Price Relationships for Mexican Fresh Tomatoes in U.S. and Mexican Terminal Markets

Presented at the 2002 WAEA Annual Meetings, Long Beach CA

Authors: Luz E. Padilla[1], Dawn Thilmany[2] and Stephen P. Davies[2] ,

[1]*Universidad Autonoma de Zacatecas and* [2]*Colorado State University*

Contact Author: Luz E. Padilla
Unidad Académica de Contaduría y Administración
Universidad Autónoma de Zacatecas
Comercio y Administración s/n Col. Progreso
Zacatecas, Zac. Mexico 98000
(52-492) 922 4577 (phone)
luze@cantera.reduaz.mx

Abstract: Tomato trade between the U.S. and Mexico has grown significantly during the past decade, with significant implications for markets in both countries. This work examines how terminal market prices for Mexican fresh tomatoes are being affected by price dynamics in distant, integrated markets by analyzing reaction patterns to various innovation shocks. We conclude that a high interdependence in the price formation process between Mexican markets and Los Angeles, as well as among Mexican markets, exists.

Growing, year round demand for fresh fruits and vegetables stimulated international trade over the last decade. In the case of fresh tomatoes, imports to the United States (U.S.) increased considerably during the 1990´s, especially from Mexico and Canada. Mexico was the leading supplier of those imports, representing 91.0 percent of total imports of fresh tomatoes on average, while Canada accounted for only 4.8 percent. Moreover, imports from Mexico have entered the U.S. every week in recent years in increasing volumes.

Tomato growers located in the Sinaloa and Baja California Peninsula of Mexico supply the majority of fresh tomatoes exported to the U.S., but they also supply domestic markets. Those regions' growers harvest about 55 percent of all Mexican fresh tomatoes. Although Mexican growers specialize in tomatoes for export markets, almost 50 percent of tomatoes do remain in the domestic market. Their main terminal markets in Mexico are Guadalajara, Monterrey, and Ciudad de Mexico, as well as Western U.S. markets. Although Florida dominates Northeast and Southeast U.S. terminal markets, Mexican tomatoes also are sold in these markets (ERS, USDA) while Florida and Mexican tomatoes often compete for the terminal markets in the North Central region.

Previous studies have shown that Mexican and American tomato markets are integrated (Padilla, 2001; Jordan and VanSickle, 1995) even though they are not in a long run competitive equilibrium. These studies conclude that the probability of finding markets that operate inefficiently increases as the distance between markets increase, possibly due to lags in information, asymmetric information and higher levels of perceived risk.

Given that Mexican export grower-shippers are able to place tomatoes in several markets (domestic and international) their decision should be influenced by price behavior in each market. The objective of this work is to examine how terminal market prices for

Mexican fresh tomatoes are being affected by each other in integrated markets (where trade flows are observed) by analyzing the reaction patterns to innovation shocks. In order to reach this objective, an unrestricted vector-autoregressive (VAR) model is designed and Granger causality tests are applied to study the market price interrelationships. Impulse response functions are then examined in order to chronicle the intertemporal price response or reaction of Mexican tomato grower-shippers (traders) to an innovation shock in each terminal market price series. There is little information about terminal market price interdependencies for Mexican fresh tomatoes, so this study provides useful information about the intermarket price transmission process for the grower-shippers, traders, and industry leaders of the U.S. and Mexico.

U.S. and Mexico Fresh Tomato Markets

Changes in tastes and preferences of American consumers have fueled an increasing demand for fresh tomatoes. Consumption per capita has grown in recent years from 15.4 lbs. in 1991 to 17.8 lbs in 2000 (Lucier et al., 2000). This consumption may be higher (19.1 lbs) when hothouse tomatoes are considered (Cook, 2002). The average U.S. rate of consumption growth from 1991 to 2000 was 2.6 percent while the average growth rate of U.S. fresh tomato production was only 1.2 percent, implying increased imports during the last decade. The ratio of imports to consumption was, on average, 27.9 percent during the 1990's. Fresh tomato imports are necessary to supplement California and Florida fresh tomato supplies. Although the Mexican share of imports has been decreasing in recent years (from 94.9 percent in 1994 to 80.8 percent in 2000), 2001 volumes were the same as 1996 in absolute terms (685 thousands tons) and 77 percent higher than in 1994.

Historically, the principal type of tomatoes imported from Mexico has been vine ripe (60.4 percent of Mexican imports), although preference for plum (roma), grape, yellow, red baby pear, cluster, specialty greenhouse and organic tomatoes increased in recent years. The imported volume of plum (roma) tomatoes in 2001 almost reached the same level as vine ripes. Similarly, demand for greenhouse tomatoes has grown rapidly,[1] reaching similar volumes as cherry tomato levels in recent years (Figure 1), suggesting a structural demand change in the U.S.

California and Florida are the two U.S. states that produce the largest amount of fresh tomatoes. Their production represents 30 percent and 43 percent, respectively, of domestic market supplies for fresh tomatoes. Florida's season runs from October to June while California's runs from May to November. Mexican producers located in Sinaloa and Baja California supply the majority of fresh tomatoes exported to the U.S. Those growers harvest about 55 percent of Mexican fresh tomato production and they optimize profits by placing varying shares of their crop in export and domestic markets. In recent years, almost 50 percent of their production has been shipped to American markets, leaving the remaining 50 percent for domestic markets. The major markets for those tomatoes are Guadalajara, Monterrey, and Mexico City which receive fresh tomatoes from Sinaloa during January to May, and from Baja California Peninsula during June to October. The remaining months, November and December, the regions of Jalisco, San Luis Potosi and Sonora supply those markets. The U.S. terminal markets that receive the majority of Mexican tomatoes are located in the Western region, including Los Angeles and San Francisco, while Florida supplies the Northeastern and Southern regions. Mexican and

---

[1] It is important to mention that greenhouse tomatoes were separately reported by USITC with a specific HTS statistical code until July 1999, so it is difficult to measure the volumes of those imported tomatoes before this date (USITC, 2001).

