Tariff and Nontariff Barrier Impacts on Illegal Migration: US Fresh Winter Tomato Market

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Abstract: A partial equilibrium, duality-based empirical model is used to measure the tariff and nontariff barrier effects on fresh tomato prices, quantities, and labour demand in Florida, USA, and Sinaloa, Mexico. Reduced-form estimates indicate that the US unit tariff has increased agricultural labour demand in Florida while reducing field labour demand in Mexico. Nontariff barriers have had a less significant impact on labour demand. Product heterogeneity may account for varying nontariff barrier impacts on fresh tomato supplies and derived labour demand. Linkages between Mexican agricultural labour supply and Florida agricultural labour demand require further analysis.

Introduction

The Immigration Reform and Control Act (IRCA) of 1986 is designed to stem the flow of illegal aliens into the USA by means of domestically oriented amnesty and employer sanctions. The economic migration "push" factors in the countries of origin such as Mexico are not covered by the IRCA. Both Mexican and US officials have argued that reduction of US-Mexican trade barriers for labour-intensive commodities would allow Mexico to export commodities rather than workers.

The factor price equalization theorem suggests that, in a general equilibrium setting, trade in commodities can substitute for labour migration (Mundell, 1957). Some partial equilibrium studies have attempted to test the proposition that liberalized trade in the US fresh winter tomato market, for which Florida and Mexico are almost the exclusive producers, could reduce illegal migration from Mexico to the USA (Emerson, 1982; Huffman, 1982; and Torok and Huffman, 1986). None of these studies, however, has attempted to quantify the effects of both tariff and nontariff barriers on labour migration for the US fresh winter tomato market. This paper examines the effects of tariff and nontariff barriers on tomato production and labour use in Florida and Mexico.

The fresh winter tomato industry in southern Florida and Sinaloa began flourishing during the 1940s and 1950s, as US per capita incomes increased and demand for fresh vegetables during winter months grew. Infrastructure investment in Mexico, access to US working capital, and low labour costs allowed Mexican growers to become more competitive. Following the US embargo on all trade from Cuba in 1962, Mexico and Florida became sole competitors during the January to May winter season.

Both producing regions have implemented measures to protect their US market shares. Florida growers have approved a federal marketing order, which establishes minimum quality standards for all imported fresh tomatoes, and Mexican producers have adopted quality control restrictions, which are administered by the Unión Nacional de Productores de Hortalizas (UNPH). Trade disputes over the US fresh winter tomato market culminated in the dumping controversy of the 1970s, which was finally resolved in favour of Mexican producers. During the last two decades, nontariff quality restrictions on both sides of the border and the US unit tariff have affected tomato production and labour use in Florida and Mexico (Bredahl, Schmitz, and Hillman, 1987).

This paper first develops a partial equilibrium empirical model of the US fresh winter tomato market and Florida and Mexico labour demand using duality theory. Structural and reduced-form estimates of the empirical model are analyzed for policy implications.

Model of Commodity Trade and Labour Demand

The empirical model is derived from a translog variable profit function (Diewert, 1984). The translog profit function in theoretically reasonable (Lopez, 1985) and performs relatively

well in Monte Carlo studies (Dixon, Garcia, and Anderson, 1987). Aggregate output supply and labour demand equations are derived from the profit function using Hotelling's lemma.

When producers in each region face the same output prices, the aggregate variable profit function displays the same homogeneity, monotonicity, and convexity properties as the individual producer's profit function (Bliss, 1978). Derivation of the output supply and labour demand functions from the aggregate profit function is attractive because both derivative functions consistently embody the underlying technology through duality mapping.

In the aggregate US tomato market, output quantity and price are assumed to be determined uniquely. Equilibrium tomato price and quantity levels are determined by the two regional product supply share equations *(1)* and *(2)* and an aggregate demand function *(3)*, as follows:

$$(1)\ (P_{ft}Y^{*}_{ft})/\Pi_{ft} = \alpha_{f1} + \beta_{f1}\ ln\ q_{ft} + \gamma_{f1}\ ln\ P_{ft} + \delta_{f1}\ ln\ A_{ft} + \omega_{f1}DUNPH_t + \theta^{J}_{f1}DJAN + \theta^{F}_{f1}DFEB$$
$$+ \theta^{M}_{f1}DMAR + \theta^{A}_{f1}DAPR + \phi_{f1}FF_t + \tau_{f1}T_t + \varepsilon_{f1t},$$

