

The Specific-Factors Model

Ronald W. Jones
University of Rochester

Most undergraduates in their first year in economics have been exposed to an important ingredient in the specific-factors model, a model in which each industry employs some factor used only in that particular industry. What happens to total output when more of a variable factor is added in a production process to a fixed quantity of this specific factor? The answer exemplifies the Law of Diminishing Returns, and this ingredient is basic in the general equilibrium context in which the specific factors model is set. David Ricardo used this concept when referring to the differential rents that various qualities of land would receive, and Jacob Viner (1931) made use of it in his famous article in which he argued with Wong, his draftsman. Gottfried Haberler (1936) in his classic text on international trade presents verbally some of the logic of what Paul Samuelson (1971) later referred to as the Ricardo-Viner model. The formal exposition of the model in general equilibrium terms was carried out by Samuelson and by Ronald Jones (1971), both of whom emphasized the usefulness of the model in the theory of international trade although the model, itself, is applicable as well to closed economies.

The nature of the model is most easily discussed in the context in which only a pair of commodities is produced in competitive conditions, with each commodity making use of a factor employed only in that sector (i.e. a *specific* factor) as well as a factor of production (typically taken to be labor) that is used in both sectors (the *mobile* factor). In a competitive equilibrium factor prices and input-output coefficients adjust to maintain full employment of all factors and with constant returns to scale characterizing production processes costs of production adjust to equal commodity prices if both

commodities are produced. The process of solving the model formally for changes in factor prices and commodity outputs when commodity prices or factor endowments are altered is more simple than that found in the Heckscher-Ohlin model (the standard model used in trade theory since the Stolper-Samuelson article appeared in 1941) in that it is not necessary to solve more than one equation at a time. The key equation is the one that asserts full employment of the mobile factor. With techniques in each sector depending only upon the wage rate relative to the commodity price in that sector (the important technological parameter being the elasticity of the demand curve for labor, exhibiting diminishing returns to labor as more is added to a given amount of the specific factor), and each output restricted by the given amount of the specific factor and the intensity of its use (that depends upon the wage/price ratio), the change in the wage rate is seen to depend upon commodity price changes and changes in factor endowments. These relationships are often portrayed in a “back-to-back” diagram, such as Figure 1. A pair of (value of) marginal product schedules face each other, each assuming given values for the quantity of the specific factor available in that sector, as well as that sector’s commodity price. The intersection point, A, reveals both the equilibrium value of the wage rate and the quantity of labor assigned to each sector.

Details of the solution are found in many places, e.g. in the Supplement to Chapter 5 of the Caves, Frankel and Jones text (2007). The important results are (i) if either commodity price increases, the wage rate also increases, but by less than in proportion; (ii) any increase in the labor endowment at constant commodity prices drives down the wage rate (to the benefit of both specific factors) and (iii) any increase in the endowment of either specific factor lowers that factor’s return, pushing up the nominal wage rate, and

thus driving down the return to the other specific factor as well. The asymmetry found in factor returns when the price of a single commodity increases reflects the asymmetry found in the mobility of the two factors: An increase in the price of the first commodity must lead to a matching increase in average cost. The return to labor is constrained by its use as well in the other sector, one that has not benefited by a price increase, while the return to the specific factor used only in the first sector is not constrained in this fashion. The consequence: the wage rate cannot increase relatively as much as p_1 , thus pushing up the return to the specific factor employed there by a magnified relative amount so that unit costs increase as much as price. With the nominal wage rate rising, the return to the specific factor in the second sector falls.

An important result in the field of political economy is immediately apparent, even in the two-commodity setting. Suppose the primary issue facing voters before an election is whether or not to impose a tariff on imports. The specific factor in the import-competing sector will be strongly in support of the tariff, while the other specific factor would be strongly opposed. This is not surprising. But what of the attitude of voters whose income is in the form of wages? Protection raises the nominal wage rate, but also increases the cost of living. This may leave many voters with the desire to stay at home on election day (especially if the weather is inclement) since their real incomes do not depend that heavily on the outcome. (Ruffin and Jones (1977) argue that on balance labor will be mildly against protection in the specific-factors model). This would help to explain relatively low voter turnout at election times in countries such as the United States. If, instead, the important issue before the voters concerns immigration, both

specific factors stand to gain or lose together, and this may result in their joining forces in a political alliance.

