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WORKING PAPER NO. 645

WAGE CHANGES IN A U.S.-MEXICO FREE TRADE AREA MIGRATION VERSUS STOLPER-SAMUELSON EFFECT

by

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Economic Research Service
U.S. Department of Agriculture

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ABSTRACT

[In this paper, we examine wage changes that can accompany trade liberalization between the United States and Mexico under a North American Free Trade Agreement (NAFTA). There are two forces at work: (1) indirect links between prices and wages as described in the Stolper-Samuelson theorem, and (2) direct effects of migration on labor supplies in the two countries. Much of the debate over potential wage changes reflects views about the links between output prices and factor prices as described in the Stolper-Samuelson theorem. We demonstrate that the analytic model underlying the Stolper-Samuelson theorem does not fully describe labor market changes that will accompany NAFTA because it assumes that factors do not migrate. We extend the 2x2x2 trade model to include endowment changes and demonstrate that price changes and migration can have opposite effects on wages. One needs an empirical model with both price changes and migration to determine which wage effect dominates following trade liberalization. Using an 11-sector computable general equilibrium (CGE) model which includes the United States, Mexico, and the rest of the world, we find that migration effects generally dominate Stolper-Samuelson effects on wages. Empirically, Stolper-Samuelson effects are very small.]

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1. Introduction

A major issue concerning the establishment of a North American Free Trade Agreement (NAFTA) is its impact on wages in Mexico and the United States. One argument is that the agreement will result in higher wages for unskilled labor in Mexico, but lower wages for unskilled labor in the United States.¹ This view can be derived from the Stolper-Samuelson theorem, which links changes in wages and profits to the changes in product prices caused by trade liberalization.² Mexico is abundant in unskilled labor relative to the U.S., and trade reform will increase Mexico's relative price of manufactured goods which it exports to the United States. According to the theorem, unskilled wages will fall in the U.S. and rise in Mexico as Mexican exports displace U.S. production of labor intensive goods.³

There are a number of difficulties in applying the Stolper-Samuelson theorem to the case of NAFTA. First and foremost is that the two countries are linked by more than trade in commodities. In particular, there is a long history of labor migration between Mexico and the U.S., and one would expect that such migration would be sensitive to wage changes brought about by NAFTA. When using the Stolper-Samuelson theorem, one assumes that aggregate factor supplies are constant and that shifts in labor demand curves determine wage changes. However, the effects of trade liberalization on wages can be ambiguous when there is international labor mobility which shifts the labor supply curve as well. One must account for the worker's migration decision.⁴

Second, Mexico currently strongly protects agriculture, especially the food corn sector, and agriculture uses rural labor relatively intensively. The Stolper-Samuelson effects are then more complex, with trade liberalization helping manufacturing, which uses unskilled labor intensively, and hurting agriculture, which uses rural labor intensively. As Mexico

¹See Leamer (1992) who argues based on the Stolper-Samuelson theorem that it is possible for wages to decline in the United States by \$1000 per year. He also assumes that Mexico acquires U.S. technology and becomes much larger, comparable to Italy in the European Community.

²The theorem starts from a trade model with two countries, two factors (labor and capital), and two commodities. When there are more than two factors and commodities (and more goods than factors), it is more difficult to predict how factor prices will change following a change in relative prices. See Jones and Sheinkman (1977) and Ethier (1984) for a discussion of multisectoral extensions of trade theorems.

³An even stronger argument is provided by the factor-price-equalization theorem, which indicates that free trade in commodities can, under various strong assumptions, lead to equalization in factor prices in the trading countries, with U.S. wages falling to meet rising Mexican wages. The theorem requires the assumption that both countries have the same technology in all sectors, differing only in aggregate factor proportions. This assumption is certainly not met in the case of the U.S. and Mexico, where observed differences in production technology are enormous.

⁴In the Hecksher-Ohlin model, trade in factors can be a substitute for trade in commodities. Both can have an identical effect on wages under certain assumptions such as unrestricted factor flows and incomplete specialization under free trade. The issue becomes more complex in U.S.-Mexico relations because technologies are very different and there are migration restrictions. One does not necessarily expect migration to have the same effect on wages as the labor demand changes described in the Stolper-Samuelson theorem.

eliminates barriers to food corn imports, the rural wage should fall.⁵ Given rural-urban migration within Mexico, the fall in rural wages will lead to an increase in the supply of labor to Mexican urban areas and to the manufacturing sectors. This will offset the increase in urban unskilled wages as the manufacturing sectors expand. There will also be an increase in migration pressure to the United States. The net wage changes in both the United States and Mexico will thus depend on a mix of Stolper-Samuelson and migration effects.

Finally, there are many existing distortions in both countries which will not be eliminated by NAFTA. For example, NAFTA does not affect trade barriers that Mexico and the United States maintain against other countries. In addition, there are other distortions, including existing taxes, subsidies, and intersectoral differences in wages and profit rates. All these complicate trade theory, requiring analysis of trade liberalization in a "second best" environment.

In this paper, we examine the links between trade policy and wage changes in the United States and Mexico. We develop an analytical model to demonstrate the impact of both migration and changes in output prices on wages. We show that, in theory, migration and output price changes can have offsetting effects on wages. Furthermore, we identify the crucial elasticities that affect the labor demand and labor supply shifts.

The analytical results suggest that one needs an empirical model which allows for both Stolper-Samuelson and migration effects to assess the wage changes that will accompany NAFTA.⁶ We use a computable general equilibrium (CGE) model which includes both the production links between factor prices and output prices, and migration equations. When specifying migration, we assume that workers migrate between rural and urban areas in Mexico, as well as to the rural and urban labor markets in the United States to maintain constant real wage differences. We discuss how our assumptions about migration, particularly the workers' migration decision, affect migration results in the model and ultimately the wage changes in each country. In the empirical model, we also explore the sensitivity of the wage changes to parameters by calculating various response elasticities.

In addition to migration, the empirical model captures other aspects of the U.S. and Mexican economies that violate the assumptions used to analyze the links between output prices and factor prices in neoclassical trade theory. There are a number of existing distortions, such as indirect taxes and sectoral wage differentials, which are incorporated in the model. We also assume Mexico and the United States have different production technologies, in the use of both intermediate inputs and primary factors.

⁵Implicitly there is a change in Mexico's domestic policy as well. We assumed that the government removes its price guarantee, by which it supports farm incomes by paying more than the market price. The quota on corn helps to support domestic prices, reducing the payment the government must make to satisfy the price guarantees. For more analysis of changes in Mexico's domestic policies see Burfisher, Robinson, and Thierfelder (1992).

⁶While NAFTA encompasses the United States, Mexico, and Canada, we focus on trade liberalization between the United States and Mexico only. Free trade with Mexico is the source of concern over wage changes in the United States.

Other aspects of the model qualify the results, but do not violate the assumptions needed to use the Stolper–Samuelson theorem. For example, rather than assume goods are homogenous, we maintain the Armington assumption that commodities are distinguished by country of origin. When the price of the imported variety changes, the price of the domestic good also changes, but by a lesser amount, depending on the elasticity of substitution. Consequently the output and wage responses are weaker than in a model with homogenous commodities.⁷ We also capture the size differences between the two countries and Mexico's high trade dependence on the United States versus the United States' lower trade dependence on Mexico. These realistic features affect the magnitude of the links between output prices and factor prices.