Florida producers appear to compete directly for North Central terminal markets (Padilla, Thilmany and Loureiro, 2001).

Tomato growers from California, Florida and Sinaloa are becoming more vertically integrated (as growers-shippers), adopting extended shipping seasons, and in some cases, produce in multiple regions throughout the year to extend their market season and diversify production and marketing risk (Wilson, Thompson & Cook, 1997; Cook, 1998). As a result, 38 grower-shippers control about 70 percent of the fresh tomato production in California, Florida and Sinaloa (Thomson and Wilson, 1997). These changes have impacted the structure and conduct of the industry, increasing the probability of non competitive behavior in some U.S.-Mexican terminal markets (Padilla, Thilmany and Loureiro, 2001). Taking these business strategies and increased trade flows into account, stronger price interdependencies among U.S.-Mexico tomato markets are expected.

Market Integration in the U.S. Mexican Fresh Tomato Market

When the LOP is observed, there exist a comovement of prices between markets, otherwise markets are segmented. Most of studies that have empirically tested the LOP have applied market analysis methods that use only prices (Lele, 1967; Timmer, 1974; Ravallion, 1986; Ardeni, 1989; Baffes, 1991; Goodwin, 1992; Jordan and VanSickle, 1995) or prices and transaction costs. Although market analysis methods that use prices and transaction costs overcome many of problems (Baulch, 1994), adding trade flow information to these models goes further by accounting for the presence of unobservable transaction costs.

Barrett and Li (2002) developed a model (BLM) that uses prices, transaction costs, and trade flow information to overcome most of problems that conventional market analysis approaches have when testing for market integration. Barrett (2001) pointed out that observance of trade flows is a sufficient statistic for testing *market integration* since it is a transfer of excess demand from one market to another, while *market equilibrium* is when zero marginal profit to arbitrage exists. Still, prices in these markets do not necessarily respond, one for one, to shocks in the other market. On the other hand

Following the BLM, Padilla (2001) built an extended parity bounds model (EPBM) to study the intermarket relationships between Mexico producing regions and three terminal markets for Mexican vine ripe tomatoes, Los Angeles, Chicago and Boston. She found markets are increasingly integrated and that as distance between markets grow, the probability of finding that markets operate efficiently decreases. Potential explanations for such inefficiencies include information or contracting lags, or the presence of unobservable transaction costs such as a quality assurance or information costs.

Unlike other studies that utilize Granger causality test for analyzing market integration, this paper assumes that Mexico and U.S. markets, as well as Mexican domestic markets for fresh tomatoes are integrated following Barrett (2001). This study applies a dynamic model (VAR) and Granger causality tests, as well as impulse response functions (IRF), to show how shocks in one market are affecting others and to chronicle intertemporal price response dynamics in these markets.

The Vector Autoregressive Model (VAR) and Granger Causality Test

In order to determine how integrated terminal market prices for Mexican fresh tomatoes in U.S. and Mexico are being affected by each other, a vector autoregressive (VAR) model was designed and tested for causality. The model was developed for five terminal markets for Mexican fresh tomatoes, three in Mexico (Guadalajara, Monterrey, and Mexico City) and two in the U.S. (Los Angeles and Chicago). Guadalajara is the closest large Mexican terminal markets to Sinaloa and receives the highest volumes, Mexico City is relevant because its size and role as supplier to many cities in the southeast region and Monterrey is one of the three biggest cities in Mexico (and is located near to the border, so fresh tomatoes are sometimes repacked and shipped to the U.S from there).

Los Angeles is the largest market in the U.S. Western region for Mexican tomatoes; and Chicago is included to see if the high competition expected between American and Mexican growers in that market influences price dynamics. For example, in the Chicago market there are some periods when arbitrageurs decide not to trade even though the possibility of positive profits exists, or other periods when they decide to trade with negative profits (Padilla, 2001). These results suggest that there are some terminal market prices for Mexican tomatoes where market disequilibria are longer and may be influenced by price behavior in other markets.

In the VAR model the price sequences $\{P_t\}$ for each terminal market is represented as a function of own lagged prices and the other terminal market's lagged prices for Mexican fresh tomatoes. The VAR model is given by

$$(1)\ P_{GDt} = a_{GD} + \sum_{f=1}^{k} b_{1f} P_{GDt-f} + \sum_{g=1}^{l} g_{1g} P_{MTt-g} + \sum_{h=1}^{m} d_{1h} P_{CMt-h} + \sum_{i=1}^{n} j_{1i} P_{LAt-i} + \sum_{j=1}^{o} l_{1j} P_{CHt-j} + e_{1t}$$

$$(2)\ P_{MTt} = a_{MT} + \sum_{f=1}^{k} b_{1f} P_{GDt-f} + \sum_{g=1}^{l} g_{1g} P_{MTt-g} + \sum_{h=1}^{m} d_{1h} P_{CMt-h} + \sum_{i=1}^{n} j_{1i} P_{LAt-i} + \sum_{j=1}^{o} l_{1j} P_{CHt-j} + e_{2t}$$

$$(3)\ P_{CMt} = a_{CM} + \sum_{f=1}^{k} b_{1f} P_{GDt-f} + \sum_{g=1}^{l} g_{1g} P_{MTt-g} + \sum_{h=1}^{m} d_{1h} P_{CMt-h} + \sum_{i=1}^{n} j_{1i} P_{LAt-i} + \sum_{j=1}^{o} l_{1j} P_{CHt-j} + e_{3t}$$

