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**Barriers to International Capital Flows:
Who Should Erect Them and How Big Should They Be?**

Marco A. Espinosa-Vega, Bruce D. Smith, and Chong K. Yip

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Abstract: Until recently, the trend in world capital markets has been toward increasing globalization. Recent events in Latin America and Asia have caused many in policy-making circles to question whether this trend should be wholly, or at least partially, reversed. It is commonly argued that—at a minimum—countries should be given the discretion to erect such barriers, at least in certain circumstances. Recent events, then, have forced a rethinking of the desirability of unrestricted world capital flows. The general presumption appears to be that the “victims” of highly volatile capital flows should be allowed to limit or restrict inflows and outflows of funds. But outflows of funds from smaller and less developed economies often represent inflows of funds to larger and more developed economies. This raises the issue of whether there would be benefits associated with larger and wealthier economies taking actions to limit capital mobility. This paper presents a formal analysis of erecting barriers to international capital flows. We find that, in contrast to conventional thinking, when there are substantial differences in per capita GDP across countries, long-run output in *all countries* can be increased by having *wealthier* economies erect some partial barriers to capital mobility. Interestingly, wealthier economies need not persuade poorer economies to cooperate: by implementing an appropriately selected tax on capital flows it will often be the case that the wealthy economy can unilaterally obtain a higher steady state welfare level for all agents in all economies. We also show that these same barriers need not eliminate endogenously arising volatility in income, capital flows, and asset returns. Under some circumstances, then, if it is desirable to reduce such volatility, this must be accomplished by other means. However, and this bears emphasis, the case for imposing barriers on capital flows does not depend critically on the ability of these barriers to eliminate excess volatility.

JEL classification: F3, G1

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Barriers to International Capital Flows: Who Should Erect Them and How Big Should They Be?

1. Introduction

Until recently, the trend in world capital markets has been towards increasing “globalization.” During the 1990’s even economies with long and successful histories of barriers to capital flows have moved in the direction of opening their financial systems to both inflows and outflows.¹

Recent events in Latin America and Asia have caused many in policy-making circles to question whether this trend should be wholly, or at least partially, reversed. Indeed, it is now commonplace to see IMF and World Bank officials advocating the desirability of various barriers to free capital mobility. And, it is commonly argued that -at a minimum - countries should be given the discretion to erect such barriers, at least in certain circumstances.

Recent events, then, have forced a rethinking of the desirability of unrestricted world capital flows. However, there is little in the way of analytical frameworks for evaluating the general consequences of increasing the magnitude of restrictions

¹For instance Korea and Taiwan.

on the flow of funds in international financial markets.² This paper is an attempt to fill this gap.

Moreover, a related issue has remained entirely unaddressed. If it is desirable to erect barriers to capital flows, who should erect them? The general presumption appears to be that the “victims” of highly volatile capital flows should be allowed to limit or restrict inflows and outflows of funds. But, outflows of funds from smaller and less developed economies often represent inflows of funds to larger and more developed economies. This raises the issue of whether there would be benefits associated with larger and wealthier economies taking actions to limit capital mobility? Our analysis suggests that the answer is yes.

Most of the attention concerning world capital markets has been focused on short term volatility. Yet, much evidence suggests that the unrestricted operation of world capital markets also acts to the detriment of long-run capital formation in poor economies.³ This raises the possibility that some restrictions on capital flows are desirable not only in reducing short-term volatility, but are also desirable from the perspective of longer-run economic development. And, indeed, we describe circumstances in which barriers to capital mobility are desirable for all countries

²See Tobin, Eichengreen and Wyplosz (1995) for an exception applied to foreign exchange markets.

³See Boyd and Smith (1997) for a summary of some evidence on this point.

from the perspective of long-run economic development and from a welfare perspective, even though they do little or nothing to mitigate short-run volatility. Thus, the case for some barriers to capital flows appears to be a strong one.

From an analytical perspective, how should one proceed in examining these issues? In our opinion, the case for interfering with unrestricted international financial trade must be based on one or more of the following lines of argument.

(1) Barriers to trade in financial assets make it easier for countries to monetize deficits, and permit them to do so relatively efficiently.⁴ But while this is an argument with much force in some contexts, it clearly does not apply to places like Japan or Korea.

(2) World capital markets, absent artificial barriers, operate frictionlessly and efficiently. But, barriers to capital flows may be desirable because they facilitate some desired reallocation of resources. We do not find this kind of reasoning compelling, as under its hypotheses desired redistributions of resources can presumably be achieved by other means that imply smaller distortions.

(3) The operation of international financial markets is subject to frictions that operate to the detriment of certain economies. This is the line of reasoning that

⁴This argument has been well-understood for some time. See, for instance, Nichols (1974) or McKinnon (1991).

we pursue.

More specifically, we consider a two country world where countries are identical except, possibly, for their policies with respect to capital flows and their initial capital stocks. In particular, each country produces a single final good using the same constant returns to scale technology with capital and labor as inputs. In each country capital investment requires some credit finance. This credit extension is complicated, in both domestic and world markets, by the presence of a standard informational friction. In order to bring the consequences of this friction to the forefront, we abstract from other features of real world economies that might lead to capital flight from certain countries, or to an international diversification motive for investors.

In this context, Boyd and Smith (1997) demonstrated that there would, under weak conditions, exist locally stable steady state equilibria where one country is permanently wealthy and one is permanently poor. Indeed, this is true even though all conditions implying the equality of long-run income levels are satisfied if the economies are closed, or if the informational friction is absent.

Moreover, Boyd and Smith show that, in such steady states, the world is poorer than it would be if all economies were closed. And, the pattern of international funds flows is necessarily perverse: that is, poor countries are net investors in

rich countries. Finally, Boyd and Smith illustrate that the unrestricted operation of world capital markets can easily lead to endogenously generated volatility along equilibrium paths that approach a steady state. Large fluctuations in incomes, capital flows, and rates of return can be observed along such paths. Such a finding, of course, suggests why we might observe so much volatility in world capital markets that seems hard to explain based on fundamentals alone. And the Boyd-Smith results suggest that endogenously arising volatility may predominantly affect the poorer country.

These results raise the possibility that barriers to capital flows are, indeed, “desirable,” at least for some countries. Here we explore the consequences of some such barriers, which are crudely meant to capture certain features of the widely praised “Chilean model.” And we derive two main results. First appropriately selected “barriers” to capital flows can be used to increase capital stocks and per capita levels of GDP in both countries. But these “barriers” should be erected by “rich,” not poor countries. Indeed, we state conditions under which increasing taxation of capital income by “rich” countries can be used to increase wealth and production in all economies. And, we establish the existence of an upper bound on the rate of capital taxation consistent with an equilibrium in world capital markets. Second, we establish sufficient conditions under which higher levels of

taxes raise the ex ante expected utility of all residents in both the rich and the poor countries. Thus, at least from the perspective of a steady state, there will be unanimous support in favor of raising taxes in the rich country.

We also show that these barriers need not eliminate or substantially reduce endogenously arising volatility in income, capital flows and asset returns. Under some circumstances, then, if it is desirable to reduce such volatility, this must be accomplished by other means.

The remainder of the paper proceeds as follows. Section 2 describes the economic environment that we consider, and section 3 discusses trade in world credit and factor markets. Section 4 examines the model in the absence of any barriers to capital flows. Section 5 introduces such a barrier, loosely motivated by Chile's widely discussed effective taxation of certain investments by foreigners. It then analyzes the long-run consequences of restrictions on capital flows, while Section 6 considers implications of these restrictions for steady state welfare. Section 7 provides illustrative examples, and offers some results on short-run dynamics. Concluding remarks are offered in section 8.

2. The Model

2.1. Environment

Consider a world economy consisting of two countries, each populated by an infinite sequence of two-period lived, overlapping generations. In each country, every generation is identical in size and composition, and contains a continuum of agents with unit mass. Within each generation, agents are divided into two types: “potential borrowers” and “lenders”. A fraction $\alpha \in (0, 1)$ of the population is potential borrowers; this fraction is the same in each country.

Let $t = 0, 1, \dots$ index time. At date t a single final good is produced in each country, using a constant returns to scale technology with capital and labor of that country as inputs. We assume the final good to be mobile across borders, while factors of production are immobile. Let K_t^i ($i = 1, 2$) denote the time t capital input, and L_t^i denote the time t labor input of a representative firm of country i . Then final output is $Y_t^i = F(K_t^i, L_t^i)$. The production function F satisfies the following conditions: it is increasing in each argument, strictly concave, and $F(0, L) = F(K, 0) = 0$ holds, for all K, L . In addition, if $k^i \equiv \frac{K^i}{L^i}$ is the capital-labor ratio of country i , and if $f(k^i) \equiv F(k^i, 1)$ denotes the intensive production function, then $f' > 0 > f''$ holds $\forall k^i$, and f satisfies the standard

Inada conditions. Finally, we assume that the inherited capital stock at date t is used in production, and that thereafter it depreciates completely. Notice that the final goods production technology is the same in each country.

With respect to endowments, all young agents are endowed with one unit of labor, which is supplied inelastically, while agents are retired when old. Individuals other than the old of period zero have no endowment of capital or final goods, while the initial old agents of country i have an aggregate capital endowment of $K_0^i > 0$.

Agents of all types are assumed to care only about old age consumption and, in addition, all agents are risk neutral. Thus all young period income is saved.⁵

Potential borrowers and lenders are differentiated by the fact that each potential borrower has access to a stochastic linear technology for converting date t final goods into date $t + 1$ capital. Lenders have no access to this technology.

The capital investment technology has the following properties. First, it is indivisible and nontradable: each potential borrower has one investment project which can only be operated at the scale q . In particular, $q > 0$ units of the final good invested in one project at t yield zq units of capital at $t + 1$, where z is an iid

⁵The fact that savings is inelastic implies that the taxation of capital income will have no effect on the steady state capital stock in a closed economy version of our model. As we will see, this will not typically be the case in open economies.