The remainder of the paper is organized as follows. In section two, we present a simple general equilibrium model with migrating and non-migrating factors to analyze the links to changes in factor prices. Except for dimensionality and substitution elasticities, this analytical model closely represents our empirical model. In section three, we describe our empirical model and compare our treatment of migration to the specification in other models. Our empirical model is a three-country, 11-sector, computable general equilibrium (CGE) model in which countries are linked through trade and labor migration flows. Since most of the migration anticipated under NAFTA will come from rural Mexico, we model farm sectors in detail, giving attention to the rural and unskilled labor markets, and to the structure of agricultural programs.

In section 4, we present model simulations. The simulations are designed to explore the two mechanisms, price changes and migration, through which trade reform leads to wage changes.⁸ In particular, we ask whether migration has a bigger impact on relative wages than do changes in relative output prices, the driving mechanism in the Stolper–Samuelson theorem. We find that migration generally has the dominant effect on wages under NAFTA. Finally, we create a distortion-free base run to provide a theoretically clean starting point to explore the Stolper–Samuelson effects in our empirical model. We then combine migration and a relative price change to analyze their impact in labor markets in the model with no distortions. This combination provides the best empirical representation of the theoretical model with migration and Stolper–Samuelson effects. We present conclusions in section 5.

2. Analytical Model

Jones (1965) describes a simple general equilibrium model in which a representative country produces two goods with two factors. Assuming full-employment and zero-profit conditions, he analyzes the price linkages and quantity relationships important to trade

⁷The household consumes both imports and domestic goods which are aggregated into a composite consumption commodity using a constant elasticity of substitution equation. Likewise, there is a constant elasticity of transformation by which domestic output is converted into goods for either domestic consumption or export. Labor and capital are used to produce the domestic output.

⁸In addition to Stolper–Samuelson and migration effects, terms-of-trade effects in the presence of economies of scale (for the United States, at least) have substantial effects on factor prices. See Brown (1993). We do not account for economies of scale in this paper.

theory. He demonstrates that changes in relative wages depend on changes in relative output prices and that changes in relative output depend on changes in both relative prices and the relative endowment. These results are summarized in equations (1) and (2).

$$(\hat{w} - \hat{r}) = (\hat{P}_1 - \hat{P}_2) \frac{1}{|\Theta|} \quad (1)$$

$$(\hat{X}_1 - \hat{X}_2) = \frac{1}{|\Lambda|} (\hat{L} - \hat{K}) + \frac{(\delta_L + \delta_K)}{|\Lambda| |\Theta|} (\hat{P}_1 - \hat{P}_2) \quad (2)$$

where a ^ indicates the percentage change in the variable and the other parameters are defined below.

w	= the payment to labor
r	= the payment to capital
X ₁	= output of good one
X ₂	= output of good two
P ₁	= price of good one
P ₂	= price of good two
L	= aggregate labor supply
K	= aggregate capital supply.

Equation (1) links changes in factor returns to changes in output prices. Equation (2) links output changes to changes in both factor endowments and relative output prices.

Relative factor intensity, in the value sense, reflects the allocation of revenue to labor and capital in production. It is represented in the determinant of the matrix of factor payment shares by sector:

$$|\Theta| = \theta_{L1}\theta_{K2} - \theta_{L2}\theta_{K1} \quad (3)$$

where θ_{ij} , $i = L, K$; $j = 1, 2$ indicates the share of revenue from production of good j that is allocated to factor i . When $|\Theta| > 0$, good one is relatively labor intensive in terms of the share of revenue allocated to labor.

Likewise, one can represent physical factor intensity in terms of the share of the endowments of labor and capital allocated to each sector. The determinant of the matrix of factor endowment shares is given by:

$$|\Lambda| = \lambda_{L1}\lambda_{K2} - \lambda_{L2}\lambda_{K1} \quad (4)$$

where λ_{ij} , $i = L, K$; $j = 1, 2$ indicates the share of the endowment of resource i used in sector j . When $|\Lambda| > 0$, good one is relatively labor intensive.

Factor substitution in production allows producers to substitute away from the factor whose price increases. For example, as the relative wage increases, both sectors become relatively more capital intensive. The following parameter represents the producer savings from switching to less labor intensive production techniques when the relative wage increases and output does not change:

$$\delta_L = \lambda_{LI} \theta_{KI} \sigma_1 + \lambda_{L2} \theta_{K2} \sigma_2 \quad (5)$$

Likewise, there are savings when producers switch to less capital-intensive production techniques when the relative payment to capital increases and output does not change:

$$\delta_K = \lambda_{KI} \theta_{LI} \sigma_1 + \lambda_{K2} \theta_{L2} \sigma_2 \quad (6)$$

where σ_j is the production response to a relative factor price change in sector j and θ_{ij} and λ_{ij} are defined above; δ_i ($i = L, K$) is positive since all components are positive.

Both relative price changes and labor supply changes can affect relative factor returns. When the relative price changes, there are indirect links to wages due to output changes. The change in production generates a change in the demand for labor. For example, when output of the labor intensive good expands, there is a net increase in labor demand.⁹ When the relative endowment changes as well, there is a direct effect on wages as the supply of labor changes. One can summarize these labor demand and labor supply effects using Jones' equations. Substituting equation (1) into equation (2) and rearranging, one finds that:

$$(\hat{w} - \hat{r}) = [(\hat{X}_1 - \hat{X}_2) - \frac{1}{|\Lambda|} (\hat{L} - \hat{K})] \frac{|\Lambda|}{(\delta_L + \delta_K)} \quad (7)$$

To incorporate the effects of changes in relative output prices on relative factor prices, one needs to know how responsive the relative output level is to a relative price change. Essentially, one must specify the shape of the production possibilities frontier (PPF) for goods one and two. The transformation elasticity is defined as:

$$\Omega = - \frac{d(X_1/X_2)/(X_1/X_2)}{d(P_1/P_2)/P_1/P_2} \quad (8)$$

In Jones' notation, the expression becomes:

⁹Both sectors do become relatively more capital intensive as the relative wage increases.

$$\Omega = - \frac{(\hat{X}_1 - \hat{X}_2)}{(\hat{P}_1 - \hat{P}_2)} \quad (9)$$

Using equations (1) and (2), which summarize technology in Jones' model, and assuming no endowment change, one can define the transformation elasticity as:

$$\Omega = - \frac{(\delta_L + \delta_K)}{|\Lambda| |\Theta|} \quad (10)$$

When there are no labor market distortions, which appear as exogenous wage differentials by sector, Ω is negative because the sign of $|\Lambda|$ equals the sign of $|\Theta|$ and δ_L and δ_K are positive by definition.¹⁰

Substituting equation (10) into equation (7), one can describe both the price effect, which works through indirect links, and the migration effect on relative factor returns.¹¹

$$(\hat{w} - \hat{r}) = [-\Omega(\hat{P}_1 - \hat{P}_2) - \frac{1}{|\Lambda|}(\hat{L} - \hat{K})] \frac{|\Lambda|}{(\delta_L + \delta_K)} \quad (11)$$

When good one is relatively labor intensive, $|\Lambda|$ is positive. Using equation (11), when the relative price of good one (the labor intensive good) increases, the relative wage increases, as specified in the Stolper-Samuelson theorem. When the labor supply increases, and prices are not held constant, there is downward pressure on wages. The wage change in response to an endowment change is independent of the relative factor intensity of good one and good two.

