

Institution-Induced Productivity Differences
and Patterns of International Capital Flows

By Kiminori Matsuyama[†]
Email: k-matsuyama@northwestern.edu;
Homepage: <http://faculty.wcas.northwestern.edu/~kmatsu/>

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Abstract: This paper studies theoretically how the cross-country differences in the institutional quality (IQ) of the domestic credit markets shape the patterns of international capital flows when such IQ differences also cause productivity differences across countries. IQ affects productivity by changing productivity-agency cost trade-offs across heterogeneous investment projects. Such institution-induced productivity differences are shown to have effects on the investment and capital flows that are *opposite* of exogenous productivity differences. This implies that the overall effect of IQ could generate *U*-shaped responses of the investment and capital flows. Among other things, this means that capital could flow from middle-income countries to both low-income and high-income countries, and that, starting from a very low IQ, a country could experience both a growth and a current account surplus after a successful institutional reform. More generally, the results here provide some cautions when interpreting the empirical evidence on the role of productivity differences and institutional differences on capital flows. It also calls into question the validity of treating the degree of financial frictions as a proxy for the quality of financial institutions, as commonly done in the literature.

Keywords: Credit composition, domestic financial frictions, endogenous productivity, institutional quality, intertemporal trade, pledgeability, productivity-agency cost trade-off, reverse capital flows, *U*-shaped patterns

JEL Classification Numbers: E22, F49, O16

1. Introduction

It is now well established that capital often flows “upstream,” i.e., from poor to rich countries, contrary to the prediction of the standard textbook neoclassical model.¹ To explain such reverse flows, one needs to abandon the central tenet of the neoclassical paradigm; rich countries are rich because they have capital/labor ratios. In reality, of course, countries differ in many dimensions. For example, some countries may be richer because they use more productive technologies. Then, capital would flow upstream, because the lenders would get higher return in the rich countries. Or, some countries may be richer due to their superior credit market institutions. Then capital would flow upstream, because rich countries do better jobs protecting the interest of lenders. Indeed, a simple theoretical model can be used to show how *exogenous* cross-country variations in productivity or in institutional quality can generate reverse capital flows (as will be demonstrated in Section 3). One might think intuitively that this logic should carry over even if productivity differences are caused by institutional quality differences.² This paper aims to show theoretically that productivity differences that arise *endogenously* due to institutional differences have effects on capital flows that are opposite of exogenous productivity differences, and that institutional differences might have non-monotonic effects on capital flows through their effects on productivity.³

In the model presented below, countries differ in the institutional quality (IQ) of their domestic credit markets. Saving flows freely across countries,

©Kiminori Matsuyama, Institution, Productivity, and Capital Flows equalizing the rate of return.⁴ In each country, entrepreneurs have access to a variety of heterogeneous investment projects with *productivity-agency cost trade-off*: a more productive project comes with a bigger agency cost. As entrepreneurs compete for funding, credit goes to the projects that generate the highest return to the lenders (net of agency cost), which are not the most productive ones. The key feature of the model is that the agency cost of each project depends not only on the nature of each project, but also on the country's IQ. More productive projects are more affected by the country's IQ, due to their bigger agency problems. In this setup, IQ differences can cause productivity differences, because IQ affects the productivity-agency cost trade-off, hence the types of projects financed in each country. And it is shown, perhaps counter-intuitively, that such an institution-induced productivity improvement, though it leads to a higher output and a higher wage just like an exogenous one, leads to a *lower* investment and a current account *surplus* (i.e., capital *outflow*), unlike an exogenous one.

Why do investment and capital flows respond differently to institution-induced productivity changes? Let me try to offer verbally an intuition to this rather counterintuitive result. (Later, this will be shown more formally, which is precisely one of the main goals of the model.) Although it is often overlooked, higher productivity generally has two effects that work in the opposite directions. The first effect is that more output can be produced with *less* investment. The second effect is that a higher rate of return makes the lender willing to finance *more* investment. In the exogenous case, both effects operate. However, under

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the relatively mild assumption, satisfied for example when the production function is Cobb-Douglas, the second effect dominates the first, which means that higher productivity leads to a higher investment, and hence to a current account deficit (i.e., capital inflow). In contrast, when productivity rises in response to a better IQ in our model, it is because the composition of credit shifts toward more productive projects, which come with bigger agency problems. This offsets any effect on the rate of return to the lender (i.e., net of the agency cost) that the resulting productivity improvement might have.⁵ This means that the first effect dominates the second, hence a lower investment and a current account surplus (i.e., capital outflow).

Note also that this makes an overall effect of IQ on capital flows generally *ambiguous*, because two effects work in the opposite directions. First, *holding productivity constant*, a better IQ causes to a current account *deficit* (i.e., capital *inflow*), because it makes the country a more attractive place to invest. Second, *induced* productivity improvement causes a current account *surplus* (i.e., capital *outflow*), because the country needs less investments to produce more output. This means that, even if the rich are more productive and have better IQ than the poor, there is no reason to expect large capital flows in either direction. Or the lack of such capital flows should not be interpreted as the *prima facie* evidence for the presence of significant barriers for international capital flows.

Some parametric examples also suggest that improving IQ, while monotonically increasing the capital stock and wages, leads initially to a *lower*

©Kiminori Matsuyama, Institution, Productivity, and Capital Flows investment and a current account *surplus* (i.e., capital *outflow*) and then to a *higher* investment and a current account *deficit*, (i.e., capital *inflow*). Such an *U*-shaped response of capital flows to IQ implies that, if countries inherently differ only in IQ, middle-income countries run a current account *surplus* (i.e., capital *outflow*), while high-income and low-income countries run a current account *deficit* (i.e., capital *inflow*). However, these countries experience capital inflows for different reasons. High-income countries experiences inflows because they do better jobs protecting the interest of lenders, while low-income countries experiences inflows because they make less efficient use of the investment.⁶ It also suggests that, starting from very low IQ, an institutional reform would help low-income countries to experience both *a growth* and *a current account surplus* at the same time.

Even when the indirect effect of IQ through productivity is not quantitatively large enough to offset its direct effect, hence unable to generate non-monotonic effects, the prediction that institution-induced productivity differences have the effects on the patterns of capital flows opposite from productivity differences due to other factors should provide some cautions when interpreting the empirical evidence. For example, imagine that the rich countries are more productive partly due to their better IQ and partly due to other mechanisms, such as human capital externalities suggested by Lucas (1990) and others. Then, one's failure to properly separate the two sources of productivity differences could lead

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one to overestimate the effects on capital flows of IQ differences and to
underestimate those of productivity differences due to human capital externalities.

More generally, the results here call into question the usefulness of the
standard dichotomy, “productivity differences” versus “credit market
imperfections,” often used in the literature on international capital flows.⁷

Furthermore, the model suggests the need for separating the quality of financial
institutions, which is an exogenous characteristic of countries, and the degree of
financial frictions, which is endogenously determined as it depends on the
equilibrium composition of credit, although the two are interpreted
interchangeably, with the latter being often used as a proxy of the former, in the
literature. The results here suggest that doing so might be highly misleading.

Many studies have already examined the effects of domestic credit market
imperfections on international capital flows.⁸ In models of Gertler and Rogoff
(1990) and Matsuyama (2004; 2005, sec. 2), countries do not differ in their
institutional quality, but the presence of credit market imperfections give advantage
to those entrepreneurs with higher net worth when competing for credit in the
world market, which could cause reverse capital flows. In models of Sakuragawa
and Hamada (2001), Caballero, Farhi, and Gourinchas (2008), Matsuyama (2008,
sec.6) and Ju and Wei (2010), among others, reverse flows occur because
countries differ in their IQ, but productivity does not respond to the IQ.⁹
Productivity responds endogenously through a change in the composition of credit
across projects with different productivity in the closed economy dynamic macro

©Kiminori Matsuyama, Institution, Productivity, and Capital Flows model of Matsuyama (2007), but the reason why the composition changes is due to an endogenous movement of borrower net worth over time, not due to a change in IQ. In the trade literature, Beck (2002), Matsuyama (2005, sec.3), and many others (see Matsuyama (2008, sec.7) for the reference), show that cross-country differences in IQ affects the patterns of trade by changing the composition of credit across sectors, with countries with higher IQ exporting in sectors with bigger agency problems. Among these studies, Antras and Caballero (2009) shows how such an institution-induced change in the patterns of trade could interact with the patterns of capital flows, but they are mainly interested in the question of whether trade and capital flows are complements or substitutes.¹⁰

The non-monotonic patterns of capital flows implied by the *U*-shaped response to IQ, i.e., current account surpluses of the middle-income countries finance current account deficits of the low- and high- income countries, might be somewhat reminiscent of the empirical finding by Gourinchas and Jeanne (2007), who called it the “allocation puzzle.” It should be noted, however, that the goal of this paper is not to offer a solution to the allocation puzzle. Rather, it is to clarify a mechanism (previously unknown, to the best of my knowledge), through which the quality of domestic financial markets affects productivity, the aggregate investment, and the patterns of capital flows.¹¹ To this end, the model developed below deliberately abstracts from many other factors that affect the patterns of capital flows. In particular, the model is set up in such a way that the aggregate saving does not respond to changes in IQ nor in productivity. In this respect, the

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recent studies by Song, Storesletten, and Zilibotti (2011) and Buera and Shin
(2010) are noteworthy. Partly motivated by the allocation puzzle, they have
shown that, when the economy starts booming after an economic reform that
triggers the process of reallocation from the old and less efficient to the new and
more efficient sectors, it experiences a current account surplus (i.e., capital
outflow) because the aggregate saving grows faster than the aggregate investment,
under the assumption that the new and more efficient sectors are borrowing-
constrained due to the domestic credit market imperfections. This might lead some
to suspect that their mechanisms would be weakened, if the institutional quality of
domestic credit markets improves as a result of the very economic reform that
triggers the boom. The result obtained here, however, suggests that such an
improvement could even magnify capital outflows generated by the economic
reform.¹² In this sense, the present study is complementary to their studies.

