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Protection and Real Wages: Old and New Trade Theories and Their Empirical Counterparts

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I. Introduction

Our purpose in this paper is to examine the issue of how tariffs, or their removal, affect wages. This is an old issue, of course, dating back in the theoretical literature of international trade to the Stolper-Samuelson Theorem and beyond. The Stolper-Samuelson Theorem, based on the assumptions of the standard Heckscher-Ohlin (H-O) Model of international trade, stated that a tariff would increase the real wage of a country's scarce factor of production. In the context of a presumed labor-scarce country like the United States, this suggests that a move closer to free trade, such as is being negotiated in the North American Free Trade Agreement (NAFTA), would reduce the real wage of labor. Since several computational models of the NAFTA, including our own Michigan Model of the NAFTA (Brown, Deardorff, and Stem, 1992a,b), provide the opposite result, our purpose in this paper will be to explain why.

The reason, of course, is to be found in various departures of the Michigan NAFTA Model from the H-O assumptions. In particular, the Michigan NAFTA Model incorporates several of the assumptions of the New Trade Theory, including particular forms of increasing returns to scale, product differentiation, and imperfect competition, none of which is permitted in the H-O Model. Our procedure here will be first to rederive the effect of a tariff on the real wage from a framework that includes these features alongside more traditional H-O linkages. From the theoretical expression we derive, it will be possible both to understand intuitively, and then to relate quantitatively, the roles that both the old and the new assumptions play in the result. In particular, we will show how the New Trade Theory assumptions serve to alter the effects of a tariff on the real wage in ways that are separate from, and often counter to, the Stolper-Samuelson Theorem. This point has been made previously by Helpman and Krugman (1985, pp.190-195), who argued that the gains from increasing returns to scale could accrue to all factors and thus permit the scarce factor to gain from trade.[1] We make the same point, but we also note that scale effects, if they arise asymmetrically in different industries, will also be shared unevenly across factors for reasons analogous to the uneven Stolper-Samuelson effects of relative price changes.

Our final step will be to use the results of a Michigan NAFTA Model scenario to quantify these several effects. This will provide some, albeit very limited, empirical perspective on the problem. Like any computable general equilibrium (CGE) model, the Michigan NAFTA Model is really a theoretical model that has only been benchmarked with real-world data and estimates of elasticities. Therefore, when we use that model to quantify the components of the effects of tariffs on the real wage, we are falling considerably short of identifying the effects themselves from the data.

The Michigan NAFTA Model is also limited in its allowance for only a single type of labor and thus a single real wage. In contrast to our analysis, Leamer (1992) uses an H-O framework in which there are two types of labor (skilled and unskilled) and physical capital in order to determine how real wages in the United States and Mexico may be affected by a free trade agreement. In his empirical analysis, he relies on factor

[1] Actually, while they argued on the basis of the benefits of increased scale, Helpman and Krugman looked formally only at a simple case in which output per firm did not rise with trade, and in which the additional gains from trade were due to variety, not reduction in cost. We allow for both of these channels for gain, as well as increased competition, in our discussion below.

endowment and trade data for the OECD countries for 1972 and 1985. He then uses his regression estimates combined with measures of Mexican factor endowments under different assumptions that allow for the relative scarcity of capital in Mexico compared to the OECD countries in order to calculate hypothetical levels of Mexican output. His results suggest that Mexico could supply sufficiently large amounts of exports of a number of products to the United States so that the real wages of U.S. workers might be adversely affected. Aside from the differences in including one versus two types of labor, our analysis differs from Leamer's insofar as we include a variety of effects that are part of the New Trade Theory. Since Leamer relies on an H-O framework, it is difficult to determine therefore the extent to which these effects may be reflected in his empirical estimates or how important these effects may be in their own right in relation to the endowment measures that he considers.

There have been some other studies in recent years – see for example Borjas, Freeman, and Katz (1991) and Revenga (1992) – that have used time series data for the United States for the 1970s and 1980s and have concluded that changes in U.S. trade may have led to reductions in the real wages of unskilled as compared to skilled workers. We may also note that Johnson and Stafford (1992) have analyzed the relation between changes in trade and real wages using a theoretical framework in which the United States is presumed to have lost its technological dominance and thus experienced lower real wages as the result of increased imports. These studies would suggest accordingly that the expansion of U.S. trade with Mexico could result in a decline in U.S. real wages of unskilled workers. However, one cannot be certain that this will occur because these studies do not allow explicitly for the role that scale and other effects associated with the New Trade Theory might play in the particular context of the trade liberalization associated with the NAFTA. In any case, since the effects of the NAFTA on the real wage that we have reported in our research depend on a variety of effects incorporated in both the Old and the New Trade Theory, it is desirable to know in more detail how they have come about.

II. A Theoretical Framework

We will examine the effect of a tariff on the real wage in the context of a theoretical framework that incorporates both H-O and New Trade Theory assumptions. The framework is not quite a fully specified model, in that effects on several variables are left unspecified. This will enable us to decompose the tariff-real wage linkage in ways that are common to any of several more complete specific models. For example, the framework is consistent with forms of imperfect competition that include monopolistic competition, oligopoly (with any of a variety of assumptions about strategic behavior), and monopoly, as well as perfect competition. It is also consistent with various forms of product differentiation, both by country (the Armington Assumption) and by firm (monopolistic competition). This amount of generality is bought at the cost of not being able to solve explicitly for effects of the tariff on such important variables as output per firm, number of firms, and the markup of price over marginal cost. These variables will therefore be calculated instead from the Michigan NAFTA Model, where the assumptions about these behaviors are more explicit.

We do not, on the other hand, strive for such generality in all respects. In the theoretical framework (though not, again, in the Michigan NAFTA Model) we allow for only two goods and two factors, so that the strong and familiar Stolper-Samuelson conclusion holds in the absence of New Trade Theory considerations. That is, we do not explore whether departures from Stolper-Samuelson in the CGE literature may result from the fact that they typically include more than two goods and sometimes factors.[2] In addition, while we do allow for departures from perfect competition in goods markets, we assume perfect competition in factor markets. Finally, in common with Stolper-Samuelson, we also assume (both here and in the Michigan NAFTA Model) that both factors are perfectly mobile between sectors. Therefore we are not allowing for the kinds of short-run departures from Stolper-Samuelson that are familiar in the specific factors model.[3]

Following the Jones (1965) explication of the Stolper-Samuelson Theorem, we start with cost-minimizing unit variable factor requirements, a_{ij}, for goods j=1,2 and factors i=L,K, that depend on the ratio of the wage of labor, w, to the rental on capital, r. However, to allow for possible increasing returns to scale, we assume that the a_{ij} include only variable factors and that there may be additional fixed factors required that do not vary with output. Also, we allow these cost-minimizing unit variable factor requirements themselves to depend on an output variable, x_j, though in a manner that does not change optimal variable input proportions. If variable returns were external to the firm, then x_j would be the output of the industry within the country or the world, depending on the reach of the externality. However, for most of our discussion we will interpret x_j as output per firm. Thus

$$a_{ij} = a_{ij}(w/r, x_j) \qquad i = L, K;\ j = 1,2 \tag{1}$$

Using the familiar notation from Jones (1965), we let θ_{ij} be the factor shares of marginal variable cost. To measure scale effects on variable cost, we define

$$\eta_j \equiv -\frac{\partial a_{ij}}{\partial x_j}\frac{x_j}{a_{ij}} \qquad i = 1,2;\ j = L, K \tag{2}$$

which is therefore zero for constant returns to scale and positive for increasing returns to scale in the variable inputs.

With this notation, letting c_j be marginal cost in industry j,

$$c_j = a_{Lj}w + a_{Kj}r \qquad j = 1,2 \tag{3}$$

the usual "hat algebra" of Jones (1965) yields

$$\hat{c}_j = \theta_{Lj}\hat{w} + \theta_{Kj}\hat{r} - \eta_j\hat{x}_j \qquad j = 1,2 \tag{4}$$

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[2] See Ethier (1984) for discussion of extension of the Stolper-Samuelson Theorem to higher dimensions.
[3] See Jones and Neary (1984) for a survey of this literature.

From this system of equations for the two industries, the changes in both the wage and the rental can be solved. Since we are concerned here only with the wage, we obtain

$$\hat{w} = \varepsilon_{L1}\left(\hat{c}_1 + \eta_1 \hat{x}_1\right) - \left(\varepsilon_{L1} - 1\right)\left(\hat{c}_2 + \eta_2 \hat{x}_2\right) \tag{5}$$

where

$$\varepsilon_{L1} \equiv \frac{1 - \theta_{L2}}{\theta_{L1} - \theta_{L2}} > 1 \tag{6}$$

is the "Stolper-Samuelson elasticity." Under H-O assumptions, such that $p_j = c_j$, this gives the effect of a rise in the price of good 1 on the wage, holding the price of good 2 constant as numeraire. It is positive and greater than one if, as we assume, good 1 is relatively labor intensive. Thus, if a tariff raises the domestic relative price of good 1, under H-O assumptions it will raise the nominal wage more than the price.

The remainder of our assumptions here, departing from H-O, allow for divergences between marginal cost and price, as well as divergences among various prices. Let p_j be prices of domestically produced goods, p_j^* be domestic prices of foreign goods, and p_j^w be world prices of foreign goods. Also, let p_j^I be an hedonic index of foreign and domestic prices in industry *j*, taking into account, as noted below, any preference for variety that may be present. We then make the following assumptions:

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Letting price be a multiple, m_j, of marginal cost, we have

$$\hat{p}_j = \hat{m}_j + \hat{c}_j \qquad j = 1,2 \tag{7}$$

Product Differentiation

If domestically produced goods are not perfect substitutes for foreign goods, either because consumers differentiate on the basis of country of origin (the Armington Assumption) or because individual firms at home and abroad produce differentiated products, then prices of both domestically produced goods may depend partially on the domestic prices of foreign goods. Letting φ_j be one minus the elasticity of p_j with respect to p_j^* (so that φ_j is zero if the two are perfect substitutes) and φ_j^+ be the elasticity of p_j with respect to p_i^* we write

$$\hat{p}_j = (1 - \varphi_j)\,\hat{p}_j^* + \varphi_j^+ \hat{p}_i^* \qquad j = 1,2;\ i \neq j \tag{8}$$

Tariffs

Letting t_j be one plus the tariff on good *j*, domestic prices of foreign goods are related to world prices by

$$\hat{p}_j^* = \hat{t}_j + \hat{p}_j^w \qquad j = 1,2 \tag{9}$$

Since we will take good 2 as numeraire and only consider a tariff on good 1, we will have $\hat{t}_2 = \hat{p}_2^* = \hat{p}_2^w = 0$.

