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FREE TRADE AND FACTOR-PRICE POLARIZATION

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Factor-price equalization between trading partners is perhaps the best known implication of the Heckscher–Ohlin–Samuelson model of production and trade. It has long been known that with more primary factors than goods, this result is not necessary. Recent studies have investigated effects of changing prices on factor payments in the three-factor, two-good trade model. This short note emphasizes that when such an economy moves from autarky to free trade, payment to a relatively cheap factor may fall, 'polarizing' factor prices. Conditions favoring this outcome are examined.

1. Introduction

Free trade equalizes payments to each productive factor between trading partners in the Heckscher–Ohlin–Samuelson model. An economy with three, rather than two, productive factors is considered in the present study. Free trade may then cause polarization of factor payments, with payment to a relatively cheap factor falling further from world level. A relatively cheap input in autarky may experience falling payment with free trade, even as production of the good 'intensive' in that factor increases. Conditions favoring this outcome are investigated.

Sufficient conditions for factor-price equalization between freely trading economies were first formulated by Lerner (1952). Samuelson (1953–1954) noted factor payments need not be equalized with more factors than goods. Much history of thought in international economics is concerned with factor-price equalization, as summarized by Samuelson (1967) and Chipman (1966). Samuelson (1971), considering the specific factors model with identical, homothetic tastes, argues free trade will cause autarky factor prices to approach world levels, but may not result in complete equalization.

Recently the three-factor, two-good general equilibrium model has received attention in studies by Batra and Casas (1976), Ruffin (1981), Takayama (1982), Suzuki (1983), Jones and Easton (1983), and Thompson (1985). This is the simplest model where complementarity in production and factor-price

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polarization may occur. Branson and Monoyios (1977) show a third factor is necessary for studying factor content of trade. The general result leading to factor-price polarization is recognized in the literature, but an argument on its plausibility has not been set forth. Polarization should be especially important for an economy with cheap labor. Free trade may depress a low autarky wage, contrary to what is suggested in the simpler two-factor model. Intuition on benefits of competition due to free trade is qualified when this implication of the three-factor model is recognized. So conditions favoring factor-price polarization assume some weight.

2. Model

Endowments of three factors (called v_1, v_2, and v_3) are assumed exogenous in perfectly inelastic supply, assuring full employment. Factor owners receive endogenous payments (w_1, w_2, and w_3), each equal between sectors due to mobility. Endogenous outputs of agriculture and manufacturing (x_A and x_M) are determined by world prices (p_A and p_M) given to a price taking, small country. Factor mixes (a_{ij}) represent cost minimizing unit inputs, where $i = 1, 2, 3$, and $j = \text{A, M}$.

Aggregate substitution terms describe how firms adjust factor usage: $s_{hi} \equiv \sum_j x\, \partial a_{hj}/\partial w_i$. It is known that (i) $s_{hi} = s_{ih}$, (ii) each s_{ii} is negative, and (iii) $\sum_i w_i s_{hi} = 0$. Factors are rescaled to unit wages, so $\sum_i s_{hi} = 0$. Any one of three non-diagonal substitution terms may be negative, indicating complementarity. Any two factors, that is, may be complements. Full employment and competitive pricing lead to the following statement of the model, as developed by Jones and Scheinkman (1977) and Takayama (1982),

$$\begin{bmatrix} s_{11} & s_{12} & s_{13} & a_{1A} & a_{1M} \\ s_{12} & s_{22} & a_{23} & a_{2A} & a_{2M} \\ s_{13} & s_{23} & s_{33} & a_{3A} & a_{3M} \\ a_{1A} & a_{2A} & a_{3A} & 0 & 0 \\ a_{1M} & a_{2M} & a_{3M} & 0 & 0 \end{bmatrix} \begin{bmatrix} \mathrm{d}w_1 \\ \mathrm{d}w_2 \\ \mathrm{d}w_3 \\ \mathrm{d}x_A \\ \mathrm{d}x_M \end{bmatrix} = \begin{bmatrix} \mathrm{d}v_1 \\ \mathrm{d}v_2 \\ \mathrm{d}v_3 \\ \mathrm{d}p_A \\ \mathrm{d}p_M \end{bmatrix}.$$

Chang (1979) shows the system determinant D is negative with three factors. A strong factor intensity ordering, holding regardless of factor payments, is postulated: $a_{1A}/a_{1M} > a_{2A}/a_{2M} > a_{3A}/a_{3M}$. For ease of notation $b_1 \equiv a_{1A}a_{2M} - a_{1M}a_{2A}$, $b_2 \equiv a_{2A}a_{3M} - a_{2M}a_{3A}$, $b_3 \equiv a_{1A}a_{3M} - a_{1M}a_{3A}$, $c_1 \equiv b_1 + b_3$, $c_2 \equiv b_1 - b_2$, and $c_3 \equiv b_2 + b_3$. Note b_1, b_2, b_3, c_1, and c_3 are all positive, while the sign of c_2 depends on factor-mix values. Factor one (three) is 'extreme' in agriculture (manufacturing), while factor two is the 'middle' factor, using terminology recently introduced by Ruffin (1981). Ruffin shows payments and endowments of extreme factors are negatively related, while payments and endowments of extreme and middle factors are positively related. These relationships hold regardless of substitutability or complementarity.

