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The Role of Stock Markets in International Economic Integration

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Abstract

The paper studies the role of stock markets in international economic integration in a two country one-good model where intertemporal optimizing behavior of infinitely-lived agents endogenously determines the rate of capital accumulation and the current account. It highlights the significance of adjustment costs and equity prices for the time path the integrated world economy follows upon introduction of intertemporal trade.

I. Introduction

Two recent developments, the establishment of stock markets in a large number of developing countries including many Eastern European economies, and the integration of these emerging markets with those of the developed countries are in the process of reshaping the world economy. These developments have redirected the attention of policymakers and economists alike to the study of regime switches from portfolio autarky to free trade and to the role stock markets play in the transition.

There exists an extensive and rapidly expanding literature which marshals a wide array of setups to pin down the determinants of interest rates,

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capital accumulation and international debt in a world with integrated goods, capital and stock markets.[1] In what follows, I wish to foreground the hitherto-unexplored consequences of the interplay between two related elements for the analysis of regime switches from portfolio autarky to intertemporal trade: Adjustment costs in investment and equity prices.

I take the contrast between the costly process of relocating physical resources across uses and countries, and the costless and instantaneous process of purchase and sale of ownership claims to these resources as fundamental. Consequently, I discard what Obstfeld [1989] characterizes as "perhaps the most unrealistic . . . assumption . . .", the assumption of "perfect international capital mobility". Instead, I emphasize both the adjustment costs involved in the relocation of physical capital, and the costless and instantaneous reshuffling of ownership claims thereto, in a world revolutionized by the advances made in communications technology.

The model I use is a two-country general equilibrium setup in which the rate of capital accumulation and the current account are endogenously determined by the intertemporal optimizing behavior of infinitely-lived agents.[2] Households are assumed to have recursive time preferences with the well-known implication that the world distribution of wealth is not hysteretic as in the constant rate of time preference model of Lipton and Sachs [1983].[3] Unlike Buiter [1981] which uses an overlapping-generations model that is not amenable to short-run analysis, the setup here enables one to completely trace the time path of the world economy starting with the short run. In addition, the adjustment-cost model developed here subsumes the model of Devereux and Shi [1991] as a special case with no adjustment costs.[4] Furthermore, in the model of Devereux and Shi [1991] the current account is more persistent than investment. However, the

1. For my purposes the most significant contributions are those of Ruffin [1979], Buiter [1981], Lipton and Sachs [1983], Frenkel and Razin [1985, 1986, 1992], Obstfeld [1989], Devereux and Shi [1991].
2. The model I develop here is a two-country extension of Karayalcin [1994].
3. For models which adopt the Uzawa-Epstein recursive time preference function in open economy models see Penati [1987], Mendoza [1991], Devereux and Shi [1991], Shi [1994], and Karayalcin [1995].
4. Though, Devereux and Shi [1991] do not discuss the regime switch from autarky to trade, their model can easily be used to do this.

strong observed correlation between domestic savings and investment suggests opposite conclusions on speeds of adjustment.[5] The present paper obtains the empirically more plausible opposite result in the presence of adjustment costs.

The conclusions that emerge from the paper attest to the importance of the role stock markets and equity prices play in the move from autarky to intertemporal trade. The opening up of trade and the immediate establishment of a world stock market ushers in a period of monotonic growth in both the world capital stock and the aggregate world consumption. The time profiles of physical capital stocks in each country, of the world real rate of interest, of national consumption levels, and of equity prices depend on whether adjustment costs exceed or fall short of a critical level determined below. The paper focuses on high adjustment costs, because as mentioned above, the transient paths implied by low costs are empirically untenable. A central finding of the paper is that if adjustment costs are high (relative to the critical level), equity prices of both the lender and borrower countries jump when stock markets are integrated. On the adjustment path equity prices of the borrower gradually decline but lie above their steady state level. Equity prices in the lender country display a nonmonotonic adjustment path, declining initially, and rising later. Another important result obtained in the paper is that under adjustment costs higher than the critical level, the world real rate of interest rises with the world capital stock and aggregate world consumption. This, of course, is impossible within a framework of instantaneous capital shiftability, as long as the marginal productivity of capital falls with an increase in the capital stock. It is impossible because in such a framework the world interest rate is uniquely determined by the marginal productivity of capital in each country, and at a point in time marginal productivities are equalized across countries by the costless and instantaneous relocation of physical capital stocks. By contrast, here such metaphysical relocation cannot occur. Instead, given the historically determined levels of physical capital stocks, at a point in time equity prices adjust to equilibriate the stock market, and thus alter the world real rate of inter-

5. On this see, among others, Feldstein and Horioka [1980], Obstfeld [1986], and Tesar [1991].

est. Over time, the rise in the world capital stock alone tends to reduce the interest rate by decreasing both the marginal productivity of capital and equity prices. As shown below, this negative effect is smaller, the higher are the adjustment costs. On the other hand, the simultaneous rise in world consumption increases the average rate of time preference. The consequent worldwide tendency to substitute current consumption for future consumption tends to raise the price of current output relative to future output, *i.e.* the world interest rate. If adjustment costs exceed the critical level, the net effect is a rise in the world real rate of interest.

