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The Return of Ricardo?

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"Reports of my death are greatly exaggerated." — Mark Twain

1. Introduction

Neoclassical trade theory is widely viewed as being theoretically elegant but empirically embarrassing. This view is based in large part on the fact that the predictions of the Heckscher–Ohlin–Samuelson (H–O–S) model are not borne out by the data. In the H–O–S model, aggregate quantities of each factor are fixed exogenously, and relative factor endowments are the primary determinants of specialization and trade. Extensive empirical tests have largely been unsupportive of this theory.[1]

In this frankly reconstructionist paper, we present a neoclassical two sector, two factor trade model which differs from the standard H–O–S model in that it incorporates endogenous capital accumulation and intertemporal optimization. We show that the predictions of this model regarding patterns of specialization and trade are very different from the H–O–S model. Because a nonsubstitution theorem applies in our economy, its predictions regarding patterns of specialization and trade are very much in the spirit of the traditional Ricardian model. Based on the predictions of this neoclassical model, we argue that neoclassical trade theory is <u>not</u> dead from an empirical point of view. On the contrary: with intertemporal optimization and endogenous capital, the neoclassical model can potentially explain many phenomena that are inexplicable within the traditional H–O–S model, including many of those which prompted the development of the "new view" of trade theory, as synthesized by Helpman and Krugman [1985].

In our "2x2x2" model, the two factors of production are capital and labor. There are two final goods in the economy: one sector produces a pure

consumption good, and the other produces a good which can either be used to augment the capital stock or may be consumed. Both sectors produce according to neoclassical, constant returns to scale production functions, and both sectors require inputs of both factors. Individuals maximize the expected value of lifetime utility gained from consumption, thus, saving is endogenous. This paper draws on, and is related to, several strands of existing literature. First, the "nonsubstitution theorem" of Samuelson [1951], Arrow [1951], and Mirrlees [1969] applies in our two sector neoclassical economy. Second, the model is related to paradigms developed by by Oniki and Uzawa [1965], Uzawa [1961,1963], Stiglitz [1970], Mussa [1978], Manning [1981], and Manning and Markusen [1982]. Third, our results on the determinants of specialization in the absence of a government are related to previous analyses by Jones [1970], Ethier and Ross [1971], and Srinivasan and Bhagwati [1980].[2]

Applied real trade theory, however, has generally not incorporated the lessons of these previous analyses. The two-sector model with fixed aggregate factor supplies—the H-O-S model—is still the dominant theory we teach our undergraduates (Enders and Lapan [1987]), our graduate students (Dixit and Norman [1980]), and that we use to address taxation issues in closed and open economies (Atkinson and Stiglitz [1980] and Dixit [1985]). It is still the model that economists think of as the "neoclassical" trade model.

In this paper we focus primarily on the determinants of specialization and trade in the steady state. An implication of the nonsubstitution theorem is that the the long run production possibility frontier facing each country is linear, as in the Ricardian model. This induces countries to specialize along the lines of privately-perceived comparative advantage, again, as

predicted by Ricardo [1817]. A further implication of the nonsubstitution theorem is that the "techniques of production"—quantities of labor and capital applied to the production process—are independent of demand conditions, including the structure of government purchases of goods and services. In the steady state, the rate of return to capital is equated to a fixed discount rate, and the autarky wage rate is invariant to the output structure of the economy. The relative price of the two final goods is similarly invariant to the output structure of the economy. Again, there emerges a strong parallel to the Ricardian single factor, fixed-coefficients model.

In this model, tax policies emerge as important determinants of the long run pattern of specialization and trade because of their potential directly to affect prices and factor returns. The model generates the following predictions for the effects of fiscal policy interventions. First, government expenditures financed by debt or lump sum taxes do not have any long run effect on the autarky interest rate, wage rate, or relative price of the two final goods. In an open economy, changes in government expenditure are unlikely to affect the established pattern of specialization and trade. Second, government taxation of output of the non-capital good (the pure consumption good) similarly does not affect the autarky interest rate, wage rate, or net-of-tax relative price of the two final goods. The gross-of-tax autarky relative price of the consumption good rises by the full amount of the tax. In an open economy, this may lead to a reversal in the established pattern of specialization. Third, we find that government taxation of output of the capital good sector does directly affect autarky factor returns and the net-of-tax relative price. As with taxation of the consumption-good sector, the established pattern of specialization and trade may shift in

response to this tax. However, there is a second source of welfare loss associated with this tax that does not arise with taxation of the consumption good sector. This is due to the fact that taxation of the capital good sector leads producers to choose socially inefficient techniques of production.

The paper is organized as follows. Section 2 lays out the two-sector model for a single economy, and explores the determinants of the long run factor returns, relative prices, and the structure of production. Section 3 studies the effects of a variety of fiscal interventions in the autarky economy. We show that the response of the economy to changes in fiscal policies is generally very different in the model with endogenous capital accumulation, compared with the standard H-O-S model. This is easy to understand—the fact that capital is endogenous gives the private economy another margin along which to adjust in response to changes in policy. In section 4, we explore the determinants of specialization and trade in a small open economy, and investigate the effects of changes in fiscal policy. Section 5 studies the general equilibrium of a two-country world. Drawing on the results of Sections 2 and 3, we examine the determinants of the long run patterns of specialization and trade in the world economy, and show that some—but not all—fiscal policies are important for the determination of specialization. Section 6 takes up the challenge posed by Helpman and Krugman [1985]: that neoclassical models cannot explain central features of international trade, and that noncompetitive models are the only alternative. Section 7 concludes with a summary of our main results, and a discussion of avenues for future research.

2. A Two-Sector Model

Following the traditional approach of real trade theory, we study first an economy operating in isolation, and then consider the effects of opening that economy to trade.

2.1 The basic two-sector model

In our two-sector economy, savings behavior is determined by intertemporal optimization by private agents. The two factors of production are privately-supplied labor and capital. These factors are both required for production of each of the two final goods produced by the economy: a nonstorable consumption good ("food") and a capital good ("machines"). We generalize the standard analysis so that output of the capital good sector may be used as a second consumption good, "machines." The output of the capital good sector, "machines," can be used as an investment good to augment the capital stocks in the two industries, or it can be consumed. The output of the consumption good sector, "food," is nonstorable and therefore can only be consumed in the period in which it is produced. The economy is populated by a single representative agent who owns the capital stock and operates the production technologies directly.

Preferences: The representative agent receives utility from two goods: food and machines. Let ρ denote the representative individual's pure rate of time discount, and let $\beta = [1+\rho]^{-1}$ denote his subjective discount factor. The aim of the individual is to maximize

$$U = \sum_{t=0}^{\infty} \beta^t u(C_{1t}, C_{2t}) \tag{1}$$

where C_{1t} denotes consumption of food and C_{2t} denotes consumption of machines.

Production technology: The two final goods are produced according to production functions which exhibit constant returns to scale in both factors together, but decreasing returns in each factor separately. Sector 1 is the consumption good (food) sector, and sector 2 produced capital (machines). The production functions are given by:

$$Y_{1t} = F_1(K_{1t}, N_{1t}) \tag{2}$$

$$Y_{2t} = F_2(K_{2t}, N_{2t}) \tag{3}$$

where K_{jt}, N_{jt} denote capital and labor used in producing sector j output. The economy-wide capital stock is denoted by K_t:

$$K_t = K_{1t} + K_{2t} \tag{4}$$

Since the primary focus of the paper is on the determinants of specialization and trade in the steady state, we need not take a stand on the short-run degree of capital mobility across sectors and across countries. So long as capital can be moved in the long run—say, by letting old capital equipment depreciate and placing new investment in a different location—the same steady state results will obtain.

Endowments: The representative agent allocates a fixed amount of time, $\bar{N}$, to market work each period.[3] This time is split between work in the two sectors:

$$N_{1t} + N_{2t} \leq \bar{N}. \tag{5}$$

Government: The government of this economy levies taxes, distributes transfers to private agents, and purchases output. Taxes may be lump sum or may take the form of sector-specific distortionary taxes on output. The tax rate on output in sector j at time t is denoted τ_{jt}. Government purchases of the output of sector j is denoted G_{jt}; government purchases do not yield utility to individuals, nor are they productive in the sense that they shift the production functions F_j.[4] Transfers to individuals of the output of

sector j are denoted T_{jt}. The government budget constraints are:

$$G_{jt} + T_{jt} = \tau_{jt} Y_{jt} \qquad j = 1, 2. \tag{6}$$

Finally, letting δ_j denote the rate of depreciation of capital in sector j, the budget constraints for this economy are:

$$Y_{1t} = C_{1t} + G_{1t} \tag{7}$$

$$Y_{2t} = C_{2t} + G_{2t} + [K_{1,t+1} - (1-\delta_1)K_{1t}] + [K_{2,t+1} - (1-\delta_2)K_{2t}]. \tag{8}$$

Equation (7) says that output of the pure consumption good (good 1) is allocated either to private or government consumption. Equation (8) says that output of the capital good may be used for private or government consumption, or to augment the capital stocks in the two sectors.