The setting of the specific-factors model has two basic interpretations. On the one hand the two specific factors may fundamentally be different, say land and capital (e.g. in Jones, 1971). On the other hand, they may represent, say, two kinds of capital that are specific in the short run but can become interchangeable with the passage of time (e.g. in the treatment by Peter Neary, 1978). As Steve Magee (1980) has argued, a sector-specific type of capital might change its attitude towards protection in the long run. The Neary interpretation has become popular in explanations of how the specific-factors model may be linked to the standard Heckscher-Ohlin model, where both factors are intersectorally mobile. Such a link was given a different rationale in the model of Kalyan Sanyal and Jones (1982), in which a country produces final commodities by using labor and *middle products*, i.e. goods in process, raw materials, or intermediate goods that can be obtained on world markets. The country may export some of its own production of middle products in exchange for imports that are better suited to its own needs in producing final consumption goods. Thus middle products produced at home with labor and the country's own specific factors can be traded for middle products requiring, say, specific factors not available at home. In other words, final consumer goods are produced with two mobile factors: labor and traded middle products. (As the Canadian economist, Doug Purvis, once remarked, in this setting Heckscher-Ohlin does not explain trade, trade explains Heckscher-Ohlin).

How does the specific-factors model match up with the Heckscher-Ohlin model? In the setting in which only two commodities are produced, differences between the

specific-factors model and the Heckscher-Ohlin model are often emphasized in the theory of international trade, especially as regards the effects of free trade upon a nation's factor returns. As Samuelson (1948) demonstrated, if endowment differences are relatively small between two countries sharing the same technology and facing the same traded goods prices, factor prices tend to be equalized by trade despite the fact that each factor has a purely national market. The specific-factors model does not share this property. With the number of factors (3) exceeding the number of produced commodities (2), any tendency for factor returns to become equalized with trade disappears. A related comparison concerns the effects of factors becoming mobile between countries. In the two-factor, two-commodity Heckscher-Ohlin model with countries sharing the same technology and endowments not too dissimilar, a movement of factor(s) from one country to another can be absorbed by a change in the composition of outputs without requiring any change in factor prices. Not so in the specific factors model with three factors and two commodities, because at given commodity prices changes in factor endowments exercise a direct effect on factor returns. This latter model is often more appreciated by labor economists who may expect labor immigration to have a depressing effect on national wage rates.

The difference between these two models tends to be less apparent when a specific-factor model with n commodities (and $n+1$ specific factors) is compared with the so-called *strong* form of the n -factor, n -commodity Heckscher-Ohlin model in which the increase of any commodity price serves to raise the return to the factor used relatively intensively in that sector and to lower the returns to all other factors (e.g. see Murray Kemp and Leon Wegge, 1969). Such a *magnification effect* of commodity prices on

factor returns is shared by the specific-factors model – the return to one specific factor is raised, and to all others is lowered. Only the return to mobile labor is not so magnified. Indeed, suppose the mobile factor is not labor, but rather some intermediate good that is produced by all of the “specific” factors. This *produced mobile factor* model (Jones and Sugata Marjit, 1991) becomes a Heckscher-Ohlin model that satisfies the strong conditions – one real winner and all others losers when a price changes – cited above.

The case can be made that the specific-factors model – with each sector having a unique specific factor but sharing mobile labor with all other sectors – is especially useful as a general equilibrium model of production because it does generalize so readily to higher dimensions and has highly appealing qualities: (i) If a single commodity price increases, the output of that commodity also rises, drawing resources (mobile labor) from *all* other sectors; (ii) If the endowment of a specific factor increases not only is its return lowered, but the consequent increase in the wage rate pushes down the returns to *all* other specific factors. This latter result may yield a consequence that is surprising – the returns to some other specific factors might fall by a greater relative extent than does that of the factor whose endowment has increased.