In addition, as long as adjustment costs exceed zero there is the possibility of nonmonotonic adjustment of physical capital stocks and equity prices – a possibility ruled out, for instance, by the zero-adjustment -cost model of Devereux and Shi [1991]. Thus, the country which reduces its steady-state physical capital stock may initially decumulate or accumulate too much, depending on the magnitude of adjustment costs.[6] In any case, this behavior is dictated by the nonmonotonic movement of numéraire equity prices which must at a point in time take on values to clear both the world output market and the world stock market. However, I show that the *relative* equity price (the ratio of the prices of equities, expressed in terms of the numéraire, issued by the firms in the two countries) adjusts monotonically and in the direction dictated by the steady-state changes in the world capital stock.

The paper is organized as follows. I begin with the autarkic country model in section II, proceed with the effects of intertemporal trade in the long-run and along the adjustment path in section III. Section IV provides some concluding remarks.

II. The Autarky Equilibrium

Consider a closed economy with two types of agents: households and firms. The economy produces a single homogeneous commodity that can

6. Obviously, a more general instantaneous utility function than the logarithmic function used by Devereux and Shi [1991] may generate nonmonotonic adjustment paths even in the absence of adjustment costs. But the fact still remains that adjustment costs in investment give rise to more complex dynamic adjustment paths by themselves.

be used for both consumption and investment. I now turn to a detailed description of household and firm behavior.

A. Households

Each household is infinitely-lived and has perfect foresight. For simplicity, I normalize the number of identical households to unity. In autarky, the portfolio of a representative household consists of a single asset – equity issued by domestic firms. Each equity represents a claim to one unit of the capital stock. Further, households supply one unit of labor inelastically per unit of time. They take the rate of return on equity, ρ, and the wage rate, w, as given and maximize the lifetime welfare functional U(C) over consumption path C:

$$\max \; U(C) = -\int_0^\infty \exp[-z(t)]\exp[-\int_0^t \rho(\tau)d\tau]dt \tag{1}$$

subject to

$$\dot{z}(t) = u[c(t);\alpha] - \rho(t), \; \alpha > 0 \tag{2}$$

$$\dot{a}(t) = \rho(t)a(t) + w(t) - c(t) \tag{3}$$

where u is the instantaneous utility function with $u > 0$, $u' > 0$ and $u'' < 0$;[7] c is consumption; α is a shift parameter measuring generalized time preference; a stands for the nonhuman wealth of a representative household.

The lifetime welfare functional U was first proposed and studied by Epstein and Hynes [1983]. It differs from the conventional time additive utility functionals frequently used in the literature by its recursivity, which implies that the marginal rate of substitution between times t and s ($s > t$) is independent of consumption before t but not after s. This structure gives rise to a variable rate of time preference Ω at time s:

$$\Omega(s) = [\int_s^\infty \exp\{-\int_s^t u(c;\alpha)d\tau\}dt]^{-1} \tag{4}$$

7. Note that in the Epstein and Hynes [1983] formulation of the endogenous time preference, the discount rate and the instantaneous utility function coincide, yielding an analytically convenient conceptualization that preserves the essential properties of more general formalizations discussed in Epstein [1987] and Obstfeld [1990].

with $\Omega > 0$. Observe that $\Omega(s)$ is the following function of the utility functional $\boldsymbol{U}$

$$\Omega(\phi(s)) = -1/\phi,\ \phi(s) \equiv \boldsymbol{U}({}_sC)$$

where ${}_sC$ stands for that part of the consumption path C beyond time s. When the consumption path is globally constant, as in long-run equilibrium, $\boldsymbol{U}({}_sC) = -1/u(\bar{c};\,\alpha)$ (overbars denote long-run equilibrium) and the rate of time preference is given by

$$\Omega(\bar{\phi}) = u(\bar{c};\,\alpha) \tag{6}$$

The condition imposed upon the instantaneous utility function that $u' > 0$ implies that Ω is increasing in the consumption path C. This assumption is called "increasing marginal impatience" by Lucas and Stokey [1984]. Though several arguments have been advanced in support of this assumption, for our purposes it is sufficient to point out that local stability will fail to obtain in its absence.[8]

The solution of the standard intertemporal utility maximization problem yields the following law of motion for the representative household's consumption

$$\dot{c} = (u'/u'')\,[\Omega(\phi) - \rho] \tag{7}$$

If we make the simplifying assumption that instantaneous utility is logarithmic so that the propensity to consume out of wealth is independent of the rate of interest and write $u(c;\alpha)$ as

$$u(c) = \alpha + ln(c), \tag{8}$$

equation (7) becomes

$$\dot{c} = [\rho - \Omega(\phi)]c \tag{9}$$

Finally, the solution of the intertemporal utility maximization problem of the representative household shows that its lifetime utility evolves according to the following dynamic law,