Competitive equilibrium: The solution of the competitive equilibrium problem for this economy is discussed in the Appendix. Notation for the utility-denominated shadow prices of labor, capital, and the two produced goods is as follows: ω is the the wage rate, q is the (gross) rental rate, p is the price of good 1 (food), and λ is the price of good 2 (machines). Variables without dates are used to refer to steady state values. We choose good 2 (the capital good) to be numeraire, denoting by P_G the gross-of-tax relative price of good 1 in terms of good 2: $P_G \equiv p/\lambda$.

The following two efficiency conditions will be used repeatedly. First, the steady state condition for efficient aggregate capital accumulation is given by:

$$q/\lambda = \beta^{-1} = 1 + \rho, \tag{9}$$

which says that the steady state ratio of the gross rental rate to the price of the capital good is one plus the discount rate. Second, the steady state condition for efficient capital use in the capital-producing sector is:

$$-q + \lambda(1-\tau_2)D_1F_2(K_2,N_2) + (1-\delta_2)\lambda = 0 \quad , \tag{10}$$

where $D_1F_2(.,.)$ denotes the derivative of F_2 with respect to its first

argument. Combining (9) and (10), we have

$$(1-\tau_2)D_1F_2(K_2,N_2) = [1-\beta(1-\delta_2)]/\beta = \rho+\delta_2 \qquad (11)$$

which is the familiar condition that the after-tax rate of return to capital in the capital-producing sector must be equated to the "effective discount rate," $\rho+\delta_2$.

2.2 The nonsubstitution theorem

A version of the "nonsubstitution theorem" of Samuelson [1951], and proven for increasingly general economies by Arrow [1951] and Mirrlees [1969] applies in this economy. As stated by Burmeister and Dobell [1970], this theorem is as follows:[5]

> "Let a feasible interest or profit rate r_o be given exogenously. In competitive steady-state equilibrium the ratios of all prices are determined by the value of r_o alone and are independent of the equilibrium quantities... Moreover, the real wage-rate in terms of every good as numeraire is determined...by the 'invisible hand of competition' and likewise depends only on the value of r_o."

Sufficient conditions for this theorem to hold are (i) that there is one nonreproducible factor (here, labor) which is required in production for every good, and (ii) at least two factors of production are required to produce every good. These conditions are satisfied for the economy under study. In their discussion of the standard neoclassical model, Burmeister and Dobell state that "We conclude this section with the observation that the nonsubstitution theorem remains valid in this neoclassical model. Indeed, it should be obvious that the nonsubstitution result is a general feature of any economic model having (1) one primary (nonproduced) factor, in this case labor, and (2) no joint production."[6]

In our neoclassical model with endogenous capital, the interest rate is, of course, endogenous. Morishima ([1964], pp. 67–69), in fact, took issue with the assumption that it was appropriate in the context of a neoclassical model to treat the interest rate as fixed. But in the steady state of a neoclassical model with optimizing agents and reproducible capital, capital is accumulated until the point at which the marginal product of capital equals the "effective discount rate" $\rho+\delta_2$; the long run supply schedule for capital is horizontal in the neoclassical model. Although the interest rate is not exogenous, its steady state value is pinned down by the first–order condition for efficient accumulation of capital. This yields the result that steady state relative prices and relative factor rewards are independent of equilibrium quantities produced. In particular, they are independent of the composition of government demand, and also are independent of the parameters of preferences, aside from the rate of time preference. The next section explores in more detail why this is so.

2.3 The PPF in the short run and in the long run

The production possibility frontier (PPF) is the set of privately efficient production points given preferences, technology, endowments, and fiscal policies. The long run PPF summarizes efficient production patterns given a fixed amount of labor input, but allows the capital stock to adjust to satisfy condition (11) for efficient capital accumulation. The nonsubstitution theorem tells us that the long run PPF is a straight line, as sketched in Figure 1. The economics behind this result can be understood as follows. Equation (11) determines the steady state after–tax marginal product of capital in sector 2 (in units of good 2) as a function of the parameters of technology, fiscal policy, and the discount factor. Since

equation (11) pins down the steady state marginal product of capital in sector 2, it also pins down the steady state capital/labor ratio in sector 2, because the homogeneity of the production functions means that the marginal products of capital and labor are functions of the capital/labor ratios alone. Thus equation (11) also pins down the real wage rate in sector 2. Since both factors are mobile across sectors in the long run, we know that the real wage rate and the real return to capital are equated across the two sectors in the steady state. Having thus pinned down the wage/rental ratio in sector 1, we have also determined the capital/labor ratio in sector 1, again using the homogeneity of the production functions.

A useful equation for the long run PPF can be developed as follows. Define output using the functions f_j, as: $Y_j = K_j f_j(N_j/K_j)$, j=1,2, which uses the fact that that the functions F_i are homogeneous of degree one. Using these definitions and the labor resource constraint we have:

$$\begin{aligned} N &= N_1 + N_2 \\ &= \left[\frac{N_1}{K_1}\right]\left[\frac{K_1}{Y_1}\right] Y_1 + \left[\frac{N_2}{K_2}\right]\left[\frac{K_2}{Y_2}\right] Y_2 \\ &= \left[\frac{N_1}{K_1}\right]\left[\frac{K_1}{K_1 f_1(N_1/K_1)}\right] Y_1 + \left[\frac{N_2}{K_2}\right]\left[\frac{K_2}{K_2 f_2(N_2/K_2)}\right] Y_2. \end{aligned}$$

The form of this equation recalls a similar equation from Jones's [1965] analysis of a two-sector model. Defining a_{Nj} implicitly as a function of N_j/K_j, we can rewrite the equation above as:

$$N = a_{N1} Y_1 + a_{N2} Y_2 \qquad (12)$$

where $a_{Nj} \equiv (N_j/K_j)/f_j(N_j/K_j) = N_j/Y_j$ for j=1,2.[7] Equation (12) defines the long run PPF for the autarky economy. The form of equation (12) suggests an interpretation of the a_{Nj} as "labor requirement coefficients" giving the

number of units of labor required for the production of one unit of good j. (They are also the inverse of the average product of labor in sector j.) In Jones's [1965] analysis, there is an analogous equation for the second factor, land, which is assumed to be nonreproducible and in fixed aggregate supply:

$$T = a_{T1}Y_1 + a_{T2}Y_2 \quad . \tag{13}$$

Given aggregate quantities of labor and land, and given the "technical coefficients" a_{Nj} and a_{Tj}, which are implicitly functions of the wage/rental ratio, (12) and (13) can be solved for equilibrium levels of Y_1 and Y_2. If the second fixed factor is viewed as capital, as in the H-O-S model, a similar computation determines sectoral outputs as functions of aggregate labor and capital, together with the a_{Nj}, a_{Kj} coefficients.

In our model, however, the second factor—capital—is not fixed exogenously and it <u>is</u> reproducible. Because labor is the only nonreproducible factor, the long run PPF is just the labor constraint, equation (12), which is usefully rewritten in "slope-intercept form" as

$$Y_2 = \frac{N}{a_{N2}} - \left[\frac{a_{N1}}{a_{N2}}\right] Y_1 \quad . \tag{14}$$

The short run PPF is the set of efficient production points given a fixed aggregate stock of capital and fixed total labor input, and with both factors mobile across sectors. These are exactly the assumptions of the standard H-O-S model. This short-run PPF (or H-O-S PPF) will typically have the familiar "bowed-out" shape sketched as the dashed line in Figure 1. This "bowed-out" shape reflects (i) the fact that technologies differ across sectors, and (ii) in the short run (as in the H-O-S model) the fixed aggregate quantity of capital means that each sector faces an upward-sloping supply schedule for capital. Although the production functions each display constant returns to scale, the fixity of aggregate capital means that each

sector faces "pecuniary diseconomies" in the terminology of Enders and Lapan [1987] since the required rate of return to capital in each sector rises as that sector employs more capital.[8] Notice that the short run PPF cuts through the long run PPF at the economy's steady state, which is point A in Figure 1. In drawing Figure 1 we have assumed that sector 1 is the capital-intensive sector, so that points southeast of point A on the long run PPF are associated with increases in the steady state capital stock. Similarly, points northwest of point A on the long run PPF are associated with decreases in the capital stock. This means that, holding fixed the aggregate quantity of capital, the short run PPF lies above the long PPF for levels of Y_2 greater than that associated with point A, and conversely.

The steady state net-of-tax relative price of the two final goods is given by the slope of the short run PPF at the point where it cuts the long run PPF. From the discussion above, we know that steady state relative prices do not depend on the pattern of expenditure in the economy, i.e., they do not depend on which point on the long run PPF represents the steady state. Each point on the long run PPF is a potential steady state, and each has an associated short run PPF. But the nonsubstitution theorem tells us that the relative price—the slope of the short run PPF at the point where it crosses the long run PPF—is the same everywhere along the long run PPF. This is sketched in Figure 2.