The rest of the paper is organized as follows. After setting up the model in
Section 2, Section 3 briefly discusses the patterns of international capital flows
when both productivity differences and IQ differences are exogenous. Section 4
shows how productivity responds to IQ through its effect on the composition of
credit and explains why such endogenous productivity differences have opposite
implications on the investment and capital flows. Section 5 looks at the patterns of
international capital flows when countries inherently differ only in IQ but IQ
differences cause productivity differences, first for the case of two projects with
two or three countries. Then, the analysis is extended for the case of a continuum

©Kiyonori Matsuyama, Institution, Productivity, and Capital Flows of projects to show that the results are not driven by the discrete or finite nature of the available projects. From Section 2 through Section 5, the model is described as a two-sector, two-period model for the ease of presentation. However, the model can also be given a one-sector, and infinite-period interpretation, as explained in Section 6. Section 7 concludes.

2. The Setup; A Two-sector, Two-period Interpretation

There are two periods: $t = 0$, “today” and $t = 1$, “future.” (Section 6.2 shows how this two-period setup can be reinterpreted as an infinite period model within an overlapping generations framework.) In $t = 0$, the endowment is allocated between consumption in $t = 0$ and investment projects. In $t = 1$, these investment projects generate capital, K , which are combined with labor, L , available in fixed supply, to produce the consumption good with CRS technology, $Y = F(K, L) \equiv f(k)L$, where $k \equiv K/L$ is the capital-labor ratio and $f(k)$ is output per labor, satisfying the usual properties, $f'(k) > 0 > f''(k)$ and $f'(0) = \infty$.

The world economy consists of a finite number of countries, indexed by $c \in C$. (For the moment, however, we suppress the country index to keep the notation simple.) In each country, there are two types of agents. First, there is a continuum of *savers/workers* with measure L , each of whom has ω units of endowment in $t = 0$ and supplies one unit of labor and earns $w(k) \equiv f(k) - kf'(k)$ in $t = 1$. They seek to maximize the quasi-linear preferences of the form:

$$U^s = V(C_0^s) + C_1^s, \quad V' > 0 > V''$$

subject to the budget constraint,

$$C_1^s = r(\omega - C_0^s) + w(k),$$

where r is the (gross) market rate of return on their saving. From the first-order condition, $V'(C_0^s) = r$, each saver/worker consumes $C_0^s = (V')^{-1}(r)$ in $t = 0$, so that their total saving is equal to:

$$S^s(r) \equiv [\omega - (V')^{-1}(r)]L.$$

Note that the saving schedule is independent of the wage rate and hence the production side of the economy.¹³ This feature of the model helps us to focus on the goal of the analysis, i.e., to understand how IQ or productivity changes affect the investment side of capital flows, by removing the saving channel, which has been the primary focus of the literature; see, for example, Song, Storesletten, and Zilibotti (2011) and Buera and Shin (2010).

Second, there is a continuum of *borrowers/entrepreneurs* with measure E , each of whom may be endowed with (small) $\omega^b \geq 0$ units in $t = 0$. They consume only in $t = 1$ and hence save all of ω^b in $t = 0$. Each entrepreneur has access to a set of indivisible projects, J . A type- j ($\in J$) project converts m_j units of the endowment to $R_j m_j$ units of “physical capital,” by borrowing $m_j - \omega^b$ at the market rate of return, r , where m_j and R_j are both fixed parameters.¹⁴ Entrepreneurs aim to maximize period-1 consumption. By running a project- j , they can obtain

$$R_j m_j f'(k) - r(m_j - \omega^b) = [R_j f'(k) - r]m_j + r\omega^b, \text{ which is greater than or equal to}$$

$r\omega^b$ (the amount obtained by lending instead of borrowing to running any project)

iff

$$(PC-j): \quad R_j f'(k) \geq r,$$

where $(PC-j)$ stands for *Profitability Constraint for a Type-j*. This constraint implies that $R_j f'(k)$ is the maximal rate of return that they are willing to offer to the lender by running a type- j project. Furthermore, each entrepreneur has access to any project type- $j \in J$. This means that, in a world with the perfect credit market, competition among entrepreneurs would drive up the market rate of return to $r \equiv \left\{ \max_{j \in J} R_j \right\} f'(k)$ and only the most productive projects, $Arg \max_{j \in J} \left\{ R_j \right\}$, would be funded.

However, the credit market is imperfect in this world. The imperfections are introduced by the assumption that borrowers/entrepreneurs can pledge no more than a fraction $0 < \lambda_j < 1$ of the project- j revenue for the repayment.¹⁵ This condition can be stated as:

$$(BC-j): \quad \lambda_j R_j m_j f'(k) \geq r(m_j - \omega^b),$$

where $(BC-j)$ stands for *Borrowing Constraint for a Type-j*. The fraction, λ_j , represents the financial friction for investing into a Type- j project, and treated as given by each agent. We will later describe how this depends on the country's IQ.

By combining $(PC-j)$ and $(BC-j)$, we may define the maximal rate of return that an entrepreneur could *credibly* offer to the lender by running a type- j project as follows:

$$(PC-j)+(BC-j): \quad r_j \equiv \frac{R_j}{\text{Max}\{1, (m_j - \omega^b) / \lambda_j m_j\}} f'(k).$$

Since each entrepreneur would prefer obtaining the credit at a rate satisfying

$r_j \leq R_j f'(k)$ than not obtaining the credit at all, and since each of them has access

to any project type- $j \in J$, bidding among entrepreneurs ensures that the credit goes

only to the projects with the highest r_j in equilibrium, so that

$$r = \text{Max}_{j \in J} \{r_j\} = \text{Max}_{j \in J} \left\{ \frac{R_j}{\text{Max}\{1, (m_j - \omega^b) / \lambda_j m_j\}} \right\} f'(k).$$

Note that the ranking of projects may depend on $\{R_j; m_j; \lambda_j\}_{j \in J}$, but not on k nor

r . This means that only one type of projects is funded by the credit market.¹⁶ By

denoting such a project-type by $j^* \equiv \text{Arg max}_{j \in J} \{r_j\}$,

$$r = \text{Max}_{j \in J} \{r_j\} = \left\{ \frac{R_{j^*}}{\text{Max}\{1, (m_{j^*} - \omega^b) / \lambda_{j^*} m_{j^*}\}} \right\} f' \left(\frac{R_{j^*} I}{L} \right),$$

where I is the aggregate investment, i.e., the total amount of the endowment left

unconsumed and allocated to the investment projects in $t = 0$, which are

transformed into capital in $t = 1$, at the rate equal to R_{j^*} , because

$$K = (R_{j^*} m_{j^*})(I / m_{j^*}) = R_{j^*} I. \quad ^{17}$$

In what follows, we focus on the case where $(BC-j)$ is more stringent than

$(PC-j)$ for all j , which can be achieved by setting $\omega^b = 0$.¹⁸ Then, $(BC-j^*)$ is

binding in equilibrium, and the above expression is simplified to:

$$r = \text{Max}_{j \in J} \{r_j\} = \text{Max}\{\lambda_j R_j\} f'(k) = (\lambda_{j^*} R_{j^*}) f'(k) = (\lambda_{j^*} R_{j^*}) f' \left(\frac{R_{j^*} I}{L} \right).$$

In words, the credit goes to the projects that generate the highest pledgeable rate of return.¹⁹ This expression can be inverted to obtain the *Aggregate Investment Schedule*, which is decreasing in r :

$$(1) \quad I(r) = \frac{L}{R_{j^*}} (f')^{-1} \left(\frac{r}{\lambda_{j^*} R_{j^*}} \right) \quad I' < 0.$$

Since the *Aggregate Saving Schedule* is an increasing function of r ,

$$(2) \quad S(r) \equiv \omega^b E + [\omega - (V')^{-1}(r)]L = [\omega - (V')^{-1}(r)]L, \quad S' > 0$$

the *Current Account Schedule*, the difference between the aggregate saving and investment, is also increasing in r :

$$(3) \quad CA(r) \equiv S(r) - I(r) = L \left[\omega - (V')^{-1}(r) - \frac{1}{R_{j^*}} (f')^{-1} \left(\frac{r}{\lambda_{j^*} R_{j^*}} \right) \right]. \quad CA' > 0$$

These schedules are illustrated by Figure 1, the Metzler diagram. If a country were in autarky, its domestic market rate of return would adjust to equate its aggregate saving and the aggregate investment, so that

$$CA(r^A) \equiv S(r^A) - I(r^A) = 0,$$

where r^A is the country's autarky market rate of return, given at the intersection of its aggregate saving and investment schedule.²⁰

Instead, imagine that this country can lend and borrow at the rate $r = r^*$, determined at the world financial market. More specifically, suppose that period-0 endowment is (intertemporally) tradeable at the price r^* for a unit of period-1 consumption good, while the capital stock generated by the project and labor are

©Kiminori Matsuyama, Institution, Productivity, and Capital Flows not tradeable. Then, if $r^A < r^*$, as depicted in Figure 1, this country runs a current account surplus (i.e., capital outflow) in $t = 0$.²¹ If $r^A > r^*$, this country runs a current account deficit (i.e., capital inflow) in $t = 0$. What is important here is that $CA(r)$ is strictly increasing in r ; it is not crucial for $S(r)$ to be increasing in r . All we need is that a higher r does not reduce the domestic saving as fast as the domestic investment.

