Protection, Growth and Trade
Essays in International Economics

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Effective Protective Rates in the General Equilibrium Model: A Geometric Note*

The purpose of this essay is to show how effective protective rates fit into the simple Heckscher–Ohlin general equilibrium model. By making very simple assumptions the richness of the theory of tariff structure as sketched out in essay 7 is lost, but more rigour and precision is given to a central element in this theory. The model is designed particularly to show that the simplifying assumption of fixed input–output coefficients does not exclude substitution between primary factors and so permits output patterns to change while maintaining full employment.

As is usual so far in the present stage of development of the theory of effective protection, we consider a small country which faces infinitely elastic import supply and export demand curves. We begin by describing its free-trade equilibrium.

There are two final products A and B, and two produced inputs M_a being the input into A and M_b the input into B. Thus we have a four-good model. There are fixed input–output coefficients; these coefficients apply to the input of M_a into A and of M_b into B. In addition we will shall invent two other products, namely V_a and V_b. These are the 'value added products' into A and B, the units being so defined that one unit of V_a is required, together with the appropriate M_a, to make one unit of A, and one unit of V_b, with the appropriate M_b, to make one unit of B. These 'value added products' or activities of A and of B represent the contributions of the primary factors to the outputs of A and of B. Finally we have two primary factors L and K, these being inputs into V_a and V_b. The stock of the primary factors is fixed. There is no domestic production of the produced inputs, M_a and M_b; they are all imported. It follows that consumption consists of A and B and production of V_a and V_b. The production functions of V_a and V_b are both constant returns to scale with continuous substitution between the inputs.

In figure 8.1 consider first the north-eastern quadrant. Quantities of A are shown along the vertical axis and of B along the horizontal. The quadrant shows consumption of these two goods and may be supposed to

* *Oxford Economic Papers*, 21 (2), July 1969, pp. 135–41.

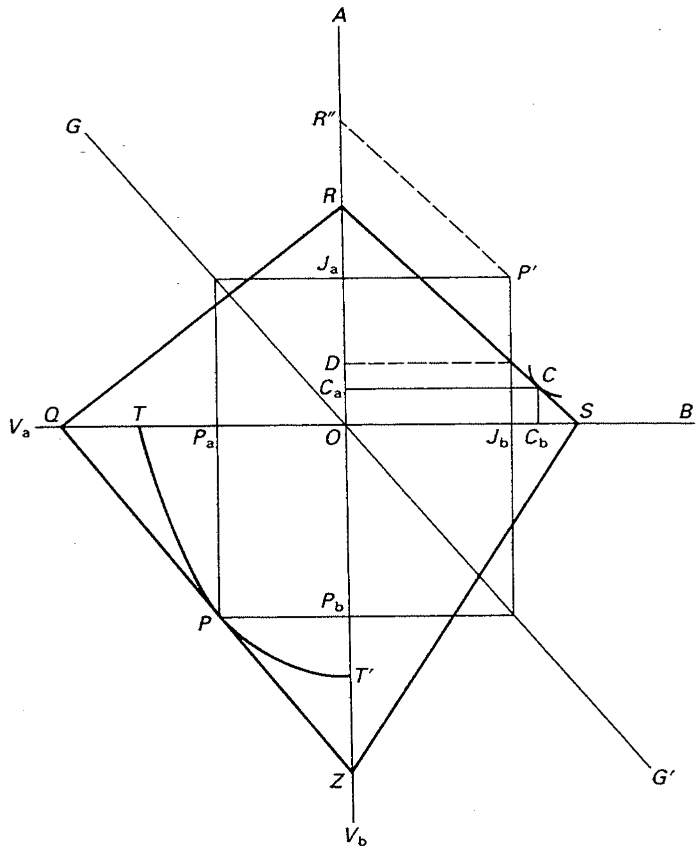

Figure 8.1

contain a map of community preference (or indifference) curves. Suppose that national income measured in terms of A (which will be taken as the *numéraire*) is OR and that the given price ratio between the two goods in the world market is given by the slope of RS. Consumption will then be at some point such as C. The slope of RS is a ratio between *nominal* prices, not effective prices. So we shall call it the nominal price ratio.