A simple expression for the steady state net-of-tax relative price is derived from the condition that factor prices are equalized across sectors and that factor payments exhaust output under constant returns to scale. Letting $w \equiv \omega/\lambda$ and $r \equiv (q/\lambda) - 1$ denote wage and (net) rental rates in units of the numeraire (good 2), straightforward algebra shows that

$$P_N = \left[\frac{a_{N1}}{a_{N2}}\right]\left[\frac{w + rk_1}{w + rk_2}\right] \quad . \tag{15}$$

Thus P_N is greater than the absolute value of the slope of the long run PPF if sector 1 is capital-intensive, i.e., if $k_1 > k_2$ at common factor prices (and conversely). The gross-of-tax relative price of good 1 in terms of good 2, is just

$$P_G = \left[\frac{1-\tau_2}{1-\tau_1}\right] P_N \quad . \tag{16}$$

Anticipating our analysis of fiscal policies, we see that equations (14) and (15) tell us that policy changes affect the long run PPF and the steady state net-of-tax relative price, P_N, only if they affect producers' choices of capital/labor ratios (which are the sole determinants of the the "labor requirement coefficients," a_{Nj}). This condition will be used repeatedly in our analysis of fiscal policy below.

3. The Effects of Fiscal Policy

In the previous section we stressed the role of the nonsubstitution theorem in determining long run output prices and factor returns. These prices depended on technological considerations and on the pattern of distortionary taxation in the economy. They did not depend on the form of private individuals' utility functions, nor did these prices depend on the composition of government demand. Because tax and expenditure policies affect the economy in very different ways, this section addresses in more detail the question of how the economy responds in autarky to changes in fiscal policy. The first experiment we consider is a change in the composition of government expenditure, in which we suppose that the changes in expenditure are financed by lump-sum taxation. The second experiment

undertaken is a change in the distortionary tax on the output of the pure consumption good. In order to isolate substitution effects induced by the tax, the tax proceeds are returned to consumers as lump-sum rebates. The third experiment is a change in the distortionary tax rate on the output of the capital good, again with lump-sum rebates.

3.1 A change in the pattern of government expenditure

To begin, suppose that the government expenditure is zero for each of the two final goods in the economy. The economy's initial steady state equilibrium is given by point A in Figure 3. Now suppose that the government decides permanently to purchase a positive amount of the pure consumption good (good 1). This change in expenditure patterns is assumed to be financed by changes in lump-sum taxation: $\Delta G_1 = -\Delta T_1$. Figure 3 illustrates the effect of this alteration in government expenditure. Because the shift in governmental expenditure patterns does not affect the after-tax marginal product of capital in sector 2, the steady-state interest rate is unchanged (see equation (11) above). Based on the analysis of section 2, we know that so long as the steady state interest rate is unchanged, there will be no change in the steady state wage rate, capital/labor ratios, or relative prices. The effect on consumers' choice is a pure wealth effect: the lump-sum tax causes their budget line to shift down, leading them to choose a point like C which is on the new budget line southwest of point A, so long as both goods are normal goods. The new steady state level of aggregate output is at point B.[9]

What happened in the short run? If we define the "short run" as in section 2, i.e., as the period over which both labor and the aggregate capital stock are fixed but mobile across sectors, the short run effects of

the increase in G_1 are exactly as predicted by the H-O-S model. The H-O-S PPF has the traditional "bowed out" shape drawn through point A in Figure 3, reflecting the fact that each sector faces an upward-sloping short-run supply curve for capital. In the H-O-S model, the increase in G_1 moves the economy from its original equilibrium at point A to a short run equilibrium with output given by a point like D. Point D is characterized by an increase in the relative price of good 1 (the slope of the short run PPF at D); an increase in the output of sector 1 and a decrease in the output of sector 2; and an increase in the relative price of the factor used intensively in sector 1 (capital, in this example).

In the new steady state with output at point B, the effect on output is larger than it was in the short run, but the short run price responses are larger than the long run responses (in the long run, relative prices P_N and P_G are unchanged from the original steady state). In the long run, the level of the capital stock rises since sector 1 was assumed to be the capital-intensive sector. For demand shocks, then, we find that the traditional H-O-S model systematically overstates price movements and understates quantity movements, relative to a model which allows endogenous adjustment of capital.[10]

3.2 Distortionary taxation of production of the consumption good

The previous section demonstrated the irrelevance of demand-side factors for steady state factor returns and the autarky relative price of the two final goods. In this section and the next we study the effects of changes in distortionary taxation of output of the two final goods. Consider first an increase in the tax rate on the output of sector 1 (food); suppose the tax rate rises from zero to τ_1. Suppose as well that all the proceeds from the

tax are rebated in a lum-sum fashion, so that there is no direct wealth effect associated with the increase in tax rates. The change in τ_1 does not alter equation (11) which determines the the steady state values of the wage/rental ratio, the capital/labor ratios, and the relative price, so none of these is altered in the new steady state. Since the tax on sector 1 does not affect capital/labor ratios in either sector, neither does it affect the a_{Nj} coefficients in (14), the equation for the long run PPF. Thus the new equilibrium must be a point on this line, as drawn in Figure 4. The gross-of-tax relative price P_G rises by the full amount of the tax, increasing from its initial value of $P_G^o = P_N^o$ to the level $P_G' = P_G^o/(1-\tau_1) = P_N^o/(1-\tau_1)$.[11] Since $P_N' = P_G'(1-\tau_1)$, we find that $P_N' = P_N^o$: the net-of-tax relative price is unaffected by the tax on sector 1. The economy was originally in equilibrium at point A in Figure 4 before the tax was imposed; the new equilibrium is at point B. The short run PPF's through points A and B both have slope $-P_N^o$. The slope of the dashed line through point B is $-P_G'$, the new steady state gross-of-tax price faced by consumers.

The tax on sector 1 output causes a welfare loss because it drives a wedge between P_G, the relative price faced by individuals purchasing output and P_N, the relative net-of-tax factor cost of producing the two goods. Note that the production point B is on the long run PPF—there is no inefficiency in the "techniques" used to produce the two goods (i.e., the tax induces no change in the a_{Nj}). In particular, the distorting tax does not affect the process of capital accumulation or the choice of capital/labor ratios used in production of either of the goods. The welfare loss arises because, in equilibrium, the economy produces and consumes a suboptimal <u>mix</u> of goods as a result of the tax.

3.3 Distortionary taxation of the production of capital

Now, consider the effects of imposing a distortionary tax on the output of sector 2 at the rate τ_2. To begin, we return again to equation (11), reproduced below:

$$(1-\tau_2)D_1F_2(K_2,N_2) = [1-\beta(1-\delta_2)]/\beta = \rho + \delta_2 \ . \qquad (11)$$

Since the right-hand size of (11) is unaffected by the tax on sector 2 output, the pre-tax marginal product of capital in sector 2 must rise enough to just offset the increase in τ_2. The increase in the required rate of return to capital in sector 2 means that producers in this sector substitute labor for capital, leading to a decline in the steady state capital/labor ratio in this sector. The decline in the capital/labor ratio is accompanied by a decline in the wage/rental ratio in sector 2, and in sector 1 as well since factors are mobile across sectors. Thus the capital/labor ratio also declines in sector 1.

Because the tax on sector 2 affects producers' choices of capital/labor ratios, the tax will affect the a_{Nj} coefficients in equation (14), the equation for the long run PPF. Since the tax on sector 2 output leads to lower capital/labor ratios in each sector, both a_{N1} and a_{N2} increase as a result of the tax. Let θ_{Kj} denote capital's share in sector j and σ_j denote the elasticity of substitution of capital for labor in sector j. Letting "hats" over a variable denote percentage deviations from steady state values, the changes in the a_{Nj} are given by $\hat{a}_{Nj} = -\theta_{Kj}\sigma_j(\hat{w} - \hat{r})$. The increase in a_{N2} has the effect of shifting down the Y_2-axis intercept of the PPF (this is just $\bar{N}/a_{N2}$, from equation (14)), and will also change its slope if production functions differ in the two sectors, so that $\hat{a}_{N1}$ differs from $\hat{a}_{N2}$. The effect of imposing the tax on sector 2 is illustrated in Figure 5, in which we have drawn the case in which sector 1 is capital intensive, so that

$\theta_{K1}>\theta_{K2}$, and in which $\sigma_1=\sigma_2$ so that the slope of the long run PPF unambiguously rises. In the case drawn in Figure 5, the net-of-tax price of good 1 (the capital intensive good) also rises—this is just the slope of the short-run PPF through the new steady state, point B. We know that point B cannot be on the pre-tax PPF, because the techniques used at point B were available before the imposition of the tax, but were not chosen. Thus we conclude that, given an amount Y_1 to be produced, less Y_2 can be produced with the new techniques compared with those used before the imposition of the tax.

The tax on the output of sector 2 causes a welfare loss via two channels. First, as in the case of a tax on sector 1, there is a welfare cost due to static inefficiency—the relative price paid by consumers differs from the relative factor cost of producing the two goods, given the choice of production technique. But there is a second cost due to the fact that the tax on the production of capital causes inefficiency in capital accumulation. The tax on the production of the capital good causes substitution away from capital as an input into production, leading to socially suboptimal capital accumulation. That is, imposing a tax on capital causes the economy to operate inside the PPF that would face a benevolent social planner. This second source of inefficiency does not arise with taxation of the consumption good, since taxation of the consumption good does not distort the process of capital accumulation. This result is familiar from the public finance literature, in which it has been shown that it is generally not advisable to tax intermediate inputs to the production process.

