Volume Title: Import Competition and Response

Volume Author/Editor: Jagdish N. Bhagwati, editor

Volume Publisher: University of Chicago Press

Volume ISBN: 0-226-04538-2

Volume URL: http://www.nber.org/books/bhag82-1

Publication Date: 1982

Chapter Title: Government Policy and the Adjustment Process

Chapter Author: Michael Mussa

Chapter URL: http://www.nber.org/chapters/c6002

Chapter pages in book: (p. 73 - 122)

4 Government Policy and the Adjustment Process

Michael Mussa

4.1 Introduction and Summary

Most standard analyses of the effects of changing conditions of international trade and of international trade policies such as tariffs and import quotas either focus on conditions of long-run equilibrium or implicitly assume that resources can be moved costlessly from one activity to another. Recent experience with the problems of adjusting to the increase in the world price of energy, to cite one dramatic instance, demonstrates that this practice of abstracting from the process of adjustment ignores many important questions of international trade policy. The purpose of this paper is to examine some of these questions in the context of a modified version of the standard two-sector model and, specifically, to analyze the interaction of various government policies with the adjustment process.[1]

The model of adjustment technology, as set forth in section 4.2, is obtained from the standard Heckscher-Ohlin-Samuelson model by assuming that the process of moving capital from one industry to another requires an input of some of the economy's available labor. This assumption gives rise to a distinction between short-run production possibilities, with a fixed distribution of capital, and long-run production possibilities, when capital is mobile. It also implies an explicit cost for capital movement in terms of reduced production of final outputs. Recognition of this cost implies that the adjustment process cannot be viewed as governed by an arbitrarily specified "speed of adjustment" that should be made as large as possible. Rather, the adjustment process must be treated as an

Michael Mussa is the William H. Abbott Professor of International Business at the University of Chicago and a research associate of the National Bureau of Economic Research. He has published extensively on the theory of international trade, international finance, and monetary economics.

economic process in which the marginal cost of more rapid adjustment is balanced against its marginal benefit.

In section 4.3, the optimal adjustment path of the economy is analyzed under the assumption that the economy is managed by a planner who maximizes the present discounted value of the economy's final output. This analysis establishes the central point that decisions about adjustment are fundamentally investment decisions in which the marginal benefit of capital movement reflects the present discounted value of the differential between the rental earned by capital in the two industries.

The main point of section 4.4 is that private maximizing behavior will lead to a socially efficient adjustment path provided that three conditions are met. First, there must be no distortions in the product or factor markets that cause privately perceived values to diverge from true social values. Second, the private discount rate used in calculating the benefit of capital movement to private capital owners must be the same as the social discount rate. Third, the expectations on which private capital owners base their estimates of the benefits of capital movement must be "rational" in the sense that they appropriately reflect the structure of the economy.

As discussed in section 4.5, when there are distortions that directly affect the adjustment process, then, in accord with the general principles of policy intervention, it is appropriate for the government to intervene to countervail these distortions. In particular, a proportional tax on factor income (which is nondistorting in a static context) distorts the adjustment process by reducing the privately perceived benefit of capital movement relative to the true social benefit. To countervail this distortion it is appropriate to grant an investment tax credit for all adjustment costs. An excess of the private discount rate over the social discount rate also reduces the privately perceived benefit of capital movement relative to the true social benefit, and requires either a subsidy to capital movement or a subsidy to the income of capital in the expanding industry. Errors of expectations by private capital owners also distort the adjustment process. However, except in the case where such errors arise from an incorrect perception of future government policy, there is no general argument that government policy can be used systematically to correct distortions resulting from errors of expectations.

When a country can affect the price that it pays for imports, the first-best policy for that country requires that the government impose an optimum tariff to make the privately perceived price of imports equal to the social marginal cost of imports. As discussed in section 4.6, the adjustment process influences optimal tariff policy. Specifically, under fairly general conditions, the optimal tariff (measured as a specific tariff) declines as the economy moves along its optimal adjustment path, starting from free trade equilibrium. Moreover, at any point along this adjustment path, the optimal tariff is greater than the tariff that would be charged with a fixed distribution of capital because the process of capital movement increases the marginal cost of domestically produced import substitutes. To achieve the optimal adjustment path, it is not necessary for the government to intervene in the adjustment process to promote the movement of resources into the import-competing industry. This reflects the general principle that no intervention in the adjustment process is required provided that the first-best policy that countervails a product or factor market distortion is implemented.

When the first-best policy is not available, the second-best combination of policies may or may not require intervention in the adjustment process. This general principle is illustrated in section 4.7 by considering second-best policies to exploit monopoly power in trade when the first-best policy of an optimally varying tariff is not available. If a constant tariff that yields the optimal steady state is imposed, the speed of convergence toward this steady state (starting from free trade) is less than socially optimal. It is appropriate therefore for the government to intervene in the adjustment process by subsidizing the movement of capital into the import-competing industry. In contrast, if the government imposes the optimal steady state import quota, the speed of convergence toward the steady state is greater than socially optimal; and it is appropriate to tax the movement of capital into the import-competing industry. If the government can employ a production subsidy but not a tariff, an import quota, or a consumption tax, the optimal second-best policy is an optimally varying production subsidy, with no intervention in the adjustment process. If the government can employ a consumption tax but not a tariff, an import quota, or a production subsidy, the optimal second-best policy includes not only the consumption tax but also intervention in the adjustment process in order to restrain the movement of capital out of the import-competing industry. This difference between the consumption tax and the production subsidy reflects the fact that under the production subsidy (but not under the consumption tax) the price facing domestic producers of the import substitute corresponds to the social marginal value of domestically produced import substitutes. Under the production subsidy, therefore, private capital owners receive the correct signal concerning the benefits and costs of capital movement, without any government intervention in the adjustment process.

The concluding section of the paper considers extensions and generalizations of the analysis in the preceding sections. First, we examine the effects of government policies directed at the adjustment process on the distribution of income among factor owners and the possible effects on the adjustment process of government policies directed at affecting the distribution of income. Next, we investigate the implications of a more general adjustment technology that allows for investment in altering the size of the capital stock, as well as in moving capital from one industry to another. Finally, we summarize the general principles concerning government policy toward the adjustment process that are implied by the present theoretical analysis and that appear likely to carry over to more elaborate and realistic models.

4.2 A Model of Adjustment Technology

To provide a formal basis for the analysis of the role of government policy in the adjustment process, it is useful to develop a simple model of adjustment technology, based on the standard two-sector model.[2] Suppose that the output of each good is produced in accord with a neoclassical, linear homogeneous production function:

$$X = F(L_X, K_X), \tag{1}$$

$$Z = G(L_Z, K_Z), \tag{2}$$

where L_X, L_Z, K_X, and K_Z are the quantities of labor and capital used in the respective industries. Let Z be the numeraire commodity, and let P, W, R_X, and R_Z denote, respectively, the price of X, the wage of labor, and the rental rates on capital in X and capital in Z, all measured in terms of Z. The total stock of capital, $\underline{K} = K_X + K_Z$, is fixed. Its distribution between X and Z is indicated by the variable K, with $K_X = K$ and $K_Z = \underline{K} - K$. At any moment of time, K is given, but it can be changed over by a process that uses some of the economy's supply of labor; specifically, suppose that [3]

$$L_I = \beta \cdot I^2, \tag{3}$$

where $I = |\dot{K}|$ is the rate at which capital is being moved from X to Z or vice versa. Labor is freely mobile, but total labor use is constrained by the fixed aggregate supply:

$$L_X + L_Z + L_I = \underline{L}. \tag{4}$$

From this specification of productive technology, we obtain the transformation function

$$Z = T(X, I, K), \tag{5}$$

which indicates the maximum amount of Z that can be produced as a function of X, I, and K. Without going into details or derivations, we may summarize the key properties of this transformation function, using the notation T_i and T_{ij} to denote the first and second partial derivatives of T. First, the marginal cost of X in terms of Z is given by $-T_X$ and is equal to the ratio of the marginal products of labor in Z and X:

$$-T_X(X, I, K) = \mathrm{MPL}_Z/\mathrm{MPL}_X. \tag{6}$$

The marginal cost of X is an increasing function of X $(-T_{XX}>0)$, an increasing function of I $(-T_{XI}>0)$, and a decreasing function of K $(-T_{XK}<0)$. Second, the marginal cost of I in terms of Z is given by $-T_I$ and satisfies

(7) $$-T_I(X,I,K) = \beta \cdot I \cdot \mathrm{MPL}_Z.$$

The marginal cost of I is zero for $I = 0$ and is greater than zero for $I > 0$; it is an increasing function of I $(-T_{II} > 0)$ and an increasing function of X $(-T_{IX} > 0)$. If X is relatively capital-intensive, then $-T_{IK} < 0$; and conversely if X is relatively labor-intensive. Third, a shift of capital from Z to X increases potential output of Z, given X and I, if and only if the value of the marginal product of capital in X (measured by $R_X = -T_X \cdot \mathrm{MPK}_X$) is greater than the value of the marginal product of capital in Z (measured by $R_Z = \mathrm{MPK}_Z$); specifically,

(8) $$T_K(X,I,K) = -T_X \cdot \mathrm{MPK}_X - \mathrm{MPK}_Z = R_X - R_Z.$$

For each feasible combination of X and I, there is a $K^*(X,I)$ such that

$$T_K(X,I,K) \gtreqless 0 \text{ according as } K \lesseqgtr K^*(X,I),$$

where $K_X^*>0$ and $K_I^*<0$. Further, $T_{KX} = T_{XK} < 0$, $T_{KI} = T_{IK} \gtrless 0$ depending on relative factor intensities, and $T_{KK} < 0$ at least in the neighborhood of points where $T_K = 0$.

Some of the properties of the transformation function are illustrated in figure 4.1. In the upper panel, the transformation curves $T(X, 0, K_0)$ and $T(X, 0, K_1)$ show the effect of a redistribution of capital $(K_1 > K_0)$ on production possibilities, after the process of capital movement is complete. The marginal cost curves $-T_X(X, 0, K_0)$ and $-T_X(X, 0, K_1)$ in the lower panel show the effect of this capital redistribution on the marginal cost of producing X. The transformation curve $T(X, I_0, K_0)$ and the associated marginal cost curve $-T_X(X, I_0, K_0)$ show the effect of a positive rate of capital movement $(I_0 > 0)$ on production possibilities for final outputs and on the marginal cost of X.

The outer envelope of all of the transformation curves $T(X, 0, K)$ is the transformation curve $T^*(X)$ implied by the standard two-sector model in which labor and capital are both freely mobile between X and Z. Formally, this "long-run" transformation curve is defined by

(9) $$Z = \bar{T}(X) \equiv T(X,0,K^*(X,0)).$$

Corresponding to this long-run transformation curve, in the lower panel of figure 4.1, is the long-run marginal cost curve $-\bar{T}_X(X)$. This long-run marginal cost curve is flatter than any of the short-run marginal cost curves $-T_X(X, 0, K)$ drawn for a fixed distribution of capital. The intersection of the long-run marginal cost curve with each of these short-

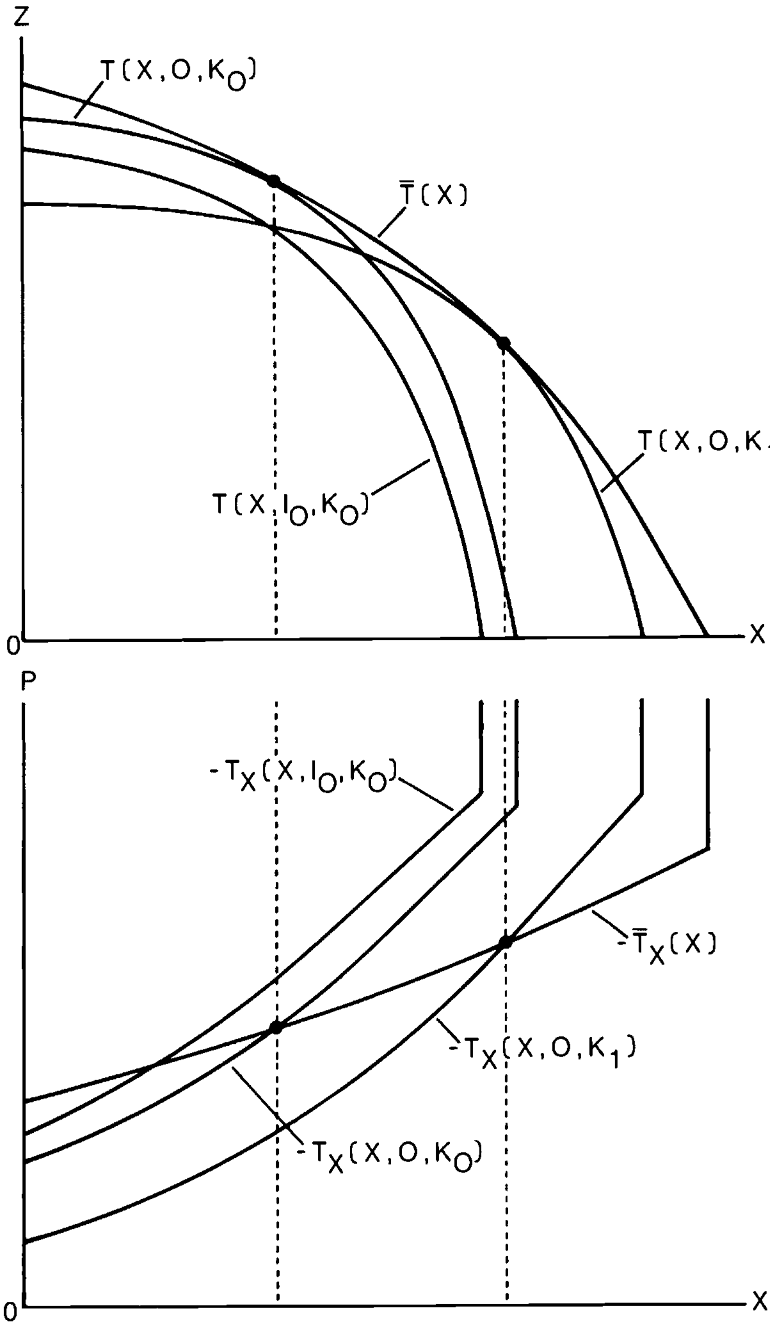


Fig. 4.1 Transformation curves and marginal cost curves for different distributions of capital and different rates of capital movement.

run marginal cost curves occurs at the level of X for which $K = K^*(X, 0)$. At the corresponding point in the upper panel of figure 4.1, the transformation curve $T(X, 0, K)$ is tangent to the outer envelope transformation curve $\bar{T}(X)$. At such points, $T_K(X, 0, K) = 0$, indicating that it is not possible to increase output of Z through any redistribution of capital without reducing output of X.

4.3 Social Optimization

Suppose that the economy whose technology was described in the preceding section is a small country that faces a fixed relative price of X in world trade, P, and a fixed world interest rate, r. The relevant objective for a social planner (leaving aside issues of income distribution) is to maximize

$$(10) \qquad \int_0^\infty (P \cdot X + Z) \exp(-r \cdot t) dt$$

subject to the constraint

$$(11) \qquad Z = T(X, |\dot{K}|, K)$$

starting from an initial distribution of capital, K_0.