$$(4)\ P_{LAt} = a_{LA} + \sum_{f=1}^{k} b_{1f} P_{GDt-f} + \sum_{g=1}^{l} g_{1g} P_{MTt-g} + \sum_{h=1}^{m} d_{1h} P_{CMt-h} + \sum_{i=1}^{n} j_{1i} P_{LAt-i} + \sum_{j=1}^{o} l_{1j} P_{CHt-j} + e_{4t}$$

$$(5)\ P_{CHt} = a_{CH} + \sum_{f=1}^{k} b_{1f} P_{GDt-f} + \sum_{g=1}^{l} g_{1g} P_{MTt-g} + \sum_{h=1}^{m} d_{1h} P_{CMt-h} + \sum_{i=1}^{n} j_{1i} P_{LAt-i} + \sum_{j=1}^{o} l_{1j} P_{CHt-j} + e_{5t}$$

where $P_{GDt,,}$ $P_{MTt,}$ P_{CMt}, P_{LAt}, y P_{CHt} are the natural logarithms of wholesale terminal market prices for fresh vine ripe tomatoes from Mexico in Guadalajara, Monterrey, Mexico City, Los Angeles and Chicago, respectively; a, ß, ?, d, f , and ? are the unknown parameters to be estimated and e is the stochastic error. The VAR length was selected by applying the Schwartz Bayesian Criterion (SBC) and the Akaike Information Criteria (AIC) within the specifications among regressions with white noise residuals. Similarly, diagnostic Liung-Box-Pierce Q-statistics were applied to ensure no serial correlation in equations. According to these statistical tests, the VAR model was lagged two periods. One condition for developing a VAR model is that all time series should be stationary (Granger, 1969; Enders, 1995). A priori, it is expected that ß$_{11}$, ?$_{21}$, d$_{31}$, f$_{41}$, and ?$_{51}$ > 0 assuming that one period lagged own prices have a direct influence on contemporaneous price behavior. The remaining estimates will empirically show the price interrelationships between terminal markets, this is, if some of those markets are influencing the others (leadership) in their price formation process or there exists a feedback between markets. The relationships for higher order lags are difficult to specify a priori.

Price behavior is addressed more formally using both a Granger causality test and an impulse response function (IRF) analysis. The Granger causality test, first proposed by Granger (1969), is an F-test of the null hypothesis that some of the cross price terms in each individual VAR equation equal zero. That is, if $\{P_{MTt}\}$ does not improve the performance of $\{P_{GDt}\}$, that means changes in $\{P_{MTt}\}$do not affect $\{P_{GDt}\}$. In the case of the Guadalajara terminal market, these tests were based on the following OLS regression equations to identify the one-way causal relation from Monterrey, Mexico City, Los Angeles, and Chicago terminal markets to Guadalajara[2].

$$(6)\ P_{GDt} = a_{GD} + \sum_{f=1}^{k} b_{1f} P_{GDt-f} + \sum_{k=1}^{m} d_{1h} P_{CMt-h} + \sum_{i=1}^{n} j_{1i} P_{LAt-i} + \sum_{j=1}^{o} l_{1j} P_{CHt-j} + e_{1t}$$

$$(7)\ P_{GDt} = a_{GD} + \sum_{f=1}^{k} b_{1f} P_{GDt-f} + \sum_{g=1}^{l} g_{1g} P_{MTt-g} + \sum_{h=1}^{m} d_{1h} P_{CMt-h} + \sum_{i=1}^{n} j_{1i} P_{LAt-i} + \sum_{j=1}^{o} l_{1j} P_{CHt-j} + e_{2t}$$

where ε_{1t} and ε_{2t} are white noise residuals. Similar equations were specified for testing causal relationships from the respective markets to Monterrey, Mexico City, Los Angeles, and Chicago terminal markets. These causality tests were bidirectional.

An instantaneous Granger causality relationship from every terminal market to the others was evaluated. For example, equation (8) was added for Monterrey to Guadalajara:

$$(8)\ P_{GDt} = a_{GD} + \sum_{f=1}^{k} b_{1f} P_{GDt-f} + \sum_{g=0}^{l} g_{1g} P_{MTt-g} + \sum_{h=1}^{m} d_{1h} P_{CMt-h} + \sum_{i=1}^{n} j_{1i} P_{LAt-i} + \sum_{j=1}^{o} l_{1j} P_{CHtt-j} + e_{1t}$$

This differs from equation (7) in that the current value of $\{P_{MT}\}$ is included.

The impulse response function (IRF) is a different way of using the VAR model for analyzing the price transmission process and the time of response to innovation shocks from one market to another. The IRF quantifies the response of a standard deviation shock in the error term (ε_{1t}, ε_{2t}, ε_{3t}, ε_{4t} or ε_{5t}) on $\{P_{GDt}\}$, $\{P_{MTt}\}$, $\{P_{CMt}\}$, $\{P_{LAt}\}$ and $\{P_{CHt}\}$.

Data and Estimation

The VAR model and the Granger Causality tests were estimated using weekly data series on the terminal market price of Guadalajara, Monterrey, Mexico City, Los Angeles, and Chicago[3] for vine ripe fresh tomatoes supplied by the main Mexican producing regions.

---

[2] For identifying one-way causal relationships from Mexico City, Los Angeles and Chicago, the group of parameters was appropriately altered.

[3] The terminal market price time series for Mexican tomatoes in the U.S. markets were constructed as an average price of a 25-pound carton of vine ripe tomatoes with two layer, 4x5, 5x6, and 5x6 configurations.

