PRODUCTION AND TRADE WITH SECTOR SPECIFIC INTERNATIONAL CAPITAL

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ABSTRACT

This paper examines capital crosshauling and other production characteristics of a small open economy which is a price taker in international markets for its finished goods and sector specific capital input. The two sectors share a pair of domestic productive factors, including labor and perhaps natural resources, energy, or skilled labor. A higher price of international capital in one sector causes that capital to leave the economy, but may lead to capital crosshauling. Prices of domestic factors are altered, which raises the potential of using taxes on international capital to influence income distribution. With the higher price of international capital, output may rise in one sector and fall in the other, or both outputs may rise or fall. Degrees of factor intensity and factor substitution determine whether crosshauling of capital or another pattern of international capital movement occurs. Resource booms and various conditions of Dutch disease are also studied.

I. INTRODUCTION

Many countries can be characterized as relying on international markets for productive capital input, much of which is sector specific. This capital machinery and equipment from international markets would provide the foundation for production in the various sectors of the economy. A change in the international price of a sector's capital input, perhaps through

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a tax or subsidy, would influence capital employment, alter the pattern of production, and redistribute income among domestic productive factors. International "crosshauling" of capital would occur if there were simultaneous inflow and outflow of capital across sectors.

A higher international price of exports or imports would bolster that sector and squeeze the rest of the economy. With international sector specific capital, the higher price would seem to be an attraction to international capital in that sector. If capital were released from the rest of the economy, tariffs and subsidies on traded goods would lead to capital crosshauling.

Consider a resource boom, the discovery of a domestic natural resource. Sectors using this newly discovered resource should expand, but the rest of the economy might shrink. This is commonly known as the "Dutch disease," referring to the discovery of natural gas which shifted production in the Dutch economy during the 1970s. Crosshauling of international sector specific capital would seem to be a natural companion to such a resource boom.

This paper examines in detail the comparative statics of a competitive fully employed economy which is a price taker in world markets for the goods it produces as well as corresponding types of sector specific capital input. Supplies of each sector's capital are perfectly elastic at the exogenous world price, with demand determining the level of capital employed. Industry is constrained not by its endowment of capital, as in the Heckscher-Ohlin-Samuelson (HOS) model, but by the international price of capital. Such a general equilibrium model of production may come close to reflecting an economy with free foreign direct investment and a few major industries dominated by multinational firms.

Suppose such an economy produces two finished goods, each traded at an international price. If labor is the only domestic input, the economy will be forced into complete specialization in a single good. Formally, the model is overdetermined because there are more exogenous prices (four) than the total of productive factors (three). Different directions, each of inherent interest, have been taken in theoretical investigations. Burgess (1978) and Jones, Neary, and Ruane (1983) assume one of the two goods is not traded internationally. Batra and Ramachandran (1980) and Khandker (1981) let multinational firms in one sector employ sector specific domestic marketing skills. Srinivasan (1983) and Thompson (1985b) suppose international capital is employed in only one sector, with a domestic specific factor employed in the other sector. Jones and Dei (1983) develop a model with endogenous capital payments and sector specific capital in only one sector. Jones, Neary, and Ruane (1991) examine the Dutch disease in a two sector model with shared labor and sector specific domestic resources as well as sector specific international capital.

The present paper analyzes a model with sector specific international capital in each of its industries and a domestic input (natural resources, energy, or skilled labor) in addition to labor. Both domestic inputs are shared by the economy's two sectors. There is ample motivation for the added domestic factor. Natural resources play a vital role in the production and trade of many countries. Energy input is a vital part of most economies. Finally, skilled labor is necessary for explaining the empirical factor content of trade.

Under assumptions of competition and cost minimization, production of each good occurs when the endowment of domestic factors of production lies within the implied cost mini-

mizing production cone. In most of the literature cited above, complete specialization and industrial shutdown are typical. In the present model, each type of capital is found to have diminishing marginal productivity in the general equilibrium: a rising (falling) international price of capital will create outflow (inflow) of the sector's capital. The return to the domestic factor used intensively in a sector is found to vary directly with the sector's capital employment in the general equilibrium. A rising international price of capital has the potential to increase output in both sectors, with crosshauling of the other sector's capital and net movement of domestic factors into the sector suffering the higher capital price.

