Globalization under Financial Imperfection *

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Abstract

The paper investigates the effects of international trade in goods and capital movement on the productivity distribution and industry-wide productivity when countries are heterogeneous in the quality of their financial institutions. In autarky, firm heterogeneity in their productivities arises in countries with poor financial institutions, while all firms adopt a high-productivity technology in countries with better financial institutions. Trade in goods will not change the productivity distribution (nor the industry-wide productivity as a result) in any country, although it lowers equilibrium interest rates in countries with poor financial institutions while it raises them in countries with better financial institutions. Allowing international capital movement in addition to the trade, however, makes a large impact on the industry. Capital flight from countries with poor financial institutions occurs, which may lead to global convergence in which all firms in the world adopt the high-productivity technology under a relatively high interest rate. But if the worldwide average of quality of financial institution is low, international capital movement will reduce worldwide production efficiency such that low-productivity firms re-emerge even in northern countries as well as in southern countries.

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1 Introduction

Recent financial turmoil reminded us of the importance of the high-quality credit market on the economy and of the significance of the financial globalization as well as the globalization in trade in goods. This paper investigates the effects of globalization in trade and capital movement on a financially-dependent industry. Countries are different in their qualities of financial institutions, so the impacts of globalization may well be different across countries.

The quality of financial institution has long been recognized to be critical to the economic prosperity. McKinnon (1973, 1993), for example, emphasizes that less-developed countries and countries in transition from socialism to democracy should develop reliable financial institution in order to achieve economic growth. He argues that countries should first improve their internal financial institutions before opening to trade in goods. He also claims that allowing free international capital mobility should be the last stage of economic liberalization to avoid unwarranted capital flight or an accumulation of foreign debt. There is also a body of research on the effect of financial development on the economic growth. Rajan and Zingales (1998), for example, find empirical evidences that financial development contributes positively to the economic growth.

Recently, Matsuyama (2005), Wynne (2005), Ju and Wei (2008), Antràs and Caballero (2009), and others have explicitly considered financial frictions in their models to examine the impacts of financial frictions (or financial imperfection) on the models' trade policy implications. Matsuyama (2005), Wynne (2005), and Ju and Wei (2008) argue that the cross-country differences in the quality of financial institutions significantly affect the structure of countries' comparative advantage and trade patterns. Antràs and Caballero (2009) theoretically examine the complementarity between international trade in goods and capital movement under financial imperfection. They show among others that trade in goods induces capital inflows to the South, which in turn stimulates international trade in goods. This result is in a stark contrast to a typical result in the traditional literature that trade in goods and international capital movement are substitutes (Mundell, 1957). Furusawa and Yanagawa (2011) also establish the complementarity between trade in goods and capital movement. Unlike Antràs and Caballero (2009), however, our model predicts that trade in goods induces capital outflow from the South. Manova (2008) also develops a model with credit-constrained heterogeneous firms. In her model, firms are faced with credit constraint in financing trade costs. Efficient firms are less financially constrained, so efficient firms in financially developed countries are more likely to engage in the export.

In this paper, we extend the model of Furusawa and Yanagawa (2011) to the one in which there are many countries and there are more than one production technologies to be chosen by entrepreneurs, in order to investigate the effects of international trade in goods and capital movement on the productivity distribution and industry-wide productivity when countries differ in the degree of financial develpment. In autarky, firm heterogeneity in their productivities arises in countries with poor financial institutions, while all firms adopt a high-productivity technology in countries with better financial institutions. Trade in goods will not change the productivity distribution and hence the industry-wide productivity in any country, although it lowers equilibrium interest rates in countries with poor financial institutions while it raises them in countries with better financial institutions. Allowing international capital movement in addition to the trade, however, makes a large impact on the industry. Capital flight from countries with poor financial institutions occurs, which may lead to global convergence in which all firms in the world adopt the high-productivity technology under a relatively high interest rate. But if the worldwide average of quality of financial institution is low, international capital movement will reduce worldwide production efficiency such that low-productivity firms re-emerge even in northern countries as well as in southern countries.

2 Model

There are N countries, each of which is populated by a mass $m_k\,(k = 1, \cdots, N)$ of individuals. We normalize the population such that the worldwide population equals 1, i.e., $\sum_{k=1}^{N} m_k = 1$. Every individual in any country owns one unit of labor and wealth of ω that is uniformly distributed on $[0, \bar{\omega}]$; thus the density of individuals whose wealth is $\omega \in [0, \bar{\omega}]$ equals $m_k/\bar{\omega}$.[1] All individuals share the same utility function over the two goods, a differentiated good X and a numeraire good Y, characterized by

$$u = \log u_x + y, \tag{1}$$

where

$$u_x = \left[\int_{\Omega_k} x(i)^{\frac{\sigma-1}{\sigma}} di\right]^{\frac{\sigma}{\sigma-1}} ; \ \sigma > 1 \tag{2}$$

denotes the subutility derived from the consumption of continuum varieties of good X, $\{x(i)\}_{i \in \Omega_k}$ (where Ω_k denotes the set of all varieties available in country k), and y denotes the consumption level of good Y. The numeraire good is competitively produced such that one unit of labor produces one unit of the good, so the wage rate equals one.

Each individual chooses a consumption profile of good X to maximize u_x subject to $\int_{\Omega_k} p(i)x(i)di \leq E$, where $p(i)$ and E denote the price for variety i and the total expenditure on all varieties of good X, respectively. It is immediate to obtain $x(i) = p(i)^{-\sigma} E / P_k^{1-\sigma}$, where $P_k \equiv \left[\int_{\Omega_k} p(i)^{1-\sigma} di\right]^{\frac{1}{1-\sigma}}$ denotes the price index of good X. We substitute this result into (2) to obtain $u_x = E/P_k$. Therefore, an individual's utility function can be written as $u = \log E - \log P_k + y$. Maximizing this with the constraint $E + y \leq I$, where I denote the individual's income (which is the sum of her labor income and the investment return from her wealth), we obtain $E = 1$. That is, each individual spends $E = 1$ on good X, so the country k's aggregate expenditure on good X is m_k.

The differentiated-good industry is characterized by the monopolistic competition with free-entry and free-exit. When a firm enters, however, it incurs an R&D (or setup) cost. There are two types of production technology (or facility). The higher the investment, the lower is the marginal cost of production. More specifically, if a firm invests g_h (g_l) units of the numeraire good, its marginal cost becomes $1/\varphi_h$ ($1/\varphi_l$). We assume that $g_l < g_h < \bar{\omega}$, $\varphi_l \equiv \varphi$, and $\varphi_l < \varphi_h \equiv \beta\varphi$, where $\beta > 1$ represents the productivity gap. To obtain the

[1] We assume that wealth is distributed uniformly to obtain simple closed-form solutions for critical variables of the model. Results would be qualitatively robust to the choice of distribution.

profits for firm i in country k (in autarky), we define the competition index

$$\tilde{\varphi}_k \equiv \left[\int_{i\in\Omega_k} \varphi(i)^{\sigma-1} di\right]^{\frac{1}{\sigma-1}}. \tag{3}$$

Since there is a continuum of varieties, each firm naturally ignores the impact of its pricing on the price index, so that firms select prices that are $\sigma/(\sigma-1)$ times their individual marginal costs. It is easy to see that the profits for firm i in country k equal

$$\pi_k(\varphi(i), \tilde{\varphi}_k) = \frac{m_k}{\sigma}\left(\frac{\varphi(i)}{\tilde{\varphi}_k}\right)^{\sigma-1}. \tag{4}$$

Individuals in country k decide whether or not they become entrepreneurs who can borrow money at a gross interest rate of R_k to finance their investments if necessary. If an individual decides to become an entrepreneur, she will choose the high-productivity technology or the low-productivity technology with which her firm operates. If she decides not to be an entrepreneur or if part of her wealth is left after the investment for her firm, she will lend out her (remaining) wealth.

The critical feature of the model is that entrepreneurs are faced with a financial constraint: entrepreneur i can borrow up to the amount such that the repayment does not exceed $\theta_k\pi_k(\varphi(i), \tilde{\varphi}_k)$, the fraction $\theta_k \in (0, 1]$ of the profits that her firm will earn. The fraction θ_k represents the quality of the financial institution of country k. (Matsuyama 2000 adopts this formulation of financial imperfection.[2]) A financial institution is perfect if $\theta_k = 1$; any entrepreneur with any amount of wealth can finance the investment for either high-productivity technology or low-productivity technology, effectively without any constraint. A financial institution is imperfect if $\theta_k < 1$; individuals with small amounts of wealth may not be able to finance the investment costs in this case. Countries vary in the quality of their financial institutions.

We can list several reasons why θ_k can be smaller than one. A natural cause of financial imperfection is the imperfection of legal enforcement.[3] Empirical evidence shows that the legal enforcement is not perfect (La Porta, *et al.*, 1998). Under imperfect legal enforcement,

[2]Matsuyama (2007) describes various economic implications of the credit market imperfection of this type.

[3]See for example Hart (1995).

a court may be able to force a borrower to pay only up to a fraction θ_k of the profits that the borrower has earned. Given this, the borrower would be likely to refuse to pay more than θ_k times the profits (which is called the "strategic default"), and thus a lender would only be willing to lend money only up to the amount such that the repayment does not exceed this value. Consequently, borrowers can only pledge θ_k times the profits. The agency problem of the lender-borrower relationship can also cause financial frictions.[4]

In the economy that we consider, there are two types of the constraints, the profitability constraints and borrowing constraints, which must be satisfied. The profitability constraints

$$\pi_k(\varphi_h, \tilde{\varphi}_k) - R_k g_h \geq 0, \tag{5}$$

$$\pi_k(\varphi_l, \tilde{\varphi}_k) - R_k g_l \geq 0, \tag{6}$$

for the high-productivity firm (or high-tech firm in short) and the low-productivity firm (or low-tech firm), respectively, simply mean that the net profits must be non-negative if firms of the respective type operate at all. The borrowing constraints, on the other hand, can be written as

$$\theta_k \pi_k(\varphi_h, \tilde{\varphi}_k) \geq R_k(g_h - \omega), \tag{7}$$

$$\theta_k \pi_k(\varphi_l, \tilde{\varphi}_k) \geq R_k(g_l - \omega), \tag{8}$$

which mean that entrepreneurs can borrow money only up to the amount such that the repayment does not exceed the fraction θ_k of the profits. It is easy to see that for each type of the firm, the profitability constraint is tighter than the borrowing constraint if θ_k is large, whereas the borrowing constraint is tighter than the profitability constraint if θ_k is small. The borrowing constraint is tighter for entrepreneurs with a small amount of wealth.