To determine r^* , let us suppose that saving can flow freely across borders to equate the rates of return everywhere. Since the world as a whole is a closed economy, the equilibrium rate of return is given by the condition:

$$\sum_{c \in C} S^c(r^*) = \sum_{c \in C} I^c(r^*) \quad \Leftrightarrow \quad \sum_{c \in C} CA^c(r^*) = 0,$$

where superscript $c \in C$, the country index, is now made explicit. Recall that $CA^c(r) \equiv S^c(r) - I^c(r)$ is strictly increasing in r . Thus, the autarky rates of returns, $\{r^{cA}\}_{c \in C}$, dictate “chains of comparative advantage” in intertemporal trade, i.e., the patterns of capital flows. If we list all countries from the left to the right in the increasing order of their autarky rates of return, $r^{1A} \leq r^{2A} \leq \dots \leq r^{cA}$, we can draw a line somewhere in the middle such that all the countries on the left side of the line experience current account surpluses and all the countries on the right side experience current account deficits, and that there must be at least one country on each side of the line. In particular, if $C = 2$, the country with the higher autarky rate runs a surplus (or capital outflow) and the other country runs a deficit (i.e., capital inflow).

3. Patterns of Capital Flows with Exogenous Productivity and IQ

First, let us consider the case where there is one type of the project, hence IQ cannot possibly affect the composition of credit, and hence productivity of projects funded. By dropping the project index, j , the aggregate investment schedule, eq.(1), becomes simply:

$$(4) \quad I(r) = \frac{L}{R} (f')^{-1} \left(\frac{r}{\lambda R} \right), \quad I' < 0.$$

In this setup, there is no need to disentangle pledgeability from IQ; the effect of a better IQ can be captured by a higher λ , which unambiguously shifts the investment schedule to the right in Figure 1, which leads to a higher r^A . Hence, if countries differ only in IQ, those with better IQs become richer (measured in the wage and per capita income) and run current account deficits (i.e., capital inflows), while those with worse IQs are poorer and run current account surpluses (i.e, capital outflows), generating the reverse patterns of capital flows.²²

In contrast, productivity parameter, R , appears twice in Eq. (4). The aggregate investment is decreasing in the first R , while increasing in the second R . They capture the two effects of (exogenously) higher productivity. On one hand, more output can be produced with *less* investment. On the other hand, the higher rate of return makes the lenders willing to finance *more* investment. Simple algebra shows $d \log(I) / d \log(R) = 1/\eta(k) - 1$, where $\eta(k) \equiv -kf''(k) / f'(k) > 0$. Higher productivity thus leads to a higher investment iff $\eta(k) < 1$, the condition satisfied, for example, for the Cobb-Douglas case, $f(k) = A(k)^\alpha$ since

$\eta(k) = 1 - \alpha$. In what follows, we will focus on the case where this condition holds. Then, a higher R shifts the investment schedule to the right in Figure 1, leading to a higher r^A . Thus, if countries differ only in exogenous productivity, those with higher R s are richer (measured in the wage and per capita income) and run current account deficits (i.e., capital inflows), while those with lower R s are poorer and run current account surpluses (i.e., capital outflows), generating the reverse patterns of capital flows.

4. Modeling Endogenous Response of Productivity to Institutional Quality

Let us now go back to the world where entrepreneurs have access to heterogeneous investment projects. As stated, projects differ both in productivity and in pledgeability. Without further loss of generality, we may also assume that projects with higher productivity come with lower pledgeability.²³ We now impose more structures to introduce *institution-dependent* productivity-agency cost trade-off.

More concretely, let pledgeability of project j in country c be decomposed into two components, as follows:

$$(5) \quad \lambda_j^c = [\Lambda(R_j)]^{\theta^c} .$$

First, $0 < \Lambda(R_j) < 1$ is the project-specific component, which is common across countries. It represents the agency problem associated with each project-type, and $\Lambda(\bullet)$ is strictly decreasing, which captures the trade-offs between productivity and

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the agency problem. Second, $\theta^c > 0$ is the country-specific component, which represents the degree of credit market imperfections in country c , thus the (inverse) measure of its IQ. With $0 < \Lambda(R_j) < 1$, a bigger θ makes pledgeability smaller, exacerbating the agency problem. Furthermore, as the credit market becomes perfect, $\theta^c \rightarrow 0$, $\lambda_j^c \rightarrow 1$ for all j , so that all projects become fully pledgeable, and hence the credit would go to the most productive projects. Note that the assumed functional form satisfies the property of *strict log-submodularity* in R and θ .²⁴ In words, a more productive project, with its bigger agency problem, suffers disproportionately more in a country with a bigger institutional problem.

Under this specification, the country's IQ affects productivity of projects funded. To see why, recall that the credit goes to the projects that generate the highest pledgeable rate of return. In other words, the market solves,

$$\max_{j \in J} \{ \lambda_j R_j \} = \max_{R_j} \{ [\Lambda(R_j)]^\theta R_j \}.$$

Figure 2 illustrates this maximization problem. As IQ deteriorates (a bigger θ), the graph, $\lambda_j = [\Lambda(R_j)]^\theta$, shifts down. Furthermore, with strict log-submodularity, this negative effect is disproportionately larger for more productive projects with bigger agency problems, which is illustrated by a tilting movement of the graph. As a result, the credit shifts towards less productive projects with smaller agency problems. In other words, the solution, $R(\theta)$, is *decreasing* in θ .²⁵

By inserting $R(\theta)$, the aggregate investment schedule, eq. (1), can be now rewritten as:

$$(6) \quad I(r; \theta) = \frac{L}{R(\theta)} (f')^{-1} \left(\frac{r}{[\Lambda(R(\theta))]^\theta R(\theta)} \right).$$

Note that $R(\theta)$ appears three times in the equation. An increase in the first $R(\theta)$ reduces the investment. This effect, i.e., less investment is needed to produce more output, is of the first-order. In contrast, the remaining effects are of the second-order, because a change in the second $R(\theta)$ and a change in the third $R(\theta)$ offsets each other. This is because $R(\theta)$ is chosen to maximize $[\Lambda(R)]^\theta R$. When $R(\theta)$ changes due to a change in θ , it is because the composition of credit shifts towards projects that are not only more productive but also subject to bigger agency problems. As a result, it has negligible effects on the pledgeable rate of return, which eliminates the usual effect of making the lenders willing to finance more investment. This is nothing but the envelope theorem. The credit market always selects the best project for the lenders under the institutional constraint. Hence, an improvement in IQ has only negligible effects on the lenders. For this reason, an increase in $R(\theta)$ through a change in θ reduces the investment, unlike an exogenous increase in R .²⁶

The above paragraph is concerned with the indirect effect of IQ on the investment through its effect on productivity. In addition, there is the direct effect of improving IQ (a lower θ), which increases the investment. The combined effect on the investment is generally ambiguous, so we need to look at some specific examples. In contrast, improving IQ (a lower θ) unambiguously increases $R(\theta)I(r, \theta)$, and hence the country's wage and per capita income.²⁷

5. Patterns of International Capital Flows with Endogenous Productivity

We now look at several examples to understand how exogenous IQ differences across countries shape the patterns of international capital flows, when IQ differences also cause productivity differences.

5.1. A Two-Project Case:

First, let us consider the case with two projects, $J = \{0,1\}$, with $R_0 < R_1$ and $1 \geq \Lambda(R_0) \equiv \Lambda_0 > \Lambda(R_1) \equiv \Lambda_1$. Thus, a type-1 project is more productive than a type-0 project, but it is more subject to the agency problem. Hence, the pledgeable rate of return declines faster for type-1 projects than for type-0 projects when IQ deteriorates (a bigger θ), as shown in Figure 3a. Only type-0 projects are financed when $\theta > \hat{\theta}$ and only type-1 projects are financed when $\theta \leq \hat{\theta}$, where the switch occurs at $\hat{\theta} \equiv \log(R_1 / R_0) / \log(\Lambda_0 / \Lambda_1)$. Figure 3b shows $R(\theta)$. Note that productivity, $R(\theta)$, jumps at $\theta = \hat{\theta}$, but the pledgeable rate of return, $[\Lambda(R(\theta))]^\rho R(\theta)$, changes smoothly at $\theta = \hat{\theta}$. Thus, when productivity changes as θ crosses $\hat{\theta}$, the first effect of productivity improvement, --less investment is needed to produce more output--, dominates the second effect,--lenders are willing to finance more investment. Hence, the investment schedule shifts to the left, when productivity increases at $\theta = \hat{\theta}$. With the fixed upward-sloping saving schedule, this translates into a nonmonotone response of r^A to a change in θ , as depicted in Figure 3c.²⁸

5.1.1: A Two-Country World

Now suppose that there are two countries, $C = \{N, S\}$, where N stands for the rich North and S for the poor South, with $\theta^N < \theta^S$. Let us assume that the two countries are identical in all other dimensions.