3. Factor price polarization

Assume production functions are identical throughout the world, and that agriculture uses factor one intensively, the manufacturing sector factor three, with factor two the middle factor. Consider an economy heavily endowed with factor one (factor one 'rich'), autarky agricultural prices p_A^a below the world level p_A^*, and p_M^a greater than p_M^*. With marginal trade liberalization, p_A rises and p_M falls in the economy, both toward world levels. These price changes create a shift along the production possibility frontier toward exported agriculture. Jones and Easton (1983) develop magnification effects of these price changes on factor payments, while Thompson (1985) derives corresponding sign patterns.

Solve for effects of these price changes on payment to factor one, eliminating s_{ii} terms, to find

$$\partial w_1/\partial p_A = N_1/D \quad \text{and} \quad \partial w_1/\partial p_M = N_2/D,$$

where

$$N_1 \equiv -s_{23}(a_{2M}+a_{3M})c_1 - s_{13}a_{2M}c_2 - s_{12}a_{3M}c_3, \quad \text{and}$$

$$N_2 \equiv s_{23}(a_{2A}+a_{3A})c_1 + s_{13}a_{2A}c_2 + s_{12}a_{3A}c_3.$$

Free trade would unambiguously cause w_1 to fall with positive N_1 and negative N_2. This becomes interesting when realized that factor one is 'extreme' in agriculture. The factor which might be anticipated to enjoy higher payment with trade suffers falling payment.

Immigration of factor one in these same conditions would cause agricultural output to fall, manufactured to rise, due to reciprocity. As demonstrated by Ruffin (1977) for the two-factor situation, the quantity version of the Heckscher–Ohlin theorem formally hinges on this Rybczynski result. Start with two economies identically endowed and with identical, homothetic tastes. Letting one unit of factor one migrate between the two, the region marginally abundant in factor one would export manufactured goods. Moving from autarky to trade, manufactured prices should rise and agricultural prices fall, the opposite of what is postulated.

Substitution and factor-mix terms would, however, vary with high degrees of immigration. It is supposed an economy with a relatively cheap factor one would be characterized by cheap agricultural goods, since factor one is extreme in agriculture. This is by no means necessary in this model, but is postulated. Exports of agriculture, by assumption, would come from an economy with a relatively cheap factor one. Factor one could be labor, factor two physical capital, and factor three human capital. Less developed countries, which are labor abundant, would then be expected to export labor intensive agriculture, importing manufactured goods extreme in human capital.

This is as straightforward as the two-factor version of the factor-price equalization argument. Little can be said about autarky prices without further assumptions regarding demand. Sufficient conditions for factor-price equalization include free trade, which equalizes prices of goods. What is called the factor-price equalization result with two factors is the unusual property that changing factor endowments do not effect factor payments with prices constant. Countries involved must also be small price takers in the world economy.

Consider the three-factor version of an illustrative diagram. (See fig. 1.) Relative payments to extreme factors are on the vertical axis, relative prices of goods on the horizontal. With only two factors, a simple increasing function can be drawn. But with three factors, the relationship becomes 'thick', as illustrated by the shaded area. Consider the situation of two countries in autarky at points H and F. Country H has both relatively cheap factor one and agricultural goods. Free trade equalizes prices of goods, but may cause polarization of factor payments. This is illustrated as H moves to H' and F to F'. Relative polarization occurs anytime the vertical distance between points of the two countries increases with trade.

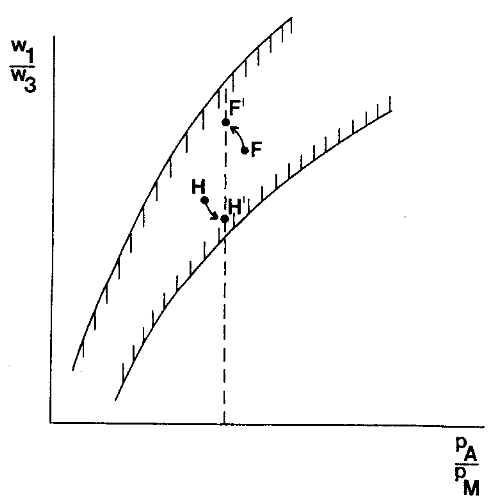

Fig. 1

Consider internal adjustments taking place in the postulated situation. A temporary excess supply of factor three is created with free trade, as production shifts away from manufacturing. Demand for factor two increases in agriculture, since factors two and three are complementary. Agricultural firms substitute the pair of inputs two and three for one. Payment to either factor two or three must rise, its percentage change outflanking the percentage rise in agricultural prices. Real income of either factor two or three, and possibly both, must rise. Demand for factor one falls, as does its payment, with full employment insured in the long run by inelastic labor supply. Percentage decline of payment to factor one must flank that of the manufactured price, so real income of factor one unambiguously falls.

