

Chapter 5

The Four Core Theorems

5.1 Introductory Remarks

As clarified in Sect. 1.2, Ricardian comparative-cost theory, neoclassical theory, and Heckscher-Ohlin theory together form the body of the traditional theory of international trade. However, the factor-proportion theory is often identified with “the” traditional theory, and the Heckscher-Ohlin theorem, together with the factor-price-equalization (FPE) theorem and two additional theorems (the Stolper-Samuelson theorem and the Rybczynski theorem), are said to constitute the four core theorems of the traditional theory of international trade.

Be it as it may, the purpose of the present chapter is to complete the treatment of the previous chapter by examining the Stolper-Samuelson and Rybczynski theorems. Both of them are comparative statics theorems, as they examine the effects of a change in some data on the general equilibrium of the economy. It is important to note that they are general theorems, in the sense that they also hold for a closed economy; but we shall be concerned with their ultimate impact on open economies.

5.2 The Heckscher-Ohlin and Factor-Price-Equalization Theorems

These have been extensively examined in the previous chapter. We only add that the factor-price-equalization theorem, though usually presented as a corollary of the Heckscher-Ohlin theorem (and we have followed standard practice in the previous chapter), is valid independently of the latter. In fact, what is really essential for FPE is the absence of complete specialization, given internationally identical technology of the constant-returns-to-scale type. When this is true, it does not matter whether international trade is due to different relative factor endowments and/or to different demand conditions (as could be the case under the neoclassical theory). See [Samuelson \(1948, 1949, 1967\)](#).

5.3 The Stolper-Samuelson Theorem

The *Stolper-Samuelson theorem* (Stolper and Samuelson, 1941) states that the increase in the relative price of a commodity favours (in the sense that it raises the unit real reward of) the factor used intensively in the production of the commodity. This can be simply shown by using the Heckscher-Ohlin theory treated in Chap. 4.

Without loss of generality we can assume that commodity A is capital intensive while the labour-intensive commodity is B . Suppose now that the domestic relative price p_B/p_A increases: given the one-to-one relation between the relative price of goods and the relative factor price, it follows that p_L/p_K increases (this is due to the fact that in our case this correspondence is monotonically increasing: see Fig. 4.5a). This shows that the relative price of labour increases, but the theorem asserts something more, i.e. that the “real price” of labour (p_L/p_A , if we use commodity A as numéraire) increases, and to prove this more passages are required.

The increase in p_L/p_K causes the capital/labour ratio to increase in both sectors (see Fig. 4.4). Since the production functions are homogeneous of the first degree, the marginal productivities are functions solely of the factor *ratio* (see Sect. 19.1.3) and, more precisely, MPK is a decreasing function, and MPL an increasing function, of K/L . Now, as we have just shown, K/L has increased in both sectors; it follows that the marginal productivity of labour (and so its unit real reward, which in perfect competition coincides with MPL) increases. This completes the proof of the theorem.

In this proof of the Stolper-Samuelson theorem we have used the Heckscher-Ohlin theorem and, in particular, we have implicitly assumed no factor-intensity reversals (this is required for the one-to-one correspondence between relative price of goods and the relative price of factors), but it is important to note that the former theorem *does not depend* on the latter in any essential way. It is in fact possible to prove the Stolper-Samuelson theorem in its general formulation independently of the Heckscher-Ohlin theorem, which dispenses us to examine what happens when there is factor-intensity reversal.

Let us then assume that the domestic relative price of commodity B increases. We also assume that, in the interval under consideration, commodity B is unambiguously labour-intensive (which does not exclude the presence of factor-intensity reversals elsewhere). The increase in p_B/p_A causes a shift on the transformation curve towards a point where more B and less A is produced (see, for example, Fig. 3.5), so that resources will have to be reallocated from the latter to the former industry. But, since B is more labour intensive than A , it follows that—at *given relative factor prices*—the proportion in which capital and labour become available as a result of the decrease in the production of A does *not* coincide with the proportion in which the expanding sector B is prepared to absorb them.