Although the Heckscher-Ohlin model may not be that useful in the many-factor case, because extremely detailed structure must be imposed before explicit solutions can be obtained, it does have a distinct advantage in that the two-factor scenario is consistent with a world in which trade takes place in many commodities. There is no two-factor, many commodity version of the specific-factor model. The theory of international trade emphasizes that trade encourages each country to specialize in a few activities in which it has the greatest comparative advantage, and the two-factor Heckscher-Ohlin model can

well illustrate that *which* commodities a country produces depends both on world commodity prices and local factor endowments. This production choice becomes endogenous – it can vary as, say, the country grows and the capital/labor endowment ratio expands. Suppose, however, that a commodity that had been produced in the past now cannot earn as high a return on its capital as some new commodity on the trading scene. If this capital had become specific, that industry may nonetheless stay in business if its capital can earn anything exceeding scrap value. That is, the specific-factor model may prove useful in modeling why it is that some industries still produce even if they would not be viable if new capital had to be raised for production (Jones, 2006).

Some disenchantment with general equilibrium models seems to be based on the widespread difficulty of obtaining comparative static results when an original equilibrium is disturbed by some change in prices or endowments. Detailed structure must be imposed on the model. Sufficient structure is a characteristic of specific-factor models and further higher-dimensional results can be obtained by employing the following kind of *variation* on such models. Consider first the way in which a “bubble” diagram can be used to illustrate a three-factor, two-commodity specific factors model in Figure 2(a). Each of the two X_i outputs is produced with specific factor K_i and mobile labor, L . Figure 2(b) adds another two sectors, with notations suggesting two countries, with Y -type capitals, K_Y^* and K_Y , specific both to country and occupation. L^* and L are, respectively, foreign and home labor forces, each specific to country but mobile between sectors, and K_X , assumed specifically used in the X -industry, is now internationally mobile. This is a five-factor, four-commodity model, whose structure has specific factors used only for the “end” products and three types of mobile factors – labor in each country

mobile between sectors but not internationally and X-type capital, mobile between countries but sector-specific. It is not difficult to analyze (see Jones, 2000, ch. 3) because it can be treated in two stages. In the first suppose that the allocation of X-type capital between home and foreign industries is kept the same so that Figure 2(b) resembles two countries each of the Figure 2(a) type. In world markets suppose the prices of X-type goods increase by the same relative amount and that of Y-type goods stay the same. In each country separately standard specific-factor results are obtained: the return to X-type capital increases relatively more than does the price of X-goods, the wage rate rises but by less than X's commodity price, and the return to Y-type capital falls. In the second stage let X-type capital become mobile internationally. In which direction does it flow? Towards the home country if, and only if, in stage 1, the return to X-type capital at home increases by more than it does abroad.

Such a comparison depends largely, and indirectly, on how much the wage rate is stimulated in each country, and this comparison, in turn, is revealed by the solution for wage changes in the specific-factors model. The formal solution was not derived earlier, but it can be shown (e.g. in Caves, Frankel and Jones, 2007, or Jones, 2000, ch. 3) to depend on the product of three terms: s_X , i_X , and θ_X . s_X is the relationship between the elasticity of demand for labor (i.e. of the marginal product curve) in the X-sector compared to the economy average. If X is "typical", this has value unity. i_X is equal to labor's distributive share in the X-sector relative to its share in the economy, and would be greater than unity if and only if X is relatively labor intensive. Finally, θ_X is the fraction of the country's income devoted to the production of X. If the X-sector is fairly typical in terms of labor demand elasticity and labor intensity, everything depends upon

the relative size of the X-industry. Suppose this is larger at home than abroad. If so, the wage rate will tend to increase more at home than abroad, and, since both countries experience the same price rise for X, the return to capital will indeed increase in both countries, but tend to increase relatively more abroad. With a greater increase in the wage rate at home, fewer “rents” are available to attract capital to the home country.

This two-stage process illustrates how the variation in the specific-factors model that is exemplified for the 4-commodity case in Figure 2(b) leads to a modeling strategy that makes use of the specific-factor logic at the first stage and then completes the analysis by asking how rates of return to a mobile factor compare in two countries. Jones and Marjit (2003) explore a different interpretation of Figure 2(b) in which the two labor forces shown there correspond to a single country’s supply of skilled and unskilled labor. An interesting question might concern the consequences on the wage premium and wage levels of a training program that converts some unskilled labor into skilled labor.