Looking at the algebraic solutions above, two conditions would favor factor-price polarization, namely (i) a negative c_2, and (ii) complementarity between factors two and three (a negative s_{23}). A negative c_2 amounts to factors one and two being close in usage between industries, while factor three is more distant. Evidence to support this conjecture is found for the United States by Thompson and Clark (1983). Skilled labor typically finds little employment in agriculture. Complementarity between capital and skilled labor is suggested by applied studies, for instance Griliches (1969), Berndt and Christensen (1974), and Brogan and Erickson (1975). Particular situations would require studies to determine whether polarization results from free trade, but the issue is theoretically open with three factors and two goods.

4. Conclusion

Free trade is recommended because of eliminated production inefficiencies and increased national welfare. Factor-price polarization would involve depressed payment to a factor already relatively cheap, while a factor relatively dear in autarky would enjoy rising payment. Higher payment would be enjoyed by owners of the middle factor. With liberalized trade, policy should attempt to discourage, via tax, substitution of other possibly complementary factors for a country's cheap input. Gainers from free trade could be forced to compensate losers. Factor-price polarization would be an especially pressing issue in less developed countries, where cheapness of labor presents a major political problem.

Appendix

Solving the system for w_{1A}, for instance, let all exogenous variables remain unchanged except p_A. Divide by dp_A:

$$\begin{bmatrix} s_{11} & s_{12} & s_{13} & a_{1A} & a_{1M} \\ s_{12} & s_{22} & s_{23} & a_{2A} & a_{2M} \\ s_{13} & s_{23} & s_{33} & a_{3A} & a_{3M} \\ a_{1A} & a_{2A} & a_{3A} & 0 & 0 \\ a_{1M} & a_{2M} & a_{3M} & 0 & 0 \end{bmatrix} \begin{bmatrix} \partial w_1/\partial p_A \\ \partial w_2/\partial p_A \\ \partial w_3/\partial p_A \\ \partial x_A/\partial p_A \\ \partial x_M/\partial p_A \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \\ 0 \end{bmatrix}.$$

Using Cramer's rule,

$$D(\partial w_1/\partial p_A) = \begin{bmatrix} s_{12} & s_{13} & a_{1A} & a_{1M} \\ s_{22} & s_{23} & a_{2A} & a_{2M} \\ s_{23} & s_{33} & a_{3A} & a_{3M} \\ a_{1M} & a_{3M} & 0 & 0 \end{bmatrix}, \quad \text{etc.}$$

Results are simplified by eliminating diagonal s_{ii} terms, since $s_{ii} = -\sum_h s_{hi}$, $h \neq i$.

References

Batra, R.N. and F.R. Casas, 1976, A synthesis of the Heckscher–Ohlin and neoclassical models of international trade, Journal of International Economics 6, 21–38.

Berndt, E.R. and L.R. Christensen, 1974, Testing for the existence of a consistent aggregate index of labor inputs, American Economic Review 64, 391–404.

Branson, W.H. and N. Monoyios, 1977, Factor inputs in U.S. trade, Journal of International Economics 7, 111–131.

Brogan, R.D. and E.W. Erickson, 1975, Capital-skill complementarity and labor earnings, Southern Economic Journal 42, 83–88.

Chang, W.W., 1979, Some theorems of trade and general equilibrium with many goods and factors, Econometrica 47, 709–726.

Chipman, J., 1966, A survey of the theory of international trade: Part 3, the modern theory, Econometrica 34, 18–76.

Griliches, Z., 1969, Capital-skill complementarity, Review of Economics and Statistics 51, 465–468.

Jones, R.W. and S.A. Easton, 1983, Factor intensities and factor substitution in general equilibrium, Journal of International Economics 15, 65–99.

Jones, R.W. and J.A. Scheinkman, 1977, The relevance of the two-sector production model in trade theory, Journal of Political Economy 85, 909–935.

Lerner, A.P., 1952, Factor prices and international trade, Economica 19, 67–84.

Ruffin, R.J., 1977, A note on the Heckscher–Ohlin theorem, Journal of International Economics 7, 403–405.

Ruffin, R.J., 1981, Trade and factor movements with three factors and two goods, Economics Letters 7, 177–182.

Samuelson, P.A., 1953–1954, Prices of factors and goods in general equilibrium, Review of Economic Studies 21, 1–20.

Samuelson, P.A., 1967, Summary on factor-price equalization, International Economic Review 58, 286–295.

Samuelson, P.A., 1971, Ohlin was right, Swedish Journal of Economics 4, 365–384.

Suzuki, K., 1983, A synethesis of the Heckscher–Ohlin and the neoclassical models of international trade: A comment, Journal of International Economics 14, 141–144.

Takayama, A., 1982, On theorems of general competitive equilibrium of production and trade – A survey of some recent developments in the theory of international trade, Keio Economic Studies 19, 1–38.

Thompson, H., 1985, Complementarity in a simple general equilibrium production model, Canadian Journal of Economics 17, 616–621.

Thompson, H. and D.P. Clark, 1983, Factor movements with three factors and two goods in the U.S. economy, Economics Letters 12, 53–60.