International Commerce and Income Distribution in Simulated Models of Production and Trade

Henry Thompson

Auburn University
www.auburn.edu/~thomph1
thomph1@auburn.edu

Prepared for WTO & World Trade II, University of Washington
Research Center for International Economics
International Economics and Finance Society

April 2001

The motivation for the WTO is to continue opening global avenues of international trade and investment. International economists might like to think their free trade arguments have been persuasive but political pressure from the growing crowd of winners should get the credit. Economics can attempt to predict the winners and losers due to international commerce and predict the sizes of their gains and losses. Free trade changes prices of traded products and international investment alters the stock of productive capital, both causing adjustments in outputs and factor prices. General equilibrium theory is relevant because adjustments should be allowed across product and factor markets.

Constant cost, neoclassical, and factor endowment models of production and trade provide a foundation for analyzing the distributional effects of international commerce. The Stolper-Samuelson theorem links price changes to factor intensity but generalizing qualitative results beyond the two dimensional model have proven difficult. Distributional effects of foreign investment in qualitatively tractable models have also been difficult to generalize.

Simulations provide insights into to which productive factors might win and lose when qualitative results are ambiguous. The present paper is a review of simulations of general equilibrium models and their estimated comparative static partial derivatives of factor prices. These simulations are based directly on factor proportions theory and are much less detailed than computable general equilibrium (CGE) models. These are simulations of the general equilibrium models of production and trade developed by Jones (1965), Jones and Scheinkman (1977), Chang (1979), Ethier (1974), Takayama (1982), and others. The US labor data is based on the eight skilled labor categories reported by the Census, aggregated in

some of the studies. Capita□ input is derived as the residual of value added after deducting labor payments.

For notation, w represents factor prices, K capital, and p output prices. The focus is on the $\delta w/\delta p$ and $\delta w/\delta K$ elasticities, namely the effects on factor prices of changing prices due to free trade and a changing capital stock due to foreign investment.

International Investment: Friends and Enemies

If the capital endowment and price of a factor are positively (negatively) related, they are international investment friends (enemies). In the present models, factor demands are downward sloping and capital is its own enemy. International investment must be a friend of some factor, suggesting disagreement over investment policy between owners of capital and at least one factor. Thompson (1983) shows that friendship is intransitive, implying that if two labor groups benefit from international investment they are enemies. Two such labor groups would want to let in foreign investment and limit each other's immigration. Being enemies, on the other hand, is transitive. If two labor groups are enemies with international investment, they must be enemies. Alliances between various labor groups on international investment policy may be problematic and the WTO can expect consistent opposition to the move to open international investment.

Clark and Thompson (1983) apply the theoretical result of Ruffin (1981) that extreme factors in the intensity ranking of the model with three factors and two goods are enemies but friends of the middle factor. In the US, capital is the extreme input in manufacturing/services, skilled labor is the extreme factor in services, and unskilled labor the middle factor. Foreign investment into the US raises unskilled wages but lowers skilled wages. Capital is the extreme input in manufacturing & agriculture in the model and increased capital raises that input and lowers output of services. The demand for skilled labor falls while the demand for the middle factor unskilled labor rises.

Clark and Thompson (1990) develop a four factor model with a separate category for semiskilled labor (sales, clerical, crafts, operators) and the service sector separate from manufacturing. Foreign investment raises unskilled wages but lowers semiskilled and skilled wages. Aggregation of semiskilled with unskilled labor disguises the negative effect of foreign investment on semiskilled wages.

Separating five labor skill groups in Canada, Clark and Thompson (1986) find that foreign investment raises only professional wages. Professional labor and capital are friends but enemies with every other type of labor, in contrast to the US. The different comparative static friendships in Canada

and the US are based entirely on factor intensity. Relative to manufacturing, agriculture is less intensive in capital and services is less intensive in skilled labor in Canada. Skilled labor is more of a "middle" factor than in the US and unskilled labor is an extreme factor. Increased capital endowment lowers service sector output and unskilled wages. Perhaps the composition of the service sectors in Canada and the US differed.

In a group of developing and industrializing countries with labor separated into skilled and unskilled labor, Clark and Thompson (1990) find there are two patterns of factor friendship. In every country, unskilled labor is a middle factor in the factor intensity and friends with foreign investment. Capital is the extreme factor in agriculture and foreign investment lowers skilled wages in Ecuador, South Korea, Taiwan, Turkey, and Venezuela. Capital is the middle factor and unskilled labor is the extreme factor in agriculture in Bolivia, Brazil, Chile, Colombia, Mauritius, and Peru, where foreign investment raises skilled wages.