A higher international price of a good increases output and raises payment to the domestic factor used intensively in that sector. There is a presumption that capital in that sector will subsequently enter the economy, with crosshauling of the other type of capital. Depending on technical conditions, however, both types of capital may come into the economy, "reverse crosshauling" may occur, or both types of capital may leave the economy. While production is found to unambiguously shift toward the sector with a rising price, the strength of the shift depends partly on the underlying international capital movements. There is an increase in the return to the domestic factor used intensively in the sector with a rising price, while the price of the other domestic factor falls.

Domestic capital owners are assumed to receive the international price of capital regardless of any domestic tax. The location of home owned capital is irrelevant to domestic income since domestic capital owners always receive the international return. Domestics supply their capital to international markets which are footloose and homogeneous. Kemp (1961) and Jones (1967) find the tax on foreign capital which optimizes national welfare when the domestic price of capital is endogenous. The present model departs from this tradition in that the small economy is a price taker in the international capital markets.

Section I presents the sector specific international capital model. Section II examines the effects of changing international capital prices. Section III examines the potential of international capital tax policy to redistribute income. A conclusion and suggestions for further research are presented in Section IV. The Appendix contains model specifications which illustrate the variety of possible comparative static outcomes.

II. THE SECTOR SPECIFIC INTERNATIONAL CAPITAL MODEL

Properties of the fundamental competitive general equilibrium model with constant returns to scale and full employment have been developed by Jones and Scheinkman (1976), Chang (1979), Takayama (1982), Thompson (1987), and others. Endogenous outputs are x_j and exogenous world prices p_j^*, $j = 1,2$. Exogenous endowments of domestic productive factors are v_3 and v_4, which can be some combination of labor and natural resources, energy, or skilled labor. Domestic factors receive endogenous payments, w_3 and w_4.

The structure of the capital markets is based on the idea of Caves (1971) and Jones (1971) that capital is mobile internationally but sector specific due to its specialized form. The two sorts of international capital employed in amounts k_1 and k_2 are paid exogenous world prices r_1^* and r_2^*, which are determined in two distinct exogenous international markets.

Cost minimizing factor inputs a_{ij} are functions of the vector of factor prices. Goods are numbered so domestic factor 3 is used intensively in Sector 1 and domestic factor 4 is used intensively in Sector 2: $a_{31}/a_{32} > a_{41}/a_{42}$. For notation, $b \equiv a_{31}a_{42} - a_{32}a_{41}$, which is positive.

Comparative static outcomes in three factor models depend on degrees of factor intensity and factor substitution, as analyzed by Jones and Easton (1983) and Thompson (1985a). Substitution terms summarize how firms facing changing factor payments would alter their inputs: $s_{hi} \equiv \Sigma_j x_j \partial a_{hj}/\partial w_i$ $(h, i = 3, 4)$ and $s_{gk} \equiv \Sigma_j x_j \partial a_{gj}/\partial r_k^*$ $(g = 1,2,3,4$ and $k = 1,2)$. Note that s_{12} and s_{21} are zero, as firms do not respond to a changing price of the other sector's capital. It is known that $s_{hk} = s_{kh}$ due to Young's theorem. Also, $s_{hh} < 0$ due to concavity of the cost function. Given linear homogeneity of the production function, $\Sigma_i w_i s_{hi} = 0$ (summed over domestic factors and capital). Factors are rescaled so each factor price equals one and $\Sigma_i s_{hi} = 0$. Factors h and k are aggregate technical substitutes if $s_{hk} > 0$, and complements if $s_{hk} < 0$.

Full employment of each productive factor ($v_i = \Sigma_j a_{ij} x_j$ and $k_j = a_{jj} x_j$) leads to the first four equations in the system (2) below. Goods are rescaled so $a_{jj} = 1$.

