2.9 Show that under the assumptions of the model the share of agriculture in total output (S_1) is bounded by its share in the labor force and in the capital stock $\rho < S_1 < \ell$. (Meaning: when agriculture is labor intensive, its share in the labor force is larger than its share in total output.)

2.10 To examine the relationship between factor intensity and factor-cost intensity, we aggregate land and capital in the sense that all nonwage income is considered as capital income. Show that when factor prices are not equal across sectors,

$$S_1 = \delta_w S_I \ell + \delta_r (1 - S_I)\rho, \quad \text{where} \quad \delta_w = w_1/w \quad \text{and} \quad \delta_r = r_1/r.$$

2.11 Assume the following utility function:

$$u(x_1, x_2) = \frac{1}{\gamma}([\frac{1}{\alpha_1}(x_1^{\alpha_1} - 1) + a\frac{1}{\alpha_2}(x_2^{\alpha_2} - 1)]^{\gamma} - 1).$$

Solve the following problem: maximize $u(\cdot)$ subject to $p_1 x_1 + p_1 x_2 = c$.

Use the first-order condition to derive the demand function

$$x_1 = \theta p^{-\sigma_D} x_2^{\eta}$$

and express the parameters in the demand in terms of the parameters of the utility function.

2.12 Use the revenue function to show how the supply side of the economy can be solved parametrically in terms of per capita value output.

3

An Evaluation of Policy Measures

Most countries implement agricultural policies. The motives behind them are not fully understood and probably are not unique. Moreover, economic policies are carried out toward other sectors as well, and as such the motives should be somewhat general. The actual policies are likely to reflect the political power of agriculture, which, as indicated in Chapter 1, may have something to do with the geographical spread of agriculture and the prevailing electoral system. Whatever the motives behind them, the policies cause distortions and have a welfare cost. This has been documented in various studies (Johnson, 1973, 1991; Cavallo and Mundlak, 1982; Binswanger and Scandizzo, 1983; Krueger, 1992; Schiff and Valdès, 1992; Tyers and Anderson, 1992; Bautista and Valdès, 1993; Hag Elamin and El Mak, 1995; among others). In general, it appears that countries tax the sector in which they have the comparative advantage. A related observation is that the protection of agriculture takes place largely in the more affluent countries, whereas the poorer countries tax agriculture. However, agriculture is affected not only by policies directed toward the sector, or sector-specific policies, but also by sector-neutral policies, such as macro policies. In fact, often the effect of such neutral policies on agriculture is stronger than that of the sector-specific policies.

In this chapter we take the first step toward evaluating the impact of economic policies. Policies are generally designed to affect prices or quantities directly; they thereby modify the equilibrium position of the economy and, as such, may affect the growth path of the economy. It is therefore instructive, even at this stage, to start discussing the impact of some typical policies.

A direct intervention in the pricing of agricultural products involves the introduction of a wedge between consumer and producer prices. In an open economy, taxes are also used to introduce a wedge between domestic and world prices and thereby affect agricultural prices indirectly. The results for closed and open economies may therefore be different. Specifically, a policy of maintaining low food prices favors agriculture in a closed economy. On the other hand, when an export tax is used to achieve low food prices in an

open economy, agriculture is taxed. Another common set of policies affects the sectoral quantity balances directly. As an example, we examine here the effect of food aid. The two sets of policies, taxes and aid, are then used to take the first step in evaluating the effect of macro policy on agriculture through the analysis of the real rate of exchange

The evaluation is greatly simplified by using a comparative statics analysis in which we are not concerned with expectations with respect to future changes in the tax rates and in which we hold resources and technology constant. This restriction is somewhat artificial. The discussion focuses on evaluating the effect of policies on resource allocation. As we shall see in subsequent discussion, changes in resource *allocation* require time. But, with time, the *quantity* of resources and the technology also change, and in part their change may be a response to the policies. In reality, therefore, we do not observe the kind of controlled experiment discussed here. Nevertheless, the gradual addition of new elements to the model is analytically convenient. Having said this, we shall see that the present model, as simple as it is, provides useful insight into the impact of commonly applied policies.

Two questions can be raised in this connection. First, to what extent does the analysis depend on an overly simplistic view of the world? Second, the discussion shows that the policies cause income loss, and as such they affect the income level; the question is whether they also affect growth. Later discussions in this volume will consider these questions.

Taxes and Subsidies

The simple economy discussed here does not include a government as an economic entity; some important policies can be analyzed within this framework by assuming that there is a costless mechanism to manage payment transfers between sectors or factors. This mechanism can be the design of the government. The important assumption made at this stage is that the government uses no resources for its activities and as such has no life of its own. It deals strictly with transfer programs. A direct consequence of this is that the income of the private sector is identical to total income, and when there are no savings, it is equal to its expenditure.

Food Subsidies: Closed Economy

Often agricultural policies emphasize low food prices. Here, we therefore use the terms *food* and *agriculture* interchangeably. Product subsidies generate

discrepancies between demand and supply prices. The model is now modified to allow for such a wedge between the two prices:

$$p_i^d = p_i^s T_i; \quad T_i \equiv (1 + t_i). \tag{3.1}$$

A negative value for t_i implies a subsidy. In a closed economy a product can be subsidized only from the income generated in the economy, and therefore the subsidy is financed by some form of tax. Assume that the tax is collected on the sales of the unsubsidized product and let p represent the supply price. Then the income-expenditure identity, in per capita terms, becomes[1]

$$p_1 y_1 + p_2 y_2 \equiv p_1 T_1 x_1 + p_2 T_2 x_2 \tag{3.2}$$

This identity reflects the fact that government has no life of its own, that the economy is closed, and that domestic production is the only source of supply and domestic private consumption is the only utilization. In what follows, it is important to keep in mind that demand, x_i, is a function of p^d, whereas supply is determined by p^s. Consequently, the economy reaches an equilibrium, subject to (3.1), when

$$y_i(p^s) = x_i(p^d). \tag{3.3}$$

Imposing the equilibrium condition on the identity in (3.2) reduces to $p_1 t_1 x_1 + p_2 t_2 x_2 \equiv 0$, which implies that the product $t_1 t_2$ is either negative or both terms are identically zero. This means that the subsidy to agriculture is financed by a tax on nonagriculture. To examine the effect of the subsidy on the equilibrium position, write

$$p^d = \frac{p_1 T_1}{p_2 T_2} = p^s T, \quad T \equiv \frac{(1 + t_1)}{(1 + t_2)} \equiv 1 + t. \tag{3.4}$$

Note that the product tt_1 is nonnegative, and is zero only if both terms are zero.[2]

For any p, under the rule of convergence, $(x_1(Tp) - y_1(p))dp \geq 0$, with equality holding only in equilibrium. When not in equilibrium and $T < 1$, the price increases to reach an equilibrium price, p_E, bounded by $p < p_E < p/T$. The proof of the upper bound is left for the reader. More generally, $(T - 1)dp \leq 0$. Once the change in p is determined, the change in the rest of the system is determined accordingly.

We now study the changes in the system graphically. The equilibrium solution is shown in the right panel of Figure 3.1. Point A is the initial equilibrium with $t = 0$. Introducing a subsidy to agriculture implies that T is

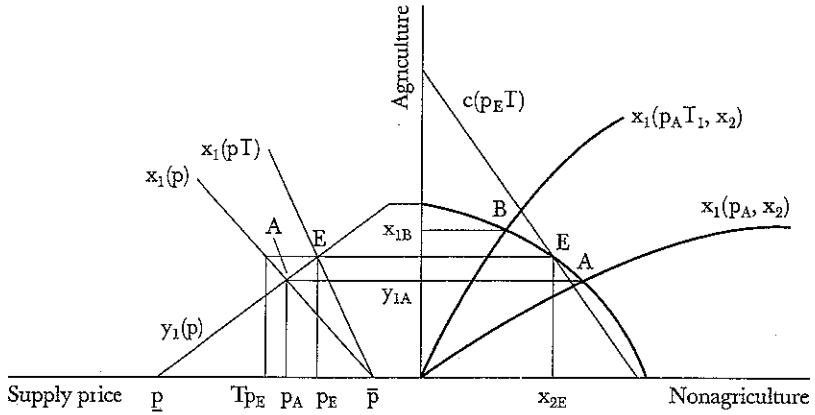

Figure 3.1 Food subsidy: Closed economy

less than 1, and the demand for agriculture $x_1(p_A T, x_2)$ rotates and intersects the transformation curve at B. Hence, at p_A there is an excess demand: $x_{1B} - y_{1A}$, and an equilibrium is reached at E, located between A and B, where $x_1(p_E T, x_{2E}) = y_1(p_E)$.

The effect of the subsidy on consumption consists of substitution and income components. The substitution effect favors the consumption of the subsidized product at the expense of the taxed product. The income effect calls for a reduction in the consumption of both products. The net effect is a reduction in the consumption, and therefore the production, of the taxed product. Because the economy is producing on the efficiency frontier, this implies an expansion of the subsidized product. The solution is also illustrated in the left panel of Figure 3.1, where the horizontal axis represents the *supply* price. When the *demand* is plotted against the *supply* price, as is the case for the restricted demand in Figure 3.1, the change is represented by a rotation of the demand curve with the point of specialization in agriculture remaining unchanged.

PROPERTY 3.1 (product market) In a closed economy, a subsidy to agriculture increases agricultural output and its supply price and decreases its demand price and the output of nonagriculture.

The tax scheme does not affect full employment or the competitive condition, and therefore the price and resource allocation functions are unaffected by it. Because consumers are utility maximizers, the new equilibrium point is

on the production efficiency frontier. However, the wedge between the demand and the supply prices causes a welfare loss. To illustrate this point, let $x_i(pT)$ be the value of the restricted demand, and evaluate the expenditure in terms of consumer prices:

$$c(pT) = x_1(pT)pT + x_2(pT) \tag{3.5}$$

The line $c(pT)$ drawn in the x_1, x_2 plane has a slope pT, and it therefore intersects the transformation curve at the point $y_i(p)$ where the slope is equal to p_E.