Unskilled labor is generally a middle factor in intensity rankings and a friend of foreign investment except in Canada. While these qualitative effects depend only on factor intensity, factor substitution included in the following simulations plays a role in determining sizes of comparative static elasticities. The following simulations also examine the effects of free trade on income distribution.

Model Simulations with Factor Substitution

Applied comparative static analysis requires data on factor shares, industry shares, and aggregate factor substitution across the economy. There is a rich literature on applied production analysis and factor substitution with applications mostly in energy and agricultural economics. The foundation of substitution is a specification of a cost or production function. Constant elasticity of substitution (CES) functions include Cobb-Douglas with its unit constant elasticity. More flexible translog functions are estimated with systems of partial derivative share equations.

In a model with factor substitution based on estimates of translog production functions across states in 1978, Thompson (1997b) finds own substitution elasticities of -1.4 for skilled labor, -1.2 for unskilled labor, and -0.9 for capital. Capital is used most intensively in agriculture, skilled labor in services, and unskilled labor in manufacturing. The strongest cross elasticities are between skilled and unskilled labor, both about 1.0, and other factors are weak substitutes. Changing prices have very elastic effects on factor prices. Free trade is projected to lower the price of imported manufactures and raise the price of exported business services in the US. Every 1% decline in the price of manufactures combined

with a 1% increase in the price of services would lower unskilled wages by 15% and raise skilled wages by 17%, very elastic effects. Regarding the influence of foreign investment, the only positive effect is a skilled wage elasticity of 0.3. The own capital elasticity is -0.3 and the unskilled wage elasticity -0.03.

Elasticities of factor prices with respect to all factor endowments are close to zero in all of the present simulations. This inelasticity is called *near factor price equalization* (NFPE). Changing factor endowments have minimal effects on factor prices because output adjustments serve as shock absorbers for the economy. Output elasticities are elastic and follow patterns at least suggested by "factor intensity." NFPE suggests that factor prices would be nearly equal across countries in competitive general equilibrium models.

Thompson (1990) reports more detailed estimates of translog production in the US including all of the eight skilled labor groups. Factors have own substitution elasticities between -1 and -3, larger than in the aggregated model, but remain weak substitutes. Combining 1% price changes in manufacturing and business services, wages of operators/fabricators fall by 6%, resource labor by 5%, and craft/repair by 1%. Wages of professionals, technical/sales, service workers, and the return to capital rise by 2% and wages of handlers by 0.2%. These impacts are much smaller than in the aggregate model, pointing to the distorting effect of aggregation. The projection that free trade will substantially shift income toward more skilled labor has been verified over the past decade. Changing technology, difficult to gauge, is likely to have contributed. In the same model, an increased capital endowment due to foreign investment will have inelastic effects on all factor prices except wages of natural resource workers.

Thompson (1997a) reports a similar model for the US with CES production. The free trade program of declining manufacturing prices and rising service prices has slightly smaller effects than with translog substitution, and wages of handlers rise slightly. Foreign investment has a weak positive impact on each type of labor, and the own capital elasticity of -0.6 reflects NFPE. All of these simulations predict skilled labor in the US will benefit from free trade while unskilled labor loses.

With CES production functions the developing and newly industrialized countries mentioned above, Thompson (1995b) predicts that unskilled labor would gain substantially with a move to free trade characterized by rising prices for exported manufactures and declining prices of imported business services. Combining 1% price changes, unskilled wages rise by 18% in Mexico, 13% in Argentina, 9% in Ecuador, 7% in Taiwan, 6% in Bolivia, Korea, and Venezuela, and 4% in Turkey. Losses of skilled labor range from -2% in Mexico to -13% in Bolivia. Losses of capital owners range from -0.3% in Turkey to -5% in Argentina and Bolivia. There is quite a bit at stake in the move toward free trade for factor owners

in these countries. Anticipating these impacts may help policymakers and the WTO in the transition toward free trade.