From competitive pricing ($p_j = \Sigma_i w_i a_{ij}$) and cost minimization,

$$dp_j^* = a_{Lj} dw_L + a_{Sj} dw_S + a_{jj} dr_j^*, \; j = 1,2. \tag{1}$$

Competitive pricing yields the two last equations in (2). Exogenous changes are collected on the right side of (2). The complete comparative static system is stated:

$$\begin{bmatrix} -1 & 0 & s_{13} & s_{14} & 1 & 0 \\ 0 & -1 & s_{23} & s_{24} & 0 & 1 \\ 0 & 0 & s_{33} & s_{34} & a_{31} & a_{32} \\ 0 & 0 & s_{34} & s_{44} & a_{41} & a_{42} \\ 0 & 0 & a_{31} & a_{41} & 0 & 0 \\ 0 & 0 & a_{32} & a_{42} & 0 & 0 \end{bmatrix} \begin{bmatrix} dk_1 \\ dk_2 \\ dw_3 \\ dw_4 \\ dx_1 \\ dx_2 \end{bmatrix} = \begin{bmatrix} -s_{11} dr_1^* \\ -s_{22} dr_2^* \\ dv_3 - s_{13} dr_1^* - s_{23} dr_2^* \\ dv_4 - s_{14} dr_1^* - s_{24} dr_2^* \\ dp_1^* - dr_1^* \\ dp_2^* - dr_2^* \end{bmatrix}. \tag{2}$$

The determinant Δ of the system matrix in (2) equals b^2 and is positive. Comparative static partial derivative effects of changes in r_j^*, p_j^*, or v_h are found with Cramer's rule. The model can alternatively be solved recursively, first for changes in factor prices, then outputs, and finally employment levels of international sector specific capital. These changes all occur simultaneously and influence each other in the general equilibrium. The production possibility frontier is found to be locally concave to the origin: $\partial x_j/\partial p_j > 0$ $(j = 1, 2)$ and $\partial x_j/\partial p_m < 0$ $(j \neq m)$.

The total number of factors (four) equals the number of international markets (two for each good plus two for each type of capital). As a result, changing endowments of domestic factors do not affect their prices: $\partial w_h/\partial v_k = 0$ $(h,k = 3,4)$. If two such economies with identical production functions traded freely with each other, their factor prices would be equal. This is the factor price equalization property familiar from the 2×2 Heckscher-Ohlin-Samuelson (HOS) model.

In fact, the structure of this model in its domestic inputs is identical to the HOS model. Reciprocal Rybczynski and Stolper-Samuelson results are found for the domestic factors:

$$\partial w_3/\partial p_1^* = \partial x_1/\partial v_3 = a_{42}/b > 0,$$

$$\partial w_4/\partial p_1^* = \partial x_1/\partial v_4 = -a_{32}/b < 0,$$

$$\partial w_3/\partial p_2^* = \partial x_2/\partial v_3 = -a_{41}/b < 0, \text{ and}$$

$$\partial w_4/\partial p_2^* = \partial x_2/\partial v_4 = a_{31}/b > 0. \tag{3}$$

A tariff will raise the price of the domestic factor used intensively in the protected sector while lowering the price of the other domestic factor. Production of each good is positively related with the endowment of the domestic factor used intensively in its production and negatively related with the endowment of the other domestic factor. These results are identical to those for an HOS model with only domestic factors.

The underlying HOS structure of the model in the two domestic factors is suggested with $dk_j = dr_j^* = 0$ $(j = 1,2)$ in (2). The Lerner-Pearce diagram of Figure 1 illustrates this HOS structure. Unit value isoquants for Goods 1 and 2 are drawn for $p_j = 1$ and equilibrium levels of international sector specific capital. With cost minimization and zero profit, a common unit value isocost line supports the two isoquants. Endpoints of the isocost line determine domestic factor prices. Input ratios are uniquely determined in each sector by cost minimizing behavior. Changing endowments of domestic factors within the production cone do not affect domestic factor prices, and factor price equalization results. If the endowment moves from point E but remains inside the production cone, w_3 and w_4 are unaffected, while x_1 and x_2 adjust according to factor intensity as in (3).