8. See Epstein [1987] and Obstfeld [1990] for theoretical arguments and empirical studies supporting "increasing marginal impatience".

$$\dot{\phi} = 1 + u(c;\alpha)\phi \tag{10}$$

B. Firms

Identical, competitive firms employ capital and labor to produce the single storable good. Since there are adjustment costs in investment, it takes $i[1+T(i/k)]$ (where T denotes the installation technology) units of output to accumulate capital, k, by i units. If, as I assume, the installation-cost function is linearly homogeneous in i and k, and satisfies

$$T = T(i/k),\ T(0) = 0,\ T'(\cdot) > 0,\ 2T'(\cdot) + (i/k)T''(\cdot) > 0, \tag{11}$$

firms, maximizing the present value of their cash flow $g(k) - i(1+T) - w$ (where $g(k)$ denotes a constant-returns-to-scale production function with the usual Inada properties), set the shadow value q of investment equal to one plus the marginal cost of investment, that is

$$q = 1 + [T(\cdot) + (i/k)T'(\cdot)] \tag{12}$$

This implies that the rate of growth of the (per-capita) capital stock, i/k, is positively related to the "Tobin-q" – the excess of numéraire equity price over the unitary replacement cost of capital,[9]

$$i/k = \dot{k}/k = \varphi(q),\ \varphi'(q) > 0,\ \varphi(1) = 0. \tag{13}$$

where the last equality indicates that when $q = 1$, that is when the shadow value of capital equals the unitary replacement cost of physical capital, investment is zero.

Moreover, in addition to (12), present-value maximization by firms yields

$$w = g(k) - g'(k)k \tag{14}$$

Having described agent behavior, I now turn to the discussion of markets and prices.

C. Markets and Prices

The real interest rate ρ, of the economy coincides with the expected rate of return on equity which is the sum of the current yield on equity,

9. Note that under our assumptions "Tobin's average q" and "Tobin's marginal q" coincide ⟨Hayashi [1982]⟩.

$(\pi + qi)/qk$, and expected – given perfect foresight, actual – capital gains, $\dot{q}/q$. Thus,

$$\rho \equiv (\pi + qi)/qk + \dot{q}/q \tag{15}$$

The first term on the right-hand side of (15) follows from the assumption that total current payout by firms to equity-holders has two components:[10] Cash dividends, $\pi \equiv g(k) - i(1+T) - w$, and the value of equity dividends, qi.

Consider now the economy's market structure. In autarky there are only two markets functioning: A market for output and a market for capital (or loanable funds). By Walras' Law these two markets are mirror images of each other. For the output market to be in equilibrium output must equal the sum of consumption and investment, thus:

$$g(k) = i(1+T)+c \tag{16}$$

which, recalling (13), solves for the numéraire equity price q as a function of the capital stock k and consumption c:[11]

$$q = q(k, c) \; q_1 > 0, q_2 < 0. \tag{17}$$

Ceteris paribus, an increase in the capital stock, k, or a decrease in consumption, c, creates an excess supply of output. This is eliminated by a rise in q, which increases investment.

In autarkic equilibrium households can hold only equity issued by domestic firms. Consequently, portfolio diversification is impossible and the stock market that plays a significant role later in the analysis lies dormant in autarky.

The three differential equations (9), (10) and (13) constitute the dynamic system governing the motion of the autarkic economy over time. By the use of standard methods, it can be easily shown that the system is (locally) saddle-path stable.

From (9) and (10) in the steady state the rate of time preference equals

10. This reflects the assumption that firms finance investment exclusively through retained earnings. It is well-known that in certainty models like this one all modes of financing are equivalent.

11. The partials immediately below and the rest of the paper are evaluated in the neighborhood of a steady state, and are given explicitly in appendix 1.

the real rate of interest:

$$u(\bar{c}_A;\alpha) = \bar{\Omega}_A = -1/\bar{\phi}_A = \bar{\rho}_A = g'(\bar{k}_A) \tag{18}$$

where subscripts A indicate autarky.

For future reference observe from (3)-(18) that

$$d\bar{k}_A/d\alpha < 0, \tag{19}$$

that is, the autarkic steady-state capital-labor ratio decreases with α.

III. The Two-Country Equilibrium

Suppose now that the world consists of two economies, labeled home and foreign, of the type described above. I shall assume that these two differ only with respect to their rate of time preference. Let the foreign country be the impatient, *i.e.* the high-rate-of-time-preference, country. In light of (4), the way to define impatience here is to stipulate that the home country is more patient than the foreign country if $\Omega^* > \Omega$ (where *'s denote foreign variables) when both face the same consumption stream. This is equivalent to requiring that $u^*(\alpha^*, c) > u(\alpha, c)$ for the same c. With our specification of the instantaneous utility function, this condition becomes $\alpha^* > \alpha$. From (19) it then follows that

$$\bar{\Omega}^*_A = \bar{\rho}^*_A > \bar{\Omega}_A = \bar{\rho}_A \tag{20}$$

so that the foreign country has the higher rate of time preference and a higher rate of return on equity in the autarkic steady state.