To determine the solution of this problem, define the current value Hamiltonian

$$(12) \qquad H = P \cdot X + Z + \theta \cdot (T(X, |\dot{K}|, K) - Z) + \lambda \cdot \dot{K},$$

where θ is a Lagrangian multiplier assigned to the constraint (11) and λ is the costate variable that represents the shadow price of a unit of capital located in X rather than Z. Assuming an interior solution, the optimum path of the economy must satisfy the following conditions (see Arrow 1968):

$$(13) \qquad \partial H / \partial X = P + \theta \cdot T_X = 0,$$

$$(14) \qquad \partial H / \partial Z = 1 - \theta = 0,$$

$$(15) \qquad \partial H / \partial \dot{K} = \text{sign}(\dot{K}) \cdot \theta \cdot T_I + \lambda = 0,$$

$$(16) \qquad \dot{\lambda} = r \cdot \lambda - \theta \cdot T_K.$$

The optimum path must also be consistent with the constraint (11), the initial condition, $K(0) = K_0$, and the boundary conditions

$$(17) \qquad \lambda \leq 0 \text{ if } K = \bar{K},$$

$$(18) \qquad \lambda \geq 0 \text{ if } K = 0.$$

The conditions (13), (14), and (15) jointly determine output of X and the rate of capital movement, $I = |\dot{K}|$, by the requirement that the marginal cost of X, $-T_X(X, I, K)$, equal P, and the requirement that the marginal cost of capital movement, $-T_I(X, I, K)$, equal $|\lambda|$. These requirements implicitly determine X and I as functions of K, $|\lambda|$, and P:

(19) $$X = \tilde{X}(K, |\lambda|, P), \quad \tilde{X}_K > 0, \quad \tilde{X}_{|\lambda|} < 0, \quad \tilde{X}_p > 0,$$

(20) $$I = \tilde{I}(K, |\lambda|, P), \quad \tilde{I}_K \gtreqless 0, \quad \tilde{I}_{|\lambda|} > 0, \quad \tilde{I}_p > 0.$$

Output of Z is determined by the constraint (11) to be

(21) $$Z = \tilde{Z}(K, |\lambda|, P) = T(\tilde{X}(K, |\lambda|, P), \tilde{I}(K, |\lambda|, P), K).$$

The direction of capital movement is determined by the sign of λ:

(22) $$\dot{K} = sign(\lambda) \cdot \tilde{I}(K, |\lambda|, P).$$

Further, since $-T_I(X, I, K) = 0$ if and only if $I = 0$, it follows that

(23) $$\dot{K} = 0 \text{ iff } \lambda = 0.$$

Given these results, the determination of the optimal path of the economy reduces to determining the optimal paths of K and λ. This may be accomplished with the aid of figure 4.2. From (23) it follows that the K axis (where $\lambda = 0$) corresponds to the combinations of K and λ for which $\dot{K} = 0$. Above this axis, $\dot{K} > 0$, and below it, $\dot{K} < 0$. From (16) it follows that

(24) $$\dot{\lambda} = r \cdot \lambda - \varphi(K, |\lambda|, P),$$

where

(25) $$\varphi(K, |\lambda|, P) = T_K(\tilde{X}(K, |\lambda|, P), \tilde{I}(K, |\lambda|, P), K).$$

Thus $\dot{\lambda} = 0$ along the line where $\lambda = \varphi(K, |\lambda|, P)/r$. Above this line, $\dot{\lambda} > 0$, and below it, $\dot{\lambda} < 0$. The $\dot{\lambda} = 0$ line intersects the K axis at the steady state distribution of capital, $\bar{K}(P)$, which is the efficient distribution of capital determined in the standard two-sector model where labor and capital are both freely mobile. At the steady state distribution of capital, the short-run marginal cost of producing the steady state output $\bar{X}$, $-T_X(\bar{X}, 0, \bar{K}(P))$, is equal to the long-run marginal cost of producing this level of output, $-\bar{T}_X(\bar{X})$; and both short-run and long-run marginal cost are equal to the given output price, P.[4]

From the dynamic system illustrated in figure 4.2, it is possible to determine the paths of K and λ, starting from any initial combination of K and λ. For each initial K, however, there is only one initial λ for which the subsequent path of K and λ converges to the steady state where $K = \bar{K}(P)$ and $\lambda = 0$. This is the value of λ that lies along the stable branch of the dynamic system illustrated in figure 4.2, which is denoted by $\tilde{\lambda}(K)$. For any initial K, a choice of an initial λ not equal to $\tilde{\lambda}(K)$ leads to a subsequent path of K and λ that ultimately violates one of the boundary

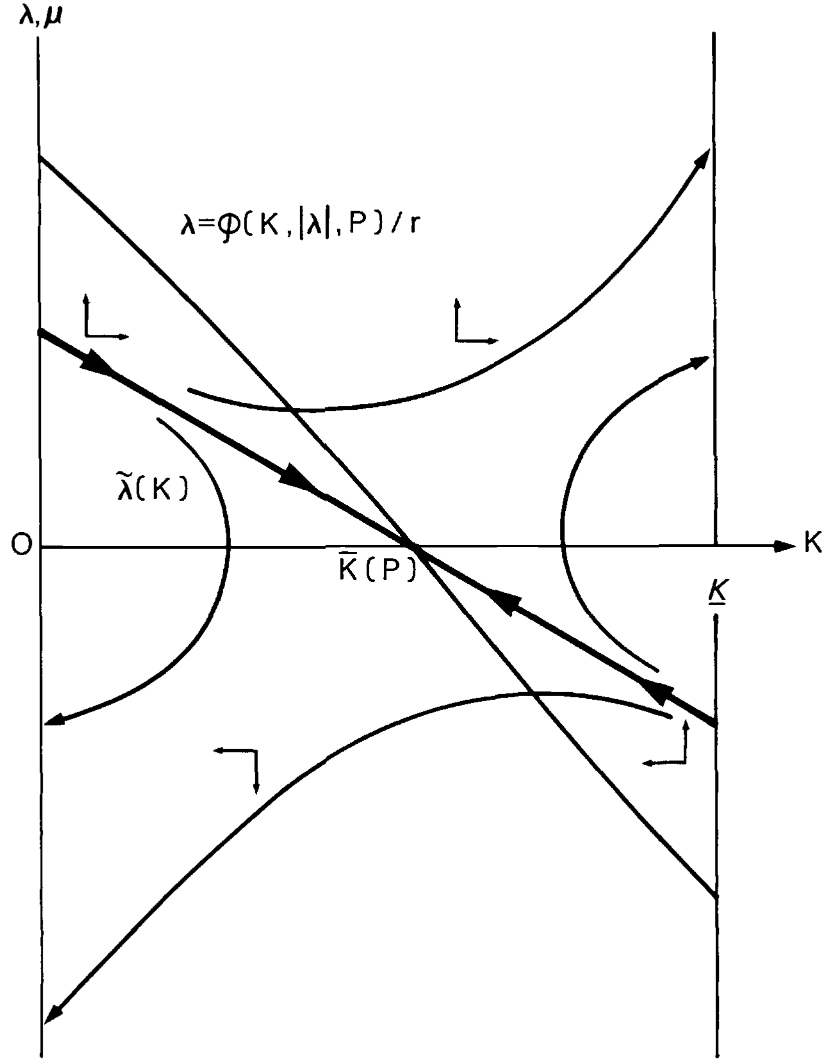


Fig. 4.2 The optimal adjustment path for the distribution of capital and the shadow price for relocating capital.

conditions (17) or (18). Such paths are clearly not optimal since it is obviously senseless to devote productive resources to moving more capital into the industry that already has all of the capital and out of the industry that has none. Thus the optimal path of K and λ is the path associated with the stable branch, and this path of K and λ determines the optimal paths for all other variables.

Finally, from the solution of the differential equation (24), it follows that

$$\tilde{\lambda}(t) = \int_t^{\infty} \varphi(\tilde{K}(s), |\tilde{\lambda}(s)|, P) \exp(-r\cdot(s-t))ds, \quad (26)$$

where $\tilde{\lambda}(s)$ and $\tilde{K}(s)$ are the values of λ and K on the optimum path at time s. This result expresses the fact that the appropriate shadow price for moving a unit of capital from Z to X is equal to the present discounted value of difference between the rental earned by a unit of capital located in X and the rental earned by a unit of capital located in Z. This result is important because it reveals that decisions about adjustment are not ordinary, static production decisions that involve comparisons of current costs with current benefits, but are fundamentally *investment decisions* that require the balancing of current costs with the present discounted value of future benefits. Specifically, in the present analysis, the optimal rate of capital movement is not determined simply by comparing the current rental differential between capital located in X and capital located in Z with the current cost of capital movement. Rather, determination of the optimal rate of capital movement requires that the planner recognize how this rental differential will change as the economy moves along its optimal path in order to establish the appropriate shadow price for moving a unit of capital from one industry to the other.

4.4 Private Maximization

Next, consider how the economic system would behave if it were governed by the decisions of individual maximizing agents rather than by a social planner. Since labor is mobile between the three production activities, maximization by individual workers implies that wage rates must be the same for labor used in X, in Z, and in capital movement. Maximization by private capital owners implies that labor in each industry will be employed up to the point where the value of its marginal product ($P\cdot \mathrm{MPL}_X(\ell_X)$ for X and $\mathrm{MPL}_Z(\ell_Z)$ for Z) is equal to the wage rate, W. These conditions determine the labor/capital ratios in each industry, $\ell_X(W/P)$ and $\ell_Z(W)$, as functions of W and P. These labor/capital ratios, in turn, determine the marginal product of capital in each industry, $\mathrm{MPK}_X(\ell_X)$ and $\mathrm{MPK}_Z(\ell_Z)$, and hence the rental rates earned by a unit of capital in each industry, $R_X(W, P) = P \cdot \mathrm{MPK}_X(\ell_X(W/P))$ and $R_Z(W) = \mathrm{MPK}_Z(\ell_Z(W))$. The service of capital movement is assumed to be provided on a competitive basis by profit maximizing firms that equate the marginal cost of providing this service, $W \cdot (dL_I/dI)$, to the price, q, that they receive for a unit of this service.[5] This assumption, together with the specification of labor requirements for capital movement given in (3), implies that the demand for labor for use in capital movement is given by $L_I(W,q) = (1/\beta)\cdot(q/2W)^2$.

In order for the economy to be in equilibrium when its behavior is governed by the decisions of individual maximizing agents, the total demand for labor must equal the available supply; that is,

$$\ell_X(W/P)\cdot K + \ell_Z(W)\cdot(\underline{K} - K) + L_I(W,q) = \underline{L}. \tag{27}$$

This condition determines the equilibrium wage rate as a function of K, q, and P:

$$W = \tilde{W}(K,q,P) \qquad \partial W/\partial K \gtreqless 0, \partial W/\partial q > 0, \partial W/\partial P > 0. \tag{28}$$

It is important to note that this formula for the equilibrium wage rate is also the formula that determines the wage rate for the social planner, with $q = |\lambda|$. This must be so because the social planner equates the value of the marginal product of labor in all production activities and is constrained by the total labor supply. It follows that with $q = |\lambda|$, private maximization results in the same allocation of labor as determined by the social planner. Hence outputs of X and Z and the rate of capital movement under private maximization are determined precisely by the functions $\tilde{X}(K,q,P)$, $\tilde{Z}(K, q, P)$, and $\tilde{I}(K, q, P)$ that were derived in the analysis of the behavior of the social planner.

It is apparent that the critical issue in determining the behavior of the economy under private maximization is the determination of the price that private capital owners will pay for capital movement. The benefit that a private capital owner believes he would enjoy from moving a unit of capital from X to Z, denoted by $\mu(t)$, is the present discounted value of the expected difference between the rental rate on capital in X and the rental rate on capital in Z; that is,

$$\mu(t) = \int_t^\infty (R_X^e(s;t) - R_Z^e(s;t))\exp(-i\cdot(s-t))\,ds, \tag{29}$$

where $R_X^e(s;t)$ and $R_Z^e(s;t)$ are the expected time paths of the rental rates on capital in X and Z, based on expectations held at time t, and i is the discount rate used by private capital owners. The price that capital owners will pay for capital movement is $|\mu|$. The sign of μ determines the direction of capital movement, in accord with

$$\dot{K} = \text{sign}(\mu)\cdot\tilde{I}(K,|\mu|,P). \tag{30}$$

Further, differentiation of (29) with respect to t, given the expected time paths of R_X and R_Z, implies that

$$\dot{\mu}^e = i\cdot\mu - \varphi(K,|\mu|,P). \tag{31}$$

This expresses the requirement that the total expected rate of return from holding capital in X rather than Z, including expected capital gains, $(R_X - R_Z + \dot{\mu}^e)/\mu$, must equal the private discount rate, i.

Different assumptions about expectations yield different conclusions about the behavior of μ. If expectations are "static" in the sense that the current economic situation is expected to persist indefinitely, then $\dot{\mu}^e = 0$ and hence μ is determined by

$$(32) \qquad \mu = \varphi(K, |\mu|, P)/i.$$

If $i = r$, then the path of μ determined by (32) is shown by the $\lambda = \varphi(K, |\lambda|, P)/r$ line in figure 4.2. It follows that the steady state distribution of capital is the same $\bar{K}(P)$ determined by the social planner, but that convergence to this steady state under private maximization with static expectations is more rapid than is socially optimal. Further, for any i, the steady state distribution of capital is $\bar{K}(P)$. The greater the value of i relative to r, the slower is the speed of convergence toward this steady state. Thus, up to a point, a high private discount rate tends to offset the distortion created by static expectations.

The social planner does not make the mistake of believing that current conditions will persist indefinitely because he calculates the effect of future capital movement on the value of λ. If private agents had the same correctness of foresight, their expectations would be "rational," in the sense that they would appropriately reflect the structure of the economic system. With rational expectations, we require that $\dot{\mu}^e = \dot{\mu}$. Hence, if $i = r$ and expectations are rational, the conditions that determine the evolution of μ and K must be precisely the same as the conditions that determine the evolution of λ and K for the social planner, as represented in figure 4.2. In addition, for expectations to be rational, they must be consistent with the boundary conditions (17) and (18).

Specifically, when all capital is removed from X and $K = 0$, capital owners should not expect that resources will continue to be devoted to the futile task of moving more capital into Z; and, conversely, when $K = \underline{K}$. This implies that the only path of μ and K that is consistent with rational expectations is the path that corresponds to the stable branch in figure 4.2 namely, the socially optimal path that maximizes the present discounted value of the economy's final output.

This key result may be summarized in the form of a general proposition:

(P1) *Private maximizing behavior will lead to a socially efficient adjustment process provided that the prices of outputs and factors and the discount rate perceived by private agents correspond to their true social values, and provided that the expectations that influence private decisions about adjustment are rational.*

This proposition has been established in the context of a specific model of adjustment technology, under the restrictive assumption that the prices of outputs and the discount rate are exogenously given and constant. It is clear, however, that the procedure used to establish this proposition in the present narrow context carries over to alternative specifications of productive technology, provided that the technology does not involve externalities or scale economies that would cause prices perceived by private agents to diverge from true social values. The assumption of constant output prices and a constant discount rate can easily be relaxed to any time paths of prices and the discount rate that are exogenously given to the production sector of the economy.[6]

4.5 Distortions of the Adjustment Process

The general theory of policy intervention suggests that government policies to improve the efficiency of the adjustment process should be directed to correcting distortions that induce the privately perceived costs or benefits of adjustment to diverge from the true social costs or benefits. It is relevant to consider the circumstances that give rise to such distortions and the policies that are appropriate to deal with them.

One important example is the distortion arising from a proportional tax on income from capital or on all factor income. Since total factor supplies have been assumed fixed, such a tax is nondistorting in the standard static production model, with either fixed or freely mobile capital. Such a tax, however, distorts the adjustment process because it causes the privately perceived benefit of capital movement to be lower than the social benefit. It τ is the proportional tax rate, then the privately perceived benefit of owning a unit of capital in X rather than Z is given by

$$b = (1 - \tau) \cdot \mu, \tag{33}$$

where μ is defined in (29) as the present discounted value of the expected before-tax difference between the rental on capital in X and the rental on capital in Z. If private capital owners have rational expectations and the private discount rate is equal to the social discount rate, then the adjustment path toward the steady state is as illustrated in figure 4.3. The K axis is still the line along which $\dot{K} = 0$. But the line along which $\dot{b} = 0$ is now determined by the condition

$$b = (1 - \tau) \cdot \varphi(K, |b|, P)/r \tag{34}$$

rather than by the condition $b = \mu = \varphi(K, |\mu|, P)/r$. The steady state distribution of capital, $\bar{K}(P)$, is the same as in figure 4.2, but the path of convergence to this steady state in figure 4.3 involves a less than socially optimal rate of capital movement.

