Journal of Agricultural and Resource Economics 28(3):435–450

An Empirical Analysis of Market Integration and Efficiency for U.S. Fresh Tomato Markets

Luz Padilla-Bernal, Dawn D. Thilmany, and Maria L. Loureiro

Fresh tomato trade between the United States and Mexico grew significantly during the 1990s. Moreover, major structural changes in U.S. produce marketing channels increase the complexity of conducting analyses to delineate the impact of liberalized trade. Following the work of Barrett, Li, and Bailey, this study implements a mixed distribution to examine spatial-price relationships between major shipping points and terminal markets for Mexican imported, and Florida and California tomatoes. Although markets are often efficiently integrated, results suggest strategic pricing and product shipments may exist and vary among terminal markets in Los Angeles, Boston, and Chicago.

Key words: market integration, North American tomato trade, spatial analysis, tomato markets

Introduction

Increasing demand for fresh produce on a year-round basis, together with increasingly liberal trade, has led to rapidly escalating fresh produce shipments throughout North America. In the specific case of fresh tomato trade between Mexico and the United States, flows increased dramatically during the 1990s, especially after the enactment of NAFTA and the 1994 Mexican peso devaluation. Fresh tomatoes imported from Mexico were considered a sensitive product under NAFTA, so U.S. tariffs on imports from Mexico were phased out entirely over the 10-year period ending in 2003.

United States tomato production averaged about 1.6 million tons over the last decade, yet 35% of U.S. fresh tomato consumption was imported in order to meet increasing year-round demand. Currently, around 80% of these imports are from Mexico [U.S. International Trade Commission (USITC)]. Vine-ripe tomatoes represent the largest share of imports from Mexico (60.4%). Increased imports during the 1990s led U.S. producers to file a formal dumping complaint against Mexican growers, arguing that decreasing domestic prices had reduced their profits and domestic market share. An initial suspension agreement established a reference price during several seasonal periods, and after a full sunset review, a second price agreement with similar restrictions was signed in December 2002 (U.S. Department of Commerce).

Luz Padilla-Bernal is research professor, Universidad Autónoma Zacatecas; Dawn D. Thilmany is associate professor, Department of Agricultural and Resource Economics, Colorado State University; and Maria L. Loureiro is a senior research economist, the Norwegian Agricultural Economics Research Institute. The authors thank Roberta Cook and two anonymous reviewers for valuable comments on earlier versions of this article. We are grateful to Consejo Nacional de Ciencia y Tecnologia and the Colorado Agricultural Experiment Station for financial support.

Review coordinated by Gary D. Thompson.

Discussion and trade analysis related to these trade negotiations focused on how to best protect U.S. producers from the potential harm of increased imports by setting reference prices to control for any potential anti-dumping behavior. Evidence suggests tariff reductions under NAFTA had only negligible impacts on trade volume (Padilla-Bernal). Yet, continued use and controversy surrounding the fairness of employing other policy instruments (reference prices) to indirectly manage supplies from Mexico motivate the need for research on imports and domestic terminal market behavior (Padilla-Bernal and Thilmany).

Defining fairness in an increasingly complex produce marketing system is not simple or straightforward (Thompson and Wilson). Over the last decade, the fresh tomato market sector experienced increased retailer concentration, leading to new trade practices between grower-shippers and retailers/wholesalers, and a marked evolution in the structure of marketing channels (Kaufman et al.; Thompson and Wilson). Although grocery retail sales are still the most important marketing channel for most fresh produce, California and Florida grower-shippers sell the majority of their product to wholesalers and distributors who repack tomatoes for selling to retailers or other intermediaries. These grower-shippers are concerned about increasing transaction costs, arguing that retail consolidation has led to abuses of market power. Imported tomatoes use the same marketing channels once they reach U.S. entry service ports; therefore, marketing costs are still comparable (with an added margin for trade costs such as insurance, international freight, loading/unloading costs, and tariffs).

The primary objective of this study is to examine price (efficiency) and trade (integration) relationships for vine-ripe tomatoes between Mexico and three representative U.S. terminal markets, with comparisons to relationships for California and Florida mature green tomatoes. Special attention is given to determining whether imports lead to more efficient marketing behavior or if there is evidence to suggest strategic marketing either by importers or domestic shippers (agents who may play a role in both supply channels). This study also provides a framework for analyzing potential noncompetitive behavior in the fresh tomato market, induced by nontariff barriers or dumping. The final goal of this investigation is to estimate regional fixed effects, which may include transaction costs above the measurable costs or other region- and season-specific effects, to infer their effect on market conditions. Through the application of an extended parity bounds model, using a quasi-maximum-likelihood technique, the probability of observing both specific intermarket conditions and fixed transaction costs for a region or season are estimated.

International Market Integration

Traditional spatial market integration research assumes two regions are in the same economic market for a homogeneous good if the difference in prices between the two regions exactly equals the transaction costs related to trade (Sexton, Kling, and Carman). Under a competitive equilibrium, trade flows occur until potential profits are exhausted. If barriers to trade exist, economic rents may persist. If the price differential is less than transaction costs, markets may be segmented or, if trade still occurs, this disparity may indicate the presence of long-run profit-maximizing strategies or short-run information failures. Autarkic markets provide an alternative explanation for segmented markets with equilibrium conditions (Spiller and Huang).