An increase in the price of a good lowers that unit value isoquant in Figure 1 toward the origin, raising the price of its intense domestic factor. Production shifts toward the sector

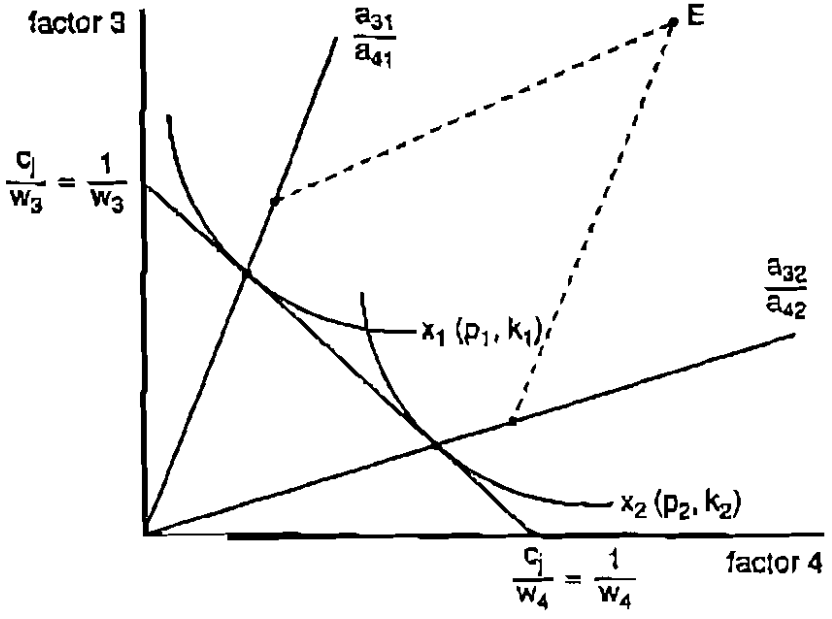

Figure 1.

with the higher price. The next section uncovers a presumption that international capital will be attracted to the expanding sector, with crosshauling of the other capital. Other patterns of international capital movement, however, are possible.

An increase in the endowment of a domestic factor shifts output toward the sector using that factor intensively. Suppose such a resource boom occurs, with an increase in the domestic factor v_4. Output in Sector 2 would rise while output in Sector 1 falls. The next section shows that Sector 2 capital is attracted to the economy while Sector 1 capital is released. In the midst of this Dutch disease, prices of both domestic factors remain unchanged. Factor prices are "in neutral" when factor endowments change in this model. The general lesson of the factor price equalization result is that output adjustments (and international capital movements in this model) are strong and flexible enough to accommodate the changed resource base of the economy without factor prices having to adjust.

III. CHANGES IN THE PRICES OF INTERNATIONAL CAPITAL

With supplies of each sector's capital perfectly elastic and other exogenous variables constant, changes in an international capital price trace its general equilibrium demand. National demands for each type of capital are described by the partial derivatives $\partial k_1/\partial r_1^*$ and $\partial k_2/\partial r_2^*$. Cofactors of these terms from (2) reduce to the determinants of models with each sector employing all three factors (and all factor endowments exogenous). Chang (1979, p. 711) directly proves these determinants are negative, as does Neary (1985) using the property that the national revenue function is positive semidefinite in capital payments. General equilibrium or *mutadis mutandis* demand for each type of capital thus slopes downward.

The fact that there is diminishing marginal productivity for capital in each sector's production function does not guarantee that a higher price of international capital will cause less of it to be employed. Output adjustment and intersector movement of domestic factors in the general equilibrium might conceivably potentially outweigh the higher capital price and induce capital to enter the economy. The property of downward sloping general equilibrium demand has to be established. A higher (lower) international capital payment creates an outflow (inflow) of that sector's capital in the general equilibrium.

The international movement of capital alters the productivity of domestic factors, causing both internal migration of domestic factors between sectors and income redistribution. Changing prices of international capital affect domestic factor payments in the general equilibrium according to:

$$\partial w_3/\partial r_1^* = -a_{42}/b < 0,$$

$$\partial w_4/\partial r_1^* = a_{32}/b > 0,$$

$$\partial w_3/\partial r_2^* = a_{41}/b > 0, \text{ and}$$

$$\partial w_4/\partial r_2^* = -a_{31}/b < 0. \tag{4}$$

A higher price of a sector's capital causes it to leave the economy and lowers the productivity and price of the domestic factor used intensively in that sector. There is an "intensity link" in equation (4), an inverse relationship between a capital price and the price of that sector's intensive domestic factor.

A rising price of one sector's capital causes that capital to leave the economy and lowers the productivity of domestic factors in that sector. The intensive domestic factor suffers a falling price in the general equilibrium, as excess supply develops in the move to the other sector. It is curious to note that factor prices in this model are more dependent on the prices of international capital than on their own supplies. The potential of using taxes on international capital to influence domestic factor income distribution is examined in the next section.