PROPERTY 3.2 (welfare loss) The gap between the demand and supply prices generates a welfare loss.

Welfare evaluation of taxes is broadly discussed (see Harberger, 1971). A simple evaluation of the loss is given below for the small open economy, which can be further generalized to the closed economy.

The demand price is the price producers obtain directly from the consumers. It declines due to the subsidy because part of the supply price is paid by the consumers indirectly, through the tax scheme. The rise in the supply price reflects the increase in the cost needed to attract resources to agriculture in order to produce the rise in food consumption induced by the subsidy. This rise in supply price is transferred to factor prices. The direction of the changes in factor prices depends on the factor-cost intensity. When agriculture is the labor-cost-intensive sector, this shift leads to an increase in the wage-rental ratio, in the sectoral capital-labor ratios, and therefore in the wage rate and to a decline in the return to capital. The wage rate measured in terms of food, referred to as food wage, w/p, increases as well. Nonagriculture being the taxed sector, its supply price $(1/p)$ and its output decline. If agriculture were capital-cost intensive, then the increase in p would result in a decrease in the wage-rental ratio and in the sectoral capital-labor ratios, which in turn would cause the real wage to decline and the real rental rate to increase.

An alternative way to view the changes in the factor markets is to note that the subsidy also affects the factor demands and thereby their prices. Specifically, the subsidy increases the output of the subsidized sector and thereby increases the demand for the factor that is used intensively in this sector. Similarly, it decreases the output of the taxed sector and thereby the demand for the factor used intensively in that sector. Consequently, the price of the factor in which the subsidized product is cost intensive increases and that of the other factor declines. For instance, when agriculture is labor-cost intensive, the subsidy to agriculture increases the wage rate and decreases the rental rate.

PROPERTY 3.3 (factor market) A subsidy to agriculture raises the price of the factor that is used more intensively by agriculture

The strength of the tax effects depends on the demand and supply elasticities. In terms of Figure 3.1, the degree of the rotation of the demand curve in the left panel depends on the demand elasticity. When the elasticity is small, the rotation will be small, and point B will be close to point A. This implies that there is little response to the subsidy by the quantity demanded. The net effect also depends on the supply elasticity.

The problem can be stated in a form familiar from partial equilibrium analysis. Differentiating (3.3) logarithmically with respect to T, subject to (3.4), yields[3]

$$\hat{p}/\hat{T} = \epsilon_{ld}/(\epsilon_{ls} - \epsilon_{ld}), \tag{3.6}$$

where ϵ_{ld} is the price elasticity of the restricted demand and ϵ_{ls} is the supply elasticity of $y_1(p)$. Since $\epsilon_{ld} < 0$, $\epsilon_{ls} > 0$, the expression is negative. The absolute value of (3.6) is less than 1, indicating that only part of the subsidy is transmitted to the supply price. Hence, $-1 < \hat{p}/\hat{T} < 0$. This result can be shown in terms of the left panel of Figure 3.1, where the new equilibrium supply price is p_E, the corresponding demand price is Tp_E, and the initial equilibrium price, p_A, is in the interval (Tp_E, p_E), whose length is determined by the size of the subsidy. The exact location of p_A in this interval depends on the values of the supply and demand elasticities. When the demand elasticity is nil, the supply price will not change, and the subsidy will be absorbed by the consumers of agriculture. On the other hand, when the supply elasticity is small relative to the demand elasticity, the subsidy benefits mostly the producers of food.

Who gains from the subsidy? This is not a trivial question. In the present framework, by assumption, demand is identical for all consumers, and therefore differences in consumption reflect only differences in income. Because the income elasticity for agriculture is low, the low-income consumers spend a larger proportion of their budget on food, and therefore their benefit from the subsidy is larger than their share in the tax needed to finance the subsidy plus their share in the total decline in income due to the distortion. The situation is reversed for high-income consumers.[4]

The subsidy increases the supply price and the agricultural output; this is achieved by a resource shift into agriculture. Therefore there is a change in the set of agents that make up agriculture. Consequently, the gains of agriculture are shared with individuals who were previously in nonagriculture. In order

to have a clear indication of sectoral gain, it is necessary to have a sector-specific factor. In the case of agriculture, this role is served by land. Following the discussion in Chapter 2, an increase in agricultural revenue will increase the rent on land. Under the assumptions made in Chapter 2, the rent is given by $R = (1 - \mu)py_1L/A$. Then, using (3.6) and the assumption of constant population and land, the elasticity of the rent with respect to T is

$$\begin{aligned}\hat{R}/\hat{T} &= \hat{p}/\hat{T} + \hat{y}_1/\hat{T} = (1 + \epsilon_{ls})\hat{p}/\hat{T} \\ &= \epsilon_{ld}(1 + \epsilon_{ls})/(\epsilon_{ls} - \epsilon_{ld}) \leq 0.\end{aligned} \tag{3.7}$$

PROPERTY 3.4 (agricultural gain) A subsidy to agriculture increases the rent on land and, as such, benefits the land owners.

The impact of the tax on rent depends on the supply and demand elasticities. The magnitude of the demand elasticity depends on whether or not the product is traded internationally. The magnitude of the supply elasticity, as we will see later on, depends on the length of the run. Therefore, it is instructive to evaluate the sensitivity of the impact to the magnitude of the elasticities. This is assigned as an exercise.

Food Subsidies: Small Open Economy

The open economy has two outlets for its product, domestic consumption and export, and two sources of supply, domestic production and import. Thus, in addition to the effect of the tax on domestic production and consumption, it also affects the trade pattern. Let x_i^c, x_i^e, and x_i^m be the per capita quantities of the ith product demanded, exported, and imported respectively. In the present discussion, we assume agriculture to be the exporting sector, and write the sectoral resource identities:

$$y_1 \equiv x_1^c + x_1^e, \quad y_2 \equiv x_2^c - x_2^m. \tag{3.8}$$

Let p^* be the world price, then trade is balanced when

$$p^*x_1^e - x_2^m = 0. \tag{3.9}$$

The analysis can be conducted conditional on any exogenously given level of trade deficit. The nature of the analysis is unaffected, but the results will depend on the level of the deficit. With zero trade deficit, the subsidy is financed domestically, and as for the closed economy, this leads to a price wedge: $p^d = Tp^s$, $T = (1 + t)$, with supply and demand given by $y_i(p^s)$ and $x_i(p^d)$

respectively. Equilibrium is achieved by imposing the zero deficit constraint as given in (3.9) above:

$$p^*[y_1(p^s) - x_1(p^d)] = [x_2(p^d) - y_2(p^s)]. \tag{3.10}$$

Rearrange (3.10) to obtain

$$p^*y_1(p^s) + y_2(p^s) = p^*x_1(p^d) + x_2(p^d) \tag{3.11}$$

or, more compactly, $y(p^*, p^s) = c(p^*, p^d)$, where $y(p^*, p^s)$ is the income generated by the production plan associated with p^s and evaluated in world prices, and similarly, $c(p^*, p^d)$ is the expenditure on the consumption plan corresponding to p^d and the budget constraint evaluated in world prices. By this definition, $y(p^*, p^*)$ is the value of the revenue function indicating the maximum attainable income evaluated in world prices under the given resources and technology. Therefore, when $p^s \neq p^*$ the tax generates a welfare loss. The reason for the loss is that producers optimize their production under domestic prices, whereas the value of their output is determined by world prices. Similarly, $c(p^d, p^d)$ is the value of the expenditure function indicating the least cost of purchasing utility level $u(x_i(p^d))$, and therefore when $p^d \neq p^*$, $c(p^d, p^d) \leq c(p^*, p^d)$.

The welfare loss has two sources: first, as for the closed economy, the inequality of domestic supply and demand prices, and second, the inequality of domestic and world prices, resulting in the budget constraint's being evaluated in terms of world prices while the consumers respond to domestic prices. The first is covered by Property 3.2, and the second will be discussed in the next section.

As an illustration, exercise 3.2 examines the case of $p^s \geq p^* \geq p^d$ and compares it with the alternative of no tax, so that domestic prices are equal to world prices. The outcome of this divergence from world prices is an increase in the supply and consumption of food and a decline in the consumption and production of nonfood.

Tariffs: Small Open Economy

Tariffs introduce a wedge between domestic and foreign prices. Countries impose tariffs for a variety of reasons; often they are used for maintaining domestic food prices below world prices. This is achieved by taxing agriculture rather than by subsidizing it, as in the case discussed above. A policy of low food prices has also been followed by developing countries in order to transfer resources from agriculture and thereby to promote industrial development.

In contrast, developed countries such as the United States or the European Community follow an opposite policy of protecting agriculture at the expense of nonagriculture.

We examine here the case of a tax on exports and a tariff on imports, at rates t_1 and t_2 respectively. The competitive forces will drive domestic prices to

$$p_i = T_i p_i^*, T_1 \equiv (1 - t_1), T_2 \equiv (1 + t_2) \quad \text{and} \quad p = Tp^*, T = T_1/T_2 \tag{3.12}$$

Producers and consumers respond to domestic rather than to world prices, and therefore the supply and the restricted demands are given by $y_i = y_i(p)$ and $x_i^c = x_i(p)$ respectively. That means that the effect of the tariff on resource allocation depends on T and not on the individual rates, T_i. This has an important consequence:

PROPERTY 3.5 (indirect taxation) Agriculture can be taxed either directly, $T_1 < 1$, or indirectly by protection of nonagriculture, $T_2 > 1$.