The specific-factors model is a simple form of general equilibrium model in which an extreme asymmetry in factor mobility is assumed – one factor is mobile and the others are not. A model in which all factors have partial mobility would of course be more complex, even if attractive for modeling dynamic movements. The Heckscher-Ohlin model also has extreme assumptions – *viz.* that the two factors (in the two factor case) have the same degree of mobility, instantaneous. As all theorists acknowledge, simplicity in model building is a strong virtue unless it rules out features of the setting that are of most concern. As illustrated above, departures from the specific-factors setting can often be better understood by making use of embedded features that do correspond to the specific-factor model even if other features are also involved. And, as

Samuelson and others have often remarked, it is the general equilibrium model that captures much of the reasoning about diminishing returns in partial equilibrium settings that even first-year students of economics can understand.

References:

Caves, Richard, Jeffrey Frankel, and Ronald W. Jones: *World Trade and Payments*, 10th edition, (Addison Wesley, Cambridge), 2007: A standard textbook used in undergraduate courses.

Haberler, Gottfried: *The Theory of International Trade*, (Wm. Hodge, London), 1936: A classic pre-war exposition of the theory of trade.

Jones, Ronald W.: "A Three-Factor Model in Theory, Trade and History," Ch. 1 in Jagdish Bhagwati, Ronald Jones, Robert Mundell and Jaroslav Vanek, (eds.), *Trade, Balance of Payments and Growth* (North-Holland, Amsterdam), 1971: Along with Samuelson (1971) the pair of articles setting out the algebraic exposition of the specific-factor model.

_____ : *Globalization and the Theory of Input Trade*, (MIT Press, Cambridge), 2000: Discusses how international trade theory is altered when some inputs into production have international markets.

_____ : "Specific Factors and Heckscher-Ohlin: An Intertemporal Blend," unpublished, (2006): Points out how a blend of the two-factor, many commodity version of Heckscher-Ohlin theory, combined with the $(n+1)$ by n dimensional specific-factors model provides a simple model of competitive trade allowing both a

heavy degree of specialization with trade and a variety of products produced by a given country.

_____ and Sugata Marjit: “The Stolper-Samuelson Theorem, the Leamer Triangle, and the Produced Mobile Factor Structure,” in Takayama, A., M. Ohyama, and H. Ohta.(eds.): *Trade, Policy, and International Adjustments* (Academic Press, 1991): An exposition of a simple n -factor, n -commodity model.

_____ : “Economic Development, Trade and Wages,” *German Economic Review*, v. 4, pp. 1-17, 2003: An adaptation of Figure 2 to the question of the wage premium between skilled and unskilled workers.

Kemp, Murray and Leon Wegge: “On the Relation between Commodity Prices and Factor Rewards,” *International Economic Review*, 1969, pp. 497-513: An extension of the Stolper-Samuelson theorem to three factors and three commodities.

Magee, Stephen: “Three Simple Tests of the Stolper-Samuelson Theorem,” in P. Oppenheimer (ed.) *Issues in International Economics*, (1980) (London, Oriel Press), pp. 138-53: An argument for the superiority of the specific-factors model in explaining supports for commercial policy.

Neary, J. Peter: “Short-Run Capital Specificity and the Pure Theory of International Trade,” *Economic Journal*, 1978: Shows how the passage of time can convert a specific-factors setting to the all-factors-mobile Heckscher-Ohlin setting.

Ricardo, David: *The Principles of Political Economy and Taxation* (Cambridge: Cambridge University Press), 1981. First publication: 1817: Shows both the argument for comparative advantage and the analysis of rents in a specific-factor setting.

Ruffin, Roy and Ronald W. Jones: "Protection and Real Wages: The Neo-Classical Ambiguity," *Journal of Economic Theory*, v. 14, pp. 337-48, 1977: Establishes a presumption that workers would prefer free trade to protection.

Samuelson, Paul A.: "International Trade and the Equalisation of Factor Prices," *Economic Journal*, v. 58, pp. 163-84, 1948: The classical argument that factor prices could be equalized between trading countries with different factor endowments.

_____ : "Ohlin Was Right," *The Swedish Journal of Economics*, 1971: An exposition of the algebra of the specific-factor setting.

Sanyal, Kalyan and Ronald W. Jones: "The Theory of Trade in Middle Products," *American Economic Review*, v. 72, pp. 16-31, 1982: An analysis of trade that is in the "middle" of the production spectrum.

Stolper, Wolfgang and Paul A. Samuelson: "Protection and Real Wages," *Review of Economic Studies*, 1941, v. 9, pp. 58-73: Shows how, in a Heckscher-Ohlin setting, a country would raise real wages if it imposes a tariff on labor-intensive imports.