An "inverse reciprocity" is found between these results and the effects of changing endowments of domestic factors on capital employments:

$$\partial w_h/\partial r_j^* = -\partial k_j/\partial v_h. \tag{5}$$

There is thus a positive relation between the endowment of a domestic factor and the employment of capital in the sector where that domestic factor is used intensively. An increased endowment of factor 4, perhaps through a resource boom, will create capital crosshauling with capital coming into Sector 2 as Sector 1 capital departs. Countries with relatively abundant or growing domestic factors of production will be natural havens for international capital in the sectors using those factors intensively. International capital mobility thus contributes to symptoms of the Dutch disease.

A change in a capital price also affects employment of the other type of capital. Solving equation (2) for the cross effect of a change in r_1^* on employment of Sector 2 capital:

$$\partial k_2/\partial r_1^* = (a_{41}c_1s_{13} + a_{31}c_3s_{14} + a_{42}c_2s_{23} + a_{32}c_4s_{24} + c_5c_6s_{34})/\Delta, \tag{6}$$

where $c_1 \equiv a_{42} + b$, $c_2 \equiv a_{41} - b$, $c_3 \equiv a_{32} - b$, $c_4 \equiv a_{31} + b$, $c_5 \equiv a_{32} + a_{42}$, and $c_6 \equiv a_{31} + a_{41}$. Analysis is symmetric for the other cross effect: $\partial k_1/\partial r_2^* = \partial k_2/\partial r_1^*$. Substitution terms s_{ij} have been eliminated according to the property $\Sigma_i s_{hi} = 0$ for every h.

The sign of equation (6) cannot be settled since the substitution terms vary in sign and the signs of c_2 and c_3 depend on factor intensity. There is at least a presumption that equation (6) is positive. If $\partial k_2/\partial r_1^*$ is positive, a higher r_1^* causes crosshauling. With a rising r_1^*, crosshauling occurs with increased productivity and inflow of Sector 2 capital as domestic factors leave Sector 1, which is also losing capital. There are, however, no necessary conditions at this level of generality for the sign of equation (6) or for capital crosshauling.

Effects of changing capital payments on the pattern of output are:

$$\partial x_1/\partial r_1^* = (-a_{42}c_1s_{13} - a_{32}c_3s_{14} - a_{42}s_{23} - a_{32}s_{24} - c_6s_{34})/\Delta,$$

$$\partial x_2/\partial r_1^* = (a_{41}c_1s_{13} + a_{31}c_3s_{14} + a_{41}a_{42}s_{23} + a_{31}a_{32}s_{24} + c_5c_6s_{34})/\Delta,$$

$$\partial x_2/\partial r_2^* = (-a_{41}^2s_{13} - a_{31}^2s_{14} - a_{41}c_2s_{23} - a_{31}c_4s_{24} - c_5^2s_{34})/\Delta, \text{ and}$$

$$\partial x_1/\partial r_2^* = (a_{41}a_{42}s_{13} + a_{31}a_{32}s_{14} + a_{42}c_2s_{23} + a_{32}c_4s_{24} + c_5c_6s_{34})/\Delta. \tag{7}$$

There is a presumption in equation (7) if all inputs are substitutes that a rising r_1^* will lower output in that sector ($\partial x_1/\partial r_1 < 0$) and raise output in Sector 2 ($\partial x_2/\partial r_1 > 0$). Domestic factors may, however, leave Sector 2 and offset the capital outflow in Sector 1 enough that $\partial x_1/\partial r_1^* > 0$. If so, there is a stronger presumption that output would fall in Sector 2 ($\partial x_2/\partial r_1^* < 0$). Sector 2 capital may, however, crosshaul ($\partial k_2/\partial r_1^* > 0$) to the extent that output in Sector 2 rises as well. These possibilities can be seen in equations (4) and (7) when there is technical complementarity or b is large enough to make c_2 or c_3 negative. The term b becomes larger with a greater difference in factor intensity between domestic inputs.