Suppose for the time being that there is a country whose financial institution is perfect, so that $\theta_k = 1$, and consider a decision made by an individual with the wealth ω in the country k. If she invests g_h on the high-productivity technology, she would obtain $\pi_k(\varphi_h, \tilde{\varphi}_k) - R_k(g_h - \omega)$. If $\omega < g_h$, she borrows $g_h - \omega$ to earn $\pi_k(\varphi_h, \tilde{\varphi}_k)$ and pay $R_k(g_h - \omega)$ back to the lenders. If

[4] See Furusawa and Yanagawa (2011) for more discussions about the specification of financial imperfection of this type.

$\omega \geq g_h$, on the other hand, she obtains $\pi_k(\varphi_h, \tilde{\varphi}_k)$ from the production of good X (from the investment of g_h) and $-R_k(g_h - \omega)$ from lending out. Similarly, if she invests g_l, she would obtain $\pi_k(\varphi_l) - R(g_l - \omega)$. Finally, if she lends out the entire wealth of hers, she would get $R_k\omega$.

An entrepreneur chooses the high-productivity technology rather than the low-productivity technology if

$$\pi_k(\varphi_h, \tilde{\varphi}_k) - R_k(g_h - \omega) > \pi_k(\varphi_l, \tilde{\varphi}_k) - R_k(g_l - \omega),$$

which can be written as

$$\pi_k(\varphi_h, \tilde{\varphi}_k)(1 - \beta^{1-\sigma}) > R_k(g_h - g_l), \tag{9}$$

since $\pi_k(\varphi_l, \tilde{\varphi}_k) = \beta^{1-\sigma}\pi_k(\varphi_h, \tilde{\varphi}_k)$ as we can see from (4). Note that this inequality does not depend on ω, so all entrepreneurs choose the same technology.

Whether or not the inequality (9) holds depends on the productivity and investment-cost parameters. In this paper, we focus on the natural case in which entrepreneurs choose the high-productivity technology if they are not financially constrained, so the inequality (9) holds. In equilibrium, some individuals become entrepreneurs while some others must be lending money to entrepreneurs, and hence the net benefit of being an entrepreneur and that of lending money must be the same. That is,

$$\pi_k(\varphi_h, \tilde{\varphi}_k) - R_k(g_h - \omega) = R_k\omega,$$

which is reduced to

$$\pi_k(\varphi_h, \tilde{\varphi}_k) = R_k g_h. \tag{10}$$

Note that this equality simply shows that profits for high-tech firms are zero: running a business does not yield extra benefits to individuals. Now, substituting this equality into (9) and rearranging terms, we obtain $\beta^{\sigma-1} > g_h/g_l$, which we assume for the rest of our analysis.

Assumption 1

$$\beta^{\sigma-1} > g_h/g_l.$$

This assumption indicates that the productivity gap is so large that the more-costly high-productivity technology is effectively more economical than the low-productivity technology. Consequently, all entrepreneurs choose the high-productivity technology while some individuals lend their wealth to those entrepreneurs. Moreover, it is easy to check that under this assumption, there does not exist equilibrium in which entrepreneurs choose the low-productivity technology.

Proposition 1 *Under a perfect financial institution, all entrepreneurs in the differentiated-good sector choose the same production technology upon entry, and hence firms are homogeneous within the sector.*

Let n_k denote the mass of firms (or equivalently the mass of entrepreneurs) in country k. Then, the total investment demands equal $n_k g_h$, while the total credit supply equals

$$\frac{m_k}{\bar{\omega}} \int_0^{\bar{\omega}} \omega d\omega = \frac{m_k \bar{\omega}}{2}.$$

By equating the credit demands and supplies, we find that the mass of firms is given by

$$n_k = \frac{m_k \bar{\omega}}{2 g_h}. \tag{11}$$

We make the following assumption to ensure that $n_k < m_k$.

Assumption 2

$$\bar{\omega} < 2 g_h.$$

Recall that the decision as to whether or not an individual becomes an entrepreneur does not depend on her wealth. This means that despite that the number of entrepreneurs is unambiguously determined, who become entrepreneurs is indeterminate under perfect financial institution. But if we suppose that only the wealthiest individuals become entrepreneurs, the wealth level of the poorest entrepreneur ω_h^* must satisfy

$$\frac{m_k}{\bar{\omega}}(\bar{\omega} - \omega_h^*) = \frac{m_k \bar{\omega}}{2 g_h},$$

which gives us

$$\omega_h^* = \bar{\omega} - \frac{\bar{\omega}^2}{2g_h}. \tag{12}$$

In this case, an individual becomes an entrepreneur if and only if her wealth level lies in the interval $[\omega_h^*, \bar{\omega}]$.

Under imperfect financial institution, however, some entrepreneurs choose the low-productivity technology due to the borrowing constraint. If θ_k is small enough that the borrowing constraint is binding for both high-productivity and low-productivity technologies, wealthiest individuals become entrepreneurs with the high-productivity technology, those who have intermediate levels of wealth become entrepreneurs with the low-productivity technology, and the poorest individuals lend out their wealth. We define critical levels of wealth, $\omega_{h,k}$ and $\omega_{l,k}$, such that all individuals with $\omega \in [\omega_{h,k}, \bar{\omega}]$ become entrepreneurs choosing the high-productivity technology while all individuals with $\omega \in [\omega_{l,k}, \omega_{h,k})$ become entrepreneurs choosing the low-productivity technology.

3 Autarkic Equilibrium

In this section, we turn to the case of financial imperfection and derive the autarkic equilibrium, in which only high-tech firms exist in financially-developed countries while both low-tech as well as high-tech firms operate in financially-undeveloped countries. Firm heterogeneity in productivity arises only if financial institution is imperfect.

Let us first introduce the normalized average productivity and write the profits for a firm as a function of this productivity measure. Since the mass of high-tech firms and that of low-tech firms (if they exist) are $m_k(\bar{\omega} - \omega_{h,k})/\bar{\omega}$ and $m_k(\bar{\omega}_{h,k} - \omega_{l,k})/\bar{\omega}$, respectively, the competition index defined by (3) can be written as

$$\begin{aligned} \tilde{\varphi}_k &= \left\{ (\beta\varphi)^{\sigma-1} \frac{m_k}{\bar{\omega}} (\bar{\omega} - \omega_{h,k}) + \varphi^{\sigma-1} \frac{m_k}{\bar{\omega}} (\omega_{h,k} - \omega_{l,k}) \right\}^{\frac{1}{\sigma-1}} \\ &= \varphi m_k^{\frac{1}{\sigma-1}} \phi_k^{\frac{1}{\sigma-1}}, \end{aligned} \tag{13}$$

where

$$\phi_k = \beta^{\sigma-1} \frac{\bar{\omega} - \omega_{h,k}}{\bar{\omega}} + \frac{\omega_{h,k} - \omega_{l,k}}{\bar{\omega}}. \tag{14}$$

(If only high-tech firms exist, the second term of the right-hand side in (14) drops out, or equivalently it can be considered to be the case in which $\omega_{l,k} = \omega_{h,k}$.) The normalized average productivity ϕ_k is the weighted sum of $\beta^{\sigma-1}$ and 1 such that the weights on these normalized productivity (with the low productivity being normalized to 1) are the mass of the high-tech firms per capita and that of low-tech firms per capita. Then, the profits for the firms can be written as

$$\pi(\varphi_h, \tilde{\varphi}_k) = \frac{m_k}{\sigma}\left(\frac{\beta\varphi}{\tilde{\varphi}_k}\right)^{\sigma-1} = \frac{\beta^{\sigma-1}}{\sigma\phi_k}, \tag{15}$$

$$\pi(\varphi_l, \tilde{\varphi}_k) = \frac{1}{\sigma\phi_k}, \tag{16}$$

for the high-tech and low-tech firms, respectively. Profits for either type of the firm decrease if the market competitiveness, measured by the normalized productivity, rises.

The four constraints that must be satisfied, provided that a firm of the corresponding productivity operates, can now be written as follows. The profitability constraints for the high-tech and low-tech firms can be written respectively as

$$(\mathrm{PC}_h) \quad R_k \leq \frac{\beta^{\sigma-1}}{\sigma\phi_k g_h}, \tag{17}$$

$$(\mathrm{PC}_l) \quad R_k \leq \frac{1}{\sigma\phi_k g_l}. \tag{18}$$

The borrowing constraints for the high-tech and low-tech firms can be written respectively as

$$(\mathrm{BC}_h) \quad R_k \leq \frac{\theta_k\beta^{\sigma-1}}{\sigma\phi_k(g_h - \omega_{h,k})}, \tag{19}$$

$$(\mathrm{BC}_l) \quad R_k \leq \frac{\theta_k}{\sigma\phi_k(g_l - \omega_{l,k})}. \tag{20}$$

If θ_k is very small, it is the borrowing constraint that binds for either type of technology, i.e., both (BC_h) and (BC_l) are binding. In this case, (PC_h) and (PC_l) are satisfied with strict inequalities. As θ_k rises, (PC_l) becomes binding and hence (BC_l) becomes slack, while (BC_h) remains binding for the high-tech firms. As θ_k rises further, (PC_l) becomes violated so that low-tech firms cease to exists. The only constraint that is binding in this case is

(BC_h). Finally, if θ_k is sufficiently large, (PC_h) is the only constraint that is binding while (BC_h) is slack.