(across borrowers and periods) random variable, which is realized at $t + 1$. We let G denote the probability distribution of z , and assume that G has a differentiable density function g with support $[0, \bar{z}]$. We let \hat{z} denote the expected value of z , i.e., $\hat{z} \equiv \int_0^{\bar{z}} zg(z)dz$. We also assume that q and the probability distribution of investment returns are the same in each economy.

The amount of capital produced by any investment project can be observed costlessly by the project owner. Any agent other than the project owner can observe the project return only by bearing a fixed cost of $\gamma > 0$ units of capital.⁶

3. Trade

3.1. Factor Markets

We assume that capital and labor are traded in competitive domestic markets at each date. Thus, if w_t^i denotes the time t real wage rate and ρ_t^i is the time t capital rental rate in country i , the standard factor pricing relationships obtain:

$$\rho_t^i = f'(k_t^i) \tag{3.1}$$

$$w_t^i = f(k_t^i) - k_t^i f'(k_t^i) \equiv w(k_t^i). \tag{3.2}$$

⁶That is, in verifying the project return, γ units of capital are used up. The assumption that capital is consumed in the verification process follows Bernanke and Gertler (1989). This cost is again identical across countries.

Notice that $w'(k) > 0$ holds and, in addition, we will assume the following.

Assumption 1. $w''(k) < 0; \forall k \geq 0$.

Assumption 1 is satisfied if, for example, f is any CES production function with elasticity of substitution no less than one. Assumption 1 guarantees the uniqueness of a non-trivial steady state equilibrium in a closed economy version of the model.

3.2. Credit Markets

All young agents in country i at t supply one unit of labor inelastically, earning the real wage rate w_t^i . For lenders this income is supplied inelastically in world credit markets. We can think of all credit extension as being intermediated in the manner described by Williamson (1986).

Potential borrowers also have young period income w_t^i , and we assume they must obtain external financing to operate their investment projects.

Assumption 2. $q > w(k_t^i)$ for all “relevant” values of k_t^i .

Let b_t^i denote the amount borrowed by the operator of a funded project (in real

terms) in country i at t ; clearly

$$b_t^i = q - w(k_t^i). \quad (3.3)$$

To obtain external funding borrowers announce loan contract terms. These terms are either accepted or rejected by intermediaries: borrowers whose terms are accepted then receive funding and operate their projects. Following Williamson (1986, 1987), a loan contract consists of the following objects. One is a set of project return realizations A_t^i for which verification of the return occurs in country i at t . Verification does not occur if $z \in B_t^i \equiv [0, \bar{z}] - A_t^i$.⁷ Second, if $z \in A_t^i$, there is a promised payment (per unit borrowed) $R_t^i(z)$. If $z \in B_t^i$, then the loan contract offers an uncontingent payment of x_t^i (per unit borrowed). All payments specified by any loan contract are in real terms.

Loan contracts offered by borrowers are either accepted or rejected by intermediaries who can be thought of as making all loans. In addition intermediaries take deposits and conduct monitoring of project returns as called for by loan contracts. Any lender can establish an intermediary. In equilibrium, intermediaries will be perfectly diversified, earn zero profits, and have a nonstochastic return on

⁷We thus abstract from stochastic state verification. Boyd and Smith (1994) show that the welfare gains from stochastic monitoring are trivial when realistic parameter values are assumed.

their portfolios. Thus they need not be monitored by their depositors.

Intermediaries behave competitively in deposit markets and therefore take the gross rate of interest on deposits at t , r_{t+1} , as given.⁸ It follows that intermediaries are willing to accept loan contract offers yielding an expected return of at least r_{t+1} . Loan contract offers must therefore satisfy the expected return constraint

$$\int_{A_t^i} [R_t^i(z)b_t^i - \rho_{t+1}^i\gamma]g(z)dz + x_t^ib_t^i \int_{B_t^i} g(z)dz \geq r_{t+1}b_t^i. \quad (3.4)$$

Notice that expected repayments must at least cover the intermediary's cost of funds - $r_{t+1}b_t^i$ - plus the real expected monitoring cost

$$\rho_{t+1}^i\gamma \int_{A_t^i} g(z)dz.$$

The latter term depends on ρ_{t+1}^i because γ units of *capital* are expended when project returns are verified. Finally, project owners must have the proper incentives to correctly reveal when a monitoring state has occurred. The appropriate incentive constraint is

$$R_t^i(z) \leq x_t^i; \quad z \in A_t^i. \quad (3.5)$$

⁸Since funds are mobile internationally, this rate of return must be the same in each country.

In addition, the repayments specified by any contract must be feasible for the borrower, so that

$$R_t^i(z) \leq \frac{\rho_{t+1}^i z q}{b_t^i}; \quad z \in A_t^i \quad (3.6)$$

$$x_t^i \leq \inf_{z \in B_t^i} \left[\frac{\rho_{t+1}^i z q}{b_t^i} \right]. \quad (3.7)$$

Equations (3.6) and (3.7) require that repayments never exceed the real value of the capital yielded by an investment project, which in state z is $zq\rho_{t+1}^i$ at $t+1$.

Borrowers will maximize their own expected utility by choice of contract terms, subject to the constraints just described. Therefore, announced loan contracts at date t will be selected to maximize

$$\rho_{t+1}^i \hat{z} q - b_t^i \int_{A_t^i} R_t^i(z) g(z) dz - x_t^i b_t^i \int_{B_t^i} g(z) dz$$

subject to (3.4)-(3.7).

The solution to the borrower's problem is to offer a standard debt contract. In particular, the borrower either repays x_t^i (principal plus interest) or else defaults. In the event of default the lender monitors the project, and retains its proceeds

net of monitoring costs. Formally, we have⁹

Proposition 3.1. *Suppose $q > b_t^i$. Then the optimal contractual loan terms satisfy*

$$R_t^i(z) = \frac{\rho_{t+1}^i z q}{b_t^i}, \quad z \in A_t^i \quad (3.8)$$

$$A_t^i = \left[0, \frac{x_t^i b_t^i}{q \rho_{t+1}^i}\right) \quad (3.9)$$

$$r_{t+1} = \int_{A_t^i} \left[R_t^i(z) - \frac{\rho_{t+1}^i \gamma}{b_t^i} \right] g(z) dz + x_t^i \int_{B_t^i} g(z) dz. \quad (3.10)$$

For future reference, the expected return received by a lender under the optimal contract, per unit of funding, is given by

$$\begin{aligned} & \int_{A_t^i} \left[R_t^i(z) - \frac{\rho_{t+1}^i \gamma}{b_t^i} \right] g(z) dz + x_t^i \int_{B_t^i} g(z) dz \\ &= x_t^i - \frac{\rho_{t+1}^i \gamma}{b_t^i} G\left(\frac{x_t^i b_t^i}{\rho_{t+1}^i q}\right) - \frac{\rho_{t+1}^i q}{b_t^i} \int_0^{\frac{x_t^i b_t^i}{\rho_{t+1}^i q}} G(z) dz \equiv \pi \left[x_t^i; \frac{b_t^i}{\rho_{t+1}^i} \right]. \end{aligned} \quad (3.11)$$

The function π gives the expected return to the lender as a function of the gross

⁹The proof of proposition 3.1 is standard: See Gale and Hellwig (1985) or Williamson (1986).

loan rate, x_t^i , the amount of external finance required, b_t^i , and the future relative price of capital, ρ_{t+1}^i .

It will be useful to make some assumptions regarding the function π . Following Williamson (1986, 1987) we assume the following:

Assumption 3. $g(z) + (\frac{\gamma}{q})g'(z) \geq 0$; for all $z \in [0, \bar{z}]$.

Assumption 4. $\pi_1[0, (\frac{b_t^i}{\rho_{t+1}^i})] > 0$.

Assumption 3 implies that $\pi_{11} < 0$. Assumptions 3 and 4 imply that π has the configuration depicted in Figure 1. Evidently, depending on the value of b_t^i/ρ_{t+1}^i , there is a unique value of x_t^i which maximizes the expected return that can be offered to any lender. We will denote this value by $\hat{x}(b_t^i/\rho_{t+1}^i)$. The function \hat{x} satisfies

$$\pi_1 \left[\hat{x}\left(\frac{b_t^i}{\rho_{t+1}^i}\right); \frac{b_t^i}{\rho_{t+1}^i} \right] \equiv 1 - \left(\frac{\gamma}{q}\right)g \left[\hat{x}\left(\frac{b_t^i}{\rho_{t+1}^i}\right)\frac{b_t^i}{\rho_{t+1}^i q} \right] - G \left[\hat{x}\left(\frac{b_t^i}{\rho_{t+1}^i}\right)\frac{b_t^i}{\rho_{t+1}^i q} \right] \equiv 0. \quad (3.12)$$

Equation (3.12) and Assumption 3 imply that

$$\hat{x} \left(\frac{b_t^i}{\rho_{t+1}^i} \right) \frac{b_t^i}{\rho_{t+1}^i q} \equiv \eta \quad (3.13)$$

where $\eta > 0$ is a constant satisfying $1 - (\frac{\gamma}{q})g(\eta) - G(\eta) \equiv 0$. When all potential

borrowers are offering the interest rate $\hat{x}\left(\frac{b_t^i}{\rho_{t+1}^i}\right)$, η is the critical project return for which a borrower's project income exactly covers loan principal plus interest. In other words, a default occurs if $z \in [0, \eta)$.

3.3. Credit Rationing

As noted by Gale and Hellwig (1985) and Williamson (1986, 1987), in this environment it is possible for credit to be rationed in either or both countries. In particular, if all borrowers want to operate their projects at date t , the total (per capita) demand for funds in each country is αq . The total per capita supply of saving is $w(k_t^i)$ in country i at t . World credit demand exceeds world credit supply, and hence credit must be rationed in the world economy, if the following assumption holds for all $t \geq 0$.

Assumption 5. $2\alpha q > w(k_t^1) + w(k_t^2)$.