There is another type of inverse reciprocity at work:

$$\partial k_h/\partial p_j^* = -\partial x_j/\partial r_h^*. \tag{8}$$

Presumptions are that a higher p_j^* will attract capital to that sector and create crosshauling. Emphasis could be on import tariffs or a higher export price. Again, however, this outcome is not necessary and results hinge on degrees of factor intensity and factor substitution. Both factor substitution and factor intensity are crucial in determining the qualitative comparative static outcomes which occur with a changing capital price. Some econometric studies suggest there is technical complementarity between capital and natural resources, energy, or skilled labor. The Appendix contains examples of how various degrees of complementarity and substitution affect the pattern of international capital and domestic output adjustments when the price of international capital changes.

As a base case, consider what would occur with an increased r_1^* when all factors are substitutes. Sector 1 capital leaves the economy, lowering the productivity of domestic factors, especially intensive factor 3 in that sector. Crosshauling of capital into Sector 2 raises the productivity of both domestic factors, especially intensive factor 4 in that sector. Both domestic factors move into Sector 2, causing productivity of Sector 2 capital to rise, which reinforces the effects of crosshauling. Crosshauling raises the productivities of both domestic factors in Sector 2, attracting them to the expanding sector. The net increase in demand for domestic factor 4 causes its price to rise, while the price of domestic factor 3 falls in the general equilibrium. All forces work toward lower output in Sector 1 and higher output in Sector 2.

IV. INTERNATIONAL CAPITAL TAX POLICY

Domestically owned capital in this model is as likely to be employed abroad as at home. Since the economy is small, the income of domestic capital owners is immune from a domestic capital tax when capital is taxed at its destination. A domestic tax of t_1 on Sector 1 capital would raise the price of capital for domestic firms to $r_1^*(1 + t_1)$, with r_1^* going to capital owners and $r_1^* t_1$ to the government. A domestic subsidy of s_1 on Sector 1 capital would lower the price of capital in Sector 1 to $r_1^*(1 - s_1)$ with r_1^* going to capital suppliers and

$r_1^* s_1$ paid by the government. Capital taxes or subsidies would cause international capital movement and change the employment of each sector's capital.

A tax on Sector 1 capital or a subsidy on Sector 2 capital would hurt the domestic factor used intensively in Sector 1, and benefit the other domestic factor according to equation (4). Income of domestic factors or domestic value added can be written $Y_D = w_3 v_3 + w_4 v_4$. An incremental tax on Sector 1 capital would change Y_D according to

$$(\partial Y_D/\partial r_1^*)dt_1 = [v_3(\partial w_3/\partial r_1^*) + v_4(\partial w_4/\partial r_1^*)]dt_1 = [a_{32}v_4 - a_{L2}v_3)/b]dt_1$$

$$= -x_1 dt_1, \tag{9}$$

using equation (4) and the full employment conditions $v_i = a_{i1}x_1 + a_{i2}x_2$, $i = 3, 4$. Domestic income falls with a capital tax, while domestic capital owners continue to receive world prices for their capital.

The total payment to Sector 1 capital employed at home is $r_1^* k_1$. Capital tax revenue would be $R_1 \equiv t_1 r_1 k_1$. An incremental change in the capital tax would alter revenue according to

$$\partial R_1/\partial t_1 = r_1^* k_1 + t_1 r_1^*(\partial k_1/\partial t_1). \tag{10}$$

If there is originally no tax ($t_1 = 0$), then $\partial R_1/\partial t_1 = r_1^* k_1$ and tax revenue gains would be $dR_1 = r_1^* k_1 dt_1$. Lost value added with the tax would be $-x_1 dt_1$ from equation (9). An incremental capital tax in Sector 1 would lower national income since $r_1^* k_1 < x_1$ with capital paid its contribution to output. If there already is a capital tax, $\partial R_1/\partial t_1 < r_1^* k_1$ since $\partial k_1/\partial t_1 < 0$ in equation (10).

While an incremental capital tax creates a fall in domestic income, production of both goods may rise. A capital tax or subsidy causes a local shift of the production frontier. Production adjusts along a Rybczynski line with constant terms of trade for the small open economy. The size of the economy's production box changes. The resource base is altered as the economy moves between Pareto optimal production equilibria in the domestic factors of production. This adjustment is unlike an optimal tariff or capital tax for a large country, which changes the international capital price or terms of trade.