In what follows I study the effects of an unexpected opening up of intertemporal trade, say at $t = 0$, in the common good and equities. To see the consequences of this move, we have to discuss first the behavior of households and firms within the context of markets.

A. Households and Firms

Domestic and foreign households face, *mutatis mutandis,* the same lifetime welfare maximization problem discussed in the previous section. Of course, the opening up of trade changes the sequence of wage rates and rates of return on equity households take as given. But, home households are still bound by the budget constraint (3) and their optimal consumption follows the law of motion given by (9). Foreign households face a similar constraint and follow a similar consumption rule.

The presence of intertemporal trade between the two countries requires a revision of the definition of household wealth. Hence,

$$a \equiv qk + q^{*}b, \quad a^{*} \equiv q^{*}k^{*} - q^{*}b \tag{21}$$

where b represents home households' holdings of equity issued by foreign firms. Given $\alpha^{*} > \alpha$ and (20), $b > 0$.[12]

Present value maximization by firms everywhere imply that equations (13) and (14) (and their foreign counterparts) hold.

B. Markets and Temporary Equilibrium

To describe the equilibrium, I shall concentrate on three markets: the world stock market, the world market for output, and the world capital market.

Assume that equities issued by domestic and foreign firms are perfect substitutes in the portfolios of households. This assumption implies that for existing *stocks* of equities to be willingly held, the expected yields on equities issued by domestic and foreign firms must be the same; that is world stock market equilibrium obtains. Thus,

$$\rho^{*} \equiv (\pi^{*} + q^{*}i^{*})/q^{*}k^{*} + \dot{q}^{*}/q^{*} = (\pi + qi)/qk + \dot{q}/q \equiv \rho \tag{22}$$

The common rate of return, ρ, on equity issued by domestic and foreign firms alike, equals the sum of the current yield and expected capital gains on any given type of equity. I assume that the installation technology T is identical across countries. It also helps to rewrite (22) in a slightly different form

$$\dot{\theta} = (\theta/q)\,[\pi + qi)/k - (\pi^{*} + \theta qi^{*})/\theta k^{*}],\ \theta = q^{*}/q. \tag{23}$$

where θ is the relative equity price.

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12. The analysis below will justify this choice.

Equilibrium in the world output market requires that world supply of output, $g(k) + g(k^*)$, equal the world consumption demand, $c + c^*$, and world investment demand, $i(1+T) + i^*(1+T^*)$, for output:

$$g(k) + g(k^*) = c + c^* + i(1+T) + i^*(1+T^*). \tag{24}$$

This can be solved for q,

$$q = q(k, k^*, \theta, c, c^*), \quad q_1 = q_2 > 0, \quad q_i < 0 \quad i = 3,4,5. \tag{25}$$

Ceteris paribus, increases in k and k^*, and decreases in θ (because it reduces q^* and, therefore, foreign investment), c, and c^* create an excess world supply of output. This is eliminated by a rise in q, which raises world investment.

I now turn to the analysis of world capital market equilibrium the clearance of which requires that net world household saving be equal to zero. It follows from (3), its foreign counterpart, and (21)-(23) that world capital market equilibrium requires

$$\dot{b} = (q^*)^{-1} [g(k) - i(1+T) + (\pi^* + q^* i^*)(b/k^*) - c] \tag{26}$$

This completes the description of the dynamic system. Using (25) in (22), (9) and its foreign counterpart solves for the point-in-time real interest rate of the economy,

$$\rho = \rho(k, k^*, \phi, \phi^*), \quad \rho_1 = \rho_2 < 0, \quad \rho_i > 0 \quad i = 3,4. \tag{27}$$

The intuition underlying the partial derivatives is as follows. A rise in k (or k^*) creates a world excess supply of output, which is eliminated by a decrease in the price of current output relative to future output, ρ. An increase in $\phi(\phi^*)$ raises the rate of time preference of home (foreign) households [(5)], making them relatively more impatient and leading to the substitution of current for future consumption. This raises ρ, the price of current output relative to future output.

(27) is used in (9) and its foreign counterpart to describe the evolution of the consumption of home and foreign households. These two equations, in conjunction with (10), (13) (and their foreign counterparts), as well as (23) and (26) yield a system of eight differential equations. This system possess-

es eight real eigenvalues, of which three are negative (see appendix 2). The transversality conditions, and the fact that the system has three predetermined variables — k, k^*, and b — imply that the system is (locally) stale.