The income and consumption evaluated at world prices are

$$y(p^*, T) \equiv p^*y_1(p) + y_2(p) \tag{3.13}$$
$$c(p^*, T) \equiv p^*x_1^c(p) + x_2^c(p).$$

Using the balanced trade constraint, we obtain $c(p^*, T) \equiv y(p^*, T)$, which is a special case of (3.11). Thus the level of consumption is determined by the income evaluated at world prices. This case is illustrated in Figure 3.2, where, given world prices, the production is at A and the consumption is at A^*. The taxation of agriculture causes production to change to B and consumption to C located on the income line $y(p^*, T)$ determined by the optimal production plan B. Obviously, the consumption possibilities represented by B are lower than those at A. The discussion is now summarized:

PROPERTY 3.6 (welfare loss) A wedge between world and domestic prices reduces the consumption possibilities of the economy.

The income loss due to the tax is given by

$$L(p^*, T) \equiv y(p^*, 1) - y(p^*, T). \tag{3.14}$$

The loss can be represented in terms of Figure 3.2 as the distance between the market lines that go through A and B. Because income is measured in terms of nonagriculture, the distance is measured horizontally, along the x-axis. We note that as T declines or, more generally, as the rate of distortion increases, the loss increases. Similarly, for $T > 1$, the loss increases with T. Thus the loss increases with the absolute value of the tax rate, $T - 1$ (see the appendix to this

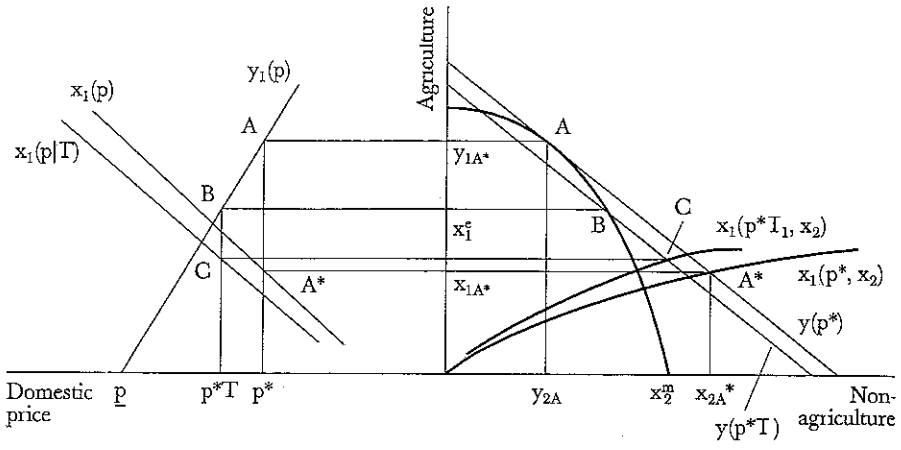

Figure 3.2 Export tax

chapter for details). Moreover, as can be seen in Figure 3.2, the loss increases at an increasing rate with the absolute value of $T - 1$. The proof is given in the appendix.

PROPERTY 3.7 (convexity of the welfare loss) The loss is a convex function of the distortion rate as given by the absolute value of $T - 1$.

We turn now to examine the effect of an export tax on trade when agriculture is the exporting sector, so that $T < 1$. In terms of Figure 3.2, $x_1(p^*T, x_2)$ rotates upward, and consumption is obtained at point C, where the demand intersects the budget line $y(p^*, T)$. The price effect of the tax is to increase agricultural consumption, whereas the income effect is in the opposite direction. For nonagriculture, or the protected sector, the price and income effects both cause consumption to decline while output increases; therefore imports decline. In order to maintain the zero trade deficit, the decline in imports implies a corresponding decline in exports.

The ratio of exports to output or, alternatively, of imports to consumption can serve as a measure of the openness of the economy. Consequently, we have

PROPERTY 3.8 (trade effect) A tax on exports reduces trade and leads to a closure of the economy

It is also instructive to illustrate the tax effect in terms of the restricted demand curve, as shown in the left panel of Figure 3.2. Since we deal with an open economy, the restricted demand declines as a result of the welfare loss caused by the tax.

In conclusion, the effect of this scheme is to shift production in the direction of the protected industry, to reduce exports of the product in which the country has a comparative advantage, and to reduce overall consumption. Clearly, this has a cost. The justification for such programs is given in terms of favorable long-run effects on the protected industry. This argument cannot be supported either on preliminary considerations or by empirical findings. In fact, when we examine the dynamics that such programs generate, we find that they have a cumulative deteriorating effect (see Mundlak, Cavallo, and Domenech, 1989).

The foregoing analysis can of course be reversed to evaluate the consequences of trade liberalization, where the country reduces the absolute value of $(T - 1)$ and as such moves closer to world prices. In this case income and consumption, both evaluated in world prices, increase. Food consumption may increase or decrease depending on the strength of the income and substitution effects, whereas the consumption of nonagriculture will increase. Agricultural production will increase at the expense of nonagriculture, and consequently trade will increase.

Trade Restrictions

Countries often impose import restrictions in order to protect agriculture as well as other sectors. Such restrictions reduce trade and increase the output of the protected sector at the expense of the other sector. In Figure 3.2, the free trade production and consumption are given by A and A^* respectively. Assume that the imposed import restriction causes production to move to point B and consumption to C, the same points that were generated by the tax scheme discussed in the previous section. In this case, we can refer to the tax rate as the shadow price of the production or import quota. When nonagriculture is the protected industry, this scheme is equivalent to a direct taxation of agriculture. The consequences for resource allocation are therefore the same as discussed in the previous section.

The two schemes differ in their benefits. Tariffs are collected by the government and therefore can be distributed to the population. The benefits from quotas go only to the holders of the quotas. In theory, the quota can be auctioned by the government, but this is seldom practiced. There is another important reason for preferring tariffs to quotas; the tax rate is known, whereas

the total damage of import restriction is not transparent and therefore does not obtain the appropriate consideration.

Taxing Factors of Production

We have seen that taxing products affects factor prices. Similarly, taxing factors of production affects product prices. Taxes on factors of production are applied for a variety of reasons. Taxation may have to do with the desire to affect income distribution directly through a tax on capital and a subsidy to labor. Conversely, it may be motivated by a desire to improve returns to capital in order to attract investment, in which case capital is subsidized at the expense of labor. It may also be motivated by the efficiency of collection. For instance, it may be easier to collect taxes on wages than on profits. In this section we consider schemes that apply uniform tax rates across sectors. Nonuniform rates generate intersectoral differences in factor prices, a case considered in Chapter 8.

Let t_w and t_r be the tax ($t > 0$) or subsidy ($t < 0$) rates on the wage and on the rental rate respectively. Labor and capital receive the observed market prices w and r respectively. The prices firms face, to be referred to as factor-cost prices, are wT_w and rT_r, where $T_w = 1 + t_w$ and $T_r = 1 + t_r$. The taxes affect the cost of production, and therefore in order to restore zero profits, the initial product prices have to change. To determine the implied change in p, write the cost functions, recalling that they are linear homogeneous in prices:

$$c_i(T_w w, T_r r) = T_r r\, c_i(\tau\omega), \quad \tau \equiv T_w/T_r.$$

We impose the zero profit restriction to obtain: $p(\tau\omega) = c_1(\tau\omega)/c_2(\tau\omega)$. The price function with factor tax included, $p(\tau\omega)$, is a generalization of $p(\omega)$. The value of $p(\tau\omega)$ is the supply price when the market-factor price ratio is ω and the tax rate is τ. The price function is differentiable, and with p being the price of the labor-cost-intensive sector, $p'(\tau\omega) > 0$. Hence, $\partial p(\tau\omega)/\partial\tau > 0$. Specifically, as τ increases, p increases accordingly. For any pair τ, ω we can find $T(\tau)$ such that

$$p(\tau\omega) \equiv T(\tau)p(\omega). \tag{3.15}$$

The function $T(\tau)$ is the (relative) product-tax equivalent of the (relative) factor tax rate τ. Under the factor-cost-intensity assumption, $T'(\tau) > 0$, and $T(1) = 1$. Hence, we derive

$$(\tau - 1)(T - 1) \geq 0, \tag{3.16}$$

with equality holding if and only if $T = \tau = 1$. For instance, a subsidy to labor will result in $\tau < 1$; therefore, by (3.16), $T < 1$, which means that such a subsidy reduces the supply price of the labor-intensive product.

PROPERTY 3.9 (product-factor tax equivalence) The supply price of the labor-cost-intensive product increases (decreases) with a relative tax (subsidy) on labor. Under equal factor intensities, the factor tax does not affect the product price.

This is the essence of the Stolper-Samuelson proposition. The relationship between the corresponding rates of change of T and τ can be derived by differentiating (3.15): $\hat{p}(\tau\omega) = \hat{T} + \hat{p}(\omega)$, or $\hat{T} = \hat{p}(\tau\omega) - \hat{p}(\omega)$, and using (2.16) to obtain

$$\hat{T} = I(\tau\omega)\hat{\tau} + [I(\tau\omega) - I(\omega)]\hat{\omega}, \tag{3.17}$$

where, recall, $I(\omega) \equiv S_{1L}(\omega) - S_{2L}(\omega)$. Thus the last term on the right is of second order of magnitude and can be neglected. The absolute value of $I(\omega)$ is less than 1, and hence the relative change of factor prices due to the tax is larger than the corresponding effect on product prices and conversely.

Once T is derived, the foregoing analysis of the product tax can be applied to determine the effect of a factor tax at a rate τ on the equilibrium position of the economy. With the introductoin of factor tax rate $\tau < 1$, the supply price of the labor-cost-intensive product declines so that this case is equivalent to that of a subsidy to the labor-cost-intensive sector illustrated in Figure 3.1. The outcome is an increase in the output and consumption of the labor-cost-intensive sector.