When credit is rationed anywhere, it also must be the case that

$$x_t^i = \hat{x}\left(\frac{b_t^i}{\rho_{t+1}^i}\right) \equiv \hat{x}\left[\frac{q - w(k_t^i)}{\rho_{t+1}^i}\right]. \quad (3.14)$$

In particular, all potential borrowers must offer the interest rate that maximizes a prospective lender's expected rate of return. Rationed (unfunded) potential bor-

rowers cannot then obtain credit by changing loan contract terms, since doing so simply reduces the expected return perceived by (all) lenders. Thus if assumption 5 and equation (3.14) hold at date t , credit rationing is an equilibrium outcome for the world economy. We henceforth focus on the case where credit rationing occurs at all dates.¹⁰

3.3.1. Payoffs Under Credit Rationing

We now describe the expected payoffs of lenders and (funded) borrowers at t when credit is rationed. Equations (3.11) and (3.14) imply that the expected return on bank loans is given by

$$\begin{aligned} \pi \left[\hat{x} \left(\frac{b_t^i}{\rho_{t+1}^i} \right); \frac{b_t^i}{\rho_{t+1}^i} \right] &\equiv \frac{\rho_{t+1}^i q}{b_t^i} \left\{ \hat{x} \left(\frac{b_t^i}{\rho_{t+1}^i} \right) \frac{b_t^i}{\rho_{t+1}^i q} - \left(\frac{\gamma}{q} \right) G \left[\hat{x} \left(\frac{b_t^i}{\rho_{t+1}^i} \right) \frac{b_t^i}{\rho_{t+1}^i q} \right] - \int_0^{\frac{\hat{x} b_t^i}{\rho_{t+1}^i q}} G(z) dz \right\} \\ &\equiv \frac{\rho_{t+1}^i q}{b_t^i} \left[\eta - \left(\frac{\gamma}{q} \right) G(\eta) - \int_0^\eta G(z) dz \right]. \end{aligned} \quad (3.15)$$

Note that the return to a lender between t and $t + 1$ is proportional to the ratio ρ_{t+1}^i/b_t^i when credit rationing obtains. The expected utility of a funded borrower

¹⁰The assumption that credit is rationed results in a substantial technical simplification. However, credit rationing is common in developing countries (McKinnon, 1973), and there is evidence of significant rationing of credit even in the United States (Japelli, 1990). Therefore this does not seem to be an empirically unreasonable assumption.

under credit rationing is given by

$$\rho_{t+1}^i \hat{z} q - r_{t+1} b_t^i - \rho_{t+1}^i \gamma G \left[\hat{x} \left(\frac{b_t^i}{\rho_{t+1}^i} \right) \frac{b_t^i}{\rho_{t+1}^i q} \right] \equiv \rho_{t+1}^i q \left[\hat{z} - \left(\frac{\gamma}{q} \right) G(\eta) \right] - r_{t+1} b_t^i.$$

Since any potential borrower could always forego operating his project and deposit his income in a bank, all potential borrowers can guarantee themselves the utility level $r_{t+1} w(k_t^i)$. Potential borrowers then prefer borrowing to lending iff

$$\rho_{t+1}^i q \left[\hat{z} - \left(\frac{\gamma}{q} \right) G(\eta) \right] - r_{t+1} b_t^i \geq r_{t+1} w(k_t^i). \quad (3.16)$$

We now define

$$\phi \equiv \hat{z} - \left(\frac{\gamma}{q} \right) G(\eta). \quad (3.17)$$

The variable ϕ represents the expected project yield per unit invested, under credit rationing, net of capital consumed by monitoring.¹¹ Then equation (3.16) can be reduced to

$$\phi \rho_{t+1}^i \geq r_{t+1}. \quad (3.18)$$

If (3.18) fails, then borrowers will prefer not to borrow.

¹¹Of course, we assume that $\phi > 0$.

4. The Open Economy

As a point of reference we begin by considering equilibria when there are no barriers to international capital flows. For reasons of technical simplicity, we also restrict attention to the case where credit is rationed in both countries.¹²

With unrestricted international borrowing and lending, clearly one equilibrium condition is that the expected returns offered by borrowers be the same in each country:

$$\pi \left[\hat{x} \left(\frac{b_t^1}{\rho_{t+1}^1} \right); \frac{b_t^1}{\rho_{t+1}^1} \right] = \pi \left[\hat{x} \left(\frac{b_t^2}{\rho_{t+1}^2} \right); \frac{b_t^2}{\rho_{t+1}^2} \right], \quad (4.1)$$

for $t \geq 0$. Given the form of the expected return function, (4.1) is equivalent to

$$\frac{f'(k_{t+1}^1)}{q - w(k_t^1)} = \frac{f'(k_{t+1}^2)}{q - w(k_t^2)}. \quad (4.2)$$

The second condition of equilibrium is that world saving equal world investment.

Let μ_t^i be the fraction of potential borrowers who obtain credit in country i at t .

¹²See Huybens and Smith (1998) for some discussion of the relaxation of this assumption in the case of a small open economy.

Then an equality between sources and uses of funds requires¹³

$$\alpha \sum_{i=1}^2 \mu_t^i [q - w(k_t^i)] = \sum_{i=1}^2 [(1 - \alpha)w(k_t^i) + \alpha(1 - \mu_t^i)w(k_t^i)]. \quad (4.3)$$

Upon rearranging terms, (4.3) yields the desired equality of savings and investment:

$$\alpha q(\mu_t^1 + \mu_t^2) = w(k_t^1) + w(k_t^2). \quad (4.4)$$

Since there is no aggregate uncertainty, the time $t + 1$ capital stock available for use in worldwide production, not inclusive of capital expended on state verification, is $\widehat{z}\alpha q(\mu_t^1 + \mu_t^2) = \widehat{z}[w(k_t^1) + w(k_t^2)]$. Total capital expenditures on state verification are $\alpha\gamma G(\eta)(\mu_t^1 + \mu_t^2) = (\gamma/q)G(\eta)[w(k_t^1) + w(k_t^2)]$. In equilibrium, therefore,

$$k_{t+1}^1 + k_{t+1}^2 = \phi[w(k_t^1) + w(k_t^2)]. \quad (4.5)$$

Finally, to guarantee that credit is rationed in each country, we require

$$\max(k_t^1, k_t^2) < \phi\alpha q$$

¹³Notice that unfunded borrowers do not wish to consume their income when young. Hence each unfunded borrower saves $w(k_t^i)$ to consume when old.

for all $t \geq 1$.

4.1. Steady State Equilibria

We begin by examining steady states. Dynamical equilibria are discussed in the next section. To facilitate our analysis, we define the function $H(k)$ by

$$H(k) = \frac{f'(k)}{[q - w(k)]}. \quad (4.6)$$

In order to characterize steady states, it will be useful to know more about the function $H(k)$. Some of its properties are stated in the following lemma.¹⁴

Lemma 4.1. *The function H satisfies*

- (a) $\lim_{k \rightarrow 0} H(k) = \infty$,
- (b) $\lim_{k \rightarrow \hat{k}} H(k) = \infty$, where $\hat{k} \equiv w^{-1}(q)$,
- (c) $H'(k) \leq 0$; $k \leq f^{-1}(q)$, and
- (d) $H'(k) \geq 0$; $k \geq f^{-1}(q)$.

Lemma 1 implies that the function H has the configuration depicted in Figure 2.

¹⁴See Boyd and Smith (1997) for a proof.

In a steady state, (4.5) and (5.1) reduce to

$$k^1 + k^2 = \phi[w(k^1) + w(k^2)]. \quad (4.7)$$

$$H(k^1) = H(k^2). \quad (4.8)$$

Boyd and Smith (1997) show that equations (4.7) and (4.8) defined loci as depicted in Figure 3. As is apparent from the figure, there is the distinct possibility that two kinds of steady state equilibria exist. (i) One is a “symmetric” steady state in which $k^1 = k^2 = k^*$, where $k^* \equiv \phi w(k^*) > 0$ is the steady-state equilibrium level of the capital stock for a closed economy. The capital stocks in each country coincide with the nontrivial steady state capital stocks that would be observed in steady state if each country were closed.¹⁵ (ii) There may also be “asymmetric” steady states in which $k^1 \neq k^2$. Boyd and Smith (1997) establish the following properties of asymmetric steady states.

(a) If $k^1 > k^2$, $k^1 > k^* > k^2$ holds.¹⁶

¹⁵This is to be expected, since the economies are identical in all respects except for their initial capital stocks. Assumption 1 implies that there is a unique nontrivial symmetric steady state.

¹⁶This result depends on the assumed concavity of $w(k)$. Under this assumption, world savings (and hence the world capital stock) is maximized by allocating a fixed stock of capital equally across countries. Parenthetically, $w''(k) < 0$ holds if $f(k)$ is any CES production function with elasticity of substitution no less than one.

- (b) In a steady state with $k^1 > k^2$, there are net capital flows *from* country 2 *to* country 1. That is, the poor country is a net investor in the rich country.¹⁷ (Parenthetically, Boyd and Smith discuss some empirical evidence indicating that the flow of private, non-guaranteed credit is from “poorer” to “richer” economies.)
- (c) In an asymmetric steady state, $k^1 + k^2 < 2k^*$ holds. Thus the world as a whole is poorer than it would be if both countries were closed economies.
- (d) An asymmetric steady state exists¹⁸ if $f(k^*) > q$ holds.

Loosely speaking, these results imply that an asymmetric steady state will exist if the costs of state verification are neither too large nor too small. Or, in other words, asymmetric steady states can be observed if financial market frictions are sufficiently great but - at the same time - not too severe. If asymmetric steady states emerge, they imply that (a) one country is richer and one country is poorer than it would be as a closed economy; (b) international capital flows perpetuate the relative poverty of the poorer country; and (c) these capital flows reduce the total level of the world economy’s income.

Together with the results on local dynamics described below, these results indicate why some countries might be tempted to erect complete or partial barriers

¹⁷Formally, $k^1 - \phi w(k^1) > 0 > k^2 - \phi w(k^2)$ holds.

¹⁸In fact, at least two asymmetric steady states exist under these conditions, since asymmetric steady states come in pairs.

to international capital flows.

4.2. Local Dynamics

In the case where $f(k) = Dk^\delta$ (Cobb-Douglas production), Boyd and Smith (1997) show that (a) the symmetric steady state is a saddle. Its stable manifold is the locus $k_t^1 = k_t^2$. It is not possible to converge to the steady state if $k_0^1 \neq k_0^2$. (b) They provide sufficient conditions under which an asymmetric steady state will be a sink.