Figure 4a depicts the case of $\theta^N < \theta^S < \hat{\theta}$. This means that $r^{AN} > r^{AS}$, which implies $CA^N < 0 < CA^S$. Thus, capital flows from S to N . In this case, both countries use the same technologies, but N 's superior institution causes the reverse flows, because the interest of lenders is better protected in N than in S .

Figure 4b depicts the case of $\theta^N < \tilde{\theta} < \hat{\theta} < \theta^S$. Again, $r^{AN} > r^{AS}$, which implies $CA^N < 0 < CA^S$. Thus, capital flows from S to N . In this case, countries differ both in productivity and in institutional quality. However, the institutional quality difference is the cause for the reverse flows. Although N is more productive than S , it is *false* to attribute the reverse capital flows to the productivity difference. Indeed, in this case, endogenous response of productivity partially offsets the effect of institutional difference on the capital flows.

Figure 4c depicts the case of $\tilde{\theta} < \theta^N < \hat{\theta} < \theta^S$. This means that $r^{AN} < r^{AS}$, which implies $CA^N > 0 > CA^S$. Hence, capital flows from N to S . However, the logic behind these capital flows from the rich to the poor is quite different from the standard neoclassical logic. In this case, S is less productive due to its inferior institution, and hence it needs to borrow from abroad. Thus, the causality runs from the underdevelopment to foreign borrowing. It is *false* to interpret this case as showing that “foreign capital” somehow undermines South’s development.²⁹

Now, imagine that, starting from the case depicted in Figure 4c, S manages to improve its institution and succeed improving its productivity, but does not catch up with N . This thought experiment is illustrated in Figure 4d. Capital flows are reversed. S 's current account turns from a deficit to a surplus. (That is, capital starts flowing out, instead of flowing in.) This illustrates one scenario in which a poor country can experience both a rapid growth and a capital outflow after the reform.

5.1.2: A Three-Country World:

Now suppose that there are three countries, $C = \{N, M, S\}$, with $\theta^N < \theta^M < \theta^S$. Again, assume that these countries are identical in all other dimensions.

Figure 5a depicts the case of $\theta^N < \tilde{\theta} < \theta^M < \hat{\theta} < \theta^S$. This means that $r^{AN} < r^{AS} < r^{AM}$, which implies $CA^N < 0 < CA^M$, so that capital flows into N , and out of M , hence reverse flows between N and M . Furthermore, among developing countries, capital flows from the more successful M to the less successful S , which is reminiscent of the allocation puzzle.

Figure 5b depicts the case of $\tilde{\theta} < \theta^N < \hat{\theta} < \theta^M < \theta^S$. This means that $r^{AN} < r^{AS} = r^{AM}$, which implies that $CA^N > 0 > CA^M, CA^S$, so that capital flows from N to M and S . This is *because* (and not despite that) the most developed N has higher productivity than M or S .

Figure 5c depicts the case of $\tilde{\theta} < \theta^N < \theta^M < \hat{\theta} < \theta^S$. This implies that capital flows into S and out of M . Again, among developing countries, capital flows from

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the more successful to the less successful among developing countries, because
(and not despite that) the more successful is more productive.

Now, consider the thought experiment, in which some developing countries, represented by M , succeeded in improving their institutions, while other developing countries, represented by S , are left behind. This is illustrated by Figure 5d, which shows that M 's current account turns from a deficit to a surplus (capital starts flowing out, instead of flowing in). Thus, M experiences both a rapid growth and a capital outflow after the reform. Furthermore, N 's current account could turn from a surplus to a deficit as a result of M 's growth.

5.2. A Continuum of Projects Case

One might think that the U -shaped patterns obtained above may be driven by the two features of the set of available technologies assumed, $J = \{0,1\}$. First, its discrete nature means that the autarky rate of return jumps when the switch occurs. Second, its finiteness means the presence of the most productive technology, type-1, so that, once a country's IQ becomes sufficient good, a further improvement in IQ could not improve productivity. To show that the U -shaped patterns can arise more generally, this subsection presents the case of a continuum of available projects with no upper-bound on productivity.

More concretely, suppose $R_j \in [R_0, \infty)$ for $j \in J = [0, \infty)$, with

$$\Lambda(R_j) = \exp \left[\frac{1}{\gamma} - \frac{1}{\gamma} \left(\frac{R_j}{R_0} \right)^\gamma \right] \text{ with } \gamma > 0.$$

Note that $\Lambda(R_0) = 1$; $0 < \Lambda(R_j) < 1$ for $R_j > R_0$ and $\Lambda(R_j)$ is decreasing in R_j .

This captures the trade-off between productivity and the agency problem.

The market selects the project the generates the highest pledgeable rate of return, i.e., the project that solves $Max\{\lambda_j R_j\} = Max[\Lambda(R_j)]^\theta R_j$. Thus,

$$R(\theta) = R_0 / \theta^{1/\gamma} \text{ with } [\Lambda(R(\theta))]^\theta R(\theta) = R_0 (e^{(\theta-1)} / \theta)^{1/\gamma} \text{ for } 0 < \theta < 1,$$

both of which are decreasing in θ . Thus, as the IQ deteriorates, the credit shifts towards less productive projects and the lenders obtain a lower rate of return.

Furthermore, $\lim_{\theta \rightarrow 0} R(\theta) = \infty$, so that productivity continues to improve as IQ improves. In contrast,

$$R(\theta) = R_0 \quad \text{with } [\Lambda(R(\theta))]^\theta R(\theta) = R_0 \quad \text{for } \theta \geq 1,$$

so that the credit goes to the least productive but fully pledgeable project.

Inserting the above expressions to

$$[\Lambda(R(\theta))]^\theta R(\theta) f' \left(\frac{R(\theta)I}{L} \right) = r,$$

and differentiating with respect to θ yield:

$$\eta \frac{d \log I}{d \theta} = \frac{1}{\gamma} \left(1 + \frac{\eta - 1}{\theta} \right), \quad \text{where } \eta(k) \equiv - \frac{k f''(k)}{f'(k)}, \quad \text{for } 0 < \theta < 1.$$

If $\eta(k) > 1$, $I(r; \theta)$ and hence r^A are increasing in θ . In this case, capital flows from the rich to the poor, simply because the more efficient rich needs less investment.

This is not an interesting case, as it has nothing to do with the endogeneity of productivity. If $\eta(k) < 1$, $I(r; \theta)$ and hence r^A are increasing in $\theta > 1 - \eta(k)$, and decreasing in $\theta < 1 - \eta(k)$.

To obtain a closed form solution, consider the Cobb-Douglas case,

$f(k) = Ak^\alpha$, so that $\eta(k)$ is constant and $\eta = 1 - \alpha < 1$. Then, the investment schedule is given by $\log I(r; \theta) = \Omega(r) + \theta - 1 - \alpha \log \theta$ for $\theta < 1$, and $= \Omega(r)$ for $\theta > 1$, where $\Omega(r)$ is independent of θ . Note that

- $I(r; \theta)$ is decreasing in $\theta < \alpha$ and increasing in $\alpha < \theta < 1$.
- $I(r; \theta) > I(r; 1)$ if $\theta < \tilde{\theta}$ and $I(r; \theta) < I(r; 1)$ if $\tilde{\theta} < \theta < 1$, where $\tilde{\theta} \neq 1$ is the second solution to $h(\theta) \equiv \theta - 1 - \alpha \log \theta = 0$, and satisfies $0 < \tilde{\theta} < \alpha$.

With the fixed upward-sloping saving schedule, this translates into *U-shaped* patterns of the (autarky) rate of return, as shown in Figure 6. Therefore, all the patterns of capital flows described for the two-projects case in the previous section can also occur for this case, where $R(\theta)$ is unbounded and responds smoothly to θ .

6. Alternative Interpretations

6.1 A One-Sector Interpretation

Up to now, the model has been given a two-sector interpretation. That is, the entrepreneurs run projects that produce tangible “physical capital,” in the capital goods sector, which is rented out to the consumption goods sector. Taken literally, this means that IQ affects the investment and capital flows through its impacts of the productivity of capital goods sector. This is consistent with the empirical evidence suggesting that the relative prices of capital goods to consumption goods are higher among less developed countries.³⁰ Nevertheless, it

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is not an essential element of the argument, and the mechanism does not rely on
the two-sector structure. To show this, this subsection offers a one-sector
interpretation of the model.