A detailed description of the effect of the factor tax on the economy is illustrated in Figure 3.3 for the case of $\tau < 1$. As a result of the factor tax, the supply price of the labor-cost-intensive sector declines, and when plotted against the market price, p, it is represented as a shift of supply from $p^s(y_1)$ to $Tp^s(y_1)$, as shown in panel III. Consequently, there is a new equilibrium at E where $y_{1E} > y_{1A}$ and $p_A > p_E$. Note that these are market, or demand, prices. The supply price, or the real price, of producing y_1, $|dy_2/dy_1|$, increases, since it is a positive monotone function of y_1.

Looking at the change in the labor market, we note that the initial allocation, $k_i(\omega)$, is not optimal under the new price with the tax, $\tau\omega$. Labor is now relatively cheaper, and firms will substitute labor for capital, but because the labor supply is fixed, there will be competition for the existing labor. As the labor-cost-intensive sector benefits more from the new prices, it is in a better position to bid away labor from the capital-cost-intensive sector. When labor

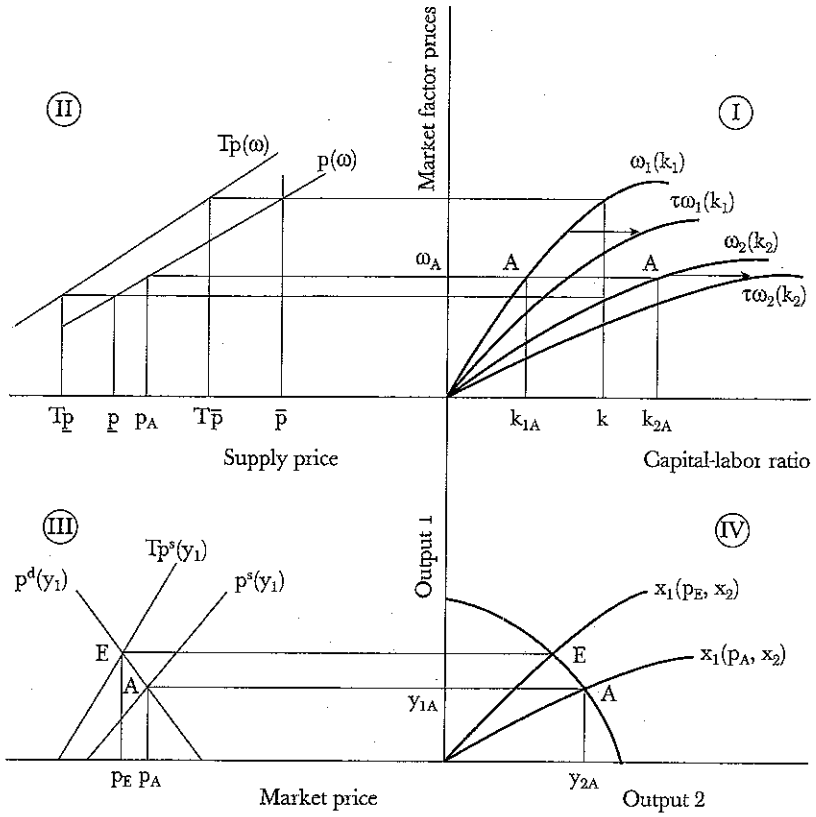

Figure 3.3 Factor tax: Closed economy

moves away from the capital-intensive sector, the capital-labor ratio in this sector increases rather than declines, as called for by the new price. To avoid it, this sector will also lose capital to the labor-intensive sector. This move is represented by a shift of the $k_i(\omega)$ functions, as shown in panel I. The corresponding shift in the price function in panel II reflects the fact that the market price of the labor-intensive product declines.

In a small open economy where the country is a price taker, $p(\tau\omega) = p^*$, where p^* is the world price; therefore $\tau\omega$ is constant, and the factor prices fully absorb the tax, $\hat{\tau} + \hat{\omega} = 0$. In this case, (3.17) yields exactly $\hat{T} = I(\omega)\hat{\tau}$. Thus the subsidy to labor will increase the supply of the labor-cost-intensive sector, and therefore its net export will increase. The final outcome of trade

depends also on the demand, which declines due to the negative income effect of the tax.

The effect on rent is given above. In the case of the small open economy, the indirect tax on agriculture has its strongest effect on rent because the price does not change, and therefore it does not compensate in part for the change in supply.

Food Aid

One form of aid to developing countries is aid in food. Sometimes food is delivered as relief from a natural disaster such as drought. Often, however, the purpose is to help the development of the country, and yet food is treated as an entity by itself. For instance, public institutions calculate country needs for food aid. What is the criterion for such calculations and, more important, how does food aid differ from general aid, which provides the recipient country with resources without restricting their product composition? The answer is simple; there is no economic criterion for the calculation of country needs for food aid, and the attempt to present it as if there is does not contribute to the clarity of the public discussion on the merit of such aid. The restriction of the aid to food changes the supply of food in the recipient country and, thereby, causes a displacement in the initial equilibrium position. The resulting changes are different for closed and for open economies.

Closed Economy

Assume the food aid to be g units per capita and to have an equilibrium price, prior to the aid, of p_A. The aid generates an excess supply at the initial price, $y_1(p_A) + g - x_1(p_A) > 0$, and therefore the equilibrium price is forced to decline. It is worth emphasizing that in this framework, where the two goods are normal, it is impossible for p to increase. Normality implies that as income increases due to aid, the demand for both goods will increase and therefore part of the augmented income will be spent on nonfood. To finance this increase in the consumption of nonfood, it is necessary that some of the additional food be traded for nonfood, and this causes the price of food to decline.[5]

The decline in food price causes food production to decline, which in turn causes a shift of resources to nonfood and an increase in its output. On the other hand, the consumption of food increases, since its price is lower (substitution effect) and the consumption possibilities increase (income effect).

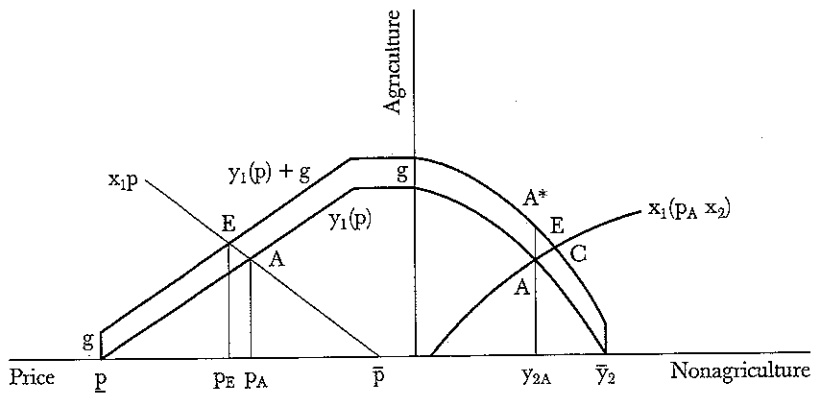

Figure 3.4 Food aid: Closed economy

This is illustrated in the right panel of Figure 3.4. Food aid generates a difference between the production and the consumption sets. The first is bounded by the transformation curve, whereas the second is bounded by the outer curve, which reflects the aid. Thus the difference between points A and A^* is g units of y_1, whereas the level of y_2 is the same at both points.

Because food aid does not affect the price equation, the output at price p_A is still given by point A, with $y_{1A} = y_1(p_A)$. At p_A the demand $x_1(p_A, x_2)$ is at C, and the supply is at A^*. Consequently, the equilibrium point E is obtained between A^* and C. The change in equilibrium is also illustrated in the left panel, where the restricted demand remains unchanged because $y_2(p)$ is unchanged. This is summarized:

PROPERTY 3.10 (food aid in a closed economy) Food aid increases the consumption of the two products and the production of nonfood. It induces a decline in food production and its price. As a result, the share of food income, py_1, in total income, $y = py_1 + y_2$, declines.

The effect on factor prices depends on factor-cost intensity. When food is labor-cost-intensive, a decline in p results in a decline in ω and a decline in k_i. Consequently the real wage rate declines, and the rate of return on capital increases. Thus, in this case, the food wage is expected to decline, contrary to statements often made that food aid increases the food wage.

The response of factor shares to the foregoing changes depends on the elasticities of substitution. It decreases (increases) the share of labor when the elasticities of substitution are smaller (larger) than one.

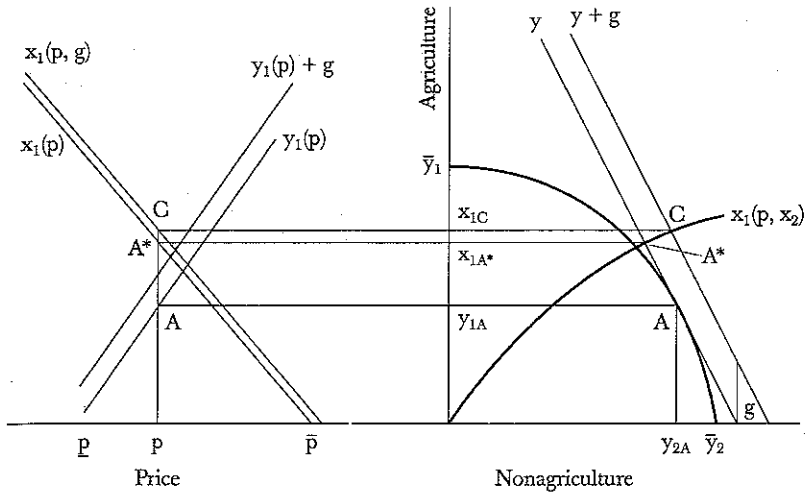

Figure 3.5 Food aid: Open economy

Small Open Economy

The country with a small open economy is a price taker, and it is assumed to be an importer of food at the going world prices. If the country is allowed to trade the aid in the world market, the aid becomes general aid, and the consumption possibilities are given by the market line with a constant price. In this case imports, net of aid, must decline.

