gamma^*_{FCM}\Omega^i_{FCM} = \rho w^i_{FCM}(1-\eta)(\mathcal{Z}^i_{FCM} - \mathcal{Z}^i_{FCM}) = 0.$$

□

Proof of Corollary 2

Proof. Given non-zero net capital flows, the steady-state aggregate output under full capital mobility is lower than under IFA. The proof follows that of Corolarry 1.

In the steady state, social welfare in country i is $C^i = \eta c^{i,e} + (1-\eta)c^{i,w} = w^i[\eta\Gamma^* + (1-\eta)R^*]$. According to equation (36), social welfare is proportional to aggregate labor income, $C^i = w^i\rho$. Due to net capital flows, aggregate investment in country H (F) is lower and so are the aggregate labor income and social welfare. □