Both factor substitution and factor intensity in the form of factor shares and industry shares influence the size of comparative static partial derivative elasticities. Thompson (1995a) addresses the issue of whether factor intensity or factor substitution has the most influence in a 3x2 simulated model of the US economy. Comparative static elasticities are compared for a wide range of substitution, including estimated translog, Cobb-Douglas, CES of 0.1 to 2, and examples of strong complementarity. Under every production technology, $\delta w/\delta p$ elasticities are similar in magnitude and $\delta w/\delta K$ elasticities are nearly identical and highly inelastic. Factor intensity plays the dominant role in determining comparative static properties of these general equilibrium models of production.

The reason factor intensity dominates is straightforward. Cost minimizing inputs are positive first derivatives of cost functions by Shephard's lemma. Factor shares and industry shares are based on these first derivatives. Factor substitution is based on derivatives of these inputs, second derivatives of cost functions. Due to concavity, the second cross derivatives will be smaller if they are positive. In the present estimates and in the literature on applied production analysis, these second derivatives are much smaller. In the inversion of the system matrix, $\delta w/\delta p$ elasticities are cofactors of large first derivatives while $\delta w/\delta K$ elasticities are cofactors of much smaller second derivatives. While it is theoretically possible to reverse these relative magnitudes, factor intensity dominates in applications.

Summarizing these simulations with factor substitution, unskilled labor is linked to the manufacturing sector and skilled labor to business services across a range of countries. The distributional impact of free trade is projected to be substantial. International investment, on the other hand, has very inelastic effects on factor prices. In the presence of free trade across competitive economies, factor prices will be nearly equal if they are not equal.

Simulations of the Specific Factors Model

Specifications of specific factors models of production can be built with the same production data by assuming some input is immobile across sectors. In a model focusing on Japanese industry wages, Thompson (1994) examines the potential of protection. The model includes shared capital input across 24 industries, each with its own industry specific labor. Assuming Cobb-Douglas production, protection in an industry has a positive elastic effect on that industry wage, weak negative effects on other industry wages, and a weak positive effect on the return to mobile capital. As an example, the elasticity of iron &

steel wages with respect to that price is nearly 4, elasticities of other wages range from -0.5 to -0.01, and the capital return elasticity is 0.1. In the specific factors model, the specific factors absorb the shocks of price changes. The relatively large $\delta w/\delta p$ elasticities suggest industry labor will lobby to maintain import protection. Foreign investment lowers the return to capital (-0.3), has elastic effects on a few industrial wages (nonmetallic minerals 2, agriculture 2, finance and iron & steel 1), and has inelastic effects on most industrial wages ranging from 0.7 in mining to 0.03 in other transport equipment. The relatively small size of the $\delta w/\delta K$ elasticities reflects NFPE.

Thompson (1996) predicts the effects of NAFTA on 17 Alabama manufacturing industries in a simulation of the specific factors model. Capital is assumed to be industry specific and labor is separated into production and non-production. Textiles, apparel, wood, and furniture are intensive in production labor, while paper, chemicals, and transport equipment are capital intensive. Assuming Cobb-Douglas production, substitution is inelastic. Effects of changing prices on outputs are very inelastic, with own output effects less than 0.1. While price changes due to NAFTA have small output effects, capital returns are sensitive to price changes. Returns to industrial capital rise or fall as much as 20%. Again, sector specific inputs absorb shock of price changes in the specific factors model. The model includes the impact of vectors of price changes constructed from a consensus reading of the literature, with industries intensive in production labor projected to face increased import competition. In the long run, changing capital returns will alter investment and significantly affect outputs. Simulations project long run output declines of up to 20% in textiles, apparel, furniture & fixtures, with similar increases in chemicals, machinery & equipment, and instruments. These projections are being confirmed as NAFTA prices unfold.

In a study of Bolivia's entry into Mercosur, Thompson and Toledo (2001a) combine estimates of $\delta w/\delta p$ elasticities under CES technology with a vector of price changes predicted in the literature. Price declines of 20% in business services and 12% in agriculture are predicted, with price increases of 30% in manufacturing, 8% in natural gas, and 4% in mining. Simulations predict large factor price adjustments, skilled labor suffering a 6% wage decline and unskilled labor a 1% decline. Sector specific capital owners in both agriculture and business services face import competition and suffer declines in their returns of about 25%. Capital returns surge in the export industries, by 47% in manufacturing, 23% in natural gas, and 14% in mining. Under various sorts of sensitivity analysis, the adjustments due to price changes are large. Thompson and Toledo (2001b) show that elasticities of factor prices with respect to output prices are identical for any CES production function.