In the H-O-S model, on the other hand, the analysis of a tax on sector 2 is completely symmetric with the analysis of a tax on sector 1. Because capital is exogenous in the H-O-S model, taxation of capital causes

substitution away from capital in production and in consumption, but does not alter the aggregate quantity of capital. Welfare losses associated with inefficient capital accumulation simply cannot arise.

4. A Two-Sector Model of a Small Open Economy

The preceding model of a closed economy may be reinterpreted as a small open economy if we view the relative price as exogenous to the small economy, being determined in world markets. Faced with this exogenous relative price, the small open economy will typically choose to specialize in production of one of the two final goods. If the world relative price of good 1, P^W, exceeds the gross-of-tax relative price P_G, the small open economy will specialize in production of good 1 (and conversely). If P^W is exactly equal to P_G—an extraordinarily unlikely case—production in the small open economy is indeterminate since all production patterns yield the same level of GDP. Thus we find that complete specialization is the most likely outcome for a small open economy. Recalling our results from section 3, we conclude that alterations in patterns of government expenditure financed by debt or lump-sum taxation will not alter the long run pattern of specialization or trade in this small economy. This is because expenditure policies of this sort do not affect the small economy's autarky relative prices and so will not affect the specialization decision in a small open economy.

Changes in tax policy, on the other hand, are very likely to alter the pattern of specialization and trade in a small open economy. If the world relative price is close to the gross-of-tax relative cost of production of the two goods, or if the change in the tax rate is large, tax changes can reverse the established pattern of specialization for a small open economy.[12]

To see this, suppose that the small economy is specialized in production of good 1, and that tax rates are zero. Now suppose that the government of the small economy imposes a tax on sector 1 in the amount τ_1. We know from our analysis of section 3 that the autarky gross-of-tax relative price rises from $P_G = P_N$ to $P_G' = P_N/(1-\tau_1)$. If the post-intervention, gross of tax relative price P_G' is still less than P^W, the small economy continues to specialize in production of good 1. Further, the wage and rental rates in terms of the numeraire (good 2)are unaffected by the tax. If, conversely, $P_G' > P^W$, the small economy will cease production of good 1 and specialize in good 2, despite the fact that it possesses (technical) comparative advantage in good 1.

Let us contrast these predictions with those of the standard H-O-S model. In that model, the small open economy would typically not be specialized in production. Imposing a tax on one sector would simply cause an increase in the relative price of that sector's output, and a decline in the quantity produced. The factor used intensively in this sector would suffer a decline in its real return. This is very different from the endogenous capital model, in which the tax causes either (i) no effect on output at all, and correspondingly no effect on factor returns or net-of-tax relative prices, so long as the pattern of specialization is unchanged, or (ii) a complete reversal of the pattern of specialization, and a decline in the return to labor. There are no moderate effects in the endogenous capital model.

Recent research by Romer [1986], Lucas [1988], King and Rebelo [1990], and Grossman and Helpman [1990] has stressed increasing returns and/or human capital accumulation as central elements to an explanation for the dramatic restructuring and "growth miracles" of some small open economies. Our two sector neoclassical model incorporates neither increasing returns nor human

capital, yet indicates that dramatic changes may nevertheless take place in the production structure of a small economy in response to apparently minor alterations in private incentives. For example, consider a small country largely engaged in labor-intensive agriculture. This economy could respond to increased openness to trade and/or a relatively small increase in relative after-tax rewards to capital-intensive manufacturing by undertaking a rapid accumulation of capital and a radical restructuring of production in the economy to a position in which manufacturing is the predominant industry. Along the transition path, the economy may appear to undergo a "growth miracle." We do not claim that endogenous growth or increasing returns are uninteresting or unimportant economic phenomena. But it is noteworthy that the simple neoclassical model has the potential to generate a dramatic restructuring of an economy in response to modest changes in incentives.

5. The 2x2x2 Model

This section presents a two country version of the two sector, two factor model developed above in which both countries are large enough to affect equilibrium prices.

5.1 A two country, two-sector model with capital mobility

The world consists of two countries, each of whose economies are described by the model developed in Section 2. For this model to be compatible with steady state growth, individuals in the two countries must have the same rate of time preference, ρ. This assumption is maintained throughout, as is the assumption $\delta_2=\delta_2^*$; together these imply that the net-of-tax return to capital in each country is equal to the common effective discount rate: $r=\rho+\delta_2$.

5.2 Patterns of long run specialization and trade

We are now ready to answer the most fundamental—and most important—question which one can ask of trade theory. What are the international patterns of production and trade? The answer is that at least one country must specialize, and both may do so. Each country exports the good in which it specializes, and imports the other. Interactions in private, competitive markets will lead this world economy to a position in which countries choose to specialize along the lines of comparative advantage as seen from the individual producer's point of view. Letting unstarred variables denote the home country and starred variables denote the foreign country, the home country has (privately-perceived) comparative advantage in good 1 if it has the lower gross-of-tax autarky relative price $P_G < P_G^*$, or:

$$\frac{a_{N1}(1-\tau_2)(w + rk_1)}{a_{N2}(1-\tau_1)(w + rk_2)} < \frac{a^*_{N1}(1-\tau^*_2)(w^* + rk^*_1)}{a^*_{N2}(1-\tau^*_1)(w^* + rk^*_2)} \quad . \tag{17}$$

Thus comparative advantage depends on technological considerations, as in the Ricardian model. But it also depends on national tax policies, both directly, through the terms involving tax rates in equation (16), and indirectly, through the effect of capital taxes on equilibrium choices of k_j and a_{Nj}. Notice also that equation (16) differs from the condition for comparative advantage in the one-factor Ricardian model, in that comparative advantage is not determined simply by the ratio of the labor requirement coefficients. In particular, the slopes of the national long run PPF's (the ratios of the a_{Nj}'s) do not necessarily predict the pattern of specialization.

Having determined comparative advantage according to equation (17), it is straightforward to determine the pattern of specialization. So long as $P_G \neq P_G^*$, at least one country will specialize, producing only one good. This

will happen no matter how small are the differences in the tax rates or the production functions. If it happens that $P_G = P_G^*$, the pattern of production and trade is indeterminate. In the absence of comparative advantage, it simply does not matter who produces what. While there is indeterminacy in the patterns of production trade, world production of each of the two goods is determinate. But with identical gross-of-tax relative prices in the two countries, the long run pattern of production is not pinned down. Because capital and final goods are transportable across sectors and countries, it is a matter of indifference where any particular unit of a good is produced.

How should we view this indeterminacy result? Our view is that it is extremely unlikely that one could observe a situation in which this indeterminacy would arise, as it requires either (i) that relative technological opportunities and relative tax rates are identical in the two countries, or (ii) that they differ in a way that leaves (relative) private marginal products across the two sectors the same in both countries. There is no reason to believe that either of these is a likely outcome. We are therefore left with a very strong prediction: in a neoclassical model in which capital is reproducible and is mobile in the long run, there is a presumption of specialization.

5.3 Open economy effects of fiscal policy

The neoclassical model predicts specialization along the lines of privately-perceived comparative advantage. Because shifts in the size and/or composition of government spending do not affect the long run choice of production techniques, these shifts are unlikely to affect world relative prices or the world pattern of specialization and trade.[13] Unless the shift in expenditure is so large that a country that previously did not produce a

particular good is induced to begin production of that good, world relative prices do not change. The composition of world output will change, as will total world output, but the answers to "Who produces what? and "Who exports/imports what?" are not affected by changes in the level and composition of government expenditure.

On the other hand, this model predicts that the pattern of specialization may shift dramatically in response to minor changes in relative tax rates. To see this, suppose that the two countries possess very similar technological possibilities, there are no distortionary taxes, and that the home country possesses comparative advantage in good 1. Let the pre-tax equilibrium be such that the home country produces both goods, and the foreign country specializes in production of good 2. Because the home country is incompletely specialized, the world net-of-tax relative price is given by the home country's autarky relative price. Now, suppose that the government of the home country imposes a tax on the production of good 1. There are two cases to consider, depending on whether the tax alters the world pattern of private comparative advantage. Suppose first that the home country retains private comparative advantage in good 1 after imposition of the tax. Building on our closed-economy results obtained earlier, we find that the gross-of-tax price of sector 1 rises by the full amount of the tax; world output of sector 1 falls (although all of it is still produced by country 1), and world output of sector 2 increases. There is no long run effect in the home country on the wage rate or the rental rate (in terms of the numeraire, good 2). As in the case of the closed economy and the small open economy, the gross-of-tax relative price increases from $P_G = P_N$ to $P_G' = P_N/(1-\tau_1)$.