This is shown in the right panel of Figure 3.5 where initially production is at A, consumption is at A^*, and food import is $x_{1A^*} - y_{1A}$. Under aid consumption moves to C, production is unchanged because p is constant, and the change in food consumption is $x_{1C} - x_{1A^*} < g$. Since the income elasticity of nonfood is greater than zero (actually greater than one), an increase in income by g units of food generates an increase in nonfood consumption. Consequently, the increase in the consumption of food is less than g. In fact, when the income elasticity of food is low, only a small fraction of g will constitute new consumption, and the remaining will result in a decline of imports.

The change caused by aid is also shown in the left panel of Figure 3.5, where the restricted demand function is shifted upward by the income effect of aid on the demand for food. This shift is smaller than the shift in the supply. Consequently, imports will decline.

To summarize, when prices are given, output is unaffected by the aid, and imports must decline. Under balanced trade such a decline in imports implies a decline in the export of nonfood. This is, of course, the mirror image of the increase of nonfood consumption while production remains constant. Thus we have:

PROPERTY 3.11 (food aid in a small open economy) Food aid to a food-importing country is likely to cause the country to substitute aid for trade.

Mixed Economy

Importing countries are not closed. Yet they are often not completely open; they may have various restrictions on trade. In general, such restrictions result in a lower domestic price for food compared with that in the world market. Therefore, the foregoing analysis needs to be generalized. The pertinent part of the system is

$$\begin{aligned} x_1^m(Tp^*, g) &= x_1^c(\underset{-}{Tp^*}, \underset{+}{y+g}) - [\underset{+}{y_1(Tp^*)} + g] \\ x_2^e(Tp^*, g) &= \underset{-}{y_2(Tp^*)} - x_2^c(\underset{+}{Tp^*}, \underset{+}{y+g}) \\ p^* x_1^m &= x_2^e, \end{aligned} \tag{3.18}$$

where y is per capita income, and T is the wedge between world and domestic price. In the closed economy the traded quantities are zero, whereas in the open economy, $T = 1$. In the mixed economy, before the aid, $g = 0$ and $T = 1$.

Food aid of g units per capita generates an income effect on demand and increases the supply of food, thereby affecting the traded quantities. The system reaches equilibrium with the aid by a combination of a decline in the domestic price ($T < 1$) and a decline of the nonaid import of food. In principle, maintaining lower food prices increases the excess demand for food and thereby increases the demand for imports. For a recipient country, this also increases the demand for aid, but it is unrealistic to assume that aid will fill growing gaps forever. The alternative is then to develop domestic production, but this possibility is not well served by low price levels. Thus, at some point, prices will have to be realigned with world prices.

The Donor Country

Donor countries of food must be surplus producers of food. Otherwise, the form of aid would not be restrictive. What is the particular advantage of giving aid in the form of food? From the perspective of the collective of all food donors, giving aid in terms of food, rather than general aid, is desirable if it increases the overall demand for food. This requires a decline in food prices in the recipient countries. Maintaining food prices below world prices requires imposing a tax on agriculture. This tax is explicit if the country maintains a free-trade policy, or implicit if the country imposes quantitative barriers to trade and as such is considered a closed economy. In both cases, this implies distortion, and thus the good intentions of aid impose some cost on the recipient countries. The efficiency, or rather the lack of it, of food aid from the point of view of the United States was initially discussed by Schultz (1960).

Sector-Neutral Policies and Agriculture

The programs discussed above are sector specific in that they affect the price or quantity of a sector directly and thus affect the income generated in the sector. However, sectoral income is also affected by sector-neutral programs, the most important of which are macro policies. The importance of macro policies for U.S. agriculture was recognized by Schuh (1974), who argued that the overvalued U.S. dollar depressed U.S. agricultural prices. The subject is also discussed by Chambers and Just (1981), Cavallo and Mundlak (1982), Longmire and Morey (1983), Rausser et al. (1986), Snape (1989), Mundlak, Cavallo, and Domenech (1990b), and in other studies cited below.

Macro policies affect domestic prices and thereby the opportunities facing producers. Commodities that are easily traded respond to this change in terms of quantities traded, whereas the others have to respond entirely in terms of domestic production and consumption. This phenomenon is related to the ability of a sector to adjust through trade and is not specific to agriculture. Because different sectors vary in this ability, they will be affected differently.

In what follows we examine the effect of the macro and trade environment on sectoral prices and quantities through their effect on the real exchange rate, a concept widely used. After the concept is introduced, we will analyze the dependence of the real exchange rate on supply and demand in the short run and its susceptibility to macro policies. The discussion of the real exchange rate continues in Chapters 4 and 5, where the impact of long-run changes is examined. Empirical aspects are introduced here and discussed in more detail in Chapter 15.

The Real Exchange Rate

Agriculture is a tradable commodity, and as such its price is affected by the rate of exchange. In order to examine such an effect we make, initially, the strong assumption that the domestic price of agriculture is $p_1 = p_1^* T_1 E$, where

p_1^* is the world price in dollars, T_1 is the tax, and E is the nominal rate of exchange which gives the price of one dollar (more generally, the price of foreign currency) in terms of domestic currency. The domestic product price ratio is $p = p_1^* T_1 E / p_2$. It is possible that nonagriculture is also tradable, and its price is $p_2^* E$. In this case, with no taxes, the domestic price ratio is the same as the world price, and a change in the exchange rate has no effect on the profitability of agriculture. In order for the exchange rate to matter, we have to assume that nonagriculture is not tradable. In this case this framework is not very meaningful, though, because if there are only two products and one is not traded, the second product will not be traded either. This is the only way to maintain balanced trade. Hence, in order to examine the impact of the exchange rate on agriculture, it is necessary to add at least one more sector into the analysis. Let the three sectors be named x, m, and h for the exporting, importing, and home (or nontradable) sectors respectively.

Even though we now have three sectors, we can still use the two-sector structure to analyze issues related to the competition between the tradable and nontradable sectors. Specifically, this allows us to discuss the impact of macro policies, and this is where we begin. This discussion will be followed by the explicit introduction of a third sector in order to discuss the impact of the world terms of trade and trade policies, which affect the competitive positions of the exportables and importables.

To force the discussion to the two-sector framework, we hold the world terms of trade, p_x^*/p_m^*, constant. This assumption allows us to treat the two traded sectors as a Hicks's composite sector and collapse the analysis to the two-sector framework.[6] The output of the tradable sector is the composite output of the importable and exportable sectors. A similar interpretation applies to demand. If p_T^* is the world price of the aggregated tradable product, and T the corresponding tax, then $p_T = p_T^* T E$ is the domestic price, and p_h the price of the home product. The domestic price ratio of the tradable to the home product is $p = p_T^* T E / p_h = p_T^* e$, where $e \equiv T E / p_h$ is the real exchange rate (RE). It measures the price of the tradable good in terms of the home good, after allowing for changes in world prices. Often, the term *real exchange rate* is applied to p rather than to e. From the point of view of the current analysis, either term is applicable because the adjustment from one to another is mechanical and does not affect the analysis. We will use both versions, and the context will identify which version is used.

Presumably, the definition shows how the nominal exchange rate, E, can affect the price of the tradable product. However, matters are not that simple in that a change in E affects both supply and demand, and consequently it affects p_h. It is for this reason that the analysis of exchange rate is conducted in terms of the real rate.

The problem has now been framed within the two-sector model, and the real exchange rate is viewed as the clearing price in the domestic market, where the tradable product is traded for the nontradable product. Thus, even though the economy is open, the supply of nontradable goods can only be produced domestically. In this sense, the economy behaves as if it were a closed economy, and the analysis of the real exchange rate can be carried out within our closed economy framework. In order to suppress at this point the effect of world prices, we set $p_T^* = 1$ so that $e = p$. Changes in the supply or demand of the two products will cause a change in e.

This model constitutes a major extension of our analysis because p_h is affected not only by E but by other macro policies as well, and this subject cannot be fully discussed within a static framework. This discussion will therefore allude heuristically to dynamic effects. The purpose of conducting the analysis in such an incomplete form is that it still allows us to capture some of the main effects of policies without extending the discussion. In so doing, it should be noted that in this analysis, the magnitude of the change in p depends on the difference in factor-cost intensity. In the limiting case when there is no difference in factor-cost intensity of the two sectors, the prices will remain unchanged.

Trade Account

A deviation from balanced trade affects the supply of the tradable product and thereby the equilibrium price. A deficit in the trade account implies an excess supply of the tradable good at the going price p, and therefore the price must decline in order for the market to clear. This case is analogous to the food aid discussed above, and we can use Figure 3.4 for illustration. We assume that there is a per capita net import of g units, and this causes a decline of RE from p_A to p_E.

The form of financing the deficit generates dynamic effects. If the deficit is generated by aid or other unilateral transfers, this is the end of the discussion. If, however, the deficit is financed by loans, it will eventually have to be repaid. Servicing the debt will reduce the supply of the tradable product in the future and thereby should eventually have an opposite effect to that of the deficit; namely, RE will have to increase. This discussion is very schematic and as such ignores various implications of such pending debts.