A tax on one sector's capital could be combined with a subsidy on the other sector's capital to distribute income toward the domestic factor used intensively in the subsidized sector and (presumably) shift production toward the subsidized sector. Policymakers have the potential to manipulate domestic factor prices and the pattern of production by taxing and subsidizing capital from the international markets. Such capital policy might be easier to implement, both politically and practically, than lump sum transfers between domestic factors. Rational policy would require, however, familiarity with the structure of production, including patterns of factor substitution and factor intensity. These results amount to much less than a general call for taxes and subsidies on international sector specific capital. Production adjustments would be time consuming and costly in practice. Lump sum transfers between domestic factors remain the least distorting policy for income redistribution.

V. CONCLUSION

This paper presents the first complete picture of an economy which is a price taker in international markets for sector specific capital as well as finished goods. This two sector model is the prototype for a productive economy with any number of sectors, the same number of shared domestic factors, and sector specific international capital. Underlying such a model is a Heckscher-Ohlin-Samuelson type of model in the domestic productive factors. Domestic capital owners act as suppliers in the international capital markets, receiving the international return to their sector specific capital input.

A tariff increases output in the protected sector and has traditional Stolper-Samuelson effects on the distribution of income among the domestic factors. Crosshauling of capital is a likely outcome of a tariff, but general capital flight, inflow of capital into both sectors, or even reverse crosshauling can occur, depending on technical conditions of factor intensity and factor substitution.

Resource booms lead to problems associated with Dutch disease. The discovery of a domestic resource deposit would cause expansion of the sector using the resource intensively and would attract international capital to the expanding sector. Production of the other sector falls as does the employment of its international capital. Prices of domestic factors, including the expanded resource, are unaffected in the present long run competitive model. One general lesson is that more flexibility in both output adjustment and international capital employment would mean smaller disturbances in domestic factor prices in the face of a resource boom. Another lesson comes from considering international differences in domestic resources. Free trade and international capital mobility would result in similar prices of the same types of domestic resources across countries.

An increase in the international price of a type of sector specific capital causes that capital to leave the economy. Income is distributed away from the domestic factor used intensively in that sector. Depending on technical conditions of factor substitution and factor intensity, the other sector's capital may enter or leave the economy as output adjusts across sectors. It is possible that an increase in the price of one sector's capital, perhaps through a tax, would locally expand the production frontier. A tax on international capital has the potential, in other words, to expand the economy's resource base.

An appeal for empirical research on the modelling of international capital is in order. Which assumption is more valid for a particular country: international capital at an exogenous price, or domestic capital at an endogenous price? Trade theorists make one assumption or the other without clear empirical guideposts. The profession needs to develop the empirical nature of international markets for productive capital.

APPENDIX

Model specifications reported in Table 1 illustrate the variety of possible comparative static results across different substitution terms. Factors of production are rescaled in these specifications so $v_3 = v_4 = r_1^* = r_2^* = 1$. Cost minimizing domestic factor-mix terms are set at

Table 1. Different Model Specifications and Comparative Static Outcomes

	A	*B*	*C*	*D*	*E*	*F*	*G*
s_{13}	0.10	0.10	0.10	0.10	0.10	0.05	0.03
s_{23}	0.10	0.10	0.10	0.10	0.10	−0.045	−0.08
s_{14}	0.10	0.10	0.10	0.10	0.10	0.10	0.38
s_{24}	0.10	0.10	0.10	0.20	0.48	0.10	0.63
s_{34}	0.10	−0.03	−0.09	−0.10	−0.11	0.05	0.07
$\partial k_2/\partial r_1^*$	0.032	−0.005	−0.002	−0.013	0.0004	0.002	0.048
$\partial x_1/\partial r_1^*$	−0.102	−0.037	−0.007	0.009	0.415	−0.003	0.055
$\partial x_2/\partial r_1^*$	0.037	0.004	−0.011	−0.010	−0.001	−0.003	0.034

$a_{31} = a_{42} = 0.4$ and $a_{41} = a_{32} = 0.1$. It follows that $b = 0.15$, $c_1 = c_4 = 0.55$, $c_2 = c_3 = -0.05$, and $c_5 = c_6 = 0.5$. Full employment of both domestic factors implies that the endogenous output levels must be $x_1 = x_2 = 2$. Rescaling goods so $a_{jj} = 1$, endogenous employment of each type of capital is $k_j \equiv a_{jj}x_j = 2$. Assuming $p_1 = p_2 = 1.5$, competitive pricing implies $w_3 = w_4 = 1$.