For international trade, two markets are spatially integrated if the prices for a commodity which is continuously traded between two countries (once appropriately adjusted for the exchange rate and transaction costs) are equal such that the law of one price holds. Numerous empirical analyses of price relationships in international markets have been developed, but the results are mixed, offering no strong support for the law of one price (Officer; Goodwin; Goodwin, Grennes, and Wohlgenant; Baffes; Ardeni; Zanias). Appealing to "modern trade theory," Miljkovic identifies several potential reasons for the failure of the law of one price, including noncontinuous trade flows, pricing to market, exchange rate risk, and geographical separation of markets.

Following Barrett, market integration is a quantity-based measure where the observance of trade flows is sufficient (but not necessary) to test if two markets are integrated. His approach draws on the intermarket transfer of Walrasian excess demand reflected in trade flows. Markets may be perfectly integrated if the markets have continuous trade flows and market prices follow the law of one price. They are imperfectly integrated when trade is observed but the arbitrage conditions are not binding. On the other hand, markets are in equilibrium when zero marginal profits to arbitrage are observed. Equilibrium can exist between markets without trade occurring under two situations. If trade flows are not observed and the arbitrage conditions hold, tradability exists, because traders should be indifferent between trading and not trading. When arbitrage conditions do not hold and trade is not observed, markets are in a segmented equilibrium.

The Extended Parity Bounds Model

In order to examine market conditions between U.S. wholesale, destination markets versus Mexican fresh tomato imports and California and Florida domestic supplies, we apply an extended parity bounds model following Barrett, Li, and Bailey, and extend the parity bounds model proposed by Baulch. In contrast to conventional methods using only prices for testing market integration, and supplementing the parity bounds model that incorporates both prices and transfer cost data, the extended parity bounds model exploits information in prices, transaction costs, and trade flows. Moreover, the extended parity bounds model allows the researcher to distinguish between market integration (defined as tradability) and market equilibrium, when zero marginal profit criteria are met.

Because the integration of transaction costs into the market analysis is one of the advantages of this approach, careful delineation and consideration of such costs is important. Transaction costs can be sorted into several mutually exclusive categories: (*a*) transportation costs, including all shipping charges; (*b*) transfer costs, which include other measurable costs, such as insurance and tariffs; and (*c*) less apparent transaction costs, such as risk premia, returns to marketing or distribution network development costs, or nontariff trade barriers. In addition to overcoming many of the problems detected in the conventional models for testing market integration, the extended parity bounds model allows for estimation of the "additional" transaction costs that are not public information.

The central idea behind the extended parity bounds model is to measure the probability of intermarket arbitrage conditions binding. Estimated probabilities make it possible to establish whether Mexican and U.S. fresh tomato markets are perfectly integrated, or other distinct market relationships exist. In addition to Mexican imports, the model is also applied to California and Florida tomato supply regions. Six regimes are defined by taking into account the intermarket equilibrium conditions specified above.

Let P_t^i and P_t^j be the wholesale terminal market price for fresh tomatoes and the FOB price, respectively, and T_t^{ji} represent measurable transfer costs from j to i. Incorporating an error term, v_t, to account for all nonobservable factors, then when $P_t^i - P_t^j = T_t^{ji} + v_t$, the expected value of the spatial arbitrage condition binds. This equality signals that the markets are integrated and in long-run competitive equilibrium whether trade is observed or not, signifying perfect integration for regimes 1 and 2 in table 1.

If expected price differentials exceed expected transaction costs, $P_t^i - P_t^j = T_t^{ji} + v_t + u_t$, two new regimes may emerge. Note that u_t is a positive random variable, defining a regime where the wholesale terminal market price exceeds the FOB prices plus the measurable transaction costs. If trade takes place, positive profits to the trading sector are implied (regime 3); otherwise it represents the case where trade appears profitable but does not take place (regime 4). However, if expected price differentials are less than expected transfer costs, $P_t^i - P_t^j = T_t^{ji} + v_t - u_t$, trade is not profitable to arbitrageurs when trade is observed. Regime 5 suggests trade takes place at a cost to the arbitrageur, while regime 6 indicates trade is not observed, and consequently, one can infer a segmented equilibrium. Table 1 summarizes the market behavior for each regime, as well as the relationships among regimes resulting in various efficiency and equilibrium market conditions.

To estimate the probability (λ_k) of observing each of the k regimes in the fresh tomato market, we estimate a switching regimes model taking into account the regime frequencies found in the sample, conditional on the binary variable of trade occurrence, and adjusted for region- and season-specific effects (discussed below). Specifically, it is assumed that the error term v_t is independently and identically distributed with mean zero and variance σ_v^2, while u_t is one-sided error, distributed independent of v_t, assuming a half normal distribution with variance σ_u^2.

Based on Weinstein, the density function of the sum of a normal random variable and truncated normal random variable is written as:

$$f(v_t + u_t) = \frac{2}{\sigma}\phi\left(\frac{v_t + u_t}{\sigma}\right)\left[1 - \Phi\left(\frac{-(v_t + u_t)\sigma_u/\sigma_v}{\sigma}\right)\right], \tag{1}$$

where $\sigma = (\sigma_v^2 + \sigma_u^2)^{½}$; ϕ denotes the standard normal density function, such that

$$\phi = f\left(\frac{v_t + u_t}{\sigma}\right) = \frac{1}{(2\pi)^{0.5}}\exp^{\left(-½\frac{(v_t+u_t)^2}{\sigma^2}\right)};$$

and Φ is the cumulative density function for the standard normal distribution. The distribution functions for the observations in each regime are determined as follows:

$$f_t^1 = f_t^2 = \frac{1}{\sigma_v}\phi\left[\frac{Y_t - T_t^{ji}}{\sigma_v}\right], \tag{2}$$

$$f_t^3 = f_t^4 = \left[\frac{2}{(\sigma_u^2 + \sigma_v^2)^{½}}\right]\phi\left[\frac{Y_t - T_t^{ji}}{(\sigma_u^2 + \sigma_v^2)^{½}}\right]\left[1 - \Phi\left[\frac{-(Y_t - T_t^{ji})\sigma_u/\sigma_v)}{(\sigma_u^2 + \sigma_v^2)^{½}}\right]\right], \tag{3}$$