In fact, at the given factor price ratio, labour and capital are made available by sector A in a *lower* proportion than that required by sector B . There follows, at the global level, an excess demand for labour and/or an excess supply of capital, with the consequence that p_L/p_K increases. As this ratio increases, cost-minimizing firms

will substitute capital for labour in both sectors, that is, they will choose techniques with a higher K/L ratio. Since the marginal productivity of labour is an increasing function of this ratio, the theorem is proved.

An implication of the Stolper-Samuelson theorem is the so-called *magnification effect* (Jones, 1965). This effect states that the increase in the *nominal* price of the benefited factor is proportionally *greater* than the increase in the commodity price. In fact, since under perfect competition we have $p_B MPL_B = p_L$ or $MPL_B = p_L/p_B$, it is obvious that the increase in MPL_B following an increase in p_B must be accompanied by an increase in p_L proportionally greater than the increase in p_B .

The relevance of the Stolper-Samuelson theorem for international economics lies in its use for the examination of the redistributive effects of tariffs. A tariff, in fact, normally causes an increase (with respect to the international price ratio) in the domestic relative price of the good on which the tariff is levied, and hence income redistribution effects due to the change in real factor rewards. This will be dealt with in depth in Sect. 10.5.1.1.

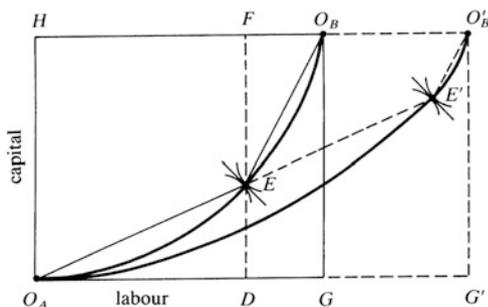
5.4 The Rybczynski Theorem

The point of departure for examining the effects of an increase in factor endowments is Rybczynski's theorem (Rybczynski, 1955) according to which the increase in the quantity of a factor (given the other) will cause an increase in the output of the commodity which is intensive in that factor and a decrease in the output of the other commodity, at unchanged commodity and factor prices.

The proof of this theorem can be given by using the box diagram (see Sect. 3.1). In Fig. 5.1 the initial box is O_AHO_BG and, given the commodity prices, we shall take E as the initial equilibrium point. The labour-intensive commodity is A , for the labour/capital ratio in its production, O_AD/ED , is higher than the labour/capital ratio in the production of B , O_BF/EF ; given the form of the locus of efficient points O_AO_B , this property holds at all points of this locus. Let us now assume that the quantity of labour increases from O_AG to O_AG' . The new equilibrium point will be E' , as this is the only point lying along the ray O_AE such that the straight-line segment drawn from this point to the new origin O'_B is parallel to O_BE . That the new equilibrium point must be characterized by this property can be shown as follows.

Since commodity and factor prices are, by assumption, unchanged, the marginal rate of technical substitution (equal, in equilibrium, to the factor-price ratio) must also be unchanged, that is, the common slope of the A - and B - isoquants at the new equilibrium point must be equal to that at the previous equilibrium point. Now, given the property of radially of homogeneous production functions (see Sect. 19.1), the A isoquant through E' has the same slope as the A isoquant through E ; similarly, as O'_BE' is parallel to O_BE , the isoquants of B have the same slope along ray O'_BE' as they had along ray O_BE , and, therefore, the B isoquant through E' has the same slope as the B isoquant through E . It follows that the isoquants through E' have

Fig. 5.1 Rybczynski's theorem



the same slope as the isoquants through E , and this shows both that E' lies on the new efficiency curve (as it fulfils the conditions of efficiency) and that E' is the new equilibrium point.

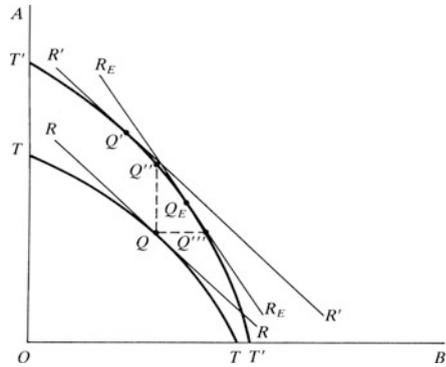
Now, since the more distant an isoquant is from its origin the greater is the production level it represents, and since $O_A E' > O_A E$, $O'_B E' < O_B E$, it follows that the output of A (the labour-intensive commodity) has increased as a consequence of the increase in the quantity of labour, whilst the output of the capital-intensive commodity B has decreased. This completes the demonstration.