The period analyzed is from January 1995 to December 2001. The time series for prices were constructed from United States Department of Agriculture (USDA), Agricultural Marketing Service (AMS) data. All time series were in terms of US dollars per 25 pounds carton[4]. Figure 2a and 2b present the time series of weekly prices for the five markets. Assuming trading costs increase with distance, the higher prices in Chicago (followed by Los Angeles) are expected. It is interesting to note that all time series behave similarly, but that some markets experience greater extreme points in volatile periods.

All equations were estimated with a constant term. Given that stationarity within time series is required for the VAR model, the Augmented Dickey-Fuller (ADF) was applied based on the estimation of the following regression.

$$(9)\quad \Delta P_t = a_0 + a_1 P_{t-1} + \sum_{j=1}^{n} b_j \Delta P_{t-j} + e_t$$

where Δ is the first difference operator, P_t represents the natural logarithm of observed prices, and e_t is a normally distributed error term. Two and four lags were used in these tests. Considering the Mackinnon critical value of -3.450 at a one percent significance level, the null hypothesis of a unit root is rejected for all time series for both two and four lags, and consequently, they are stationary (Table 1). Given these time series proprieties, a VAR model in levels can be estimated.

Los Angeles received Mexican tomatoes every week during the period analyzed. Chicago did not receive Mexican vine ripe tomatoes in 77 weeks during the period studied. In order to rigorously obtain the univariate time series properties, the missing 77 observations were determined considering the average price (Xlarge, large and medium) of a 25-pound carton of mature green tomatoes, assuming that these two type of tomatoes are substitutes (albeit imperfect).

[4] Information for terminal market prices in Guadalajara and Mexico City were reported for 10 kg cartons, and 15 kg in Monterrey. The conversion to pounds used a factor of 2.20462 pounds per kilogram.

Empirical Results

Since the matrix specified in the VAR model is symmetric, the right hand side (RHS) variables are predetermined and the error terms are assumed to not be serially correlated, so ordinary least squares (OLS) was used in the estimation. The results of the estimation of the VAR model are presented in Table 2. As expected, in all terminal market price equations, the one-period lagged own price was positive and statistically significant ($p<0.01$). Thus, a one percent increase in last period's price led to a 0.42, 0.43, 0.50, 0.81, and 0.45 percent increase in the contemporaneous price of Guadalajara, Monterrey, Mexico City, Los Angeles, and Chicago terminal market prices, respectively. All Mexican market prices, Guadalajara, Monterrey, and Mexico City, and Chicago's price were sensitive to the Los Angeles price. The parameter estimates on Los Angeles's one-period lagged price for these markets were statistically significant ($p<0.01$), positive, and nearly the same magnitude as the parameter estimate on their own one-period lagged price (0.35, 0.39, 0.42, and 0.59, respectively). The parameter estimates on Los Angeles's two-period lagged price for the three Mexican markets were also statistically significant ($p<0.01$), but negative. These results suggest a large influence from the Los Angeles market in the price formation process of Mexican markets.

Its probably best to talk about the sum of the coeffcients, and their effects, rather then independently review the results at one and two lags. Look in Enders /talk to Harvey Cutler about this.

The parameter estimates on Chicago's one-period lagged price were not statistically significant for Mexican and Los Angeles market prices. But the parameter estimate on Chicago's two-period lagged price for the Los Angeles market was significant ($p<0.01$), suggesting some pricing influences between American markets. Guadalajara's one and two-period lagged price for Los Angeles were statistically significant (p=0.07 and p=0.02, respectively). Guadalajara's price also affects Monterrey and Mexico City's prices, given the significance of its two-period lagged price in those markets (p<0.01). A similar situation occurs when we consider Monterrey's one-period lagged price for the other two domestic market prices, as they were statistically significant (p<0.01). Finally, the parameter estimate on Mexico City's one-period lagged price was significant for only Monterrey's terminal market price. These results provide evidence that Mexican markets have a strong interrelationship. The results of the goodness of fit tests for Guadalajara, Monterrey, Mexico City, Los Angeles, and Chicago are R^2 values of 0.65, 0.68, 0.72, 0.60, and 0.69. The results of Granger causality tests are presented in Table 3. All F-statistics for the one-way causality tests on Los Angeles terminal market prices were statistically significant (p<0.001), so the null hypothesis of no granger causality is rejected. This indicated that Los Angeles, a dominant market for the largest volumes of Mexican fresh tomatoes, is significantly affecting the price formation process of all other markets analyzed. Similarly, changes among Guadalajara, Mexico City and Monterrey's prices affected all the other markets studied, except Chicago. One exception is that changes in Mexico City's price, the more distant Mexican terminal market from the producing regions, did not impact the Guadalajara terminal market price. It may be that since the route to Mexico City from the principal producing regions is through Guadalajara, Guadalajara impacts Mexico City's price, but not vice versa.

Although Chicago did not influence (p>0.30) any Mexican market prices (and vice versa), the relationships between American markets (Chicago → Los Angeles, Los Angeles → Chicago) is evident. According to results on one-way Granger causality tests, there is a bilateral causality (causal relationships run both ways) between the two American markets and most Mexican markets (except Mexico City to Guadalajara). These results suggest that there is not a market leader in the price formation process among these markets.

Significant, instantaneous causal relationships run in both directions among all market prices analyzed. F-statistics in each market pair analyzed were statistically significant (p=0.05). The null hypothesis of no instantaneous causality was rejected, suggesting that information flow among all those markets is relatively efficient (Jordan and VanSickle, 1995), although other tests indicate that information flows may be asymmetric. The process of price shock transmissions from one market to another is felt on each market in at least one week. These results provide indirect evidence that increased usage of high technology for communications may be improving market information flows.