Table 1. Intermarket Regimes and Market Conditions from Extended Parity Bounds Model

Regime Definition	Intermarket Conditions	Probability
<---------- **Trade Is Observed** ---------->		
REGIME 1. Perfect Integration with Trade	$P_t^i - P_t^j = T_t^{ji} + v_t$	λ_1
REGIME 3. Inefficient Integration (positive marginal profits to arbitrage)	$P_t^i - P_t^j = T_t^{ji} + v_t + u_t$	λ_3
REGIME 5. Inefficient Integration (negative marginal profits to arbitrage)	$P_t^i - P_t^j = T_t^{ji} + v_t - u_t$	λ_5
<---------- **Trade Is Not Observed** ---------->		
REGIME 2. Perfect Integration without Trade	$P_t^i - P_t^j = T_t^{ji} + v_t$	λ_2
REGIME 4. Segmented Disequilibrium	$P_t^i - P_t^j = T_t^{ji} + v_t + u_t$	λ_4
REGIME 6. Segmented Equilibrium	$P_t^i - P_t^j = T_t^{ji} + v_t - u_t$	λ_6

Market Behavior	Market Condition	Probability
Intermarket arbitrage conditions are binding[a]	Perfectly Integrated (*PI*)	$\lambda_1 + \lambda_2 = PI$
Intermarket arbitrage conditions hold (zero marginal trader profit)	Market Equilibrium (*ME*)	$\lambda_1 + \lambda_2 + \lambda_6 = ME$
Trade is observed or the intermarket arbitrage conditions are binding[a]	Intermarket Tradability (*IT*)	$\lambda_1 + \lambda_2 + \lambda_3 + \lambda_5 = IT$
Trade is observed but intermarket arbitrage conditions do not hold	Inefficiently Integrated (*II*)	$\lambda_3 + \lambda_5 = II$
Trade is observed but intermarket arbitrage conditions do not hold	Overly Competitive Behavior (*OC*)	$\lambda_5 = OC$
Trade is not observed and intermarket arbitrage conditions hold	Segmented Equilibrium (*SE*)	$\lambda_6 = SE$
Trade is not observed and intermarket arbitrage conditions do not hold	Segmented Disequilibrium (*SD*)	$\lambda_4 = SD$

[a] For regime 2, intermarket arbitrage conditions are exactly binding, so traders are indifferent between trading or not. Trade flows may or may not be observable.

$$(4) \qquad f_t^5 = f_t^6 = \left[\frac{2}{(\sigma_u^2 + \sigma_v^2)^{1/2}}\right]\phi\left[\frac{Y_t - T_t^{ji}}{(\sigma_u^2 + \sigma_v^2)^{1/2}}\right]\left[1 - \Phi\left[\frac{(Y_t - T_t^{ji})\sigma_u/\sigma_v}{(\sigma_u^2 + \sigma_v^2)^{1/2}}\right]\right],$$

where $Y_t \equiv P_t^i - P_t^j$ represents the price differential between the wholesale terminal market price of the importing market and the FOB price of the exporting market, and $T_t^{ji} \equiv \beta_1 D_1 + \beta_2 D_2 + CIF_t^{ji} + TX_t^{ji} + DT_t^{ji}$ represents the measurable transfer costs from j to i.

The transfer costs captured by the model can vary across shipping regions (or equivalently, by the season of trading). Specifically, D_1 and D_2 are two indicator variables included to account for fixed effects from specific regions or seasons, where $D_1 = 1$ if the shipping points are Sinaloa, Mexico, or Florida, and zero otherwise (depending on whether it is a part of the domestic or imported tomato price analysis). These locations correspond to tomatoes shipped from December to May or November to June, respectively.

Similarly, $D_2 = 1$ if the shipping points are Baja California, Mexico, or California, and zero otherwise. These two locations correspond to tomatoes traded from June to November or July to October, respectively. Consequently, the parameters β_1 and β_2 estimate any region- or season-specific effect not already accounted for with the inclusion of domestic transportation, tariff, and international trading costs. CIF_t measures insurance, international freight, and loading/unloading costs; TX_t denotes tariffs; and DT_t represents domestic transportation costs at time t.

The likelihood function for the extended parity bounds model can be expressed as follows:

$$(5)\qquad L = \prod_{t=1}^{T} \left\{ A_t * \left[\lambda_1 f_t^1 + \lambda_3 f_t^3 + \lambda_5 f_t^5 \right] + (1 - A_t) * \left[\lambda_2 f_t^2 + \lambda_4 f_t^4 + \lambda_6 f_t^6 \right] \right\},$$

where A_t is a binary variable equal to one if trade occurred in period t, and 0 otherwise. Maximizing the log-likelihood function in (5) yields estimates of the probabilities of each regime (λ_k), region/season-specific costs for marketing fresh tomatoes (β's), and the variances σ_v^2 and σ_u^2, subject to the constraint that $\Sigma_k \lambda_k = 1$, and $\lambda_k \geq 0 \; \forall \, k$. If trade is always observed, only the respective parameters for regimes 1, 3, and 5 are calculated.