Imagine that the economy produces the single consumption good, using the
endowment and labor. In $t = 0$, entrepreneurs may invest m_j units of the
endowment to set up a type- j firm. A type- j firm produces the consumption good
in $t = 1$, using the labor input, n , with a concave production function, $y_j = \varphi_j(n)$.
Each firm hires labor in the competitive labor market at the wage rate, w , so that
its employment would be determined by $\varphi_j'(n_j) = w$. Hence, the profit that could
be earned from running a type- j firm is $\pi_j \equiv \max\{\varphi_j(n) - wn\} =$
 $\varphi_j(n_j) - \varphi_j'(n_j)n_j$.

Suppose that $\varphi_j(n) \equiv F(R_j m_j, n) = f(R_j m_j / n)n$, where R_j is a parameter.
Then, for a given wage rate, w , the employment and the profit by a type- j firm can
be written as $n_j = R_j m_j / k$ and $\pi_j = (R_j m_j) f'(k)$, where k is defined uniquely for
each w by $w = f(k) - kf'(k)$. If a type- j firm can pledge up to λ_j fraction of its
profit, the pledgeable rate of return for lending to type- j firms would be $\lambda_j \pi_j / m_j$
 $= \lambda_j R_j f'(k)$, so that the credit flows only to those firms with the highest $\lambda_j R_j$. By
denoting such firms by $j^* = \text{Arg max}_{j \in J} \{\lambda_j R_j\}$, the equilibrium rate of return
earned by the lenders is

$$r = \lambda_{j^*} R_{j^*} f'(k).$$

Since each active firm hires $n_{j^*} = R_{j^*}m_{j^*}/k$, summing up across all firms yield the labor market equilibrium condition,

$$L = \sum n_{j^*} = R_{j^*} \sum m_{j^*} / k = R_{j^*} I / k ,$$

where I is the aggregate investment. By combining these expressions, we obtain

$$r = \lambda_{j^*} R_{j^*} f'(k) = \lambda_{j^*} R_{j^*} f'(R_{j^*} I / L),$$

from which eq.(1) and hence eq.(4) and eq.(6) will also follow. This alternative interpretation thus gives the same predictions on the relationship between IQ, the investment and capital flows.

According to this interpretation, there is no separate investment good sector. Investment is an productivity-enhancing expenditure of the consumption goods sector; $R_{j^*} = R(\theta)$ is the realized productivity parameter in the consumption good sector; and k represents the organizational (i.e., intangible) capital per worker, embodied in the firms that set up by entrepreneurs. The assumption of nontradeability of k might be more natural under this interpretation. Furthermore, for $f(k) = Ak^\alpha$, $AR(\theta)^\alpha$ may be viewed as the TFP of the consumption goods sector firms.³¹

6.2 An Infinite Period Interpretation in an OLG framework

Some readers may find the two-period setup developed above too restrictive, because each country's intertemporal trade must be in balance due to the Walras' Law, so that $CA_0 = CA(r) > 0$ in $t = 0$ implies $CA_1 = -CA(r) < 0$ in $t = 1$. Thus, taken literally, any country experiencing a capital outflow today will

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 experience a capital inflow in the future. However, the above setup can be given
 an infinite-period interpretation by embedding the structure into an overlapping
 generations framework.³²

Imagine now that there is an infinite number of periods, extending from $t = 0, 1, 2, \dots$. In period t , a continuum of savers/workers, with their total endowment ωL_t and total labor supply L_t , and a continuum of entrepreneurs of mass E_t are born and live for two periods. Those born in the same period interact with each other just as described above. Thus, the savers/workers born in period- t finance the projects run by the entrepreneurs born in period- t , and the savers/workers born in period- t work with capital generated by the projects in their second period (period $t+1$). In this setup, there is no interaction across different generations. This means that, from the intertemporal budget constraint of each agent, the current account of generation born in period- t (generation- t) in period $t+1$ must be equal to the negative of the current account of this generation- t in period t .

Consider a particular country whose IQ is given by θ . Then, the investment in period t is

$$I_t = \frac{L_t}{R(\theta)} (f')^{-1} \left(\frac{r_{t+1}}{[\Lambda(R(\theta))]^\theta R(\theta)} \right) \equiv L_t I(r_{t+1}; \theta),$$

which differs from eq.(6) only in that L_t may vary over time. Likewise, the saving by generation- t in period t can be written as:

$$S_t^t = L_t \left[\omega - (V')^{-1}(r_{t+1}) \right] \equiv L_t S(r_{t+1}),$$

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so that the current account by generation- t in period t can be written as:

$$CA_t^t \equiv L_t \left[\omega - (V')^{-1}(r_{t+1}) - \frac{1}{R(\theta)} (f')^{-1} \left(\frac{r_{t+1}}{[\Lambda(R(\theta))]^\theta R(\theta)} \right) \right] \equiv L_t CA(r_{t+1}; \theta)$$

Since the current account by generation- $(t-1)$ in period t must be equal to the negative of the current account by this generation in period- $(t-1)$,

$$CA_t^{t-1} \equiv -L_{t-1} CA(r_t; \theta),$$

the current account of this country in period t is equal to:

$$CA_t \equiv CA_t^{t-1} + CA_t^t = -L_{t-1} CA(r_t; \theta) + L_t CA(r_{t+1}; \theta).$$

Suppose $L_t \equiv (1 + g)L_{t-1}$, where $g > 0$ is a constant rate of population (or Harrod-neutral productivity) growth, which is common across all countries. Then, in per capita term, this country's current account is:

$$ca_t \equiv \frac{CA_t}{L_t} = -CA(r_t; \theta) + (1 + g)CA(r_{t+1}; \theta).$$

In this environment, the autarky equilibrium path of this country is characterized by a constant autarky rate of return, $r_t = r^A$ given by

$ca_t = gCA(r^A; \theta) = 0$. If this country has access to the world financial market

where it could lend or borrow at $r_t = r^*$,

$$ca_t = gCA(r^*; \theta) > 0 \quad \text{if } r^* > r^A; \quad ca_t = gCA(r^*; \theta) < 0 \quad \text{if } r^* < r^A.$$

Thus, the country experiences a current surplus (deficit) and capital outflows (inflows) if its autarky rate is lower (higher) than the world rate, each period. This

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way, all of the results on the effects of IQ differences discussed in the two-period
setup can be restated in an infinite period setup.

7. Concluding Remarks

This paper proposes a stylized model of the world economy to study theoretically how the cross-country differences in the institutional quality (IQ) of the domestic credit markets shape the patterns of international capital flows when such IQ differences also cause productivity differences across countries.

Institution affects productivity by changing the composition of credit across heterogeneous investment projects with different productivity. Such institution-induced productivity differences are shown to have effects on the investment and capital flows that are opposite of productivity differences due to other factors.

This implies that the overall effect of IQ could generate *U*-shaped responses of the investment and capital flows, which means, among other things, that there is no reason to expect capital inflows when a country is more productive and has better institution protecting the interest of lenders, even if saving flows freely across borders to equalize the rates of return; that capital flows out from middle-income countries and flows into both low-income and high-income countries, and that, starting from a very low IQ, a country could experience both a growth and a current account surplus after a successful institutional reform. These results should provide some cautions when interpreting the empirical evidence on the role of productivity differences and institutional differences on capital flows. It

©Kiminori Matsuyama, Institution, Productivity, and Capital Flows suggests the need to separate institution-induced productivity differences from other sources of productivity differences. It also suggests that it might be misleading to proxy the quality of financial institutions, which is an exogenous characteristic of countries in the model, by any measure of financial frictions, which are endogenously determined. More generally, they call into question the usefulness of the standard dichotomy, “productivity differences” and “credit market imperfections,” often used in the literature of international capital flows. In addition, several features of the model, such as poor IQ preventing productive technologies from being adopted, institutional changes causing productivity change, countries with faster productivity growth having lower rates of return (in a closed economy), etc., might have wider applications outside of the patterns of capital flows.

Obviously, the model can be extended in many different directions. Let me just discuss one of them, instead of trying to provide an exhaustive list. In the above model, IQ differences cause productivity differences across countries. In reality, the causality should run in both directions; the difference in the quality of domestic credit markets may be at least in part due to the differences in productivity or more generally in the level of development. Such reverse causality from productivity to IQ may be modeled, for example, by introducing the governments which choose how much to invest to improve the credit market institutions or even simply decide how much to enforce the payment to the lenders.³³ It would be interesting to investigate how such a two-way causality

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between productivity and IQ affect the patterns of capital flows. The model
developed here should serve as a useful building block for that purpose.