Next we come to the north-western quadrant. The vertical axis shows again quantities of A and the horizontal axis shows this time quantities of V_a. Now the price of V_a (pV_a) is determined as a residual by the price of A (pA) and the price of a unit of M_a (pM_a), defining units of M_a so that one unit of M_a is required for each unit of A. The price of M_a is of course also given in the world market. If $pM_a = \alpha pA$, then $pV_a = (1-\alpha)pA$, or

$pV_a/pA = (1 - \alpha)$. This price ratio is represented by the slope of RQ, the price of V_a being OR/OQ. Another name for the price of V_a could be the effective price of A as distinct from its nominal price. It is the price of *activity* A as distinct from *product* A.

Similarly we can obtain the price of V_b – that is the effective price of B – from the nominal price of B and the price of M_b, defining units of M_b and V_b again so that a unit of M_b and a unit of V_b are required to produce a unit of B. The southern part of the vertical axis shows quantities of V_b, and the price of V_b is assumed to be OS/OZ measured in terms of B or OR/OZ measured in terms of the *numéraire* A. Thus the slope of the line SZ gives the price ratio between the nominal and the effective price of B just as the slope of RQ gives such a price ratio for A.

Finally we link up the points Q and Z to obtain the ratio between the prices of V_a and V_b, namely the effective price ratio. This will determine the pattern of production just as the nominal price ratio has determined the pattern of consumption. But before looking at production more closely, let us pause for a moment. We have a quadrilateral $SRQZ$. The slope of SR gives the nominal price ratio, determined from outside by the world prices of A and B. The slope of RQ gives the ratio of the nominal to the effective price of A, determined by (a) the nominal price of A, (b) the nominal price of M_a, and (c) the choice of units of M_a and V_a, which depends in turn on the input–output coefficients in A. Similarly the slope of SZ gives the ratio of the nominal to the effective price of B. Finally, the slope of QZ is derived from these three price ratios, and is the effective price ratio. The latter can alter if any one of four prices (pA, pB, pM_a, pM_b) given from outside alters or if one or both of the two input coefficients change. One can experiment with changing shapes of the quadrilateral in response to exogenous changes in any of the prices or in the input coefficients.

The next step is to draw a production possibility curve for V_a and V_b, derived from the stocks of the primary factors L and K and the two production functions. Geometrically we may imagine an Edgeworth box with the stocks of L and K as the dimensions, points in the box representing possible primary factor allocations between V_a and V_b, optimal points being along the usual contract curve which traces out tangency points of the isoquants. To each point on the contract curve corresponds a point on the production possibility curve TT'. This curve is drawn as continuously concave to the origin, implying that there is substitution between the factors in each industry and that the factor intensities between V_a and V_b differ. Movements along TT' have familiar effects on relative and absolute factor prices, the direction of effect depending on which product is intensive in which factor (Stolper and Samuelson, 1941). The changes in relative factor prices will lead to appropriate factor substitutions in each industry. For example, if V_a is L-intensive relative to V_b a movement along the curve towards V_a will lead to a rise in the price of L relative to that of K, and to substitution of K for L in both activities V_a and V_b.

Assuming perfect competition and no externalities the production point is determined in the usual way by the tangency of the relevant price ratio – this time the effective price ratio – so that the point of production is P. It should be noted that the four given world prices and the two fixed input coefficients determine not just a single quadrilateral, but a map of such quadrilaterals, all with the same slopes. One of them will yield a tangency point with the production possibility curve, and so represent the level of income appropriate to free trade and full employment. It is this particular one which we have drawn as $SRQZ$.

We now know production P and income OR, both determined by the production possibility curve and the effective price ratio, and consumption C, determined by this income, by the nominal price ratio and by the community preference (indifference) map. It remains to show trade. Draw a 45° line GOG' through the north-western and south-eastern quadrants. By drawing a perpendicular and a horizontal from P to the axes we find that production of V_a is OP_a and of V_b is OP_b. Continuing these two lines to the 45° line and then drawing a horizontal to the A axis and a perpendicular to the B axis we obtain the outputs of A and B, namely OJ_a and OJ_b that must be associated with the outputs of V_a and V_b given originally by the point P. This follows from our assumption that one unit of V_a is required to make one unit of A and one unit of V_b to make one unit of B. The point P' in the north-eastern quadrant is the production point, showing outputs of A and B, and corresponds to P in the south-western quadrant. Drawing a horizontal and a perpendicular to the axes from C we find that consumption of A is OC_a and of B is OC_b. The differences between the production quantities and the consumption quantities yield exports of A of J_aC_a and imports of B of J_bC_b. At the given price ratio between A and B exports of A exceed imports of B, because exports of DC_a pay for imports of J_bC_b, leaving exports of J_aD. These are required to pay for imports of M_a and M_b. A little more geometry could show imports of M_a and M_b separately, each valued in terms of A, and it could be proven that these imports must sum to J_aD. Furthermore the gross value of output OR'' (derived by drawing $R''P'$ parallel to RS) must exceed the net value of output (equal to income) of OR by the value of imports of the two produced inputs, i.e. $R''R = J_aD$.