Data Description

The extended parity bounds model was estimated using weekly data for imported Mexican vine-ripe tomatoes from January 1995 through August 1999,[1] and California and Florida mature green tomatoes through December 1999.[2] Shipping point prices from Nogales, Arizona, and San Diego, California, for Mexican tomatoes and for Fresno, California, and Orlando, Florida, tomatoes are in nominal terms and were constructed from U.S. Department of Agriculture/Agricultural Marketing Service (USDA/AMS 1999a) data. If prices for tomatoes of any specific type or particular source were reported, it was assumed a fairly significant volume was traded in that market [as noted by USDA/AMS (1999a) when volume is light]. Tariffs (*TX*) for imported Mexican vine-ripe tomatoes and aggregate import charges for international freight, insurance, and other charges (*CIF*) were constructed on a dollar basis with information reported by the USITC.

Terminal-market wholesale prices and domestic transportation[3] data are taken from USDA/AMS (1999a, b). Because there is no weekly time series of FOB prices available for Sinaloa, Mexico, and Baja California, Mexico, these price series were determined by deducting the sum of import charges and tariffs from the weekly shipping point prices at Nogales, Arizona, and San Diego, California. For the construction of the trade flow dummy variable ($A_t = 1$ if there are trade flows, and $A_t = 0$ otherwise), it was assumed trade flows were observed only when prices for vine-ripe or mature green tomatoes were

[1] These series represent the average price of 25-pound cartons of vine-ripe tomatoes (delineated by production area in Mexico, the United States, or other countries) with two-layer, 4 × 5, 5 × 5, and 5 × 6 configurations. From December to May, Mexican prices are for tomatoes grown in Sinaloa, Mexico, crossing through Nogales, Arizona. From June to November, these prices are for tomatoes produced in Baja California, Mexico, crossing through Otay Mesa (near San Diego, California).

[2] This price series is an arithmetic average price of 25-pound mature green tomato cartons. From November to June, prices are for Florida tomatoes, and from July to October, prices are for tomatoes grown in California. Terminal market prices were calculated similarly.

[3] This series is a simple average of the weekly rate range reported by the USDA/AMS (1999b) that shippers or receivers pay, including truck broker fees, and taking the actual shipping point (for Mexican and domestic supplies) into consideration.

reported at the shipping point and at the terminal market. All time series were expressed in nominal terms of U.S. dollars per 25-pound carton for both vine-ripe and mature green tomatoes.

Currently, around 80% of U.S. fresh tomato imports are from Mexico (USDA/Economic Research Service). These imports supplement California and Florida supplies, and vine-ripe tomatoes represent the largest share of imports from Mexico (60.4%)—although demand is increasing for likely substitutes such as roma and hothouse tomatoes from Mexico and other trading partners, such as Canada (Thompson). It is important to note that different types and sources of tomatoes increasingly differentiate tomatoes at retail.[4] Finally, the United States exports fresh tomatoes to Mexico, but these exports decreased significantly after the 1994 Mexican peso devaluation (from 21,915 to 4,792 tons in 1998). Thus, no market relationships between the United States and Mexican consumer markets are incorporated in this study.

From late fall to late spring, the majority of fresh tomatoes imported from Mexico go to western U.S. markets. While Florida shipments dominate the northeastern and southern markets, Florida and Mexican crops often compete more directly for markets in the midwest region (Thompson and Wilson; Love and Lucier). These seasons are the primary focus of this analysis, as U.S. markets receive tomatoes from a broader set of U.S. seasonal suppliers not accounted for in this study during the summer and early fall months. In order to examine the price relationships between Mexican and U.S. markets for vine-ripe tomatoes, three representative terminal markets are studied: Los Angeles in the west, Chicago in the midwest, and Boston[5] in the northeast. For mature green tomatoes supplied by California and Florida, only Chicago and Boston markets are modeled because California dominates the Los Angeles market.

Prices and Trade Relationships

Although the United States has seen fresh tomato imports from Mexico every week in recent years, only the western markets have received Mexican tomato shipments with this frequency. Los Angeles, Chicago, and Boston respectively demanded 48,351 tons, 6,084 tons, and 2,497 tons of tomatoes from Mexico in 1994, and subsequent shipments increased considerably in each market (USDA/AMS 1999a). Meanwhile, shipments of fresh tomatoes from California and Florida have declined in relative terms (Padilla-Bernal). This decreasing demand for U.S. mature green tomatoes is consistent with a shift in consumer preferences away from mature green tomatoes toward other types of tomatoes, in addition to increased foreign competition (Calvin and Cook et al.).

Chicago and Boston did not receive vine-ripe Mexican tomatoes year-round, possibly due to the distance from Mexican shipping points. The Chicago market exhibits stronger seasonal competition between Mexico and domestic producers, receiving trade flows of vine-ripe tomatoes from Mexico during 81.5% of the 1995–1999 period analyzed, while Boston received Mexican tomatoes during only 42.6% of the same period. For both of these markets, "other" U.S. tomato production regions likely also play a role. The supply

[4] This study accounts for differences through separable price analyses when possible, but since little specific data are available on hothouse tomatoes, a domestic alternative to counterseasonal imports from Mexico is not explored here.