The three negative eigenvalues of the system obtained in appendix 2 have the ranking $\gamma_1 < \gamma_2 < \gamma_3$ if $1 < \varepsilon\varphi'(1)$ (where $\varepsilon \equiv -g''(k)k/g'(k)$). The ordering is reversed if $1 > \varepsilon\varphi'(1)$.[13] Since this ordering affects the adjustment of the system, it is useful to consider its determinants here. It follows from the ranking that the higher are ε and $\varphi'(1)$, the more likely is the ranking $\gamma_1 < \gamma_2 < \gamma_3$. That is, the higher is the elasticity of marginal productivity of capital with respect to capital, and (as can be shown from the properties of the installation cost function T) the lower is the cost of installation, the more likely it is for γ_1 to be the lowest negative eigenvalue. Moreover, as installation (or adjustment) costs approach zero, $\varphi'(1) \to \infty$, $\gamma_1 \to \infty$, and $\mu \to 1$. That is, ***mutatis mutandis***, as adjustment costs approach zero, the eigenvalues γ_2 (because $\mu = 1$) and γ_3 coincide, as should be expected, with the eigenvalues of Devereux and Shi [1991], whose model assumes no adjustment costs. Since, I shall be concentrating on the consequences of adjustment costs for the time path of the world economy, it is useful to define a critical value for $\varphi'(1)$ as

$$\tilde{\varphi}'(1) = \varepsilon^{-1} \tag{28}$$

I shall call adjustment costs "high" ("low") if they are at such a level that $\varphi'(1) < \tilde{\varphi}'(1)$ $[\varphi'(1) > \tilde{\varphi}'(1)]$. The ranking $\gamma_1 > \gamma_2 > \gamma_3$ holds when adjustment costs are high.

C. The Steady State

First observe from (12), its foreign counterpart, and the definition of θ that in the steady state

$$\bar{q} = \bar{q}^* = \bar{\theta} = 1 \tag{29}$$

Using the definitions of π and π^*, and setting (9), (10), (13) (and their foreign counterparts), (23), and (26) equal to zero yields

13. For reasons of space, and at the expense of completeness, I shall not discuss the case $\varepsilon\varphi'(1)=1$, the solution for which can be readily obtained by standard methods.

$$\bar{\Omega} = u(\bar{c}, \alpha) = \bar{\rho} = -1/\bar{\phi} = g'(k) = \bar{\Omega}^* = u^*(\bar{c}^*, \alpha^*) = \bar{\rho}^* = -1/\bar{\phi}^* = g'(k^*) \quad (30)$$

which, recalling the assumption that $\alpha^* > \alpha$, give the result that $\bar{c} > \bar{c}^*$. Also, observe from (30) that in the steady-state international trade in equity equalizes the lifetime welfare of the home country, ϕ, with that of the foreign country, ϕ^*.

Further, using (3) (and its foreign counterpart), (30), and $\bar{c} > \bar{c}^*$, I obtain the fact that the home country is a net creditor at the steady state, *i.e.* $\bar{b} > 0$.

The following propositions are then easily established:[14]

Proposition 1: *The common steady-state intertemporal-trade capital-labor ratio lies between the autarkic capital-labor ratios.*

Corollary 1: *International trade in equity increases the steady-state world capital stock.*

Corollary 2: *International trade in equity lowers (raises) steady-state wages and raises (lowers)steady-state interest rates in the patient (impatient) country.*

Proposition 2: *International trade in equity raises (lowers) steady-state nonhuman wealth in the patient (impatient) country.*

Proposition 3: *International trade in equity raises (lowers) steady-state consumption of households of the patient (impatient) country.*

Corollary 3: *International trade in equity increases steady-state world consumption.*

Proposition 1 and its corollary 2 confirm the results of Ruffin [1979] and Buiter [1981]. Proposition 2 directly contradicts the result derived by Ruffin [1979] who uses an ad hoc savings rule. One way to interpret proposition 2 is to use it with the corollary to proposition 1, which, put differently, states that international trade raises the steady-state rate of return on nonhuman wealth, and lowers the steady-state rate of return on human wealth in the patient country. Thus, households in this country can be viewed as optimally changing the composition of their wealth: they accumulate nonhuman wealth (that is, equities) the rate of return on which rises. Foreign households do the opposite.

14. The proofs of the following are omitted for reasons of space. They are available from the author upon request.

D. The Adjustment Path

To see how the two economies adjust on the convergent path when trade is unexpectedly introduced, consider the following laws of motion for k and k^* obtained from the linearized system in Appendix 2 by using standard methods:[15]

$$\dot{k} = (1/2)\,[k(t) - \bar{k}]\,(\gamma_1 + \gamma_2) + (1/2)\,[k^*(t) - \bar{k}^*]\,(\gamma_2 - \gamma_1) \quad (31a)$$

$$\dot{k}^* = (1/2)\,[k(t) - \bar{k}]\,(\gamma_1 - \gamma_2) + (1/2)\,[k^*(t) - \bar{k}^*]\,(\gamma_2 + \gamma_1) \quad (31b)$$

$$b(t) - \bar{b} = \pi_1 \exp(\gamma_1 t) + \pi_2 \exp(\gamma_2 t) + \pi_3 \exp(\gamma_3 t), \;\; \pi_i < 0 \;\; i = 1,2,3. \quad (31c)$$

It immediately follows from (31) and the ranking of eigenvalues that if adjustment costs are low (that is if $\gamma_1 < \gamma_2 < \gamma_3$) the capital stocks k and k^* will adjust faster than the foreign asset holdings, b, of home households, or, to put it differently, the current account will be more persistent than world investment, as in Devereux and Shi [1991].[16] However, the strong correlation observed between domestic savings and investment ⟨Feldtein and Horioka [1980]; and Tesar [1991]⟩ suggests the opposite conclusion about the speeds of adjustment. Consequently, in what follows I shall focus on the case where adjustment costs are higher than the critical level so that $\gamma_1 > \gamma_2 > \gamma_3$.