$$(2)\ (P_{mt}Y^{*}_{mt})/\Pi_{mt} = \alpha_{m1} + \beta_{m1}\ ln\ q_{mt} + \gamma_{m1}\ ln\ P_{mt} + \delta_{m1}\ ln\ A_{mt} + \omega_{m1}DTAR_t + \eta_{m1}DMO_t$$
$$+ \theta^{J}_{m1}DJAN + \theta^{M}_{m1}DMAR + \theta^{A}_{m1}DAPR + \phi_{m1}ER_t + \tau_{m1}T_t + \varepsilon_{m1t},\ \text{and}$$

$$(3)\ Y^{r}_t = \alpha_r + \beta_r\ ln\ P^{r}_t + \gamma_r\ ln\ I_t + \delta_r\ ln\ W_t + \varepsilon_{rt},$$

where P = wholesale price of tomatoes, Y = supply of tomatoes, Π = profit, q = wage rate, f = Florida, m = Mexico, Y^r = US demand for tomatoes, P^r = retail price of tomatoes, I = US real disposable income, and W = percentage of women employed in the US labour force (the other variables are defined below). Following LaFrance (1985), the demand function *(3)* may be interpreted as an incomplete demand system with only one commodity of interest; i.e., fresh tomatoes.

Due to a paucity of labour supply data, the Florida and Mexican labour markets are modelled only with derived labour demand equations *(4)* and *(5)*, as follows:

$$(4)\ -(q_{ft}X^{*}_{ft})/\Pi_{ft} = \alpha_{f2} + \beta_{f2}\ ln\ P_{ft} + \gamma_{f2}\ ln\ q_{ft} + \delta_{f2}\ ln\ A_{ft} + \omega_{f2}DUNPH_t + \theta^{J}_{f2}DJAN$$
$$+ \theta^{F}_{f2}DFEB + \theta^{M}_{f2}DMAR + \theta^{A}_{f2}DAPR + \phi_{f2}FF_t + \tau_{f2}T_t + \varepsilon_{f2t},\ \text{and}$$

$$(5)\ -(q_{mt}X^{*}_{mt})/\Pi_{mt} = \alpha_{m2} + \beta_{m2}\ ln\ P_{mt} + \gamma_{m2}\ ln\ q_{mt} + \delta_{m2}\ ln\ A_{mt} + \omega_{m2}DTAR_t + \eta_{m2}DMO_t$$
$$+ \theta^{J}_{m2}DJAN + \theta^{M}_{m2}DMAR + \theta^{A}_{m2}DAPR + \phi_{m2}ER_t + \tau_{m2}T_t + \varepsilon_{m2t},$$

where X = hired labour force. The plausible assumption is made that the aggregate wage rates are determined exogenously because Sinaloan minimum daily wages are established by the Mexican federal government and, in southern Florida, minimum hourly wage rates are established by the US government with tomato piece rates set to compete for citrus field labour. The assumption of exogenously determined wage rates is tantamount to assuming an infinitely elastic aggregate labour supply in each region.

Dichotomous variables are included in the empirical model to represent the imposition of the US unit tariff (*DTAR*) and nontariff barriers by Mexico's UNPH (*DUNPH*) and the US federal marketing order (*DMO*). These trade barriers are viewed as exogenously imposed restrictions that increase the fixed costs of production but do not affect the price-taking behaviour of individual producers.[2]

Monthly dummy variables (*DJAN, DFEB, DMAR, DAPR*) are appended to reflect seasonality in production (Torok and Huffman, 1986).[3] In addition to seasonal weather patterns, frosts occur every three years on average in Florida. Thus a dummy variable representing Florida frost shocks (*FF*) is also included.