Figure 1 shows the relationship between θ_k and the binding constraints. The figure depicts the curves that represent these constraints when they are binding. The locations of the curves for the profitability constraints do not depend on θ_k, so they are common across all countries. Whereas those for the borrowing constraints depend on θ_k, and hence they are different across countries. The area on and below each curve is the set of $(\omega_{h,k}, R_k)$ that satisfies the corresponding constraint. As we show later, the BC_h and BC_l curves intersect with each other at a common $\omega_{h,k}$ (denoted by ω_h^A) regardless of the level of θ_k. Both of these curves shift up (at the same rate) as θ_k rises. Thus, if θ_k is small enough, (BC_h) and (BC_l) are the relevant binding constraints as we can see from the figure. If θ_k is large such that the intersection between the BC_h and BC_l curves lies above the PC_l curve, (PC_l) would be violated if this intersection still described the equilibrium. This means that (PC_l), instead of (BC_l), and (BC_h) are the binding constraints in this range of θ_k. As θ_k rises, the equilibrium point moves down along the PC_l curve and reaches the point at which low-tech firms cease to exist ($\omega_{h,k} = \omega_h^*$). As θ_k further rises, $\omega_{h,k} = \omega_h^*$ continues to hold and R_k rises with (BC_h) being the only binding constraint. Then finally, if θ_k is so large that the BC_h curve is located above the PC_l curve at $\omega_{h,k} = \omega_k^*$, (PC_h) is the only binding constraint that faces country k.

In summary, we obtain the following result, which is thoroughly discussed in the subsequent subsections.

Proposition 2 *In autarky, firms with different productivity levels operate in countries whose financial institution is relatively poor, while firms are homogeneous in countries with better financial institution. The equilibrium interest rate increases with the quality of financial institution for countries that have either poor financial institution or rather developed institutions. The interest rate decreases with the quality of financial institution, however, for countries whose financial institutions are in the intermediate levels.*

Note that we have established an important proposition that financial imperfection can be a cause of firm heterogeneity within an industry.

Now, we are ready to derive the equilibrium for a representative country k in each of the four regions classified by the respective binding constraints. As Figure 2 indicates, if θ_k is smaller than a threshold θ^I (Region I), the constraints that are biding are (BC$_h$) and (BC$_l$). If $\theta^I \leq \theta_k < \theta^{II}$ (Region II), the binding constraints are (BC$_h$) and (PC$_l$). In Region III where $\theta^{II} \leq \theta_k < \theta^{III}$, (PC$_l$) is violated and (BC$_h$) is binding. Finally in Region IV where $\theta^{III} \leq \theta_k < 1$, (PC$_h$) is binding while (BC$_h$) is slack.

3.1 Region I: (BC$_h$) and (BC$_l$) are binding

This subsection derives the equilibrium for country k such that θ_k is so small that (BC$_h$) and (BC$_l$) are binding in equilibrium. The equilibrium conditions are the two binding borrowing constraints,

$$R_k = \frac{\theta_k \beta^{\sigma-1}}{\sigma\phi_k(g_h - \omega_{h,k})}, \tag{21}$$

$$R_k = \frac{\theta_k}{\sigma\phi_k(g_l - \omega_{l,k})}, \tag{22}$$

and the capital market clearing condition

$$\frac{m_k}{\bar{\omega}}(\bar{\omega} - \omega_{h,k})g_h + \frac{m_k}{\bar{\omega}}(\omega_{h,k} - \omega_{l,k})g_l = \frac{m_k\bar{\omega}}{2}. \tag{23}$$

It follows immediately from (21) and (22) that the ratio of the maximum amount of borrowing by the high-tech firms to that by low-tech firms is constant, that is we have

$$g_l - \omega_{l,k} = \beta^{1-\sigma}(g_h - \omega_{h,k}) \tag{24}$$

in equilibrium. Then, we rewrite (23) as

$$g_h[\bar{\omega} - g_h + (g_h - \omega_{h,k})] + g_l[g_h - g_l - (g_h - \omega_{h,k}) + (g_l - \omega_{l,k})] = \frac{\bar{\omega}^2}{2},$$

and substitute (24) into this equation to obtain

$$g_h - \omega_{h,k} = \frac{\bar{\omega}^2 - 2g_h(\bar{\omega} - g_h) - 2g_l(g_h - g_l)}{2[g_h - (1 - \beta^{1-\sigma})g_l]} \equiv A. \tag{25}$$

It follows from (24) and (25) that the thresholds of wealth, $\omega_{h,k}$ and $\omega_{l,k}$, do not depend on θ_k, so all countries whose θ_ks fall in this region have common thresholds of $\omega_{h,k}$ and $\omega_{l,k}$, which we call ω_h^A and ω_l^A:

$$\omega_h^A = g_h - A, \tag{26}$$

$$\omega_l^A = g_l - \beta^{1-\sigma} A. \tag{27}$$

For the capital market clearing condition, given by (23), to make sense, ω_l^A must be smaller than ω_h^A. It follows from (26) and (27) that $\omega_l^A < \omega_h^A$ is equivalent to $g_h - g_l > (1 - \beta^{1-\sigma})A$, which can be written as

$$2g_h(g_h - g_l) > (1 - \beta^{1-\sigma})[\bar{\omega}^2 - 2g_h(\bar{\omega} - g_h)]. \tag{28}$$

The right-hand side of this inequality increases with $\bar{\omega}$, so that $\bar{\omega}$ should be small enough to meet the condition. Indeed, the condition (62) is equivalent to the inequality of the following assumption.

Assumption 3

$$\bar{\omega} < g_h + \left\{ \frac{g_h[(1 + \beta^{1-\sigma})g_h - 2g_l]}{1 - \beta^{1-\sigma}} \right\}^{\frac{1}{2}}.$$

Moreover, we need the following assumption to make Assumption 3 meaningful.

Assumption 4

$$\beta^{1-\sigma} > \frac{2g_l - g_h}{g_h}.$$

Note that Assumption 4 is satisfied if $g_h > 2g_l$. It is also readily verified that the inequality in Assumption 3 implies that of Assumption 2, so Assumption 2 is redundant.

We can readily obtain the normalized average productivity and the gross interest rate in equilibrium. We substitute $\bar{\omega} - \omega_{h,k} = \bar{\omega} - g_h + g_h - \omega_{h,k} = \bar{\omega} - g_h + A$ and $\omega_{h,k} - \omega_{l,k} = g_h - g_l - (g_h - \omega_{h,k}) + (g_l - \omega_{l,k}) = g_h - g_l - (1 - \beta^{1-\sigma})A$ into (14) to obtain

$$\phi_k = \frac{1}{\bar{\omega}}[\beta^{\sigma-1}(\bar{\omega} - g_h) + g_h - g_l + (\beta^{\sigma-1} + \beta^{1-\sigma} - 1)A]. \tag{29}$$

Then, we substitute this equilibrium normalized average productivity into (21) to obtain

$$R_k = \frac{\theta_k \beta^{\sigma-1}\bar{\omega}}{\sigma A[\beta^{\sigma-1}(\bar{\omega} - g_h) + g_h - g_l + (\beta^{\sigma-1} + \beta^{1-\sigma} - 1)A]}. \tag{30}$$

As (30) indicates, any change in θ_k will induce an offsetting change in R_k. In partial equilibrium analyses, the development of financial institution generally increases the number of firms because it becomes easier for entrepreneurs to finance the investment costs. But this seemingly obvious causality breaks down in this general equilibrium model. The productivity distribution of the industry hinges critically on the total credit supply that is fixed in the autarkic economy. That is why the financial development, for example, will increase the interest rate to offset an induced increase in credit demands. As long as θ_k is sufficiently small, a rise in θ_k simply raises R_k without affecting the productivity distribution, characterized by the thresholds $\omega_{h,k}$ and $\omega_{l,k}$, and hence the normalized average productivity, as indicated in (29). This movement is also depicted in Region I of Figure 2. We assume that the smallest θ_k is large enough that the corresponding R_k^A is greater than 1.[5]

3.2 Region II: (BC$_h$) and (PC$_l$) are binding

If θ_k is relatively large so that the intersection between the BC$_h$ curve and the BC$_l$ curve in Figure 1 lies above the PC$_l$ curve, the constraint that is binding for low-tech firms will be (PC$_l$) instead of (BC$_l$). We can easily calculate the threshold value θ^I, noting that at $\theta_k = \theta^I$ (BC$_l$) and (PC$_l$) are both satisfied with equality when $\omega_{l,k} = \omega_l^A$. We obtain the threshold value θ^I of θ_k by equating the right-hand sides of (18) and (20):

$$\begin{aligned} \theta^I &= \frac{g_l - \omega_l^A}{g_l} \\ &= \frac{A}{\beta^{\sigma-1} g_l}, \end{aligned} \tag{31}$$

where we have used (27).

If $\theta_k < \theta^I$, the analysis for Region I applies to country k's autarkic equilibrium. If $\theta^I \leq \theta_k < \theta^{II}$, however, the equilibrium pair of $(\omega_{h,k}, R_k)$ is given by the intersection between the BC$_h$ curve and the PC$_l$ curve in Figure 1. Since PC$_l$ curve is upward-sloping, both $\omega_{h,k}$ and R_k fall as θ_k increases. As θ_k rises, more high-tech firms enter the market (i.e., $\omega_{h,k}$ decreases), which pushes low-tech firms out of the market (i.e., $\omega_{l,k}$ increases). Some low-

[5] Although the curve in the lower panel of Figure 2 extends from the origin, the part in the neighborhood of the origin is irrelevant due to this assumption.

tech firms survive, nevertheless, despite that the market becomes more competitive; the interest rate R_k falls so that they can survive. This phenomenon is shown in Region II of Figure 2.

To make the above argument more precise, we derive the equilibrium productivity distribution and interest rate. The equilibrium conditions are the binding conditions of (BC_h) and (PC_l):

$$R_k = \frac{\theta_k \beta^{\sigma-1}}{\sigma \phi_k (g_h - \omega_{h,k})}, \tag{32}$$

$$R_k = \frac{1}{\sigma \phi_k g_l}, \tag{33}$$

and the capital market clearing condition given by (23).