Country Size

If the country is small, then p_j^w are unaffected by the tariff. However, if the country is large, then that is not the case. Again taking good 1 as numeraire, we capture this with

$$\hat{p}_1^w = -\Omega \hat{t}_1 \tag{10}$$

Thus Ω is a measure of country size.

Real Wages, Price Indices, and Love of Variety

We assume that the utility function of the representative worker is

$$U = \alpha_1 \log\left[\sum_{i=1}^{n_1} (x_{i1})^{\rho_1} + \sum_{i=1}^{n_1^*} (x_{i1}^*)^{\rho_1}\right] + \alpha_2 \log\left[\sum_{i=1}^{n_2} (x_{i2})^{\rho_2} + \sum_{i=1}^{n_2^*} (x_{i2}^*)^{\rho_2}\right] \tag{11}$$

where

$$\rho_j = 1 - \frac{1}{\sigma_j} \qquad j = 1,2 \tag{12}$$

and $\sigma_j > 1$ are the elasticities of substitution among varieties of good *j*. The utility of the worker then depends on a real wage defined in terms of an hedonic price index that takes account of the preference for variety that is implicit in (11) when σ_j is less than infinite:

$$\hat{p}_j^I = (1 - \delta_j)\left(\hat{p}_j - \frac{\hat{n}_j}{\sigma_j - 1}\right) + \delta_j\left(\hat{p}_j^* - \frac{\hat{n}_j^*}{\sigma_j - 1}\right) \qquad j = 1,2 \tag{13}$$

where δ_j is the import share of good *j*, and n_j, n_j^* are the numbers of varieties of (firms producing) domestic and imported versions of good *j*.

The real wage, ω, is then

$$\hat{\omega} = \hat{w} - \alpha_1 \hat{p}_1^I - \alpha_2 \hat{p}_2^I \tag{14}$$

Solutions

By substituting into (14), first (5) and (13), and then substituting $\hat{c}_j$ from (7), this becomes

$$\hat{\omega} = \varepsilon_{L1}\left(\hat{p}_1 - \hat{m}_1 + \eta_1\hat{x}_1\right) - \left(\varepsilon_{L1} - 1\right)\left(\hat{p}_2 - \hat{m}_2 + \eta_2\hat{x}_2\right)$$
$$- \alpha_1\left[\left(1-\delta_1\right)\left(\hat{p}_1 - \frac{\hat{n}_1}{\sigma_1 - 1}\right) + \delta_1\left(\hat{p}_1^* - \frac{\hat{n}_1^*}{\sigma_1 - 1}\right)\right] \tag{15}$$
$$- \alpha_2\left[\left(1-\delta_2\right)\left(\hat{p}_2 - \frac{\hat{n}_2}{\sigma_2 - 1}\right) + \delta_2\left(\hat{p}_2^* - \frac{\hat{n}_2^*}{\sigma_2 - 1}\right)\right]$$

This is our basic result. It breaks down the effects of a tariff on the real wage into a variety of components that we will discuss and quantify as we go along. These include, in the first term of the first line, the basic Stolper-Samuelson result of a magnified effect of the price on the wage. But they also include, in the first line, various effects that may occur through changing markups, changes in output per firm, and changes in the domestic price of the other good. Finally, in the second and third lines, they include effects on the real value of a given nominal wage, both through the prices of domestic and imported goods in both sectors, and through changes in the numbers of goods available.

For purposes of discussion of these effects, some further manipulation and sorting of the effects in (15) is useful, taking into account the effects among different prices that were assumed above, as well as the effects of a tariff on the non-price variables in (15). For the latter, and again in order to encompass a variety of more specific assumptions about market and industry structure, we simply assume that the variables depend on the relative domestic prices of the two foreign-produced goods, p_1^* / p_2^*, and hence, since we fix p_2^* as numeraire, on p_1^* alone:

$$\hat{m}_j = \mu_j \hat{p}_1^* \qquad j = 1,2 \tag{16}$$

$$\hat{x}_j = \chi_j \hat{p}_1^* \qquad j = 1,2 \tag{17}$$

$$\left(\hat{n}_j, \hat{n}_j^*\right) = \left(\nu_j, \nu_j^*\right)\hat{p}_1^* \qquad j = 1,2 \tag{18}$$

The signs of these parameters will be discussed shortly as we examine the specific effects.

If we now substitute (8) and (16-18) into (15) and let $\hat{p}_2^* = 0$ as numeraire, we get the real wage in terms only of p_1^*. Using (9) and (10), the latter can be expressed in terms of the tariff change. With some combining and rearranging of terms, the result is as follows:

$$\hat{\omega} = \Delta(1-\Omega)\hat{t}_1 \tag{19}$$

where

$$
\begin{aligned}
&(a)\ \Delta = \varepsilon_{L1} - \alpha_1 \\
&(b) \qquad -(\varepsilon_{L1} - \alpha_1)\varphi_1 - \alpha_1\delta_1\varphi_1 \\
&(c) \qquad -\left[(\varepsilon_{L1} - 1)\varphi_2^+ + \alpha_2(1-\delta_2)\varphi_2^+\right] \\
&(d) \qquad +\left[-\varepsilon_{L1}\mu_1 + (\varepsilon_{L1} - 1)\mu_2\right] \qquad (20) \\
&(e) \qquad +\left[\varepsilon_{L1}\eta_1\chi_1 - (\varepsilon_{L1} - 1)\eta_2\chi_2\right] \\
&(f) \qquad +\left[\alpha_1 \frac{(1-\delta_1)\nu_1 + \delta_1\nu_1^*}{\sigma_1 - 1} + \alpha_2 \frac{(1-\delta_2)\nu_2 + \delta_2\nu_2^*}{\sigma_2 - 1}\right]
\end{aligned}
$$

III. Economic Linkages between Tariffs and Real Wages

At this point it is useful to review in intuitive terms the various mechanisms by which a tariff may affect the real wage. For this purpose, we will first run through the logic of the Stolper-Samuelson Theorem itself, then identify the various modifications in this logic that arise when elements of the New Trade Theory are included.

The Logic of the Stolper-Samuelson Theorem

Under the usual assumptions of the H-O model, the Stolper-Samuelson story can be told as follows. Suppose that a country increases a tariff on its (labor-intensive) import good. A number of logical implications follow, each of which is stated below.

1. In a small country, a tariff will raise the price of the imported good by the amount of the tariff.
2. With homogeneous goods, the rise in price of the import good will be matched by an equal rise in price of the import-competing good.
3. This rise in the relative price of the import-competing good will cause the economy's resources to shift towards it and away from export goods.
4. From the Heckscher-Ohlin Theorem, import competing goods will make intensive use of the scarce factor. Therefore, this shift of resources will raise demand for, and hence the price of, the scarce factor relative to the abundant factor.
5. With free entry into the import-competing sector, zero profit requires that the average prices of all factors employed there rise (relative to the price of the export good) by the same amount as the price of the import-competing good.
6. If the scarce factor is not the only factor employed there, this, together with the rise in its price relative to other factors, requires that the scarce factor rise in price also relative to the price of the import-competing good.
7. Since the prices of imports and import-competing goods are equal and have both risen relative to all other prices, this rise in the scarce factor price is therefore an increase in real terms.

That is all that is needed to confirm the Stolper-Samuelson Theorem under the usual assumptions. Now consider how various alternative assumptions might or might not interfere with this chain of logic:

Terms of Trade Effects

Under the usual assumption of homogeneous products, the above logic is correct in assuming that there are no terms of trade effects. World prices are given for both imports and exports, and these cannot be changed by a tariff. Terms of trade effects do arise, however, either if there is product differentiation or if the country is not small. Terms of trade effects do not, of themselves, interfere with Stolper-Samuelson, as we will note. But they are important for the broader issue of the effect of the NAFTA, since they matter for the effect of the Mexican tariff on the United States.

Terms of Trade Effects of Product Differentiation, Small Country

With product differentiation and a small country, the tariff still raises the domestic price of, and reduces the demand for, imports. The price of the imports themselves on the world market will not change, however, because the country is small. If the country's export goods are differentiated from the goods with which they compete abroad though (either by country of origin or by firm), then their prices can change. The shift in demand away from the now tariff-encumbered imports toward domestic goods will raise their price, causing the price of the country's exports to rise relative to its imports. Thus the tariff improves the terms of trade, even for a small country, when there is product differentiation.

This improvement in the terms of trade to some extent undermines the Stolper-Samuelson logic above, since it means that domestic goods rise in price relative to the numeraire world export-competing goods. This rise in price lowers both the nominal and the real values of the factor price increase. These effects are illustrated in (20) in line (c), where φ_2^+ measures the extent to which substitution from imported good 1 to domestic good 2 causes the price of the latter to rise. This increase both reduces the extent to which the relative price of good 1 rises on the domestic market (the first term in (c)), and increases the cost of consuming the domestic good (the second term in (c)). Since this rise in price only occurs because of the increased domestic price of imports, it cannot be as large as that increase, and the increased real factor return must survive. Product differentiation may, as noted below, have a more direct effect in undermining the Stolper-Samuelson logic, but it does not do so through terms of trade effects.

Terms of Trade Effects for a Large Country, Homogeneous Products

If the country is not small, there can also be terms of trade effects of the more usual sort. However, with homogeneous products these effects again cannot interfere with the Stolper-Samuelson logic, except under the extreme conditions of the Metzler paradox. For a large country, the tariff will now fail to raise the price of imports by the full amount of the tariff. This is indicated above by $\Omega > 0$. Indeed, following Metzler, if enough of the tariff revenue is spent on the export good (more than the private sector would have spent), there can be such a fall in demand for imports that their world price falls by more than the tariff ($\Omega > 1$), causing the domestic (tariff-inclusive) price of imports to fall too.