[5] Weekly truck rate reports from the USDA/AMS (1999b) are available for only seven cities (including Chicago and Los Angeles). The Boston series was estimated by extrapolating from rates reported for New York, calculating a per mile average, and multiplying by the miles from the shipping point to Boston rather than New York.

volume from other southeastern and midwestern states is less than California and Florida, yet during some summer weeks, may significantly influence pricing and trade volumes in Chicago and Boston. The discontinuous trade is likely due to seasonality of production, but may also have some relationship with prevailing reference price agreements. If market forces drive prices too low in any week, Mexican shipments are suspended until prices rise enough to exceed the reference price.

In order to examine the price and trade relationships for mature green tomatoes in Chicago and Boston, the shipping point price, wholesale-terminal market price, and measurable transaction costs time series were assembled taking into account the year-round U.S. supply. Due to the relatively small trade flows of fresh tomatoes from the United States to Mexico, and because Boston and Chicago are strictly consumption markets, only unidirectional analyses are developed for tomatoes in these markets.

Transaction Costs

Transaction costs are not only those costs incurred when shipping the product from one location to another, referred to here as transfer costs such as freight, insurance, and loading/offloading costs, tariffs, and domestic transportation. They also include information costs such as learning about arbitrage opportunities, costs resulting from governmental policies and their enforcement, and hedging costs required to make arbitrage a riskless activity (Spiller and Huang). When trading internationally, transaction costs become arguably higher than those of domestic markets due to differences in language, culture, laws, and dispute procedures, as well as imperfect information sources (Thilmany and Barrett). In addition, there exist other transaction costs due to uncertainty about government regulations in foreign markets, exchange rate policy, tariffs, and nontariff barriers (Abdel-Latif and Nugent).

In short, whether analyzing domestic or international markets, arbitrage costs are those marginal costs that must be incurred in order to perform riskless arbitrage (Spiller and Wood). Clearly, obtaining a full, direct, and exact measure of transaction costs in domestic or international markets is difficult given the inherent unobservability of some of these costs.

The observable transaction costs or transfer costs for marketing Mexican vine-ripe tomatoes applied in this study are the import charges representing the aggregate cost of all freight, insurance, and other charges, costs, and expenses (*CIF*) incurred in bringing fresh tomatoes from Sinaloa or Baja California to the first port of entry in the United States. Nogales and San Diego serve as the dominant ports of entry for tomatoes.[6] Tariffs (*TX*) were estimated based on the calculated duties reported by the USITC (1999). Calculated duties represent the estimated import duties collected and they are estimated on the applicable rate of duty for Mexican vine-ripe tomatoes as shown in the Harmonized Tariff Schedule for the United States (USITC). Finally, domestic transportation (*DT*) represents expenses required in order to deliver tomatoes from the original shipping point to the terminal market.

Table 2 gives the means, standard deviations, and coefficients of variation of the publicly available or transfer costs. The highest *CIF* ($0.56) and tariffs ($0.27) are reported

[6] Although the USITC reports fresh tomato imports from Mexico through seven U.S. Customs Service ports (Nogales, Arizona; Los Angeles, San Diego, and San Francisco in California; El Paso and Laredo in Texas; and Chicago, Illinois), virtually all imports from Mexico (97.6%) enter through Nogales (68.1%) and San Diego (29.5%).

Table 2. Fresh Tomatoes: Means and Standard Deviations of Measurable Transaction Costs, 1995–1999 ($/25-pound carton)

Shipping Point and Wholesale Terminal Market	Mean	Standard Deviation	Coefficient of Variation	Number of Observations
Charges for International Freight, Insurance, and Other Charges (*CIF*):[a]				
▸ From Sinaloa and Baja California to Nogales, AZ and San Diego-Los Angeles	0.38	0.27	72.92	244
▸ From Sinaloa and Baja California to Nogales, AZ and San Diego-Chicago	0.42	0.27	64.95	199
▸ From Sinaloa and Baja California to Nogales, AZ and San Diego-Boston	0.56	0.22	39.64	104
Tariffs (*TX*):				
▸ Mexican vine-ripe tomatoes–Los Angeles	0.24	0.13	53.26	244
▸ Mexican vine-ripe tomatoes–Chicago	0.25	0.12	50.20	199
▸ Mexican vine-ripe tomatoes–Boston	0.27	0.10	38.00	104
Domestic Transportation (*DT*):				
▸ From Nogales, AZ and San Diego to Los Angeles	0.46	0.03	6.63	244
▸ From Nogales, AZ and San Diego to Chicago	1.34	0.28	20.75	199
▸ From Nogales, AZ and San Diego to Boston	2.10	0.43	20.37	104
▸ From Orlando, FL and San Diego to Chicago	1.19	0.35	29.41	262
▸ From Orlando, FL and San Diego to Boston	1.77	0.79	44.27	262
Total Observed Transaction Costs:				
▸ From Sinaloa and Baja California to Los Angeles	1.08	0.37	33.79	244
▸ From Sinaloa and Baja California to Chicago	2.01	0.32	15.72	199
▸ From Sinaloa and Baja California to Boston	2.93	0.37	12.49	104
▸ From Orlando, FL and San Diego to Chicago	1.19	0.35	29.41	262
▸ From Orlando, FL and San Diego to Boston	1.77	0.79	44.27	262

[a] The mean changes because Chicago and Boston terminal markets do not receive Mexican vine-ripe tomatoes during every period.

for tomatoes delivered to Boston. In general, the closer the market to the Mexican border, the lower the domestic transportation costs. The Los Angeles market reports the lowest average domestic transportation cost ($0.46) with the lowest variability (coefficient of variation is 6.63%). In order to reach Chicago and Boston, Mexican tomatoes incur higher domestic transportation costs ($1.34 and $2.10, respectively) than California and Florida mature green tomatoes (with expenditures of $1.19 to Chicago and $1.77 to Boston). The highest coefficient of variation for domestic transportation costs is for U.S. tomatoes in Boston (44.27%), signaling this terminal market has the highest relative marketing cost uncertainty.