An implication of the Rybczynski theorem is the so-called *magnification effect* (Jones, 1965), according to which the output of the expanding sector increases more than proportionally to the increase in the factor. This can easily be checked in Fig. 5.1. With constant returns to scale, the isoquant index is proportional to the distance from the origin, hence we can measure the increase in the output of A by $EE'/O_A E$, which is clearly greater than the proportional increase in labour (given by $GG'/O_A G$).

5.4.1 An Alternative Diagram

An alternative representation of this theorem can be given by a diagram which uses the transformation curve. At the same time we shall also explain an important corollary of Rybczynski's analysis, namely that the increase in the quantity of a factor (at unchanged quantity of the other factor) will cause a decrease in the relative price of the commodity that is intensive in that factor. In Fig. 5.2, TT is the initial transformation curve which shifts to $T'T'$ as a consequence of the increase in the quantity of labour, Q and Q' are the two equilibrium points (production points in the case of an open economy) at the same commodity price ratio ($R'R'$ and RR are parallel). Since A is the labour-intensive commodity, its output will increase and the output of B will decrease, that is, Q' must be situated to the left of Q'' (which is the point at which the output of B is the same as that at Q). However, point Q' is only hypothetical. Since the $R'R'$ line is higher than the RR line, and since each of these can be interpreted as an isoincome line, $R'R'$ represents a higher national

Fig. 5.2 Rybczynski's theorem and relative price of goods



income at constant prices (that is, at the same prices existing at the initial equilibrium point Q) than that represented by RR . Now—if we exclude inferior goods—this increase in income will cause an increase in the demand for *both* commodities; since, as we have seen, the output of B is lower, there will be an excess demand for this commodity which will cause an increase in its relative price (p_B/p_A) and, consequently, in its output. Therefore the new equilibrium point will be found in the stretch $Q''Q'''$ of the curve $T'T'$: only there, in fact, is the output of both A and B higher than at E . It can also be seen from the figure that at any point included in this stretch, for example Q_E , the relative price of A is lower, as this price is measured by the (absolute value of the) slope of the $R_E R_E$ line with respect to the A axis, which is smaller than the analogous slope of the RR line.

This holds in a closed economy. But what about an open economy? To answer this question we must distinguish between a small and a large economy, and take the structure of trade into consideration. In all cases we keep the assumption that no good is inferior.

1. Suppose that A is the import good and B the export good. The domestic demand increases for both commodities. Since at Q' the output of B is lower while its domestic demand is higher, the domestic excess supply (i.e., the supply of exports) decreases. Thus in the international market there will be a decrease in the supply of B . We now must distinguish whether the country under consideration is small or large. In the former case the decrease of the supply of B will have a negligible effect on the international market, so that the international price ratio (terms of trade) p_B/p_A will not change, and consequently the domestic price ratio will not change (in the model, it is equal to the terms of trade). Thus the production point remains at Q' .

On the contrary, if the country is large, the decrease in its supply of exports will cause an excess demand for B in the international market, hence an increase in p_B/p_A , and the production point will move somewhere between Q'' and Q''' .

2. Consider now the case in which the import good is B . Since at Q' the output of B is lower while its domestic demand is higher, the domestic excess demand increases. Thus in the international market there will be an increase in the

demand for B . In the case of a small country, this increase will have a negligible effect, so that the international price ratio (terms of trade) p_B/p_A will not change, and the production point remains at Q' .

On the contrary, if the country is large, the increase in its demand for B will cause an excess demand for B in the international market, hence an increase in p_B/p_A , and the production point will move somewhere between Q'' and Q''' .

In conclusion, if we exclude the case of a small country, the result in an open economy is the same as in a closed economy.

The relevance of Rybczynski's theorem in international trade theory lies in its use to examine the effects of international factor mobility (see Sect. 6.8.1), and to examine the effects of growth, when the cause of growth is an increase in factor endowments (see Sect. 13.4).

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