If that happens, then the above chain of causation starts out in the opposite direction, and leads to completely reverse effects on everything, including factor prices.

However, failing that, the improvement in the terms of trade will mean that the domestic price of imports will not rise by as much as the tariff, but it will still rise. Since the Stolper-Samuelson argument depends only on the sign, not the size, of this rise in price, the rest of the logic continues to hold.

Direct Effects of Product Differentiation

Now consider how product differentiation can interfere with the Stolper-Samuelson logic more directly. The argument depended in part on a tariff raising the domestic price of import-competing goods by the same amount as the imports themselves. With product differentiation this will not occur. Instead, the increased price of the imports will cause substitution toward domestic goods and raise their price, but the substitution will not be perfect and the price rise will be less than that of the imports.

At the end of the argument, then, where it is shown that the scarce factor will rise in price relative to the import-competing good, this is no longer sufficient to assure that this is a real increase. It may seem unlikely, but the possibility exists that owners of the scarce factor spend such a large fraction of their income on the import (not the import-competing) good that its still higher price relative to their factor price will make them worse off. Thus we have one mechanism whereby product differentiation can lead a tariff to lower the real price of the scarce factor.

This is seen in the two terms of line (b) of (20). In the first term, product differentiation ($\varphi_1 > 0$) reduces the size of the increase in p_1 and therefore reduces the positive Stolper-Samuelson effect on the real wage. At the same time, in the second term of line (b), by leaving the price of the imported version of good 1 above that of the domestically produced version, it reduces the purchasing power of a given wage in proportion to the share of those imports in consumption ($\alpha_1\delta_1$).

Imperfect Competition

Imperfect competition can also lead to this result, through a different channel, if there are profits made in an industry. In that case, there is no need for cost to equal price, and therefore for average factor prices to rise by as much as the price of the import-competing good. If the tariff somehow increases market power in the import-competing sector, so that the markup of price over cost rises, then average factor prices in that sector will rise by less than the goods price. It then follows that even though the price of the scarce factor rises relative to other factors, it need not rise relative to the good itself. If the good is heavily demanded by the scarce factor owners, then the tariff may lower their real return.

These effects appear in line (d) of (20), where μ_1 represents the effect of the tariff on the markup in domestic industry 1. To the extent that a tariff makes this industry less competitive, this markup will rise and reduce the real wage effects of the tariff. The markup in industry 2, on the other hand, has the opposite effect. Were it to rise as a result of the tariff (as seems unlikely), then factor costs in industry 2 would have to fall relative to industry 1, increasing the needed rise in the relative wage. If, as seems more likely, the tariff in industry 1 increases competition in industry 2 and lowers the markup there ($\mu_2 < 0$), then this further offsets the Stolper-Samuelson effect.

Increasing Returns to Scale

Whether increasing returns to scale strengthen or weaken the Stolper-Samuelson argument depends on what the tariff does to output per firm (or to industry or world output if the increasing returns are external to the firm). This in turn depends on details of the industry that are not explicit in our framework. For example, if there were no entry of firms so that the number of firms was fixed, then a tariff might expand demand for domestically produced goods and output per firm would rise. Alternatively, if there is free entry, a tariff might attract more firms but the output of each might decline.[4] If firm output does rise in the import-competing sector, then costs there will fall for given factor prices, and the restoration of a given markup will require an even larger increase in average factor prices.[5] Therefore the real return to the scarce factor will rise even more. If on the other hand the tariff lowers firm outputs in the import-competing sector and raises costs, then the opposite will occur. Similarly, if the tariff in sector 1 changes output per firm in sector 2, then analogous effects arise there as well, though there a reduction in costs hurts the real wage, since it reduces the relative cost increase of the import sector that must be accommodated by changing factor prices.

To better understand these effects of scale on factor prices, consider an increase in firm output in sector 1, while holding prices and mark-ups constant. The increase in x_1 reduces marginal cost in sector 1, thereby raising the mark-up of price over marginal cost. In order to restore the original mark-up in sector 1 without changing goods prices or disturbing sector 2, we must manipulate factor prices so as to raise marginal cost in sector 1 without changing marginal cost in sector 2. This, in a manner that is completely analogous to the Stolper-Samuelson response to a relative price change, is accomplished by raising the return to the factor used intensively in sector 1, labor, and lowering the return to the other factor.

Therefore, an increase in firm output raises the return to the factor used intensively in that sector and lowers the return to the other factor. Note however, from equation (15), that if scale were to rise in both sectors and if the scale elasticities were the same, then the returns to both factors would rise. (This result is analogous to the fact that an equiproportionate rise in the prices of both goods will also raise the return to both factors of production.)

In line (e) of (20), all of these effects are represented by the changes in output per firm in the two sectors caused by the tariff, χ_1 and χ_2, together with the extent of scale economies in each, η_1 and η_2.

Variety

The final consideration is product variety, which is likely to be inherently ambiguous in its effects on real wages. A tariff seems likely to lead to entry of firms and products in the domestic import-competing industry, but cause exit and a reduction in products by foreigners in that industry and by both domestic and foreign firms in the export sector. Thus, unless there is a relatively strong preference for variety in the import sector compared to the export sector, together with a preference for domestic instead of foreign

[4] The direction of change in firm output depends, in some circumstances at least, on how the elasticity of demand for firm output varies with price.

[5] If the markup changes, then that is handled by the effect already discussed above.

varieties, the presumption will be that the tariff will lower welfare and thus the real wage still further on this account.

These effects appear in line (f) of (20), where four different changes in numbers of firms all appear with positive coefficients.

We turn now to use the Michigan NAFTA Model to evaluate some likely effects of the NAFTA for wages in Mexico, Canada, and the United States.

IV. Description of the Michigan NAFTA Model

Thus far, we have set out a somewhat general, though simplified, theoretical framework designed to decompose the linkages between a tariff and the real wage, and we have provided some intuition about these linkages that may be present in both the Old and the New Trade Theories. We wish now to quantify the different linkages, using our multi-country, multi-sectoral Michigan NAFTA CGE Model. The equations, variables, and parameters of the model are set out in detail in the appendix below. In what follows we will describe briefly some of the main features of the model.[6]

The Michigan NAFTA Model is a large scale computable general equilibrium model that is capable of evaluating the comparative static effects of changes in trade policy on factor prices, economic welfare, the intersectoral allocation of resources, and the international allocation of production. Countries of the model are aggregated into three broad groups. Each of the NAFTA members (the United States, Canada, and Mexico) is modeled individually; another 31 major trading countries are aggregated to create a fourth country;[7] and the remaining countries of the world are consigned to residual rest-of-world supply and demand equations. The countries of the model produce, consume, and trade 23 tradable aggregate products. In addition, there are six nontraded goods. The market structure in each sector is either perfectly competitive or monopolistically competitive, depending on the degree of scale economies in production.[8]

Final demand equations in each country are obtained assuming a representative consumer who maximizes utility subject to a budget constraint,[9] and intermediate demands are derived from the profit maximization decisions of representative firms in each sector. Products in both the perfectly competitive and monopolistically competitive industries are assumed to be characterized by some degree of product differentiation. In the cases where markets are taken to be perfectly competitive, products are differentiated

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[6] The remainder of this section is adapted from Brown, Deardorff and Stem (1992a).

[7] The 31 other countries include 16 industrialized countries – Australia, Austria, Belgium-Luxembourg, Denmark, Germany, Finland, France, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Sweden, Switzerland, and the United Kingdom – and 15 newly industrializing countries – Argentina, Brazil, Chile, Colombia, Greece, Hong Kong, India, Israel, Portugal, Singapore, South Korea, Spain, Taiwan, Turkey, and Yugoslavia.

[8] The six nontraded sectors, which are ISIC one-digit industries 4-9, are assumed to be perfectly competitive, as is the first tradable sector, agriculture. The remaining tradable sectors – 21 3-digit ISIC manufacturing industries plus ISIC 2, Mining and Quarrying – are assumed to be monopolistically competitive.

[9] Household income underlying the final demand equations is set at the level that will hold the trade balance equal to its level in the base data set. This procedure is, in principle, equivalent to setting income equal to factor payments plus tariff revenue.

by country, while in the monopolistically competitive industries products are differentiated by firm.[10]

Turning to the factor markets, the variable input requirements are taken to be the same for the two market structures. Primary and intermediate input aggregates are required in fixed proportion to output.[11] In the monopolistically competitive industries, additional fixed inputs of capital and labor are required.[12] Capital and labor are assumed to be perfectly mobile between sectors and the returns to capital and labor are determined to equate factor demand to an exogenous supply of each factor.

Perfectly competitive firms set price equal to marginal cost, while monopolistically competitive firms maximize profits by setting price as an optimal markup over marginal cost. The number of firms in each industry is determined by the condition that there are zero profits.

International trade in goods is assumed to be subject to tariffs and nontariff barriers (NTBs). NTBs are incorporated by endogenously solving for the *ad valorem* tariff-equivalent rate that would hold imports within each product category covered by NTBs at a predetermined level. An *ad valorem* tariff variable in each product category is then an average of this NTB tariff-equivalent rate and the nominal tariff rate, using the NTB coverage ratio to weight the NTB tariff equivalent.[13]

The bilateral tariff rates are aggregated up from the line-item level using bilateral trade as weights. U.S. tariffs applying to imports from Mexico are then scaled down by factors that reflect the proportions of value in each sector accounted for by U.S. exports to Maquiladora plants in Mexico.

Equilibrium prices are determined in world markets. In the perfectly competitive industries, total demand for each national variety must equal national output. For monopolistically competitive industries, total demand for the variety produced by each firm must equal production by the firm. The *ad valorem* tariff variable discussed above then links equilibrium prices determined in the world system to prices paid by consumers in the country system.

The model is linear in form and thus can be solved by substitution and matrix inversion. The base year is 1989 for data on production, employment, and trade. Input-output coefficients for the production functions were derived from the U.S. input-output table for 1977, the Mexican table for 1980, and the Canadian table for 1976.

