Chapter 40
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Stolper-Samuelson (production) box

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General equilibrium economics stresses the interplay between output markets and input markets across the entire economy. The production box of Stolper and Samuelson (1941) solidifies the link between product prices and input prices in a competitive neoclassical economy focusing on the issue of a tariff and the real wage.

In the production box with two factors and two products, the intuitive property is that a higher price raises demand and the relative price of the intensive factor of production for that product. The Stolper-Samuelson theorem relates directly to the underlying theorem of Heckscher (1919) and Ohlin (1924) that a country would import the product using its relatively scarce factor intensively with a tariff reducing imports and raising the relative price of the scarce factor. The production box mirrors the exchange box of Edgeworth (1904) and Pareto (1906) to complete the general equilibrium economy conceptualized by Walras (1874).

Figure 1 is a production diagram with inputs of capital K and labor L for products 1 and 2. Cost minimization implies the slope of the convex neoclassical isoquant for product 1 equals the slope of the isocost line. The marginal rate of substitution equals the wage rent ratio w/r. Positive diminishing marginal productivity implies convexity of the isoquant. Product 2 has a similar cost minimizing equilibrium.

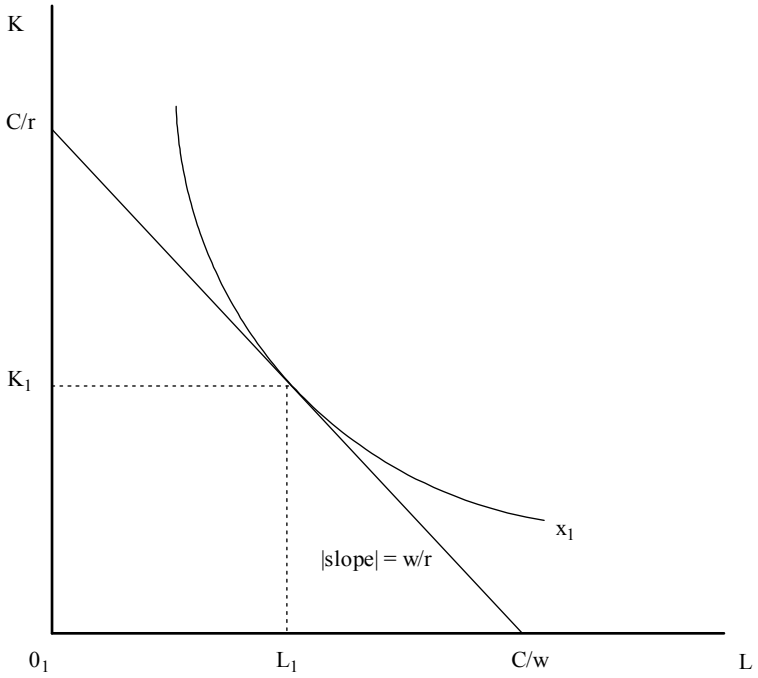

Figure 1. Cost minimization

The production box in Figure 2 combines the two products with the origin O_2 for product 2 in the upper right hand corner. The length of the box is the endowment of labor $L = L_1 + L_2$ and its height the capital endowment $K = K_1 + K_2$. Equilibrium in production determines factor prices and the distribution of factors between sectors.

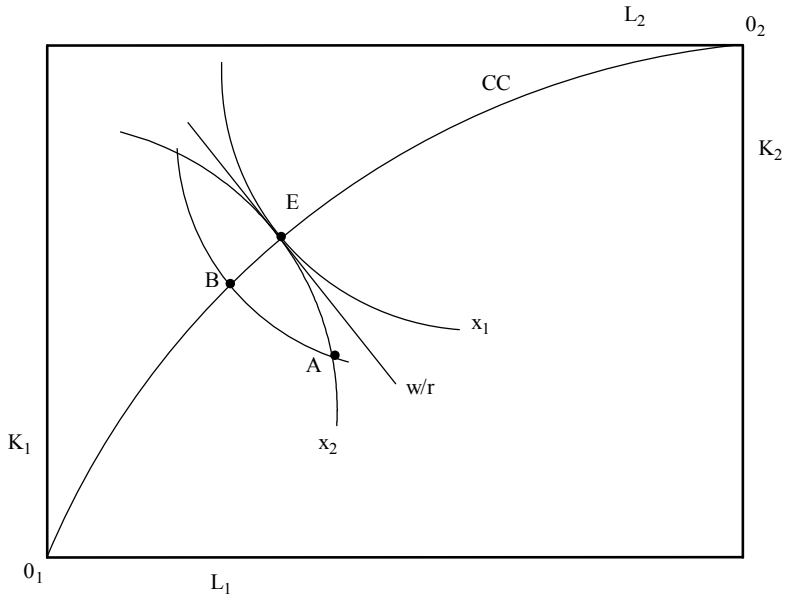

Figure 2. Equilibrium in the production box

With perfect factor mobility between the two sectors, the wage would be the same in each sector as would the capital rent. Cost minimization and factor mobility together imply the economy operates on the locus of tangencies of isoquants, namely the contract curve CC in Figure 2. Neoclassical homothetic production implies a unique contract curve. Product 1 is capital intensive with the contract curve above the diagonal and K_1/L_1 greater than K_2/L_2. Moving northeast along the contract curve, product 1 expands and the wage-rent ratio w/r falls but the capital/labor ratio remains higher in industry 1.