To compare the magnitude of the two changes, compare the coefficient on the percent change in prices to the coefficient on the percent change in the endowment. After simplifying, the coefficient on the relative price change reduces to:

$$\frac{1}{|\Theta|} \quad (12)$$

When there is no endowment change, this coefficient describes the links between factor prices and output prices stated in the Stolper-Samuelson theorem. The more extreme the differences in factor intensities, the bigger the relative factor price change following a change in output prices. The coefficient on the relative endowment change reduces to:

¹⁰Jones (1971) describes conditions such that the sign of $|\Lambda|$ does not equal the sign of $|\Theta|$. Essentially, $\Omega < 0$. See Thierfelder (1992) for a discussion of Jones' model with factor market distortions and an extension to include efficiency wage sectors which justify the presence of wage differentials.

¹¹One can show that equation (11) reduces to equation (1) when the endowment is constant.

$$- \frac{1}{\delta_L + \delta_K} \quad (13)$$

The coefficient indicates the change in factor intensity in each sector following an endowment change, when output prices can vary. This coefficient reduces to zero when output prices are held constant.¹² In this case, relative factor prices do not change and one can derive the Rybczynski results.

A migration change essentially is an endowment change in Jones' specification. We assume workers migrate in response to relative wage differences. To determine migration levels, one must evaluate the labor market equilibrium in each country as well as the migration equation. The system of labor demand and labor supply equations by country, including migration between countries, is solved simultaneously. Labor demand in each country is a function of the output price and the relative wage. The vertical labor supply curve shifts when labor migrates. In theory, one might expect labor to migrate in response to wage differentials and move until wages are equal in both countries.¹³ Studies of wages in the United States and Mexico suggest that existing wage differentials will persist under trade liberalization, so we assume labor migrates to maintain a constant wage differential between the two countries.¹⁴

To identify sources of the wage change in a simple general equilibrium model with migration, one can consider the forces affecting labor supply and demand independently. Labor demand shifts depend on changes in the relative output price given factor intensities in production. For example, an increase in the output of the labor intensive good means that labor demand will increase. The magnitude of the labor demand shift depends on the output elasticity to a relative price change and on the elasticity of labor demand to an output change. Given a fixed aggregate labor supply, the wage will increase following an increase in the price of the labor intensive good.

When one allows labor to migrate, and assumes workers migrate to maintain fixed wage differentials, labor moves into the country that experiences the wage increase under no migration. The increase in labor supply reduces the wage. Since the supply curve shifts, the wage elasticity of labor demand matters in determining wage changes in the home country. Migration occurs until the initial wage differential has been re-established. When

¹²From equations (9) and (10), one can show that:

$$\frac{1}{\delta_L + \delta_K} = \frac{(\hat{P}_1 - \hat{P}_2)}{(\hat{X}_1 - \hat{X}_2)}$$

Equation (13) reduces to zero when relative output prices are held constant.

¹³See Mundell (1957) for further discussion.

¹⁴For example, Reynolds (1992) projects a wide gap between relative wages across the two countries regardless of forces that would promote convergence. Levy and van Wijnbergen (1993) assume that labor migrates within Mexico to maintain a fixed real income differential.

the labor demand curve is inelastic, a small amount of migration is needed to affect wages and restore the initial differential. More migration occurs when the labor demand curves in each country are more elastic.

As summarized in equation (11), wage changes become indeterminate when one allows migration in conjunction with price changes in the analytical two-country model. One needs to specify in more detail what motivates migrants. To determine the wage changes that will accompany NAFTA, one must use an empirical model which accounts for trade and migration flows. In an empirical model, the magnitude of the labor demand and labor supply changes will depend on the elasticities implicit in the observed base-year equilibrium. From the base data for each country, one can calculate empirically the output elasticity to a price change, the elasticity of labor demand to output changes, and the wage elasticity of labor demand by sector from data on the United States and Mexico.

3. Three-Country CGE Model

3.1 Core FTA-CGE Model

Our empirical model builds on earlier models of the U.S.-Mexico free trade area (FTA) by Hinojosa-Ojeda and Robinson (1992) and Robinson *et al.* (1993).¹⁶ The FTA-CGE model is an 11-sector, three-country, computable general equilibrium model. The production and consumption behavior in the United States and Mexico is modeled in detail, and the two countries are linked through trade and migration flows. There are import demand and export supply equations to represent the interaction between the rest of the world and either the United States or Mexico. Table 1 presents aggregate data for the United States and Mexico, as well as the trade flows between them; the data are used to generate the benchmark or base solution of the FTA-CGE model. Mexico is a much smaller and poorer economy and has a higher share of trade in GDP than the U.S. The U.S. market accounts for over 60% of Mexican exports, while Mexico buys only about 5% of total U.S. exports. As is typical of a developing country, rural labor is a large share of the Mexican labor force: 23.8% compared to 1.1% for the U.S.

Table 2 shows the sectoral structure of GDP, employment, and trade for the two countries, as well as existing trade barriers. The model's 11 sectors include four farm and one food processing sector. The food corn sector refers to corn used for human consumption. In Mexico, this includes white corn, the small proportion of domestic yellow corn used for food, and No. 2 yellow corn imports from the U.S., which are assumed to enter food use. In the U.S., the food corn sector refers to its world exports of No. 2 yellow corn. The program crops sector is composed of the other crops eligible for U.S. deficiency payments — feed corn, food grains, soybeans, and cotton. Other agriculture includes livestock, poultry, forestry and fishery, and other miscellaneous agriculture. The fruits and vegetables sector in Mexico includes beans, a major food crop.

¹⁶The latter provides a complete listing of the equations of the model. The FTA-CGE model is implemented using the GAMS software, which is described in Brooke, Kendrick, and Meeraus (1988).

Table 1 — Comparative Aggregate Data, U.S. and Mexico

	Mexico	U.S.
GDP (\$US billions, 1988)	175.0	4485.7
Per Capita GNP (\$US, 1988)	1,760	19,990
<u>Trade flows (percent of GDP)</u>		
Total exports	16.5	7.9
Exports to partner	10.1	0.4
Total imports	5.8	11.6
Imports from partner	4.3	0.9
<u>Employment structure (percent)</u>		
Rural labor	23.8	1.1
Urban unskilled labor	14.1	17.7
Urban skilled labor	37.1	48.5
White collar workers	25.0	32.7
Total	100.0	100.0
Population, ages 15-64 (millions)	49	162
Total population (millions)	84	246

Sources:

Per capita GNP, and population data refer to 1988 and come from World Bank, World Development Report 1990. Mexico's GDP is calculated using official exchange rates. Employment data are unpublished data from Dolores Nieto, Colegio de Mexico. Trade and GDP data are from U.S. and Mexican social accounting matrices developed by the Economic Research Service, U.S. Department of Agriculture (USDA/ERS).

The base year for Mexico is mostly 1988.¹⁶ The U.S. uses a 1987 base year because of the severe contraction of agricultural output following the 1988 drought. Bilateral trade flows are from 1988. Because of the volatility in U.S. 1987-88 agricultural output, the model follows Adams and Higgs (1986) in the use of a "synthetic" base year for the U.S., imposing 1988 U.S.-Mexican bilateral trade flows on a 1987 base U.S. economy.