For more detail on the values of the key parameters of the model, see Brown, Deardorff and Stem (1992a).

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[10] In both cases, we adopt a modified version of the approach to product differentiation suggested by Dixit and Stiglitz (1977) and Spence (1976). Consumers and producers are assumed to use a two-stage procedure to allocate expenditure across differentiated products. At the first stage, expenditure is allocated across goods, without regard for the country of origin or the producing firm. At this stage the utility function is taken to be Cobb-Douglas, and the production function requires inputs in fixed proportion. In the second stage, expenditure on each monopolistically competitive good is allocated across competing firms without regard to place of production. However, in the case of perfectly competitive goods, individual firm supply is indeterminate. Therefore, expenditure on each good must be allocated across individual countries. The aggregation function in the second case is CES.

[11] Expenditure on primary inputs is allocated between capital and labor, assuming that a CES function is used to form the primary input aggregate.

[12] It is assumed that fixed capital and labor are used in the same proportion as variable capital and labor so that the production function is homothetic.

[13] For additional details, see Deardorff and Stern (1990, pp. 23-24).

V. Adaptation of the Theory to the Michigan NAFTA Model

In order to adapt the theoretical framework discussed in Section II to the Michigan NAFTA Model, we need only to incorporate the zero-profits condition into equation (15). Here, we assume that costs can be decomposed into fixed cost plus variable cost, the latter of which is taken to be proportional to output. Therefore, zero profits implies that

$$\hat{p}_j = \hat{c}_j - \frac{(m_j - 1)}{m_j}\hat{x}_j \tag{21}$$

Comparing this zero-profits equation (21) with mark-up equation (7), we can see that

$$\hat{m}_j = -\frac{(m_j - 1)}{m_j}\hat{x}_j \,. \tag{22}$$

Substituting (22) and (9) into (15), and taking note of the fact that the scale elasticity of marginal cost is zero in the Michigan NAFTA Model (increasing returns enters only through the presence of fixed cost), gives

$$\begin{aligned}\hat{\omega} = {} & \varepsilon_{L1}\left[\hat{p}_1 + \frac{(m_1 - 1)}{m_1}\hat{x}_1\right] - (\varepsilon_{L1} - 1)\left[\hat{p}_2 + \frac{(m_2 - 1)}{m_2}\hat{x}_2\right] \\ & - \alpha_1\left[(1 - \delta_1)\left(\hat{p}_1 - \frac{\hat{n}_1}{\sigma_1 - 1}\right) + \delta_1\left(\hat{p}_1^w + \hat{t}_1 - \frac{\hat{n}_1^*}{\sigma_1 - 1}\right)\right] \quad . \\ & - \alpha_2\left[(1 - \delta_2)\left(\hat{p}_2 - \frac{\hat{n}_2}{\sigma_2 - 1}\right) + \delta_2\left(\hat{p}_2^w + \hat{t}_2 - \frac{\hat{n}_2^*}{\sigma_2 - 1}\right)\right]\end{aligned} \tag{15'}$$

Using (15’) we can decompose the change in wages under the NAFTA into five components: (a) The Stolper-Samuelson effect captures the change in the wage due to the reallocation of resources between sectors accompanying a change in relative prices within an economy. (b) The terms of trade effect captures the increase in the real wage due to a rise in the price of domestic varieties relative to imports. A rise in the price of domestic varieties relative to foreign varieties raises the value of the marginal product of labor in terms of imported goods. (c) The scale effect captures the rise in the real wage due to the realization of economies of scale. (d) The tariff effect captures the increase in the real wage due to the removal of the consumption tax on imports. (e) The product variety effect captures the rise in the real wage due to the increased number of differentiated products available.

Rearranging equation (15'), $\hat{\omega}$ is then the sum of the following five terms:

$$
\begin{aligned}
&(a)\ \textit{Stolper-Samuelson} && (\varepsilon_{L1} - \alpha_1)\,\hat{p}_1 - (\varepsilon_{L1} - 1 + \alpha_2)\,\hat{p}_2 \\
&(b)\ \textit{terms of trade} && \alpha_1\delta_1(\hat{p}_1 - \hat{p}_1^w) + \alpha_2\delta_2(\hat{p}_2 - \hat{p}_2^w) \\
&(c)\ \textit{economies of scale} && \varepsilon_{L1}\frac{(m_1-1)}{m_1}\hat{x}_1 - (\varepsilon_{L1} - 1)\frac{(m_2-1)}{m_2}\hat{x}_2 \qquad (23) \\
&(d)\ \textit{tariff change} && -\alpha_1\delta_1\hat{t}_1 - \alpha_2\delta_2\hat{t}_2 \\
&(e)\ \textit{product variety} && \frac{\alpha_1}{\sigma_1 - 1}\left[\delta_1\hat{n}_1^* + (1-\delta_1)\hat{n}_1\right] + \frac{\alpha_2}{\sigma_2 - 1}\left[(1-\delta_2)\hat{n}_2 + \delta_2\hat{n}_2^*\right]
\end{aligned}
$$

VI. Real Wage Effects in NAFTA Scenarios

The real wage decomposition of equation (23) has been applied to two NAFTA scenarios analyzed using the Michigan Model. Scenario A examines the effect of trilateral tariff elimination. Scenario B additionally allows for a capital inflow into Mexico from the rest of the world that raises Mexico's capital stock by ten percent.

It is straightforward to calculate the terms-of-trade, tariff, and variety effects from the data and model results. The combined Stolper-Samuelson and scale effects are then found as a residual from the effect on the real wage calculated from the model. Results are reported in Table 1.

Tariff Elimination Only

Consider first, Scenario A: NAFTA Tariff Elimination. The "Total" column, indicating percent change in the real wage, is just the sum across the preceding four columns. Note, for example, that the real wage in Mexico rises by 0.46 percent. The tariff component (0.41 %) is of the expected sign. A tariff reduction lowers the consumer price index in Mexico, thereby raising the purchasing power of a worker's wages.

The terms-of-trade effect (-0.06) is negative. For Mexico, import prices rose relative to domestic goods, measured in world prices, offsetting some of the gain associated with the tariff reduction. Mexico's terms-of-trade loss is a byproduct of the fact that its current average tariffs are higher than for other members of the NAFTA.

The variety effect (-0.16%) is also negative for Mexico. Trade liberalization has the effect on Mexico of reducing the number of firms while raising the output of those firms who survive. The associated realization of economies of scale is therefore to some extent offset by the negative effect of reducing the variety of goods available for consumption. Mexican workers are hurt particularly by this loss of variety, because of the important role that Mexican goods play in their consumption bundle prior to free trade.

Finally, as expected, the change in relative prices and the realization of economies of scale also pull up the Mexican real wage by about 0.27 percent. Liberalization was expected to raise the real return to Mexico's abundant factor of production, via the normal Stolper-Samuelson reasoning. But since scale and relative price effects are combined here, we cannot determine from this result whether the Stolper-Samuelson effect is being augmented or offset by a scale effect, although we would expect that both would be contributing to the positive change in the real wage.[14]

Notice also that the combined scale and relative price effects are pulling up the U.S. wage as well. We have previously reported that the NAFTA wil1 increase the real wage in the United States, but we were uncertain what the source of this result might be. Here we see that we still have a positive effect on the real wage after removing the several effects of terms of trade, variety, and the direct effect of tariffs on the price of imports. To the extent that Stolper-Samuelson considerations were to dominate what is left, we would have normally expected that liberalization would lower the real return to labor, but this is not what we find. Evidently scale effects are dominating any Stolper-Samuelson effects that may be present, and raising the real wage in the United States at the same time that wages rise in Mexico.

There are two possible explanations for this result. First, scale gains may have been "tilted" in favor of labor; that is, they may have been most pronounced in the import-competing, labor-intensive sectors of the United States. In models with monopolistic competition, liberalization tends to have its strongest pro-competitive effects in sectors that are most heavily protected. As discussed above, if imports are labor-intensive, then the wage-rent ratio will tend to rise under such circumstances.

However, it is also possible that scale gains were uniformly positive across sectors. In this case, it would be the level, not the tilt, of the scale effects that would matter, and all factors of production would tend to benefit from economies of scale. We will look in a moment at the industry breakdown of these effects to determine whether the level effect or the tilt effect dominates.

Tariff Elimination with Investment

Turn now to scenario B. Here we consider a combination of trilateral tariff removal and a ten percent increase in Mexico's capital stock coming from outside the NAFTA countries. From Table 1 it is clear that the rise in the capital stock has its most pronounced effect on product variety. Note that Mexican labor now gains 0.67% due to increased variety. The capital inflow seems to have increased the overall size of the Mexican economy. In this scenario, Mexico now produces both more output and more variety.

The scale-cum-Stolper Samuelson effects in this scenario are also quite pronounced. Mexican labor experiences a 5.47 percent increase in the real wage. The other effects on the other countries are not noticeably different from Scenario A, however, suggesting that, for labor at least, the inflow of investment into Mexico should not be a major concern.

Decomposition by Industry

At this point we are unable to go much further than the results reported in Table 1. We had hoped to be able to further decompose the wage effects of the NAFTA so as to separate the Stolper-Samuelson and scale effects. We have as yet, however, been unable to do this. The simple two-sector theoretical framework explored above makes this decomposition appear more straightforward than it really is. In a model of many sectors,

[14] See below, however, where we find some evidence to suggest the opposite.

such as the Michigan NAFTA model, the counterpart of the relative price and scale effect in equation (23) is unfortunately not obvious.

We can nonetheless attempt to gain some insight into the relative importance of these scale and price effects for wages by performing our decomposition for each industry individually. In Tables 2-5, we report for each industry the percent changes in producer prices, $\hat{p}_j$ and the markup-adjusted percent changes in firm outputs, $[(m_j - 1)/m_j]\hat{x}_j$, that together with the Stolper-Samuelson elasticities comprise the Stolper-Samuelson and economies-of-scale effects that we identified in equation (23). Tables 2 and 3 report these changes for the United States and Mexico, respectively, under the tariff-only liberalization Scenario A. Similar calculations are reported in Tables 4 and 5 for the tariffs-with-investment scenario. In all of these tables, the industries are ranked according to labor's share in primary input cost, which is also reported. A final column in each table reports the sum of the price and scale effects, essentially the same as the bracketed expressions in the first line of equation (15'), but for each industry individually.