In this case, the equilibrium productivity distribution depends on θ_k. It follows immediately from (32) and (33) that the equilibrium threshold $\omega_{h,k}$ is determined by

$$g_h - \omega_{h,k} = \theta_k \beta^{\sigma-1} g_l,$$

so that the higher is θ_k the larger the mass of the high-tech firms as the upper panel of Figure 2 indicates. The aggregate capital demands by the high-tech firms are given by $g_h m_k(\bar{\omega} - g_h + \theta_k \beta^{\sigma-1} g_l)/\bar{\omega}$ and the rest of the capital is used by low-tech firms. Therefore, the mass of low-tech firms per capita is given by

$$\begin{aligned} & \frac{1}{m_k g_l}\left[\frac{m_k \bar{\omega}}{2} - \frac{m_k g_h}{\bar{\omega}}(\bar{\omega} - g_h + \theta_k \beta^{\sigma-1} g_l)\right] \\ & = \frac{1}{2\bar{\omega} g_l}[\bar{\omega}^2 - 2g_h(\bar{\omega} - g_h) - 2\theta_k \beta^{\sigma-1} g_h g_l]. \end{aligned}$$

Since (BC_l) is slack in this case, not all individuals whose wealth levels satisfy (BC_l) become entrepreneurs. But if we suppose that wealthier individuals become entrepreneurs, the threshold $\omega_{l,k}$ would increase as the upper panel of Figure 2 shows.

Now, the normalized average productivity is given by

$$\begin{aligned} \phi_k &= \frac{\beta^{\sigma-1}}{\bar{\omega}}(\bar{\omega} - g_h + \theta_k \beta^{\sigma-1} g_l) + \frac{1}{2\bar{\omega} g_l}[\bar{\omega}^2 - 2g_h(\bar{\omega} - g_h) - 2\theta_k \beta^{\sigma-1} g_h g_l] \\ &= \frac{1}{2\bar{\omega} g_l}[\bar{\omega}^2 + 2(\beta^{\sigma-1} g_l - g_h)(\bar{\omega} - g_h + \theta_k \beta^{\sigma-1} g_l)]. \end{aligned} \tag{34}$$

It follows from Assumption 1 that ϕ_k increases with θ_k.

We substitute (34) into (33) to obtain the equilibrium gross interest rate:

$$R_k = \frac{2\bar{\omega}}{\sigma[\bar{\omega}^2 + 2(\beta^{\sigma-1}g_l - g_h)(\bar{\omega} - g_h + \theta_k\beta^{\sigma-1}g_l)]}. \tag{35}$$

In this case, the higher is θ_k, the lower the equilibrium interest rate as depicted in the lower panel of Figure 2.

3.3 Region III: Only (BC$_h$) is binding

If $\theta^{II} \leq \theta_k < \theta^{III}$ the BC$_h$ curve is located between the PC$_l$ curve and the PC$_h$ curve at $\omega_{h,k} = \omega_h^*$ in Figure 1. When $\theta_k = \theta^{II}$, both (PC$_l$) and (BC$_h$) are binding at $\omega_{h,k} = \omega_h^*$. Thus, it follows from (18) and (19) that

$$\begin{aligned} \theta^{II} &= \frac{g_h - \omega_h^*}{\beta^{\sigma-1}g_l} \\ &= \frac{g_h^2 + (\bar{\omega} - g_h)^2}{2\beta^{\sigma-1}g_h g_l}, \end{aligned} \tag{36}$$

where we have used (12) to derive the second equality.

In this region, (PC$_l$) is violated and (BC$_h$) is binding in country k:

$$R_k = \frac{\theta_k\beta^{\sigma-1}}{\sigma\phi_k(g_h - \omega_{h,k})}. \tag{37}$$

Since only high-tech firms operate, the equilbrium threhold of wealth is given by $\omega_{h,k} = \omega_h^*$ as shown in (12), and the mass of high-tech firms per capita equals $\bar{\omega}/2g_h$. Consequently, we have $g_h - \omega_h^* = [g_h^2 + (\bar{\omega} - g_h)^2]/2g_h$ and

$$\phi_k = \frac{\beta^{\sigma-1}\bar{\omega}}{2g_h}, \tag{38}$$

and hence we have from (37) that

$$R_k = \frac{4\theta_k g_h^2}{\sigma\bar{\omega}[g_h^2 + (\bar{\omega} - g_h)^2]}. \tag{39}$$

In this region, R_k increases linearly with θ_k as the lower panel of Figure 2 indicates.

3.4 Region IV: Only (PC$_h$) is binding

Finally, if θ_k is large enough such that $\theta^{III} \leq \theta_k \leq 1$, (BC$_h$) becomes slack and only (PC$_h$) is the binding constraint:

$$R_k = \frac{\beta^{\sigma-1}}{\sigma\phi_k g_h}. \tag{40}$$

To derive the threshold θ^{III}, we note that if $\theta_k = \theta^{III}$, both (PC$_h$) and (BC$_h$) are binding at $\omega_{h,k} = \omega_h^*$. Thus, we have from (17) and (19) that

$$\begin{aligned} \theta^{III} &= \frac{g_h - \omega_h^*}{g_h} \\ &= \frac{g_h^2 + (\bar{\omega} - g_h)^2}{2g_h^2}. \end{aligned} \tag{41}$$

As in Region III, only high-tech firms operate, so $\phi_k = \beta^{\sigma-1}\bar{\omega}/2g_h$. Thus, we have from (40) that $R_k = 2/\sigma\bar{\omega}$. The gross interest rate does not depend on θ_k as illustrated in Figure 2.

4 Free Trade Equilibrium

This section considers the case in which all countries are completely open to international trade in goods. We show among others that trade in goods will not affect the productivity distribution in the industry in any country of the world.

To derive the equilibrium conditions, we first derive the profits for firms in free trade. Since all firms in the world compete in a level field in every country's market, the competition index is the same for all countries and it is written as

$$\begin{aligned} \tilde{\varphi}_k &= \left\{(\beta\varphi)^{\sigma-1}\sum_{i=1}^{N}\frac{m_i}{\bar{\omega}}(\bar{\omega} - \omega_{h,i}) + \varphi^{\sigma-1}\sum_{i=1}^{N}\frac{m_i}{\bar{\omega}}[\omega_{h,i} - \hat{\omega}_l(\omega_{h,i})]\right\}^{\frac{1}{\sigma-1}} \\ &= \varphi\phi_w^{\frac{1}{\sigma-1}}, \end{aligned}$$

where

$$\begin{aligned} \phi_w &= \beta^{\sigma-1}\sum_{i=1}^{N}\frac{m_i}{\bar{\omega}}(\bar{\omega} - \omega_{h,i}) + \sum_{i=1}^{N}\frac{m_i}{\bar{\omega}}(\omega_{h,i} - \omega_{l,i}) \\ &= \sum_{i=1}^{N} m_i\phi_i, \end{aligned} \tag{42}$$

where ϕ_i is defined in (14) as ϕ_k. Each firm derives profits from every country in the world, so the profits for high-tech firms and low-tech firms can be written as

$$\pi_k(\varphi_h, \tilde{\varphi}_w) = \sum_{i=1}^{N} \frac{m_i}{\sigma} \left(\frac{\beta\varphi}{\tilde{\varphi}_w} \right)^{\sigma-1} = \frac{\beta^{\sigma-1}}{\sigma\phi_w},$$
$$\pi_k(\varphi_l, \tilde{\varphi}_w) = \frac{1}{\sigma\phi_w},$$

respectively.

Substituting these profits for corresponding profits in the four constraints (5)-(8), we find that the constraints can be reduced to the same inequalities (17)-(20) in the autarkic equilibrium except that ϕ_w is substituted for ϕ_k:

$$(\mathrm{PC}_h) \quad R_k \leq \frac{\beta^{\sigma-1}}{\sigma\phi_w g_h},$$
$$(\mathrm{PC}_l) \quad R_k \leq \frac{1}{\sigma\phi_w g_l}, \tag{43}$$
$$(\mathrm{BC}_h) \quad R_k \leq \frac{\theta_k \beta^{\sigma-1}}{\sigma\phi_w (g_h - \omega_{h,k})}, \tag{44}$$
$$(\mathrm{BC}_l) \quad R_k \leq \frac{\theta_k}{\sigma\phi_w (g_l - \omega_{l,k})}. \tag{45}$$

Recall that ϕ_k is always cancelled out and hence it is absent in the equalities that determine the thresholds θ^I, θ^{II}, and θ^{III} in the autarkic equilibrium. Similarly, in this case, ϕ_w is cancelled out in the derivation of a threshold so that we have the same equalities that determine the free-trade equilibrium thresholds as in the case of autarky.

Moreover, since the same capital market clearing condition, expressed in (23), as in the case of autarky applies here, we find that $\omega_{h,k}$ and $\omega_{l,k}$ in the free trade equilibrium are the same as those in autarky for any country k. Consider, for example, a country k with $\theta_k < \theta^I$, where (BC_h) and (BC_l) are the binding constraints. It follows from (44) and (45) that the same equality as in (24) holds. Then, it is easy to see that together with the capital market clearing condition (23), this equality gives us $\omega_{h,k} = \omega_h^A$ and $\omega_{l,k} = \omega_l^A$ also in free trade. The productivity distribution will not change as a result of the trade liberalization, nor does the normalized average productivity ϕ_k.

However, opening to trade will change the gross interest rates through the changes in the firms' profits. We can see from (29), (34), and (38) that ϕ_k is weakly increasing in θ_k as depicted in Figure 3. Since ϕ_w is the weighted average of ϕ_ks as indicated in (42), this implies that there is a threshold θ^R in Region II such that $\phi_k < \phi_w$ if and only if $\theta_k < \theta^R$. Consequently, R_k falls in country k with $\theta_k < \theta^R$ as a result of trade liberalization, whereas it rises in country k with $\theta_k > \theta^R$. In autarky, financial imperfection lessens the market competitiveness in the South, which benefited the firms in the South. Trade liberalization, however, forces the southern firms to compete in a tougher environment so that their profits decline. This decreases interest rates in the South through a decrease in the effective capital demands. Since exactly the opposite occurs in the North, the interest rates in the North rise as a result of trade liberalization.