The model is in the theoretical tradition of neoclassical, trade-focused, CGE models.¹⁷ Each sector produces a composite commodity that can be transformed according to a constant elasticity of transformation (CET) function into a commodity sold on the domestic market or

¹⁶The data base is documented in Burfisher, Thierfelder, and Hanson (1992). Unpublished data on Mexican employment were compiled by Dolores Nieto, Colegio de Mexico.

¹⁷Robinson (1989) and de Melo (1988) survey single-country, trade-focused, CGE models.

Table 2 — Sectoral Structure of U.S. and Mexican Economies, Base Solution

Commodity	Sectoral shares (percent) in:										Bilateral import barriers	
	GDP		Employment		Imports		Exports					
	U.S.	Mexico	U.S.	Mexico	U.S.	Mexico	U.S.	Mexico	U.S.	Mexico	U.S.	Mexico
Food corn	0.0	0.7	0.0	6.3	0.9	0.0	0.3	0.0	0.0	0.0	0.0	45.0
Program crops	0.5	1.1	0.4	5.3	2.9	0.0	3.3	0.1	0.0	0.0	0.0	12.9
Fruits/vegetables	0.2	1.1	0.4	3.5	0.1	0.6	0.4	3.0	13.2	12.5	13.2	12.5
Other agriculture	0.8	5.1	1.4	8.6	1.3	1.7	0.4	3.8	0.6	8.9	0.6	8.9
Food processing	1.7	6.2	1.5	2.5	5.2	2.2	2.9	3.6	3.8	8.2	3.8	8.2
Other light mfg.	4.5	5.5	5.1	2.7	4.3	15.0	7.0	6.0	4.7	8.1	4.7	8.1
Oil and refining	2.2	2.9	0.5	0.5	5.0	12.0	2.7	10.2	1.5	8.8	1.5	8.8
Intermediates	5.6	8.2	4.5	3.2	16.8	13.0	14.0	12.3	2.2	8.0	2.2	8.0
Consumer durables	1.9	2.5	1.7	0.8	14.5	28.3	10.0	18.7	1.8	12.0	1.8	12.0
Capital Goods	5.2	3.4	4.9	2.2	25.6	24.6	31.8	12.0	3.6	12.7	3.6	12.7
Services	77.4	63.3	79.6	64.4	23.5	2.6	27.5	30.3	0.0	0.0	0.0	0.0

Notes:

Bilateral import barriers are the combined rate of trade-weighted tariffs and tariff equivalents of quotas on trade between Mexico and the U.S. Percent composition columns sum to 100%, except for rounding error. Data are for 1987 for U.S. and 1988 for Mexico.

Sources:

Burfisher, Thierfelder, and Hanson (1992).

into an export. Output is produced according to a constant elasticity of substitution (CES) production function in primary factors, and fixed input-output coefficients for intermediate inputs. The model simulates a market economy, with prices and quantities assumed to adjust to clear markets. All transactions in the circular flow of income are captured. Each country model traces the flow of income (starting with factor payments) from producers to households, government, and investors, and finally back to demand for goods in product markets.

Consumption, intermediate demand, government, and investment are the four components of domestic demand. Consumer demand is based on Cobb-Douglas utility functions, generating fixed expenditure shares. Households pay income taxes to the government and save a fixed proportion of their income. Intermediate demand is given by fixed input-output coefficients. Real government demand and real investment are fixed exogenously.

We use import demand equations based on the Almost Ideal Demand System (or AIDS).¹⁸ The AIDS function is a flexible functional form that can generate arbitrary values of pairwise substitution elasticities at a given set of prices, and also allows expenditure elasticities different from one. It generates more realistic empirical price behavior than does the more common CES formulation.

The model includes six primary factors and associated factor markets: rural labor, urban unskilled labor, urban skilled labor, professional labor, capital, and agricultural land. Full employment for all labor categories is assumed and aggregate supplies are set exogenously. The model can incorporate different assumptions about factor mobility, including labor migration (discussed below). In the experiments reported here, we assume that agricultural land is immobile among crops, but that all other factors are intersectorally mobile, including capital. Note, however, that labor markets are segmented. Rural labor does not work in the industrial sectors, and urban labor does not work in agriculture. These labor markets are linked through separate migration equations. The results should be seen as reflecting adjustment in the long-run, with capital able to leave the agricultural sectors.

Agricultural trade policies and domestic farm programs are modeled explicitly, including tariffs, import quotas, input subsidies to producers and processors, Mexico's tortilla subsidies to low income households, and the U.S. deficiency payment program. Deficiency payments and the tariff-equivalents of quotas are determined endogenously and are not treated as fixed *ad valorem* wedges.

There are three key macro balances in each country model: the government deficit, aggregate investment and savings, and the balance of trade. Government savings is the difference between revenue and spending, with real spending fixed exogenously but revenue depending on a variety of tax instruments. The government deficit is therefore determined endogenously. Real investment is set exogenously, and aggregate private savings is

¹⁸The AIDS specification in this model draws on work by Robinson, Soule, and Weyerbrock (1991).

determined residually to achieve the nominal savings-investment balance.¹⁹ The balance of trade for each country (and hence foreign savings) is set exogenously, valued in world prices.

Each country model solves for relative domestic prices and factor returns, which clear the factor and product markets, and for an equilibrium real exchange rate which brings aggregate export supply and import demand into balance, given the exogenous aggregate balance of trade in each country. The model determines two equilibrium real exchange rates, one each for the U.S. and Mexico, which are measured with respect to the rest of the world. The reported exchange rate is the price-level-deflated exchange rate; it is the nominal exchange rate deflated by a domestic price index. The cross rate (U.S. to Mexico) is implicitly determined by an arbitrage condition. In this class of models, which include a non-traded domestic variety of each commodity, the real exchange rate is essentially the ratio of the prices of non-tradable to tradable goods in each country.²⁰ Since commodities are valued in local currency (pesos in Mexico and dollars in the United States), prices within each country are normalized to a country-specific domestic price index.²¹ The numeraire goods are aggregates of the non-traded goods in each country. This specification is convenient for a model in which the commodities are not homogenous.

We do not specify production and consumption details for the rest of the world. Instead we specify world demand and supply functions for traded goods, largely by assuming fixed world prices.²² In effect, the model specifies sectoral export supply and import demand functions for each country, and solves for a set of world prices that achieve equilibrium in world commodity markets. At the sectoral level, in each country, demanders differentiate goods by country of origin and exporters differentiate goods by country of destination.

Four types of elasticity parameters are used in the model. The production specification requires sectoral elasticities of substitution among primary factors. The CET export supply functions require elasticities of transformation between goods sold on the home and export markets. The AIDS import demand functions require sectoral income elasticities and substitution elasticities for home goods and for goods from each import source. We have drawn on estimates and "guesstimates" from various studies, including Hinojosa and Robinson (1992); Hanson, Robinson, and Tokarick (1993); and Reinert and Shiells (1991).²³

¹⁹Enterprise savings rates are assumed to adjust to achieve the necessary level of aggregate savings in each country.

²⁰See Devarajan, Lewis, and Robinson (1993) for a further discussion of the real exchange rate in CGE models.

²¹This specification, by which we hold the domestic price index constant in the United States and Mexico, is used in other multi-country CGE models. See for example, Reinert, Roland-Holst, and Shiells (in this volume).

