Free Trade and Foreign Capital:
Income Redistribution in Simulated Trade Models

Henry Thompson

Department of Agricultural Economics
Auburn University, AL 36849
334-844-2910, fax 5639
thomph1@auburn.edu

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The present paper compares the quantitative impacts changing prices and capital endowments across simulated factor proportions and specific factors models. Various technologies, countries, and aggregates of skilled labor are included. A free trade "program" of 1% price changes and a 1% change in the capital stock are the standards of comparison across models. These simulations illustrate two quantitative properties. First, when prices change due to the free trade advocated by the WTO factor intensity has a much stronger influence than factor substitution on the resulting income distribution. Second, price changes due to free trade have a much stronger influence than incoming foreign capital.

Key words: simulations, general equilibrium, trade, foreign capital

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WTO success in its goal to "help producers of goods and services, exporters, and importers conduct their business" will result in a redistribution of income across factors of production due the price changes associated with free trade. The income redistribution explains in part the lack of complete support for either free trade or foreign capital, which also raises but redistributes income. Directly addressing income redistribution should ease the transition toward free trade.

In comparative static models of small open economies, trade would change prices of traded products and cause factor price adjustments. The Stolper-Samuelson qualitative price link is based on factor intensity but little intuition has developed beyond the model with two factors and two products. Similarly, income redistribution due to foreign capital has been difficult to generalize beyond simple models. More fundamentally, there is not much insight into the magnitudes of these general equilibrium comparative static effects. The quantitative implications of introducing specific factors of production have not been explored. Finally, quantitative distortions due to aggregation have not been investigated. Simulations can provide insight into these theoretical issues.

The present paper synthesizes a series of simulations of the general equilibrium model of production and trade developed by Jones (1965), Chipman (1966), Jones and Scheinkman (1977), Chang (1979), Ethier (1974), and Takayama (1982) and based directly on the insights of Edgeworth, Heckscher, Ohlin, Vanek, and Samuelson. Underlying assumptions are homothetic neoclassical production functions with constant returns, competitive pricing of homogeneous products in small open economies, and full employment of homogeneous factors of production. The present simulations are more theoretical exercises than policy oriented computable general equilibrium models developed, for instance, by Fullerton, Shoven, and Whalley (1985) or Hertel and Tsigas (1988).

Factors of production in the present simulations include the various skill groups of labor from the eight skill categories reported by the US Census. Clark, Hofler, and Thompson (1988) show that none of these groups should be aggregated and the present arbitrary aggregations reveal the sizes of distortions. Capital is derived as the residual of value added from the Census of Manufacturing. The simulations include models with specific factors of production allowing comparison of the impacts on shared and specific factor prices.

For notation, let w represent endogenous factor prices, p prices of finished products exogenous to the small open economy, and K the exogenous capital endowment. The present focus is on the sizes of general equilibrium $\delta w_i/\delta p_j$ and $\delta w_i/\delta K$ elasticities, the effects of prices and foreign capital on factor prices. There is ample motivation, including the income redistribution due to trade policy and taxes or subsidies on foreign capital.

Theoretical Anticipations

Changing prices of traded products with endowments held constant affect factor prices as reflected in the general equilibrium $\delta w_i/\delta p_j \equiv w_{ij}$ elasticities. In the model with two factors and two products, the Stolper-Samuelson (19xx) theorem establishes a qualitative link between products and factors based on factor intensity. The magnification effect of Jones

(1965) establishes that any ranking of percentage changes in prices of products must be flanked by percentage changes in factor prices. Regarding the w_{ij} matrix of comparative static elasticities, for every price p_m there must be a factor h such that $w_{mh} > 1$ and a factor k such that $w_{mk} < 0$. Some factor owner must win in terms of real wages while another must lose due to a price change. The w_{ij} elasticities in the present simulations are elastic and consistent with the magnification effect.

A changing capital endowment with prices of traded products held constant affect factor prices as reflected in the general equilibrium $\delta w_i/\delta K \equiv w_{iK}$ elasticities. Foreign capital in the present models is assumed to directly affect to the exogenous capital endowment. Capital may be either home or foreign owned: $K = K_h + K_f$. For present purposes, assume foreign capital K_f is the source of an exogenous change in K. While national income increases with foreign capital, the entire increase goes to the capital owner due to a competitive envelope property. In the two factor model, $Y = wL + rK$ and the income change due to capital increment is $\delta Y/\delta K = r + L\delta w/\delta K + K\delta r/\delta K$. Output is homogenous of degree 1 in inputs and marginal products are homogenous of degree 0. If factors are paid marginal products, Euler's theorem implies $L\delta w/\delta L + K\delta r/\delta K = 0$ and $\delta Y/\delta K = r$. With constant prices, the change in K has no effect on factor prices due to factor price equalization (FPE). As a general property, the w_{iK} elasticities are nearly zero in the present simulations.