To see how the world economy evolves after the integration of world stock markets, it is useful to begin with the transient paths of the world capital stock k^w, world consumption c^w, and the world real rate of interest.

As regards the first, using (31a) and (31b) yields $k^w(t) - \bar{k}^w = 2\beta_2 \exp(\gamma_2 t) < 0$, which indicates that the world capital stock monotonically rises towards its steady-state value along the convergent path. The motion of k^w on this path is driven by the long-run change it undergoes. The speed of adjustment $-\gamma_2$ of the world capital stock depends on the magnitude of adjustment costs. Quite intuitively, the higher are such costs, the slower is the adjustment of k^w.

To see the adjustment of world consumption c^w along the convergent path, note that the dynamics of k^w imply that world investment jumps on

15. The values of the parameters π_i below, as well as the solutions for the time paths of $c, c^*, \theta, \phi, \phi^*$ are available from the author upon request.

16. For the signs of π_i (i=1–3) see appendix 2.

impact. Given the predetermined level of k and k^* on impact, this implies from world capital market equilibrium condition (24) that world consumption drops at $t = 0$. Intuitively, the long-run increase in k^w is accomplished by this drop in c^w, which increases world saving. Along the convergent path, as the world output increases (due to the rise in k^w) c^w rises towards its higher steady-state level (recall corollary 3). Formally, this result can be written as $[c^w(t)-\bar{c}^w] = \sigma_3(c+c^*)\beta_3\exp(\gamma_2 t) < 0$ (for $t < \infty$). Further, the higher are adjustment costs, the lower is the speed of adjustment $-\gamma_2$ of world consumption.

The dynamic behavior of the world real rate of interest along the convergent path is given by,

$$\dot{\rho} = 2[c + c^* + 2k\varphi'(1)]^{-1}\gamma_2\beta_2\exp(\gamma_2 t)\rho\varepsilon[\tilde{\varphi}'(1) - \varphi'(1)],\ \beta_2 < 0. \quad (32)$$

In models where capital stocks can be instantaneously and costlessly relocated across countries, the monotonic increase in the world capital stock along the convergent path would (as long as the marginal productivity of capital falls with the capital stock) imply a decrease in the world real interest rate along this path. This is not necessarily the case if such relocation is subject to adjustment costs. Though the the world real rate of interest still adjusts monotonically here, the presence of adjustment costs may in fact cause this rate to increase along the convergent path at the same time as the world capital stock falls. As (32) shows, if adjustment costs exceed the critical level $\dot{\rho} > 0$ for $t < \infty$. Intuitively this result can be explained in the following manner. First, the increase in the world capital stock along the convergent path creates an excess supply of world output. To eliminate this excess supply, the price of current output relative to future output, ρ, must fall [(27)], increasing world investment. The higher are adjustment costs, the smaller is the required increase in world investment; thus, the smaller will be the decrease in the world real interest rate. Second, the simultaneous rise of world consumption along the convergent path increases, on net, lifetime welfare, ϕ and ϕ^*[(4)], and the average rate of time preference [(5)]. The consequent net worldwide tendency to substitute current consumption for future consumption raises the price of current output relative to future output, namely the world real interest rate ρ. If adjustment costs are high, this second effect dominates the first, with the net result of a rising world real interest rate along the convergent path. On the other hand, with low

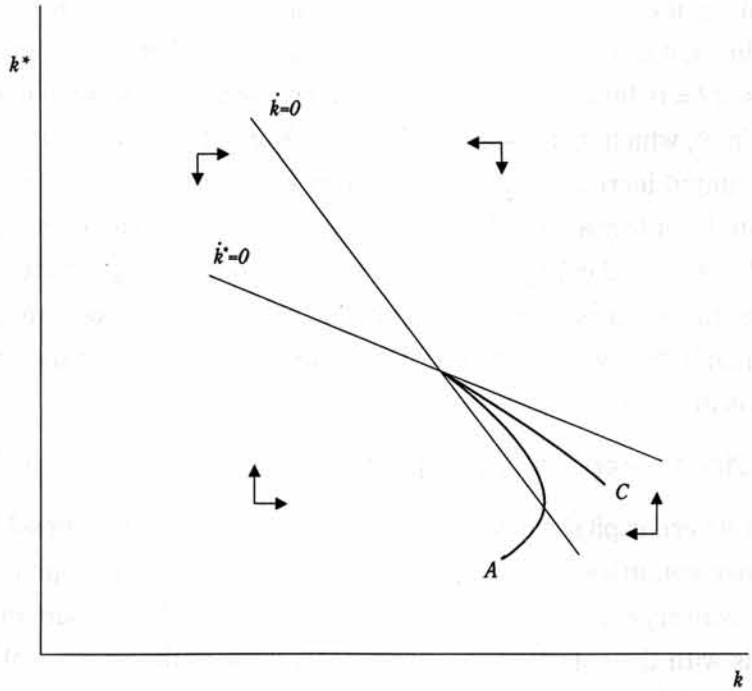

Figure 1
Adjustment of Capital Stocks

adjustment costs ρ falls along the convergent path.