Together these results imply that an initially poor economy can be permanently impoverished by the operation of unrestricted world capital markets. Intuitively, borrowers in the rich country have relatively high incomes, and hence they have a superior ability to provide internal finance for their own projects. In the presence of the CSV problem, as noted by Bernanke and Gertler (1989), the ability to provide internal finance acts to mitigate financial market frictions. The Boyd-Smith results specify conditions under which this factor is so important that it can never be overcome by an initially poor economy, at least if international capital flows are unrestricted.¹⁹

Boyd and Smith (1997) also show that dynamic equilibrium paths approaching

¹⁹As indicated by Gertler and Rogoff (1990), the same forces are likely to be at work in an economy where investment is subject to a moral hazard problem.

asymmetric steady states can easily exhibit endogenously generated oscillation. Thus excessive volatility, of the kind we seem to observe widely, can also be a consequence of unrestricted capital mobility.

5. Barriers to Capital Flows

We now turn to our primary task: to examine how erecting barriers to capital flows affect the equilibria of the world economy. For analytical simplicity - and in keeping with widely noted cases such as Chile and more recently Malaysia and Taiwan - we model these barriers as taxes on capital income. Suppose now the government of country i ($i = 1, 2$) levies a constant proportional tax τ^i on capital income. This tax may be levied on all agents with capital income, or it may be levied on foreign investors alone.²⁰ Then the no arbitrage condition becomes

$$\frac{f'(k_{t+1}^1)}{q - w(k_t^1)} = \frac{1 - \tau^2}{1 - \tau^1} \frac{f'(k_{t+1}^2)}{q - w(k_t^2)}, \forall t \geq 1 \quad (5.1)$$

Given the values (k_0^1, k_0^2) , equations (4.5) and (5.1) describe the evolution of

²⁰If taxation of capital income applies only to foreigners, we may proceed as follows. In steady states with $k^1 > k^2$, set $\tau_2 = 0$. Equation (5.1) then remains the appropriate equilibrium condition, even if only foreign investors are taxed, as country 2 investors must be indifferent between investing in country 1 and country 2 (recall that country 1 receives net capital inflows). Country 1 investors will invest only in country 1.

equilibrium sequences $\{k_t^1, k_t^2\}$. To fix ideas - and without loss of generality - we henceforth assume that $\tau^1 > \tau^2$.

It is easy to see that steady state equilibrium values (k^1, k^2) satisfy (4.7) and

$$H(k^1) = \frac{1 - \tau^2}{1 - \tau^1} H(k^2). \quad (5.2)$$

Figure 4 depicts the loci defined by (4.7) and (5.2). Evidently, the locus defined by (4.7) is identical to that in Figure 3, and it is unaffected by changes in the tax rates τ^1 and τ^2 . We now describe the loci defined by (5.2).

I) It is easy to verify that $(1 - \tau^2)H(k^2)/(1 - \tau^1)$ attains a minimum at $k^2 = f^{-1}(q)$. Moreover, since $\tau^1 > \tau^2$ holds, the equation

$$H(k^1) = \frac{1 - \tau^2}{1 - \tau^1} H[f^{-1}(q)]$$

has two solutions (see Figure 5). We denote the smallest (largest) of these by \underline{k} (\bar{k}). It is easy to verify that $\underline{k} < f^{-1}(q) < \bar{k}$.

II) It should now be apparent that for all $k^1 \in [0, \underline{k})$ ($k^1 \in (\bar{k}, w^{-1}(q))$) (5.2) is satisfied by two values of k^2 . If $k^1 = \underline{k}$ or $k^1 = \bar{k}$, clearly (5.2) can be satisfied only by setting $k^2 = f^{-1}(q)$. And, (5.2) has no solution for $k^1 \in (\underline{k}, \bar{k})$.

Moreover, since $H'(k^1) < 0$ for all $k^1 \in (0, \underline{k}]$, we have that the locus defined by (5.2) is upward (downward) sloping when $(k^1, k^2) \in \{(0, \underline{k}) \times (0, f^{-1}(q))\}$ ($\in \{(0, \underline{k}) \times (f^{-1}(q), w^{-1}(q))\}$). Similarly, since $H'(k^1) > 0$ for all $k^1 \in [\bar{k}, w^{-1}(q))$, the locus defined by (5.2) is downward (upward) sloping for all $(k^1, k^2) \in \{(\bar{k}, w^{-1}(q)) \times (0, f^{-1}(q))\}$ ($\in \{(\bar{k}, w^{-1}(q)) \times (f^{-1}(q), w^{-1}(q))\}$). Thus (5.2) defines two distinct loci with the shapes shown in Figure 4.

III) Since the locus defined by (4.7) passes through the points $(0, k^*)$ and (k^*, k^*) , and since (5.2) defines a locus passing through $(0, w^{-1}(q))$, there necessarily exists at least one nontrivial steady state equilibrium if $w(k^*) < q$.²¹ If there is only one nontrivial steady state, this will have $k^1 \leq \bar{k}$. In addition, if $\bar{k} < k^*$ holds,²² then there will necessarily exist at least one additional nontrivial steady state with $k^1 > \bar{k} > f^{-1}(q) > k^2$.

IV) Figure 4 depicts the possibility that there are three nontrivial steady state equilibria. As already noted, if $f(k^*) > q$ and if $k^* > \bar{k}$ hold, there will be a steady state with $k^1 > \bar{k} > f^{-1}(q) > k^2$, as well as a steady state with $k^2 > f^{-1}(q) > \underline{k} > k^1$. The third steady state, denoted by point B in the figure, will also have $k^1 > k^2$, but $k^1 > k^* > k^2 > f^{-1}(q)$ will be satisfied.

²¹This condition applies if borrowers cannot fully fund their own projects in the closed economy steady state.

²²Note that this condition can only hold if $f(k^*) < q$.

5.0.1. Comparative Statics

Figure 6 shows the comparative statics consequences of an increase in τ^1 (or, equivalently, of a reduction in τ^2). As indicated in the figure, an increase in τ^1 - or a reduction in τ^2 - shifts the leftmost (rightmost) of the loci defined by (5.2) to the left (right). If country 1 is the poor country (point C), the result is to reduce the capital stocks of both countries. If, on the other hand, country 1 is relatively wealthy and country 2 is quite poor ($f^{-1}(q) > k^2$, as at point A), then an increase in the tax rate by country 1 can increase the capital stocks of both countries. If country 1 is relatively wealthy, and if country 2 is not too poor ($k^2 > f^{-1}(q)$, as at point B), an increase in τ^1 (a reduction in τ^2) raises the capital stock in country 1 while it lowers the capital stock of country 2.

The results of Boyd and Smith (1997) suggest - and our numerical results confirm (see section 6) - that steady states like points A and C in Figures 4 and 6 will be asymptotically stable. Steady states corresponding to point B are saddles. Hence points like B can be approached only from a set of initial conditions that has measure zero. If the world economy converges to any steady state at all, it generically will be a steady state in which one country is relatively poor. Such steady states are represented by points A and C in the Figures.

Let us now consider in more detail point A in Figures 4 and 6. If $\phi w'(k^2) < 1$

holds at point A, then an specially interesting possibility emerges. If the world economy is at a steady state like point A, and if the rich (poor) country increases (reduces) the rate of capital taxation, then there will be an increase in the steady state capital stock of both countries. Thus per capita GDP will rise, asymptotically, in each country if the rich country increases (the poor country reduces) barriers to capital flows. Why should this be the case? Intuitively, an increase in capital income taxation in country 1 reduces the attractiveness of investing there. As a consequence, k^2 rises. But, with a more equal distribution of per capita capital stocks, world savings increases as well. The higher level of world savings causes the capital stock of both countries to rise. Thus the per capita production level of each country rises as the relative taxation of capital income in country 1 is increased.

It is now interesting to ask two questions. (a) Under what conditions will there be a steady state like point A in Figure 6 (with $\phi w(k^2) < 1$)? (b) Is there a limit to how much the rich country can increase its barriers to capital flows without having an adverse impact on the capital stock of one or both economies? The following proposition provides answers to these questions.

Proposition 5.1. *Suppose that $k^* > f^{-1}(q)$ holds. Define $\tilde{k} \equiv (w')^{-1}(1/\phi)$, and*

k^+ by the relation²³

$$k^+ - \phi w(k^+) = \phi w(\tilde{k}) - \tilde{k}.$$

Then $\tilde{k} < k^* < k^+$. Moreover, if $\phi w(k^+) < q$ is satisfied, then there exists a value $\tau^* \in (\tau^2, 1)$ with the following properties:

- (a) For $\tau^1 \in (\tau^2, \tau^*)$, there are at least two steady state equilibria with $k^1 > \bar{k} > k^2 > 0$.
- (b) If $\tau^1 = \tau^*$, then there is a unique steady state with $k^1 > \bar{k} > k^2 > 0$.
- (c) If $\tau^1 > \tau^*$, then there is no steady state with $k^1 > \bar{k}$ (or, for that matter with $k^1 > \underline{k}$).
- (d) If $\tilde{k} < f^{-1}(q)$ holds, then for $\tau < \tau^*$ there is a steady state with $k^2 < \tilde{k}$.

Proof of proposition 5.1. If $\tau^1 = \tau^2$, then $k^* > f^{-1}(q)$ implies the existence of two asymmetric steady states (see Boyd and Smith, 1997). In addition,

$$\lim_{\tau^1 \rightarrow 1} \bar{k} = w^{-1}(q).$$

Since $k^+ < w^{-1}(q)$, there is no steady state with $k^1 > k^2$ for τ^1 sufficiently large.