Although the nature of technical change in both producing regions is distinct, substantial changes in production technology have occurred over the past two decades; e.g., Florida yields have increased due to the adoption of plastic mulch technology (Taylor and Wilkowske, 1984) and Mexican producers have switched from direct seeding to transplanting greenhouse seedlings (Zepp and Simmons, 1979). Because these changes have occurred gradually, a continuous time trend variable (T) is included to track temporal changes in both regions.[4]

Exchange rate movements have affected the profitability of Mexican tomatoes. During the 1960s and mid-1970s, the Mexican peso was consistently overvalued in the sense that the real exchange rate, defined as $ER_r = ER_n(WPI_{MEX}/WPI_{US})$, exceeded the nominal exchange rate ER_n (Longmire and Morey, 1983). During those harvest seasons, gross revenue in US dollar terms was unchanged, but variable harvest costs incurred in Mexico were diminished by overvaluation of the Mexican peso. The producer product supply and labour share equations were shifted out by the degree of overvaluation. Thus a measure of overvaluation of the Mexican peso (ER) is introduced.

Regional acreage (A) is included as a fixed factor because intraseasonal harvest decisions are made on the basis of a given planted area. Although time-series data are used, harvest season data from January to May reflect tomato quantities, prices, and labour quantities used once planting decisions are made and implemented.

Data and Estimation

Monthly observations for all the variables enumerated were used for the winter harvest season from January to May for 1964-81. Because volatility in perishable commodity prices is not adequately reflected in monthly average prices, an expected monthly price was generated using a weighted moving average of the mean, variance, and skewness of weekly f.o.b. price.

Due to nonlinearities in the variables, the identification conditions for the structural model are slightly modified from the usual linear identification conditions (Brown, 1983). The structural model is overidentified using Brown's criteria. The most efficient estimator is two-stage least squares. A systems estimator such as three-stage least squares cannot be used due to singularity of the estimated covariance matrix.[5]

Econometric Results

The parameter estimates of the structural model are not presented because a complete check of the regularity conditions of the "parent" regional profit functions is not possible; the output supply and labour share equations do not contain all the parameters of the "parent" functions. The structural elasticities displayed in Table 1 represent the partial effects on the endogenous variables of changes in the right-hand side structural variables (Chavas, Hassan, and Johnson, 1981). Elasticities for the dichotomous tariff and nontariff variables are not defined.

The structural elasticities conform to prior expectations. Florida tomato supply is more price responsive, probably due to the longer shelf life afforded by mature green tomatoes. Once Mexican vine ripe tomatoes are harvested, they must be marketed rapidly to prevent spoilage. Sinaloan labour demand is more wage and output price responsive. The Sinaloan wage bill accounts for 38 percent of production costs, whereas Florida labour costs represent only 27 percent of production costs (Zepp and Simmons, 1979).

Table 1–Structural Elasticities Evaluated at Sample Means

	Y/P	Y/q	Y/A	X/q	X/P^x	X/A
Florida	0.00136	0.00046	-0.00191*	-2.21603*	1.37511	0.88651*
	(0.00231)	(0.00234)	(0.00061)	(1.08401)	(1.06774)	(0.28268)
Mexico	0.00062	0.02044	-0.01671	-2.52097*	2.09019*	8.11950*
	(0.01986)	(0.01850)	(0.04214)	(0.37844)	(0.40633)	(0.86225)

	Y^x/P^x	Y^x/I	Y^x/W
US Demand	0.81589*	-0.20118	0.24572
	(0.40850)	(0.47917)	(1.66080)

*Significant at the 0.95-percent level.
Note: Asymptotic standard errors are in parentheses.

Reduced-Form Estimates

The reduced form of the structural nonlinear-in-variables model does not yield a closed-form solution (Brown, 1983). The tariff and nontariff effects on tomato production and labour demand can be analyzed, however, through an approximation to the true reduced form. A second-order Taylor series expansion in the logarithms of the exogenous variables was regressed on each of the endogenous variables. For ease of interpretation, only the tariff and nontariff reduced-form estimates are presented in Table 2.

Despite the decreasing ad-valorem equivalent of the unit tariff (Zepp, 1981), the tariff has had a much more significant impact on fresh tomato trade than nontariff barriers. The unit tariff has been in effect throughout all the seasons analyzed; marketing order and UNPH restrictions have been intermittent and varying in degree over the same period. Hence, tariff impacts are more apparent when measured over the past two decades. Although the impacts of marketing order barriers and UNPH restrictions are not all as expected, both US marketing order and Mexican trade restrictions have had effects of comparable magnitude. Many discussions of nontariff barriers in the US fresh winter tomato have mentioned Mexican market interventions, but few have demonstrated the magnitude of UNPH market restrictions.