The impulse response function (IRF) is a different way of utilizing the VAR model to understand the impact of one market price on another. Through the IRF, it is possible to trace out the time path of the various shocks of the error term (ε_{1t}, ε_{2t}, ε_{3t}, ε_{4t} or ε_{5t}) on the variables (P_{GDt}, P_{MTt}, P_{CMt}, P_{LAt} and P_{CHt}) contained in the VAR model (Enders, 1995) and visually analyze how terminal market prices respond to hypothetical one standard deviation shocks.

Figures 3a and 3b shows the time path price response of $\{P_{GDt}\}$, $\{P_{MTt}\}$, $\{P_{CMt}\}$, and $\{P_{LAt}\}$ to a one standard deviation shock in the respective innovations of Guadalajara, Monterrey, Mexico City, and Los Angeles[5]. All the four terminal market prices presented in Figures 3a and 3b at first showed a short term effect with respect to their own shock and that dissipated within 12 weeks for Mexican markets and eight weeks for Los Angeles. The

---

[5] Given that Granger causality tests showed that there is not a bidirectional relationship between Chicago and Mexican markets, the Chicago market price was excluded from Figure 3, even though it was included in IRF calculations.

reaction of Monterrey and Mexico City to one innovation shock in Guadalajara is very similar, converging to their long run levels within roughly 10 or 12 weeks. It suggests that, although all markets are interacting, Guadalajara exerts a higher influence on other domestic markets. Similarly, Guadalajara and Mexico City react to a one unit innovation from Monterrey initially increasing prices during the first two weeks, then returning to their equilibrium path during the following four weeks. It should be noted that the Guadalajara and Monterrey reactions to one standard deviation innovations from Mexico City follows a similar pattern to Monterrey's shock on Guadalajara's price, but with a slightly smaller peak. The reaction of the three Mexican markets to one innovation shock in Los Angeles follows similar behavior, increasing prices in the first two to three weeks and returning to equilibrium in the following two weeks, then putting downward pressure on prices before returning to an equilibrium path. It is interesting to note that Los Angeles takes longer (over seven weeks) to return to a long run equilibrium after a innovation shock from Guadalajara than after a shock from Monterrey or Mexico City, meaning that those two markets (that are located farther away from Los Angeles) have lower influence on this market. (But also, they seem to have the negative reaction that is not the case in Guad. Although results obtained from the IRF analysis show similarities in the reaction pattern among markets (which support the Granger causality findings), it should be noted that the reaction in Monterrey, Mexico City and Los Angeles to one innovation shock in Guadalajara have greater magnitudes than similar shocks from the other markets, suggesting that Guadalajara is the key market in the price formation process for vine ripe fresh tomatoes in those markets.

I'm kind of running quickly here to get to the plane, but it seems that there is evidence of an overreaction in the relationships between Mexico City, Monterrey and Los Angeles. There is some kind of overshooting in the reactions, as all of them become negative before dying out. This never seems to happen between Guadalajara's shocks in any of the other markets (excpet maybe LA). This suggests that information is absorbed quickly, but maybe too quickly in the distant markets. Look at the second lags to see if they are significant and negative, as that might be what is causing this. Its intersting that what seems to be ok for Gaudlaharja is excessive in some of the other markets. Maybe shipments are going a little fast. As I look some more, maybe its mostly that there is a overreaction in ineractiosn with the LA market, due as you say to distnace, but maybe less than perfrect marketing channels as well.

Conclusions

This study applies an unrestricted VAR model, Granger causality tests and impulse response functions to examine terminal market price interrelationships between integrated markets (trade is observed between producing regions and terminal markets) for Mexican fresh tomatoes. Five markets are analyzed, two in the U.S. (Los Angeles and Chicago), as well as the three most important Mexican markets (Guadalajara, Monterrey and Mexico City). One major conclusion is that there exists a high interdependence in the price formation process between Mexican domestic markets and Los Angeles, the top receiving market of Mexican fresh tomatoes in the U.S., as well as between Mexican markets. This is, when a price change occurs in one market, the effect of this change is eventually reflected in each other market. The influence of one innovation shock from Guadalajara has a higher impact on Monterrey and Mexico City than shocks in the opposite direction, suggesting that Guadalajara’s location (the closest market to the Sinaloa producing region and almost the same distance from Baja California as Monterrey) exerts a great influence in the price formation process within Mexican markets. Chicago, located farther away from the Mexican producing regions, is influenced in its price formation process only by the Los Angeles market price, signaling again that distance is an important factor. The importance of distance may be due to the increasingly large share of transaction costs and levels of risk associated with transporting perishable products across regions. Overall, the results suggest that information flows between producing regions and terminal markets is relatively efficient. Grower-shippers and produce traders have knowledge about what is happening in each market, which is result of a highly vertically integrated market and increasingly high-tech market communications, so that market agents are ready to take action when opportunities are present.