Parts (a)-(c) of the proposition then follow from continuity and the intermediate

²³It is easy to verify that, under our assumptions, the values \tilde{k} and k^+ exist and are unique if $\phi w'(0) > 1$.

value theorem. For part (d), note that if $\tilde{k} < f^{-1}(q)$, and if there is any steady state equilibrium with $k^1 > k^2$, then there must be at least one steady state with $k^2 < \tilde{k}$. ■

Proposition 5.1 asserts that a steady state having the properties of point A in Figure 6 exists if: (i) $\phi w'[f^{-1}(q)] > 1$ holds, (ii) τ^1 exceeds τ^2 , and (iii) τ^1 is not too large. When conditions (i)-(iii) are satisfied, there exists a value $\bar{\tau} \in (\tau^*, \tau^2)$ such that, when $\tau^1 = \bar{\tau}$, k^1 is maximized subject to the constraints imposed by the equilibrium conditions.²⁴ Similar reasoning applies at point C, where country 2 is the rich country.

The argument just given, then, suggests that there is a case for barriers to unrestricted capital flows, at least at steady states like A or C. But, the barriers should be erected by the wealthy country - at least from the point of view of world income. Barriers to capital flows in the poorer countries should be reduced.²⁵

²⁴The largest possible value of k^1 is, of course, k^+ .

²⁵It is important to note that, in the absence of the CSV problem, an increase in capital taxation by country 1 would necessarily reduce the steady state capital stock of country 1 so long as $\tau^1 \geq \tau^2$. It would also reduce the steady state capital stock of country 2 if $k^1 \leq \tilde{k}$. And, in this case, country 1 would maximize its own steady state capital stock by setting $\tau^1 < \tau^2$.

6. Steady State Welfare

Proposition 5.1 established conditions under which a steady state equilibrium exists with $k^2 < \tilde{k}$ (such a steady state is represented by point C in Figure 4). In this section we focus our attention on steady states of this type. And, as we are entitled to do (see footnote 20), we assume that capital income earned in each country is taxed only if it accrues to the resident of a foreign country. Given these focuses we know that higher values of τ^1 (within the range $(\tau^2, \bar{\tau}]$) lead to higher levels of the steady state capital stock and steady state GDP in each country. What we would now like to know is the following: as τ^1 is increased (again in the interval $(\tau^2, \bar{\tau}]$), what happens to the steady state welfare of different agents in different countries?

To begin we state conditions under which higher levels of taxes raise the ex ante expected utility of all country 1 residents. Thus, at least from the perspective of a steady state, there will be unanimous supporting country 1 for raising τ^1 . Then, we state conditions under which increases in τ^1 (up to the level $\bar{\tau}$) raise the ex ante expected utility of all agents –including country 2 residents in a steady state. In this case, obviously, it is unambiguous that it is desirable to set τ^1 no lower than $\bar{\tau}$.

To simplify matters, we assume that the final goods production technology has the Cobb-Douglas form $f(k) = Dk^\delta$, with $\delta \in (0, 1)$. We also note that the utility of a lender in country i is (since only the capital income of foreign residents is taxed) $\psi w(k^i)H(k^i)$. And, from the discussion in section 3, we know that the utility of a borrower, conditional on receiving funding, is given by the expression

$$\begin{aligned}\phi q f'(k^i) - r b^i &= \phi q f'(k^i) - \psi H(k^i)[q - w(k^i)] \\ &= (\phi q - \psi) f'(k^i)\end{aligned}$$

In addition, the probability of receiving funding for a potential borrower is $\mu^i = k^i / \phi \alpha q$. It follows that the ex ante (prior to the revelation of whether funding is received) expected utility of a potential borrower is

$$V(k^i) \equiv \left(\frac{\phi q - \psi}{\phi \alpha q} \right) k^i f'(k^i) + \left(\frac{\phi \alpha q - k^i}{\phi \alpha q} \right) \psi w(k^i) H(k^i); \quad i = 1, 2 \quad (6.1)$$

We now state our first welfare result. The result asserts conditions under which the utility of lenders is increasing in k^i .

Proposition 6.1. (a) Suppose that $k^i \geq f^{-1}(q)$. Then $w(k^i)H(k^i)$ is strictly increasing in k^i . (b) Suppose that $\delta \geq 0.5$. Then $w(k^i)H(k^i)$ is strictly increasing in k^i .

The proofs of propositions 6.1-6.3 appear in appendices A-C respectively. The proposition implies that lenders in country 1 always benefit from actions that raise k^1 . Lenders in country 2 necessarily benefit from actions that raise k^2 if $\delta \geq 0.5$.

We now need to determine when potential borrowers benefit, in an ex ante sense, from increases in the capital stock. Differentiating (6.1) we obtain

$$\begin{aligned} \phi\alpha q V'(k^i) &= (\phi q - \psi) f'(k^i) \{1 + [k^i f''(k^i)/f'(k^i)]\} \\ &+ \left(\frac{\phi\alpha q - k^i}{k^i}\right) \psi w(k^i) H(k^i) \left\{ \frac{k^i w'(k^i)}{w(k^i)} + \frac{k^i H'(k^i)}{H(k^i)} \right\} \\ &- \psi w(k^i) H(k^i). \end{aligned} \tag{6.2}$$

We now state conditions under which $V'(k^i) > 0$ holds for the relatively wealthy country.

Proposition 6.2. Suppose that $\phi q > \psi$, and that $w(k^+) \leq q - (\psi/\phi)$.²⁶ Then $V'(k^i) > 0$ holds for all $k^i \in [f^{-1}(q), k^+]$ if the following two conditions are

²⁶This condition implies that (3.18) holds for all $k^i \leq k^+$.

satisfied:

$$(q/D)^{1/\delta} \geq \delta\phi q\alpha/(1+\delta) \quad (6.3)$$

$$\delta[(1-\delta)D]^{(1/\delta)} \geq \frac{[q - (\psi/\phi)]^{(1/\delta)}}{\phi\alpha q}. \quad (6.4)$$

Since $k^1 \in [f^{-1}(q), k^+]$ at point A in figure 4, it follows that $V'(k^1) > 0$ if the conditions of the proposition are satisfied. Thus, when these conditions hold, both potential borrowers and lenders in country 1 benefit (in an ex ante sense) from increases in τ^1 (as long as $\tau^1 \in [\tau^2, \bar{\tau})$). Intuitively, if the probability of receiving a loan is sufficiently low, which the conditions of proposition 6.2 guarantee, then the ex ante welfare of potential borrowers will not differ significantly from the welfare of savers. As a result, policy actions that increase the steady state capital stock will also increase the ex ante expected utility of potential borrowers.

Evidently, if the conditions of proposition 6.2 are satisfied, potential borrowers and lenders (at least from the perspective of the steady state) in country 1 will unanimously approve high taxation of capital income earned by foreigners. And, if $\delta \geq 0.5$, at a point like A , higher taxation of this income is also beneficial to lenders in country 2. We now describe when potential borrowers in country 2 are also benefited by increases in τ^1 (starting from the point A in Figure 4).

Proposition 6.3. *Suppose that $\delta \geq 0.5$ and $\phi\alpha q \geq \psi(1 - \delta + \delta^2)/\delta^2$. Then $V'(k^i) > 0$ holds for all $k^i \leq f^{-1}(q)$.*

It is now clear that if the conditions of proposition 6.2, and 6.3 hold simultaneously, all agents in all countries benefit from setting $\tau^1 = \bar{\tau}$ (in a steady state). And we emphasize that these are merely sufficient, and far from necessary conditions for such a result to obtain.

7. Examples

We now provide some examples illustrating these points. In particular, we provide several examples with 3 nontrivial steady states, as in Figure 4. In addition, we demonstrate that, in the examples, the steady states at A and C are asymptotically stable, while the steady state at B is a saddle. Finally, the examples illustrate that dynamical equilibrium paths approaching points A and C can display endogenous oscillation as they do so. Thus not only can the operation of international capital markets impoverish one of the countries, but it can lead to fluctuations arising as the result of self-fulfilling prophecies.

To analyze local dynamics at each steady state, we replace (4.5) and (5.1) with

the linear approximation

$$(k_t^1 - k^1, k_t^2 - k^2)' = J(k_{t-1}^1 - k^1, k_{t-1}^2 - k^2)',$$

where J is the Jacobian matrix

$$J = \begin{bmatrix} \frac{\partial k_t^1}{\partial k_{t-1}^1} & \frac{\partial k_t^1}{\partial k_{t-1}^2} \\ \frac{\partial k_t^2}{\partial k_{t-1}^1} & \frac{\partial k_t^2}{\partial k_{t-1}^2} \end{bmatrix}$$

with all partial derivatives evaluated at the appropriate steady state. The properties of the local dynamics are then governed by the eigenvalues of J .

7.1. Example 1

The specific numerical example we consider has $f(k) = .85k^{.66}$, $q = .045$, $\gamma = .1064711$, and $g(z) = \bar{z}^{-1}$ (uniform distribution) with $\bar{z} = 3.73205$ and $\gamma = 0.1064711$. For these parameter values $\phi = 1$ and $\eta = 1.36603$ hold.

If $\tau_1 = \tau_2 = 0$ is satisfied, so that there is no taxation of interest income, and therefore no interference with capital flows, then there are three nontrivial (k^1, k^2) pairs: $(k^1, k^2)^C = (0.00161283, 0.032879)$, $(k^1, k^2)^B = (0.025966, 0.025966)$

and $(k^1, k^2)^A = (0.032879, 0.00161283)$.²⁷

As noted previously, Boyd and Smith (1997) show that the symmetric steady state is a saddle (here the relevant eigenvalues are .66 and 2.65). The symmetric steady state cannot be approached unless $k_0^1 = k_0^2$. The eigenvalues at each asymmetric steady state are $0.517917 \pm 0.406507i$. It follows that the asymmetric steady states are sinks, and that equilibrium paths approaching them display endogenously arising volatility that dampens asymptotically.

If τ_1 is set equal to 0.1 (with $\tau_2 = 0$), then there continue to be three steady states. The steady state corresponding to point *A* in Figure 6 has $k^1 = 0.033739$ and $k^2 = 0.002164$, so that country 2 continues to be quite poor relative to country 1. Nonetheless, an increase in the rate of capital income taxation by country 1 has led to an increase in the capital stock of each country (relative to the asymmetric steady state that obtains with $\tau_1 = \tau_2 = 0$). And the proportional effect on the capital stock of country 2 is much larger than that in country 1: the steady value of k^2 rises by more than 34% while the steady state value of k^1 rises by only 2.6%. Finally, we note that this asymmetric steady state continues to be a sink, and that paths approaching it continue to display endogenous volatility. The relevant

²⁷It is easy to verify that credit is rationed in each country in each of the steady states, and that (3.18) is satisfied. This is true for all of the tax rates considered here.

eigenvalues of J are $\lambda = .05484 \pm 0.3949i$.