Corresponding to each of Tables 2-5, we have also graphed the results in Figures 1-4. In each case, the purpose is to identify visually whether these price and scale effects tend to rise or fall with labor intensity. As explained above, to the extent that the price changes vary systematically with labor intensity, then they will lead to Stolper-Samuelson effects on wages. A "tilt" in favor of labor intensive sectors will raise the real wage, a tilt against them lower it. Similarly, if changes in scale vary systematically with labor intensity, then these too will have Stolper-Samuelson-like effects on real wages. If scale changes are tilted in favor of the industries with high labor share, then this will tend to raise real wages and lower rents, and if scale changes are tilted against high labor shares, the opposite will occur.

However, unlike the effects of prices, uniform scale changes also have an effect. Whereas a uniform increase in all prices in the same proportion would not alter the real wage (merely changing the numeraire), a similarly uniform increase in scale in all sectors would raise both factor prices by the same proportion. All of this should be evident from equation (23).

The graphs, then, are intended to show whether the price and scale changes are tilted in this way for or against labor intensive sectors, and, in the case of scale effect, also to indicate these "level effects" of uniform scale expansions. It is, however, somewhat difficult to draw strong conclusions from the diagrams. At this point we offer only the visual impression that we think we can see there, and we leave it to the reader to agree or disagree.

In Figure 1, for the United States, it does seem to be the case that the scale changes are tilted slightly upward, so that the scale effect is positively correlated with labor's cost share. As one might expect, tariff liberalization may have had its strongest pro-competitive effects on the labor-intensive sectors in the United States. Consequently, Stolper-Samuelson-like effects associated with increased scale of production in the labor-intensive sectors may have played a role in raising the U.S. wage.

Price effects for the United States also conform to expectations, in that they appear to be tilted downward in Figure 1, though the trend is even less pronounced. As a labor-scarce country, the labor-intensive sectors in the United States are the most heavily protected. Therefore, producer-price changes following liberalization ought to be negatively correlated with labor cost share, and this appears to be the case in Figure 1.

Note, however, that the price component clearly dominates scale. One wonders, then, whether the Stolper-Samuelson type effects associated with the positive correlation between scale and labor-cost share is sufficient to explain the rise in the U.S. wage under the NAFTA. It is perhaps more likely that the overall rise in scale in the United States is drawing up the wage; that is, that the level effect of scale is more important that the combined tilt effects of price and scale together.

These patterns are less evident for Mexico, as shown in Figure 2, although it appears again that scale is positively correlated and price is negatively correlated with labor-cost share. Two industries seem to be most responsible for the observed results: nonferrous metals, which has a labor-cost share of 0.27 in Mexico, and electrical machinery, which has a labor cost share of 0.43.

This is somewhat surprising since Mexico, as the capital-scarce country, might normally be expected to protect its capital-intensive industries. Thus, liberalization should have *lowered* scale and *raised* price in the labor-intensive sectors. However, the opposite appears to be the case. The two most heavily tariff-protected industries in Mexico are wearing apparel and footwear. Therefore, intra-industry specialization, rather than inter-industry specialization, may characterize the NAFTA.

Similar results emerge under scenario B in which capital inflows accompany tariff removal. Price and scale effects are reported in Tables 4 and 5 and depicted in Figures 3 and 4 for the United States and Mexico, respectively. For both countries, scale appears to be positively correlated and producer-price to be negatively correlated with labor-cost share. Scale effects are positive or zero in every single industry in both countries, with the lone exception of nonferrous metals in the United States. Despite this fact, scale still appears to be dominated by price changes.

VII. Conclusion

As we have seen in this paper, the innovations of the New Trade Theory can certainly have important implications for the effects of protection on real wages. By introducing increasing returns to scale, imperfect competition, and product differentiation into a loosely general equilibrium model, we add significantly to the number of linkages between a tariff and the real wage, well beyond the effect traditionally taken into account in the Stolper-Samuelson Theorem. These effects can easily, in theory at least, more than offset the Stolper-Samuelson prediction and lead, for example, to a negative effect of the imposition of a tariff on the real wage of the scarce factor. Some of the channels for this effect that we have identified are reductions in scale, reductions in competition as evidenced by increases in markups, relative price effects that become possible when domestic and foreign goods are imperfect substitutes, and changes in the variety of goods available to consumers. These channels would work in the opposite direction for removal of a tariff.

We have also made a preliminary attempt to quantify some of these effects in the context of the Michigan NAFTA Model, where our earlier work had indicated that the freer trade of the NAFTA would raise real wages in both the United States and Mexico, the former being a surprising result in terms of the Stolper-Samuelson Theorem. Since the Michigan NAFTA Model incorporates a number of features of the New Trade

Theory, we undertook to decompose this effect on the real wage into various components embodying these innovations.

To some extent we were successful. Our Table 1 is able to distinguish several of these effects. However, it leaves two of the most important – the Stolper-Samuelson relative price effect and the effect of increasing returns to scale – intertwined. The combined effect of scale and relative price, it turns out, is enough to generate a rise in the real wage in all three NAFTA countries. Thus the other effects reported there – terms of trade, tariff change, and variety – do not account for the violations of Stolper-Samuelson that we observed.

In an effort to disentangle the scale and price effects of the NAFTA, therefore, we also reported and graphed them for individual industries, ranked by labor shares. Here, although our conclusions are based only on visual inspection of these data and graphs, we conclude the following:

1. Positive scale effects are present in almost all industries in both the United States and Mexico, and the "level effect" of these, we know theoretically, works to raise real wages.
2. Scale effects seem also to be positively correlated with labor intensity, especially in the United States. This asymmetric incidence, or "tilt," of the scale effects would, by itself, tend to raise real wages still further, through a mechanism analogous to the Stolper-Samuelson Theorem but acting through cost rather than price.
3. Scale effects are, however, negatively correlated with price effects, and when they disagree in sign the latter are almost uniformly larger. Therefore, the apparent negative correlation between price effects and labor shares in the United States is likely to dominate the tilt effects of scale, leaving the net effect of the asymmetric incidence of both being negative for the real wage.
4. Thus it appears that the tilt of the scale effects only partially offsets the tilt of the price effects on the real wage. It is instead the overall level of the scale effects that turns the net effect on the real wage positive.
5. In Mexico, we also find, surprisingly, a negative correlation between price changes and labor share. Thus even though Mexico is presumably capital scarce in comparison with the United States, it appears that Mexican tariff protection has tended to favor labor-intensive sectors instead. Thus the rise in the real wage in Mexico due to the NAFTA is also perhaps better attributed to the effects of scale, together with other innovations of the New Trade Theory, than to the more traditional Stolper-Samuelson mechanism.

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Table 1

North American Free Trade
Decomposition of the Effects on the Real Wage

	Percent Changes in the Real Wage Due to				
	Scale and Relative Price	Terms of Trade	Tariff Change	Variety	Total
Scenario A: NAFTA Tariff Elimination					
United States	0.05	0.01	0.01	0.00	0.07
Canada	0.36	-0.06	0.14	0.03	0.47
Mexico	0.27	-0.06	0.41	-0.16	0.46
Scenario B: NAFTA Tariff Elimination Plus Capital Inflow into Mexico					
United States	0.06	0.00	0.01	0.02	0.09
Canada	0.36	-0.06	0.14	0.02	0.48
Mexico	5.47	-0.32	0.41	0.67	6.23

Table 2: NAFTA Only, United States

Price and Scale Effects, Ranked by Labor Share

Product		Labor Share	Price Change	Scale Change	Sum
1	Agriculture	0.24	0.15	0.00	0.15
2	Mining, Quarrying	0.25	0.18	0.01	0.19
4	Utilities	0.26	0.21	0.00	0.21
8	Financial Services	0.28	0.21	0.00	0.21
35B	Petroleum Products	0.36	0.19	0.01	0.20
38A	Misc. Mfrs.	0.36	0.11	0.04	0.15
310	Food	0.47	0.10	0.04	0.14
35A	Chemicals	0.54	0.05	0.06	0.11
331	Wood Products	0.59	0.09	0.04	0.13
6	Wholesale Trade	0.60	0.20	0.00	0.20
36A	Nonmetal Min. Prod.	0.62	0.15	0.02	0.17
341	Paper Products	0.62	0.06	0.05	0.11
7	Transportation	0.62	0.21	0.00	0.21
372	Nonferrous Metals	0.65	0.32	-0.03	0.29
355	Rubber Products	0.67	0.00	0.08	0.08
381	Metal Products	0.68	0.14	0.03	0.17
382	Nonelec. Machinery	0.69	0.10	0.04	0.14
323	Leather Products	0.69	0.01	0.07	0.08
321	Textiles	0.71	-0.22	0.15	-0.07
342	Printing, Publishing	0.71	0.12	0.03	0.15
362	Glass Products	0.74	0.09	0.05	0.14
384	Transport Equipment	0.75	0.12	0.03	0.15
332	Furniture, Fixtures	0.76	0.03	0.07	0.10
383	Electrical Machinery	0.76	0.14	0.03	0.17
322	Clothing	0.79	-0.28	0.17	-0.11
324	Footwear	0.81	-0.02	0.08	0.06
371	Iron, Steel	0.81	0.14	0.03	0.17
5	Construction	0.81	0.16	0.00	0.16
9	Personal Services	0.86	0.20	0.00	0.20