If, however, the tax increase is sufficiently large, or if the two countries were not too different before the imposition of the tax, the tax increase can alter the pattern of private comparative advantage inducing a dramatic shift in the pattern of specialization. Let P_G^* denote the autarky gross-of-tax relative price of good 1 in the foreign country. If the home country tax on sector 1 is large enough so that $P_G' > P_G^*$, then the home country will cease production of good 1 altogether. The home country will specialize in production of good 2, and the foreign country will produce good 1 and perhaps some of good 2 as well. Again, this response is reminiscent of our analysis of the response of the small open economy to a tax on sector 1. Clearly, this reversal of established patterns of specialization and trade will be more likely the more similar are private opportunities in the two countries before the change in tax policy.

The analysis of the imposition of a tax on sector 2 proceeds in an analogous manner, drawing on our previous analysis of a closed economy and using the condition for comparative advantage to determine the post-tax pattern of specialization. A tax on sector 2 differs in two respects from a tax on sector 1. First, we know that there is an additional welfare cost associated with the fact that the tax distorts capital accumulation. Second, we know that the tax affects the choice of the a_{Nj} coefficients and capital/labor ratios k_j which enter condition (17) determining private comparative advantage.

The lesson from this section can be stated quite simply: government expenditure policies matter very little (if at all) for the determination of specialization and trade. Tax policies matter a great deal, and changes in tax policy can potentially be the source of dramatic international changes in patterns of specialization and trade. The predictions of this model have a

decidedly Ricardian flavor since long-run factor allocation and production patterns are determined completely by comparative advantage considerations.

6. The New View of International Trade

Recently, a new approach to trade theory has been advanced; Helpman and Krugman (1985) present a comprehensive treatment of this new approach. With its twin assumptions of increasing returns to scale at the firm level combined with Chamberlinian monopolistic competition, this "new view" undertook a radical departure from the neoclassical assumptions of constant returns to scale and perfect competition. This departure was motivated by a desire to explain features of the data viewed as inexplicable within the traditional framework. Helpman and Krugman (1985) are explicit about the perceived failings of neoclassical theory, which they detail in a section entitled "Why we need a new theory of trade", as follows: "We can identify four major ways in which conventional trade theory seems to be inadequate in accounting for empirical observation: its apparent failure to explain the volume of trade, the composition of trade, the volume and role of intrafirm trade and direct foreign investment, and the welfare effects of trade liberalization."[14] Although Helpman and Krugman acknowledge the conceptual and technical difficulties involved in manipulating models with increasing returns and imperfect competition, they view this approach as essential to understanding these stylized facts. In this section, we investigate the extent to which the inability of the H-O-S model to explain these empirical regularities stems from its assumption of the fixity of both factors of production. With the endogeneity of capital accumulation and long run capital mobility, the concept of "factor endowments" no longer has any content—the "similarity" of countries is an endogenous feature of the model's

equilibrium. Because of this, our neoclassical model with endogenous capital accumulation can potentially provide explanations for trade phenomena that are unexplainable within the H-O-S framework.

Let us take the four "stylized facts" in turn. First, can we explain why similar countries experience large and growing volumes of trade? Our model predicts at least partial—and perhaps complete—specialization. Since individuals in each country value all produced goods, they must necessarily trade in order to consume their preferred consumption basket. If the economies involved are growing over time, the volume of trade must expand over time as well. If, over time, economies transit from an initial position of autarky to a position of specialization as transportation technology and communication links improve, this model can explain explain growth over time in trade as a percentage of GNP.

The neoclassical model, then, easily explains an increasing volume of trade as countries grow. Whether these trading partners are "similar" in terms of their capital/labor ratios depends on the form of the production functions and on distortionary taxes in the two countries. That is, the "similarity" or "dissimilarity" of countries is determined endogenously in the neoclassical model. If production functions are not too different for different goods, the requirement that the after-tax rate of return be equalized across countries provides a force leading to equilibrium capital/labor ratios that are similar across countries.

The second criticism of traditional models is based on their inability to explain two-way trade in goods with similar "factor content." As discussed above, equilibrium factor supplies in the neoclassical model are endogenous, as are equilibrium choices of "factor content." It is certainly possible that, in equilibrium, producers in the two countries select similar

capital/labor ratios to produce their respective goods. Unified capital markets are again one force that might lead this to be the case. Combined with the presumption of specialization, this leads directly to the phenomenon of two-way trade in "similar" goods, where "similar" is defined in terms of factor content.

What about the large volume of trade attributable to intrafirm trade by multinationals, and the phenomenon of direct foreign investment? The neoclassical model, with its assumption of constant returns production functions, is (trivially) consistent with a multitude of industrial structures. To say more about why one structure is preferred to another, an international theory of industrial organization is necessary, and Helpman and Krugman provide a good deal of structure in this area.

The fourth perceived difficulty with traditional models, as discussed by Helpman and Krugman, involves their view that trade liberalizations often benefit all parties—something that the traditional H-O-S model does not predict. In that model, for example, removing protective tariffs on one sector harms the factor used intensively in that sector, while benefiting the other factor. In our dynamic neoclassical model, trade barriers in the form of taxes, tariffs or quotas can lead to inefficient world patterns of specialization. Thus removal of these barriers can potentially leave all factors in all countries better off in the long run, once efficient patterns of specialization are established. If the trade barriers affect the rate of return to capital in the capital-producing sector, the analysis of section 3 shows that these the trade barriers cause inefficiency in capital accumulation as well as inefficiency caused by substitutions in consumption. Removing these barriers could well leave everyone better off in the long run.

Finally, one argument often used to support monopolistic competition as a modeling strategy is the fact that the U.S. is observed both to export and import the same good: shoes, for example. In a model with monopolistic competition, the shoes that the U.S. exports are not exactly the same, from a consumer's point of view, as the shoes it imports from Italy. For understanding trade flows at this level of disaggregation, the monopolistic competition story is a compelling one. But it seems likely that a model combining monopolistic competition with the endogenous capital accumulation mechanisms studied in this paper would retain the salient feature of this neoclassical model: a nonsubstitution theorem implying a strong presumption of specialization. The difference would be that specialization would occur in particular types of particular goods.

7. Summary and conclusions

This paper has presented a dynamic two-sector model with endogenous saving and capital accumulation, and has examined the long run properties of the model with particular emphasis on the model's predictions about the long run response to changes in fiscal policy. A "nonsubstitution theorem" holds for this economy, with the implication that long run PPF is linear for each country. This fact has strong implications for patterns of specialization and trade. Countries specialize along the lines of privately perceived comparative advantage—a result that is decidedly Ricardian in flavor. Comparative advantage may arise from differences in relative technical possibilities or from differences in relative tax rates across the two countries.

The open economy implications of this result are striking. Minor differences either in production technologies or in relative tax rates lead

at least one country to specialize in production of only one good. Correspondingly, small changes in private incentives can lead to dramatic reorganizations of industrial structure, and to apparent "growth miracles" as the economy transits to the new steady state. The model predicts very different consequences arising from changes in expenditure policies versus tax policies. Changes in government expenditure are likely to leave the pattern of specialization and trade unchanged. In any case, they cannot completely reverse established patterns. Changes in tax rates, on the other hand, can lead to a complete reversal in the world pattern of specialization.

We confronted our neoclassical model with the charges leveled by Helpman and Krugman—that received neoclassical theory based on the H–O–S model cannot explain salient features of international trade. We concluded that the 2x2x2 model with endogenous capital accumulation can potentially explain many of these phenomena without departing from the classical assumptions of constant returns to scale and perfect competition.

Does anything weigh against the forces pushing the economy toward long run specialization? One candidate is nontradability of particular classes of goods. Another reason for nonspecialization is risk associated with the production process, as in the work of Ruffin [1974a,b]. If there is country-specific randomness in the amount of output produced from a given level of input—due, for example, to technological shifts, weather, or random machine failures—then it is efficient to produce the same good in more than one location. The amount of "locational diversification" that is desirable depends on the cross-country correlation of these shocks, and on the strength of comparative advantage in the absence of these shocks. Whether this effect is likely to be quantitatively important is an interesting subject for future research.

This paper has focused primarily on the steady state of the two-sector neoclassical economy. What role remains for the standard H-O-S model? In Baxter [1990], I develop the dynamic implications of the 2x2x2 model, incorporating variable labor supply and costs of adjustment to capital across sectors and across countries. With high costs of moving capital internationally, and modest costs of moving capital across sectors, the H-O-S model can emerge as a description of "medium run" equilibrium. But it does so only if variations in world investment flows are negligible. Since much of the process of sectoral reallocation involves changes in the location of new net investment, and since empirically it is the case that aggregate investment moves strongly in response to most disturbances, one must be skeptical about the usefulness of the H-O-S model.