When $\tau_1 = .1$, the steady state corresponding to point B has $k^1 = 0.028339$ and $k^2 = 0.0234395$. This steady state is a saddle: the eigenvalues of J are 0.70183 and 1.77418 .

For this example, if $\tau_2 = 0$, then $\bar{\tau} = 0.361124$. When $\tau_1 = \bar{\tau}$, then $k^1 = k^+ = 0.03637976$, and $k^2 = \tilde{k} = 0.0076486$. Of course setting $\tau_1 = \bar{\tau}$ maximizes the capital stock of country 1. And, the capital stock of country 2 can only be increased further at the expense of a lower capital stock in country 1. But note that the capital stock of country 2, while still quite low relative to that of country 1, is more than 3.5 times greater than was the case with $\tau_1 = 0.1$. Thus increases in the rate of taxation by country 1 can have substantial long-run benefits for country 2.

The steady state corresponding to point A in Figure 6 continues to be a sink when $\tau_1 = \bar{\tau}$: the eigenvalues of J are $0.78592 \pm 0.25543i$. Thus, in this example, country 1 cannot eliminate endogenous volatility.

Finally, we observe that $f(\bar{k}) < q$ holds. But the steady state corresponding to point B in Figure 6 has $k^1 = 0.0363795$ and $k^2 = 0.0076498$, so that points A and B are only trivially different. This fact indicates that $\bar{\tau}$ is not much less than

τ^* .²⁸ Thus country 1 cannot set its tax rate much above $\bar{\tau}$ without eliminating all steady states that have $k^1 > k^2$.

8. Conclusions

This paper presents a formal analysis of erecting barriers to international capital flows. Specifically, we review the conventional presumption, which appears to be that the “victims” of highly volatile capital flows should be allowed to limit or restrict inflows and outflows of funds. We find that, in contrast to conventional thinking, when there are substantial differences in per capita GDP across countries, long-run output in all countries can be increased by having wealthier economies erect some partial barriers to capital mobility. Note that these wealthier economies need not persuade poorer economies to cooperate: by implementing an appropriately selected tax on capital flows it will often be the case that the wealthy economy can unilaterally obtain a higher steady state welfare level for all agents in all economies. And, finally, we also establish the existence of an upper bound on the rate of capital taxation that maximizes the rich country’s GDP in a steady state.

We also show that these same barriers need not eliminate endogenously arising

²⁸ τ^* is quite difficult to locate numerically.

volatility in income, capital flows and asset returns. Under some circumstances, then, if it is desirable to reduce such volatility, this must be accomplished by other means. However, and this bears emphasis, the case for imposing barriers on capital flows does not depend critically on the ability of these barriers to eliminate excess volatility.

9. Appendices

A. Proof of proposition 6.1.

(a) $w'(k^i) > 0$ holds $\forall k^i$. And, for $k^i \in [f^{-1}(q), w^{-1}(q))$, $H'(k^i) \geq 0$ holds.

Thus $w(k^i)H(k^i)$ is strictly increasing in k^i . \square

(b) Note that $w(k^i)H(k^i) = w(k^i)f'(k^i)/[q - w(k^i)]$. If $\delta \geq 0.5$, then $w(k^i)f'(k^i)$

is nondecreasing in k^i . The claim follows immediately. \square

B. Proof of proposition 6.2.

Given our specification of the production technology,

$$kf''(k)/f'(k) = \delta - 1, kw'(k)/w(k) = \delta \text{ and } kH'(k)/H(k) = \delta - 1 + \{\delta w(k)/[q - w(k)]\}$$

hold. Substituting these relations into (6.2) and rearranging terms yields

$$\phi \alpha q V'(k^i) = \delta(\phi q - \psi) f'(k^i) \tag{9.1}$$

$$+\psi w(k^i)H(k^i) \left\{ \left(\frac{\phi\alpha q - k^i}{k^i} \right) \left[(2\delta - 1) + \left(\frac{\delta w(k^i)}{q - w(k^i)} \right) \right] - 1 \right\}$$

It follows from (9.1) and the definition of H that $V'(k^i) > 0$ holds iff

$$\delta(\phi q - \psi) \geq \left[\psi \frac{w(k^i)}{q - w(k^i)} \right] \left\{ 1 - \left(\frac{\phi\alpha q - k^i}{k^i} \right) \left[\frac{\delta q}{q - w(k^i)} - (1 - \delta) \right] \right\} \quad (9.2)$$

We now observe that

$$1 \geq \left(\frac{\phi\alpha q - k^i}{k^i} \right) \left\{ \frac{\delta q}{q - w(k^i)} - (1 - \delta) \right\} \quad (9.3)$$

holds $\forall k^i \geq f^{-1}(q) = (q/D)^{1/\delta}$ iff

$$1 \geq \delta \left[\frac{\phi\alpha q - (q/D)^{1/\delta}}{(q/D)^{1/\delta}} \right] \quad (9.4)$$

is satisfied. Rearranging terms in (9.4) yields (6.3). Moreover, when (9.3) obtains, we may proceed as follows. Since $w(k^+) \leq q - (\psi/\phi)$, it follows that $\psi/[q - w(k^i)] \leq \phi$ for all $k^i \leq k^+$. Therefore, $\psi w(k^i)/[q - w(k^i)] \leq \phi w(k^i) \leq \phi q - \psi$ holds for all $k^i \leq k^+$. Using this fact in (9.2), it is evident that $V'(k^i) > 0$ holds for all $k^i \in [f^{-1}(q), w^{-1}[q - (\psi/\phi)]]$ if (6.3) and

$$\left(\frac{\phi\alpha q - k^i}{k^i}\right) \left\{ \frac{\delta q}{q - w(k^i)} - (1 - \delta) \right\} \geq (1 - \delta) \quad (9.5)$$

holds. We now establish conditions that are sufficient for the satisfaction of (9.5).

To do so, we note that for all $k^i \in [f^{-1}(q), w^{-1}[q - (\psi/\phi)]]$, (9.5) is satisfied if

$$\delta(\phi\alpha q - k^i) \geq (1 - \delta)k^i. \quad (9.6)$$

Rearranging terms in (9.6), yields the equivalent condition

$$\delta\phi\alpha q \geq k^i \quad (9.7)$$

But, since $k^i \leq w^{-1}[q - (\psi/\phi)] = \{[q - (\psi/\phi)]/(1 - \delta)D\}^{1/\delta}$, (9.3) must hold $\forall k^i \in [f^{-1}(q), k^+]$ if

$$\delta\phi\alpha q \geq \left[\frac{q - (\psi/\phi)}{(1 - \delta)D} \right]^{1/\delta}. \quad (9.8)$$

This establishes the proposition. \square

C. Proof of proposition 6.3

If $\delta \geq 0.5$, then

$$\psi \left[\frac{w(k^i)}{q - w(k^i)} \right] \left\{ 1 - \left(\frac{\phi \alpha q - k^i}{k^i} \right) \left[\frac{\delta q}{q - w(k^i)} - (1 - \delta) \right] \right\} < \psi \left[\frac{w(k^i)}{q - w(k^i)} \right]$$

holds. It follows that $V'(k^i) > 0$ if

$$\delta(\phi \alpha q - \psi) \geq \psi \left[\frac{w(k^i)}{q - w(k^i)} \right] \quad (9.9)$$

is satisfied. But, for $k^i \leq f^{-1}(q)$, $\frac{w(k^i)}{q - w(k^i)} \leq (1 - \delta)/\delta$. Thus (9.2) (and $V'(k^i) >$

0) holds for all $k^i \leq f^{-1}(q)$ if

$$\phi \alpha q \geq \psi(1 - \delta + \delta^2)/\delta^2. \square \quad (9.10)$$

10. References

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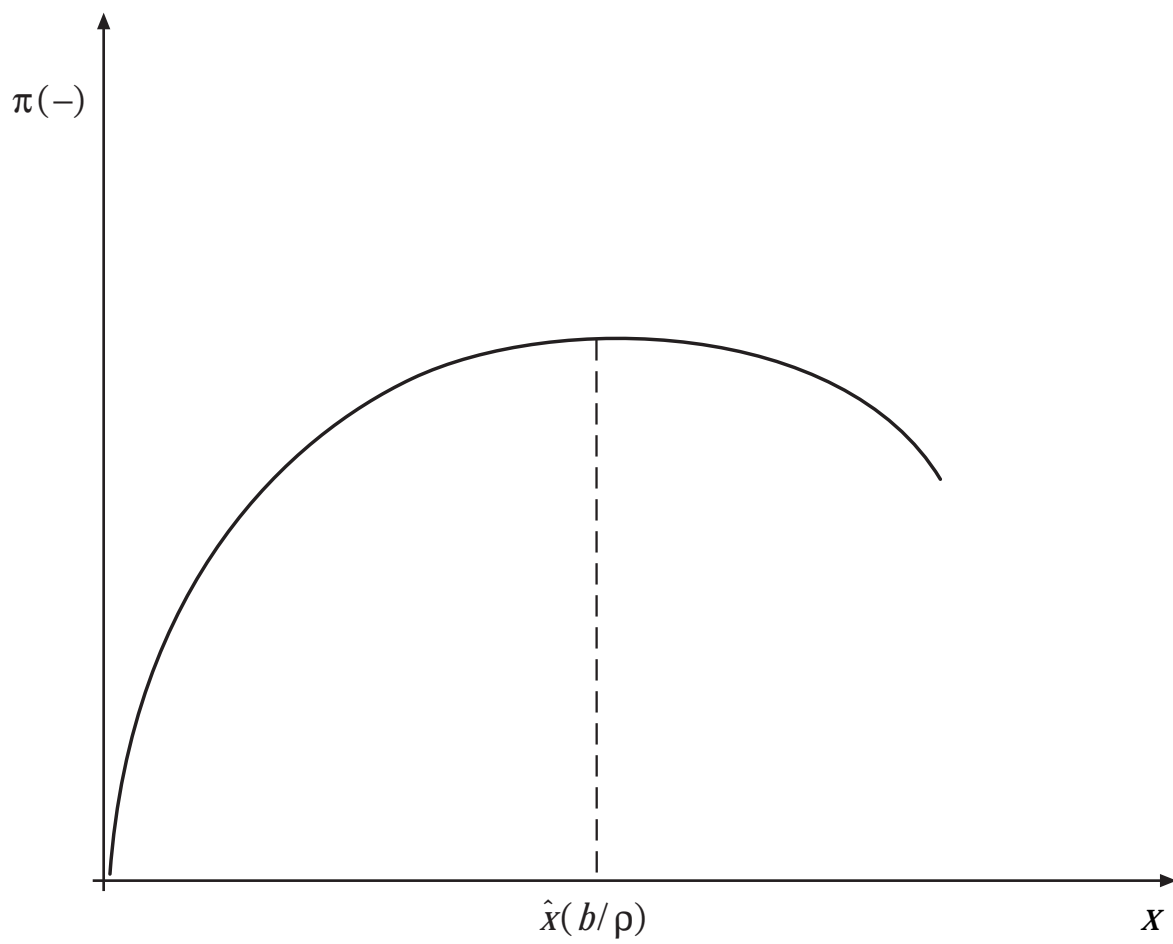