The measurable transaction costs ($CIF + TX + DT$) were included as a ratio to the adjusted FOB price for Sinaloa, Baja California, California, and Florida (table 3). This ratio represents the percentage markup above the adjusted FOB price to give the landed price of tomatoes at terminal markets. The highest average ratio was for vine-ripe tomatoes grown in Mexico and marketed in Boston (44.51%) and Chicago (30.40%), while the highest variability is reported for mature green tomatoes marketed in Boston.

Table 3. Transaction Costs/FOB Price Ratio Summary Statistics, 1995–1999 (%)

Shipping Point and Wholesale Terminal Market	Mean	Standard Deviation	Coefficient of Variation	Number of Observations
From Sinaloa and Baja California to Los Angeles	16.70	10.26	61.41	244
From Sinaloa and Baja California to Chicago	30.40	15.05	49.52	199
From Sinaloa and Baja California to Boston	44.51	20.82	46.78	104
From Florida and California to Chicago	15.31	8.07	52.74	262
From Florida and California to Boston	23.32	15.37	65.90	262

Estimation Results

The quasi-maximum-likelihood estimation of the extended parity bounds model was conducted using TSP International version 4.5. Results from estimation of equation (5) for Mexican vine-ripe and California and Florida mature green tomatoes are summarized in table 4. Most of the estimated coefficients are statistically significant. The Wald test for joint significance of the parameter estimates rejected the null hypotheses that these estimates and sigmas were equal to zero.

As expected, the market nearest the supply regions, Los Angeles, has the highest probability (83%) of perfect market integration with Mexican markets, while perfect integration is expected in Boston for only 6% of all cases. Mature green tomatoes in the Boston market have a higher probability of perfect integration (54%) with California and Florida markets. As distance between markets increases, it could be argued that the risk of doing business in those markets increases due to time lags for shipping and the associated loss in quality, and consequently, the probability of having higher nonobservable transaction costs or a longer adjustment period increases.

In Chicago, perfectly integrated markets with no trade (regime 2 with binding intermarket arbitrage conditions) for Mexican tomatoes had an estimated probability which was indistinguishable from zero, suggesting perfect integration only when trade occurs. The small number of observations (45) for the no-trade regimes, and the relatively high probability of finding a segmented equilibrium regime (17%), may help to explain this finding. The highest probability of trade taking place with the potential for positive profits was for vine-ripe tomatoes in Chicago (27%), and for mature green tomatoes in Boston (30%). This finding may imply a less transparent barrier to market entry exists in some periods, or adjustment to price and costs changes takes longer (perhaps due to distance). One possible explanation for the high probability of potential profits to arbitrage, together with the low likelihood of perfect integration without trade in the Chicago market, is increasing trade flows. Total tomato demand in Chicago in 1995 was 63,378 tons, and grew to 82,219 tons in 1998. Such increases may temporarily lead to greater returns to pre-established networks in that market, and positive profits may be sustained as the market returns to equilibrium.

In Boston, the probability of a segmented disequilibrium was 36% for vine-ripe tomatoes, suggesting trade appears profitable but it does not take place. Meanwhile, the probability of finding apparent negative profits to arbitrage of 24% for vine-ripe and 16% for mature greens is not completely unexpected. During summer and early fall months, several local supply sources (Georgia, Virginia, Maryland, and Pennsylvania)

Table 4. Extended Parity Bounds Model Estimates for Mexican and U.S. Tomatoes, 1995–1999

Description	Mexico-Los Angeles	Mexico-Chicago	Mexico-Boston	California & Florida-Chicago	California & Florida-Boston
Sinaloa (β_1)	1.23*** (9.65)	2.20*** (7.74)	0.59*** (2.58)	—	—
Florida (β_1)	—	—	—	1.74*** (6.07)	2.68*** (10.59)
Baja California (β_2)	0.61*** (5.20)	1.49*** (6.08)	0.23 (0.82)	—	—
California (β_2)	—	—	—	-0.17 (-0.65)	0.99*** (3.29)
σ_v^2	0.95*** (8.34)	1.04*** (5.62)	0.65*** (3.88)	0.81*** (3.18)	1.16*** (5.45)
σ_u^2	2.21*** (4.17)	2.34*** (10.99)	3.34*** (17.44)	2.17*** (12.21)	2.50*** (8.23)
<---------- **Trade Is Observed** ---------->					
λ_1	0.83*** (7.73)	0.37*** (3.17)	0.06** (2.23)	0.36** (2.55)	0.54*** (3.42)
λ_3	0.12* (1.77)	0.27*** (2.65)	0.12*** (3.95)	0.26*** (3.41)	0.30** (2.25)
λ_5	0.05 (0.96)	0.18*** (2.78)	0.24*** (6.53)	0.38*** (2.94)	0.16** (2.45)
<---------- **Trade Is Not Observed** ---------->					
λ_2	—	0.001 (0.32)	0.11** (2.48)	—	—
λ_4	—	0.009 (1.03)	0.36*** (6.56)	—	—
λ_6	—	0.17*** (6.86)	0.11*** (3.85)	—	—
No. of Observations	244	244	244	262	262
No-Trade Observations	—	45	140	—	—
Log Likelihood	-398.77	-624.88	-763.37	-532.43	-549.42
p-Value for Wald Test [a]	0.00	0.00	0.00	0.00	0.00
t-Statistics for H_0: $\beta_1 = \beta_2$	4.84	2.49	1.55	6.69	6.66
p-Value	(0.00)	(0.01)	(0.11)	(0.00)	(0.00)

Notes: Single, double, and triple asterisks (*) denote statistical significance at the 10%, 5%, and 1% levels, respectively. Values in parentheses are asymptotic t-statistics.