All this seems a little complicated, but is simply meant to show the relationship between the roles of the nominal and the effective price ratio, one helping to determine the pattern of consumption and the other the pattern of production. As pointed out above, it also emphasizes that the simplifying assumption of fixed input–output coefficients in the production functions of A and B does not exclude substitution between primary factors in the production functions of V_a and V_b. The crucial ingredient in the analysis is the concept of the 'value added product' which is really just the net output of the *activity* producing A or B.

The next step is to introduce tariffs, import subsidies, export subsidies and export taxes. All revenues are assumed to be redistributed and subsidies financed in non-distorting ways. The essential point is simple. Nominal protective rates on A and B will change the nominal price ratio facing domestic consumers and hence the pattern of consumption. These two nominal rates (tariff or import subsidy for B and export subsidy or tax for A), together with any tariffs on M_a and M_b, will change the two effective prices facing domestic producers, the extent of these changes for given nominal protective rate changes depending on the input coefficients. The proportional changes in the effective prices are the effective protective rates. They can be derived for each from the effective protective rate formula as given in essay 7. So we obtain the change in the effective price ratio facing producers and hence the change in the pattern of production.

It is important to stress that changes in price *ratios*, not absolute price changes, matter. If, for example, the rate of nominal tariff for B happened to be the same as the rate of export subsidy for A there would be no change in the pattern of consumption since the nominal protective rates would then be equal. Similarly the movement of resources will depend on *relative* effective rates. For example, as the result of a nominal tariff on B of 20 per cent combined with a tariff on M_b of 10 per cent and a free trade price ratio pM_b/pB of 50 per cent, the effective rate of B will be 30 per cent. If an export subsidy on A of 15 per cent is then combined with no tariff or import subsidy on M_b, and the free trade price ratio pM_a/pA is 75 per cent, the effective rate of A will be 60 per cent so that resources will move out of B into A even though the effective rate for B has been positive.

We shall now represent a new tariff-distorted equilibrium. It must be noted here that the new equilibrium must satisfy two requirements. First, domestic consumption and production must be determined by the tariff-distorted domestic nominal and effective prices. Secondly, trade must satisfy the given set of undistorted world prices since the value of exports must be equal to the value of imports at world prices. As this is quite clear from the familiar two-product geometry it need not be elaborated here. I proceed directly to describe the final situation.

In figure 8.2 the new tariff-distorted quadrilateral is given by $S^*R^*Q^*Z^*$. There is a map of such tariff-distorted quadrilaterals, $S^*R^*Q^*Z^*$ being the one which yields a tangency point P^* with the production possibility curve. So output is given by that point and the corresponding point $P^{*\prime}$ in the north-eastern quadrant. Now through P^* we draw an undistorted (free-trade) quadrilateral $S'R'Q'Z'$. This quadrilateral $S'R'Q'Z'$ belongs to the set of free-trade quadrilaterals to which $SRQZ$ in figure 8.1 also belongs, but $S'R'Q'Z'$ is *within* $SRQZ$. Comparing the slope of R^*S^* with that of $R'S'$, and the slope of Q^*Z^* with that of $Q'Z'$ we see that, as drawn, the nominal tariff on B must have been greater than the nominal export subsidy (if any) on A and the effective protective rate for B must have been greater than the effective rate for A. The nominal and/or effective rates for A could, of course, have been zero or negative; as pointed out above, in this model only changes in *relative* prices, not the *absolute* price changes, are relevant.