Figure 1 depicts the determination of the (per-capita) domestic and foreign capital when adjustment costs are high ($\gamma_2 < \gamma_1$). The figure shows that if the world economy starts from point C, both k and k^* adjust monotonically (as in Devereux and Shi [1991]). In addition, there exists the possibility of nonmonotonic adjustment of capital stocks: a possibility ruled out by models with instantaneous shiftability of capital stocks across countries. Figure 1 depicts one possible nonmonotonic adjustment path emanating from point A. The figure shows that with high adjustment costs k may initially rise and then fall towards its steady-state level. The intuition for this results is as follows. Long-run equilibrium in the world stock market requires that the gap between the marginal productivities of the two capital stocks be eliminated. Thus, for instance, on impact, given expectations and capital stocks, integration of the world stock market creates a stock excess demand for foreign equities which have a higher rate of return. To clear this excess demand the

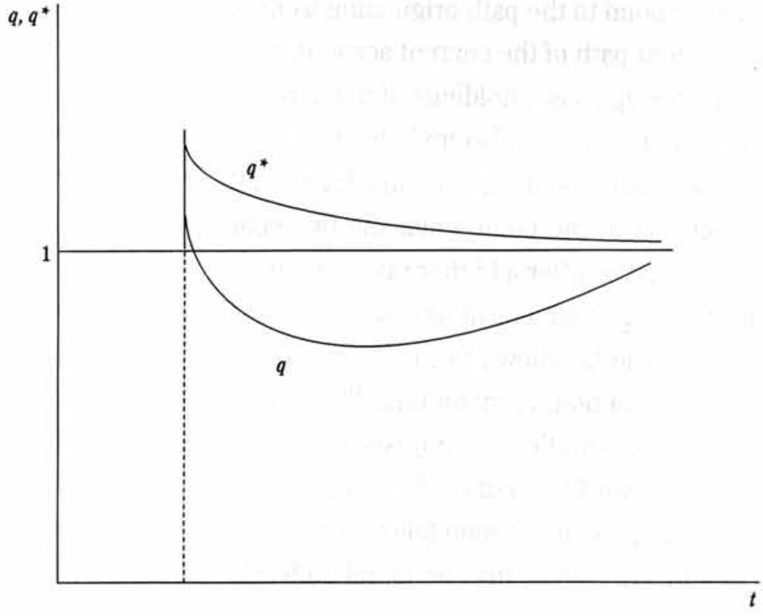

Figure 2
The Time Path of Equity Prices

home equity price q, and foreign equity price q^* must respectively drop and jump [(22)], increasing (decreasing) the current yield on home (foreign) equities. From (13) and its foreign counterpart, it then follows that home (foreign) investment should fall (rise) on impact. However, on impact, world consumption drops, generating an excess supply of world output, the elimination of which requires an increase in both q and q^*, or an increase in home and foreign investment. Since both effects push q^* and foreign investment up, both on impact and along the convergent path, k^* adjusts monotonically upwards. Yet, the two effects have opposing demands on q and home investment. With high adjustment costs the second effect dominates initially, raising k at first; as shown in Figure 1, the first effect comes to dominate later, giving rise to a nonmonotonic adjustment path for k.[17]

(13) and its foreign counterpart imply that we can use Figure 1 to trace the time paths of q, q^*, and θ. This is done in Figure 2, where the paths

17. If adjustment costs are low the nonmonotonic adjustment path of k just reverses itself, with k initially falling and then rising.

depicted correspond to the path originating from point A in Figure 1.

The adjustment path of the current account, $\dot{b}(t)$ immediately follows from (31c): the net foreign asset holdings of home households rises monotonically towards its long-run equilibrium level, that is, the home economy runs a current account surplus along the adjustment path. Intuitively, this follows from the fact that at the point when the two economies are opened up to trade foreign equities offer a higher rate of return.

Turning to the adjustment of national consumption levels along the convergent path, it can be shown formally from the solutions for $c(t)$ and $c^*(t)$ that home consumption, c, monotonically rises towards its long-run level, while foreign consumption, c^*, adjusts nonmonotonically. Intuitively, the monotonic rise in world output explains the time path of home consumption, while that of foreign consumption follows from the change in the distribution of world wealth, effected by intertemporal trade, along the convergent path.