As indicated in the lower panel of Figure 4, the interest rate schedule shifts down in Region I, whereas it shifts up in Region III and Region IV. In Region II, the interest rate schedule is flat in the free trade equilibrium, that is all countries in this region have the same interest rate; they are faced with the binding (PC_l), given by (43), which is independent of θ_k (unlike the one in autarky, given by (33) with ϕ_k shown in (34))

Figure 4 shows the equilibrium productivity distribution and interest rate, and compares them with those in autarky. As we have seen, the productivity distribution characterized by $\omega_{h,k}$ and $\omega_{l,k}$ is not affected by trade liberalization for any country. Trade liberalization, however, exacerbates the impact of financial development on the interest rate. The interest rate is, in general, positively (but weakly) related to the quality of financial institution, except in Region II in autarky. Because trade liberalization benefits the firms in the North and hurts the firms in the South, it induces the interst rates in the South to become even lower and those in the North to become even higher.

Proposition 3 *Opening to trade will not change the productivity distribution of the industry for any country. The interest rate falls, however, for countries with poor financial institutions, while it rises for countries with better financial institutions.*

5 Free Trade and Capital Movement

We have seen that opening to trade will not affect the productivity distribution of the industry. The story will be quite different, however, if countries liberalize capital movement as well as trade in goods. More specifically, perfect capital mobility across countries will induce capital to move from the South to the North, which in turn leads to global convergence in the productivity distribution. In equilibrium, all countries fall in the same region, one of the four regions characterized in the autarkic equilibrium. If they fall in Region I, for example, low-tech firms as well as high-tech firms operate in all countries including the North. If they fall in Region III or Region IV, on the other hand, only high-tech firms operate in all countries including the South. Which region they will fall in as a consequence of capital account liberalization will be shown to depend on the worldwide average of the quality of financial institution.

In equilibrium under free trade and free capital movement, the interest rate as well as the normalized average productivity will be the same across countries. Thus, the four constraints (5)-(8) can be written as

$$(\mathrm{PC}_h) \quad R_w \leq \frac{\beta^{\sigma-1}}{\sigma\phi_w g_h}, \tag{46}$$

$$(\mathrm{PC}_l) \quad R_w \leq \frac{1}{\sigma\phi_w g_l}, \tag{47}$$

$$(\mathrm{BC}_h) \quad R_w \leq \frac{\theta_k\beta^{\sigma-1}}{\sigma\phi_w(g_h-\omega_{h,k})}, \tag{48}$$

$$(\mathrm{BC}_l) \quad R_w \leq \frac{\theta_k}{\sigma\phi_w(g_l-\omega_{l,k})}, \tag{49}$$

where R_w denotes the gross interest rate that prevails in any country of the world.

We find immediately that the profitability constraints (46) and (47) are common for all countries, so if (47) is violated for one country, for example, it is violated for all countries. Therefore, there are four possibilities. In Case I, (PC_h) and (PC_l) are satisfied with strict inequalities so that (BC_h) and (BC_l) are binding for all countries. In Case II, (PC_l) is satisfied with equality, and hence (PC_h) is satisfied with strict inequality. In this case, (PC_l) and (BC_h) are the binding constraints that characterize the equilibrium. In Case III, (PC_l) is violated and (PC_h) is satisfied with strict inequality, so that (BC_h) is biding for all countries. Finally in Case IV, (PC_h) is satisfied with equality, so that it is the only binding constraint for all countries.

It appears that these four cases have perfect correspondences to the four regimes that we have considered in the case of autarky. As we will show shortly, it is indeed the case. Just as the countries are categorized into the four regimes in the autarkic equilibrium according to their θ_ks, the possible equilibrium here will be categorized into the four cases according to the worldwide weighted average of θ_ks. Somewhat surprisingly, the same threshold values, θ^I, θ^{II}, and θ^{III}, will also apply to the equilibrium categorization here.

5.1 Case I: (BC_h) and (BC_l) are binding

In this case, conditions (48) and (49) hold with equality. It follows from these conditions that for any k,

$$g_l - \omega_{l,k} = \beta^{1-\sigma}(g_h - \omega_{h,k})$$

and

$$\frac{g_h - \omega_{h,k}}{\theta_k} = \frac{g_h - \omega_{h,1}}{\theta_1}$$

hold, so that we have

$$g_h - \omega_{h,k} = \frac{\theta_k}{\theta_1}(g_h - \omega_{h,1}) \tag{50}$$

and

$$g_l - \omega_{l,k} = \frac{\theta_k \beta^{1-\sigma}}{\theta_1}(g_h - \omega_{h,1}). \tag{51}$$

Then, the capital demands by high-tech firms can be written as

$$g_h \sum_{k=1}^{N} \frac{m_k}{\bar{\omega}}(\bar{\omega} - g_h + g_h - \omega_{h,k}) = \frac{g_h}{\bar{\omega}}\left[\bar{\omega} - g_h + \frac{\bar{\theta}}{\theta_1}(g_h - \omega_{h,1})\right],$$

while those by low-tech firms can be written as

$$\begin{aligned}
& g_l \sum_{k=1}^{N} \frac{m_k}{\bar{\omega}}(\omega_{h,k} - \omega_{l,k}) \\
= \;& g_l \sum_{k=1}^{N} \frac{m_k}{\bar{\omega}}[g_h - g_l + (g_l - \omega_{l,k}) - (g_h - \omega_{h,k})] \\
= \;& \frac{g_l}{\bar{\omega}}\left[g_h - g_l - \frac{\bar{\theta}}{\theta_1}(1 - \beta^{1-\sigma})(g_h - \omega_{h,1})\right],
\end{aligned}$$

where $\bar{\theta} \equiv \sum_{k=1}^{N} m_k \theta_k$ represents the worldwide (weighted) average of the quality of financial institution. Adding these demands give us the total capital demands in the world, which is expressed by the left-hand side of the following worldwide capital market clearing condition:

$$\frac{1}{\bar{\omega}} \left\{ g_h(\bar{\omega} - g_h) + g_l(g_h - g_l) + \frac{\bar{\theta}}{\theta_1}(g_h - \omega_{h,1})[g_h - (1 - \beta^{1-\sigma})g_l] \right\} = \frac{\bar{\omega}}{2}.$$

We solve this equation to obtain

$$\frac{g_h - \omega_{h,1}}{\theta_1} = \frac{A}{\bar{\theta}},$$

and consequently,

$$g_h - \omega_{h,k} = \frac{\theta_k}{\bar{\theta}} A, \tag{52}$$

$$g_l - \omega_{l,k} = \frac{\theta_k}{\bar{\theta}} \beta^{1-\sigma} A, \tag{53}$$

for any country k, where A is defined in (25).

We can use (52) and (53) to derive the normalized average productivity as

$$\begin{aligned} \phi_w &= \beta^{\sigma-1} \sum_{k=1}^{N} \frac{m_k}{\bar{\omega}} (\bar{\omega} - g_h + g_h - \omega_{h,k}) + \sum_{k=1}^{N} \frac{m_k}{\bar{\omega}} [g_h - g_l + (g_l - \omega_{l,k}) - (g_h - \omega_{h,k})] \\ &= \frac{1}{\bar{\omega}} [\beta^{\sigma-1}(\bar{\omega} - g_h) + g_h - g_l + (\beta^{\sigma-1} + \beta^{1-\sigma} - 1)A]. \end{aligned} \tag{54}$$

Note that the equilibrium normalized average productivity ϕ_w is identical to ϕ_k in (29), the normalized average productivity in a country k in Region I in autarkic equilibrium.

Consequently, the equilibrium gross interest rate, which can be derived from (BC_h) together with (52) and (54), is also the same as the autarkic gross interest rate that prevails in country k in Region I with θ_k replaced by $\bar{\theta}$ (see (30)):

$$\begin{aligned} R_w &= \frac{\theta_k \beta^{\sigma-1}}{\sigma \phi_w (g_h - \omega_{h,k})} \\ &= \frac{\bar{\theta} \beta^{\sigma-1} \bar{\omega}}{\sigma A[\beta^{\sigma-1}(\bar{\omega} - g_h) + g_h - g_l + (\beta^{\sigma-1} + \beta^{1-\sigma} - 1)A]}. \end{aligned} \tag{55}$$

Capital moves from the South to the North. As shown in (25), $g_h - \omega_{h,k} = A$ in the absense of international capital movement. Comparing this outcome with the one in (52), we find that all countries with $\theta_k > \bar{\theta}$ attract capital while those with $\theta_k < \bar{\theta}$ experience capital outflow. Capital flows out from the South significantly in total so that capital becomes so much abundant in the North allowing even low-tech firms to survive also in those countries. Capital movement in this case decreases worldwide production efficiency.

This type of equilibrium emerges if $\bar{\theta}$ is small enough. To find the threshold value of $\bar{\theta}$, we note that both (BC_l) and (PC_l) are satisfied with $g_l - \omega_{l,k}$ given by (53) for any country k. Then, it is readily seen that the threshold value of $\bar{\theta}$ is equal to θ^I, which is given by (31).

5.2 Case II: (BC_h) and (PC_l) are binding

In this case, both (47) and (48) hold with equality. The mass of low-tech firms is smaller than that in Case I, and hence the worldwide average productivity is higher.

To find the productivity distribution of the industry in each country, we first obtain from (47) and (48) that

$$\frac{g_h - \omega_{h,k}}{\theta_k} = \beta^{\sigma-1} g_l,$$

for any country k. Then, the capital demands by high-tech firms are given by

$$g_h \sum_{k=1}^{N} \frac{m_k}{\bar{\omega}} (\bar{\omega} - g_h + g_h - \omega_{h,k}) = \frac{g_h}{\bar{\omega}} (\bar{\omega} - g_h + \bar{\theta}\beta^{\sigma-1} g_l).$$

The total mass of low-tech firms in the world is determined from the worldwide capital market clearing condition as $[\bar{\omega}^2 - 2g_h(\bar{\omega} - g_h) - 2\bar{\theta}\beta^{\sigma-1} g_h g_l]/2\bar{\omega} g_l$. Location of low-tech firms must be consistent with (BC_l) in every country, but is otherwise indeterminate.