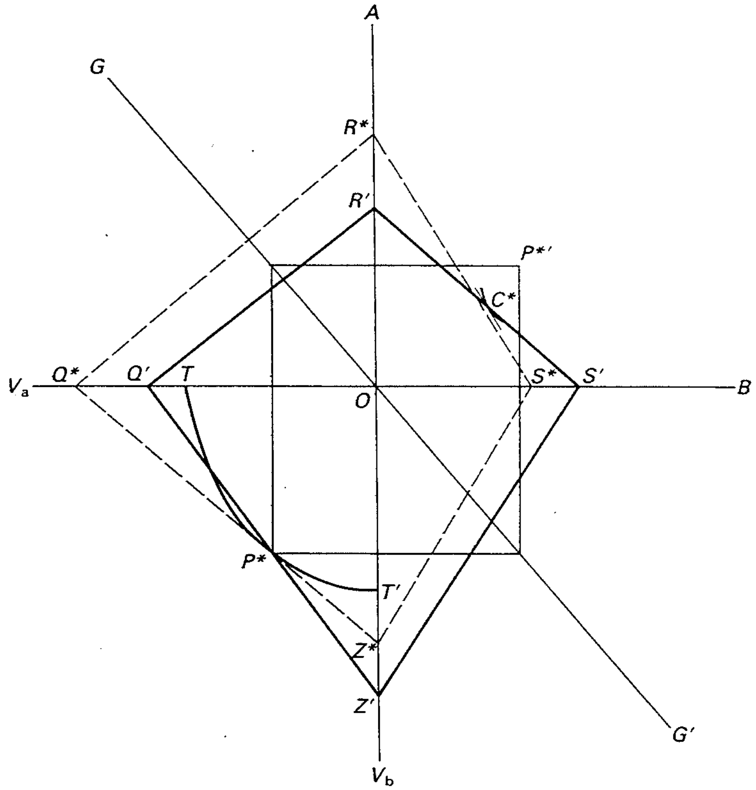

Figure 8.2

The new consumption point has to satisfy two conditions: First, it must be on the free-trade quadrilateral $S'R'Q'Z'$ – and hence must be on the line $R'S'$ – so as to satisfy the requirement that exports equal imports at free-trade prices. Secondly, since the consumption pattern is now determined by the tariff-distorted domestic nominal price ratio, it must be at a point on $R'S'$ where an indifference curve has the same slope as R^*S^*. The new consumption point is thus C^*. Relating this consumption point to the production point $P^{*\prime}$ we find that, as drawn, production of B is greater than consumption of B, so that B has turned from an import into an export; it must have obtained not just a tariff but also an export subsidy (unless an import subsidy was given for M_b). In addition, as in free trade, production of A is greater than consumption of A ($P^{*\prime}$ is above C^*), so that there are exports of A. Hence exports of A and of B now pay for imports of M_a and M_b. This was, of course, only one possible, and not a necessary, result.

One could go on to show the new export and import quantities, but this would only clutter up the diagram. The main point is made: in a model with two goods consumed and two goods produced it is possible to introduce some of the central ideas of the new theory of effective rates. But one must go on in two directions, first to allow substitution not just in the V_a and V_b production functions but also in the A and B production functions, and secondly to less elegant but more useful models with many goods produced and consumed.

Reference

Stolper, W. and Samuelson, P. A. 1941: Protection and real wages. *Review of Economic Studies*, 9, 58–73.

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The Substitution Problem in the Theory of Effective Protection*

The simple theory of effective protection has been developed with the assumption of fixed coefficients between any particular good and its produced traded inputs. The purpose here is to remove this assumption and to consider the general equilibrium implications of doing so.[1]

One can imagine each product to be produced by produced inputs plus its 'value-added product', the latter in turn being produced by primary factors. As shown in essay 8, it is possible to have fixed coefficients between a good and its produced inputs and yet have normal substitution between primary factors in the 'value-added' production functions. The price of the value-added product is the effective price and the effective protective rate is the proportional increase in this price brought about by the structure of tariffs and other trade taxes and subsidies. The analysis here is meant to provide answers to two questions. The first is how substitution between produced inputs and the value-added product affects actual effective protection provided by a protective structure. The second question is what errors in measurement result from such substitution. In particular, if the input–output coefficients of the protection situation are used for measurements, will substitution cause the measured rates to exceed or fall short of the actual effective rates?

* *Journal of International Economics*, 1, Feb. 1971, pp. 37–57. Abbreviated: a section on substitution between different produced traded inputs has been excluded. I am indebted to John Black, Ronald Jones, Peter Lloyd and Richard Portes.

1. The substitution problem was first discussed in a partial equilibrium context by Corden (1966), now essay 7. The present essay is a revision of the relevant part of this earlier essay as well as an extension to general equilibrium. The following papers also touch on or deal with substitution and effective protection: Anderson and Naya (1969), Balassa (1971), Balassa et al. (1970), Ethier (1972), Finger (1969), Grubel and Lloyd (1971), Guisinger (1969), Humphrey and Tsukahara (1970), Jones (1971), Leith (1968, 1971), Ramaswami and Srinivasan (1968, 1970), Tan (1970), Travis (1968), Walker (1968).