Table 3: NAFTA Only, Mexico

Price and Scale Effects, Ranked by Labor Share

Product		Labor Share	Price Change	Scale Change	Price Plus Scale
8	Financial Services	0.18	0.35	0.00	0.35
6	Wholesale Trade	0.19	0.32	0.00	0.32
2	Mining, Quarrying	0.21	-0.35	0.36	0.01
36A	Nonmetal Min. Prod.	0.24	-0.26	0.23	-0.03
310	Food	0.25	0.01	0.13	0.14
332	Furniture, Fixtures	0.26	-0.25	0.26	0.01
1	Agriculture	0.26	0.22	0.00	0.22
322	Clothing	0.27	0.07	0.11	0.18
372	Nonferrous Metals	0.27	-2.65	1.12	-1.53
38A	Misc. Mfrs.	0.28	-0.87	0.44	-0.43
341	Paper Products	0.29	-0.13	0.20	0.07
321	Textiles	0.33	0.04	0.11	0.15
331	Wood Products	0.34	0.04	0.13	0.17
7	Transportation	0.35	0.26	0.00	0.26
35A	Chemicals	0.35	-0.54	0.32	-0.22
382	Nonelec. Machinery	0.37	-0.85	0.42	-0.43
362	Glass Products	0.37	-0.91	0.46	-0.45
355	Rubber Products	0.38	0.04	0.11	0.15
371	Iron, Steel	0.38	-0.32	0.23	-0.09
342	Printing, Publishing	0.39	-0.30	0.23	-0.07
323	Leather Products	0.40	-0.29	0.23	-0.06
381	Metal Products	0.40	-0.73	0.40	-0.33
384	Transport Equipment	0.41	0.21	0.02	0.23
383	Electrical Machinery	0.43	-4.02	1.57	-2.45
35B	Petroleum Products	0.46	-1.31	0.62	-0.69
4	Utilities	0.54	-0.47	0.00	-0.47
324	Footwear	0.56	-0.52	0.30	-0.22
5	Construction	0.64	-0.32	0.00	-0.32
9	Personal Services	0.82	0.07	0.00	0.07

Table 4: NAFTA with Investment, United States

Price and Scale Effects, Ranked by Labor Share

Product		Labor Share	Price Change	Scale Change	Price Plus Scale
1	Agriculture	0.24	-0.15	0.00	-0.15
2	Mining, Quarrying	0.25	-0.12	0.01	-0.11
4	Utilities	0.26	-0.10	0.00	-0.10
8	Financial Services	0.28	-0.09	0.00	-0.09
35B	Petroleum Products	0.36	-0.12	0.01	-0.11
38A	Misc. Mfrs.	0.36	-0.19	0.04	-0.15
310	Food	0.47	-0.20	0.04	-0.16
35A	Chemicals	0.54	-0.26	0.06	-0.20
331	Wood Products	0.59	-0.23	0.05	-0.18
6	Wholesale Trade	0.60	-0.10	0.00	-0.10
36A	Nonmetal Min. Prod.	0.62	-0.15	0.03	-0.12
341	Paper Products	0.62	-0.26	0.06	-0.20
7	Transportation	0.62	-0.09	0.00	-0.09
372	Nonferrous Metals	0.65	0.25	-0.11	0.14
355	Rubber Products	0.67	-0.33	0.09	-0.24
381	Metal Products	0.68	-0.08	0.00	-0.08
382	Nonelec. Machinery	0.69	-0.16	0.03	-0.13
323	Leather Products	0.69	-0.33	0.09	-0.24
321	Textiles	0.71	-0.59	0.18	-0.41
342	Printing, Publishing	0.71	-0.19	0.04	-0.15
362	Glass Products	0.74	-0.23	0.06	-0.17
384	Transport Equipment	0.75	-0.16	0.03	-0.13
332	Furniture, Fixtures	0.76	-0.29	0.07	-0.22
383	Electrical Machinery	0.76	-0.10	0.01	-0.09
322	Clothing	0.79	-0.67	0.20	-0.47
324	Footwear	0.81	-0.39	0.11	-0.28
371	Iron, Steel	0.81	-0.13	0.02	-0.11
5	Construction	0.81	-0.13	0.00	-0.13
9	Personal Services	0.86	-0.10	0.00	-0.10

Table 5: NAFTA with Investment, Mexico

Price and Scale Effects, Ranked by Labor Share

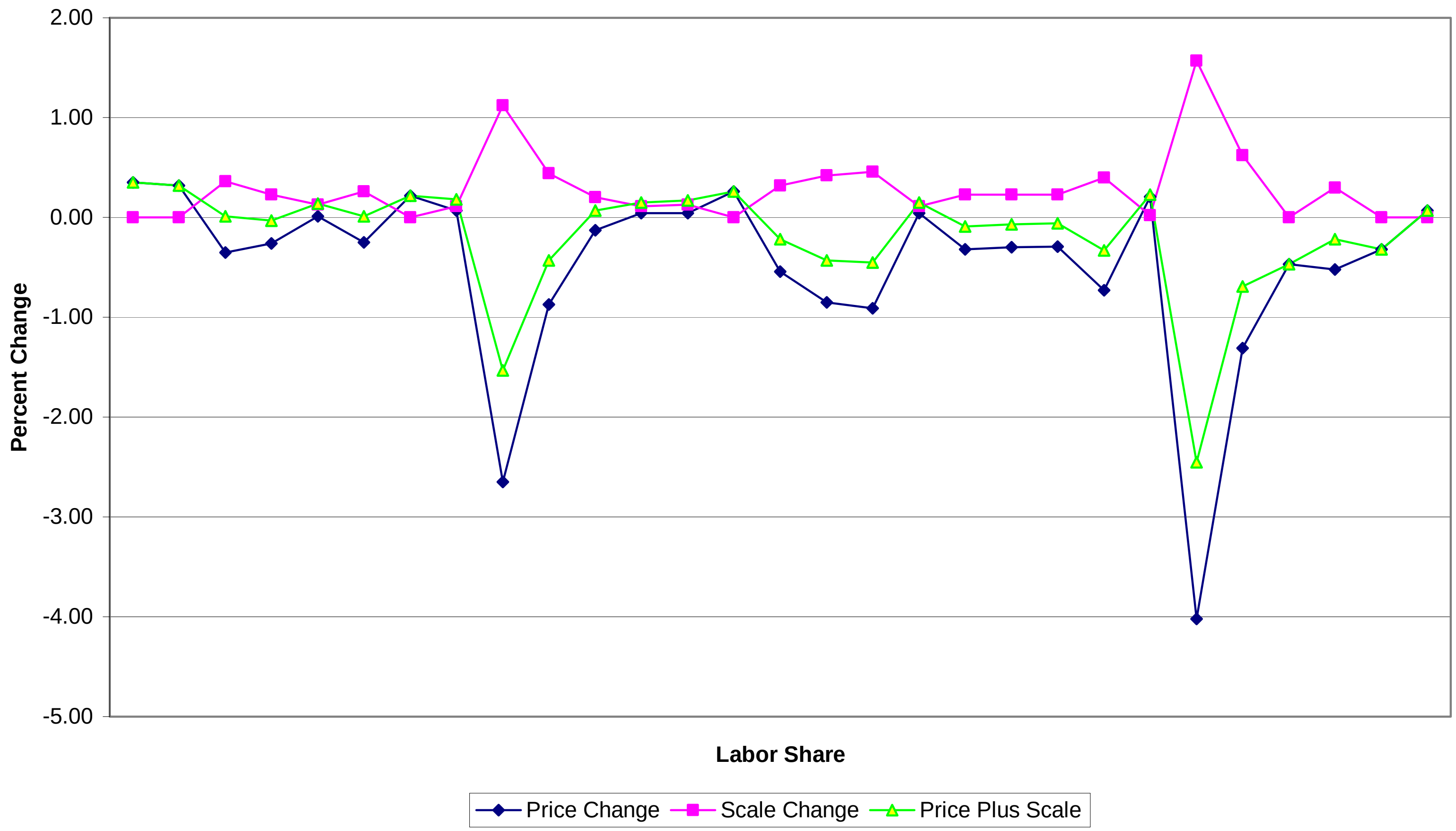
Product		Labor Share	Price Change	Scale Change	Price Plus Scale
8	Financial Services	0.18	2.04	0.00	2.04
6	Wholesale Trade	0.19	1.86	0.00	1.86
2	Mining, Quarrying	0.21	-2.89	2.57	-0.32
36A	Nonmetal Min. Prod.	0.24	-2.26	1.64	-0.62
310	Food	0.25	0.25	0.84	1.09
332	Furniture, Fixtures	0.26	-0.68	1.15	0.47
1	Agriculture	0.26	1.36	0.00	1.36
322	Clothing	0.27	-0.83	1.19	0.36
372	Nonferrous Metals	0.27	-15.10	6.40	-8.70
38A	Misc. Mfrs.	0.28	-4.71	2.51	-2.20
341	Paper Products	0.29	-3.32	2.49	-0.83
321	Textiles	0.33	-1.21	1.46	0.25
331	Wood Products	0.34	0.75	0.78	1.53
7	Transportation	0.35	1.17	0.00	1.17
35A	Chemicals	0.35	-5.21	2.95	-2.26
382	Nonelec. Machinery	0.37	-6.01	3.09	-2.92
362	Glass Products	0.37	-2.58	1.98	-0.60
355	Rubber Products	0.38	-1.36	1.52	0.16
371	Iron, Steel	0.38	-9.61	4.31	-5.30
342	Printing, Publishing	0.39	-2.71	2.08	-0.63
323	Leather Products	0.40	-0.99	1.41	0.42
381	Metal Products	0.40	-7.20	3.72	-3.48
384	Transport Equipment	0.41	-4.89	2.90	-1.99
383	Electrical Machinery	0.43	-11.11	5.03	-6.08
35B	Petroleum Products	0.46	-10.71	5.75	-4.96
4	Utilities	0.54	-1.89	0.00	-1.89
324	Footwear	0.56	-0.24	1.42	1.18
5	Construction	0.64	-1.56	0.00	-1.56
9	Personal Services	0.82	3.26	0.00	3.26