The normalized average productivity is given by

$$\begin{aligned} \phi_w &= \frac{\beta^{\sigma-1}}{\bar{\omega}} (\bar{\omega} - g_h + \bar{\theta}\beta^{\sigma-1} g_l) + \frac{1}{2\bar{\omega} g_l} [\bar{\omega}^2 - 2g_h(\bar{\omega} - g_h) - 2\bar{\theta}\beta^{\sigma-1} g_h g_l] \\ &= \frac{1}{2\bar{\omega} g_l} \left[\bar{\omega}^2 + 2(\beta^{\sigma-1} g_l - g_h)(\bar{\omega} - g_h + \bar{\theta}\beta^{\sigma-1} g_l)\right]. \end{aligned} \tag{56}$$

Note that ϕ_w is the same as ϕ_k in (34) with θ_k replaced by $\bar{\theta}$. The normalized average productivity is greater than that in the inefficient equilibrium in Case I. In this case, moreover, the higher the average quality of financial institution, the higher the normalized average productivity.

By substituting (56) into (47) (satisfied with equality), we obtain the equilibrium interest rate as

$$R_w = \frac{2\bar{\omega}}{\sigma[\bar{\omega}^2 + 2(\beta^{\sigma-1}g_l - g_h)(\bar{\omega} - g_h + \bar{\theta}\beta^{\sigma-1}g_l)]}, \tag{57}$$

which is again the same as R_k in Region II in the case of autarky, shown in (35), with θ_k replaced by $\bar{\theta}$. Note also that the higher the average quality of financial institution, the lower the equilibrium interest rate so that low-tech firms can survive even in a tougher environment with more high-tech firms.

This type of equilibrium is observed as long as $\bar{\theta}$ is higher than θ^I and smaller than another threshold value. At the upper threshold, (PC_l) is binding with $\phi_w = \beta^{\sigma-1}\bar{\omega}/2g_h$, the normalized average productivity when all firms adopt the high-productivity technology. Substituting this value of ϕ_w into (47) gives us

$$R_w = \frac{2g_h}{\beta^{\sigma-1}\sigma\bar{\omega}g_l}.$$

Together with (57), this equation gives us the result that the upper threshold value of $\bar{\theta}$ is the same as θ^{II} that is defined in (36). That is, the equilibrium characterized here prevails if $\theta^I \leq \bar{\theta} < \theta^{II}$.

5.3 Case III: Only (BC_h) is binding

If $\bar{\theta}$ is rather high, (PC_l) is violated so that only high-tech firms operate in equilibrium. When only (BC_h) is binding, it follows from (48) that

$$g_h - \omega_{h,k} = \frac{\theta_k}{\theta_1}(g_h - \omega_{h,1}) \tag{58}$$

for any k. Capital demands in country k can be written as

$$\frac{m_k g_h}{\bar{\omega}}(\bar{\omega} - \omega_{h,k}) = \frac{m_k g_h}{\bar{\omega}}(\bar{\omega} - g_h + g_h - \omega_{h,k})$$

and hence the worldwide capital market clearing condition becomes

$$g_h \sum_{k=1}^{N} \frac{m_k}{\bar{\omega}} \left[\bar{\omega} - g_h + \frac{\theta_k}{\theta_1}(g_h - \omega_{h,1})\right] = \frac{\bar{\omega}}{2},$$

which gives us

$$\frac{g_h - \omega_{h,1}}{\theta_1} = \frac{\bar{\omega}^2 - 2g_h(\bar{\omega} - g_h)}{2g_h\bar{\theta}}.$$

Then it follows from (58) that

$$g_h - \omega_{h,k} = \frac{\theta_k[\bar{\omega}^2 - 2g_h(\bar{\omega} - g_h)]}{2g_h\bar{\theta}}, \tag{59}$$

for any k including $k = 1$.

In this equilibrium, only high-tech firms operate in any country in the world. Capital moves from the South to the North, as we can see from (59) that the threshold wealth of being an entrepreneur is lower in a country with a high θ_k. International capital movement makes the industry in the South shrink and that in the North expand.

To derive the equilibrium interest rate, we note that the total mass of high-tech firms per capita equals $\bar{\omega}/2g_h$ so that the normalized average productivity equals

$$\phi_w = \frac{\beta^{\sigma-1}\bar{\omega}}{2g_h}, \tag{60}$$

Substituting (59) and (60) into (48) (satisfied with equality), we obtain the equilibrium gross interest rate as

$$R_w = \frac{4\bar{\theta}g_h^2}{\sigma\bar{\omega}[g_h^2 + (\bar{\omega} - g_h)^2]}. \tag{61}$$

Again, R_w is the same as R_k in Region III in the case of autarky, shown in (39), with θ_k replaced by $\bar{\theta}$.

This equilibrium prevails if $\theta^{II} \leq \bar{\theta} < \theta^{III}$, where θ^{III} is defined in (41). To see this, we substitute (60) into (46) to find that $R_w = 2/\sigma\bar{\omega}$, the gross interest rate at which (PC_h) is satisfied with equality. At the threshold value of $\bar{\theta}$, this interest rate must be equal to R_w in (61). The resulting equation shows that the threshold value of $\bar{\theta}$ is equal to θ^{III}.

5.4 Case IV: Only (PC_h) is binding

If $\theta^{III} \leq \bar{\theta} \leq 1$, all firms adopt the high-productivity technology and they are all break-even. The normalized productivity is $\phi_w = \beta^{\sigma-1}\bar{\omega}/2g_h$. It follows from (46) (satisfied with equality) that the gross interest rate equals $R_w = 2/\sigma\bar{\omega}$, which is the same as that in Region IV in the case of autarky.

5.5 Summary of the results

We have shown the intersting finding that the productivity distributions will converge across countries and the worldwide economic variables, such as the interest rate, will become the same as in autarkic equilibrium in country k whose quality of financial institution θ_k is equal to its worldwide average $\bar{\theta}$. Thus, the relationship between the average quality of financial institution and the average worldwide theresholds wealth levels of entrepreneurs (which characterize the worldwide productivity distributions) is exactly the same as the relationship between θ_k and $(\omega_{h,k}, \omega_{l,k})$. This relationship can be seen in the upper panel of Figure 2 (with θ_k replaced by $\bar{\theta}$ and ω_k replaced by its worldwide average). Similarly, the relationship between the average quality of financial institution and the gross interest that prevails in the world can be read from the lower panel of Figure 2 with the appropriate adjustment of the variables. As in the case of autarky, the latter relationship is not monotone. They have positive relationships in the range of $\bar{\theta}$ where either the inefficient or the efficient equilibrium prevails (i.e., in Cases I, III, and IV). But the interest rate is negatively related in the range of $\bar{\theta}$ where the less efficient equilibrium prevails (i.e., in Case II). In this range, the higher the average quality of financial institution, the higher is the average productivity of the industry so that the interest rate must be lower for low-tech firms to survive.

We record these findings in the following proposition.

Proposition 4 *International capital movement in addition to trade in goods entails global convergence in the productivity distribution. Capital movement enhances worldwide production efficiency if the worldwide average of the quality of financial institution is high. It will reduce worldwide production efficiency allowing low-tech firms to survive with a low equilibrium interest rate, however, if the average quality of financial institution is low.*

Corollary 1 *Worldwide efficiency of production may be enhanced by restricting international capital movement in southern countries.*

6 Globalization and Income Distribution

Globalization (which we define here as opening to trade in goods and capital movement) affects income distribution within each country as well as across countries. We have seen that globalization entails capital movement from the South to the North, which induces the interest rate to rise in the South and to fall in the North. In addition, firms in the South come to face tougher competition in the world while those in the North benefit from the market expansion led by globalization; globalization reduces profits for firms in the South and increase those for firms in the North.

This section closely examines the impact of globalization on income redistribution within each country. We show that entrepreneurs' incomes fall (rise) while lenders' income rise (fall) as a result of globalization in the North (South). Since rich individuals become entrepreneurs while poor individuals become lenders under financial imperfection, we can conclude from this observation that income inequality widens in the North and narrows in the South.

To see this, we recall that an entrepreneur with the wealth ω obtains $\pi_{h,k} - R_k(g_h - \omega)$ if she produces a good with the high-productivity technology and $\pi_{l,k} - R_k(g_l - \omega)$ with the low-productivity technology. A lender with the wealth ω, on the other hand, obtains $R_k\omega$ from the investment. For entrepreneurs, an increase in $\pi_{h,k}$ and $\pi_{l,k}$ is good news, whereas an increase in R_k is only preferable if they also lend out residual wealths after their investment on the production projects, i.e., if $g_h - \omega < 0$ or $g_l - \omega < 0$. For lenders, an increase in R_k is unambiguously good news.

One criterion with which we judge the impact of globalization on income redistribution is the rate of reward from investing their wealths, which is given by $[\pi_{h,k} - R_k(g_h - \omega)]/\omega$ for high-tech entrepreneurs, $[\pi_{l,k} - R_k(g_l - \omega)]/\omega$ for low-tech entrepreneurs, and R_k for lenders. Since we are especially interested in the impact of globalization on income inequality, we take the ratio of the reward rate for a high-tech entrepreneur, for example, to that for a lender to obtain

$$\frac{(\pi_{h,k}/R_k) - g_h}{\omega} + 1. \tag{62}$$

This ratio falls with ω and converges to 1 as ω goes to infinity; the richer an entrepreneur, the more benefits she reap from lending than from running a business. We are interest in how this ratio changes as a result of globalization. To this end, we need only to see the impact on the ratio of the profits to the interest rate, i.e., $\pi_{h,k}/R_k$. It follows from $\pi_{l,k} = \beta^{1-\sigma}\pi_{h,k}$ that the impact on the income inequality between a low-tech entrepreneur and a lender is positively related with that between a high-tech entrepreneur and a lender and hence assessed from (62).