[a] Wald test for the hypothesis that the set of parameters (σ_v^2, σ_u^2, β_1, β_2, λ_1, λ_2, λ_3, λ_4, λ_5, and λ_6) are jointly zero.

may influence prices and trade flows from the more time-integrated suppliers included in this study. According to these results, it may be a risky or difficult proposition to trade fresh tomatoes in Boston given a high rate of unobservable transaction costs and high variability in the share of marketing costs, leading to periods when arbitrageurs decide to not take advantage of potential positive profits. There are other periods when, despite the apparent lack of profits to be made, distributors still decide to trade—suggesting intense competition between Florida and Sinaloa tomato shippers as they strive to expand market share, and willingly absorb temporary losses.

In this model, both observed and estimated regional or seasonal fixed effects (which may include additional transaction costs) can vary across seasons and shipping areas. The estimates of fixed effects beyond the measurable costs were significant with two exceptions, the Chicago market for mature green tomatoes from California, and the Boston market for vine-ripe tomatoes from Baja California. The null hypothesis of $\beta_1 - \beta_2 = 0$ was tested, and the difference between these fixed effects is significant except between the Mexican shipping points and Boston terminal market. A simple mean of the FOB price observations from each shipping point was calculated to determine the ratio of estimated additional transaction costs (betas) to these prices (table 5). This estimated transaction cost share ranges from 7.26% to 27.06% for vine-ripe tomatoes, and from 12.79% to 26.96% for mature green tomatoes between 1995 and 1999.

Interestingly, the parameter estimates of the additional, estimated transaction costs always are higher when the shipping regions are Sinaloa or Florida, or during the winter and spring seasons. This result was not expected because direct transportation costs are already accounted for, but there are some reasons to believe that the winter and early spring season may experience some unique market conditions. First, with generally higher prices in the winter, a simple markup pricing strategy would suggest a higher fixed transaction cost from marketers. Also, during the high production seasons for these two shipping regions, increased trade flows of other produce crops may increase demand and garner short-term premia for produce marketing services.

In the case of fresh tomatoes from Mexico, β_1 and β_2 (estimated fixed effects for Sinaloa and Baja California tomatoes) in the Boston market were unexpectedly lower than in the other markets. Table 3 documents that the measurable transfer costs from Mexico to Boston are already quite a bit higher than other markets, so the lower fixed effect may simply compensate for the large, measurable marketing margin. Still, the relatively high probability of the market exhibiting a segmented disequilibrium condition, where profits are possible but not acted upon by Mexican shippers, suggests market structure or conduct may dampen price response during some weeks.

The Chicago market shows conditions similar to Boston for mature green tomatoes shipped from Florida. Unexpectedly, Boston has a higher estimated fixed effect than Chicago, even though Boston is fewer miles from Florida than is Chicago. In this case, the higher probability of overly competitive behavior would imply lower marketing costs are a price discrimination strategy to assist Florida supplies in gaining market share in Chicago.

There is further evidence to complement these findings. Mexico accounted for an increasingly smaller share of the Boston market than Florida and California (10% in 2001 compared to 64% during the 1995–1999 period). Although the market share for Mexican tomatoes increased in Chicago in later years (from 24% in 1995 to 34% in 1998), it still remains low compared to the 57% market share held by U.S. supplies during the same period.

To summarize, table 6 shows the probability estimates of particular market conditions prevailing in the fresh tomato market. Perfect integration was found with 83% probability between Mexico-Los Angeles, and 54% of the time between California and Florida-Boston, while the probability of perfect integration was less than 40% for the remaining pairs of markets analyzed. As expected, intermarket tradability occurred with 100% probability between Mexican markets and Los Angeles, and between the California/ Florida producing regions and both Chicago and Boston terminal markets.

Table 5. Mean of FOB and Terminal Market Price and Estimated Fixed Region/ Season Effect/Mean FOB Prices, 1995–1999

Description	Los Angeles	Chicago	Boston
Mean Sinaloa FOB price[a]	$8.13	$8.13	$8.13
Mean Baja California FOB price	$7.92	$7.92	$7.92
Mean Florida FOB price		$9.79	$9.94
Mean California FOB price		$8.02	$7.74
Estimated Additional Transfer Costs/Mean FOB Price (percent):			
β_1 as % of Sinaloa FOB price[b]	15.13%	27.06%	7.26%
β_2 as % of Baja California FOB price	7.70%	18.81%	—[c]
β_1 as % of Florida FOB price		17.77%	26.96%
β_2 as % of California FOB price		—[c]	12.79%

[a] Simple mean of all price observations used in the estimation by shipping region. Values are dollars per 25-pound carton.
[b] Estimated beta divided by simple mean of FOB prices for that shipping region.
[c] Beta was not statistically significant.