Simulations of Factor Proportions Models of Production and Trade

The foundation of factor substitution is a cost or production function. Uzawa (1962) develops the properties of constant elasticity of substitution (CES) production. Cobb-Douglas

(CD) production functions have unitary elasticities of substitution. Balistreri, McDaniel, and Wong (2002) point out that CD technology cannot be rejected as a null hypothesis for 20 of 28 US manufacturing industries, and 7 of the others have Leontief technology. Cobb-Douglas may be a reasonable starting place for simulations. Flexible translog functions allow variation in the elasticity of substitution along isoquants and are typically estimated with systems of partial derivative factor share equations.

In a model with translog production estimated across US states, Thompson (1997b) estmates own factor price elasticities of -1.4 for skilled labor, -1.2 for unskilled labor, and -0.9 for capital. The strongest cross price elasticities are between skilled and unskilled labor, both about unit value, and capital is a weak substitute for both types of labor. Weak substitution between capital and labor is characteristic in all the present estimates and consistent with Arrow, Chenery, Minhas, and Solow (1961).

Free trade is projected to lower US prices of manufactures but raise prices of exported business services. Changing prices have elastic effects on factor prices in the comparative statics. Table 1 reports factor price adjustments for a free trade "program" with the price of manufactures falling 1% and the price of business services rising 1%. The extremely elastic effects for skilled and unskilled labor in the top of Table 1 suggest there is a great deal at stake in a move toward free trade. In stark contrast, foreign capital has nearly no effect at all on skilled and unskilled wages as shown in Table 2. These results are robust across a number of simulations with translog, CES, or Cobb-Douglas production.

* Table 1 * Table 2 *

Elasticities of factor prices with respect to factor endowments are close to zero in all the present simulations, *near factor price equalization* (NFPE). If the numbers of factors and products are equal, FPE holds and $\delta w/\delta K = 0$. Outputs serve as "shock absorbers" for factor markets leaving very small impacts on factor demands.

In a 3x2 model of the US economy, Thompson (1995a) compares the influence of factor intensity and substitution on comparative static elasticities in simulations with translog, Cobb-Douglas, CES, and production with strong complementarity. The w_{ij} elasticities are consistent across all simulations and the w_{iK} elasticities are all nearly identical and close to zero (NFPE).

Disaggregating the eight labor skill groups, Thompson (1990) reports own translog factor price elasticities somewhat larger in magnitude, between -1 and -3. Nevertheless, factors remain weak substitutes because of the influence of factor shares in the cross price elasticities. Aggregation lowers the degree of substitution, as anticipated in the theoretical literature. The disaggregated factor price adjustments in Table 1 are much smaller than in the aggregated model but remain elastic as implied by the magnification effect. Aggregation exaggerates w_{ij} elasticities, which are cofactors of factor shares that increase with aggregation. NFPE holds for disaggregated labor in Table 2 with foreign capital's inelastic effects except for the wage of resource workers due to the very high share of capital in agriculture.

Thompson (1997a) examines a similar model with CES production and a wide range of substitution for sensitivity. The free trade program has slightly smaller effects than with translog production and handlers wages rise slightly. Foreign capital has a weak positive impact on all wages. A wide variation in the CES has very little impact on the comparative static results. These simulations reveal a startling robustness across production technologies.

With CES production in a group of less developed and newly industrialized countries, Thompson (1995b) finds unskilled labor would gain substantially with free trade characterized by higher prices for exported manufactures and lower prices for imported business services. In the 1% free trade program in Table 3, unskilled wages increase up to 18% in Mexico. There should be opponents to free trade, however, with losses of skilled labor ranging up to 13% in Bolivia and capital losses as high as 5% in Argentina and Mexico. While labor disaggregation would decrease these elasticities, free trade involves sizeable price changes. There is evidently quite a bit at stake in NICs and LDCs in the move toward free trade.