²²In two sectors, corn and program crops, we assume downward sloping world demand curves for U.S. exports, and hence world prices are not fixed for these sectors.

²³In lieu of econometric estimation, one can do sensitivity analysis to check for the robustness of the model results using alternative elasticity parameters. See Burfisher, Robinson, and Thierfelder (1992) for a discussion of model sensitivity to the elasticities used in the food corn sector, a major source of migrating labor. See Burfisher (1992) for a discussion of model sensitivity to parameters in all sectors.

3.2 Migration

In the FTA-CGE model, we specify three migration flows: rural Mexico to rural U.S. labor markets, urban unskilled Mexico to urban unskilled U.S. labor markets, and internal migration within Mexico from rural to unskilled urban labor markets.²⁴ In equilibrium, international migration adjusts to maintain a specified ratio of real average wages, $wgdf_{mig}$, for linked labor markets in the two countries, measured in a common currency. Similarly, internal migration in Mexico maintains a specified ratio of average real wages between the rural and unskilled urban markets. The international migration equation is:

$$WF_{mig, mx} = wgdf_{mig} \cdot WF_{mig, us} \cdot \frac{EXR_{mx}}{EXR_{us}} \quad (14)$$

where the index *mig* refers to the migration flow, $WF_{mig,k}$ is the real average wage, and EXR_k is the exchange rate. The domestic labor supply in each skill category in each country is adjusted by the migrant labor flow. In the internal migration equation for Mexico, rural and urban workers compare wages within Mexico, and there is no exchange rate effect.

Migration flows generated by the FTA-CGE model refer to changes in migration from a base of zero. They should be seen as additional migration flows due to the policy change, adding to current flows.²⁵ Current migration flows are substantial, both within Mexico and between Mexico and the U.S.²⁶ In addition, the net migration flows generated by the model represent workers, or heads of households. In recent years, a substantial share of migrants have been family members. The model thus probably understates total increased migration due to a policy change, since family members will tend to migrate with workers.

Other empirical studies of U.S. trade with Mexico also include migration. For example, Levy and van Wijnbergen (1993) allow migration between rural and urban unskilled labor markets to maintain a fixed differential, as we do in our model. They model Mexico alone and do not account for migration to the United States. In addition, they use a utility based measure of real wage differences, and account for transfer income and land rent in rural income. In this model, we assume only a wage comparison. In a larger version of this model, which includes 28 sectors and distinguishes irrigated and non-irrigated land, we also account for land rent in rural household income.²⁷ The correct differential in the

²⁴There is no internal migration between the urban and the rural labor market in the United States, but the two labor markets are implicitly linked, given the other migration flows.

²⁵Since NAFTA does not specify changes in migration laws, these numbers should be interpreted as changes in migration pressure; they indicate an increase in the potential for illegal immigration.

²⁶Various researchers have placed the net increase of undocumented Mexican immigrants in the U.S. to be around 100,000 a year during the 1980s. See Bean, Edmonston, and Passel (1990).

²⁷See Burfisher, Robinson, and Thierfelder (1992). We define real wages in terms of a single aggregate price index in each country. Levy and van Wijnbergen (1993) account for differences in consumption patterns across household groups.

migration equation depends on the workers' motivation. If workers migrate to remit income, utility measures based on personal consumption would not be appropriate. Instead, one would want a wage differential that incorporates exchange rate changes.

In a simple model of two goods and two factors, Hill and Mendez (1984) consider the effects of trade liberalization on the wage differential between the United States and Mexico. Using a migration elasticity, they then compute the amount of migration that would accompany the new wage differential. Our specification includes the migration effect and the price effect on wages simultaneously.

4. Model Results

4.1 Scenarios

As summarized in table 3, we specify five scenarios which are designed to explore wage and migration changes that accompany bilateral tariff and quota elimination between the United States and Mexico, but with no changes in domestic policies.²⁸ In the first three scenarios, we make alternative assumptions about labor migration to decompose the effects of relative price changes and migration on wages. In the scenario with full migration, we consider the sensitivity of migration to different model assumptions, focusing on the role of exchange rates and fixed wage differentials.

In scenarios 4 and 5, we explore the relationship between international migration and Stolper-Samuelson effects in our empirical model. We remove distortions from the empirical model to create a theoretically clean base, consistent with the assumptions used in the Stolper-Samuelson theorem. In scenarios 4a and 4b, we look for Stolper-Samuelson wage effects following the introduction of various tariffs, which cause relative output price changes in Mexico and the U.S. In scenario 5, we introduce both a U.S. tariff and international migration into the distortion-free model, showing the dominance of migration effects on wages over Stolper-Samuelson effects under NAFTA.

4.2 Labor Migration and the Effects of NAFTA

In scenario 1, we consider bilateral trade liberalization between the United States and Mexico when there are no migration flows, in effect restricting rural labor to the farm sectors. To evaluate migration effects, we extend scenario 1 and allow internal migration within Mexico between rural and urban unskilled labor markets in scenario 2. Finally, in scenario 3 we allow both internal Mexican migration and international migration flows between the rural and urban unskilled labor markets in Mexico and the United States, in conjunction with bilateral trade liberalization.

²⁸See Robinson, *et al.* (1993); Burfisher, Robinson, and Thierfelder (1992); and Burfisher (1992) for analysis of the economic effects and policy implications of NAFTA, using the FTA-CGE model. In these papers, we consider a wide range of policy scenarios. For example, we consider changes in agricultural policies, particularly the elimination of Mexico's input subsidies to agriculture. We find substantially higher migration flows when Mexico eliminates domestic support in conjunction with NAFTA, as opposed to trade liberalization alone.

Table 3 — Description of Scenarios

No.	Scenario	Description
1.	Free trade, no migration	Remove all bilateral tariffs and quotas.
2.	Free trade, internal Mexican migration	Scenario 1 plus allow rural-urban migration in Mexico.
3.	Free trade, international migration	Scenario 1 plus both rural-urban migration in Mexico, and labor migration between the U.S. and Mexico.
4a.	Stolper–Samuelson effects	Effects of a Mexican tariff in a distortion-free base model in which we remove factor payment differentials, sectoral differences in indirect and value added taxes, and bilateral tariffs and quotas. High transformation and substitution elasticities to minimize the effect of the Armington Assumption. No farm programs in either Mexico or the United States.
4b.	Stolper–Samuelson effects	Effects of a U.S. tariff in a distortion-free base model described in 4a.
5.	Stolper–Samuelson and migration	Migration and a U.S. tariff in a distortion-free base model described in 4a.

We find that international migration reverses the effects of NAFTA on rural wages in the U.S. and Mexico (table 4). With no migration, liberalization of the highly protected farm sectors causes Mexico's rural wage to decline over 5%, while the U.S. rural wage rises 0.8%, consistent with the Stolper–Samuelson theorem. Increasing the mobility of rural labor diminishes the effects of falling Mexican farm prices on rural wages. When we assume labor can migrate between rural and urban areas in Mexico, Mexican rural wages decline by only 2%. As 180,000 workers migrate to urban areas, the decline in the labor supply partially offsets effect of a decline in labor demand on the rural wage. Urban unskilled wages in Mexico decline by 2%, despite the increase in labor demand as output expands under NAFTA. When we do not allow migration, Mexico's urban unskilled wages rise 0.4%, reflecting the increase in the demand for labor as the manufacturing sectors expand. In Mexico's urban labor market, the migration effects dominate the labor demand changes.