It follows from the analysis in the previous section that both ϕ_k and $\omega_{h,k}$ increase (decrease) if $\theta_k < (>)\bar{\theta}$ as a result of globalization. This observation help us determine the impact of globalization on $\pi_{h,k} = \beta^{\sigma-1}/\sigma\phi_k$.

Let us first examine the case where $\bar{\theta}$ is so small that $\bar{\theta} < \theta^{\alpha}$, where θ^{α} is defined as indicated in Figure 5. For countries with $\theta_k < \bar{\theta}$, globalization entails a rise in ϕ_k and hence a fall in $\pi_{h,k}$. Since the interest rate rises in such countries (which can easily be seen in Figure 5), we find that $\pi_{h,k}/R_k$ falls in countries with $\bar{\theta} < \theta^{\alpha}$. If $\theta_k = \bar{\theta}$, both $\pi_{h,k}$ and R_k are not affected by globalization. (Impacts of globalization in such threshold cases are easily inferred, so we will henceforth skip all such threshold cases.) Finally, if $\theta_k > \bar{\theta}_k$, globalization induces ϕ_k to go down, so that $\pi_{h,k}$ increases, and R_k to decrease. Thus, $\pi_{h,k}/R_k$ increases in such countries. In summary, it can be said that $\pi_{h,k}/R_k$ decrases in the South and increases in the North. Income inequality shrinks in the South and expands in the North.

It is easy to see that the same conclusion obtains in the case where $\bar{\theta}$ is rather high such that $\theta^{\alpha} < \bar{\theta} < \theta^{\beta}$, where θ^{β} is defined as indicated in Figure 5.

A more careful analysis is needed if $\bar{\theta}$ is in the intermediate range such that $\theta^{\alpha} < \bar{\theta} < \theta^{\beta}$. In this rage, even if $\theta_k < \bar{\theta}$ so that ϕ_k increases as a result of globalization, R_k may decrease in some countries unlike in the previous cases. An example of such cases is depicted in Figure 6, in which globalization induces ϕ_k to increase and R_k to decrease for countries with $\theta_k \in (\theta^{a}, \bar{\theta})$. Table 1 shows how the profits and the interest rate change as a result of globalization when $\bar{\theta}$ lies as indicated in Figure 6 so that the equilibrium interest rate R_w is greater than $R_w^{\alpha} \equiv 2g_h/\sigma\bar{\omega}\beta^{\sigma-1}g_l$ and smaller than $R_w^{\beta} \equiv \bar{\omega}/\sigma g_l[\beta^{\sigma-1}(\bar{\omega}-g_h)+g_h-g_l+(\beta^{\sigma-1}+\beta^{1-\sigma}-1)A]$. As shown in the table, both $\pi_{h,k}$ and R_k decrease in countries with $\theta_k \in (\theta^{a}, \bar{\theta})$ and they increase in countries with $\theta_k \in (\bar{\theta}, \theta^b)$. Thus, the impact on income inequality appears to be indeterminate for those countries. In these regions of financial development, however, (BC$_h$) is binding both before and after globalization. Therefore, we can rewrite the ratio of the profits to the interest rate as

$$\frac{\pi_{h,k}}{R_k} = \frac{\beta^{\sigma-1}/\sigma\phi_k}{\theta_k\beta^{\sigma-1}/\sigma\phi_k(g_h - \omega_{h,k})} = \frac{g_h - \omega_{h,k}}{\theta_k}. \tag{63}$$

Since globalization induces capital outflow (i.e., an increase in $\omega_{h,k}$) for countries whose θ_k is smaller than $\bar{\theta}$, whereas it induces capital inflow (i.e., an decrease in $\omega_{h,k}$) for countries whose θ_k is greater than $\bar{\theta}$, using (63), we find that $\pi_{h,k}/R_k$ decreases if $\theta_k \in (\theta^a, \bar{\theta})$ and increases if $\theta_k \in (\bar{\theta}, \theta^b)$. Together with the results in other regions summarized in Table 1, we conclude that even in the case where $\theta^\alpha < \bar{\theta} < \theta^\beta$, globalization decreases (increases) $\pi_{h,k}/R_k$ if and only if $\theta_k < (>)\bar{\theta}$. That is, income inequality shrinks in the South and expands in the North.

Finally, it is easy to see that if $\bar{\theta} \geq \theta^{III}$, $\pi_{h,k}$ decreases while R_k increases if $\theta_k < \theta^{III}$, and they are unchanged by globalization for countries with $\theta_k \geq \theta^{III}$. That is, income inequality shrinks in the South.

The following proposition summarizes our findings about the impact of globalization on income inequality within a country.

Proposition 5 *As a result of globalization, income inequality shrinks in the South and expands in the North.*

7 Concluding Remarks

We have investigated the impact of globalization, i.e., opening to trade in goods and capital movement, on a monopolistically-competitive industry under financial imperfection. We have found that trade in goods alone will not affect the productivity distribution of the industry, but capital movement (in addition to trade) will drastically change the productivity distribution. Trade in goods and international capital movement affect the economy very differently in the presence of financial imperfection.

Capital outflow has been considered to be detrimental to southern countries. But this study shows that it can also harm productivity in northern countries. Capital account liberalization is not just a problem that faces the South but is a global problem including the North.

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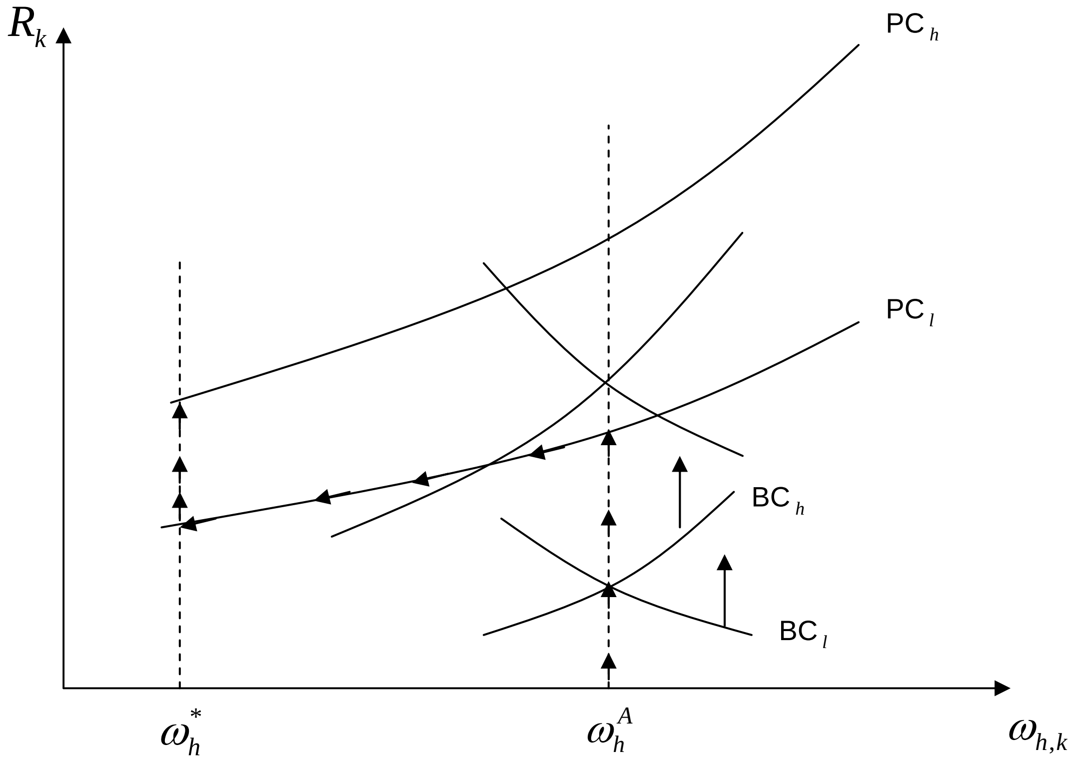