* Table 3 *

The relative influence of factor shares and substitution

The underlying reasons for the dominance of factor shares in the w_{ij} elasticities is straightforward. Elasticities of substitution $\varepsilon_{ik} \equiv [\delta(a_{ij}/a_{kj})/\delta(w_k/w_i)]/[(w_k/w_i)/(a_{ij}/a_{kj})]$ are constant along isoquants with CES production and CD is a special case with $\varepsilon_{ik} = 1$. Factor shares $\theta_{kj} \equiv w_k a_{kj}/p_j$ dominate derivation of the cross price elasticities $\sigma_{ik} \equiv (\delta a_{ij}/\delta w_k)(w_k/a_{ij})$. Sato and Koizumi (1973) show that $\sigma_{ik} = \theta_{kj}\varepsilon_i$. For CD technology, it follows that $\sigma_{ik} = \theta_{kj}$. In estimates of translog production, the ε_{ik} terms tend to cluster around unit value. In the simulations, the matrix of cross price elasticities σ_{ik} is combined with the matrix of factor shares θ_{kj} and a matrix of industry shares into a comparative static system, diminishing the overall influence of substitution.

Relative sizes of w_{ij} and w_{iK} elasticities are due to properties of cost functions. Cost minimizing factor inputs are positive first derivatives of cost functions by Shephard's lemma, $\delta c/\delta w = a$, and factor shares θ_{kj} are built from these first derivatives. Factor substitution elasticities are based on second derivatives of cost functions: $\delta a/\delta w = \delta^2 c/\delta w^2$. Own effects are negative and the interactive cross terms $\delta a_i/\delta w_k = \delta^2 c/\delta w_i \delta w_k$ are generally small, ensured by addivity and concavity constraints. In the comparative statics, the w_{ij} elasticities are cofactors of larger first derivatives while w_{iK} elasticities are cofactors of smaller second derivatives. For the special case of even models, w_{ij} elasticities are completely independent of substitution and w_{iK} elasticities are all zero.

Simulations of Specific Factors Models of Production and Trade

In a specific factors model of the Japanese economy, Thompson (1994) examines the potential effects of protection across industrial wages with Cobb-Douglas production. Protection of an industry has a positive elastic effect on that wage, weak negative effects on other industrial wages, and a weak positive effect on the capital return. The example of a 1% change in the price of iron & steel, critical in trade policy debates, is reported in Table 4.

* Table 4 *

The underlying principle behind the quantitative difference in the factor price effects is that specific factors absorb the shock due to a price change. If factors were mobile across sectors, there would be a dampened impact because factor supply adjusts across industries. An increase in foreign capital has a slight negative effect on the return to capital and elastic effects on a few industrial wages but very inelastic effects on most industrial wages.

In a study of the effects of projected NAFTA price changes on 17 Alabama manufacturing industries, Thompson (1996) utilizes industry specific capital with separate production and nonproduction labor and Cobb-Douglas production. The literature predicts industries intensive in production labor will face increased import competition under NAFTA. Testing various vectors of price changes for sensitivity, output effects are inelastic with own output elasticities less than 0.1 as summarized in Table 5. Sector specific capital returns are very sensitive to price changes with returns adjusting as much as 20%. In the long run, such changes in capital returns would alter investment and significantly affect outputs. The model then projects long run output adjustments in the range of 20%. Across simulations, production wages fall from 1% to 7% while nonproduction wages rise up to 3%.

* Table 5 *

In a study of Bolivia's entry into Mercosur, Toledo and Thompson (2001) combine CES production with the government projection of Mercosur price changes in a specific factors model with shared skilled and unskilled labor. Results are summarized in Table 6. Skilled and unskilled labor are projected to suffer moderate wage declines, while capital returns vary widely. These factor price adjustments are robust over a range of sensitivity analysis. A theoretical property is uncovered in these simulations, namely that w_{ij} elasticities are identical for any CES production function.

* Table 6 *

Conclusion

Support for the WTO goal of free trade is less than universal. The present simulations suggest that one reason for opposition to free trade is the large degree of income redistribution that would occur. Price changes due to free trade can be expected to substantially alter income distribution inside trading economies following patterns suggested by factor intensity or relative factor shares. While defining factor intensity remains a theoretical challenge in complex economies with many factors and many products, relative factor shares anticipate the general equilibrium price links.