When we assume there is international migration, 360,000 rural Mexican workers (6% of the farm labor force) migrate to either urban Mexico or to the U.S. This decline in the supply of rural workers causes Mexican rural wages to rise by 1.0%, dominating the agricultural price decline which works to reduce farm wages. In the U.S., the increase in rural labor supply causes rural wages to fall by 1.0%, despite the upward pressure of rising farm prices on rural wages.

Table 4 — Real Factor Returns under a U.S.-Mexico FTA, with and without Migration, Percent Change from Base

	No migration	Internal migration	Internal and international migration
Migration		--- 1,000 persons ---	
U.S. rural	0	0	20
U.S. urban unskilled	0	0	400
Mexican rural-urban	0	180	340
U.S. factor prices		--- Percent change from base ---	
Rural	0.8	0.9	-1.0
Urban unskilled	-0.1	-0.1	-1.0
Union	0.0	0.0	0.1
Professional	0.0	0.0	0.0
Agric. land	0.5	0.5	0.7
Capital	-0.1	-0.1	0.0
Mexican factor prices			
Rural	-5.3	-1.9	1.0
Urban unskilled	0.4	-1.9	1.0
Union	0.6	0.6	0.4
Professional	0.5	0.5	0.3
Agric. land	-6.6	-6.7	-7.6
Capital	0.2	0.3	0.2

With international migration, the changes in the labor supply in Mexico's urban labor market depend on the net effect of labor entering from the rural areas and labor leaving to the U.S. urban areas. Under NAFTA, migration to the United States dominates and the Mexican urban labor supply declines. The decrease in labor supply and the increase in labor demand associated with output changes following NAFTA complement each other in terms of the effect on the urban wage in Mexico. The Mexican urban wage increases 1%, compared to an increase of 0.4% when only labor demand changes affect the wage in scenario 1.

In the United States, the urban wage declines further with international migration than in scenario 1, with no migration. With no migration, the decline in the demand for urban unskilled labor (following the price changes associated with NAFTA) reduces the urban unskilled wage by 0.1%. This Stolper-Samuelson effect is quite small. The increase in the supply of urban unskilled labor, in the scenario with migration, reduces the urban unskilled wage further. It declines by 1.0% in the United States—still small, but an order of magnitude larger than the Stolper-Samuelson effect.

Although the wage effects of NAFTA are dominated by migration flows, the effects of NAFTA on prices and factor demand are consistent with changes described in the Stolper-Samuelson theorem. The magnitude of these changes are summarized in table 5.

Table 5 — Price, Output, and Labor Demand Effects of an FTA with Internal and International migration (Scenario 3), Percent Change from Base

			Labor demand:	
	Output price	Output	rural	urban unskilled
United States	--- Percent change from base ---			
Food corn	3.1	6.7	10.2	na
Program crops	0.1	0.7	2.0	na
Fruit/vegetables	-0.1	0.4	1.6	na
Other agriculture	0.0	0.2	1.5	na
Food mfg.	0.1	0.1	na	2.2
Other light mfg.	0.1	0.1	na	2.2
Oil/gas	0.2	0.0	na	2.1
Intermediates	0.0	0.2	na	2.3
Consumer durables	0.0	0.2	na	2.2
Capital goods	0.0	0.1	na	2.2
Services	0.0	0.1	na	2.1
Mexico				
Food corn	-4.7	-13.1	-17.4	na
Program crops	-1.2	-5.5	-7.4	na
Fruit/vegetables	1.3	5.2	5.5	na
Other agriculture	0.2	0.0	-0.6	na
Food mfg.	0.1	-0.5	na	-1.9
Other light mfg.	0.3	0.6	na	-0.9
Oil/gas	1.7	0.0	na	-1.5
Intermediates	0.4	1.4	na	-0.1
Consumer durables	0.2	4.7	na	3.1
Capital goods	0.3	2.8	na	1.3
Services	0.2	-0.3	na	-1.7

Notes: Scenario 3 assumes removal of bilateral tariffs and quotas, and internal and international migration. NA denotes that the factor is not employed in that sector.

In Mexico, the most dramatic changes occur in the food corn sector, which has the highest initial protection, a tariff equivalent of 45%.

Aggregate effects of NAFTA are reported in table 6. Unlike the case of factor prices, aggregate results of NAFTA are almost unchanged by varying the migration assumptions in scenarios 1-3. For the U.S., there are no measurable aggregate efficiency gains from trade liberalization with Mexico in scenarios 1 and 2, and migration largely accounts for the small

Table 6 — Aggregate Effects of a U.S.-Mexico FTA, with and without Migration, Percent Change from Base

	Scenario 1: No migration	Scenario 2: Internal migration	Scenario 3: Internal and international migration
--- Percent change from base ---			
Real GDP - U.S.	0.0	0.0	0.1
Real GDP - Mexico	0.5	0.6	0.3
Exchange rate - U.S.	0.0	0.0	0.0
Exchange rate - Mexico	2.1	2.2	2.0
U.S. exports to Mexico	8.4	8.7	8.6
U.S. exports to rest	0.0	0.0	0.2
U.S. imports from rest	0.1	0.1	0.2
Mexican exports to U.S.	5.0	5.0	5.1
Mexican exports to rest	4.7	5.0	4.6
Mexican imports from rest	-0.6	-0.6	-0.8
Farm program expenditure:			
U.S.	-0.7	-0.7	-0.5
Mexico	-1.5	-1.9	-2.6
Terms of trade:	--- Index, base = 1.0 ---		
U.S. to Mexico	1.01	1.01	1.01
U.S. to world	1.00	1.00	1.00
Mexico to U.S.	0.99	0.99	0.99
Mexico to world	0.99	0.99	0.99

Notes: The "real exchange rate" is the price-level deflated exchange rate using the GDP deflator. A positive change represents a depreciation. Exports are valued at world prices (in dollars).

increases in GDP in scenario 3. In Mexico, real GDP increases slightly in all scenarios, but is lowest in scenario 3, because labor migration to the U.S. reduces its labor endowment.

Bilateral trade increases significantly in all three NAFTA scenarios. For the U.S., NAFTA is trade creating in all three scenarios, with imports rising from both Mexico and the rest of the world. For Mexico, NAFTA results in very small trade diversion as imports from the United States replace imports from the rest of the world.

Both countries' farm program expenditures fall under all three scenarios. In the U.S., the decline in expenditure reflects a decline in the deficiency payment because farm prices

rise with export growth to Mexico.²⁹ In Mexico, farm program expenditures fall because of the decline in farm output. Bilateral trade expansion occurs with virtually no effect on the international terms of trade.

Sectoral results are presented in table 7. Bilateral export growth of both countries under NAFTA is highest in the farm sectors, reflecting the fact that both countries have provided relatively high trade protection to their agriculture. Agricultural trade growth is accomplished mostly through changes in crop mix, with little change in total farm output in either Mexico or the U.S. The net effect of labor migration for the agricultural sectors is to shift farm production from Mexico to the U.S., and to increase U.S. farm exports to Mexico.

4.3 Sensitivity of Migration Results to Model Specification

Since migration effects largely determine the wage changes following NAFTA, we explore the sensitivity of migration to our specification. We do sensitivity experiments against scenario 3, which includes bilateral trade liberalization and international migration.