Finally, since this paper has abstracted completely from growth considerations, a few words on this topic seem warranted. If exogenous technical change is introduced in a way that permits steady state growth, then the economy can be transformed into a stationary economy that differs from the one studied in this paper only in that it has an altered discount factor (see Baxter [1988]). The analysis of this paper can therefore be reinterpreted at no additional cost as applying to an economy in which the "engine of growth" is exogenous technical change. Another approach which is perhaps more appealing is to have an endogenous "engine of growth." King and Rebelo [1990] study a two-sector model of a small open economy in which one sector produces a consumption/investment good and a second sector produces human capital. Both sectors require inputs of both goods, and capital is internationally mobile. King and Rebelo find that the findings of the present paper (that tax policies are important for the level and structure of economic activity) are translated in their setting into important effects of

tax policies on steady state growth rates. Grossman and Helpman [1990] study a model with increasing returns to scale and endogenous "R&D" but without capital. They also find that policy can dramatically affect growth rates. Clearly, a fruitful path for future research is the further integration of capital theory and endogenous growth into general equilibrium models of the international economy.

Appendix

This appendix provides details of the equilibrium problem described in Section 2. All variables are as defined in that section. For simplicity, we assume that capital is instantly and costlessly mobile across sectors. This assumption is completely innocuous for the steady state behavior of the economy, which is the main subject of the paper. The competitive equilibrium is computed as the solution to the following Lagrangian problem:

$$\begin{aligned}\mathcal{L} = \sum_{t=0}^{\infty} \beta^t \Big\{ & u(C_{1t}, C_{2t}) \\ & + \sum_{t=0}^{\infty} \omega_t \, [\bar{N} - N_{1t} - N_{2t}] \\ & + \sum_{t=0}^{\infty} q_t \, [K_t - K_{1t} - K_{2t}] \\ & + \sum_{t=0}^{\infty} p_t [(1-\tau_{1t}) Y_{1t} + T_{1t} - C_{1t}] \\ & + \sum_{t=0}^{\infty} \lambda_t [(1-\tau_{2t}) Y_{2t} + (1-\delta_1) K_{1t} + (1-\delta_2) K_{2t} + T_{2t} - C_{2t} - K_{t+1}] \Big\} \end{aligned} \tag{A1}$$

The multipliers may be interpreted as utility-denominated shadow prices as follows:

ω_t = the wage rate;

q_t = the (gross) rental rate;

p_t = the price of good 1 (food);

λ_t = the price of good 2 (machines).

Letting D_j denote the derivative with respect to the j^{th} argument, the first-order necessary conditions for this problem are:

$$C_1: \quad D_1 u(C_{1t}, C_{2t}) - p_t = 0 \tag{A2}$$

$$C_2: \quad D_2 u(C_{1t}, C_{2t}) - \lambda_t = 0 \tag{A3}$$

$$N_1: \quad -\omega_t + p_t (1-\tau_{1t}) D_2 F_1 (K_{1t}, N_{1t}) = 0 \tag{A4}$$

$$N_2: \quad -\omega_t + \lambda_t (1-\tau_{2t}) D_2 F_2 (K_{2t}, N_{2t}) = 0 \tag{A5}$$

$$K_1: \quad -q_t + p_t(1-\tau_{1t})D_1F_1(K_{1t},N_{1t}) + (1-\delta_1)\lambda_t = 0 \tag{A6}$$

$$K_2: \quad -q_t + \lambda_t(1-\tau_{2t})D_1F_2(K_{2t},N_{2t}) + (1-\delta_2)\lambda_t = 0 \tag{A7}$$

$$K: \quad \beta q_{t+1} - \lambda_t = 0 \tag{A8}$$

together with the resource constraints, the government budget constraint, and the "transversality condition":

$$\lim_{t\to\infty} \beta^t \lambda_t K_{t+1} = 0 \quad . \tag{A9}$$

With time subscripts removed, these equations characterize the steady state of this economy. Steady state versions of (A7) and (A8) appear in the text as equations (10) and (9), respectively.

Endnotes

1. See, for example, Leontief [1953], Bharadwaj [1962], Moroney and Walker [1966], Stolper and Restramp [1961], Tatemoto and Ichimura [1959], and Wahl [1961].

2. Jones [1970] studies a static model and concludes that at least one country was likely to be completely specialized, and that patterns of specialization would be dictated by technological considerations. Ethier and Ross [1971] study the specialization decision under a number of assumptions about saving, and Srinivasan and Bhagwati [1980] study specialization in a small open economy using a deterministic two-sector growth model.

3. In this paper we have abstracted from the labor/leisure choice. The steady state properties of the model are not affected in any substantive way if substitution along the labor/leisure margin is permitted. This is because the central model element is the fixed, nonreproducible amount of time available to an individual. Variable leisure is, however, important for short run dynamics, and this feature is incorporated into the model of Baxter [1990].

4. See Baxter and King [1988,1990] for analyses of productive and utility-yielding government spending in the context of a one-sector, closed economy model.

5. Burmeister and Dobell [1970], pp. 242-243.

6. Burmeister and Dobell [1970], page 280.

7. Jeremy Greenwood suggested this felicitous choice of notation and the analogy to Jones's work. I am embarrassed not to have thought of it myself.

8. Enders and Lapan [1987], page 111.

9. These diagrams are drawn without indifference curves since, in addition to goods consumed by private individuals, the government purchases goods, and a portion of the output of sector 2 is used to maintain the capital stocks in the two sectors. Further, different points on the long run PPF correspond to different aggregate capital stocks and hence different steady state requirements for maintenance capital. Thus one cannot superimpose the private individual's indifference map on the diagrams in the usual way to locate equilibrium consumption points.

10. Studies which allow international capital flows yet retain a fixed world stock of capital include those of Atsumi [1970], Jones and Ruffin [1971], and Bismas [1972].

10. This follows in a straightforward way from equation (A6) in the Appendix. Notice that nothing in (A6) changes in response to the tax, except for τ_1 and

p. Letting p_o denote the pre-intervention, gross-of-tax, utility-denominated price of good 1, and p_1 denote the post-intervention price, we obtain

$P_1(1-\tau_1) = P_o$. Since there is no change in λ, the steady state utility-denominated price of good 2, we obtain $P'_G = P^o_G/(1-\tau_1) = P^o_N/(1-\tau_1)$.

11. The effects of a tax on sector 2 for a small open economy can be studied in a similar fashion. We therefore omit this case in the interest of conserving space and the reader's patience.

12. Government expenditure policies may affect specialization and trade decisions in the presence of trade restrictions, in the presence of "domestic content" or "buy American" policies that apply to the government, or in the case in which government expenditures augment the public capital stock, thus shifting marginal product schedules for privately-owned capital and labor.

13. Helpman and Krugman [1985], page 2.

References

Amano, A. (1977) "Specific Factors, Comparative Advantage and International Investment," *Economica* 44, 131–44.

Arrow, K. (1951) "Alternative Proof of the Substitution Theorem for Leontief Models in the General Case," Chapter IX in Activity Analysis of Production and Allocation, ed. by T.C. Koopmans (New York, 1951).

Atkinson, A.B. and J.E. Stiglitz (1980) Lectures on Public Economics, McGraw–Hill, New York.

Atsumi, H. (1970) "The Long Run Offer Function and a Dynamic Theory of International Trade," Journal of International Economics 1, 267–299.

Baxter, M. (1988) "Dynamic Real Trade Models: New Directions for Open Economy Macroeconomics," Rochester Center for Economic Research working paper No. 167, October 1988.

———— (1990) "Dynamic Response in the Two–Sector Neoclassical Trade Model," manuscript.

Baxter, M. and R. King (1988) "Multipliers in Equilibrium Business Cycle Models," Proceedings of the Second World Basque Congress, San Sebastian, Spain.

———————— (1990) "Fiscal Policy in General Equilibrium," Rochester Center for Economic Research Working Paper #244.

Bharadway, R. (1962) "Factor Proportions and Structure of Indo–U.S. Trade," Indian Economic Journal, October 1962, 105–116.

Bismas, T. (1972) "Non–Shiftable Capital and Imported Inputs in Economic Growth and International Trade," Ph.D. Dissertation, University of Rochester.

Burmeister, E. and A. Dobell (1970) Mathematical Theories of Economic Growth, Macmillan, New York.

Dixit, A.K. (1985) "Tax Policy in Open Economies," in Handbook of Public Economics, A.J. Auerbach and M. Feldstein, Eds., Elsevier Science Publishers B.V., The Netherlands.

Dixit, A.K. and V. Norman (1980) Theory of International Trade, Cambridge Economic Handbooks, Cambridge University Press, Cambridge, UK.

Enders, W. and H.E. Lapan (1987) International Economics: Theory and Policy, Prentice–Hall, New Jersey.

Ethier, Wilfred and S. A. Ross (1971) "International Capital Movements and Long Run Diversification," *Journal of International Economics* 1, 304–314.

Grossman, G. and E. Helpman (1990) "Comparative Advantage and Long-Run Growth," American Economic Review 80, (September 1990) 796-815.

Heckscher, E. (1919) "The Effect of Foreign Trade on the Distribution of Income," *Ekonomisk Tidskrift* 21, 497-512.

Helpman, E. and P. Krugman (1985) *Market Structure and Foreign Trade*, MIT Press, Cambridge, Massachusetts.

Inada, K. (1968) "Free Trade, Capital Accumulation, and Factor Price Equalization," *Economic Record* 44, 322-512.