The theoretical literature has concentrated on isolating conditions under which there would be unambiguous qualitative factor intensity links but only limited intuition has evolved. Quantitative price effects in these competitive models tend to follow patterns suggested by a straightforward comparison of factor shares. The effects of changing prices of products on factor prices are elastic, implying substantial redistribution of income due to free trade. Specific factors are especially sensitive to price changes.

Further simulations can gauge the quantitative implications of various theoretical modifications of the model: variable returns, nonhomothetic production, different production functions, different utility functions, international monopoly or monopsony power, heterogeneous products, heterogeneous factors, unemployment, elastic factor supply, joint production, and so on. The effects of aggregation can be examined in simulations. Different countries or regions and specific policy issues can be examined. More detailed production data can be used with a focus on selected disaggregated industries.

Foreign capital has very small impacts on factor prices. The present simulations suggest factor price equalization at least nearly holds in competitive economies. Given the long run goal of raising unskilled wages in labor abundant countries, trade holds more potential than foreign capital that is not linked to trade. The WTO has it right in that trade is the avenue to toward raising income but there might not be enough appreciation of the potential of trade to alter factor prices.

The WTO goal of improving "the welfare of the peoples of the member countries" may mask the high stakes for various groups within the member countries. It bears repeating that the move to free trade promises to substantially redistribute income among factors of production. Simulations of trade models anticipate this income redistribution and may assist domestic and international policymakers in their efforts at a transition to free trade.

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Table 1. US Factor Price Adjustments to "Trade Program" of 1% Price Changes

3 factor model, translog production*	
Skilled wage	17%
Unskilled wage	-15%
Capital return	2%
Disaggregated labor adjustment, translog production**	
Professional wage	2%
Technical wage	2%
Service wage	2%
Resource wage	-5%
Craft wage	-1%
Operator wage	-6%
Handler wage	0%
Capital return	2%

* Thompson (1997b); robust for Cobb-Douglas, CES, and compliments, Thompson (1995a)

** Thompson (1990); robust for CES production, Thompson (1997a)

Table 2. US Factor Price Adjustments to 1% Increase in Foreign Capital

3 factor model, translog production*

Skilled wage	0.3%
Unskilled wage	-0.0%
Capital return	-0.3%

Disaggregated labor with translog production**

Professional	0.1%
Technical	0.1%
Service	0.1%
Resource	1.3%
Craft	0.1%
Operators	0.0%
Transport	0.1%
Handlers	0.1%
Capital	-0.3%

* Thompson (1997b); robust for Cobb-Douglas, CES, and compliments, Thompson (1995a)

** Thompson (1990); robust for CES production, Thompson (1997a)

Table 3. NIC and LDC Adjustment to 1% Trade Program*

	Unskilled wage	Skilled wage	Capital return
Mexico	18%	-2%	-5%
Argentina	13%	-2%	-5%
Ecuador	9%	-6%	-1%
Taiwan	7%	-3%	-4%
Bolivia	6%	-13%	-5%
Korea	6%	-4%	-1%
Venezuela	6%	-9%	-0%
Turkey	4%	-10%	-0%

* CES production, Thompson (1995b)

Table 4. Japanese Industry Specific Labor*

	Δ1% iron & steel price
Iron & steel wage	4%
Other industrial wages	-0.5% to -0.01%
shared capital	0.1%

	Δ1% in capital
Capital return	-0.3%
Nonmetallic minerals wages	2%
Agricultural wages	2%
Finance wages	1%
Iron & steel wages	1%
Other wages	0%

* Cobb-Douglas production, Thompson (1994)

Table 5. NAFTA and Alabama Manufacturing with Industry Specific Capital*

Various vectors of price changes for sensitivity

Short run output effects under 0.1%

Specific capital returns change up to 20%

Similar long run output effects

Labor intensive industries lose ↓

Textiles

Apparel

Furniture

Capital intensive industries win ↑

Chemicals

Transport equipment

Machinery

Instruments

Production wages ↓

-1% to -7%

Nonproduction wages ↑

up to 3%

* Cobb-Douglas specific factors model, Thompson (1995)

Table 6. Mercosur and Bolivia with Industry Specific Capital

Sector specific capital, shared skilled and unskilled labor*

	Projected price changes	%Δ Capital returns
Business services	-20%	-25%
Agriculture	-12%	-25%
Mining	4%	14%
Natural gas	8%	23%
Manufacturing	30%	47%

%Δ Shared labor	
Skilled wage	-6%
Unskilled wage	-1%

* CES production, Toledo and Thompson (2001)