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Income Redistribution, Trade Prices, and International Capital in Simulated Trade Models

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Abstract

The present paper compares the quantitative impacts of changing prices and capital endowments on income distribution across simulated factor proportions and specific factors models. These models include different production functions, aggregates of skilled labor, and countries. A free trade "program" of 1% changes in prices and capital stocks are the standard of comparison. These simulations illustrate two general quantitative properties. When prices change due to trade, factor intensity has a much stronger influence than factor substitution on income redistribution. Second, foreign capital has a much weaker influence on income redistribution short of improvement in technology.

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

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International trade and capital both increase and redistribute income across domestic factors of production. This income redistribution may explain in part the lack of universal support for free international commerce. In comparative static models of small open economies, price changes due to trade cause factor price adjustments. The Stolper-Samuelson qualitative price link is based on factor intensity but little intuition has developed beyond the two factor, two good model. Similarly, income redistribution due to foreign capital has been difficult to generalize beyond simple models. Further, there is little insight into the magnitudes of these general equilibrium effects. The quantitative implications of introducing specific factors of production have not been explored. Finally, there has been no investigation of the quantitative distortions of aggregation. Simulations provide insight into these 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), based directly on the classic work 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 the policy oriented computable models such as those of Fullerton et al. (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. Capital input is derived as the residual of industrial value added from the Census of Manufacturing. Clark et al. (1988) show that none of these labor groups can be aggregated and the present aggregations provide insight into the resulting distortions. Simulations include models with specific factors of production allowing comparisons with impacts on shared factors.

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. Analysis begins with estimates of $\delta w_i/\delta p_j$ and $\delta w_i/\delta K$ elasticities, the effects of changing prices and foreign capital on factor prices. A free trade "program" of 1% price changes is multiplied by the matrix of $\delta w_i/\delta p_j$ comparative static elasticities to derive potential percentage changes in factor prices. Similarly, 1% changes in the capital stocks are multiplied by the matrix of $\delta w_i/\delta K$ elasticities to project potential effects of foreign capital.

Theoretical anticipations

Changing prices of traded products with constant endowments affect factor prices as reflected in the general equilibrium $\delta w_i/\delta p_j$ elasticities, denoted by w_{ij}. In the model with two factors and two products, the Stolper-Samuelson (1941) theorem establishes a qualitative link between prices of products and factors based on factor intensity. The magnification effect of Jones (1965) shows that any ranking of percentage changes in prices of products is 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 $w_{mk} < 0$. For any ceteris paribus price change, some factor owner must win in terms of real income while another must lose. The w_{ij} elasticities in the present simulations are elastic, illustrating the magnification effect.

A changing capital endowment with prices of traded products held constant affects factor prices as reflected by $\delta w_i/\delta K$ or w_{iK} elasticities. Foreign capital in the present models is assumed to directly add to an exogenous capital endowment with no change in the underlying production function. While national income rises, the entire gain goes to the capital owner due to thecompetitive envelope property. As a general property, the derived w_{iK} elasticities are nearly zero in all of the present simulations.

Simulations of factor proportions models of production and trade

The foundation of factor substitution is a specified cost or production function. Cobb-Douglas (CD) production functions have unitary elasticities of substitution. Balistreri et al. (2001) point out that CD technology cannot be rejected as a null hypothesis for 20 of 28 US manufacturing industries, and all but one of the others have Leontief technology, suggesting Cobb-Douglas is a reasonable starting place for simulations. Flexible translog functions developed by Christensen et al. (1973) allow variation in the elasticity of substitution along isoquants and are typically estimated with systems of partial derivative factor share equations. Uzawa (1962) develops properties of constant elasticity of substitution (CES) production.

In a model with translog production estimated across US states, Thompson (1997b) estimates 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 only about unit value, with capital a weak substitute for both types of labor. Weak substitution between capital and labor is consistent with the literature, including Arrow, Chenery et al. (1961).

Free trade might be expected to lower the US price of aggregated manufactures while raising the relative price 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 aggregate manufactures falling 1% and the price of services rising 1%. The extremely elastic wage effects for suggest there is a great deal at stake in the move toward free trade. In stark contrast, a change in the stock of capital has negligible wage effects in Table 1. Further, free trade generally causes prices to change much more than 1% while a 1% increase in the capital stock would represent huge investment. These results are robust across a number of simulations of Cobb-Douglas, CES, and translog production.

Table 1. US factor price adjustments to "trade program" and capital stock change

	1% price changes [%]	1% increase in K [%]
3 factor model[a]		
Skilled wage	17	0.3
Unskilled wage	-15	-0.0
Capital	2	-0.3
Disaggregated labor adjustment, translog production[b]		
Professional wage	2	0.1
Technical wage	2	0.1
Service wage	2	0.1
Resource wage	-5	1.3
Craft wage	-1	0.1
Operator wage	-6	0.0
Handler wage	0	0.1
Capital	2	-0.3

[a] Thompson (1997b); robust for Cobb-Douglas, CES, and compliments, Thompson (1995a).
[b] Thompson (1990); robust for CES production, Thompson (1997a).

Elasticities of factor prices with respect to factor endowments are close to zero in all the present simulations, a result I have called *near factor price equalization* (NFPE). With an equal number of factors and products, FPE holds and $\delta w/\delta K = 0$. When endowments change, outputs serve as "shock absorbers" leaving little impact 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 with Cobb-Douglas, CES, translog, and production with very strong complements. The w_{ij} elasticities are consistent across all simulations and the w_{iK} elasticities are all nearly identical and close to zero.