Elimination of the tax on income from capital would, of course, remove this distortion of the adjustment process. Other considerations of government policy, such as the need for revenue, however, may make the elimination of this tax impractical. An alternative policy would be to

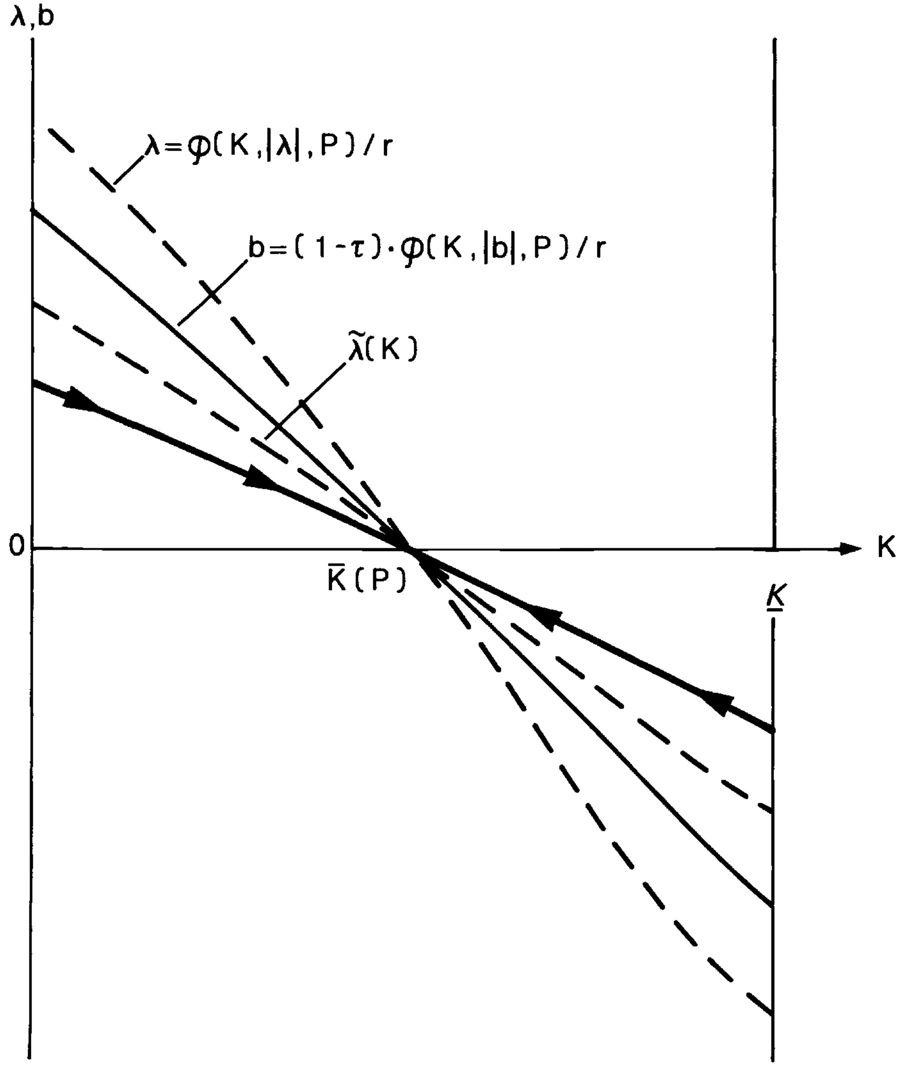


Fig. 4.3 The adjustment path when a tax is imposed on the income from capital.

remove the distortionary effect of the tax on the adjustment process by allowing an investment tax credit which permits the deduction of adjustment costs from taxable income. The value of this credit is the price paid for a unit of capital movement, q, multiplied by the tax rate, τ. With this credit, the total privately perceived benefit of moving capital from Z to X becomes

$$b = (1 - \tau) \cdot \varphi + \tau \cdot b. \tag{35}$$

It follows immediately that $b = \mu$. This establishes the proposition

(P2) *To correct the distortion of the adjustment process created by a proportional tax on income from capital (or all factor income) it is appropriate to grant an investment tax credit that allows the deduction of all adjustment costs.*

The general argument for this investment tax credit is essentially the argument for a consumption-based expenditure tax, rather than an income tax. An income tax distorts intertemporal choices because of the double taxation of savings. An investment tax credit that allows income used for productive investment to avoid taxation removes this distortion.

A second possible cause of distortion of the adjustment process is an excess of the private discount rate, i, over the social discount rate, r.[7] From the analysis in sections 4.3 and 4.4, it is clear that an excess of i over r reduces the privately perceived benefit of capital movement relative to the true social benefit. Like a tax on income from capital, an excess of i over r does not affect the steady state distribution of capital, but it does reduce the rate of convergence toward this steady state to less than the socially optimal rate.

One policy that would correct this distortion would be to eliminate whatever is responsible for the excess of i over r. If this is not possible, an alternative policy would be to subsidize capital owners in the industry where capital earns a higher rental or tax capital owners in the industry where capital earns a lower rental. The required subsidy is equal to the difference $i - r$ multiplied by the privately perceived benefit of owning capital in the high-rent industry. Assuming that owners of capital in X are either subsidized or taxed (whichever is appropriate), the privately perceived benefit of owning capital in X rather than Z becomes

$$b(t) = \int_t^\infty (\varphi(s) + (i - r) \cdot b(s)) \exp(-i \cdot (s - t)) ds. \tag{36}$$

Assuming rational expectations, differentiation of (36) with respect to t yields

$$\dot{b} = r \cdot b - \varphi. \tag{37}$$

Thus, with the income subsidy for owners of capital in the high-rent industry and with rational expectations, the differential equation that determines the evolution of b is the same as the differential equation that determines the evolution of λ for the social planner. It follows that with the subsidy and with rational expectations, the adjustment path of the economy under private maximization will be socially optimal.

It is difficult to conceive, however, of a government that would systematically subsidize capital owners who already earn high rental rates or systematically tax those who earn low rental rates. An alternative and probably more attractive policy would be to subsidize the movement of capital out of the low-rent industry. From (36) it follows that the required subsidy to capital movement is given by

$$\sigma(t) = \int_t^\infty (i - r) \cdot |\lambda(s)| \exp(-i \cdot (s - t))\, ds, \tag{38}$$

where the path of $\lambda(s)$ is determined by the stable branch in figure 4.2. The required subsidy is approximately proportional to the price of capital movement, $q(t)$; specifically,

$$\sigma(t) \cong ((i - r)/(i + \epsilon)) \cdot q(t), \tag{39}$$

where ϵ is the speed of convergence of q toward its steady state value of zero. This establishes the proposition

(P3) *To correct the distortion of the adjustment process created by an excess of the private discount rate over the social discount rate, it is appropriate to subsidize the movement of capital at a rate that is approximately proportional to the cost of capital movement, using a subsidy rate that is itself approximately proportional to the difference between the private and social discount rates.*

The specific result for the appropriate subsidy rate given in (39) depends on the details of the present model of the adjustment process. More generally, it can be argued that an excess of i over r discourages all forms of investment and hence makes a general subsidy to all forms of investment a desirable policy.

Errors of expectations are a third potentially important cause of distortions of the adjustment process. For example, the analysis of static expectations in the discussion of private maximizing behavior demonstrated that this particular deviation from rationality causes the benefits of capital movement to be overvalued and hence results in too rapid convergence of the distribution of capital to its steady state distribution. To correct this distortion (assuming that expectations could not be altered) would require the imposition of a tax on capital movement. Other errors of expectations that cause the benefits of capital movement to be undervalued by private capital owners would justify a reverse policy of subsidizing capital movement.

In general, however, it is difficult to argue that errors of expectations would lead systematically to either overvaluation or undervaluation of the benefits of capital movement. The only general circumstance in which intervention may be required to correct errors of expectations is when such errors are intrinsically related to other government policies. For instance, if a government intends to provide temporary assistance to an industry injured by import competition, it should adopt policies to ensure that such assistance does not lead to increased investment in the distressed industry. Otherwise, the assistance that is granted may strengthen political pressures to make such assistance permanent rather than temporary. Indeed, the expectation that even temporary assistance may be granted to industries adversely affected by import competition may distort the adjustment process by inducing owners of factors in such industries to delay adjustment in the hope that protective measures may make adjustment unnecessary. Thus the social cost of measures to protect particular industries from import competition is not limited to the industries in which such measures are adopted, but also extends to other industries where adjustment is influenced by the expectation that such measures may be adopted.

Finally, the adjustment process may be afflicted by the usual problems of externalities, monopoly and monopsony power, and taxes and subsidies that distort the economic system in general. In fact, the adjustment process may be more exposed to such afflictions than other economic activities. Social insurance programs that provide benefits on the basis of previous experience in a particular industry or region (whatever their social value) tend to limit the incentive for adjustment by those who would lose benefit entitlements as a result of moving to other industries or regions. Special privileges granted to existing producers in a particular industry or region, such as preferential access to lower cost energy sources or freedom from certain zoning or environmental restrictions, provide an artificial incentive for inefficient but established producers to remain in an industry or region and an artificial impediment to the establishment of new an more efficient producers. Legal restrictions on plant closings such as have been proposed in many states limit both the outward movement of resources from declining activities and the willingness to invest in new areas. In general, the political opposition to economic change and the measures to which it gives rise tend to reduce the speed of adjustment and to distort the adjustment process.

4.6 Adjustment to an Optimum Tariff

The adjustment process must be taken into account not only in designing policies to correct distortions of that process, but also in adopting policies to serve other objectives. A specific example of this general problem that illustrates many important principles is the imposition of an optimum tariff by a country that desires to exploit its monopoly power in international trade.

The relevant objective for a social planner who recognizes that the marginal cost of imports rises as the volume of imports rises is to maximize

$$\int_0^{\infty} (U(C) + B) \exp(-r \cdot t) dt \tag{40}$$

subject to the constraints

$$Z = T(X, |\dot{K}|, K), \tag{41}$$

$$Z - B = J(C - X), J(0) = 0, J' > 0, J'' > 0, \tag{42}$$

where C measures home consumption of X, B measures home consumption of Z, and the foreign offer function, J, indicates the volume of home exports, $Z - B$, required to pay for home imports, $C - X$. For simplicity, it is assumed that the social discount rate is constant and that the marginal utility of consumption of Z is constant and equal to unity. The initial distribution of capital, K_0, is assumed to be the steady state distribution appropriate to free trade.

To determine the solution of the planner's optimization problem, define the current value Hamiltonian

$$\begin{aligned} H = {} & U(C) + B + \theta \cdot (T(X, |\dot{K}|, K) - Z) \\ & + \alpha \cdot (J(C - X) - (Z - B)) + \lambda \cdot \dot{K}, \end{aligned} \tag{43}$$

where θ and λ retain their previous interpretations and α is a Lagrangian multiplier assigned to the offer function constraint. In addition to the initial condition $K(0) = K_0$, the boundary conditions (17) and (18), and the constraints (41) and (42), the optimum path of the economy must satisfy the conditions

$$\partial H / \partial C = U' + \alpha \cdot J' = 0, \tag{44}$$

$$\partial H / \partial B = 1 + \alpha = 0, \tag{45}$$

$$\partial H / \partial X = \theta \cdot T_X - \alpha \cdot J' = 0, \tag{46}$$

$$\partial H / \partial Z = -\theta - \alpha = 0, \tag{47}$$

$$\partial H / \partial \dot{K} = \text{sign}(\dot{K}) \cdot \theta \cdot T_I + \lambda = 0, \tag{48}$$

$$\dot{\lambda} = r \cdot \lambda - \theta \cdot T_K. \tag{49}$$

To interpret the conditions (44) through (48), it is useful to think of the planner as establishing a relative price P for a unit of X in terms of Z. The planner sets C so that the marginal utility of consumption of X, $U'(C)$, is equal to P, thus determining C as a function of P:

$$C = U'^{-1}(P). \tag{50}$$

The planner sets imports of X so that their marginal cost, $J'(C-X)$, is equal to P, thus determining

(51) $$C - X = J'^{-1}(P).$$

The planner determines X and $I = |\dot{K}|$ so that the marginal cost of X, $-T_X(X, I, K)$, is equal to P and the marginal cost of I, $-T_I(X, I, K)$, is equal to $|\lambda|$. These conditions jointly determine X and I through the functions $\tilde{X}(K, |\lambda|, P)$ and $\tilde{I}(X, |\lambda|, P)$ introduced in section 4.2, with Z given by $\tilde{Z}(K, |\lambda|, P)$. The value of P that is set by the planner must satisfy the condition

(52) $$U'^{-1}(P) - J'^{-1}(P) = \tilde{X}(K, |\lambda|, P).$$

This condition implicitly determines P as a function of K and $|\lambda|$:

(53) $$P = \hat{P}(K, |\lambda|), \partial\hat{P}/\partial K < 0, \partial\hat{P}/\partial\lambda > 0.$$

This result, in turn, determines C, $C - X$, X, I, Z, and $B = Z - J(X - C)$ as functions of K and $|\lambda|$.