Figure 1: Effect of an increase in θ_k

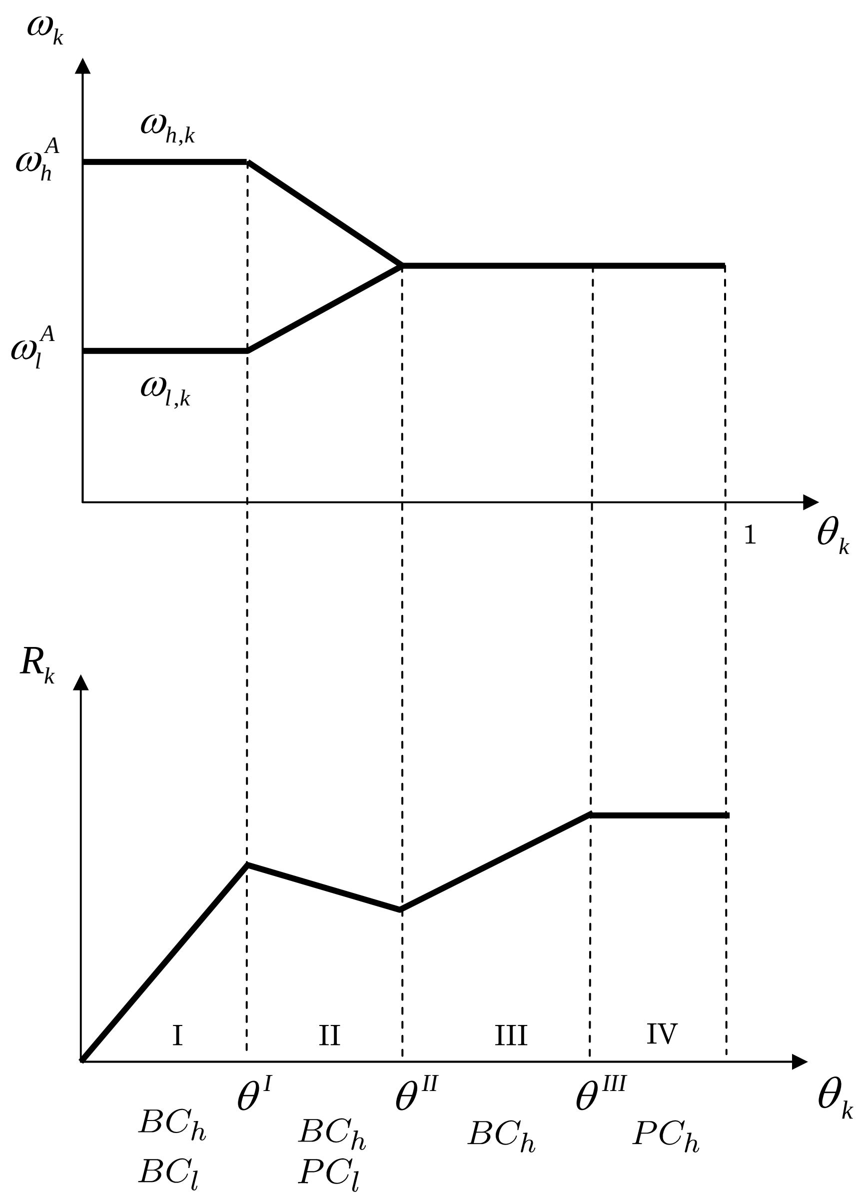

Figure 2. Productivity Distribution and Interest Rate

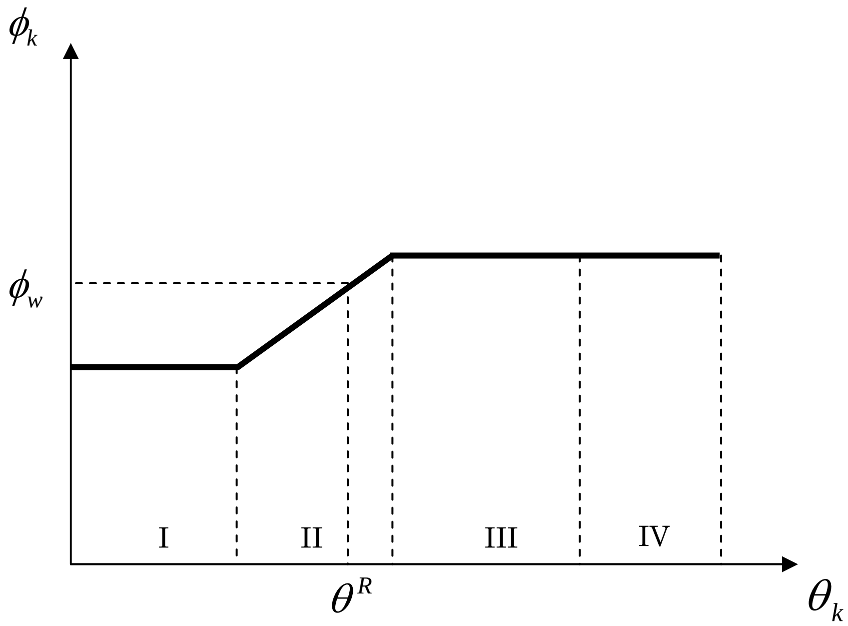

Figure 3. Normalized average productivity in autarky and free trade

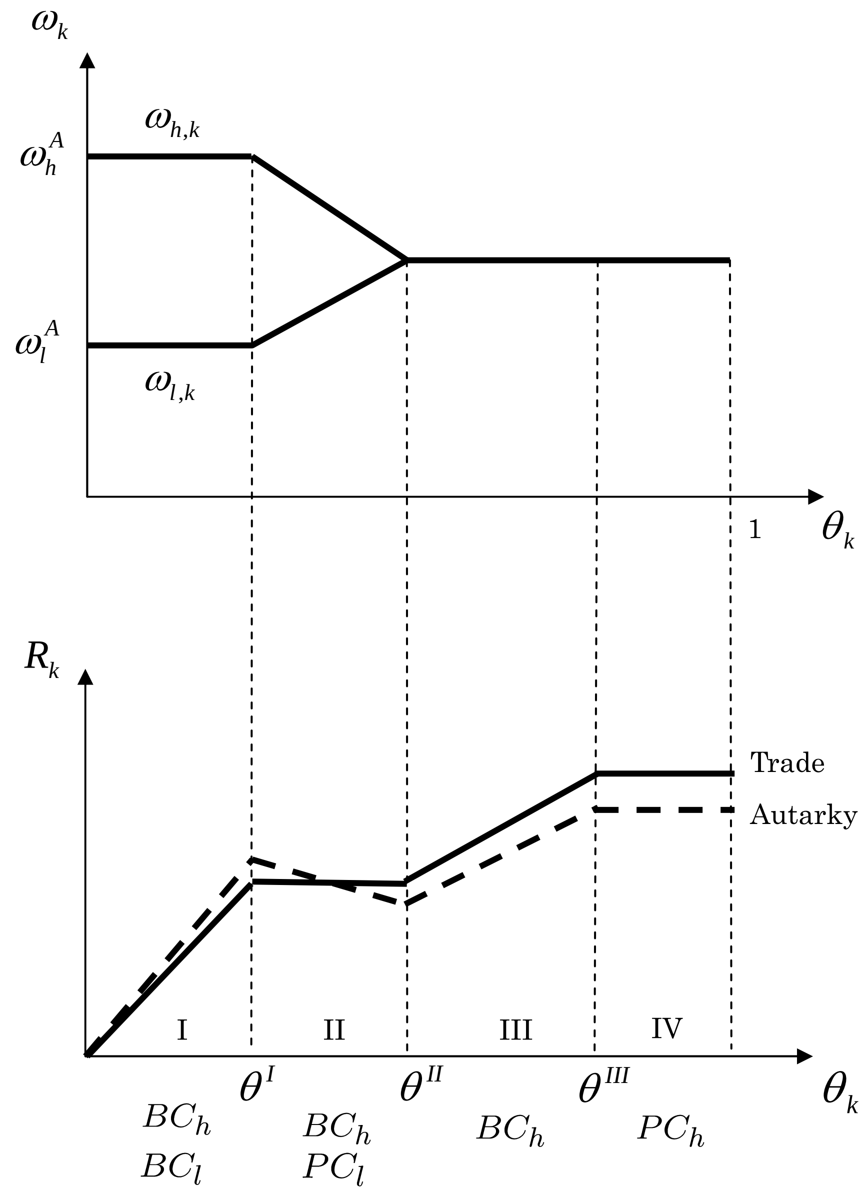

Figure 4. Trade Equilibrium

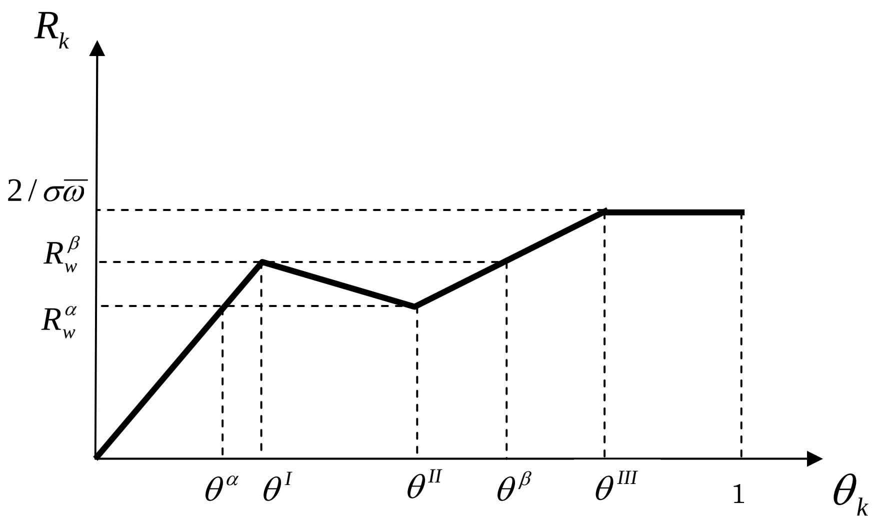

Figure 5. Classification of Countries with Different Financial Development

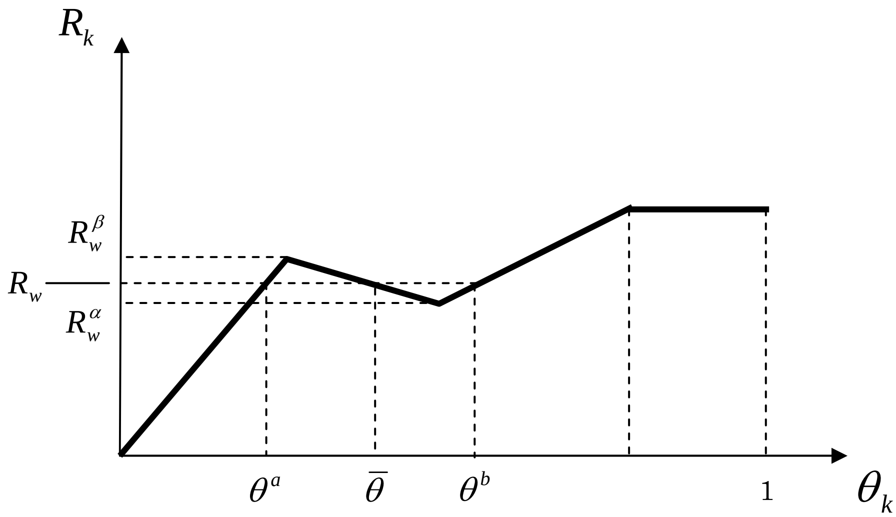

Figure 6. Effect of Globalization on Income Inequality

	$(0, \theta^a)$	$(\theta^a, \bar{\theta})$	$(\bar{\theta}, \theta^b)$	$(\theta^b, 1)$
$\Delta\pi_{h,k}$	$-$	$-$	$+$	$+$
ΔR_k	$+$	$-$	$+$	$-$

Table 1. Effect of Globalization on Profits and Interest Rate