Government Expenditures

The analysis is extended by assuming that the government now becomes an entity with its own demand function for the two products. The effect of this

extension on the economy depends on three important aspects: the product composition of government expenditures, the substitution in consumption of government and private expenditures, and finally, how the government finances its activity

With government, the aggregate demand consists now of two components, private and government (or public) The composition of government demand is likely to differ from that of the private sector In general governments use a lower proportion of the traded good compared with the private sector. Therefore increasing the share of government in total demand will increase the demand for the home good, increase its price, and lower RE

The strength of this effect depends on the substitution between private and government expenditures In part, the public good consists of services, such as education, health, or infrastructure, which are close substitutes to similar services that could be provided by the private sector. In this case, an increase in the expenditure of the public sector reduces the expenditure of the private sector However, governments do not limit their activities to the production of public goods desired by the private sector Often a large component of government expenditures generates services that do not substitute for private demand. Why would governments produce services that are not demanded by consumers? The answer is not unique, and it is related to the nature of the political process. This subject is beyond the scope of the present discussion, and therefore only a short comment is made on it below.

More formally, we now extend the utility function to include government expenditure of g units per capita For simplicity, it is assumed that the utility function is weakly separable, so that the marginal rate of substitution of x_1 for x_2 is independent of g: $u = u(B(x_1, x_2), g)$. Consequently, the private demand, $x_1(p, x_2)$, is independent of g.

In order to analyze the effect of g on RE, assume that it is financed by a uniform tax that does not affect relative prices. Thus the new equilibrium position will depend on the composition of g To simplify matters, assume that g consists exclusively of the nontradable product, and that the demand for the tradable product comes exclusively from the private sector. The sectoral balances can then be written as $x_1 \equiv y_1$, $x_2 + g \equiv y_2$ Consequently the demand for the tradable good is written as $x_1 = x_1(p, y_2 - g)$. An increase in g reduces the amount of the nontradable product available for households. Because of the positive relationship between x_1 and x_2, this causes a decrease in the demand for the tradable product, and therefore its price should decline. Thus,

$$\frac{\partial x_1}{\partial g} = \frac{\partial x_1}{\partial x_2} \frac{dx_2}{d(y_2 - g)} \frac{d(y_2 - g)}{dg} < 0$$

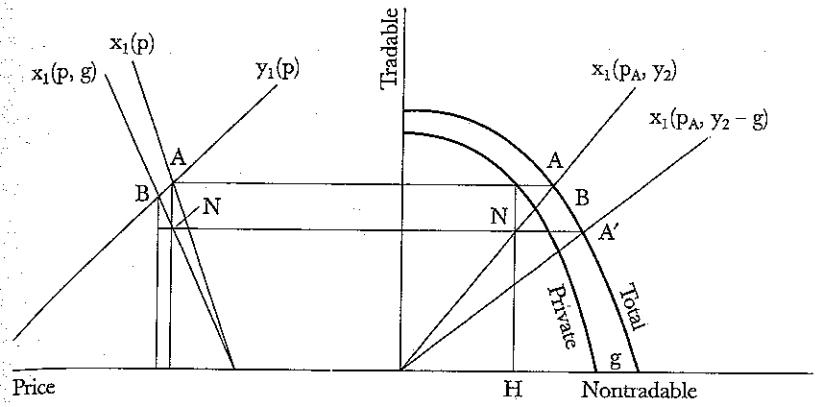

Figure 3 6 The real exchange rate

The effect of government is illustrated in Figure 3.6, where the appearance of government changes the demand in favor of the nontradable good. For any output of the nontradable good, y_2, the supply to the private sector is $y_2 - g$ For this supply to be absorbed at price p_A, the demand for the tradable good is $x_1(p_A, y_2 - g) < x_1(p_A, y_2)$. The demand now intersects the transformation curve at A' instead of at A, the initial equilibrium with $g = 0$. This rotation generates an excess supply of the tradable product, and a new equilibrium is achieved at B with $p_B < p_A$, indicating a lower real exchange rate

The analysis can also be carried out in terms of the market for goods for the private sector. The diversion of g units of y_2 away from private consumption can be represented as a horizontal shift of the transformation curve At p_A production is at A, but the quantity of the nontradable product available for private consumption is given by H. Consequently the quantity demanded of the tradable product is reduced to N, which constitutes a point on the restricted demand of the private sector. Thus there is an excess supply of the tradable good, and its price declines. The private demand curve $x_1(p, x_2)$ rotates to the left until a new equilibrium is reached The output of the tradable good at the new equilibrium is above N The total consumption of the nontradable good in the economy increases, but part of this consumption, g, is produced for the public sector, whereas the private production of the nontradable product declines

The analysis in terms of the restricted demand is similar in nature. The restricted demand for the tradable product by the private sector is $x_1(p, g)$ Because some of the nontradable product is consumed by the public sector, it

is taken away from the private sector, and this causes the function to rotate to the left. Since, by assumption, the government does not consume the tradable good, the supply to the private sector is given by the aggregate supply function $y_1(p)$, and as such is unaffected by g. Consequently reducing the demand for the tradable good, which is produced with a constant supply function, causes the price to decline

To be sure, the outcome depends on the product composition of government demand. Hypothetically, if g consisted largely of the tradable product instead of the nontradable one, the real exchange rate would have risen with g. In general, the public sector uses mainly the nontradable good, and thereby, as shown above, it suppresses the real rate of exchange. This change is associated with lower production of the tradable good. Because agriculture is a component of the tradable sector, it suffers from such a change. The exact impact on the composition of the tradable sector requires more information, but this is not important for our present discussion.

Method of Finance

The outcome also depends on the method used by the government to finance its expenditures. If the government conducts a balanced budget, it must tax the private sector to the extent of its expenditure, and the foregoing analysis applies. The effect of a uniform tax was discussed above. The effect of a nonuniform tax can be analyzed by first considering a uniform tax and then applying a different tax scheme.

When the government runs a deficit, the method of financing the deficit also affects RE and the speed at which it changes. If the deficit is financed by borrowing from abroad, this leads to a deficit in the current account, and as we have seen, this has a suppressing effect on RE. In this case the government expenditure increases the demand for the nontradable good, whereas the finance of the expenditure increases the supply of the tradable good. Alternatively, the government can borrow domestically. Since, however, the economy is assumed to be open, borrowing domestically will cause interest rates to increase above the world level and thereby induce an inflow of foreign capital, which presses the interest rates back to their initial level. This method is therefore very similar to borrowing from abroad.

Thus far the discussion has dealt with a barter economy. To complete the discussion we also consider the use of money to finance the debt. We assume that prior to the formation of the debt, individuals had been holding the desired amount of money. The printing of money to finance the purchases of the government disturbs this equilibrium, and therefore individuals will exchange money for commodities in order to restore it. When the nominal exchange rate is fixed, the price of the tradable product is constant, and the expanded demand for the tradable good is met by an increase in net imports. On the other hand, an increase in supply of the nontradable good can be achieved only from domestic production, and this implies an increase in its price and consequently a decline in RE. The increase in net imports, or inflow of capital, generates a deficit in the current account and as such it is not sustainable. Thus, eventually, the country will have to take measures to control both the inflation and the trade deficit.

When the exchange rate is flexible, part of the response to the inflationary pressure generated by the monetization of the deficit will be to increase the nominal exchange rate. In this case the decline in RE should be smaller than under a fixed exchange rate regime. However, even if the exchange rate is completely free to vary, the real exchange rate will decline because the monetization facilitated a change in the composition of aggregate demand and in the equilibrium position of the economy.

The foregoing discussion abstracts from the effects that such changes in macro policies generate on expectations for inflation and future policies, which in turn affect the dynamics of the economy. This subject is beyond the scope of the present discussion. The main findings of the present discussion, however, prevail under a more complex environment. This assertion will be substantiated by empirical results to appear subsequently.

Factor Markets

The effect of the aforementioned measures on the product price is uniquely signed. On the other hand, the effect on factor prices depends on the factor-cost intensity. It is usually assumed that the home good is labor-cost intensive, in which case a decrease in the real exchange rate is associated with an increase in the wage-rental ratio.

Sometimes the real exchange rate declines by a reverse chain of events. Labor, and perhaps more specifically labor in the public sector, succeeds in increasing its wage rate without a corresponding change in productivity. This in turn increases the wage-rental ratio and causes a decline in RE.

Trade Policy

Trade policies here are defined as policies aimed at affecting trade directly through prices or through quantity restrictions. The full range of possibilities is covered by the discussion of the internal terms of trade below, whereas here

we consider only a program that applies a uniform tax to the two tradable products. In this case, we can think of the real exchange rate as the supply price of the tradable good, and therefore the effect of the program on this rate is easily judged by its effect on the output composition. If the output of the tradable product increases, the real exchange rate increases accordingly. For instance, consider an incentive to the traded sector, to be financed by the nontradable sector. This will cause a shift of resources into the production of tradable goods and thereby an increase of the real exchange rate. This policy can be illustrated with the use of Figure 3.1, by identifying sectors 1 and 2 with the tradable and home sectors respectively. The demand price of the tradable product is $(1-t)p$, where p is the supply price. Consequently, the equilibrium p increases from p_A to p_E.

Internal Terms of Trade

We turn now to examine the internal terms of trade, for which we need to deal with the tradable sectors separately. The domestic price of a tradable product is $p_j = p_j^* T_j E$, $j = x, m$, where T is the tax. The domestic terms of trade are determined by the world terms of trade and by the trade policy: $p_x/p_m = (p_x^*/p_m^*)(T_x/T_m)$. Specifically, it is independent of the price of the home good. This is true only if the tradable sectors are homogeneous in the sense that they do not contain a component of the home good. Actually, this is not the case, but for now, it helps to sharpen the discussion to assume such homogeneity. On the other hand, a change in the terms of trade affects the domestic demand and supply of x and m. This causes a supply effect through the change in resource allocation and a demand effect through the substitution and income effects. Thus the terms of trade affect the price of the home good and thereby the real exchange rate, with the causality going one way.