Figure 1: Metzler Diagram

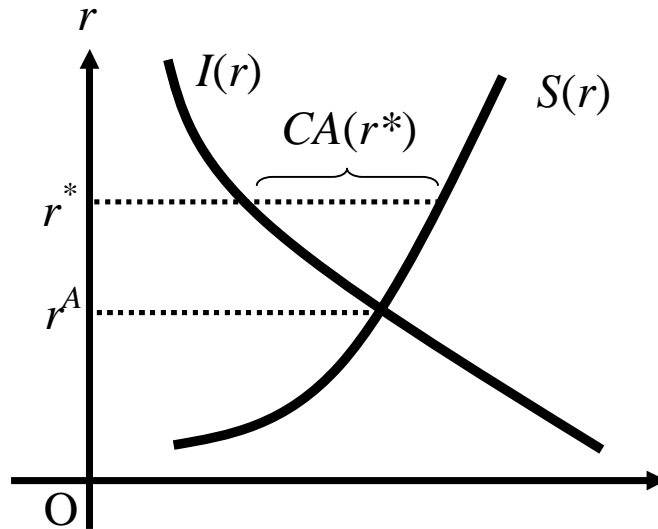


Figure 2: Endogenous Productivity Response to Institutional Quality Change

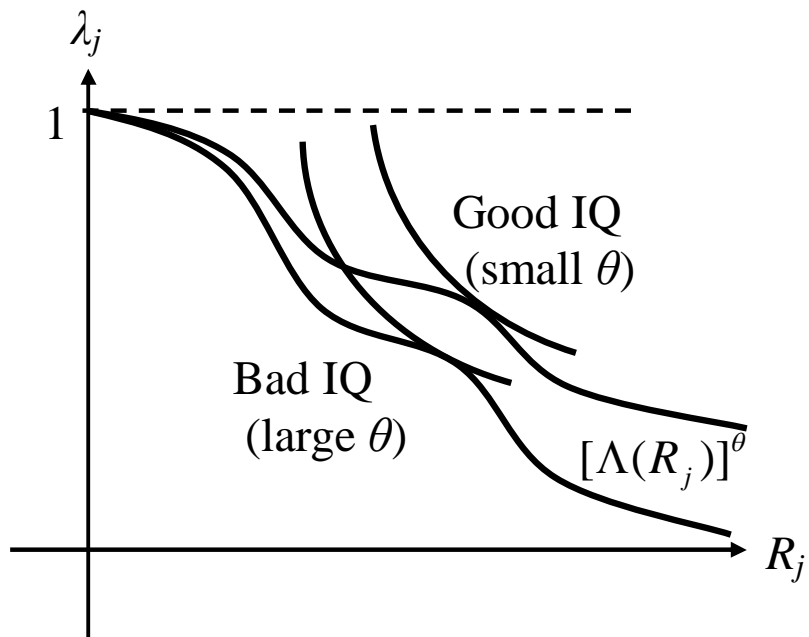


Figure 3: A Two-Project Case

Figure 3a

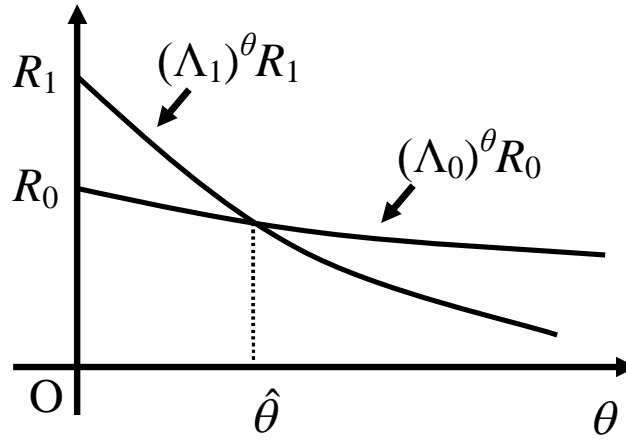


Figure 3b

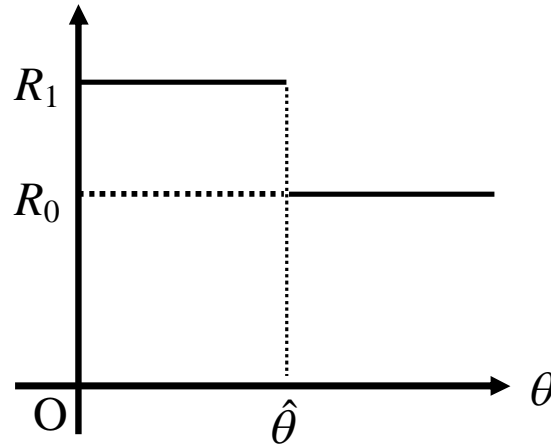


Figure 3c

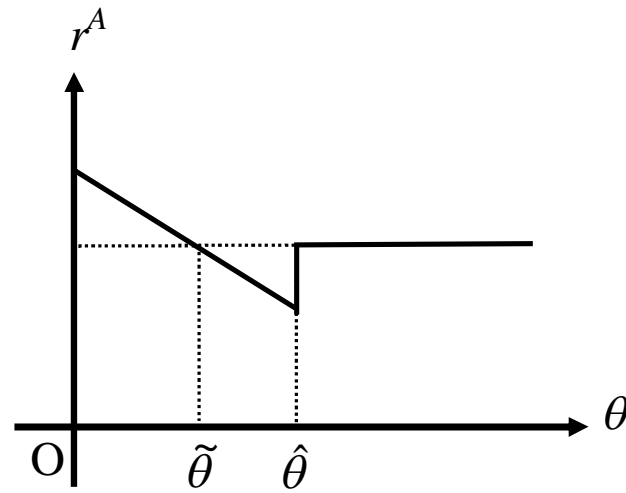


Figure 4: A Two-Country World

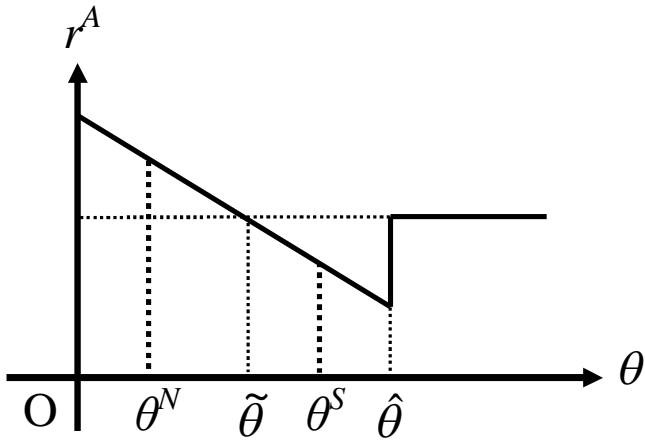


Figure 4a

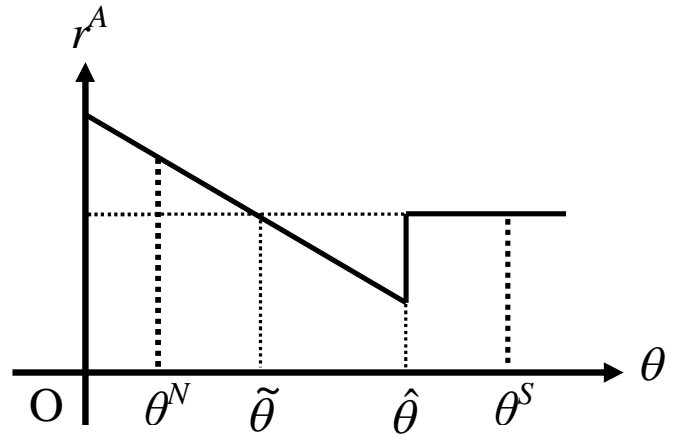


Figure 4b

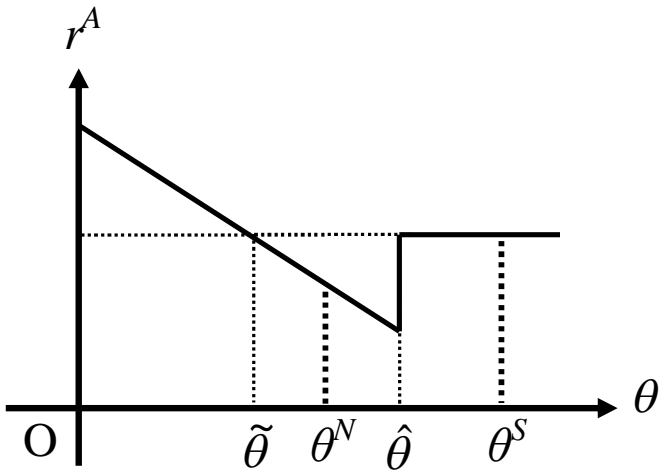


Figure 4c

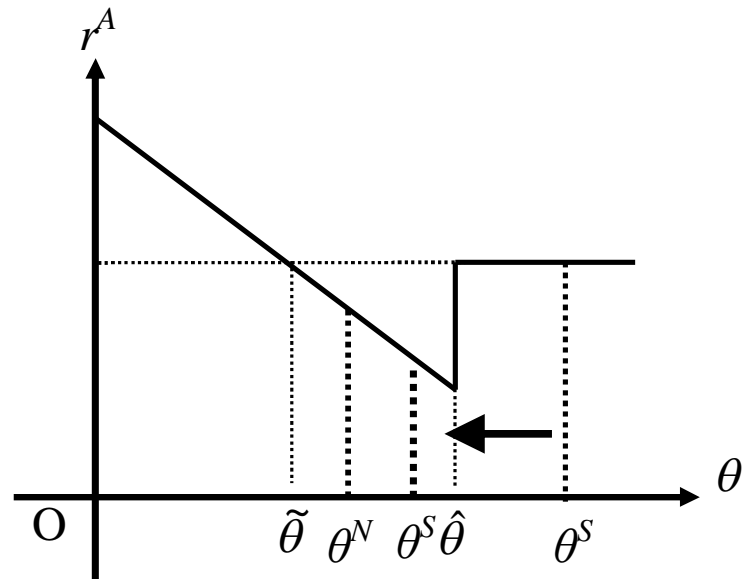


Figure 4d

Figure 5: A Three-Country World

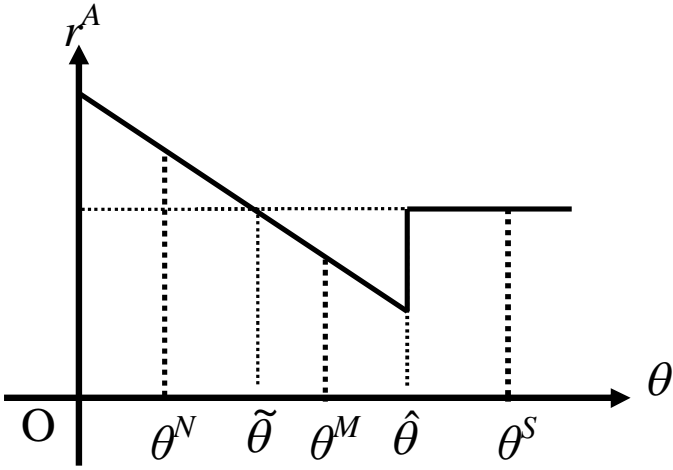


Figure 5a

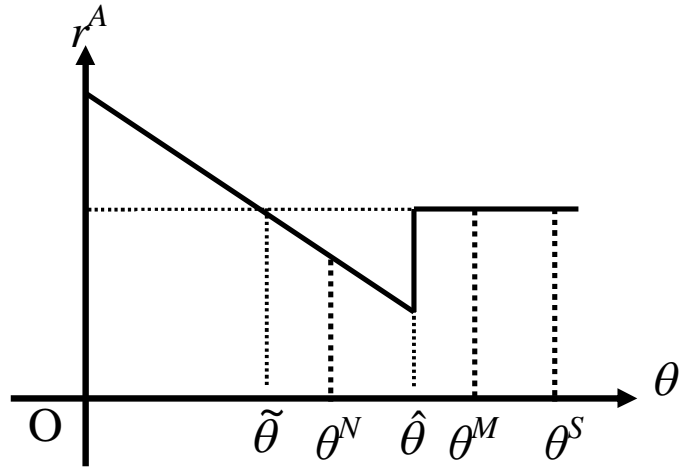


Figure 5b

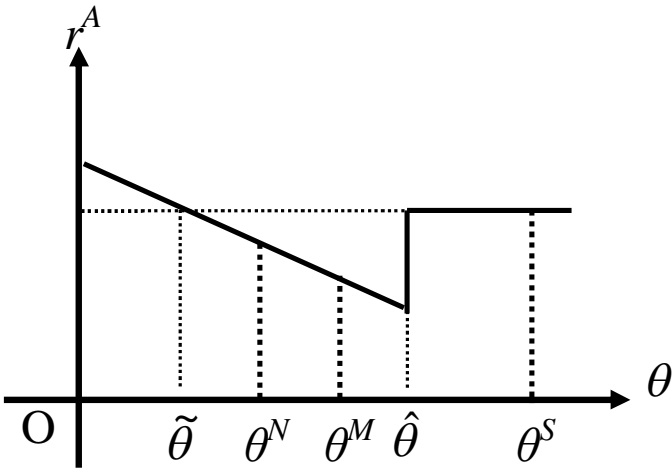


Figure 5c

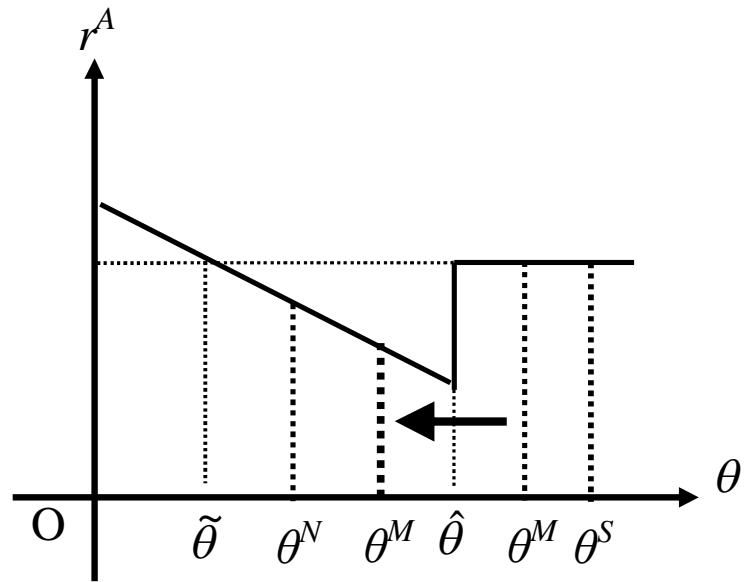
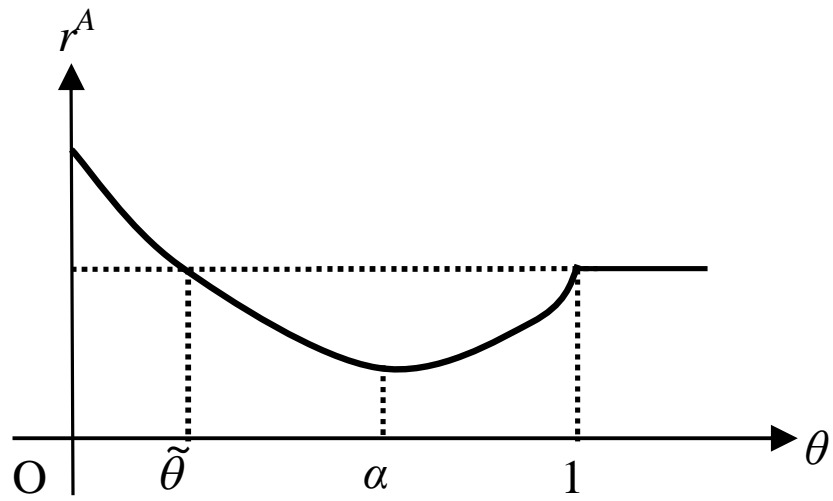


Figure 5d

Figure 6: A Continuum of Projects Case



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Endnotes:

¹ See, for example, Gourinchas and Jeanne (2009) and Prasad, Rajan, and Subramanian (2007).

²For example, they seem to have this intuition in mind when Caballero, Farhi, and Gourinchas (2008, Footnote 7) argued that allowing limited financial commitment to affect output and growth in their model would exacerbate their results.

³ To economize language, we simply say “exogenous productivity differences” to mean productivity differences caused by factors unrelated to (i.e., “exogenous to”) the institutional quality of domestic credit markets, which also include endogenous productivity differences due to other factors, such as human capital externalities discussed by Lucas (1990) and others.

⁴ Thus, unlike Aoki, Benigno and Kiyotaki (2009) and Caballero and Krishnamurthy (2001), no international financial market imperfection is present in this model. A country’s poor IQ reduces the rate of return to lending to its entrepreneurs, regardless of the nationality of lenders. All lenders from all countries earn the same rate of return. See Caselli and Feyrer (2007) for the evidence in support of this. Besides, adding barriers to international capital flows into models could reduce the volume, but could not change the sign of net asset positions of countries, as pointed out by Gourinchas and Jeanne (2009).