Prices of domestic factors adjust to a rising r_1^* according to $\partial w_3/\partial r_1^* = -2.67$ and $\partial w_4/\partial r_1^* = 0.67$ from equation (4). Due to rescaling, these two partial derivatives are also elasticities. A 1% increase in r_1^* ($dr_1^* = 0.01$) implies $dw_3 = -0.027$ and $dw_4 = 0.067$; w_3 would drop to 0.9733 while w_4 climbs to 1.0067. Income of the domestic inputs changes according to $\partial Y_D/\partial r_1^* = v_3(\partial w_3/\partial r_1) + v_4(\partial w_4/\partial r_1) = -2.67 + 0.67 = -2 < 0$. The 1% increase in r_1 would drop Y_D from 2.0 to 1.98.

Different sets of substitution terms are specified in Table 1. Each column in Table 1 represents a different model specification. The substitution matrix is completed according to $s_{ii} = -(s_{i3} + s_{i4})$, $i = 1,2$, and $s_{jj} = -(s_{1j} + s_{2j} + s_{34})$, $j = 3,4$. Each of the postulated substitution matrices is negative semidefinite. Comparative static results from equations (6) and (7) describe crosshauling and the output effects of a change in r_1^*. If $\partial k_2/\partial r_1^* < 0$, both $\partial x_1/\partial r_1^*$ and $\partial x_2/\partial r_1^*$ cannot be positive since resources depart the economy. The other seven possible sign patterns of the three comparative static partial derivatives are illustrated in Table 1.

In Specification *A*, all factors are substitutes and crosshauling of international capital occurs. Output in Sector 1 would decline with the higher r_1^*, while output in Sector 2 rises. This is the base case, with all influences working in the same direction as described in the body of the paper.

Domestic factors 3 and 4 are weak complements in Specification *B* and do not move as easily to Sector 2 with the higher r_1^*. The factor 4 which does move to Sector 2 is substituted for the capital in that sector, which leaves the economy. Output in Sector 2 just manages to rise with the higher r_1^*.

Domestic factors are stronger complements in Specification C. Outputs in both sectors fall as both types of capital leave the economy with the higher r_1^*.

In Specification D, domestic factors are strong complements and factor 4 is a relatively strong substitute for capital in Sector 2. Even with a higher r_1^*, output in Sector 1 rises. The

complementary domestic factor 4 is pulled into Sector 1. Output and capital employment drop in Sector 2.

Stronger substitution between capital in Sector 2 and domestic factor 4 creates the crosshauling in Specification *E*. Output in Sector 2 barely falls as complementary domestic inputs are attracted to Sector 1. The incoming capital in Sector 2 softens the output decline relative to Specification D.

In Specification *F*, capital in Sector 2 and domestic factor 3 are complements. A higher r_1^* causes w_3 to fall, and demand for complementary capital in Sector 2 rises. Enough domestic factor 4 is attracted to Sector 1 that output in Sector 2 falls, even with crosshauling. The departing capital in Sector 1 leads to the decline in Sector 1 output.

Stronger complementarity between capital in Sector 2 and domestic factor 3 characterizes the last specification. Factor 4 is strongly substituted for capital in Sector 1, while capital is strongly substituted for factor 4 in Sector 2 in Specification *G*. Crosshauling occurs, and both outputs increase with the higher r_1^*.

These model specifications indicate only one way each of the seven possible sign patterns of these comparative static results can occur. These specifications exhaust the possible qualitative comparative static outcomes, but not the ways of attaining them. Other situations of substitution, complementarity, and factor intensity could lead to the same range of outcomes. Writing out the statics would develop a picture of how outputs and capital inputs adjust. Elasticities of each endogenous variable with respect to r_1^* are one half of the reported partial derivative, since $r_1^* = 1$ and $k_2 = x_j = 2$.

A tariff would create the expected crosshauling of capital in Specifications *A* and *B*, attract both types of capital to the economy in Specifications *C* and *F*, create reverse crosshauling in Specifications *D* and *E*, and result in an outflow of both types of capital in Specification *G*.

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