Figure 1. US Imports of Fresh Tomatoes from Mexico

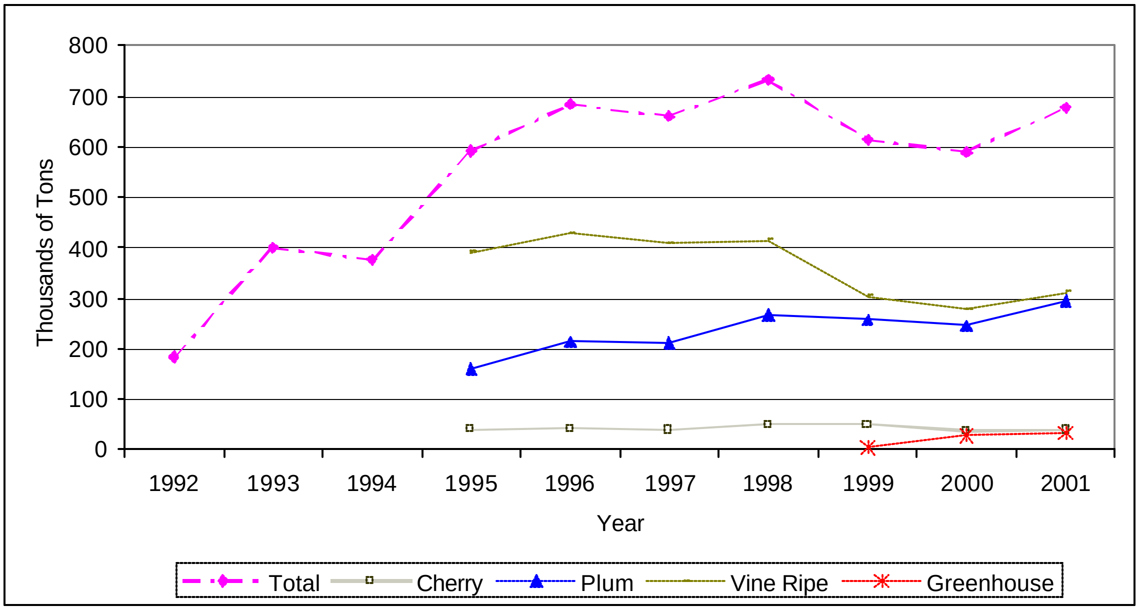


Figure 2a. Terminal Market Prices for Mexican Fresh Tomatoes (1995-1998)

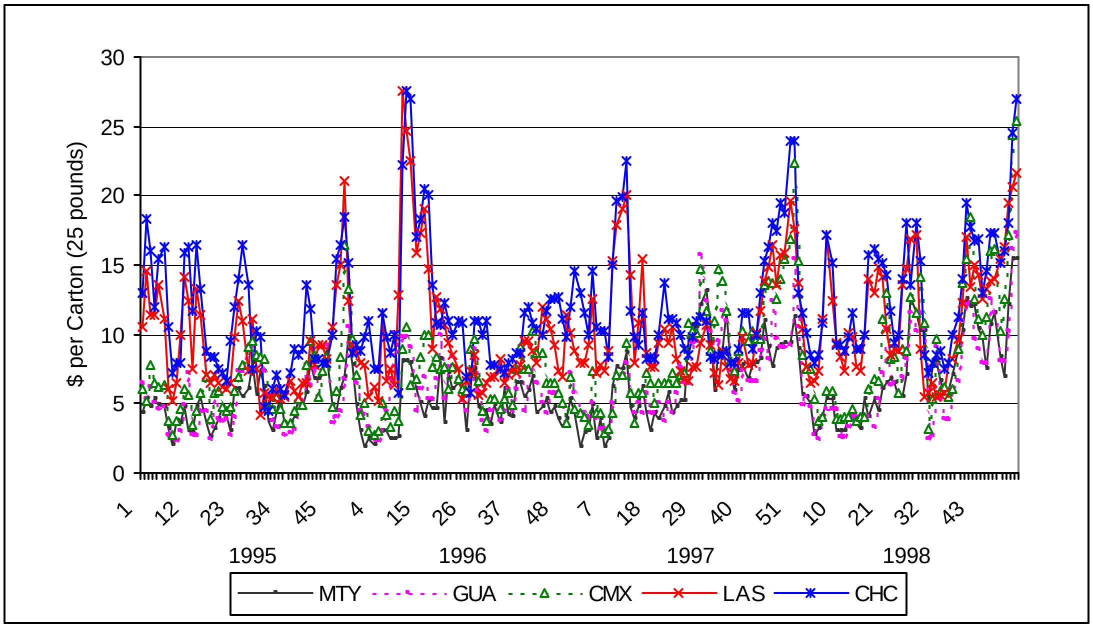
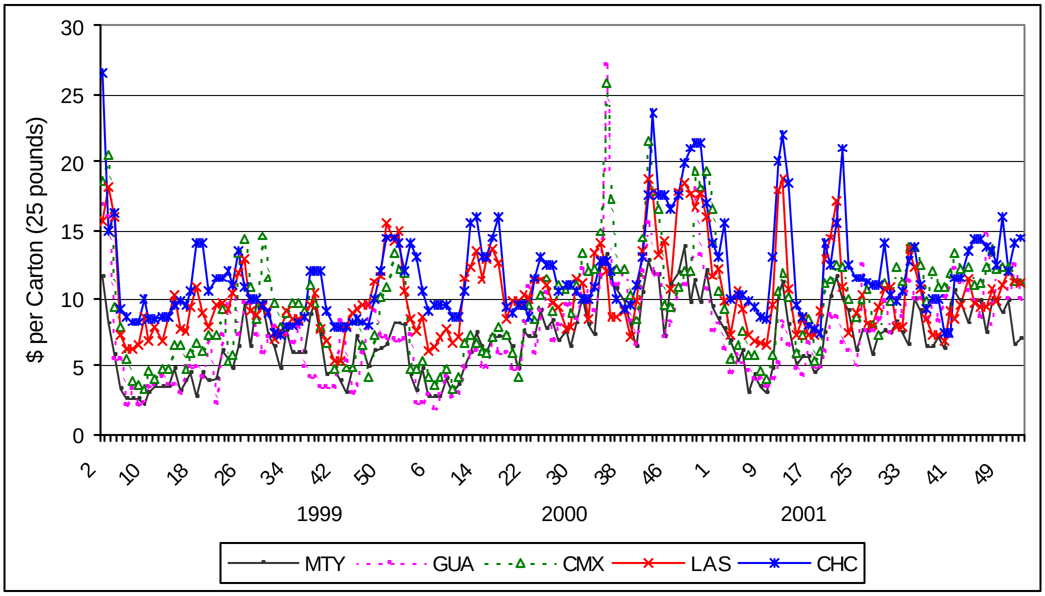
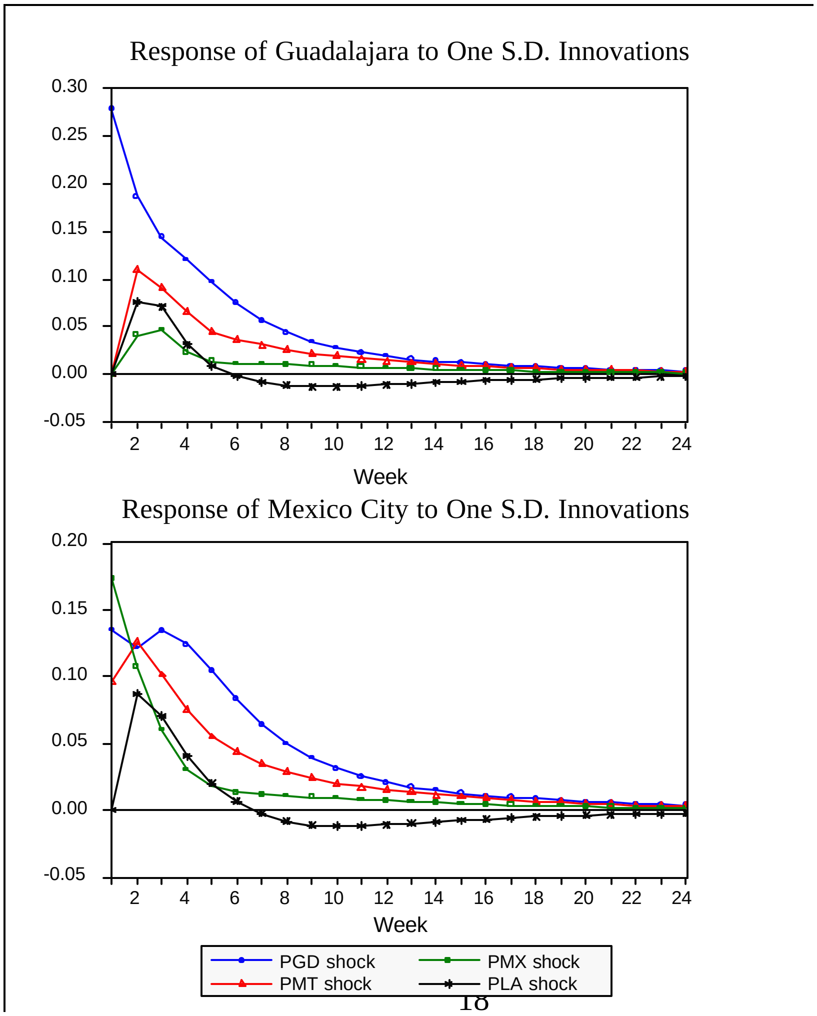