Disaggregating the eight labor skill groups, Thompson (1990) reports somewhat larger own translog factor cross price elasticities, between -1 and -3. Factors remain weak substitutes because of the strong influence of factor shares in deriving cross price elasticities. Aggregation lowers the degree of substitution as anticipated in the literature. These disaggregated factor price adjustments in Table 1 are much smaller than in the aggregated model but remain elastic according to the magnification effect. Aggregation exaggerates the w_{ij} elasticities, cofactors of factor shares that increase when aggregated. NFPE holds for the disaggregated labor groups in Table 1 except for the wage of resource workers due to a very high capital share 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 the wage of handlers rises slightly. Foreign capital has a weak positive impact on all wages. Regarding robustness, wide variations in the CES have very little impact on the comparative static results.

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 of Table 2, unskilled wages rise 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 lower estimated elasticities, free trade involves sizeable price changes. There is apparently quite a bit at stake inside the NICs and LDCs as they move toward free trade.

Table 2. NIC and LDC adjustment to 1% trade program[a]

	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

[a] CES production, Thompson (1995b).

Relative influence of factor shares and substitution

The underlying reason for the dominance of factor shares in the w_{ij} elasticities is straightforward. Elasticities of substitution ε_{ik} defined as $\delta ln(a_{ij}/a_{kj})/\delta ln(w_k/w_i)$ are constant along isoquants with CES production and with CD production they equal 1. Cross price elasticities σ_{ik} defined as $(\delta lna_{ij}/\delta lnw_k)$ depend almost entirely on factor shares θ_{kj}, written as $w_k a_{kj}/p_j$. Sato and Koizumi (1973) show that $\sigma_{ik} = \theta_{kj}\varepsilon_{ik}$. With CD technology, it follows that $\sigma_{ik} = \theta_{kj}$. In the present estimates of translog production, the ε_{ik} are close to unit value.

Relative sizes of the 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 simulations, a derived matrix of cross price elasticities σ_{ik} is combined with a matrix of factor shares θ_{kj} and a matrix of industry shares into a comparative static system. The derived w_{ij} elasticities are cofactors of relatively large factor shares while w_{iK} elasticities are cofactors of smaller substitution terms. Generally, w_{ij} elasticities appear to depend little on substitution and w_{iK} elasticities are nearly zero. In 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

In a specific factors model of the Japanese economy, Thompson (1994) examines the potential effects of protection across industrial wages given 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 is reported in Table 3.

Table 3. Japanese industry specific labor[a]

	Δ1% iron & steel price [%]
Iron & steel wage	4
Other industrial wages	-0.5 to -0.01
Shared capital	0.1
	Δ1% in capital stock
Capital return	-0.3
Non-metallic minerals wages	2
Agricultural wages	2
Finance wages	1
Iron & steel wages	1
Other wages	0

[a] Cobb-Douglas production, Thompson (1994).

Specific factors absorb price shocks. If a specific factor were to become mobile across industries, there would be a dampened price effect. An increase in foreign capital has a slight negative effect on the return to capital, very inelastic effects on most industrial wages, and elastic effects on a few industrial wages.

The NAFTA literature anticipates US industries intensive in production labor will face increased import competition. In a study of the effects of projected NAFTA price changes on 17 Alabama manufacturing industries, Thompson (1996) uses Cobb-Douglas production with industry specific capital, production labor, and nonproduction labor. Testing various vectors of price changes for sensitivity, output effects are found to be inelastic with own output elasticities less than 0.1 as summarized in Table 4. Sector specific capital returns are very sensitive with returns adjusting as much as 20% to the vector of 1% price changes. In the long run, such capital return shocks would significantly affect investment and subsequently 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 increase up to 3%.

Table 4. NAFTA and Alabama manufacturing with industry specific capital[a]

Short run output effects < 0.1%
Δ specific capital returns, up to 20% - similar long run output effects
(-) labor intensive industries ↓ textiles, apparel, furniture
(+) capital intensive industries ↑ chemicals, equipment, machinery, instruments
-1% < %Δ production wages < -7%
0% < %Δ nonproduction wages < 3%

[a] Cobb-Douglas production, Thompson (1995), various vectors of price changes.

In a study of Bolivia’s entry into Mercosur, Thompson and Toledo (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 5. Skilled and unskilled labor are projected to suffer moderate wage declines, while sector specific capital returns vary widely. These factor price adjustments are robust over a range of sensitivity analysis. A novel theoretical property is uncovered by these simulations, namely that the w_{ij} elasticities are invariant with respect to the elasticity of substitution given CES production.

Table 5. Mercosur and Bolivia with industry specific capital[a]

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

[a] CES production, Toledo and Thompson (2001).

Conclusion

Support for free trade is less than universal and the present simulations suggest the high degree of potential income redistribution may be a primary reason. Price changes due to free trade can be expected to substantially alter income distribution following patterns suggested by factor intensity or relative factor shares. While defining factor intensity remains a theoretical challenge 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 price links but very little intuition has evolved. It is reassuring that quantitative price effects tend to follow patterns suggested by factor shares. Elastic effects of changing prices on factor prices imply substantial income redistribution with a move to free trade, and specific factors are especially sensitive.

Simulations can gauge the quantitative implications of variable returns, nonhomothetic production, various production and cost functions, different utility functions, international monopoly and monopsony power, heterogeneous products and factors, unemployment, elastic factor supply, joint production, and so on. The effects of aggregation can be examined in simulations. Specific policy issues for various countries or regions and can be examined. Detailed production data can focus on disaggregated industries.

The present simulations suggest factor price equalization would at least nearly hold across competitive economies and foreign capital has a negligible impact on factor prices. It bears repeating that the move to free trade promises to substantially redistribute income among factors of production. To reach the goal of raising unskilled wages in poor countries, trade holds more potential than foreign capital.

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