The paths of K and λ may be determined with the aid of the phase diagram shown in figure 4.4. The rate of capital movement from Z to X is determined by

(54) $$\dot{K} = \mathrm{sign}(\lambda) \cdot \tilde{I}(K, |\lambda|, \hat{P}(K, |\lambda|)).$$

This rule is slightly different from the rule (22) that determines $\dot{K}$ in figure 4.2 because P is no longer fixed; but it is still true that $\dot{K} = 0$ along the K axis, is positive above the K axis, and is negative below the K axis. The evolution of λ is determined by

(55) $$\dot{\lambda} = r \cdot \lambda - \psi(K, |\lambda|),$$

where

(56) $$\psi(K, |\lambda|) = \varphi(K, |\lambda|, \hat{P}(K, |\lambda|)).$$

The line along which $\dot{\lambda} = 0$ is determined by the condition $\lambda = \psi(K, |\lambda|)/r$, which is similar to the condition that determines the $\dot{\lambda} = 0$ line in figure 4.2, except that P is no longer fixed. The steady state distribution of capital, $\bar{K}$, is the unique value of K for which $\psi(K, 0) = 0$. The relative output price that is associated with $\bar{K}$ is $\bar{P} = \hat{P}(\bar{K}, 0)$. This capital stock distribution and relative output price are precisely the same as would be obtained in the standard static analysis of the optimum tariff, under the assumption that capital is freely mobile between industries. The path of convergence to this steady state is along the stable branch of the dynamic system determined by (54) and (55), as illustrated by the function $\hat{\lambda}(K)$ shown in figure 4.4. Specifically, starting from $K_0 < \bar{K}$ (because the amount of capital allocated to X under free trade is less than under the

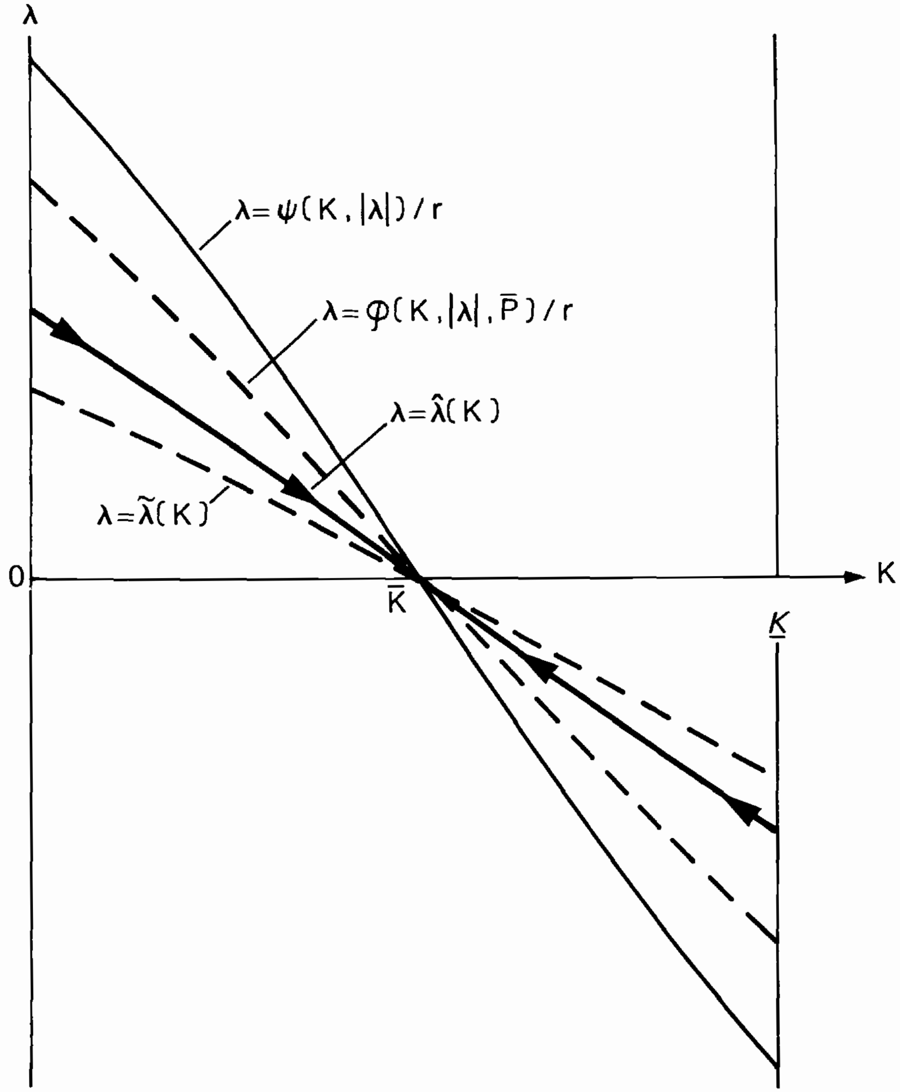


Fig. 4.4 The adjustment path under an optimally varying tariff.

optimum tariff), we move down the $\hat{\lambda}(K)$ line in figure 4.4 until we reach the steady state position where $K = \bar{K}$ and $\lambda = \hat{\lambda}(\bar{K}) = 0$.[8]

If private capital owners have rational expectations and the same discount rate as the social planner, and if there are no other distortions, the optimum path of the economy can be obtained by imposing an optimum tariff that varies with the distribution of capital. Stated as a specific tariff of τ units of Z per unit of X, the required tariff rate is given by

(57) $$\tau(K) = \hat{P}(K, |\hat{\lambda}(K)|) - \hat{P}^*(K, |\hat{\lambda}(K)|),$$

where $\hat{P}^*(K, |\hat{\lambda}(K)|)$ is the relative price of X facing foreign suppliers of home imports, as determined by

(58) $$P^* = J(C - X)/(C - X),$$

where $X = \tilde{X}(K, |\hat{\lambda}(K)|, \hat{P}(K, |\hat{\lambda}(K)|))$ and $C = U'^{-1}(\hat{P}(K, |\hat{\lambda}(K)|))$. When this tariff is imposed, the privately perceived cost of imports becomes $P^* + \tau(K)$. The requirement of equilibrium in the market for X, as expressed by the condition (52), ensures that the equilibrium relative price of X facing domestic producers and consumers is given by $\hat{P}(K, |\hat{\lambda}(K)|)$, provided that private capital owners have rational expectations and hence assign the same value to capital movement as the social planner.

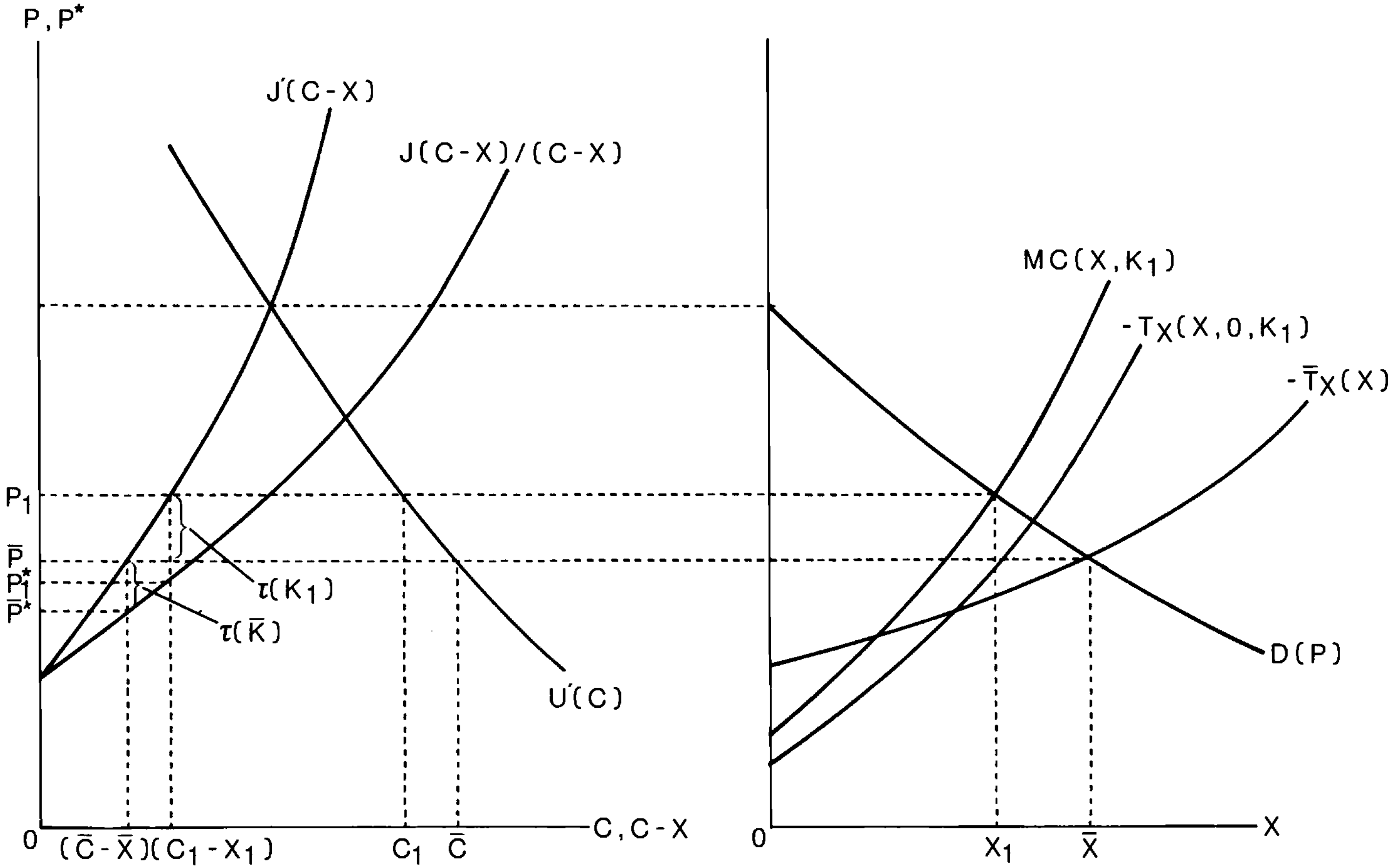
The optimum tariff at the steady state position of the economy, $\tau(K)$, is the same as the optimum tariff calculated in the standard static trade model; it is the tariff that equates the privately perceived cost of imports, $P^* + \tau$, to their social marginal cost, $J'(C - X)$, and to both the marginal utility of X consumption, $\underline{U}'(C)$, and the long-run marginal cost of domestic X production, $-\bar{T}_X(X)$. The optimum steady state tariff $\tau(\bar{K})$ and the associated steady state position of the economy are the same as those obtained in the standard two-sector model in which labor and capital are both freely mobile.

The importance of the adjustment process for optimum tariff policy is indicated by the variation in $\tau(K)$; specifically,[9]

(P4) *As K rises toward $\bar{K}$, imports declines and, provided that the difference between the marginal and average cost of imports increases with increases in imports, τ (K) declines.*

This proposition may be established with the aid of figure 4.5. In the left-hand panel, the curve labeled $U'(C)$ indicates the demand for consumption of X as a function of the price, P, facing domestic consumers; the curve labeled $J(C - X) / (C - X)$ indicates the supply of imports of X as a function of the price, P^*, received by foreign suppliers; and the curve labeled $J'(C - X)$ indicates the marginal cost of imports of X. Under the optimum tariff, imports are carried to the point where their marginal cost is equal to the price facing consumers. It follows that the optimum tariff required at any given level of imports is equal to the vertical distance between the $J'(C - X)$ and the $J(C - X) / (C - X)$ curves at that level of imports. By assumption, this distance increases as the level of imports increases. In the right-hand panel, the curve labeled $D(P)$ indicates the demand facing domestic producers of X as a function

Fig. 4.5 Determination of the optimum tariff for a given distribution of capital.



of P, under the assumption that imports are carried to the point where their marginal cost equals P. This $D(P)$ curve is the horizontal difference between the $U'(C)$ and the $J'(C-X)$ curves in the left-hand panel. The curve labeled $MC(X, K_1)$ indicates the marginal cost of domestically produced X, given a distribution of capital K_1, between K_0 and $\bar{K} > K_0$, when $I = |\dot{K}|$ is set at its optimum value, $\tilde{I}(K_1, |\hat{\lambda}(K_1)|, P(K_1, |\hat{\lambda}(K_1)|))$. The intersection of the $MC(X, K_1)$ curve and the $D(P)$ curve determines the appropriate value of P (which satisfies [52]) when the distribution of capital is K_1. Feeding this price into the left-hand panel, the intersection of this price line with the $U'(C)$ curve determines domestic consumption of X, and the intersecton with the $J'(C-X)$ curve determines imports of X. The vertical distance between the $J'(C-X)$ curve and the $J(C-X)/(C-X)$ curve at this level of imports determines the optimum (specific) tariff $\tau(K_1)$ that is appropriate for the given distribution of capital. As K increases along the path of convergence to the optimum steady state, the $MC(X, \bar{K}_1)$ curve in the right-hand panel shifts downward and to the right both because the increase in K directly reduces the marginal cost of producing X $(-T_{XK} < 0)$ and because the reduction in resources devoted to capital movement $(d\tilde{I}/dK < 0$ for $K < \bar{K})$ reduces the marginal cost of producing X $(-T_{XI} > 0)$. It follows that as K rises toward $\bar{K}$, the value of P determined in the right-hand panel declines. Hence, in the left-hand panel, the level of imports declines and so does the optimum (specific) tariff $\tau(K)$.

It is not possible to prove that $\tau(K)$ is a decreasing function of K for K greater than $\bar{K}$ because as K declines toward $\bar{K}$ along the optimal adjustment path a declining I and a declining K have opposite effects on the marginal cost of producing X. However, it is possible to show that

(P5) *For any $K \neq \bar{K}$, the optimum (specific) tariff $\tau(K)$ is greater than the optimum (specific) tariff that would be charged if the distribution of capital were held fixed.*

In particular, if the distribution of capital were fixed at $K_1 < \bar{K}$ and no resources were devoted to capital movement, the relevant marginal cost curve for domestically produced X would be the curve $-T_X(X, 0, K_1)$ in the right-hand panel of figure 4.5. The intersection of this marginal cost curve with the $D(P)$ curve determines the appropriate value of P when the distribution of capital is fixed at K_1. This price is necessarily less than the price determined by the intersection of the $MC(X, K_1)$ curve and the $D(P)$ curve because a positive rate of capital movement which draws resources out of the production of final goods increases the marginal cost of producing X. It follows that the optimum tariff when the distribution of capital is fixed at K_1 is less than $\tau(K_1)$. The same argument applies for any $K \neq \bar{K}$ since a positive $I = |\dot{K}|$ always increases the marginal cost of producing X.

These propositions concerning the influence of the adjustment process an optimum tariff policy remain valid under more general assumptions about the utility function and productive technology. If consumers can borrow and lend at a world interest rate equal to their subjective discount rate, the amount spent on consumption will be a constant proportion of the consumer's unchanging wealth. Regardless of the form of the flow of utility function, generally represented by $V(C, B)$, the demand curve for consumption of X, shown by the curve in the left-hand panel of figure 4.5, will not shift over time. Hence the proofs of propositions (P4) and (P5) go through as before.[10] If consumers are restricted to spending only their current income (equal to the value of domestic output, $P \cdot X + Z$, plus the redistributed tariff proceeds, $\tau \cdot (C - X)$), the demand curve in the left-hand panel will shift over time unless, as previously assumed, $V(C, B) = U(C) + B$. This assumption (which implies that the marginal propensity to spend on X is zero and the marginal propensity to spend on Z is one) can easily be relaxed. If both X and Z are normal, the demand curve will shift to the right as income grows along the adjustment path, implying a rightward shift of the $D(P)$ curve in the right-hand panel. This rightward shift of the $D(P)$ curve (at the previous equilibrium price), however, is smaller than the rightward shift of the $MC(X, K)$ curve. The reason is that only a fraction of the increase in the value of X output (equal to the excess of short-run marginal cost over long-run marginal cost, less the reduction in tariff revenue) corresponds to the increase in consumer income, and, since X and Z are both normal, only a fraction of this increase in income is spent on X. It follows that P declines as we move along the path of convergence to the steady state (starting from $K_0 < \bar{K}$) and propositions (P4) and (P5) remain valid. Generalizing this argument, it is clear that these propositions remain valid provided that Z is not strongly inferior. With respect to productive technology, the key features that are vital in establishing propositions (P4) and (P5) are that the shift of resources into X reduces the marginal cost of producing X ($-T_{XK} < 0$) and that the process of moving these resources increases the marginal cost of producing X ($-T_{XI} > 0$). The propositions concerning the behavior of the optimum tariff along the economy's adjustment path should remain valid under alternative specifications of productive technology that retain these two essential features.

Finally, it is important to note a general proposition concerning government intervention into the adjustment process:

(P6) *To correct the distortion due to a divergence between the privately perceived cost of imports and the social marginal cost, the government must impose an optimum (specific) tariff $\tau(K)$ that varies appropriately along the economy's adjustment path. Given this tariff, the government should not intervene in any other manner to affect the adjustment process.*

This proposition reflects the general principle that government policy should aim directly at distortions that impair the efficiency of the economic system. The correct policy to deal with a divergence between the private and social cost of imports is an optimum tariff which makes the privately perceived cost of imports correspond to their true social marginal cost. The appropriate tariff, $\tau(K)$, reflects the nature of the adjustment process. However, once the optimum tariff has been adopted, it is not necessary or desirable for the government to intervene in the adjustment process, unless there is some distortion that directly affects this process (such as those discussed in section 4.5). Moreover, it is clear that these principles apply to other distortions of product and factor markets. In each case the correct (first-best) policy is the policy that directly countervails the distortion. The required magnitude of the policy intervention will, in general, reflect the nature of the adjustment process. However, provided that there is no direct distortion of the adjustment process, no additional intervention into that process will be required to ensure the full efficiency of the economic system.