Jones, Ronald W. (1965) "The Structure of Simple General Equilibrium Models," *Journal of Political Economy* 73:6, 557-72.

_____ (1967) "International Capital Movements and the Theory of Tariffs and Trade," *Quarterly Journal of Economics* 81, 1-38.

_____ (1970) "The Role of Technology in International Trade," in *The Technology Factor in International Trade*, ed. Raymond Vernon, New York: National Bureau of Economic Research, 73-92.

Jones, R. and R. Ruffin (1971) Trade Patterns with Capital Mobility," Journal of International Economics 1, 307-332.

King, R. and S. Rebelo (1990) "Public Policy and Economic Growth: Developing Neoclassical Implications," NBER Working Paper #3338.

Leontief, W. (1953) "Domestic Production and Foreign Trade: The American Capital Position Re-Examined," Proceedings of the American Philosophical Society 97, September 1953, 332-349.

Lucas, R. (1988) "On the Mechanics of Economic Development," Journal of Monetary Economics 22, 696-715.

Manning, R. (1981) "Specialization and Dynamics in a Trade Model," Economic Record, September 1981, 251-260.

Manning, R. and J. Markusen (1982) "Dynamic Non-substitution and Long-Run Production Possibilities," manuscript, University of Western Ontario.

Mirrlees, J. (1969) "The Dynamic Nonsubstitution Theorem," Review of Economic Studies, January 1969, 67-76.

Morishima, M. (1964) Equilibrium, Stability, and Growth (Oxford, 1964).

Moroney, J. and J. Walker (1966) "A Regional Test of the Heckscher-Ohlin Hypothesis, Journal of Political Economy, December 1966, 573-586.

Mussa, M. (1978) "Dynamic Adjustment in the Heckscher-Ohlin-Samuelson Model," Journal of Political Economy 86, 775-791.

Ohlin, Bertil (1933) *Interregional and International Trade*, Cambridge, Massachusetts: Harvard University Press.

Oniki, H. and H. Uzawa (1965) "Patterns of Trade and Investment in a Dynamic Model of International Trade," *Review of Economic Studies* 32, 15–38.

Ricardo, D. (1817) The Principles of Political Economy and Taxation.

Romer, P. (1986) "Increasing Returns and Long Run Growth," Journal of Political Economy 94, 1002–1037.

Ruffin, R. (1974a) "International Trade Under Uncertainty," Journal of International Economics 4, 243–259.

_____. (1974b) "Comparative Advantage Under Uncertainty," Journal of International Economics 4, 261–273.

Samuelson, P. (1951) "Abstract of a Theorem Concerning Substitutability in Open Leontief Models." Chapter VII in Activity Analysis of Production and Allocation, ed. by T.C. Koopmans, New York: Wiley, 1951.

Srinivasan, T. and J. Bhagwati (1980) "Trade and Welfare in a Steady State," in Chipman, J. and C. Kindleberger (eds.) *Flexible Exchange Rates and the Balance of Payments*, North–Holland.

Stiglitz, J. (1970) "Factor Price Equalization in a Dynamic Economy," Journal of Political Economy, 456–488.

Stolper, W. and K. Restramp (1961) "Input–Output Table for East Germany with Applications to Foreign Trade," Bulletin of the Oxford University Institute of Statistics, November 1961, pp. 379–392.

Tatemoto, M. and S. Ichimura (1959) "Factor Proportion and Foreign Trade: The Case of Japan," Review of Economics and Statistics, November 1959, 442–446.

Uzawa, Hirofumi (1961) "On a Two–Sector Model of Economic Growth I," *Review of Economic Studies* 29, 40–47.

_____ (1963) "On a Two–Sector Model of Economic Growth II," *Review of Economic Studies* 30, 105–118.

Wahl, D. (1961) "Capital and Labor Requirements of Canada's Foreign Trade," Canadian Journal of Economics and Political Science, August 1961, 349–358.