Homothetic production implies an equal slope of all isoquants along any ray from the origin. One implication is that the contract curve does not cross the diagonal. If a point on the diagonal is on the contract curve then every other point would be as well. This necessary lack of a factor intensity reversal, however, is unique to the two dimensional model.

The two isoquants have the same slope and the production equilibrium point E in Figure 2. At any point such as A off the contract curve, the isoquant slopes are unequal. At point A the marginal value of labor is higher in sector 2, labor is bid into that sector, capital is similarly bid into sector 1, and the economy converges to equilibrium at some point between B and E on the contract curve.

A tariff raises the price of the import competing product and shifts production in its direction along the contract curve and leading to the Stolper-Samuelson factor price adjustment. Figure 3 illustrates the effect of a tariff on imported product 1. Output increases from x_1 to x_1' as sector 2 output declines from x_2 to x_2' and both capital and labor move to sector 1.

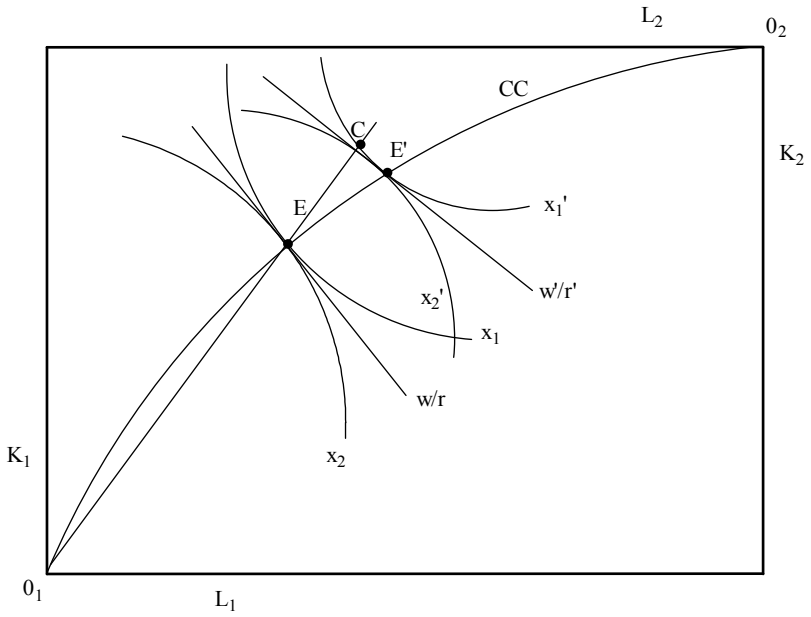

Figure 3. A tariff on product 1 and factor prices

Expansion of the capital intensive sector 1 increases the relative demand for capital, lowering the wage/rent ratio. Homothetic production implies an equal w/r along ray O_1C in Figure 3 and the tariff induced equilibrium at E' is below point C on isoquant x_1'. The relative wage falls from w/r to w'/r'. This result is the Stolper-Samuelson theorem that an increase in the relative price of the capital intensive product raises the relative price of capital.

This general statement shows the Stolper-Samuelson theorem has application beyond tariffs and applies to any price change regardless of its source. Other applications include price changes induced by changes in domestic taxes, tastes, income, regulation, restructuring, monopoly power, or technology. The model can also be modified to examine the impact of factor market distortions such as minimum wages, union contracts, labor subsidies, and investment taxes.

As the expanding capital intensive import competing sector 1 becomes more labor intensive, sector 2 might be expected to become more capital intensive but both sectors become more labor intensive. The decrease in production of the labor intensive product explains this paradox.

The algebra of the Stolper-Samelson theorem developed by Samuelson (1953) and Jones (1965) lays a foundation for extending the general equilibrium model to include more inputs and products as in Chipman (1966), Ethier (1974), and Jones and Scheinkman (1977). The production structure with more factors is illustrated in the model with a third factor as developed by Ruffin (1981) and Thompson (1985). Beyond the two dimensional model, defining factor intensity is problematic as illustrated in the 3x3 model by Thompson (2001). One consistent result is that a tariff must raise the real return to some factor of production and lower some other real return consistent with the magnification effect of Jones (1965).

The algebraic model along with improved production data has led to highly detailed computable general equilibrium models that expose a myriad links between tariffs and wages. It is no exaggeration to say that the Stolper-Samuelson theorem stimulated these advances in economic thought. Another advantage of the algebraic model is that theoretical assumptions can be relaxed parametrically as in Thompson (2003).

The Stolper-Samuelson production box provides underlying intuition on the link between product prices and factor prices keeping attention focused on cost minimization and substitution in production. The Stolper-Samuelson theorem also expands awareness from partial to general equilibrium to include the secondary effects of changing prices across the economy. The Stolper-Samuelson production box will remain a crucial component of economic thought.

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