To avoid sidetracking, we leave the details of the background analysis to Appendix 3A, where the excess demand function for the home good, $\Phi(p_x/p_h, p_m/p_h)$ is derived. We differentiate the excess demand at the equilibrium point, where its value is zero, and rearrange the terms to show the dependence of the real exchange rate on the terms of trade. The expression for the exportables is

$$d\ln(p_x/p_h) = \omega(d\ln p_x - d\ln p_m), \tag{3.19}$$

where here $\omega \equiv \Delta_m/(\Delta_m + \Delta_x)$, $\Delta_j \geq 0$ is the excess supply elasticity of the home good with respect to the price of the jth good. As such, ω measures the degree of substitution between the importables and the home good. De-

compose the price to the two components, foreign terms of trade and the tax, assume ω to be locally constant, and integrate the equation to get

$$\ln(p_x/p_h) = a + \omega\ln(p_x^*/p_m^*) + \omega\ln T. \tag{3.20}$$

This is a measure of the real exchange rate in terms of exportables. A similar expression can be derived for importables:

$$\ln(p_m/p_h) = a - (1-\omega)\ln(p_x^*/p_m^*) - (1-\omega)\ln T. \tag{3.21}$$

Let $p_T \equiv (p_x)^b(p_m)^{1-b}$, and combine equations (3.20) and (3.21) to obtain the expression for the conventional measure, $p = p_T/p_h$, which can be thought of as an aggregate of the two measures:

$$\ln p = a - (1-b-\omega)\ln(P_x^*/P_m^*) + (1-b-\omega)\ln T_m - (1-b-\omega)\ln T_x. \tag{3.22}$$

When $b = 1$, the price of the tradables is the same as that of the exportables and p varies positively with the foreign terms of trade. The opposite is true when $b = 0$.

The message of equation (3.22) is that if foreign prices and trade policies are constant, then domestic prices will remain unchanged. This equation represents only the effect of the terms of trade on the real exchange rate. We also have to include the effect of the macro policies, which is additive, on the real exchange rate. Let s be the vector of the pertinent macro variables and ϵ be the vector of the corresponding elasticities, we can write the final form of the empirical equation:

$$\begin{aligned}\ln p = a - 1(1-b-\omega)\ln(P_x^*/P_m^*) + (1-b-\omega)\ln T_m \\ - (1-b-\omega)\ln T_x + \epsilon s.\end{aligned} \tag{3.23}$$

Tradability and Sectoral Prices

The tradable-nontradable dichotomy is a convenient analytic device, but its empirical application is not that simple. In a multi-product and multi-input economy with intermediate products, it is difficult to designate a sector which has no tradable inputs. In this case, a change in a given price, and specifically in the rate of exchange, affects all sectors. For instance, if housing requires imported inputs, then a change in import price affects the construction cost. On the other hand, tradable sectors have nontradable inputs. When buying

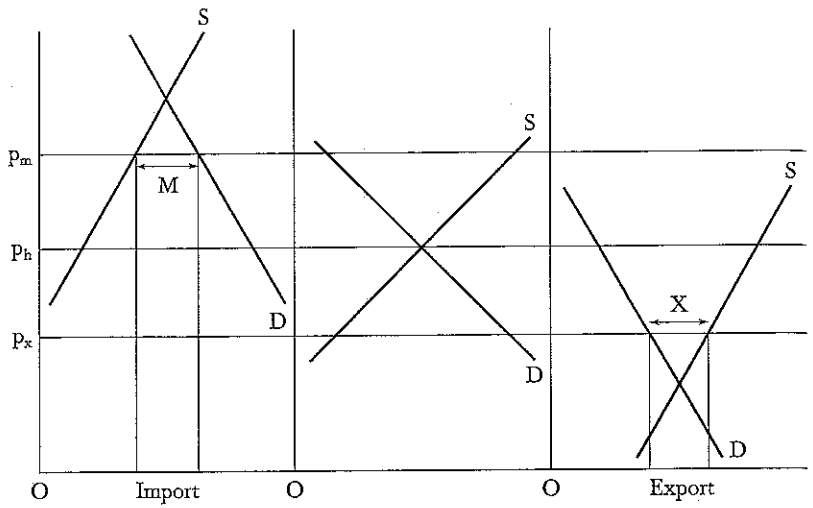

Figure 3 7 The product composition of agriculture: Trade orientation

a foreign car the consumer pays not only for the car but also for domestic services, such as the dealer's time and facilities.

Our interest in this model at this point is derived from our interest in the effect of policies on sectoral prices, where the sectoral definition depends on one's interest, and ours is the dichotomy of agriculture and nonagriculture. In reality, each of these sectors is an aggregate of many products, which can be grouped into importable, exportable, and home goods. This grouping is determined by the cost structure and demand as illustrated in Figure 3 7. A big spread between import and export prices creates a scope for the middle group of nontraded products. This spread reflects transportation costs, broadly defined, between countries as well as high distribution costs within the countries. The latter reflects the fact that agriculture is spread geographically throughout the country, and in many countries with poor infrastructure the costs are high. On top of this, taxes and similar programs affect the wedge between the border prices.

With such a decomposition, the aggregate sectoral price is determined by the prices of the individual components We can think of this price as being the cost function of the aggregate product, so that the price of sector j is

$$P_j = \alpha_0 P_{xj}^{\alpha_1} P_{mj}^{\alpha_2} P_{hj}^{1-\alpha_1-\alpha_2},$$

where P_{xj}, P_{mj}, and P_{hj} are the domestic prices of the exportable, importable, and home goods respectively. Rearranging,

$$\frac{P_j}{P_{hj}} = \alpha_0 \left(\frac{P_{xj}}{P_{hj}}\right)^{\alpha_1} \left(\frac{P_{mj}}{P_{hj}}\right)^{\alpha_2} \qquad (3\ 24)$$

The ratio of the sectoral price to the price of the home good is expressed as a geometric-weighted average of the real exchange rate of exportable and importable goods respectively The effect of the real exchange rate depends on the sum of the exponents, which provides us with a measure of the degree of tradability of the sector. Different sectors can be ranked according to their degree of tradability. The price of the more tradable sectors is more responsive to changes in the real exchange rate.

In principle, the sectoral price equation can be estimated. Countries publish data on the prices of exported and imported goods. The problem is with the nontraded good, because such a good does not exist in the form that it appears in the theory Therefore, empirical analysis requires the use of substitutes. Empirical applications are discussed in Chapter 15

On Openness and Agriculture

As we have seen, the response of an economy to changes in the economic environment depends on whether the economy is closed or open. Also, we have noted that even an open economy is closed to some extent in that not all products can be imported. When it comes to agriculture, Chapter 1 mentioned that for the world as a whole, only 10–12 percent of world production is traded internationally and that countries tend to meet changes in demand by local production. On the surface, it seems that by doing so, countries do not fully utilize their comparative advantage. To gain better insight into this issue, we need more structure, which requires a detour from the main course of the current discussion

Most countries import some agricultural products, export others, while the bulk of products are not traded at all. The structure is described in Figure 3 7. As indicated above, the spread between import and export prices reflects the fact that agriculture is distributed geographically throughout the country, and in many countries with poor infrastructure, the costs are high. Taxes and similar programs affect the wedge between the border prices and as such contribute to the spread. On the face of it, all these considerations complicate the relationships between world and domestic prices Indeed, as

Johnson (1973, 1991) observed, there are considerable differences among countries in the prices of agricultural commodities, which he took as a sign that world agriculture is in disarray. The fact of the matter is that there are considerable differences in the prices of other commodities as well. The relative difference in the prices of shirts between the streets of Bangkok and those in Europe or the United States is probably bigger than the relative difference between the price of Thai and Japanese rice. One can then extend Johnson's observation to other sectors. Thus agricultural policies or, more generally, trade policies are not the only culprit, and sometimes not the main one. Some of the cross-country differences can be traced to differences in factor prices.

All this has an important implication for our thinking about the dynamics of world agriculture. Under free trade, we can think of the world as being a closed economy, so that producers face a downward-sloping demand function that constrains production growth. The trend in world prices is determined by the relative growth in world demand and supply. But as indicated above, the bulk of agricultural production is consumed domestically and is not traded in the world market. Therefore, the question is to what extent are domestic prices influenced by world prices. This is of course an empirical question, and this is the way it should be answered.

The Law of One Price

The relationship between domestic and world prices is an old and well-investigated subject under the title of the *law of one price*. The idea is that, abstracting from the cost of transportation and taxes, trade should equate commodity prices across countries. As stated above, there are large price differences across countries which indicate that the law does not hold in practice. This is the static situation, but there is a dynamic aspect as well, which is related to the question of what happens to domestic prices if the world price changes. This turns our attention to price changes, and to avoid problems of units of measurement, we should examine *relative* price changes.

The subject is analyzed by Mundlak and Larson (1992) in reference to the (relative) law of one price, where the domestic price, P, is expressed as a product of the world price, P^*, the nominal exchange rate, E, and the tax policy $S = (1 + t)$. This formulation assumes that the product is homogeneous, so that the world and domestic prices refer to the same product, and that marketing margins and other nontradable inputs are ignored. This is an unrealistic assumption, and therefore a stochastic disturbance U is added. The

domestic price of product i in year t is $P_{it} = P^*_{it} E_t S_{it} U_{it}$. If we rewrite it, with lowercase letters indicating logs, we have

$$p_{it} = p^*_{it} + e_t + s_{it} + u_{it} \tag{3.25}$$

$$u \sim IID(\mu, \sigma^2); \quad E(eu) = E(su) = E(p^* u) = 0$$

When the disturbance represents nontransitory shocks, its mean, μ, is not necessarily zero.