In the model, exchange rates can affect migration because we assume labor evaluates wages in a common currency. Totally differentiate the migration equation, equation (14):

$$\hat{W}F_{MX} = wgd f + \hat{W}F_{US} + \hat{e}r_{MX} - \hat{e}r_{US} \quad (15)$$

where a ^ designates percent change. It is possible that, while real wages measured in a common currency are equated, wages can grow at different rates measured in the domestic currency. One might even observe migrants moving from a labor market where real wages (in domestic prices) are rising to one in which they are falling. As the dollar appreciates relative to the peso, the peso value of the U.S. wage increases. If the exchange rate change is large enough, the U.S. wage in dollars might fall while its peso value rises.

The issue is in the specification of what motivates migrants. For example, if they are motivated by a desire to accumulate savings which they intend to repatriate, then migration will be sensitive to changes in the exchange rate. On the other hand, if workers care about the differences in the amounts of non-traded goods they can consume within each country, then migration will be insensitive to changes in the exchange rate.

To eliminate the exchange rate effects on the migration decision, we fix the exchange rate in the migration equation at the base year level. Under bilateral trade liberalization, we find that urban unskilled migration from Mexico to the United States falls by half compared to scenario 3, in which the depreciating Mexican peso affects migration (table 8). In scenario 3, the decrease in the value of the peso makes dollar wages more attractive to potential migrants. Likewise, migration from rural Mexican to the rural labor market in the United States falls when the exchange rate does not affect the migration decision.

²⁹U.S. deficiency payments are modeled endogenously, with unit payments falling when producer prices rise. See Burfisher, Robinson, and Thierfelder (1992), Kilkenny (1991), and Kilkenny and Robinson (1990) for a discussion of how farm programs are modeled in the FTA-CGE model.

Table 7 — Sectoral Effects of an FTA on the U.S. and Mexico, with and without Migration, Percent Change from Base

	No migration		Internal migration		Internal and international migration	
	Output	Exports	Output	Exports	Output	Exports
United States						
Farm	0.2	44.5	0.2	47.9	0.4	51.3
Corn	4.9	128.4	5.2	134.9	6.7	141.8
Program crops	0.3	36.8	0.3	41.0	0.7	44.0
Fruit/vegetables	0.1	13.3	0.1	13.1	0.4	11.9
Other agric.	0.1	8.9	0.1	9.3	0.2	8.8
Food processing	-0.1	8.7	-0.1	9.0	0.1	8.5
Other light mfg.	0.0	7.4	0.0	7.6	0.1	7.1
Oil/gas	0.0	17.8	0.0	18.0	0.0	17.7
Intermediates	0.1	8.4	0.1	8.4	0.2	8.0
Consumer durables	0.0	9.5	0.0	9.5	0.2	9.3
Capital goods	0.1	9.5	0.1	9.5	0.1	9.2
Services	0.0	-2.4	0.0	-2.4	0.1	-2.6
Mexico						
Farm	0.1	10.2	-0.3	9.4	-1.1	8.8
Corn	-8.8	0.0	-10.8	0.0	-13.1	0.0
Program crops	-3.7	0.0	-4.5	0.0	-5.5	0.0
Fruit/vegetables	7.7	21.7	6.5	21.2	5.2	21.1
Other agric.	0.6	2.2	0.5	2.0	0.0	2.0
Food processing	0.1	7.7	0.0	7.6	-0.5	7.7
Other light mfg.	0.7	8.8	0.8	8.9	0.6	9.0
Oil/gas	0.0	4.3	0.0	4.3	0.0	4.5
Intermediates	1.5	4.0	1.6	4.1	1.4	4.2
Consumer durables	4.3	5.5	4.7	5.8	4.7	5.8
Capital goods	2.8	7.7	2.9	7.8	2.8	7.7
Services	-0.2	0.1	-0.1	0.2	-0.3	0.2

Notes: Real output and exports. Exports are to partner country (U.S. or Mexico).

When we eliminate the exchange rate effects, both rural and urban unskilled wages fall in Mexico under NAFTA. In Mexico's rural labor market, migration effects no longer dominate the effects of relative price changes in Mexico. Migration will, however, substantially mitigate the downward pressure on wages—the rural wage declines by 0.5% as opposed to 5.3% in the scenario with NAFTA and no migration.

The labor supply change in Mexico's urban unskilled labor market is more complex. There is a decline in the labor outflow to the U.S. urban unskilled labor market; 195,000

workers leave as opposed to 400,000 when exchange rates affect migration. While the workers entering from Mexico's rural labor market also declines (254,000 migrate from rural areas to the urban areas, as opposed to 340,000 migrants with exchange rate effects), the net result is an increase in the supply of urban unskilled labor. In contrast, there is a decrease in the labor supply when exchange rates are included in the migration decision. The increase in labor supply dominates the labor demand changes, and the urban unskilled wage declines by 0.5% in Mexico.

Migration effects still dominate in the United States, but have less of an impact on wages, reflecting the decline in the migration flows. Rural and urban unskilled wages each fall by 0.5% in the United States when there is no exchange rate effect, as opposed to a decline of 1.0% each with an exchange rate effect.

When modeling migration, we assume the wage differentials between the United States and Mexico are held constant at their base year levels. This treatment reflects a view that changes associated with NAFTA will not affect the wage differential in the migration equation; for example, we assume no changes in U.S. immigration restrictions. The results are certainly sensitive to this assumption. From equation 15, one can see that migration responds to changes in the wage differential parameter exactly the same as to changes in the exchange rate. For example, if Mexico grows more rapidly than the U.S., the model will generate a large decrease in migration in order to maintain the wage differential. Over the long run, with increased Mexican growth, one expects to observe growth in wages, a narrowing of the wage differential between the two countries, and a reduction in migration pressure. We have not sought to capture this mix of effects in the model because these long-run trends are not directly related to NAFTA, and the FTA-CGE model has been used primarily to explore the impact of NAFTA.

4.4 Implied Elasticities

In our analytical work, we identify three elasticities that affect the magnitude of migration. While we do not do sensitivity tests around the elasticities, we can define the values implicit in our data on the U.S. and Mexican economies.³⁰ The differences in elasticities help to explain the patterns of migration changes we observe in the empirical model.

The labor demand elasticities indicate the amount of migration needed to maintain fixed wage differentials across the linked labor markets (table 8). The more elastic the labor demand curve, the easier it is for the labor market to absorb labor without generating a large wage increase. For example, rural labor in Mexico can migrate either to the rural labor market in the United States or to the urban unskilled labor market in Mexico. The labor demand elasticity in Mexico's urban unskilled labor market is -1.83 while the labor demand elasticity in the U.S. urban unskilled labor market is -0.88. This difference in the labor demand elasticities helps to explain the "domino effect" we observe: rural workers in Mexico first go to the cities and then enter the U.S. urban unskilled labor market.

³⁰These elasticities, however, are from a general equilibrium model, not a partial equilibrium model in which only one variable changes. The numbers we report are effectively the ratios of two total derivatives.