Figure 2b. Terminal Market Prices for Mexican Fresh Tomatoes (1999-2001)



Source: AMS, USDA.

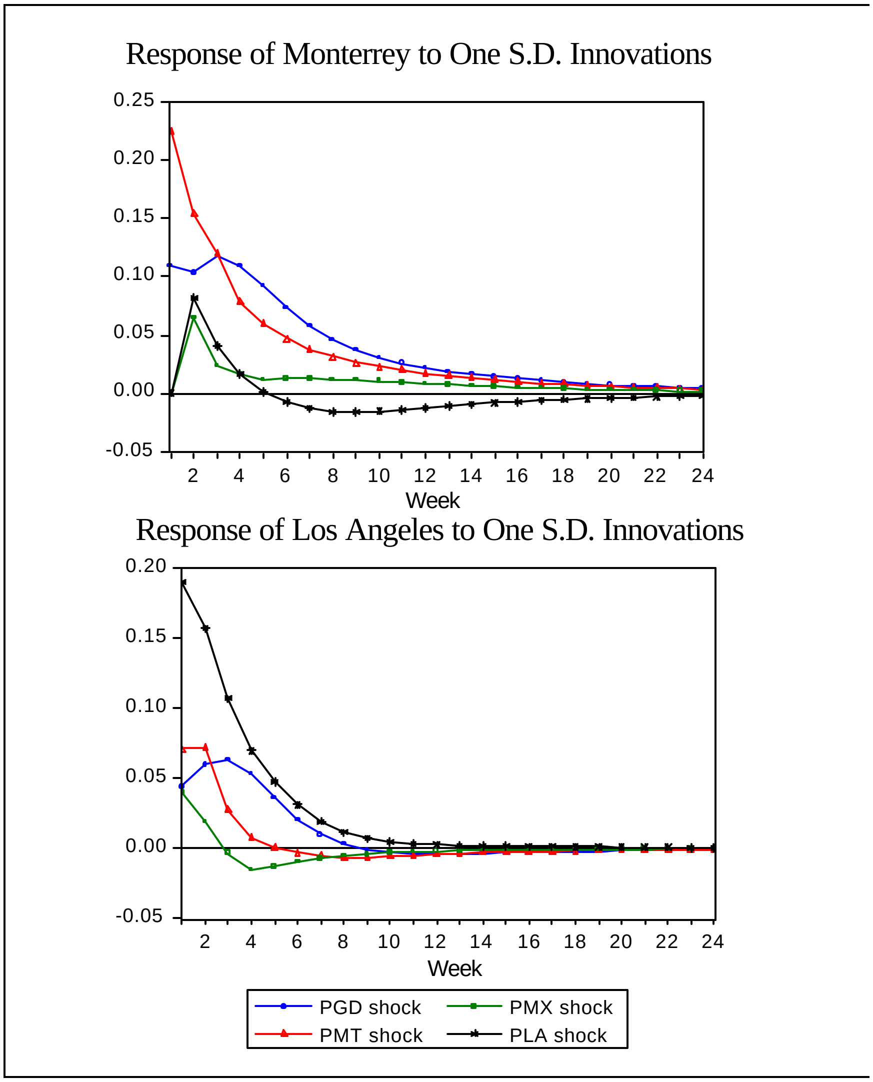
Figure 3a. VAR Impulse Response Functions-Guadalajara and Mexico City Prices