4.7 Second-best Policies and the Adjustment Process

When the first-best policy that directly countervails a distortion of the product or factor markets cannot be implemented, it may be that the second-best combination of policies includes intervention into the adjustment process, even though such intervention would not be desirable if the first-best policy were available. To illustrate this general point, it is useful to consider second-best policies to deal with the distortion resulting from the failure to impose an optimum tariff, when such a tariff (and other equivalent policies) cannot be implemented.

4.7.1 A Constant Tariff

First, consider the case where the optimum steady state tariff $\tau(\bar{K})$ is imposed, but where it is not possible to vary the tariff as the economy moves its adjustment path. It is easily established that

(P7) *If the constant tariff $\tau(\bar{K})$ is imposed, the steady state of the economy is the same as under the optimally varying tariff $\tau(K)$; but, under the hypothesis of (P4), the speed of convergence to the steady state, starting from $K_0 < \bar{K}$, is less than under the optimally varying tariff.*

The conclusion that the steady state of the economy is unchanged follows the fact that in the standard two-sector model (with labor and capital both freely mobile) there is a unique equilibrium for each specific tariff rate. The present specification of adjustment technology ensures that this steady state equilibrium will be achieved as the end result of the adjustment process. Further, from proposition (P4) we know that $\tau(K) > \tau(\bar{K})$ for any $K < \bar{K}$ and hence that the price established under the optimally varying tariff $\tau(K)$ is greater than the price that would be established, at that K, under the tariff $\tau(\bar{K})$. Since the relative price of X is higher under the tariff $\tau(K)$, it follows that the incentive to move capital from Z to X must be stronger. Hence speed of convergence toward the steady state is faster under the optimally varying tariff than under the constant tariff $\tau(\bar{K})$.

If the tariff is fixed at $\tau(\bar{K})$, then it is appropriate for the government to intervene in the adjustment process in order to obtain a more efficient adjustment path. Without going into the details of the derivation of the government's optimal intervention policy, it may be stated that the government should subsidize the rental on capital used in X at a rate $\delta(K) \cdot T_{XK}$ and tax the movement of capital from Z to X at a rate $-\delta(K) \cdot T_{XI}$, where

$$\delta(K) \gtreqless 0 \text{ according as } K \gtreqless \bar{K}. \tag{59}$$

The subsidy on the rental of capital in X is necessary to raise the privately perceived benefit of capital movement to the level of the true social benefit. Given this subsidy on the rental of capital in X, the tax on capital movement is necessary to correct a divergence between the privately perceived cost of capital movement and the true social cost which arises because capital movement that draws resources out of domestic X production increases imports of X, and these increased imports have a social marginal cost that exceeds their privately perceived cost. As the economy converges to its steady state, the required subsidy on the rental of capital in X and the required tax on the movement of capital from Z and X both decrease to zero.

Alternately, if no subsidy is paid on the rental of capital in X, it is necessary to subsidize the movement of capital from Z to X at the rate given by

$$\delta(K) \cdot T_{XI} + \int_t^\infty \delta(K) \cdot T_{XK} \exp(-r \cdot (s-t))\, ds. \tag{60}$$

This subsidy to capital movement does not make the privately perceived benefit equal to the true social benefit or the privately perceived cost equal to the true social cost; but it does leave exactly offsetting distortions to benefits and costs. Hence it produces the second-best optimum path for the economy (if expectations are rational and $i = r$), given the constraint that the tariff cannot be varied (and that other equivalent policies cannot be used).

4.7.2 A Constant Import Quota

Second, consider the case where the government restricts imports by means of an import quota rather than a tariff. If we allow the quota, Q, to vary with the distribution of capital, then we can determine the optimally varying quota, $Q(K)$, by simply setting the import quota at any given K equal to the level of imports that would occur under the optimally varying tariff $\tau(K)$. Thus, as one would expect from the standard propositions concerning the equivalence of tariffs and import quotas, there is no difference between the optimal path that can be achieved with an optimally varying quota and the optimal path achieved with an optimally varying tariff.[11]

The path that results from setting the quota at its optimal steady state level, $Q(\bar{K})$, however, is different from the path that results from setting the tariff at $\tau(\bar{K})$. This difference reflects more than the general principle that a quota that is equivalent to a tariff under one set of economic conditions is not necessarily equivalent to the same tariff under different economic conditions. This difference also reflects the endogeneity of the process governing the change in economic conditions, and the differential impact of the import quota $Q(\bar{K})$ and the tariff $\tau(\bar{K})$ on this process. In particular, it may be established that

(P8) *Starting from an initial $K_0 < \bar{K}$, the speed of convergence to the steady state under a constant import quota $Q(\bar{K})$ is more rapid than the socially optimal speed of convergence under an optimally varying quota or tariff, and, a fortiori, more rapid than the speed of convergence under the constant, steady-state-equivalent tariff $\tau(\bar{K})$.*

To demonstrate this result, note that in the proof of (P4) it was established that the level of imports falls as K rises toward $\bar{K}$ along the adjustment path produced by the optimally varying tariff $\tau(K)$. It follows that the optimally varying quota $Q(K)$ falls as K rises toward $\bar{K}$. Thus, for any $K < \bar{K}$, the steady state quota $Q(\bar{K})$ restricts imports more than the optimally varying quota $Q(K)$ (which is equivalent to the optimally varying tariff $\tau(K)$). It follows that the domestic relative price of X under the quota $Q(\bar{K})$, at any $K < \bar{K}$, is greater than the price under the optimally varying quota. This higher relative price of X means a stronger incentive to move capital from Z and X and hence a more rapid speed of convergence to the steady state than under the optimally varying quota. The last statement in (P8) follows immediately from (P7).[12]

Further, from proposition (P8) it is clear that if a constant import quota $Q(\bar{K})$ were imposed to move the economy from its free trade equilibrium to its optimal steady state position, the government should also intervene in the adjustment process to slow the speed of convergence toward the steady state. It should adopt policies that are the reverse of the policies described in the preceding subsection for the case of the constant tariff $\tau(\bar{K})$.

4.7.3 A Production Subsidy

Third, consider the case where the government can subsidize domestic production of the import good, but cannot tax domestic consumption, impose a tariff, or adopt any equivalent policies.[13] The problem for the social planner is to maximize (40) subject to the constraints (41) and (42) and the additional constraint

$$U'(C) = P^* = J(C - X)/(C - X), \tag{61}$$

which expresses the requirement that domestic consumption of X will be carried to the point where its marginal utility, $U'(C)$, is equal to the foreign relative price, $P^* = J(C - X)/(C - X)$.

To determine the solution of this problem, define a modified version of the current value Hamiltonian given in (43):

$$\begin{aligned} H = {} & U(C) + B + \theta \cdot (T(X, |\dot{K}|, K) - Z) \\ & + \alpha \cdot (J(C - X) - (Z - B)) \\ & + \beta \cdot (U'(C) - (J(C - X)/(C - X))) + \lambda \cdot \dot{K}, \end{aligned} \tag{43'}$$

where β is a Lagrangian multiplier assigned to the constraint (61), and every other variable has its previous role and interpretation. The optimum path of the economy must satisfy the same conditions given for the optimum tariff in section 4.6, with the addition of the constraint (61), and the modification of the conditions (44) and (46) to the following:

$$\partial H/\partial C = U' + \alpha \cdot J' + \beta \cdot (U'' - a) = 0, \tag{44'}$$

$$\partial H/\partial X = \theta \cdot T_X - \alpha \cdot J' + \beta \cdot a = 0, \tag{46'}$$

where

$$a = dP^*/d(C - X) = (J'/(C - X)) - (J/(C - X)^2) > 0. \tag{62}$$

Two important implications of these conditions (which may be stated without going into a detailed description of the second-best optimal path of the economy) are summarized in the following proposition:

(P9) *To induce private agents (with rational expectations and $i = r$) to follow the second-best optimal path, it is necessary for the government to give a subsidy to domestic producers of X which varies appropriately with the distribution of capital and which makes the price received by domestic producers, P, equal to the social marginal value of domestically produced X. Given this production* *subsidy, no direct intervention into the adjustment process is required to achieve the second-best optimal path of the economy.*

The required production subsidy (measured in units of Z per unit of domestically produced X) may be determined from the conditions (61), (44′), and (46′) to be

$$\sigma = (-U''/(a - U''))\cdot(J' - P^*). \tag{63}$$

Given this subsidy, the price received by domestic producers of X, $P = P^* + \sigma$, is an appropriate weighted average of the value to consumers of additional X consumption, $U'(C) = P^*$, and the marginal cost of imports, $J'(C - X)$; specifically,

$$P = (a/(a - U''))\cdot P^* + (-U''/(a - U''))\cdot J', \tag{64}$$

where the weights are the fractions by which an additional unit of domestically produced X would increase domestic consumption and reduce imports, respectively. This production subsidy will vary with the distribution of capital; but it is not possible to establish general propositions similar to (P7) and (P8) that characterize the nature of this variation. Nor is it possible to say, in general, whether the steady state value of K under the second-best production subsidy is greater or less than $\bar{K}$ under the optimum tariff.

The conclusion that no intervention in the adjustment process is required follows from the fact that the production subsidy makes the prices confronting the production sector of the economy (which includes the adjustment process) correspond to true social marginal values. In particular, since the condition (48) remains intact, it follows that the government need not tax or subsidize the movement of capital; and since the condition (49) remains intact, it follows that the government need not tax or subsidize the rental received by capital in either industry.

4.7.4 A Consumption Tax

Fourth, consider the case where the government can tax domestic consumption of the import good, but cannot subsidize domestic production, impose a tariff, or adopt any equivalent policies. The problem for the social planner is now to maximize (40) subject to the constraints (41) and (42) and the additional constraint

$$-T_X(X, |\dot{K}|, K) = P^* = J(C - X)/(C - X), \tag{65}$$

which expresses the requirement that the price facing domestic producers of X is the price prevailing in foreign trade.

To determine the solution of this problem, define a new modified current value Hamiltonian

$$(43'') \qquad H = U(C) + B + \theta\cdot(T(X,\dot{K},K) - Z)$$
$$+ \alpha\cdot(J(C-X) - (Z-B))$$
$$+ \gamma\cdot(-T_X(X,\dot{K},K) - (J(C-X)/(C-X)))$$
$$+ \lambda\cdot\dot{K},$$

where γ is a Lagrangian multiplier assigned to the constraint (65) and every other variable has its previous role and interpretation. The optimum path must satisfy the usual initial and boundary conditions, the constraints (41), (42), and (65), and the following modified forms of the conditions (44) through (49):

$$(44'') \qquad \partial H/\partial C = U' + \alpha\cdot J' - \gamma\cdot a = 0,$$

$$(45'') \qquad \partial H/\partial B = 1 + \alpha = 0,$$

$$(46'') \qquad \partial H/\partial X = \theta\cdot T_X - \alpha\cdot J' - \gamma\cdot(T_{XX} - a) = 0,$$

$$(47'') \qquad \partial H/\partial Z = -\theta - \alpha = 0,$$

$$(48'') \qquad \partial H/\partial\dot{K} = \mathrm{sign}(\dot{K})\cdot(\theta\cdot T_I - \gamma\cdot T_{XI}) + \lambda = 0,$$

$$(49'') \qquad \dot{\lambda} = r\cdot\lambda - \theta\cdot T_K + \gamma\cdot T_{XK},$$

where $a = dP^*/d(C-X) > 0$ is defined in (62).

From (45'') and (47''), it follows that $\theta = -\alpha = 1$. Given this result, it follows from (65) and (46'') that

$$(66) \qquad \gamma = (J' - P^*)/(a - T_{XX}) > 0.$$

Further, define $P^c = U'(C)$ as the price facing domestic consumers. This price is enforced by a consumption tax of τ^c units of Z per unit of X consumed, which makes $P^c = P^* + \tau^c$. From (44''), (46''), and (66), it follows that

$$(67) \qquad \tau^c = -\gamma\cdot T_{XX} = (-T_{XX}/(a - T_{XX}))\cdot(J' - P^*).$$

This makes sense since it implies that P^c is an appropriate weighted average of the marginal cost of domestically produced X, $-T_X = P^*$, and the marginal cost of imports, $J'(C-X)$,

$$(68) \qquad P^c = P^* + \tau^c = (a/(a - T_{XX}))\cdot P^*$$
$$+ (-T_{XX}/(a - T_{XX}))\cdot J',$$

where the weights are the fractions by which domestic production and imports would be increased if consumption of X were increased by a unit.

The consumption tax, however, is not the only policy that the government must employ to place the economy on its second-best optimal path. As indicated in the following proposition, the government must also intervene in the adjustment process:

(P10) *When the price facing domestic producers is constrained to equal the foreign price P^*, the second-best combination of policies includes a tax on domestic consumption of X, a tax on the movement of capital, and a subsidy on the rental of capital used in X.*

From (48″), it follows that the required tax on the movement of capital is given by $-\gamma \cdot T_{XI} > 0$. From (49″), it follows that the required subsidy on the rental of capital used in X is given by $-\gamma \cdot T_{XX} > 0$. These interventions are required in order to make the privately perceived costs and benefits of capital movement correspond to the true social costs and benefits.

The rationale for this intervention into the adjustment process can easily be understood by considering what would happen, starting from steady state free-trade equilibrium, if the government imposed only a consumption tax. This tax would reduce consumption and hence reduce imports. This is beneficial since (at the initial equilibrium) the marginal cost of imports exceeds their marginal value of consumers. By reducing the foreign price P^*, which is the price facing domestic producers, the consumption tax would also reduce domestic production of X, thereby tending to increase imports. This is harmful, but the harm is unavoidable since (by assumption) the government cannot intervene to make the price to domestic producers differ from P^*. The reduction in price of X facing domestic producers also reduces the rental on capital in X below the rental on capital in Z. This motivates private capital owners to move capital from X to Z. In the short run, this is harmful because the process of capital movement diverts resources from domestic production of X and increases imports which have a marginal cost that is higher than P^*. In the long run, this is harmful because even after the process of movement is complete, the lower capital stock in X means less domestic production of X and hence larger imports. To counteract the short-run harm associated with the process of capital movement, it is appropriate for the government to tax capital movement. To counteract the long-run harm that would result from a redistribution of capital away from X and toward Z, it is appropriate for the government to remove the motivation for this redistribution by subsidizing the rental earned by capital employed in producing X.

The steady state position resulting from the combination of policies in (P10) is the same as the equilibrium position in the standard two-sector model when the government uses the second-best combination of a consumption tax and a subsidy to capital used in X. The subsidy to capital used in X is beneficial because it operates, in part, like a production subsidy; but this benefit must be balanced against loss of efficiency resulting from the factor market distortion associated with a subsidy to factor use.[14]

If a subsidy cannot be paid on the rental of capital used in X, then as a third-best policy the government should combine a tax on the consumption of X with a tax on the movement of capital out of X. Indeed, if the optimal steady state level of capital in X under the policies of (P10) were above the initial level K_0, it would be appropriate for the government to levy a prohibitive tax on the movement of capital in order to prevent the consumption tax from moving the distribution of capital even further from the optimal steady state distribution.

Finally, it is important to indicate why it is appropriate for the government to intervene in the adjustment process in conjunction with a consumption tax, but not in conjunction with a production subsidy. This is because the adjustment process resides in the production sector of the economy and the production subsidy removes all distortions from this sector of the economy; specifically, it makes the relative price of X facing domestic producers correspond to the social marginal value of an additional unit of domestically produced X. In contrast, under the consumption tax, the price facing domestic producers of X does not equal the social marginal value of an additional unit of domestically produced X. This divergence between price and social marginal value distorts the adjustment process and hence justifies additional government intervention to correct this distortion. If the adjustment process resided exclusively in the consumption sector of the economy rather than the production sector, then no intervention into the adjustment process would be required in conjunction with a consumption tax, but such intervention would be required in conjunction with a production subsidy. More generally, if the adjustment process is partly in the production sector and partly in the consumption sector, then some intervention into the adjustment process will be desirable in conjunction with either a second-best consumption tax or a second-best production subsidy. Moreover, this principle applies not only to second-best policies to deal with a divergence between the social and private cost of imports, but also to second-best policies to deal with other distortions.