Figure 1: NAFTA Only, United States

Price, Scale Effects, vs. Labor Share

Figure 2: NAFTA Only, Mexico

Price, Scale Effects, vs. Labor Share



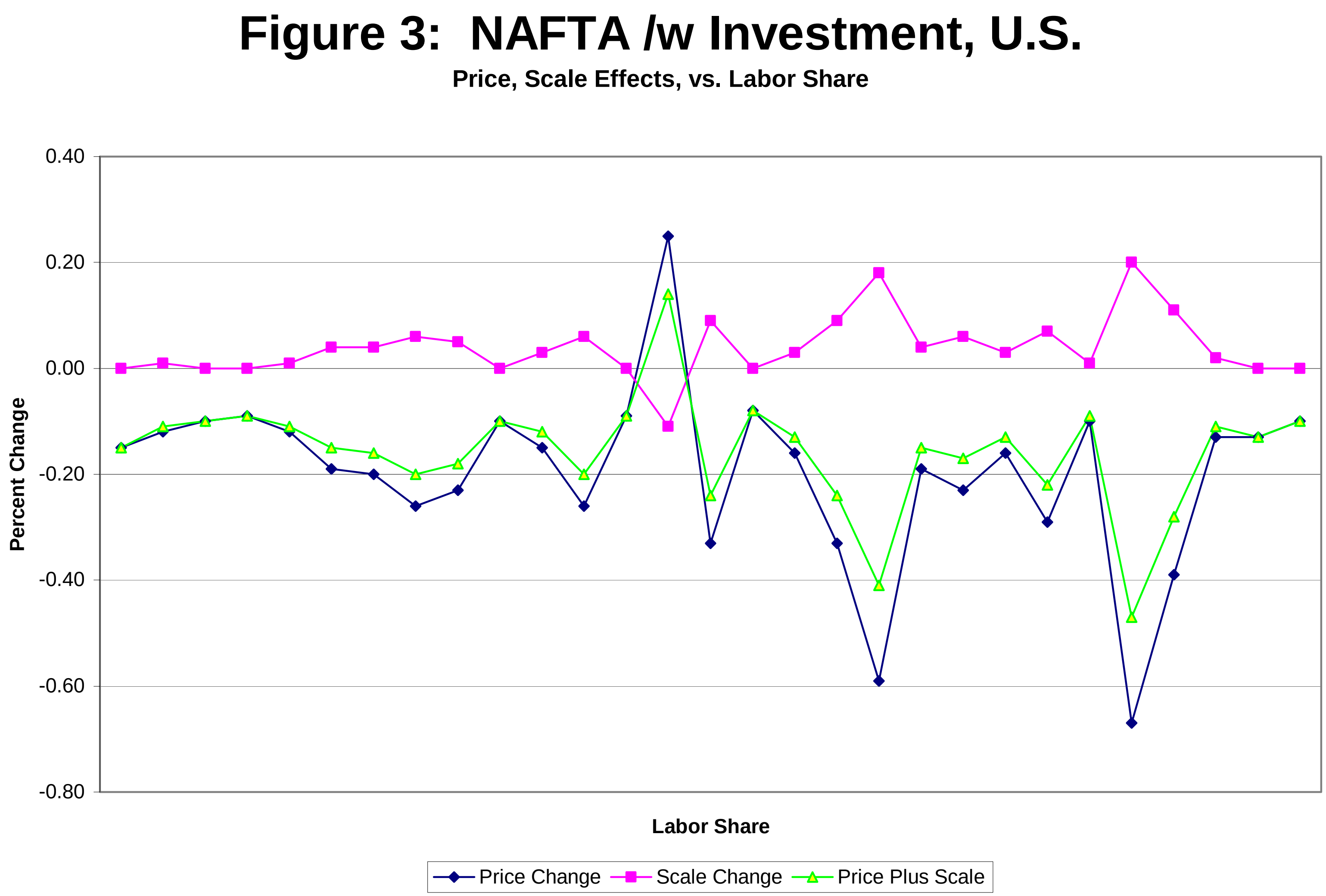


Figure 3: NAFTA /w Investment, U.S.
Price, Scale Effects, vs. Labor Share
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
Percent Change
Labor Share
Price Change
Scale Change
Price Plus Scale

Figure 4: NAFTA /w Investment, Mexico

APPENDIX

The Michigan NAFTA Model: Equation, Notation, and Explanation

COUNTRY EQUATIONS (*i* = 1,…,*m*)

A. Final Demand

(1) $\hat{C}_{ij}^{T} = \hat{E}_i - \hat{P}_{ij}^{T}$ $\qquad j = 1,\ldots,n$

(2) $\hat{C}_{ij}^{N} = \hat{E}_i - \hat{P}_{ij}^{N}$ $\qquad j = n+1,\ldots,n'$

B. Intermediate Demand

(3) $\hat{Z}_{ijk}^{T} = \hat{S}_{ik}$ $\qquad j = 1,\ldots,n;\ k = 1,\ldots,n'$

(4) $\hat{Z}_{ijk}^{N} = \hat{S}_{ik}$ $\qquad j = n+1,\ldots,n';\ k = 1,\ldots,n'$

C. Total Demand

(5) $\hat{D}_{ij}^{T} = v_{ij0}\hat{C}_{ij}^{T} + \sum_{k=1}^{n'} v_{ijk}\hat{Z}_{ijk}^{T}$ $\qquad j = 1,\ldots,n$

(6) $\hat{D}_{ij}^{N} = v_{ij0}\hat{C}_{ij}^{N} + \sum_{k=1}^{n'} v_{ijk}\hat{Z}_{ijk}^{N}$ $\qquad j = n+1,\ldots,n'$

D. Product Demand

(7) $\hat{D}_{ij}^{M} = \hat{D}_{ij}^{T} + \sigma_{ij}\theta_{ij}^{i}\left(\hat{P}_{ij}^{*} - \hat{P}_{ij}^{M}\right) - \dfrac{\sigma_{ij}\theta_{ij}^{i}}{\sigma_{ij}-1}\hat{n}_{ij}$ $\qquad j = 1,\ldots,n$

(8) $\hat{D}_{ij}^{r} = \hat{D}_{ij}^{M} + \sigma_{ij}\left(\hat{P}_{ij}^{M} - \hat{P}_{ij}^{r}\right)$ $\qquad j = 1,\ldots,n;\ r \neq i;\ r = 1,\ldots,m$

(9) $\hat{D}_{ij}^{E} = \hat{D}_{ij}^{M} + \sigma_{ij}\left(\hat{P}_{ij}^{M} - \hat{P}_{ij}^{E}\right)$ $\qquad j = 1,\ldots,n$

(10) $\hat{D}_{ij}^{i} = \hat{D}_{ij}^{T} + \sigma_{ij}\theta_{ij}^{M}\left(\hat{P}_{ij}^{M} - \hat{P}_{ij}^{*}\right) - \dfrac{\sigma_{ij}\theta_{ij}^{i}}{\sigma_{ij}-1}\hat{n}_{ij}$ $\qquad j = 1,\ldots,n$

E. Prices

$$\hat{P}_{ij}^{T} = \theta_{ij}^{i}\hat{P}_{ij}^{*} + \theta_{ij}^{M}\hat{P}_{ij}^{M} - \frac{\theta_{ij}^{i}}{\sigma_{ij}-1}\hat{n}_{ij} \qquad j = 1,\ldots,n \tag{11}$$

$$\hat{P}_{ij}^{M} = \sum_{r=1}^{m+1}\theta_{ij}^{rM}\hat{P}_{ij}^{r} - \sum_{r=1}^{m}\frac{\theta_{ij}^{r}}{\sigma_{ij}-1}\hat{n}_{rj} \qquad j = 1,\ldots,n \tag{12}$$

$$\hat{P}_{ij}^{r} = \hat{P}_{wj}^{r} + \hat{t}_{ij}^{rMeq} \qquad j = 1,\ldots,n;\ r \neq i;\ r = 1,\ldots,m+1 \tag{13}$$

$$\hat{P}_{ij}^{*} = \hat{P}_{wj}^{i} \qquad j = 1,\ldots,n \tag{14}$$

$$\hat{P}_{ij}^{N} = M\hat{C}_{ij} \qquad j = n+1,\ldots,n' \tag{15}$$

$$\hat{P}_{ij}^{*} = \theta_{ij}^{MC}M\hat{C}_{ij} + \theta_{ij}^{FC}\left\lfloor \hat{P}_{ij}^{V} + \hat{n}_{ij} - \hat{S}_{ij} \right\rfloor \qquad j = 1,\ldots,n \tag{16}$$

$$\hat{P}_{ij}^{*} = M\hat{C}_{ij} + \frac{\hat{\eta}_{ij}}{\eta_{ij}+1} \qquad j = 1,\ldots,n \tag{17}$$

$$\hat{P}_{ij}^{V} = \theta_{ij}^{L}\hat{w}_{i} + \theta_{ij}^{K}\hat{r}_{ij} \qquad j = 1,\ldots,n' \tag{18}$$

F. Marginal Cost

$$M\hat{C}_{ij} = b_{ij0}\frac{\theta_{ij}^{VK}}{\theta_{ij}^{MC}}\hat{P}_{ij}^{V} + \sum_{k=1}^{n'}\frac{b_{ikj}}{\theta_{ij}^{MC}}\hat{P}_{ik} \qquad j = 1,\ldots,n' \tag{19}$$

G. Demand for Primary Inputs

$$\hat{V}_{ij} = \hat{S}_{ij} - \hat{n}_{ij} \qquad j = 1,\ldots,n' \tag{20}$$

$$\hat{L}_{ij} = \theta_{ij}^{VK}\hat{V}_{ij} - \overline{\sigma}_{ij}\theta_{ij}^{K}(\hat{w}_{ij} - \hat{r}_{ij}) + \hat{n}_{ij} \qquad j = 1,\ldots,n' \tag{21}$$

$$\hat{K}_{ij} = \theta_{ij}^{VK}\hat{V}_{ij} + \overline{\sigma}_{ij}\theta_{ij}^{L}(\hat{w}_{ij} - \hat{r}_{ij}) + \hat{n}_{ij} \qquad j = 1,\ldots,n' \tag{22}$$

H. Nontradable Goods Market Equilibrium

$$\hat{S}_{ij}^{N} = \hat{D}_{ij}^{N} \qquad j = n+1,\ldots,n' \tag{23}$$

I. Demand Elasticities

(24) $$\hat{\eta}_{rj}^{i} = \frac{(\sigma_{ij} - 1)\theta_{ij}^{r}}{\eta_{rj}^{i} n_{rj}} \left[\hat{P}_{ij}^{r} + \hat{D}_{ij}^{r} - \hat{P}_{ij}^{T} - \hat{D}_{ij}^{T}\right] \qquad j = 1,\ldots,n;\ r \neq i;\ r = 1,\ldots,m$$