Two questions are of interest for our discussion. First, what proportion of the variations in world prices is transmitted to domestic prices? Second, what proportion of the variations in domestic prices can be attributed to variations in world prices? The answers to both questions are obtained, in principle, by estimating the following equation:

$$p_{it} = \alpha + \beta p^*_{it} + \gamma e_t + \epsilon_{it} \tag{3.26}$$

The basic equation (3.25) can be expressed in terms of (3.26) subject to the restrictions $H_1 : \beta = 1$, $H_2 : \gamma = 1$. The coefficient β is the elasticity of the domestic price with respect to the world price, to be referred to as the elasticity of transmission. The value of this elasticity is the answer to the first question. A value of 1 implies that the variations in world prices are fully transmitted to the domestic prices, whereas a value of 0 implies no transmission at all. Why would this elasticity differ from unity? Several reasons can be offered. First, omitted variables, specifically s, are correlated with p^*. Second, there may be measurement errors in p^*. Such errors may reflect the fact that the world price used in a given study differs from the one pertinent for the particular country because prices relate to different qualities broadly interpreted. Third, if the economy is closed, the world price is irrelevant. Of course, very few countries are completely closed, but many countries are partially closed by means of trade policies, and this may affect the value of the estimate.

To answer the second question, note that the contribution of world prices, measured in domestic currencies, to the variations in p are given by the value of R^2 of the regression (3.26). A low value means that only a small proportion of the variations in domestic prices are accounted for by world prices and exchange rates, and the main sources of the variations are due to the other variables in question.

Various forms of equation (3.26) were estimated. By way of generalization, the deviation from unitary transmission elasticity is, on the whole, surprisingly small. Such deviation is in part due to policy measures and in part due to domestic inputs that are not necessarily synchronized with world agricultural

prices. This does not imply that policies generated with respect to particular products are not important in affecting the prices of these products. They certainly affect the price levels, and whenever a country taxes agriculture, the domestic prices will differ from world prices. Consequently, there are cross-country variations of prices. However, such policies did not prevent domestic prices from moving along with world prices. Furthermore, the world price is the major contributor to variations in domestic prices.

What then is the role for domestic supply and demand? They determine the traded quantities of traded goods, and the prices of traded goods affect to a large extent the prices of the specific factors in agriculture and thereby the supply of nontraded goods. This is basically the mechanism of the factor-price equalization. For instance, depressed world prices affect land prices, agricultural wage rates through their effect on labor supply, and the price of quasi-fixed inputs. This spreads to all commodities.

To conclude, even though domestic policies affect prices, they cannot prevent the covariation of domestic prices with world prices in the long run and therefore do not change the direction of the developments called for by the fundamentals. There may be a simple reason for this. Price distortion is costly, and as we have seen, it increases at an increasing rate with the rate of taxation. Public resources, just like private resources, are finite, and therefore there is a limit to the intervention.

Appendix 3A

1. The loss function is increasing with the absolute value of the tax rate.

   We limit our interest here to efficient production plans (points on the transformation curve), in which case we can write y_2 as a function of y_1: $L(p^*, T) = y(p^*) - [p^* y_1(T) + y_2(y_1(T))]$. Then $dL/dT = -dy_1/dT[p^* + dy_2/dy_1]$. Recall that $-dy_2/dy_1 = p$, $p = Tp^*$, $dp/dT = p^*$. Then $(dy_1/dT) = p^* dy_1/dp$ and for $T \neq 1$ we have $dL/dT = (dy_1/dp)p^{*2}(T - 1)$, and sign $dL/dT = \text{sign}(T - 1)$.

2. The loss function is convex in the absolute value of the tax rate, $T - 1$.

   Label $y(T) = p^* y_1(T) + y_2(y_1(T))$ and note that p^* is held constant. Then we can suppress p^* and write $L(p^*, T) = y(1) - y(T)$. Note that $y(T)$ is a sum of concave functions in T. To see this, select $h = \lambda T + (1 - \lambda)$, $0 \leq \lambda \leq 1$, then following the proof in Chapter 2 of the concavity of the transformation curve, $y(h) \geq (1 - \lambda)y(1) + \lambda y(T)$ (see Appendix 2A). Thus, $y(T)$ is concave, and its negative is convex. As $y(1)$ is independent of T, $L(p^*, T)$ increases at an increasing rate as the absolute value of $T - 1$ increases.

3. The real exchange rate.

ASSUMPTIONS: We consider a small open economy, divided into three sectors, x, m, and h, with production functions $F_j(K_j, L_j)$. Assume that the nominal exchange rate is 1, then the world prices in local currency are p_x^* and p_m^*. The intensity assumption is $k_x(\omega) > k_m(\omega) > k_h(\omega)$, for any given ω.

Supply

Tradable

Prices: The wage-rental ratio is determined by price function $\omega^* = \omega(p_x^*/p_m^*)$.

Inputs: The capital-labor ratio is determined by $k_j^* = k_j(\omega^*)$. Let $L_T = L_x + L_m$; $\ell = L_x/L_T$. Let $k_T = \ell k_x^* + (1 - \ell)k_m^*$. Hence $k_x^* > k_T(\omega^*) > k_m^*$.

Factor prices: Determined at k_j^* from the production functions.

Output: $Y_x = L_T[\ell f_x(k_x^*)]$, $Y_m = L_T[(1 - \ell) f_m(k_m^*)]$.

The output of the two tradable sectors is thus determined conditional on L_T.

Note that $p_x^* f_x(k_x^*) = w^* + r^* k_x^*$, and $p_m^* f_m(k_m^*) = w^* + r^* k_m^*$, Hence

$$p_T^* Y_T = L_T[w^* + r^* k_T^*] = w^* L_T + r^* K_T$$

Nontradable

Given ω^*, the price ratio p_x^*/p_h^* is determined by the price function $\frac{p_x^*}{p_h^*} = \frac{p_x}{p_h}(\omega^*)$, but p_x^* is known, and thus p_h^* can be determined. The capital-labor ratio, $k_h^* = k_h(\omega^*)$, is constant, and value output is $p_h^* Y_h = L_h(w^* + r^* k_h^*)$. Because all the asterisked variables are determined by p_x^* and p_m^* we can summarize the supply side conditional on L_h : $Y_h(p_x^*, p_m^*, L_h)$.

Real exchange rate

Note that the supply of the T and h sectors is linear in their labor input. Consequently, the real exchange rate is constant. To see this, write the output differential:

$$p_T^* dY_T = w^* dL_T + r^* dK_T$$
$$p_h^* dY_h = w^* dL_h + r^* dK_h$$

Under the resource constraints, $-dL_T = dL_h$ and $-dK_T = dK_h$, hence

$$p_h^* dY_h = -p_T^* dY_T,$$
$$-dY_h/dY_T = p_T^*/p_h^*$$

This implies a constant real exchange rate, determined solely by the terms of trade, independently of demand. This is not a coincidence, because the supply does not reflect any attribute that distinguishes between the tradable and the nontradable sectors. To amend this, we have to introduce a specific factor to the production function of one or more of the sectors. But before that, we complete the discussion of this model by bringing in demand.

Demand

The composition of production is determined by the demand so as to meet the zero deficit condition. National income can be determined from the factor costs. The per capita output is

$$y^* = w^* + r^* k.$$

Sectoral per capita demand is given by $x_j(p_x^*/p_h^*, p_m^*/p_h^*, y^*, g) \equiv x_j^*$, where y^* is income (which reflects the technology and resources) and g is a parameter affecting the composition of demand, $\partial(x_h/x_T)/\partial g > 0$. Again, the asterisked values are determined by p_x^* and p_m^*. We can write for the total demand of nontradable,

$$X_h^* = X_h(p_x^*/p_h^*, p_m^*/p_h^*, Y^*, g).$$

Equilibrium

Let $(\cdot) \equiv (p_x^*/p_h^*, p_m^*/p_h^*, Y^*, g)$, then $\Phi(\,) = X_h(\,) - Y_h(p_x^*, p_m^*, L_h)$ is the excess demand for the home good. For equilibrium, set it equal to zero, solve for L_h, and with knowledge of L_h, the rest of the system is solved for. A change in g affects the composition of production but not the prices. The fulfillment of the budget constraint implies zero trade deficit.

Specific Factors

The introduction of a fixed factor makes the production function display decreasing returns to scale in K and L. Although any sector may have specific factors, the natural one for our discussion is the home-good sector because it is the specific factor that makes it nontradable.

To underline the importance of the specific factors, consider an increase in p_x^*. This causes a decline in ω^* (x is the capital-intensive sector), and consequently a rise in the real exchange rate. This change is consistent with the fact that resources will have to move to the exportable sector to facilitate the supply response there, and hence the relative price of x will increase. Now consider an extreme alternative, where the home good (h) is produced by only a specific factor, "land," whose supply is fixed, and the demand for h is a function of the income generated by the export sector. The rise in P_x^* will induce an increase in the demand for h and hence an increase in p_h, and thus a decline in the real exchange rate. This is in contrast to the above analysis. The time pattern of the response depends on the speed of the resource allocation, as discussed subsequently.

Exercises

3.1 (Indirect taxation)
A subsidy to agriculture is financed by taxing sectoral income at the rate of $0 < t < 1$. The collected tax is distributed as a subsidy to agriculture. Show that this scheme amounts to taxing nonagriculture.

3.2 (Policy reform)
Assume a small two-sector open economy operating at world prices, p^*. Agriculture is the exporting sector.

(a) Write down the equations fully specifying the model describing this economy.

(b) Show graphically the initial position of the economy.

Under political pressure, the country is now subsidizing agriculture by setting $p^s > p^* > p^d$. The policy is financed by a lump sum tax of equal rate per capita.

(c) Using the specification in (a), where possible sign the effect of the policy on production, consumption, export, and income evaluated in terms of world prices.

(d) Illustrate graphically the changes examined in (c) above.

3.3 How does a subsidy to agriculture in a closed economy affect: (a) factor prices and (b) factor shares?