The tariff and nontariff barrier impacts on the derived demand for labour in each region are mixed. Product heterogeneity may be one cause of an apparently anomalous increase in output and decrease in labour demand associated with UNPH restrictions. When production of less labour-intensive mature green tomatoes substitutes for more labour-intensive vine ripe tomatoes, labour use may decline. However, the tariff impact indicates that Mexican labour demand declines while Florida labour demand increases.

Conclusions

The US unit tariff has had the most significant impact on fresh winter tomato trade in the USA. Marketing order restrictions and Mexico's UNPH short-run interventions had had less effects on tomato prices, quantities, and labour demand in both regions. The unit tariff has affected labour demand most by increasing Florida labour demand and diminishing Mexican labour demand.

Table 2-Reduced-Form Estimates of Tariff and Nontariff Impacts

Exogenous Variables	Endogenous Variables Y_f	Y_m	X_f	X_m	P_f	P_m	P^r
DUNPH	-3.452	3.616	0.174	-3.647	-1.214	-0.773	-1.774
	(6.536)	(3.281)	(5.256)	(12.943)	(0.982)	(1.730)	(1.568)
DMO	-4.656	2.050	2.862	0.065	-1.333	0.462	0.304
	(6.355)	(3.190)	(5.110)	(12.585)	(0.954)	(1.682)	(1.525)
DTAR	31.313*	2.333	8.717*	-6.611	-2.613*	0.170	2.825*
	(5.775)	(2.899)	(4.644)	(11.435)	(0.867)	(1.528)	(1.385)
R^2	0.86	0.95	0.83	0.91	0.55	0.85	0.90
D-W	1.82	1.97	1.14	2.04	1.56	1.72	1.52

*Significant at the 0.95-percent level.
Note: Standard errors are in parentheses.

Product heterogeneity appears to be an important factor in determining the derived demand for labour in tradeable commodities. Tariff and nontariff barriers may have differential effects on labour demand in both countries, depending on the labour intensity of mature green and vine ripe tomatoes. Full assessment of labour migration and trade barrier elimination would require analysis of Mexican labour supply and labour migration linkages with US agricultural labour markets. Qualitative analysis suggests that internal Mexican agricultural migrant labourers would continue migrating to the USA once their seasonal jobs end in May, producing a counterintuitive increase in illegal migration (Thompson, Amon, and Martin, 1986).

Notes

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[2]Nontariff barriers may not be entirely exogenously determined. Short-run restrictions imposed by UNPH are recommended by a committee that growers may influence. Unfortunately, insufficient data are available for endogenizing nontariff barrier decision rules.

[3]Note that the seasonal dummy *DFEB* is not included in the Mexico share equations because the tariff dichotomous variable (*DTAR*), combined with *DJAN* and *DFEB*, would have been perfectly collinear with the intercept.

[4]Various combinations of dummy variables to represent pre- and postadoption periods were rejected for lack of statistical significance.

[5]With labour as the only variable input, the output and input shares sum to one. Therefore, the corresponding blocks of the estimated variance-covariance matrix are singular.

References

Bliss, C. (1978) *Capital Theory and Distribution of Income*, North Holland, New York, N.Y., USA.

Bredahl, M.E., Schmitz, A., and Hillman, J.S. (1987) "Rent Seeking in International Trade: Great Tomato War," *American Journal of Agricultural Economics*, Vol. 69, pp. 1-10.

Brown, B.W. (1983) "Identification Problem in Systems Nonlinear in the Variables," *Econometrica*, Vol. 51, pp. 175-196.

Chavas, J.P., Hassan, Z.A., and Johnson, S.R. (1981) "Static and Dynamic Elasticities and Flexibilities in Systems of Simultaneous Equations," *Journal of Agricultural Economics*, Vol. 32, pp. 177-187.

Diewert, W.E. (1984) "Applications of Duality Theory," in Intrilligator, M.D., and Kendrick, D.A. (Eds.) *Frontiers of Quantitative Economics*, North Holland, Amsterdam, Netherlands.