⁵The alert reader might notice that this is an application of the envelope theorem, as will be shown more formally later. The market always selects the project that maximizes the rate of return to the lender, holding IQ constant. When an improvement in IQ changes the project selection by relaxing the borrowing constraint, the effect on productivity is of the first-order, but the effect on the rate of return to the lender is of the second-order.

⁶One interpretation for the negative correlation between foreign capital inflows and growth among low-income countries, suggested by Prasad, Rajan, and Subramanian (2007), and Prasad and Rajan (2008), is that the costs of inflows of foreign capital would exceed the benefits among countries below a certain threshold level of institutional development, due to a real exchange rate

overvaluation and the resulting loss of competitiveness. My model suggests a reverse causality, from poor institution to low productivity and then to foreign capital inflows.

⁷ For example, Acemoglu (2008, Chapter 19.2) organizes his discussion on capital flows along this dichotomy, by following the development of the literature, while questioning the validity of this dichotomy at the same time.

⁸ As noted in Footnote 4, this is different from assuming frictions in international financial markets, although the existing empirical studies on capital flows pays little attention to this distinction.

⁹Strictly speaking, reverse flows in the Caballero-Farhi-Gourinchas model occurs because some countries have a limited supply of saving vehicles. However, they suggested that this could be attributed to the country's institutional problem. In the Ju-Wei model, the presence of FDI, which could bypass the institutional problem, may further amplify the reverse flows of financial capital. In all these models, including Sakuragawa-Hamada and my previous models on capital flows, a conceptual distinction between the financial friction and the IQ is not necessary, as the IQ would not change the composition of credit across projects with different degrees of agency problems. Such a distinction is crucial for understanding the mechanism in this paper.