Figure 1

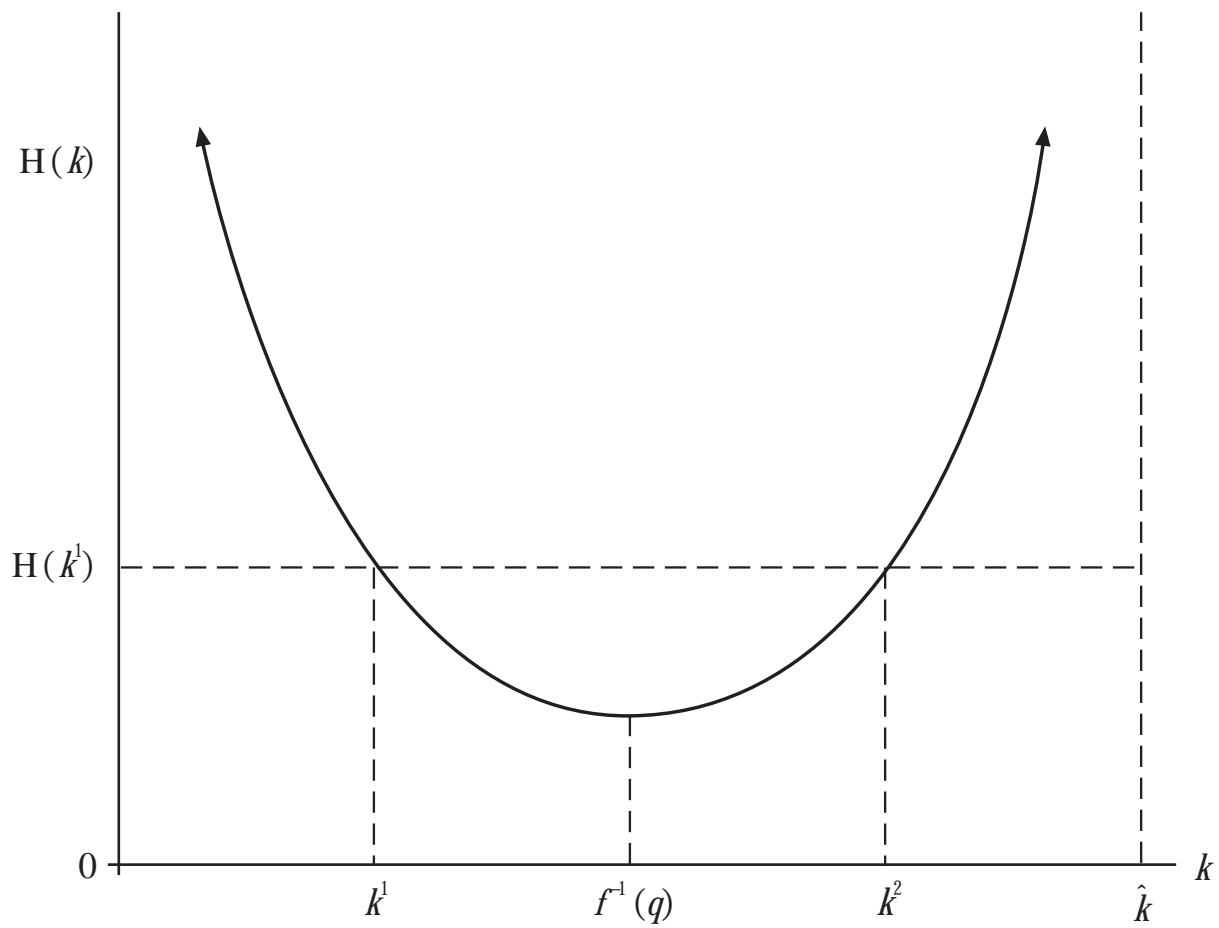


Figure 2

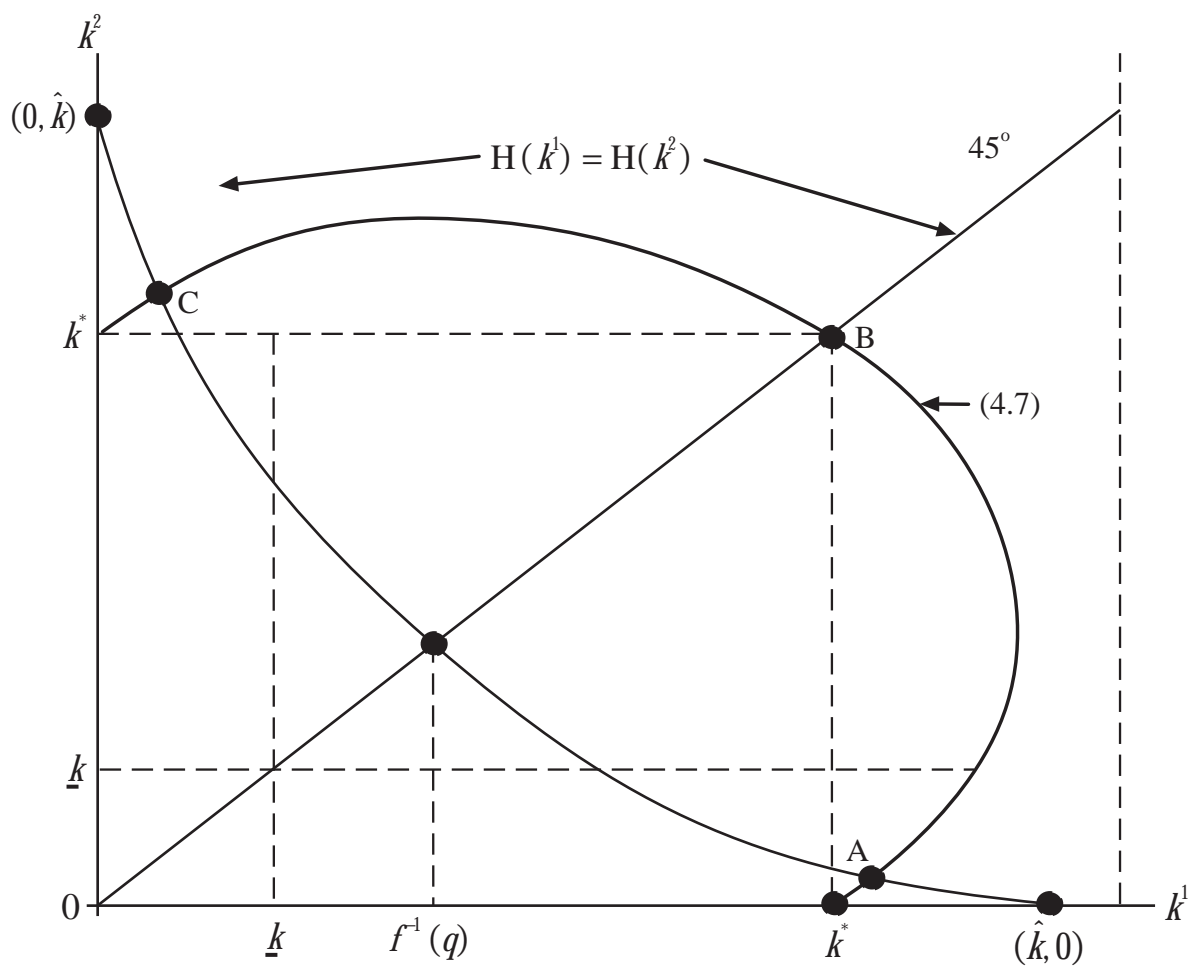


Figure 3

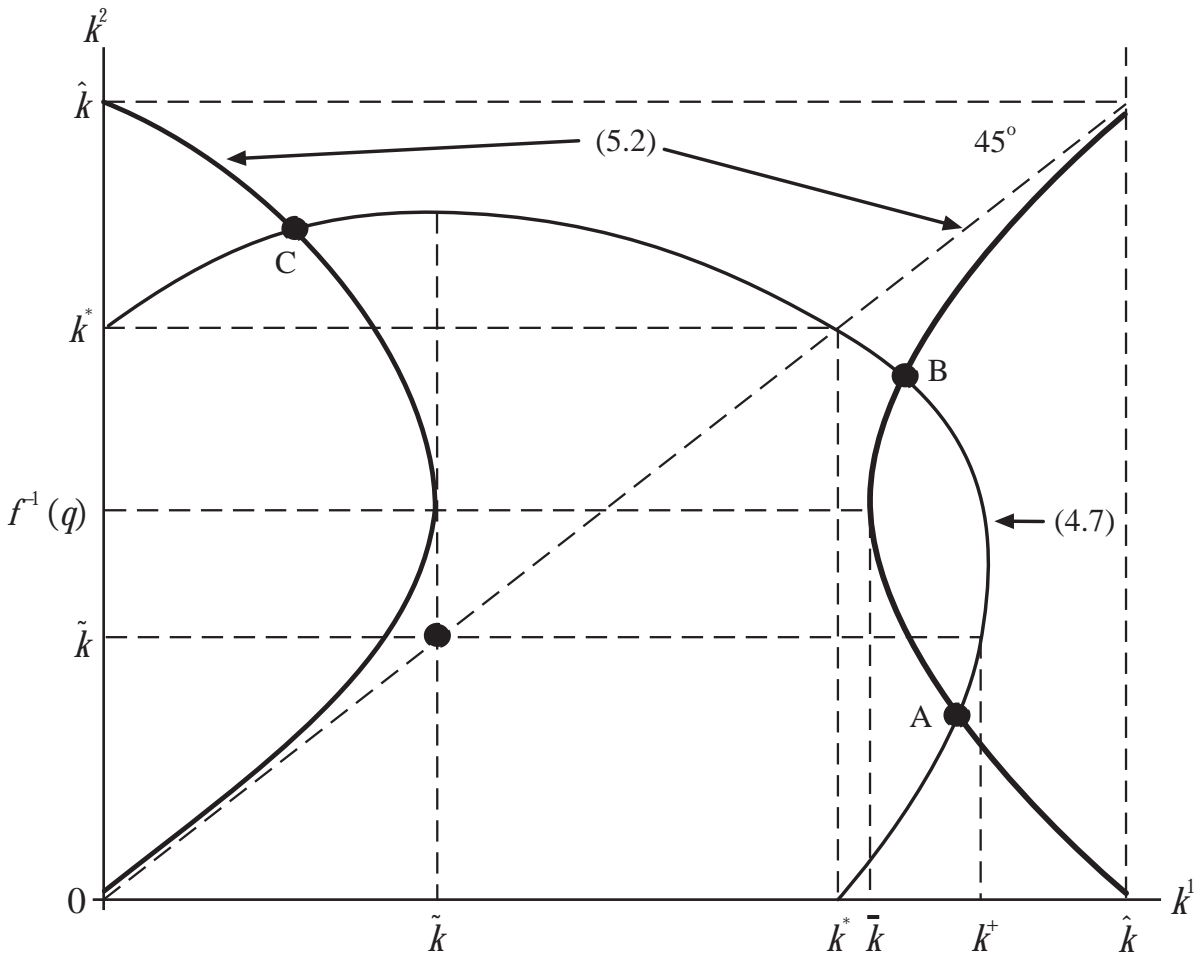