(25) $$\hat{\eta}_{ij}^{i} = \frac{(\sigma_{ij} - 1)\theta_{ij}^{i}}{\eta_{ij}^{i} n_{ij}} \left[\hat{P}_{ij}^{*} + \hat{D}_{ij}^{i} - \hat{P}_{ij}^{T} - \hat{D}_{ij}^{T}\right] \qquad j = 1,\ldots,n$$

(26) $$\hat{\eta}_{ij} = \sum_{r=1}^{m} \delta_{ij}^{r} \frac{\eta_{rj}^{i}}{\eta_{ij}} \hat{\eta}_{rj}^{i} \qquad j = 1,\ldots,n$$

J. Primary Factors Market Equilibrium

(27) $$\sum_{j=1}^{n'} h_{ij}^{K} \hat{K}_{ij} = \hat{K}_{i}^{0}$$

(28) $$\sum_{j=1}^{n'} h_{ij}^{L} \hat{L}_{ij} = \hat{L}_{i}^{0}$$

K. National Income Determination

(29) $$dB_{i}^{T} = dB_{i0}^{T}$$

L. Nontariff Barriers

(30) $$\hat{t}_{ij}^{rMeq} = \hat{t}_{ij}^{r} + \left(\hat{D}_{ij}^{r} - \hat{Q}_{ij}^{r} + \hat{n}_{rj}\right) \frac{\theta_{ij}^{rQ}}{\sigma_{ij}\left(1 - \theta_{ij}^{rQ}\right)} \qquad j = 1,\ldots,n;\ r \neq i;\ r = 1,\ldots,m$$

WORLD EQUATIONS

A. Trade Balance

(31) $$\begin{aligned} dB_i^T &= \sum_{j=1}^{n}\left[X_{ij}\hat{P}_{wj}^i + \sum_{r\neq i}^{m} X_{ij}^r\left(\hat{D}_{rj}^i + \hat{n}_{ij}\right) + X_{ij}^E L_E\right] \\ &\quad - \sum_{j=1}^{n}\left[M_{ij}^E\left(\hat{P}_{wj}^E + \hat{D}_{ij}^E\right) + \sum_{r\neq i}^{m}\left(\hat{P}_{wj}^r + \hat{D}_{ij}^r + \hat{n}_{rj}\right)\right] \end{aligned} \qquad i = 1,\ldots,m$$

B. Tradable Goods Market Equilibrium

(32) $$S_{ij}^T\hat{S}_{ij}^T = D_{Ej}^i L_E + \sum_{r=1}^{m} D_{rj}^i\left(\hat{D}_{rj}^i + \hat{n}_{ij}\right) \qquad j = 1,\ldots,n;\ i = 1,\ldots,m$$

(33) $$dS_j^E = \sum_{i=1}^{m} D_{ij}^E\hat{D}_{ij}^E \qquad j = 1,\ldots,n$$

(34) $$dS_j^E = S_j^E\varepsilon_j^E\hat{P}_{wj}^E \qquad j = 1,\ldots,n$$

B. ROW Import Licensing

(35) $$0 = \sum_{j=1}^{n}\left[\left(dS_j^E + S_j^E\hat{P}_{wj}^E\right) - M_j^E L_E - \sum_{i=1}^{m} M_{Ej}^i\hat{P}_{wj}^i\right]$$

Variables

C_{ij}^{T}, C_{ij}^{N} Final demand for tradable and nontradable goods j in country i.

E_i Household income in country i.

P_{ij}^{T}, P_{ij}^{N} Price index of tradable and nontradable goods j in country i.

Z_{ijk}^{T}, Z_{ijk}^{N} Intermediate demand for tradable and nontradable goods j by industry k in country i.

S_{ik} Production of good k in country i.

D_{ij}^{T}, D_{ij}^{N} Total demand for tradable and nontradable goods j in country i.

D_{ij}^{M} Total demand for imports of good j in i.

P_{ij}^{M} Price index of import good j in country i.

P_{ij}^{*} Price of domestic good produced by a representative firm in industry j in country i.

n_{ij} Number of firms in industry j in country i.

D_{ij}^{r} Demand in country i for the good produced by a representative firm in industry j in country r.

t_{ij}^{rMeq} Tariff equivalent imposed by country i on imports of good j from country r.

P_{wj}^{i} World price of good j produced in country i.

MC_{ij} Marginal cost of a representative firm in country i in industry j.

P_{ij}^{V} Price index of primary input aggregate in industry j in country i.

η_{ij} Perceived elasticity of demand by a representative firm in industry j, country i.

η_{rj}^{i} Perceived elasticity of demand by a firm in industry j, country i on its sales to country r.

w_i Wage paid to labor in country i.

r_i Return to capital in country i.

V_{ij} Primary input aggregate demanded by a representative firm in industry j in country i.

L_{ij} Demand for labor in industry j in country i.

K_{ij} Demand for capital in industry j in country i.

B_{i}^{T} Country i's trade balance.

Q_{ij}^{r} Quota restriction on imports of good j from country r by country i.

L_E Import licensing variable for ROW.

Parameters

v_{ij0} Final consumption share of total purchases of good j in country i.

v_{ijk} Intermediate demand for good j by industry k share of purchases of good j in country i.

σ_{ij} Elasticity of substitution between different varieties of good j in country i.

θ_{ij}^{M} Fraction of expenditure on good j in country i devoted to imports.

θ_{ij}^{r} Fraction of expenditure on good j in country i devoted to goods produced in country r.

θ_{ij}^{MC} Variable input share of total cost in industry j in country i.

θ_{ij}^{FC} Fixed cost share of total cost in industry j in country i.

θ_{ij}^{L} Labor's share of expenditure on primary inputs in industry j in country i.

θ_{ij}^{K} Capital's share of expenditure on primary inputs in industry j in country i.

θ_{ij}^{VK} Variable capital's share of total capital employed in industry j in country i.

b_{ij0} Primary input share of total cost in industry j in country i.

b_{ijk} Intermediate input k's share of total cost of production in industry j, country i.

$\overline{\sigma}_{ij}$ Elasticity of substitution between capital and labor in industry j in country i.

δ_{ij}^{r} Fraction of sales by a representative firm in industry j in country i that go to country r.

h_{ij}^{K} Fraction of capital in country i employed in industry j.

h_{ij}^{L} Fraction of labor in country i employed in industry j.

K_i^0 Capital stock in country i.

L_i^0 Labor supply in country i.

B_{i0}^{T} Trade balance of country i.

t_{ij}^{r} Tariff imposed by country i on imports of good j from country r.

θ_{ij}^{rQ} Fraction of imports of good j by country i from country r that are subject to quantitative restrictions.

X_{ij} Country i's exports of good j.

X_{ij}^{r} Country i's exports of good j to country r.

M_{ij}^{r} Country i's imports of good j from country r.

S_j^E ROW supply of good *j*.

ε_j^E ROW supply of good *j* price elasticity.

Explanation of Equations

Notes: Circumflex denotes percent change

"d" denotes a level change

"T'" refers to tradable goods, indexed j=l,…,n

"N" refers to nontradable goods, indexed j=n+l,...,n'

Country Equations

A. Final demand is derived assuming that all households share a common Cobb-Douglas utility function. The percent change in the demand for tradables (j=l,...,n)and nontradables (j=n+l,...,n') is therefore the difference between the percent changes in income and prices.

B. Intermediate demand is derived assuming that all tradable and nontradable goods are required in fixed proportion to production. The demand for each tradable good as an intermediate input is thus proportional to the change in production.

C. Total demand for each good is obtained by summing over final and intermediate demands.

D. Product demand allocates demand for each industry across individual suppliers in all countries, assuming total demand is a CES function of demands from individual suppliers. Allocation is made to all imports (equation 7) and individual domestic suppliers (equation 10), and then expenditure on imports is allocated to individual foreign suppliers (equation 8) and the rest of world (equation 9). In each case, demand depends on relative prices and the number of competing firms.

E. The tradable price index (equation 11) is a weighted average of import prices and prices from individual domestic suppliers. The import price index (equation 12) is a weighted average of all individual foreign firms. All landed prices are related to the world prices, adjusted for tariffs and import quotas (equation 13), except for the price of the domestically produced varieties (equation 14) to which tariffs do not apply.

All nontradable goods markets are taken to be perfectly competitive (equation 15). However, the tradable goods industries are taken to be monopolistically competitive, and firms must incur a fixed cost that is independent of output. The price of tradable goods must therefore cover both marginal cost and average fixed cost (equation 16) and is an optimal markup of price over marginal cost, where the markup is determined by the firm's perceived elasticity of demand (equation 17).

The price of the primary input aggregate (equation 18) is a weighted average of the returns to primary inputs, capital and labor.

F. Marginal cost is the fraction of primary and intermediate inputs that are variable.

G. The primary input aggregate (equation 20), which is a CES aggregate of capital and labor, is required in fixed proportion to firm production. The allocation between labor (equation 21) and capital (equation 22) depends on the wage-rent ratio.

H. The market clearing condition for the nontradable goods sectors requires that supply be equal to demand (equation 23), but that price be equal to marginal cost (equation 15).

I. The firms' perceived elasticity of demand is derived from each firm's demand curve. Firms first calculate the elasticity of demand for their good in each market (equations 24 and 25) and then take a weighted average across all markets.

J. Primary factor market clearing requires that the demand for each factor, summed over all industries, must equal the supply of each factor.

K. National income is equal to the sum of factor payments plus redistributed tariff revenue. This is, according to Walras's Law, equivalent to imposing a balanced trade condition.

L. The import tariff equivalent that connects world prices to landed prices is an average of the *ad valorem* import tariff and the tariff equivalent of any quantitative import restrictions that may apply.

World Equations

A. The trade balance is calculated as the difference between the value of exports and the value of imports.

B. The tradable goods market clearing condition requires that the supply by each firm be equal to its demand summed over all country markets. Rest-of-world supply (equation 34) is an ad hoc supply equation applying a supply elasticity to world price.

C. The rest-of-world is assumed to use an import licensing scheme which holds the value of total demand equal to export revenue.