¹⁰Also relevant are the empirical findings of Rajan and Zingales (1998) and Caselli and Feyrer (2007) that financial development shifts the sectoral composition toward more capital intensive; and Buera, Kaboski, and Shin (2011), Caselli and Feyrer (2007), Greenwood, Hercowitz, and Krusell (2000), and Hsieh and Klenow (2007) that the relative prices of capital goods to consumption goods are higher among less developed countries. To explain this, Buera, Kaboski and Shin (2011) constructed a two-sector model in which productivity responds endogenously to IQ by affecting the sectoral composition.

¹¹Through a quite different mechanism, Aoki, Benigno and Kiyotaki (2009) generates non-monotonic patterns of the autarky interest rate and of capital flows in a small open economy model, where the entrepreneurs could pledge a fraction of future output to the domestic lender,

while they could pledge none of future output to the foreign lender. Investment productivity is an exogenous characteristic of entrepreneurs. Non-monotonicity occurs because low productive entrepreneurs could attract credit along with high productive ones when and only when the pledgeable issue among the domestic agents is severe enough. They interpret higher pledgeability among domestic agents as an improvement in the country's institutional quality, even though it would put the foreign lender at greater disadvantage, thereby adding more international distortions.

¹²Of course, it is important that the reform reduces but does not eliminate the credit market imperfections for this to be true. As stressed in Matsuyama (2008), credit market imperfections have generally non-monotonic effects, so that one should not study the effects of improving the credit market by making a binary comparison between a model with the perfect credit market and a model without.

¹³The two assumptions are responsible for this feature. First, the quasi-linearity ensures that all the income effect is entirely absorbed by period-1 consumption. (In addition, the quasi-linearity rules out the possibility of a backward-bending saving schedule.) Second, the wage income is not earned in $t = 0$. Considering that $t = 1$ should be interpreted to include all future periods, these assumptions are not so unreasonable. However, they are not necessary to make the saving schedule independent of the wage rate. Alternatively, this can be achieved, for example, by separating the identity of the savers and the workers, and assuming that the workers do not save.

¹⁴ Although we assume, for simplicity, the scale of investment m_j as a fixed parameter, it should become clear later that entrepreneurs would not gain even if they were allowed to invest less than m_j . What is crucial is that they face the upper-bound, m_j , and cannot invest by infinite amount. See Footnote 19 for more detail.

¹⁵ See Tirole (2005) for the pledgeability approach for modeling credit market imperfections, and see Matsuyama (2008) for a variety of applications in macroeconomics. Although various stories of agency problems can be told to justify the assumption that only a fraction is pledgeable,

its main appeal is the simplicity, which makes it suitable for studying general equilibrium implications of credit market imperfections.

¹⁶This means that, when the composition of credit changes, it switches from one type to another completely. (In the case of a tie, the entrepreneurs would pick the project type that is more productive.) This “bang-bang” nature of compositional changes, while not a realistic feature of the model, makes the analysis highly tractable.

¹⁷ Given that each entrepreneur face the upper-bound, m_{j^*} , it is necessary to assume that there are sufficiently many entrepreneurs, $E > I / m_{j^*}$, to ensure the interior solution for I . This is the only role that the parameter E plays in the model.

¹⁸ In addition, setting $\omega^b = 0$ for all countries eliminates the reverse capital flows mechanism that operate through the cross-country differences in the borrower net worth, already studied by Gertler and Rogoff (1991) and Matsuyama (2004, 2005) and others. (Taken literally, $\omega^b = 0$ would also imply that the entrepreneurs who are denied credit would have zero consumption. However, this implication can easily be removed by giving them some non-storable endowments that can be consumed but cannot be used in the investment, without affecting any of the analysis.)

¹⁹ Since $r = (\lambda_{j^*} R_{j^*}) f'(k) < R_{j^*} f'(k)$, $(PC-j^*)$ holds with strict inequality, which has two implications. First, the equilibrium allocation of the credit necessarily involves credit rationing. With entrepreneurs being homogeneous, the credit is allocated randomly to a fraction of the entrepreneurs, while the rest are denied credit. The latter would not be able to entice lenders by promising a higher rate of return, because that would violate $(BC-j^*)$. For more discussion on this feature of the model, see Matsuyama (2008, Remark 3). Second, the entrepreneurs would have an incentive to invest more if they had access to a linear technology. This is the reason for introducing diminishing returns in investment technologies in the form of an upper-bound. On the other hand, entrepreneurs would not gain from investing project- j less than m_j . The

indivisibility assumption can thus be dropped without changing the results, except that the credit rationing now take the form of not every entrepreneur being able to invest up to m_j .

²⁰ Note that r^A is independent of L , a feature that turns out to be convenient later in Section 6.2.

²¹ Recall that, in the balance-of-payment accounting, a surplus in the current account,

$CA^c(r) \equiv S^c(r) - I^c(r) > 0$ is a deficit in the financial account (used to be called the “capital account”), $FA^c(r) \equiv I^c(r) - S^c(r) < 0$, and hence a capital outflow.

²² This result has already been reported in Matsuyama (2008, sec.6).

²³ It is without loss of generality, because within the set of all feasible projects, the entrepreneurs would always choose a project on the frontier where both R and λ cannot be increased. Hence, the analysis may be restricted to the frontier of the feasibility set, along which R and λ are negatively related. In this section, we are assuming that two or more projects are on the frontier. Otherwise, the credit would always flow into the most productive project, effectively bringing the model back to the homogeneous project case discussed in the previous section.

²⁴ See Topkis (1998) for mathematics of super- and sub-modularity and Costinot (2009) for a recent application to international economics. More generally, $\lambda_j^c = \tilde{\Lambda}(R_j; \theta^c) < 1$ is *strictly log-submodular* in R and θ iff $\partial^2 \log \tilde{\Lambda} / \partial R \partial \theta < 0$ (for a twice-differentiable case). The assumed functional form in (5) is not crucial, as long as it satisfies strict log-submodularity. Nevertheless, eq. (5) is algebraically simple and more convenient because it can be decomposed into the project-specific and country-specific components to discuss them separately.

²⁵ With a continuum of projects with the range of R_j being an interval, as in the case studied in Section 5.2, this can also be shown for a more general smooth function, $\lambda_j^c = \tilde{\Lambda}(R_j; \theta^c) < 1$ as follows. As $\Phi(R; \theta) = \log \tilde{\Lambda}(R; \theta) + \log R$ is maximized at $R = R(\theta)$, $\Phi_R(R(\theta); \theta) = 0$ and $\Phi_{RR}(R(\theta); \theta) < 0$. Thus, whenever $R(\theta)$ is differentiable, applying the implicit function theorem yields $R'(\theta) = -\Phi_{R\theta}(R(\theta); \theta) / \Phi_{RR}(R(\theta); \theta)$, and hence $\text{sgn } R'(\theta) = \text{sgn } \Phi_{R\theta}(R(\theta); \theta) =$

$\text{sgn } \partial^2 \log \tilde{\Lambda} / \partial R \partial \theta < 0$. (Note: this demonstration requires no assumption on the sign of

$\Phi_{RR}(\bullet; \theta)$.)

²⁶It is worth noting that the statement, an increase in $R(\theta)$ through a change in θ reduces the investment, is quite general. It does not depend on J , $\Lambda(\bullet)$, nor $f(\bullet)$. Nor does it depend on the assumption of strict log-submodularity, which only plays a role in determining how $R(\theta)$ depends on θ .

²⁷To see this, for a fixed $r = [\Lambda(R(\theta))]^\theta R(\theta) f'(k)$, a lower θ increases $[\Lambda(R(\theta))]^\theta R(\theta)$ and hence $k = R(\theta)I/L$, $y = f(k)$, and $w = f(k) - kf'(k)$.

²⁸Figure 3c is drawn for $\Lambda_0 = 1$, which implies that the graph is flat for $\theta > \hat{\theta}$. For $\Lambda_0 < 1$, the graph would have a negative slope after it jumps upward at $\theta = \hat{\theta}$. The assumption, $\eta(k) < 1$, ensures that the graph starts at $\theta = 0$ above the dotted line, and cross the dotted line at $\theta = \tilde{\theta} < \hat{\theta}$. If $\eta(k) > 1$, the graph could stay below the dotted line for all $\theta < \hat{\theta}$.

²⁹A common interpretation in the empirical literature seems that inflows of foreign capital would cause a real exchange appreciation, which leads to the loss of competitiveness of the industries.

³⁰See, for example, Buera, Kaboski, and Shin (2011), Caselli and Feyrer (2007), Greenwood, Hercowitz and Krusell (2000), and Hsieh and Klenow (2007).

³¹Uzawa (1969) is among the first to formulate capital as a productivity index in the production function, with the investment being interpreted as any productivity-shifting expenditure, which includes but is not limited to manufacturing or purchasing capital goods. He attributed the idea to Penrose (1959).

³²See Obstfeld and Rogoff (1996, Ch.2) for a survey on overlapping generations models of the current account.

³³One might think that, once we allow for the possibility that the governments cannot commit to enforce the payments by the domestic entrepreneurs, they would choose not to enforce only when

the lenders are foreigners, which might invalidate the assumption that the lenders from all countries earn the same rate of return. However, as Broner and Ventura (2010, 2011) have recently argued, the governments may not necessarily have the means to discriminate the domestic and foreign lenders.