Dixon, B.L., Garcia, P., and Anderson, M. (1987) "Usefulness of Pretests for Estimating Underlying Technologies Using Dual Profit Functions," *International Economic Review*, Vol. 28, pp. 623-633.

Emerson, R.D. (1982) "Trade in Products and International Migration in Seasonal Labor Markets," *American Journal of Agricultural Economics*, Vol. 64, pp. 339-346.

Huffman, W.E. (1982) "International Trade in Labor Versus Commodities: U.S.-Mexican Agriculture," *American Journal of Agricultural Economics*, Vol. 64, pp. 989-999.

LaFrance, J.T. (1985) "Linear Demand Functions in Theory and Practice," *Journal of Economic Theory*, Vol. 37, pp. 147-166.

Longmire, J., and Morey, A. (1983) *Strong Dollar Dampens Demand for U.S. Farm Exports*, Foreign Agricultural Economic Report No. 193, Economic Research Service, US Department of Agriculture, Washington, D.C., USA.

Lopez, R. (1985) "Structural Implications of a Class of Flexible Functional Forms for Profit Functions," *International Economic Review*, Vol. 26, pp. 593-601.

Mundell, R.A. (1957) "International Trade and Factor Mobility," *American Economic Review*, Vol. 4, pp. 321-335.

Taylor, T.G., and Wilkowske, G.H. (1984) "Productivity Growth in the Florida Fresh Winter Vegetable Industry," *Southern Journal of Agricultural Economics*, Vol. 16, pp. 55-61.

Thompson, G., Amon, R., and Martin, P. (1986) "Agricultural Development and Emigration: Rhetoric and Reality," *International Migration Review*, Vol. 20, pp. 575-597.

Torok, S.J., and Huffman, W.E. (1986) "U.S.-Mexican Trade in Winter Vegetables and Illegal Migration," *American Journal of Agricultural Economics*, Vol. 68, pp. 246-260.

Zepp, G.A., and Simmons, R.L. (1979) *Producing Fresh Winter Vegetables in Florida and Mexico*, ESCS-72, Economic Research Service, US Department of Agriculture, Washington, D.C., USA.

Zepp, G.A. (1981) *U.S. Winter Fresh Tomato Price and Quantity Projections for 1985*, ESS-4, Economic Research Service, US Department of Agriculture, Washington, D.C., USA.

DISCUSSION OPENING—*Robert W. Dubman* (Economic Research Service, US Department of Agriculture)

The paper presented by Thompson is a significant step towards quantifying the effects of tariff and nontariff barriers on input demands. Most major factors that could influence the fresh winter tomato market have been accounted for in the model. The structure of the model and the econometrics are commendable.

One significant econometric point, however, stands clear. The unit tariff may not be best represented by a dummy variable. The variable *DTAR* is the central variable from which most conclusions were drawn. A dummy variable may not adequately reflect the intensity of the tariff and may be picking up influences other than the tariff. Perhaps including the total tariff revenues or adjusting the prices would lead to more precise and unadulterated estimates.

The IRCA's goal is to eliminate the flow of illegal aliens into the USA. We need to question whether a trade barrier reduction would allow Mexico to export commodities rather than workers. Product substitution may allow Florida farmers to circumvent a tariff by producing nontariff- or nonlabour-intensive crops. Florida farmers may still want to take advantage of relatively inexpensive Mexican labour to grow, for example, other vegetable

crops. The wages for farmworkers in Mexico are likely to remain well below wages for farmworkers in the USA. In addition, the Mexican tomato farms are more labour intensive. That nontariff barriers were found insignificant may indicate that product substitution is occurring. Only a general equilibrium analysis can deal with all commodities and inputs at once.

The method may be difficult to duplicate for other commodities. In particular, winter tomatoes are grown in two regions with a common source for labour. The tariff and nontariff barriers are clear. Commodities other than winter tomatoes may be grown in several regions facing a myriad of nontariff barriers. Thus, the data requirement and number of equations may be unmanageable for other commodities.

In conclusion, the economic impacts of legislation restricting the mobility of farmworkers must consider the fairness of the law and the impacts on all parties. The partial equilibrium analysis appears to be lacking in this respect. However, Thompson's paper does give convincing evidence that lowering tariffs may be as effective as immigration control in restricting labour mobility.

[No general discussion of this paper was reported.]