Table 6. Estimates of the Probability for Fresh Tomato Market Conditions

Market Condition	Probability	Mexico-Los Angeles	Mexico-Chicago	Mexico-Boston	Calif. & Florida-Chicago	Calif. & Florida-Boston
Perfectly Integrated	$\lambda_1 + \lambda_2 = PI$	0.83	0.37	0.17	0.36	0.54
Market Equilibrium	$\lambda_1 + \lambda_2 + \lambda_6 = ME$	0.83	0.54	0.28	0.36	0.54
Intermarket Tradability	$\lambda_1 + \lambda_2 + \lambda_3 + \lambda_5 = IT$	1.00	0.82	0.53	1.00	1.00
Inefficiently Integrated	$\lambda_3 + \lambda_5 = II$	0.17	0.45	0.36	0.64	0.46
Overly Competitive Behavior	$\lambda_5 = OC$	0.05	0.18	0.24	0.38	0.16
Segmented Equilibrium	$\lambda_6 = SE$	—	0.17	0.11	—	—
Segmented Disequilibrium	$\lambda_4 = SD$	—	0.01	0.36	—	—

The probability of tradability between Mexico and Chicago was 82%, while between Mexico and Boston this probability dropped to 53%. Although it is clear that those markets are highly integrated in the sense of tradability, it is not possible to say the same about equilibrium. The probability of market equilibrium was 83% for Mexico-Los Angeles, 54% for Mexico-Chicago, and only 28% for Mexico-Boston. The average market shares during the 1995–1999 period for Mexican tomatoes in Los Angeles, Chicago, and Boston, were 63%, 25%, and 10%, respectively. Empirical findings and market share data suggest as distance increases between the Mexican supply regions and U.S. markets, and Mexico's share of the market declines, market equilibrium declines.

California and Florida tomato market conditions are similar to those of Mexican tomatoes, as the equilibrium condition is expected 54% of the time in Boston, and only 36% of the time in Chicago. Some inefficiencies appear likely in those two markets for both Mexican and U.S. tomato marketers.

Conclusions

This study applies a spatial equilibrium mixed distribution method to examine the vine-ripe tomato market relationships between Mexico and the United States. The analysis attempts to determine differential market conditions in regions that are markedly different in several respects, including distance from competing production regions and consumer market size. Subsequently, the price and trade relationship analysis was conducted for Mexican and domestic tomato shipments to three U.S. consumer markets—Los Angeles (a high demand market near Mexican supply regions), as well as Chicago and Boston (both demand centers distant from Mexican production regions).

Increased trade flows of fresh tomatoes from Mexico to the United States imply increased market integration (tradability) between Mexican and U.S. markets, especially with the terminal markets closest to the border. This has also translated to a higher incidence of market equilibrium for those markets, while the opposite is true for markets located farther away from the producing regions, such as Chicago and Boston. Estimates of the probability of inefficiently integrated markets in Chicago and Boston are relatively high, ranging from 36% between Mexico-Boston to 64% between California/Florida and Chicago. The prevalence of segmented disequilibrium and less perfect competitive behavior in those markets suggests a high level of risk and uncertainty, or possibly information failures that either wrongly encourage trade flows between regions generating negative marginal profits or prevent trade flows from taking place when positive profits are possible. Given the current trade policy regime and increasing integration among tomato growers and shippers, these imperfect market conditions may also be evidence of strategic market shipments and price discrimination.

One of the objectives of this work is to provide a framework for analyzing potential strategic behavior in the fresh tomato market given the antidumping complaints filed against Mexican grower/shippers, and to identify markets where trade disputes may arise. U.S. growers have argued they experienced lower domestic prices, profits, and an overall loss of market share due to Mexican producers and shippers selling fresh tomatoes at less than the fair market value. This dispute was suspended by an agreement, which was renegotiated in the winter of 2002, between the U.S. Department of Commerce and Mexican tomato growers. In short, Mexican tomatoes cannot be sold at less than a reference FOB price in Nogales, San Diego, and Laredo.

Although fresh tomato competition occurs among firms (Thompson and Wilson), the formal trade disputes are between regions. This analysis may inform future trade negotiations, as it represents the aggregation of individual firms' reactions and strategies to regional market signals and reference prices which influence market dynamics in some periods. Based on findings from this study, discriminatory trading practices across U.S. terminal markets may prove to be just as significant to producer claims of harmful market activity as aggregated Mexican shipping prices. More detailed analysis, focusing on specific market conditions cited in trade disputes, is warranted.

Limitations and Future Research

Although market integration analysis is an effective approach for modeling price relationships across regions or countries, it has several limitations that weaken its ability to inform marketing and trade policy. Prices serve as rich, informative signals of demand

and supply conditions, but do not foster an understanding of the complex marketing channels and trading relationships which influence produce marketing cost structures. This study used three representative markets and four representative supply regions (San Joaquin Valley shipments to Los Angeles and smaller mid-Atlantic shipments to Eastern markets are not integrated in this study). Also, some of the fastest growing product lines (hothouse and specialty tomatoes) and increasingly influential buyers (retailers and food service buyers) are absent from this study's data.

Inclusion of transaction costs into the spatial equilibrium are essential, yet there are data limitations leading to potential measurement error in the constructed transaction cost series, while other transaction costs are inferred through model estimation due to the absence of data on all market activities. To achieve convergence of the model, these inferred transaction costs were constrained to be time-invariant, but the seasonality present in the constructed transaction cost series may address this limitation to some degree. Nevertheless, these limitations point out the need for richer data on transaction costs.

Still, this research illustrates the varying relationships across regional markets and is meant to encourage further analysis of these topics as richer data become available. These findings cannot be the sole evidence used in discussions on spatial trade behavior among tomato marketers, but should be used in conjunction with other analyses in describing the effects of various suppliers' marketing strategies on prices and shipments.

[*Received October 2002; final revision received August 2003.*]

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