4.8 Extensions, Generalizations, and Conclusions

So far, the analysis in this paper has focused exclusively on the issue of the economic efficiency of the adjustment process and has ignored the important quetions concerning the effects on the distribution of income of government policies directed at the adjustment process. The preceding analysis has also been limited in that it has been based on a single, specific model of adjustment technology. The purpose of this section is to partially remedy these deficiencies and to summarize the general principles concerning the role of government policy in the adjustment process that are suggested by the present theoretical analysis.

4.8.1 Income Distribution and the Adjustment Process

In discussing questions of income distribution, it is important to distinguish between the "personal distribution of income" and the "functional distribution of income." The "personal distribution of income" refers to the distribution of income among individuals in the society, by income levels, but not to the levels of income of specific individuals. Theoretical analyses of economic equity are usually concerned with this concept of the distribution of income. The "functional distribution of income" refers to the distribution of income among different types of factors of production, as determined by the prices paid for the productive services they supply. Changes in the functional distribution of income, in general, imply important changes in the incomes of specific individuals in the society, and hence are of great interest to these individuals. But, without strong assumptions about the distribution of ownership of various factors of production among individuals, it is not possible to reach conclusions concerning the consequences for the personal distribution of income of changes in the structure of factor prices.

Since the model analyzed in previous sections does not include specific assumptions about the distribution of factor ownership, it cannot be used to investigate questions concerning the personal distribution of income. It can, however, be used to examine two general and important questions relating to the functional distribution of income: What is the effect of various government policies designed to affect the efficiency of the adjustment process on the functional distribution of income? What is the effect of government policies designed to affect the functional distribution of income on the efficiency of the adjustment process? These questions are of considerable importance because individual factor owners are obviously concerned with the effects of government policies on the incomes of the particular factors that they own, and because much government policy (particularly in the area of international trade policy) is directed to protecting the incomes of particular factor owners, regardless of any general objectives of economic equity related to the personal distribution of income.

With respect to long-run equilibrium, the model of productive technology described in section 4.2 is identical to the standard two-sector model. Hence the Stolper-Samuelson theorem describes the long-run equilibrium response of factor rewards to any change in the relative output price. Specifically, assuming that X is relatively capital-intensive, it follows that an increase in P will increase the rental received by capital, measured in terms of either X or Z, and will decrease the wage received by labor, measured in terms of either X or Z.

In discussing the short-run effects of policy and parametric changes on the functional distribution of income, it is necessary to distinguish between three factors. The mobile factor, referred to as "labor," earns the same wage in both final goods industries and in the activity of capital movement. Holding the amount of labor devoted to capital movement constant, an increase in P increases the wage measured in terms of Z and reduces the wage measured in terms of X, implying that labor has no clear-cut short-run interest in policies that either increase or reduce P. Since capital movement uses only labor, however, an increase in the rate of capital movement increases the wage in terms of both goods, implying a short-run benefit to labor. Capital employed in X enjoys a short-run gain, measured in terms of both goods, from an increase in P, holding constant the amount of labor used in capital movement; and conversely for capital employed in Z. An increase in the wage rate induced by an increase in the demand for labor in capital movement is disadvantageous to capital employed in either industry.[15]

When there is a divergence between the short-run response and the long-run response of a factor price to a policy or parametric change, the interest of the factor owner is presumably determined by the effect on the present discounted value of his income stream. If X is relatively capital-intensive, owners of capital initially employed in X will be very likely to benefit, in terms of present discounted value, from an increase in the relative price of X.[16] If the movement of capital requires only small amounts of labor (i.e., if the coefficient β in [3] is small), then capital will shift rapidly from Z to X, with little impact on the wage rate from the use of labor in capital movement. In this case, owners of capital initially employed in Z will also benefit from an increase in P. Moreover, if β is small, owners of capital initially employed in either industry are likely to benefit and workers are likely to lose, in terms of present discounted value, from a subsidy to capital movement imposed subsequent to an increase in P. This is because the short-run effect of the subsidy to capital movement in increasng the wage rate will be outweighed by the decline in the wage rate and the increase in the rental rates associated with the more rapid shift of capital from the labor-intensive to the capital-intensive industry. On the other hand, if β is small, then a subsidy to capital movement will benefit workers and harm capital owners in the event of a decrease in P. If β is large, then a subsidy to capital movement may benefit workers and harm capital owners in the event of any change in P. This is because labor will have sharply declining marginal productivity in capital movement. Hence a subsidy to capital movement will increase the wage rate over a substantial period of time, by increasing the demand for labor in capital movement, but will not increase to a commensurate extent the speed of movement of capital from one industry to another.

These results illustrate the implications of the model discussed in previous sections for the incidental consequences for the functional distribution of income of government policies directed at affecting output prices and/or the process of adjustment. A related issue is the effect on the process of adjustment of policies directed toward affecting the functional distribution of income. Specifically, suppose that there has been a decline in the relative price of X in world trade and that, for political reasons, the government desires to protect owners of capital (including human capital) employed in X, the import-competing industry, from the consequences of this price change. Of course, the government might simply impose a tariff that would keep the domestic relative price of X at its previous level. But suppose this tariff cannot be imposed, either because the government recognizes the production and consumption distortion losses it would generate or because other domestic political considerations preclude the tariff or because the government fears foreign retaliation. Further, suppose that the objective of government policy is not to protect owners of capital employed in X from the long-run deterioration of the income of capital in both industries that would result from a reduction in the relative price of the capital-intensive good, but only to protect them from the additional loss that they suffer relative to owners of capital initially located in Z. The first-best policy to achieve this objective is a lump-sum wealth transfer to the owner of each unit of capital initially employed in X equal to the present discounted value of the difference between the rental of a unit of capital employed in Z and the rental of a unit of capital employed in Z. An equivalent policy is a flow transfer to owners of capital initially employed in X equal to the difference between the rental on capital employed in Z and the rental on capital employed in X. Both of these policies are nondistorting with respect to the process of adjustment.

It is important to recognize that a flow transfer paid to owners of capital *initially* employed in X is very different from a flow transfer paid to owners of capital that *remains* employed in X. The latter policy which makes receipt of the transfer contingent on capital remaining in X seriously distorts the adjustment process. In fact, if the level of the subsidy were set equal to the current rental differential between capital located in Z and capital located in X, then all incentive for capital movement would be removed and there would be no adjustment toward the new long-run equilibrium appropriate for the lower world relative price of X. More generally, if the transfer to owners of capital in X was set equal to a fraction of the rental differential or was made to decline gradually over time, some incentive for capital movement would be retained, but the rate of capital movement would be reduced to below the socially optimal rate. This is because the linking of transfer payments to the current location of capital, rather than its initial location, creates an artificial incentive to keep capital employed in X.

If practical or political considerations rule out wealth and income transfers as a means for compensating those adversely affected by changing conditions of international trade, a government might resort to "adjustment assistance" as an alternative means of providing such compensation. It is noteworthy that in the model developed in this paper, adjustment assistance in the form of a subsidy to capital movement is not likely to be beneficial to owners of capital initially employed in the capital-intensive industry when there is a decline in the relative price of that industry's output. In the short run, such a subsidy will work to the disadvantage of capital owners by increasing the demand for labor in capital movement and thus the wage rate. In the longer run, more rapid movement of capital out of the capital-intensive industry and into the labor-intensive industry implies that the return to capital in both industries will decline more rapidly, in accord with the dictates of the Stolper-Samuelson theorem. From this theorem, it also follows that a subsidy to capital movement is more likely to be beneficial to owners of capital initially employed in the labor-intensive industry when that industry suffers a decline in its relative output price.

These results concerning the effects of adjustment assistance do not necessarily apply under alternative assumptions about productive technology, particularly the technology of the adjustment process, or under other assumptions about the form of adjustment assistance. They do illustrate, however, the general proposition that assistance to factors of production in moving out of declining industries is *not* necessarily beneficial to the owners of these factors. Moreover, it should be emphasized that whatever the income distributional consequences of adjustment assistance, such assistance is likely to interfere with the efficiency of the adjustment process, unless it countervails some other distortion that affects the adjustment process.

4.8.2 Alternative Adjustment Technologies

In the model of adjustment technology presented in section 4.2, the economy's total capital stock is assumed fixed and the only adjustment activity consists of using labor to move capital from one industry to another. It is useful to consider briefly the implications of a more general model of adjustment technology, which retains the same basic assumptions about the technology for producing final outputs, but allows adjustment both in the distribution of capital between industries and in the total size of the capital stock. Specifically, suppose that capital in each industry depreciates at a constant exponential rate δ and that the amount of labor required to replace depreciating capital, create new capital, and move capital from one industry to another is given by

$$L_I = H(I_X + I_Z) + Q_X(\dot{K}_X) + Q_Z(\dot{K}_Z), \tag{69}$$

where $I_X = \dot{K}_X + \delta \cdot K_X$ measures gross investment in capital in X and $I_Z = \dot{K}_Z + \delta \cdot K_Z$ measures gross investment in capital in Z. The function $H(\ )$ determines the amount of labor required to produce the new capital for the two industries; it is assumed that $H' > 0$ and $H'' \geq 0$. The functions $Q_X(\ )$ and $Q_Z(\ )$ are the "Penrose functions" which indicate the amount of labor required to alter the scale of production facilities in order to accommodate changes in the size of the capital stock employed in a particular industry; it is assumed that $Q_X(0) = Q_Z(0) = 0$, $Q'_X(0) = Q'_Z(0) = 0$, $Q''_X > 0$, and $Q''_Z > 0$.[17]

To illustrate the general implications of the adjustment technology embodied in (69), it is useful to consider three special cases. First, suppose that the depreciation rate is zero and that the aggregate capital stock $K_X + K_Z$ is fixed. In this case (69) reduces to

$$L_I = Q_X(\dot{K}_X) + Q_Z(-\dot{K}_X). \tag{70}$$

This labor requirements function is a generalization of the labor requirements function for capital movement given in (3). Since the two labor requirements functions (3) and (70) share all of the same essential properties, they share all of the same implications.

Second, suppose that the Penrose functions, Q_X and Q_Z, are eliminated from (69), and further suppose that marginal labor requirements for capital goods production, $H'(I_X+I_Z)$, are strictly increasing as a function of total gross investment.[18] To analyze the process of adjustment under this assumption about adjustment technology, it is useful to define $\mu_X(t)$ and $\mu_Z(t)$ as the present discounted values of the stream of rentals that would be produced by a unit of capital initially located in the two respective industries at time t; that is, [19]

$$\mu_X(t) = \int_t^\infty R_X(s)\exp(-(r+\delta)\cdot(s-t))\,ds, \tag{71}$$

$$\mu_z(t) = \int_t^\infty R_Z(s)\exp(-(r+\delta)\cdot(s-t))\,ds. \tag{72}$$

Since newly produced capital can be located at zero cost in either industry, it will be located only in the industry for which $\mu_X(t)$ or $\mu_Z(t)$ is the largest, and the level of gross investment will be determined by the condition

$$W\cdot H'(I_X+I_Z) = \max(\mu_X(t), \mu_Z(t)), \tag{73}$$

where W is the wage rate consistent with the requirement of labor market equilibrium, namely,

$$\ell_X(W/P)\cdot K_X + \ell_Z(W)\cdot K_Z + H(I_X+I_Z) = \underline{L}. \tag{74}$$

Given P, the conditions (73) and (74) jointly determine W and I_X+I_Z as functions of K_X, K_Z, μ_X, and μ_Z. When $\mu_X \neq \mu_Z$, net investment in each industry is determined by the allocation of all newly produced capital to the industry with the highest μ. The rental rates on capital in the two industries, the allocation of labor between industries, and their outputs are also determined as functions of the state variables, K_X and K_X, and the costate variables, μ_X and μ_Z, given P.

For the economy to have a steady state, associated with a given value of P, in which the capital stock in both industries is positive, it must be the case that at this steady state $\mu_X = R_X/(r+\delta)$ is equal to $\mu_Z = R_Z/(r+\delta)$. For this to happen, the rental rates on capital in the two industries, as well as the wage rates paid to labor, must be the same. Thus, at the steady state equilibrium, the conditions of the two-sector model with respect to product and factor prices must apply, implying that the steady state wage rate and the steady state rental rates on capital in both industries are determined by the output price ratio and the properties of the production functions for final outputs; say, $W = W^*(P)$ and $R_X = R_Z = R^*(P)$. It follows that the steady state values of μ_X and μ_Z, denoted by an underscore, are given by

$$\underline{\mu}_X = R^*(P)/(r+\delta) = \underline{\mu}_z. \tag{75}$$

Further, since gross investment in the steady state must equal total depreciation, it follows that the steady state capital stocks in the two industries, denoted by $\underline{K}_X$ and $\underline{K}_Z$, must satisfy

$$W^*(P)\cdot H'(\delta\cdot(\underline{K}_X+\underline{K}_Z)) = R^*(P)/(r+\delta). \tag{76}$$

The combinations of K_X and K_Z that satisfy this condition are illustrated by the line labeled $\underline{KK}$ in figure 4.6, which has a slope of -1. In addition, the steady state capital stocks must be consistent with full employment of the economy's supply of labor; that is,

$$\begin{aligned}\ell_X(W^*(P)/P)\cdot\underline{K}_X + \ell_Z(W^*(P))\cdot\underline{K}_Z \\ + H(\delta\cdot(\underline{K}_X+\underline{K}_Z)) = \underline{L}.\end{aligned} \tag{77}$$

The combinations of K_X and K_Z that satisfy this condition are illustrated by the line labeled $\underline{LL}$ in figure 4.6. This line is flatter than the $\underline{KK}$ line because, by assumption, X is relatively capital-intensive, implying that $\ell_X(W^*(P)/P) < \ell_Z(W^*(P))$. The intersection of the $\underline{KK}$ line and the $\underline{LL}$ line in figure 4.6 determines the steady state capital stocks for the two industries and the aggregate steady state capital stock, $\underline{K} = \underline{K}_X + \underline{K}_Z$, appropriate for the given output price ratio.