Figure 4

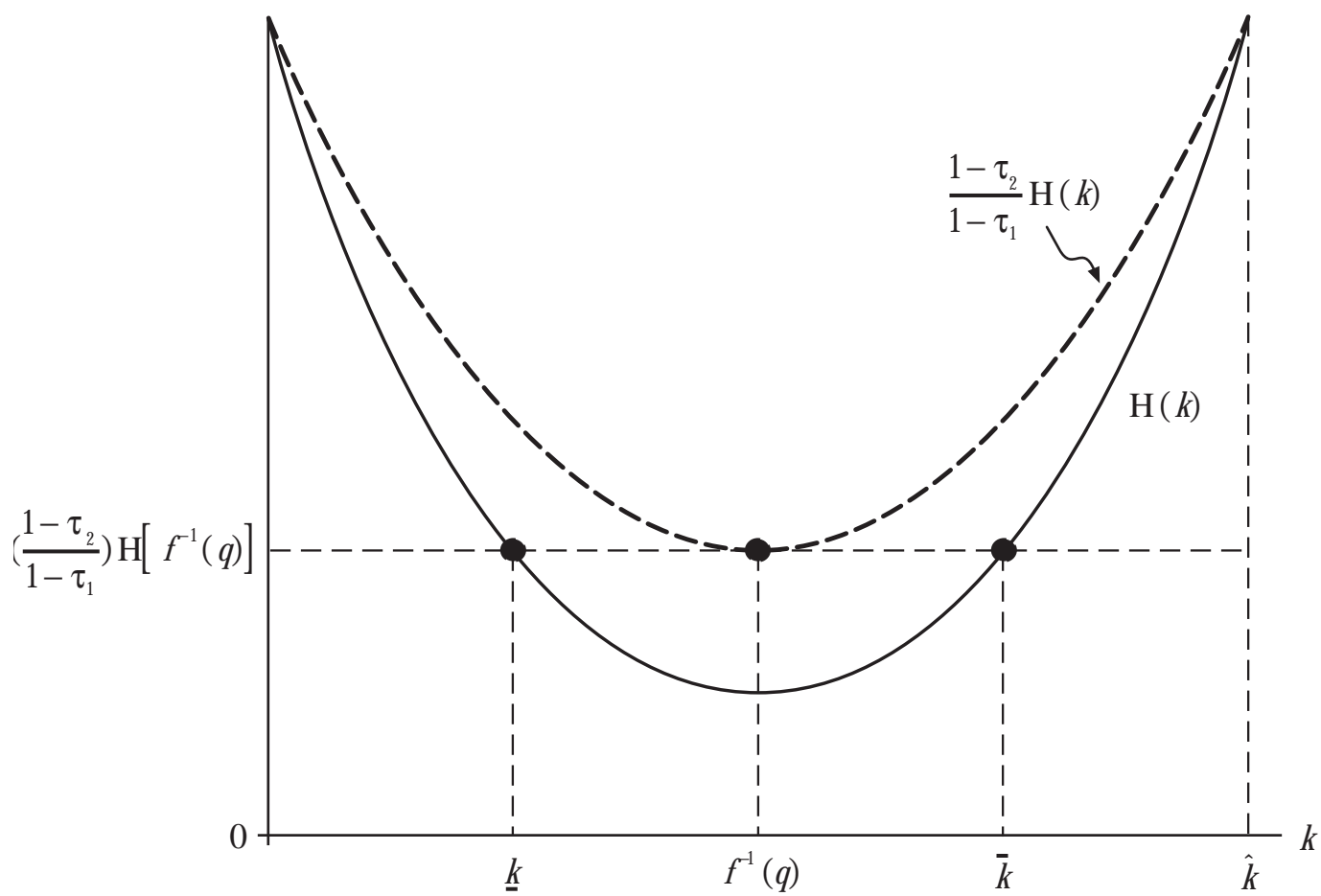


Figure 5

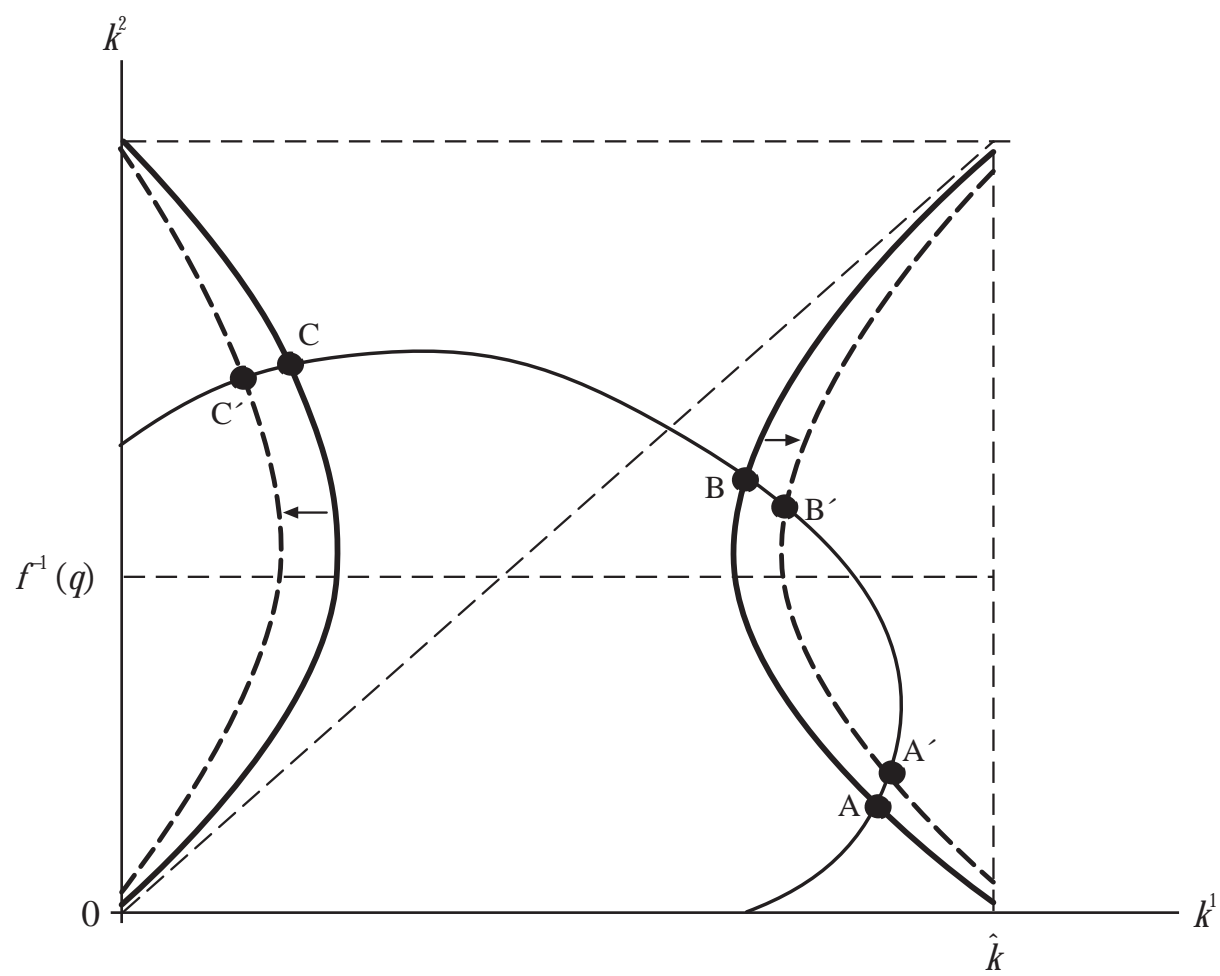


Figure 6
An increase in τ