Table 8 – Implied Elasticities in the FTA-CGE Model

	United States	Mexico
Elasticity of labor demand with respect to the average wage:		
Rural labor	-0.88	-0.75
Urban unskilled labor	-1.87	-1.83
Output supply elasticity of corn with respect to output price	1.09	0.71
Elasticity of rural labor demand with respect to corn output	1.40	1.44

The output supply elasticity indicates the responsiveness of output to a relative price change. When output is very responsive to a relative price change, indicating curvature on the production possibilities frontier, there is potential for large migration flows. The output supply elasticity for corn, a sector which contracts under NAFTA, is 1.09. This slightly elastic supply curve and the dramatic price shock under NAFTA contribute to the large migration of workers out of Mexico's rural labor markets.

When output changes in response to a relative price change, the demand for labor also changes. For example, as the labor intensive good expands, the labor demand curve shifts to the right. If the labor demand curve is very responsive to output changes, one anticipates high levels of migration as there is initially pressure for wages to increase in that country. Focusing on corn, an important source of migration, we find that the elasticity of labor demand with respect to output is 1.44 in Mexico.

4.5 Stolper-Samuelson Effects in the 11-Sector Model

Our empirical results suggest that migration effects dominate the wage effects in equation (11) from the analytical model. However, one problem could be that a model of trade between the United States and Mexico violates the assumptions needed to develop the links between output prices and factor prices described in the Stolper-Samuelson theorem. The empirical model then becomes a poor test of the wage changes described in the analytical model. To better replicate the analytical model, we eliminate some of the distortions in the empirical model. We remove price distortions such as tariffs and quotas and remove sectoral differences in indirect and value added taxes. To minimize the impact of the Armington assumption, we increase the export transformation and import substitution elasticities. Other distortions that violate the assumptions of the Stolper-Samuelson theorem remain, including technology differences.

We introduce a relative price change in this stylized model by adding a 25% tariff on Mexican global corn imports, which raises Mexico's rural wage (table 9). Since corn is relatively labor intensive, this link between output prices and factor prices is consistent with the Stolper-Samuelson theorem. In the U.S., conversely, corn output declines and rural

Table 9 — Stolper-Samuelson Effects of Tariffs, with and without Migration, Percent Change from Base

	Mexican 25% tariff on corn	U.S. 50% tariff on fruits and vegetables	U.S. tariff with migration
Mexico	--- Percent change from base ---		
Corn output	8.8	0.6	0.1
Fruit and vegetable output	-0.1	-16.8	-17.0
Corn imports	-85.2	-2.4	-0.5
Rural wage	2.3	-1.4	0.0
United States			
Corn output	-6.8	-0.3	0.0
Fruit/vegetable output	0.2	1.0	1.1
Fruit/vegetable imports	-1.2	-90.6	-90.1
Rural wage	-0.7	0.4	-0.1
	--- 1,000 persons ---		
Mexican-U.S. rural migration	0	0	4
Mexican-U.S. unskilled migration	0	0	47
Mexican rural-urban migration	0	0	54

Notes: Real output and exports. Trade is to partner country (U.S. or Mexico).

wages fall.

A 50% tariff on U.S. global fruit and vegetable imports demonstrates a similar result: U.S. fruit and vegetable output rises, imports fall, and the U.S. rural wage rises. In Mexico, fruit and vegetable output falls dramatically, reflecting that Mexican exports to the U.S. accounts for a large share of Mexican production, and Mexican rural wages decline.

We next introduce migration into the scenario of a 50% tariff on U.S. fruit and vegetable imports. Because labor can now migrate out of Mexican agriculture, Mexican rural wages no longer fall when the U.S. imposes a tariff. In this scenario, 58,000 Mexican farm workers (about 1% of total farm labor) migrate out of Mexican agriculture, and 4,000 migrate to the U.S. For the U.S., we find that the effects of even a small labor migration flow dominate the Stolper-Samuelson effects of relative price changes. U.S. rural wages now decline with the introduction of a U.S. tariff.

In both countries, imports drop sharply following the imposition of a tariff, reflecting our assumption of very high elasticities of import substitution and export transformation in the distortion-free, non-Armington base. The result is much greater specialization than we would observe in the FTA-CGE model. This treatment biases the model in favor of Stolper-Samuelson effects, and should be viewed as an outer-bound estimate of the response of trade to changes in relative prices. Yet, even with the dramatic (and empirically unlikely)

changes in trade observed in the stylized model, the Stolper–Samuelson links to wages are found to be small, and migration flows are enough to reverse the price effects. An important policy implication is that, in the presence of migration, the U.S. adoption of a tariff can hurt both countries.

5. Conclusion

Much of the debate over potential wage changes arising from the creation of NAFTA reflects views about the links between output prices and factor prices as described in the Stolper–Samuelson theorem. The model underlying the theorem assumes no international factor mobility, which is obviously unrealistic for the U.S. and Mexico, where there is significant labor migration. We develop an analytic trade model that includes both relative-price and migration effects, and show that the two effects on wages work in opposite directions. Furthermore, migration effects can more than fully offset relative-price effects. When one accounts for migration, any assessment of the net change in wages arising from changes in trade policy becomes an empirical question.

To analyze the empirical importance of the two mechanisms, we use an 11-sector FTA-CGE model of the United States and Mexico, in which the two countries are linked by trade and migration flows. We find that Stolper–Samuelson effects occur, but that they are very small, and have perhaps been given too much emphasis in the debate over the wage effects of NAFTA. Furthermore, migration effects largely dominate indirect price effects, generating wage changes under NAFTA that are contrary to expectations based on the Stolper–Samuelson theorem alone. For example, with no migration, removing protection causes rural wages in Mexico to fall (and rural wages in the U.S. to rise), reflecting Mexico's current high levels of protection to agricultural sectors. These results are consistent with the Stolper–Samuelson theorem. When we allow migration, however, the wage effects are reversed. The decline in the rural labor supply in Mexico causes the rural wage to rise rather than fall. Conversely, in the U.S., the rural wage falls, due to the increased rural labor migration from Mexico.

The analysis is more complex in the urban unskilled labor markets, where Mexican workers migrate both from rural areas to urban areas in Mexico, and from urban areas in Mexico to urban areas in the United States. In this case, we find that including migration reinforces the relative-price effects of NAFTA on urban unskilled wages. In Mexico, there is a net decline in supply of, as well as an increase in demand for, urban unskilled labors; both effects create pressure for the Mexican urban unskilled wage to rise. On the U.S. side, increased migration under NAFTA leads to small wage declines for both rural and urban unskilled workers.

Because of the importance of migration in determining the wage effects of NAFTA, we explore the sensitivity of our empirical model to the specification of migration. The amount of migration is sensitive to the treatment of the exchange rate in the migration equation. If workers in Mexico make wage comparisons in a common currency (say, because they are at least partly motivated by a desire to remit income), then the amount of migration is sensitive to changes in the exchange rate. Under NAFTA, the model projects a real

depreciation of the Mexican Peso, which causes larger migration flows than would occur in a model in which migration is insensitive to changes in the exchange rate.

Finally, migration is very sensitive to the wage differential between the two countries. Given that Stolper-Samuelson effects are empirically very small, and given that technology is vastly different between the two countries, one would not expect to see any significant downward pressure on U.S. wages arising from changes in commodity trade and relative prices. Increased Mexican growth, however, would raise Mexican wages and lead to a significant decline in migration pressure. Our results support the view that both countries gain from NAFTA if it succeeds in its primary goal of increasing Mexican growth.

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