A change in the output price ratio alters the steady state position of the economy. The steady state responses of the wage rate and the rental rates of capital in the two industries are the same as in the standard two-sector model. This reflects the assumption that newly produced capital can be installed at zero cost in either industry and hence must earn the same steady state rental in either industry. It is not the case, however, that the aggregate capital stock and the supply of labor used to produce final

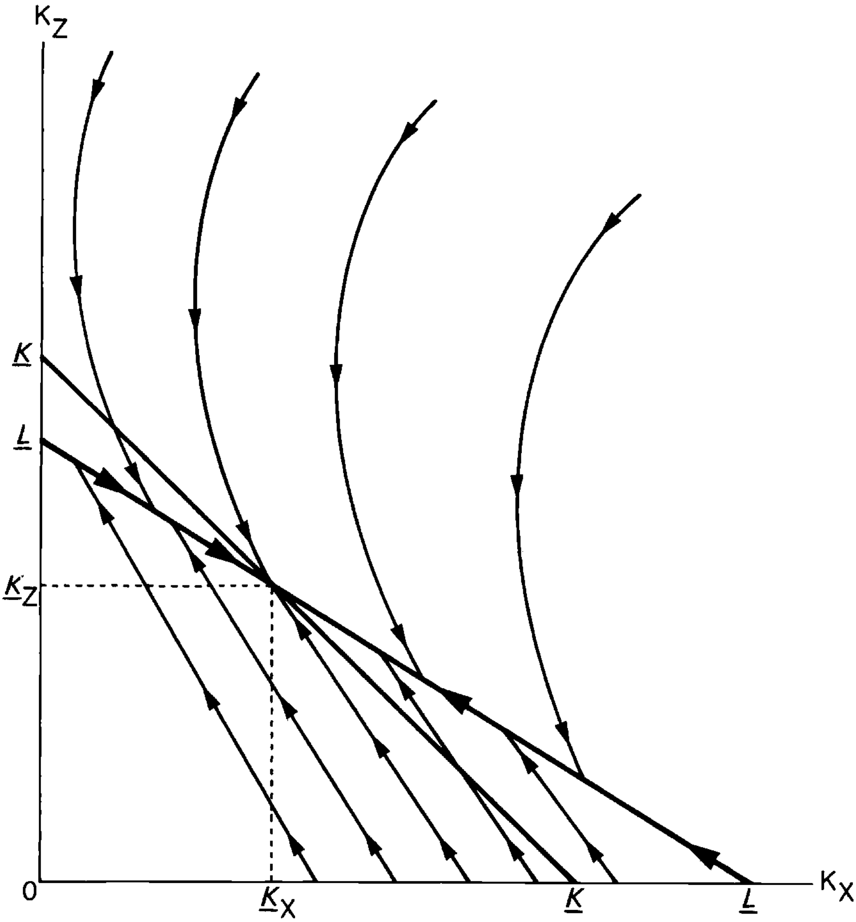


Fig. 4.6 Steady state capital stocks and adjustment paths when there are not installation costs.

outputs remain unchanged in the face of a change in P, as they are assumed to do in the standard two-sector model. Specifically, an increase in P, the relative price of the capital-intensive good X, increases the aggregate steady state capital stock, $\underline{K} = \underline{K}_X + \underline{K}_Z$, and increases the amount of labor required to support this capital stock, $L_I = H(\delta \cdot \underline{K})$, thereby reducing the amoung of labor, $\underline{L} - L_I$, used to produce final outputs. From the Rybczynski theorem, it follows that output of X rises and output of Z declines by significantly more than would be the case if the aggregate capital stock and the amount of labor used to produce final outputs both remained constant in the face of the increase in P.[20]

The nature of the process of convergence to the steady state appropriate for a given value of P is also illustrated in figure 4.6. It may be shown that for combinations of K_X and K_Z lying below the $\underline{L}\underline{L}$ line, μ_Z is always greater than μ_X, implying that the entire production of new capital will be allocated to maintaining and increasing capital in Z and that capital in X declines at the rate $\delta \cdot K_X$. Thus, below the $\underline{LL}$ line, the direction of movement is upward and toward the left, until this line is reached. Above the $\underline{LL}$ line, it may be shown that μ_X is always greater than μ_Z, implying that all newly produced capital is allocated to X and that K_Z declines at the rate $\delta \cdot K_Z$. Far above the $\underline{LL}$ line, production of new capital will not be sufficient to maintain the level of K_X, and both K_X and K_Z will be falling. Nearer to the $\underline{LL}$ line, production of new capital will exceed $\delta \cdot K_X$, implying that K_X will be rising while K_Z is declining. When the $\underline{LL}$ line is reached, from either above or below, the economy moves along this line in the direction of its steady state position $(\underline{K}_X, \underline{K}_Z)$. Along this line, the wage rate and rental rates on capital are at their steady state values, $W^*(P)$ and $R^*(P)$, and $\mu_X = \mu_Z = R^*(P)/(r+\delta)$. The level of gross investment, $I_X + I_Z$, and the amount of labor allocated to producing new capital, $L_I = H(I_X + I_Z)$, are both at their steady state values, $\delta \cdot (\underline{K}_X + \underline{K}_Z)$ and $H(\delta \cdot (\underline{K}_X + \underline{K}_Z))$, respectively. Movement along the $\underline{LL}$ line is achieved by allocating the supply of new capital to the two industries in a manner that keeps the economy on this line.

Three features of this adjustment process deserve special notice. (1) Since the $\underline{LL}$ line will always be reached in finite time, the wage rate and the rental rates on capital in the two industries will reach their steady state values, determined by the standard two-sector model, in finite time. (2) The capital stock in an industry need not converge monotonically to its steady state value, if the economy starts from a point off the $\underline{LL}$ line. This lack of monotonicity also applies to the outputs of the two industries, but not to the aggregate capital stock, the level of gross investment, or factor prices. (3) The movement of capital from one industry to another is achieved by allocating the production of new capital so as not to replace capital that depreciates in the industry that should have a declining capital stock. Thus, in this special case of the general adjustment technology (69), the movement of capital is not "costly" in the sense that it does not require an explicit use of scarce factors of production.

The third special case of (69) is the general case where the Penrose functions, $Q_X(\dot{K}_X)$ and $Q_Z(\dot{K}_Z)$, are added on to the function $H(I_X+I_Z)$. For a given relative output price and given values of the state variables, K_X and K_Z, and the costate variables, μ_X and μ_Z, as defined in (71) and (72), the momentary equilibrium wage rate and the levels of gross and net investment in the two industries are determined by the requirements

$$W \cdot [H'(I_X+I_Z) + Q'_X(\dot{K}_X)] = \mu_X, \tag{78}$$

$$W \cdot [H'(I_X+I_Z) + Q'_Z(\dot{K}_Z)] = \mu_Z, \tag{79}$$

$$\ell_X(W/P) \cdot K_X + \ell_Z(W) \cdot K_Z + H(I_X + I_Z) + Q_X(\dot{K}_X) + Q_Z(\dot{K}_Z) = \underline{L}. \tag{80}$$

Given the solutions for the wage rate and the levels of gross and net investment in the two industries, the amounts of labor employed in producing the two final outputs, the levels of these outputs, and the rental rates for capital in the two industries are also determined as functions of K_X, K_Z, μ_X, and μ_Z, given P.

By assumption, $Q_X(0) = Q_Z(0) = 0$ and $Q'_X(0) = Q'_Z(0) = 0$. It follows that in steady state equilibrium, where $\dot{K}_X = \dot{K}_Z = 0$, the Penrose functions and their derivatives disappear from (78), (79), and (80). Thus, with respect to steady state equilibrium, (80) reduces to (74), and (78) and (79) reduce to (73), plus the requirement that $\mu_X = \mu_Z$. It follows that the conditions that must apply in steady state equilibrium under the general form of (69) are the same as those that apply in the special case where the Penrose functions are omitted from (69). Hence the analysis of steady state equilibrium under the general form of (69) is exactly the same as under this previously considered special case.

Where the Penrose functions do matter is in analyzing the process of convergence toward the steady state. When these functions are eliminated from (69), any difference between μ_X and μ_Z (that is, anywhere off the $\underline{LL}$ line in figure 4.6) implies that all of gross investment is allocated to the industry with the higher shadow price for a unit of capital. This applies even in the neighborhood of the steady state (off of the $\underline{LL}$ line), where the difference between μ_X and μ_Z is small, but the level of gross investment is relatively large (equal approximately to its steady state level, $\delta \cdot (\underline{K}_X + \underline{K}_Z)$). When the Penrose functions are present in the adjustment technology, we no longer have this peculiarity. In the neighborhood of the steady state, where the difference between μ_X and μ_Z is small, gross investment will be divided between the two industries so that the level of net investment in each industry is close to its steady state value of zero, for otherwise the conditions (78) and (79) would not be satisfied. In fact, there must be a region in the neighborhood of the steady state where net investment in both industries is positive, and another region where net investment in both industries is negative. These regions exist because, when the Penrose functions are present in the adjustment technology, the movement of capital is a costly activity, and this cost cannot be avoided simply by reallocating newly produced capital between the two industries.

The exact pattern of adjustment of the capital stocks in the two industries to their respective steady state values, $\underline{K}_X$ and $\underline{K}_Z$, depends on the exact properties of the Penrose functions. One possible pattern of adjustment is illustrated in figure 4.7. In this figure, the $\dot{K}_X = 0$ line and the $\dot{K}_Z$

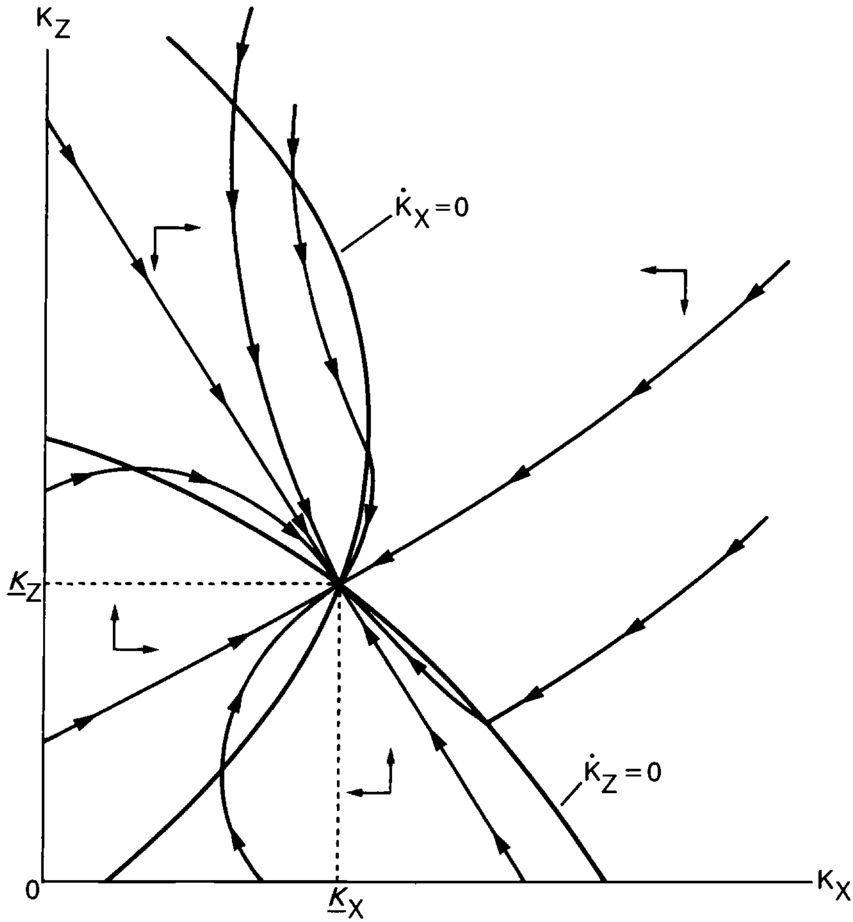


Fig. 4.7 Steady state capital stocks and adjustment paths with increasing marginal installation costs.

= 0 line show the combinations of K_X and K_Z for which net investment in the two industries, respectively, is equal to zero. These lines intersect at the steady state point ($\underline{K}_X$ and $\underline{K}_Z$) and divide the plane into four regions: a region where $\dot{K}_X > 0$ and $\dot{K}_Z > 0$; a region where $\dot{K}_X < 0$ and $\dot{K}_Z < 0$; a region where $\dot{K}_X > 0$ and $\dot{K}_Z < 0$; and a region where $\dot{K}_X < 0$ and $\dot{K}_Z > 0$. The arrows in the diagram indicate the direction of movement of the capital stock in each industry in each of the four regions. Convergence to the steady state is necessarily noncyclic, though it need not be the case that the capital stock in each industry converges monotonically to its steady state value.

4.8.3 General Conclusions

It is worthwhile to investigate the generality of the conclusions reached earlier in this paper under the alternative adjustment technology specified in (69). First, the key proposition that private maximizing behavior will lead to a socially optimal adjustment path, provided that there are no distortions in the economy, that the private discount rate is equal to the social discount rate, and that private agents have rational expectations, remains valid under the adjustment technology specified in (69). Under private maximization, the shadow prices μ_X and μ_Z that are used by the social planner to guide level and disposition of investment are replaced by the values that private asset owners assign to units of capital located in the two industries. Provided that there are no distortions in the economic system that cause the rental received by private capital owners to differ from the values of the marginal products of capital in the two industries, provided that the discount rate used by private asset owners is equal to the social discount rate, and provided that expectations concerning future rentals earned by capital in the two industries are rational, the values of units of capital located in the two industries assigned by private asset owners will equal the shadow prices established by the social planner. The process of adjustment that occurs under the guidance of these capital values will be the same as that determined by the social planner. Moreover, it is clear that this principle of the social optimality of the adjustment process under private maximizing behavior (which is a special case of Adam Smith's principle of the invisible hand) carries over to more general assumptions about adjustment technology and to more general models of production of final outputs.

Second, when there are distortions that directly affect the adjustment process, there is rationale for government intervention to directly countervail these distortions. In particular, it remains true under the adjustment technology specified in (69) that a proportional tax on income from capital (or on all factor income) distorts the adjustment process, even if such a tax allows an appropriate deduction for depreciation. The reason is that such a tax reduces privately received (after tax) rentals from capital ownership to below the true social rentals and hence induces private asset owners to assign lower values to units of capital located in either industry than would be assigned by the social planner. This results in a steady state capital stock that is smaller than the socially optimal capital stock and, in general, also distorts the process of convergence toward the steady state. An investment tax credit that allows capital owners to deduct from their current tax liability both the cost of newly produced capital and the costs of variations in the scale of production associated with the Penrose functions, but eliminates subsequent depreciation allowances, will correct this distortion. In the long run, however, such a credit will have a serious effect on the government's tax revenue since it amounts to an elimination of the tax on income from capital for all capital that is installed after the credit is instituted. If the lost revenue cannot be replaced by lump-sum nondistorting taxes, then the benefits of reducing the disincentives to capital accumulation by the investment tax credit will have to be weighed against the distortions created by the alternative taxes used to replace the lost tax revenue.

Third, when there are distortions in the product or factor markets that do not specifically affect the adjustment process, such as the failure to impose an optimum tariff, then the first-best policy is to countervail these distortions directly. In general, the countervailing tax or subsidy will not be constant, but will vary with the size and distribution of the economy's capital stock. However, provided that the first-best policy to correct the product market distortion is implemented, no further intervention into the adjustment process will be required in order to ensure a socially optimal adjustment path.

Fourth, preliminary analysis suggests that the specific propositions concerning the behavior of the optimum tariff along the path of convergence to the steady state that were stated in section 4.6 probably do generalize to the adjustment technology specified in (69). In particular, it may be shown that the relative positions of the steady state equilibria under free trade and under the optimum tariff are such that convergence of the capital stock in each industry and of the aggregate capital stock to their steady values under the optimum tariff, starting from the free trade steady state, are monotonic when the Penrose functions are eliminated from (69). This point is critical in establishing the analogs of the propositions (P4), (P5), (P7), and (P8) for the adjustment technology specified in (69). It cannot be presumed, however, that specific propositions concerning properties of the adjustment path are generally invariant to the specification of adjustment technology.

Fifth, when the first-best policies to correct product or factor market distortions are not available, the second-best combination of policies *may* involve intervention into the adjustment process. This is the case whenever the adjustment process becomes distorted as a result of a second-best policy directed at some other distortion. In particular, the imposition of a consumption tax as a second-best policy to correct for a divergence between the social marginal cost of imports and their privately perceived cost should generally be combined with a policy to discourage the movement of resources out of the import-competing sector that would otherwise be induced by the depressing effect of the consumption tax on the price facing domestic producers of the import good. A second-best production subsidy, however, will not require additional intervention into the adjustment process because this subsidy removes all distortions from the production sector of the economy, which is assumed to include the adjustment process.