IV. Conclusion

In conclusion let us bring together the as yet disparate elements of the analysis and form a coherent picture of the effects of intertemporal trade. The moment trade is opened up, three markets are globally unified. First, the stock market, which ensures that equity-holders are satisfied with the exiting *stock* composition of their assets at a point in time, and which lay dormant in autarky, springs into action. Second, a world capital market, in which *flows* of equity of uniform yield are traded in exchange for current output, comes into being. Third, output markets are unified: now *world* demand for output has to match the *world* supply of output. One consequence of the interaction among these markets is an immediate equalization of the rates of return on home and foreign equities that are perfect substitutes in the portfolios of households everywhere. Given the historically determined capital stocks in each country, and that these stocks *cannot* be costlessly and instantaneously relocated across countries, such equalization of the rates of return is effected through changes in equity prices. Trade then ushers in a period of growth in both the world capital stock and aggregate world consumption. This period is marked by a redistribution of the world wealth, through which the patient home households accumulate equities issued by foreign firms, while the impatient foreign households decumulate the same. Hence, the home country runs a current account surplus throughout the adjustment period. Meanwhile, the world interest rate may monotonically rise or fall depending on whether the adjustment costs exceed or fall short of the critical level. The magnitude of such costs also determines the speeds and patterns of adjustment of the variables under study. Thus, for instance, if adjustment costs are high, the home physical capital stock initially rises and later declines.

Appendix 1

Partial derivatives of (17), (25) and (27) are as follows

(17) $q_1 = \rho[k\varphi'(1)]^{-1} > 0,\ q_2 = -[k\varphi'(1)]^{-1} < 0$

(25) $q_1 = q_2 = \rho[k\varphi'(1)]^{-1} > 0, q_3 = -1/2 < 0, q_4 = q_5 = -[2k\varphi'(1)]^{-1} < 0,$

(27) $\rho_1 = \rho_2 = [g''(k)k\varphi'(1)][2\{k\varphi'(1)\}+c+c^*]^{-1} < 0,$
$\rho_3 = c\rho^2[2\{k\varphi'(1)\}+c+c^*]^{-1} > 0,\ \rho_4 = (c^*/c)\rho_3 > 0$

Appendix 2

In this appendix I study the dynamic properties of the international trade equilibrium. Linearizing (9), (10), (13) (and their foreign counterparts), (23), and (26) around the steady state I obtain

$$\begin{bmatrix} \dot{k} \\ \dot{k}^* \\ \dot{b} \\ \dot{\theta} \\ \dot{c}^* \\ \dot{c} \\ \dot{\phi}^* \\ \dot{\phi} \end{bmatrix} = \begin{bmatrix} \rho/2 & \rho/2 & 0 & -\nu & -1/2 & -1/2 & 0 & 0 \\ \rho/2 & \rho/2 & 0 & \nu & -1/2 & -1/2 & 0 & 0 \\ \rho/2 & \omega & \rho & \nu & 1/2 & -1/2 & 0 & 0 \\ g'' & -g'' & 0 & \rho & 0 & 0 & 0 & 0 \\ c^*\delta & c^*\delta & 0 & 0 & 0 & 0 & c^*\kappa & m \\ c\delta & c\delta & 0 & 0 & 0 & 0 & m & c\kappa^* \\ 0 & 0 & 0 & 0 & -(\rho c^*)^{-1} & 0 & \rho & 0 \\ 0 & 0 & 0 & 0 & 0 & -(\rho c)^{-1} & 0 & \rho \end{bmatrix} \begin{bmatrix} k-\bar{k} \\ k^*-\bar{k}^* \\ b-\bar{b} \\ \theta-\bar{\theta} \\ c^*-\bar{c}^* \\ c-\bar{c} \\ \phi^*-\bar{\phi}^* \\ \phi-\bar{\phi} \end{bmatrix}$$

where

$$\nu \equiv -(1/2)k\varphi'(1),\ \omega \equiv g''(k)b-\rho/2,\ \delta \equiv \varphi'(1)k[c+c^*+2\varphi'(1)k]^{-1}g''(k)$$

$$\kappa \equiv -\rho^2[c+c^*+2\varphi'(1)k]^{-1}[c+2\varphi'(1)k],\ \ \kappa^* \equiv -\rho^2[c+c^*+2\varphi'(1)k]^{-1}[c^*+2\varphi'(1)k]$$

$$m \equiv cc^*\rho^2[c+c^*+2\varphi'(1)k]^{-1}$$

Manipulation yields the following characteristic equation:

$$(\rho-\gamma)^2[\kappa\varphi'(1)g''(k)-\gamma(\rho-\gamma)][(\rho-\gamma)\gamma+\rho][(\rho-\gamma)\gamma+\mu)]=0$$

from which I obtain the following eigenvalues:

$$\gamma_1 \equiv (1/2)\{\rho-[\rho^2-4\varphi'(1)g''(k)k]^{1/2}\},$$

$$\gamma_2 \equiv (1/2)\{\rho-[\rho^2+4\mu[\rho-(1/2)g''(k)(c+c^*)]]^{1/2}\},$$

$$\gamma_3 \equiv (1/2)\{\rho-[\rho^2+4\rho]^{1/2}\}$$

$$\mu = 2\kappa\varphi'(1)[c+c^*+2k\varphi'(1)]>0$$

The ranking of the eigenvalues in the text are now readily obtained.

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