Viner, Jacob: "Cost Curves and Supply Curves," *Zeitschrift fur Nationalokonomie*, Vol. III, 1931, pp. 23-46. Reprinted in A.E.A., *Readings in Price Theory* (Allen and Unwin, London), 1953: A discussion of a firm's short-run and long-run average cost curves, with a dispute over geometry.

Cross-references: Heckscher-Ohlin Model, Political Economy of Protection, Migration, Trade and Wages.

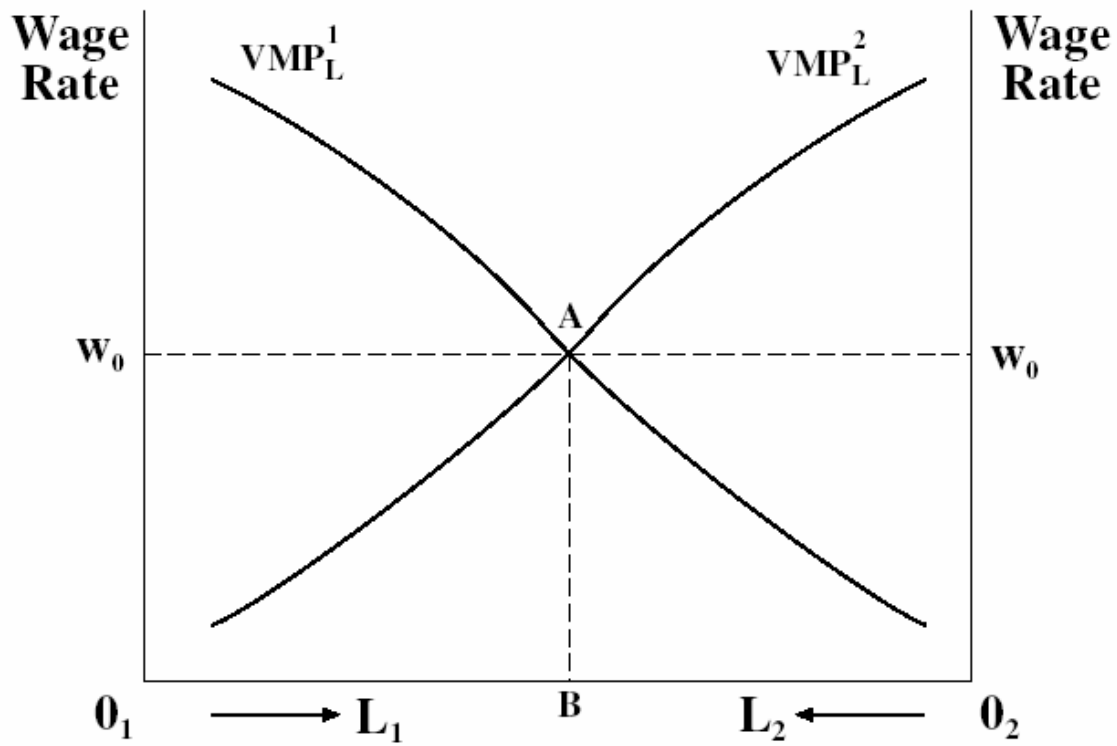
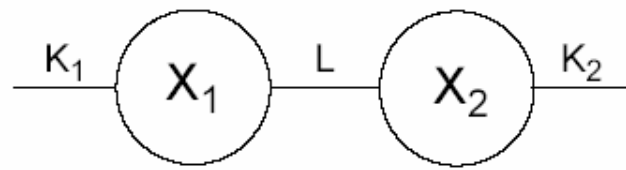


Figure 1: Wage Rate Determination

(a)



(b)

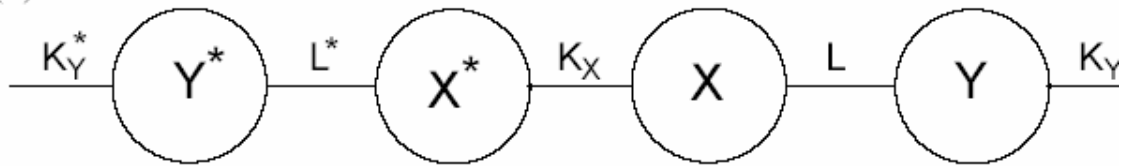


Figure 2