Finally, it is worthwhile to summarize the general philosphy concerning government policy toward the adjustment process that is suggested by the preceding analysis. Adjustment to changing conditions of international trade and to other causes of economic change generally involves investment decisions in which the costs of adjustment must be weighed against the expected future benefits. In many economies, such decisions are to a large extent made by private agents who pursue their individual self-interest. A principal objective of government policy should be to create an environment in which the decisions of these agents lead to a socially appropriate outcome by removing the general distortions, including the distortions associated with government taxes and transfers, that cause the privately perceived benefits or costs of adjustment to diverge substantially from the true social benefits or costs. In addition, there may be instances of clearly identifiable distortions of the adjustment process for particular industries, perhaps resulting from government policies pursued for other purposes, that justify specific interventions to either enhance or impede the adjustment process. Lastly, care must be taken in designing policies to compensate factor owners who suffer losses as a result of changing economic conditions in order to ensure that such compensation does not interfere unduly or unnecessarily with the private incentive to achieve socially efficient adjustment.

Notes

1. The process of adjustment to changing conditions of international trade and the influence of the adjustment process on government policy have not been totally neglected in the literature; see, in particular, Baldwin, Mutti, and Richardson (1978), Kemp and Wan (1974), Lapan (1976), Mayer (1974), Mussa (1978), and Neary (1978).

2. This model of adjustment technology is the same as that presented in Mussa (1978).

3. It is inconvenient to assume that labor requirements for capital movement are proportional to the rate of capital movement because this implies that the marginal cost of capital movement is always strictly positive. With a strictly positive marginal cost of capital movement, the economy will not, in general, converge to a steady state position that is the same as the equilibrium position in the standard two-sector model. Instead, as Kemp and Wan (1974) point out, there are "hysteresis effects" which make the steady state position of the economy dependent on its initial position. To avoid the difficulties associated with such "hysteresis effects" and preserve as much as possible the properties of the standard two-sector model, it is convenient to assume that labor requirements for capital movement are determined by (3).

4. The $\dot{\lambda} = 0$ line in figure 4.1 is shown as everywhere negatively sloped. It cannot be proved that the $\dot{\lambda} = 0$ line will necessarily have this property. However, it can be shown that there is a unique intersection of the $\dot{\lambda} = 0$ line with the $\dot{K} = 0$ line (identical with the K axis), occurring at the optimal steady state value of K that corresponds to the distribution of capital determined in the standard two-sector model. At this steady state, the $\dot{\lambda} = 0$ line is negatively sloped. Everywhere except in the neighborhood of the steady state K, the $\dot{\lambda} = 0$ line is bounded away from the K axis. These facts are sufficient to establish that there is a unique optimum path converging to the steady state which lies above the K axis for $K < \bar{K}(P)$ and below the K axis for $K > \bar{K}(P)$. It follows that the distribution of capital always converges monotonically to its optimal steady state distribution.

5. The assumption of competitive behavior is questionable since the production function for capital movement is not linear homogeneous. The assumption of competitive behavior

could be justified, however, if firms producing the service of capital movement were assumed to use a Cobb-Douglas production function, $I = (L_I \cdot S_I)^{1/2}$, where L_I is the amount of labor employed by such a firm and S_I is the amount of capital so employed. Capital used in producing the service of capital movement is specific to that activity, and the total amount of such capital is equal to $\bar{S}_I$. The demand for labor by firms supplying the service of capital movement would, under these assumptions, be given by $L_I(W, q) = \bar{S}_I \cdot (q/2W)^2$.

6. In the analysis of the optimum tariff in section 4.6 and of various second-best policies in section 4.7, the path of the output price is endogenously determined by the general equilibrium of the economic system. This endogenous determination of prices creates no difficulties for proposition (P1). All that is necessary is that individual agents take these prices as given and act in their own best interest.

7. This difference might be due to the finite life of individuals or to an excess of the private cost of risk over the social cost or to other factors. Somewhat less plausibly, it might be assumed that the private discount rate is less than the social discount rate. Obviously, this would require the exact reverse of the policies appropriate to correct for an excess of the private discount rate over the social discount rate.

8. The $\lambda = \psi(K, |\lambda|)/r$ line is steeper than the $\lambda = \varphi(K, |\lambda|, \bar{P})/r$ line because $\hat{P}(K, |\lambda|) > \bar{P}$ for $K < \bar{K}$ and $\lambda > 0$. It follows that the speed of convergence to the steady state under the optimally varying tariff along the $\lambda = \hat{\lambda}(K)$ line is greater than the speed of convergence to the steady state along the $\lambda = \tilde{\lambda}(K)$ line constructed for a constant $P = \bar{P}$.

9. If we make the stronger assumption that the proportional difference between the marginal cost of imports, J', and the average cost of imports, $J/(C-X)$, increase as imports increase, we may conclude that the optimal *ad valorem* tariff, $\tau(K)/\hat{P}^*(K, |\hat{\lambda}(K)|)$, declines as K rises toward $\bar{K}$. However, neither of these assumptions is guaranteed by the standard properties of the foreign offer function. If the marginal cost of imports tends toward a constant value as imports rise, both the optimum specific tariff and the optimum *ad valorem* tariff may rise as K rises toward $\bar{K}$. The level of imports, however, should always decline as K rises toward $\bar{K}$, and so should the domestic relative price of the import good.

10. Since the relative output price is changing along the adjustment path, there is some difficulty in defining the appropriate measure of the discount rate. The basic point remains, however, that the amount spent on consumption will depend on wealth, not current income. Hence, if wealth is not changing significantly as the economy moves along the adjustment path, the position of the demand curve in the left-hand panel of figure 4.5 will remain approximately constant.

11. For a general discussion of the circumstances under which tariffs and quotas are and are not equivalent, see Bhagwati (1965), Falvey (1975, 1976), and Fishelson and Flatters (1975).

12. Even if the hypothesis of (P7) is not valid and the tariff $\tau(K)$ rises as K rises to $\bar{K}$, it is still true that, for any $K < \bar{K}$, the import quota $Q(\bar{K})$ results in lower imports and a higher domestic price of X than the tariff $\tau(\bar{K})$. Hence the quota $Q(\bar{K})$ induces more rapid convergence to the steady state than the tariff $\tau(\bar{K})$, starting from any $K_0 < \bar{K}$.

13. For a general analysis of production subsidies, consumption taxes, factor market interventions, and other second-best policies, see Johnson (1960), (1965), Bhagwati and Ramaswami (1963), Bhagwati, Ramaswami, and Srinivasan (1969), and Dornbusch (1971).

14. The desirability of factor market interventions when an optimum tariff is ruled out is well established; see Bhagwati and Ramaswami (1963) and Bhagwati, Ramaswami, and Srinivasan (1969).

15. A detailed analysis of the short-run and long-run effects of relative price changes on factor incomes, under the assumption that the amount of labor used for capital movement is constant, is implied by the results given in Mussa (1974).

16. If no capital movement took place, owners of capital employed in X would gain permanently in terms of both goods. When the process of capital movement is complete, the long-run gains to all capital owners are larger than the gains that owners of capital in X

would enjoy if no capital movement took place. The only possible cause of loss to owners of capital initially employed in X is from the increase in the wage rate induced by the use of labor in capital movement. It is unlikely that this increase in the wage would be sufficiently large and endure sufficiently long for owners of capital initially employed in X to suffer a loss in terms of present discounted value of rental income from an increase in P.

17. The implications of alternative assumptions about adjustment technology are also investigated in Mussa (1978). The concept of the "Penrose function" is discussed in Uzawa (1968, 1969).

18. If marginal labor requirements are constant, then, as discussed in Mussa (1978), there will be only one output price ratio at which both final outputs will be produced in the steady state.

19. There is an error in Mussa (1978) in that the discount factor used in defining μ_X and μ_Z does not take account of the depreciation of capital.

20. Formally, the effects of an increase in P on $\underline{K}_X$ and $\underline{K}_Z$ may be determined by applying the standard technique of comparative statics analysis to (76) and (77). Specifically, from the properties of the two-sector model, it follows that since X is capital-intensive, an increase in P reduces $W^*(P)$, increases $R^*(P)$, and increases both $\ell_X(W^*(P)/P)$ and $\ell_Z(W^*(P))$. From (76) and the fact that $H'' > 0$, it follows that the steady state capital stock, $\underline{K} = \underline{K}_X + \underline{K}_Z$, must rise as a result of an increase in P; geometrically, in figure 4.6, the $\underline{KK}$ line shifts outward from the origin. The increase in ℓ_X and ℓ_Z implies that the $\underline{LL}$ line, defined by equation (77), shifts toward the origin. The shifts of the $\underline{KK}$ and $\underline{LL}$ lines imply that $\underline{K}_X$ rises by more than the increase in $\underline{K}$ and that $\underline{K}_Z$ declines. Moreover, the changes in both $\underline{K}_X$ and $\underline{K}_Z$ are larger than would occur if the aggregate capital stock remained constant, as determined by shifting only the $\underline{LL}$ line in figure 4.6.

References

Arrow, K. J. 1968. Applications of control theory to the decision sciences. In *Mathematics of the decision sciences*, part 2. Providence, R.I.: American Mathematical Society.

Baldwin, R. E., J. Mutti, and J. D. Richardson. 1978. Welfare effects in the United States of significant multilateral tariff reduction. Department of Economics, University of Wisconsin, Madison, processed in April.

Bhagwati, J. N. 1965. On the equivalence of tariffs and quotas. In R. Baldwin et al., eds., *Trade growth and the balance of payments*, pp. 53–67. Chicago: Rand McNally.

Bhagwati, J. N., and V. K. Ramaswami. 1963. Domestic distortions and the theory of optimum subsidy. *Journal of Political Economy* 71, no. 1: 33–50.

Bhagwati, J. N., V. K. Ramaswami, and T. N. Srinivasan. 1969. Domestic distortiors, tariffs, and the theory of optimum subsidy: Further results. *Journal of Political Economy* 77, no. 6: 1005–10.

Dornbusch, R. 1971. Optimal commodity and trade taxes. *Journal of Political Economy* 79, no. 6: 1360–68.

Falvey, R. E. 1975. A note on the distinction between tariffs and quotas. *Economica* 42, no. 167 (August): 319–26.

———. 1976. A note on quantitative restrictions and capital mobility. *American Economic Review* 66, no. 1: 217–20.
Fishelson, G., and F. Flatters. 1975. The (non) equivalence of optimal tariffs and quotas under uncertainty. *Journal of International Economics* 5, no. 4: 385–93.
Johnson, H. G. 1960. The cost of protection and the scientific tariff. *Journal of Political Economy* 68, no. 5: 327–45.
———. 1965. Optimal trade intervention in the presence of domestic distortions. In R. Baldwin et al., eds., *Trade growth and the balance of payments*, pp. 3-34. Chicago: Rand McNally.
Kemp, M. C., and H. Wan. 1974. Hysterisis of long-run equilibrium from realistic adjustment costs. In G. Horwich and P. Samuelson, eds., *Trade, stability, and macroeconomics*. New York: Academic Press.
Lapan, H. E. 1976. International trade, factor market distortions, and the optimal dynamic subsidy. *American Economic Review* 66, no. 3: 335–46.
Mayer, W. 1974. Short-run and long-run equilibrium for a small open economy. *Journal of Political Economy* 82, no. 5: 955–67.
Mussa, M. L. 1974. Tariffs and the distribution of income: The importance of factor specificity, substitutability, and intensity in the short and long run. *Journal of Political Economy* 82, no. 6: 1191-1203.
———. 1978. Dynamic adjustment in the Heckscher-Ohlin-Samuelson model. *Journal of Political Economy* 86, no. 5: 775–91.
Neary, J. P. 1978. Short-run capital specificity and the pure theory of international trade. *Economic Journal* 88, no. 334: 488–510.
Uzawa, H. 1968. The Penrose curve and optimum economic growth. *Economic Studies Quarterly* 31: 1.
———. 1969. Time preference and the Penrose effect in a two-class model of economic growth. *Journal of Political Economy* 77, no. 4: 628–52.

Comment Alasdair Smith

Michael Mussa's paper strongly questions on efficiency grounds the desirability of government intervention in the process by which resources are reallocated intersectorally in response to changing world market conditions. The argument is a natural (though far from trivial) extension to an intertemporal context of the well-known Bhagwati-Johnson-Ra-

Alasdair Smith is professor of economics at Sussex and was a lecturer in economics at the London School of Economics. He is a former editor of *Economica*, and the author of several papers on international trade theory. In 1979–80 he was a visiting associate professor of economics at the University of Rochester.

maswami-Srinivasan optimal policy rules. A crucial feature of the model is the assumption of rational expectations. Although there are doubts that one could reasonably raise about this hypothesis, there are also very good reasons for this to be a benchmark hypothesis in any intertemporal policy model, and I do not question its validity here.

Rather, my concern is whether a model in which income distributional issues are absent can do justice to the real-world motivations for trade-related adjustment assistance and to the consequent second-best issues.

In at least some of the literature on the second best there is a reasonable justification for policy choices being restricted. Tariffs, for example, may be chosen rather than subsidies to deal with domestic distortions because the direct cost to the government budget or the political cost may be less. It is not clear, however, why a government should be subject to the constraints which Mussa discusses: if, for example, it has the capability to calculate optimal tariffs and quotas, it surely has the capability to vary these restrictions over time.

There are two important sets of second-best issues touched on at the end of section 4.5, but because of the neglect of income distribution, they are dismissed as pure distortions.

One possible motivation for giving trade adjustment assistance is simply to provide compensation from the gainers to the losers from trade, in an attempt to reduce or eliminate political opposition to the efficient allocation of resources. It is clear that in general such bribes cannot be paid in a nondistorting way, so we have the second-best problem of balancing the need for such payments against the desire for full efficiency. (Incidentally, it may be this aspect of trade adjustment assistance which justifies benefits in excess of ordinary unemployment benefits. When there are intranational shocks, there are strong producer lobbies within the country in favor of the change, so it is harder to assemble a coalition of losers who, unbribed, can stop change.)

The second aspect of trade adjustment assistance not adequately treated by Mussa is the social insurance motivation. This may partly be for the entirely fortuitous reason that the three-factor model which is the natural framework of analysis for this issue is normally presented with labor as the mobile factor and capital as sector-specific. Yet the real problems with adjustment to shocks surely arise for workers with sector-specific skills, high moving costs, and so on. The capital market provides insurance for stockholders, who can choose the extent to which they face risks. Workers, by contrast, for reasons having to do with moral hazard and adverse selection, may not be able to obtain their desired amount of insurance against unemployment or dislocation. Even if riskier industries pay higher wages there remains the problem of *ex post* equity: a wage which compensates for a 10 percent chance of becoming unemployed may not, after the event, be regarded as adequate compensation to the 10 percent who actually become unemployed. Again, we have interesting second-best questions: whether the points sketched above justify the existence of a social insurance program, whether and how equity and efficiency come into conflict, and how such a conflict is optimally resolved.

So although the message of this paper, that there are no obvious *efficiency* grounds for instituting trade adjustment assistance programs, may be thoroughly convincing, that message should not be misunderstood.

As a postscript, I offer an alternative explanation of the issue discussed at the start of section 4.5. In the pure Heckscher-Ohlin-Samuelson model, taxes on factor income are taxes on rents and so are nondistorting. In the present model, a tax on capital income is distortionary. Mussa says this is essentially because it has an effect like the effect of an income tax on saving. But there is no capital accumulation here. It may be more insightful to interpret the rent on the fixed capital stock as the lower of the two sectoral rates of return. The rate of return differential is a return to the elastically supplied activity of moving capital, so a tax on this is not a tax on rents. The "investment tax credit" proposed by Mussa is nondistorting simply because it removes the tax on the rate of return differential.

It is also worth pointing out that the "capital-moving" sector has decreasing returns but operates competitively, so rents are being accrued here too. I conjecture that with Mussa's "investment tax credit," although only rents are taxed, not all rents are taxed, and that other nondistorting taxation schemes exist where the rents of the (fixed number of) capital-moving entrepreneurs as well as the rents of capital and labor are taxed.