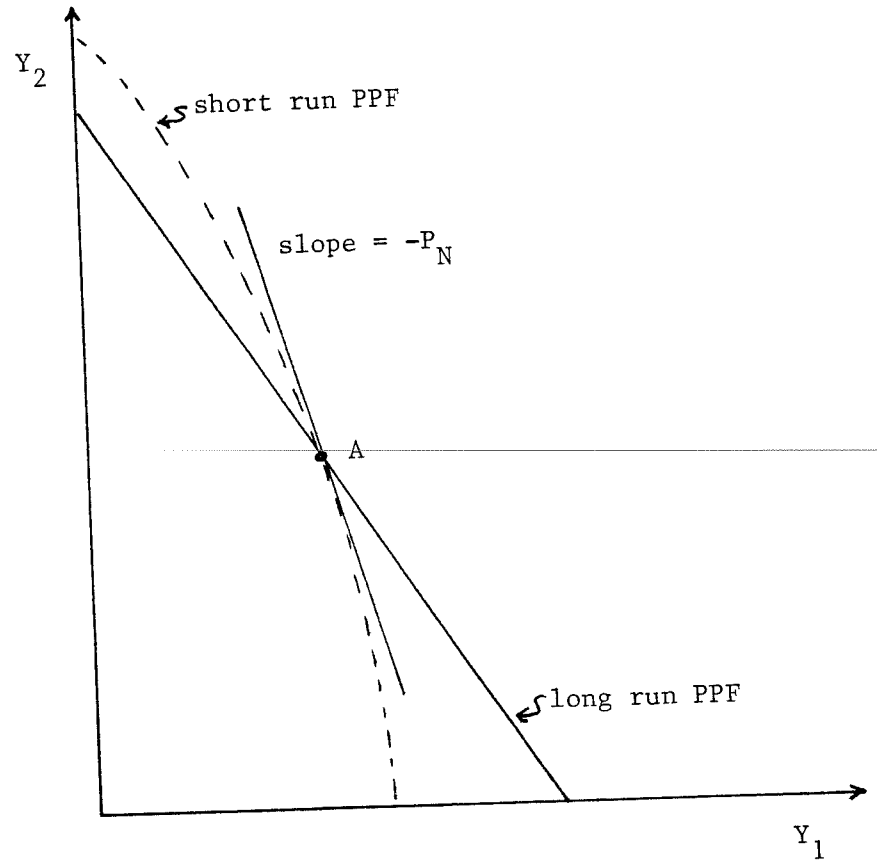

FIGURE 1

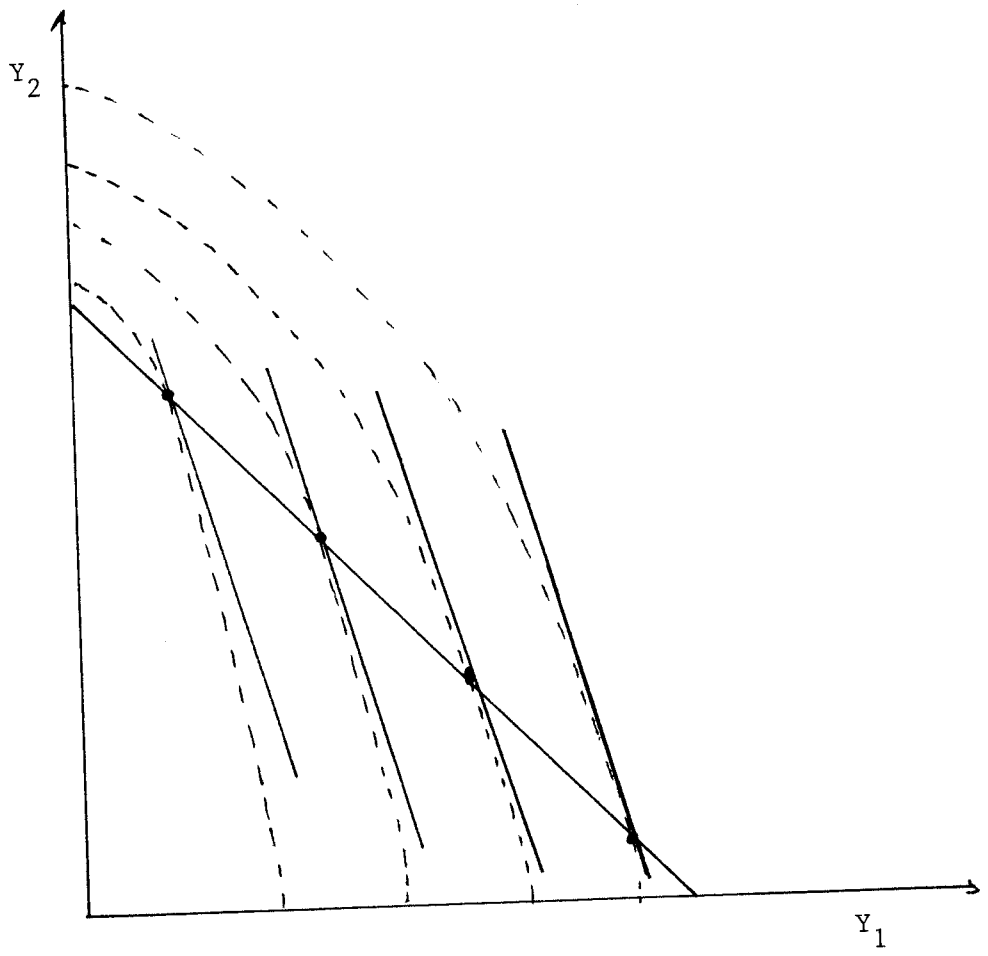

FIGURE 2

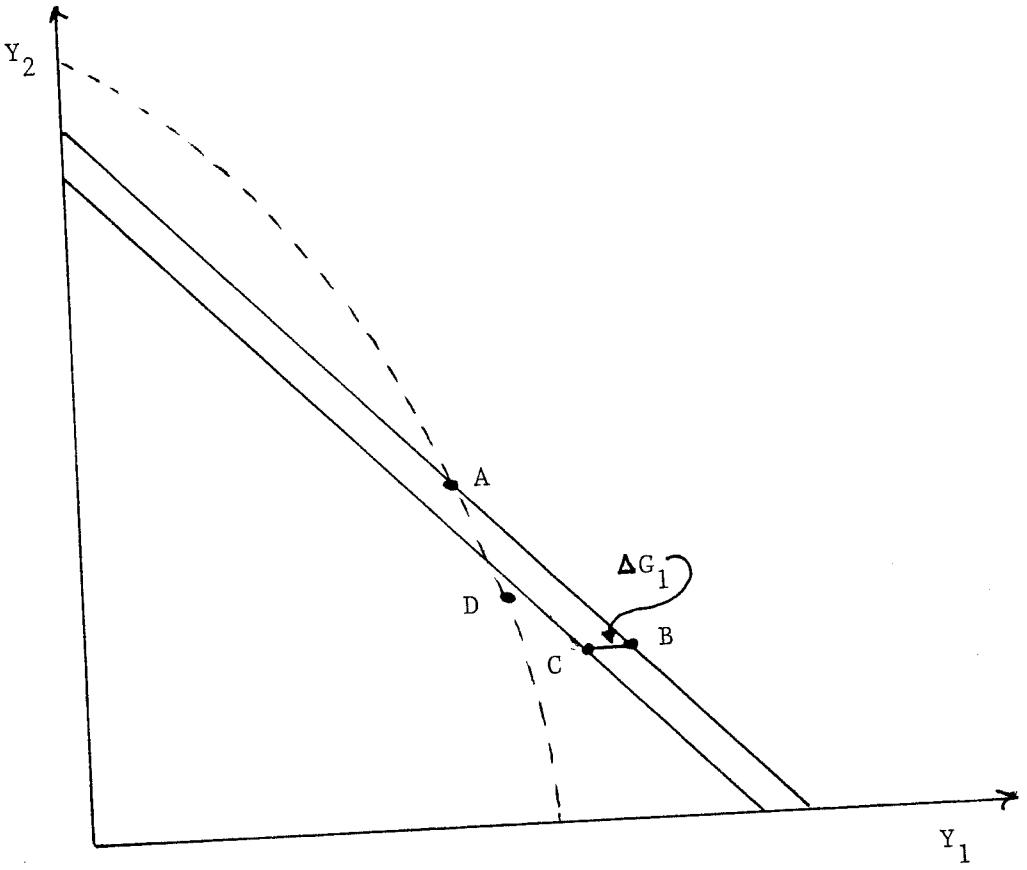

FIGURE 3

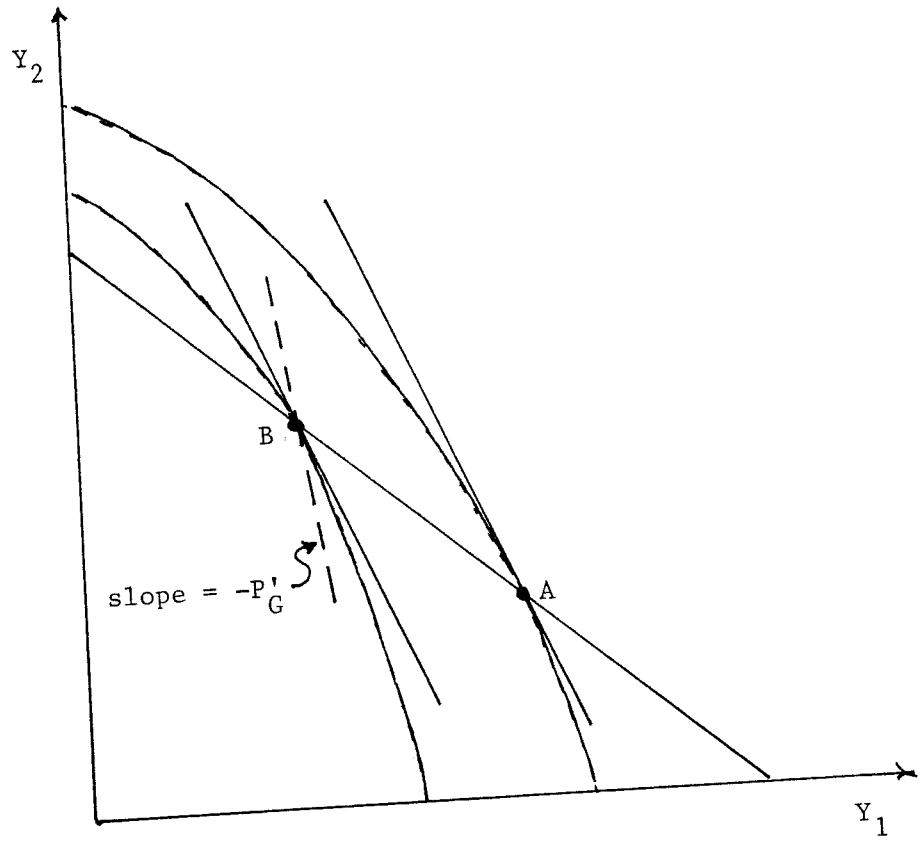

FIGURE 4

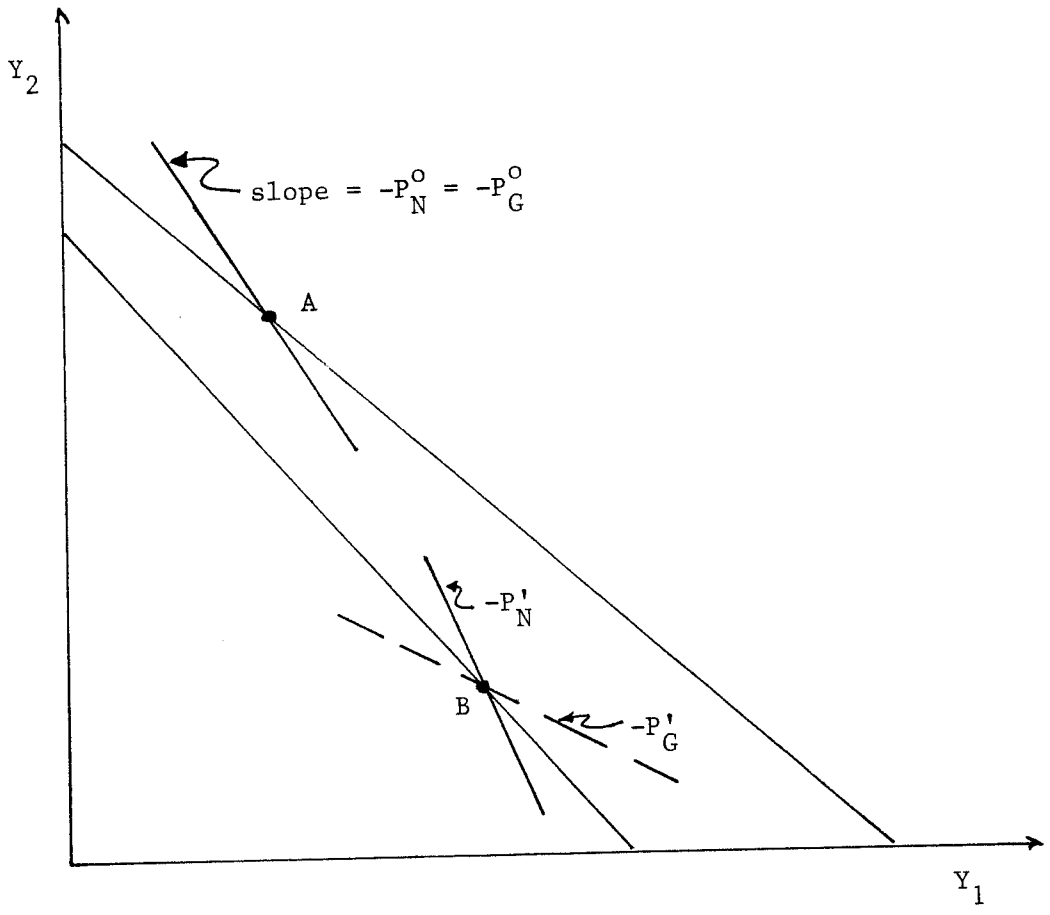

FIGURE 5