Future Research and Policy Implications

The present line of research can be extended to include more detailed data sets, primary energy inputs, other countries, and improved estimates of factor substitution. An input/output structure and production of intermediate products can be included. Models can focus on particular industries with other industries more highly aggregated. The distorting effects of aggregation can be studied. Clark, Hofler, and Thompson (1988) show there are at least eight different skill groups of labor in US manufacturing, implying that applications with more aggregated labor contain distortions.

The main lesson of the present simulations is that free trade can be expected to substantially alter the distribution of income across factors following a pattern suggested by factor intensity. International investment will have much smaller impacts on factor prices.

Policymakers must decide whether to attempt to govern the income distribution due to free trade. All parties could conceivably be better off with a Pareto improving move to free trade, although practice is far removed from theory. The economic ideal of competition is that all factors are paid according to their marginal productivities. In the global economy short of monopolies and externalities, all prices should be determined in free markets. Dismantling the barriers to international trade and investment encourages global efficiency, but vested interests will oppose any policy change that lowers their own income.

Policymakers can be expected to stumble when left to juggle potentially conflicting concerns of equity and efficiency, not to mention political pressure from various groups. Economists also stumble, although the vast majority continues to advocate free international commerce, a position should raise our marginal productivity in the long run. In the meantime, the WTO provides a high profile platform to promote our science.

References

Chang, Winston (1979) Some Theorems of Trade and General Equilibrium with Many Goods and Factors, *Econometrica* 47, 709-26.

Clark, Don, Richard Hofler, and Henry Thompson (1988) Separability of Capital and Labor in US Manufacturing, *Economics Letters* 26, 197-201.

Clark, Don and Henry Thompson (1983) Factor Movements with Three Factors and Two Goods in the US Economy, *Economics Letters* 12, 53-60.

Clark, Don and Henry Thompson (1986) Immigration, International Capital Flows, and

Long Run Income Distribution in Canada, *Atlantic Economic Journal* 14, 24-9.

Clark, Don and Henry Thompson (1990) Factor Migration and Income Distribution in Some Developing Countries, *Bulletin of Economic Research* 42, 131-40.

Clark, Don and Henry Thompson (1990) International Factor Migration and the US, *Atlantic Economic Journal* 18, 74-8.

Ethier, Wilfred (1974) Some of the Theorems of International Trade with Many Goods and Factors, *Journal of International Economics* 4, 199-206.

Jones, Ron (1965) The Structure of Simple General Equilibrium Models, *Journal of Political Economy* 73, 557-72.

Jones, Ron and Jose Scheinkman (1977) The Relevance of the Two-Sector Production Model in Trade Theory, *Journal of Political Economy* 85, 909-35.

Takayama, Akira (1982) On Theorems of General Competitive Equilibrium of Production and Trade: A Survey of Recent Developments in the Theory of International Trade, *Keio Economic Studies* 19, 1-37.

Thompson, Henry (1983) Factor Migration and Income Redistribution in International Trade, *Keio Economic Studies* 20, 65-70.

Thompson, Henry (1990) Simulating a Multifactor General Equilibrium Model of Production and Trade, *International Economic Journal* 4, 21-34.

Thompson, Henry (1994) An Investigation into the Quantitative Properties of the Specific Factors Model of International Trade, *Japan and the World Economy* 6, 375-88

Thompson, Henry (1995a) Factor Intensity versus Factor Substitution in a Specified General Equilibrium Model, *Journal of Economic Integration* 10, 283-97.

Thompson, Henry (1995b) Free Trade and Income Redistribution in Some Developing and Newly Industrialized Countries, *Open Economies Review* 6, 265-80.

Thompson, Henry (1996) NAFTA and Industrial Adjustment: A Specific Factors Model of Production, *Growth and Change* 27, 3-28.

Thompson, Henry (1997a) Free Trade and Income Redistribution across Labor Groups: Comparative Statics for the US Economy, *International Review of Economics and Finance* 6, 181-92.

Thompson, Henry (1997b) Free Trade and Income Redistribution in a Three Factor Model of the US Economy, *Southern Economic Journal*, 1074-83.

Thompson, Henry and Hugo Toledo (2001a) Bolivia and South American Free Trade, *International Trade Journal*, forthcoming Spring.

Thompson, Henry and Hugo Toledo (2001b) A Note on General Equilibrium Price Elasticities with CES production, manuscript.