Response of Guadalajara to One S.D. Innovations

Response of Mexico City to One S.D. Innovations

Figure 3b. VAR Impulse Response Functions - Monterrey and Los Angeles Prices



Note: PGD=Guadalajara, PMT=Monterrey, PMX=Mexico City, and PLA=Los Angeles.

References

Ardeni, P.G. "Does the Law of One Price Really Hold for Commodity Prices?" *Amer. J. Agr. Econ.* 71(1989):661-69.

Baffes, J. "Some Further Evidence on the Law of One Price: The Law of One Price Still Holds." *Amer. J. Agr. Econ*. 73(1991):1264-73.

Barrett, C.B. "Measuring Integration and Efficiency in International Agricultural Markets." *Rev. Agr. Econ*. 23(2001): 19-32.

Barrett, C.B and J.R. Li. "Distinguishing Between Equilibrium and Integration in Spatial Price Analysis." *Amer. J. Agr. Econ.* 84(2002): 292:307.

Baulch, R. J. *Spatial Price Equilibrium and Food Market Integration*. Ph.D. Dissertation. Food Research Institute. Stanford University. November 1994.

Cook, R. *International Trends in the Fruit and Vegetable Sector*. Department of Agricultural and Resource Economics. UC Davis. May 1998.

Cook, R. "Emerging Hothouse Industry Poses Challenges for California's Fresh Tomato Industry." Department of Agricultural and Resource Economics. UC Davis. Giannini Foundation of Agricultural Economics. 2002.

Enders, W. *Applied Econometric Time Series*. John Wiley & Sons. United States of America. 1995.

Goodwin, B.K. "Multivariate Cointegration Tests and the Law of One Price in International Wheat Markets." *Rev. Agr. Econ*. 14(1992): 117-24.

Granger, C.W. "Investigating Causal Relations By Econometric Models and Cross-Spectral Methods." *Econometrica* 37(1969): 424-38.

Jordan, K.H. and J.J.VanSickle. "Integration and Behavior in the U.S. Winter Market for Fresh Tomatoes". *J. Agr. and Appl. Econ*. 27(1995): 127-37.

Lele, U.J. "Market Integration: A Study of Sorghum Prices in Western India." *J. Farm Econ.* 49(1967): 147-59.

Lucier, G. et al. "Factors Affecting Tomato Consumption in the United States." *Vegetables and Specialties.* VGS-282. ERS, USDA. November 2000: 26-32.

McNew K. "Spatial Market Integration Definition, Theory, and Evidence." *Agr. Res. Econ. Rev*. 25(1996): 1-11.

Padilla B.,L.E. “Price and Trade Relationships in the Mexico-U.S. Fresh Tomato Market. Ph. D. Dissertation. Colorado State University. September 2001.

Padilla, L.E., D. Thilmany, and M.L. Loureiro. “Tradability and market Equilibrium for U.S.-México Fresh Tomatoes.” Paper presented at the WAEA Meetings. Logan, Utah. July 2001.

Thompson, G.D. and P.N. Wilson. “The Organizational Structure of the North American Fresh Tomato Market: Implications for Seasonal Trade Disputes”. *Agribusiness*. 3(1997): 533-47.

Timmer, P.C. “A Model of Rice Marketing Margins in Indonesia.” *Food Res. Inst. Stud*. 13(1974): 145-67.

Ravillion, M. “Testing Market Integration.” *Amer. J. Agr. Econ*. 68(1986): 102-9.

U.S. Department of Agriculture. Agricultural Marketing Service. "Market Information System." Institute of Food and Resource Economics. University of Florida. http//www.ifas.ufl.edu. 1999, 2000, 2001.

U.S. Department of Agriculture. Economic Research Service. *U.S. Tomato Statistics 1960-98*. Publication # 92010. USA. 2000.

U.S. International Trade Commission. *Monitoring of U.S. Imports of Tomatoes*. Investigation No. 332-350. Publication 3473. November 2001.

Wilson, P. N, G.D. Thompson, and R.L. Cook. “Mother Nature, Business Strategy, and Fresh Produce.” *Choices*. (1997): 18-21; 24-25.

Table 1. Augmented Dickey-Fuller Test on Terminal Market Prices

Terminal Market	Test Statistics	
	Two lags	Four Lags
Guadalajara	-5.557*	-5.305*
Monterrey	-5.389*	-4.631*
México City	-5.143*	-4.739*
Los Angeles	-7.033*	-6.673*
San Francisco	-7.202*	-6.718*

*/ Denotes 1 percent significance level.

Table 2. Vector Autoregression Model Parameter Estimates for Mexican Fresh Tomato Markets

Terminal Market	Variable	Dependent Variable: Natural Logarithm of Prices				
		Guadalajara P_{GDt},	Monterrey P_{MTt}	Mexico City P_{CMt}	Los Angeles P_{LAt}	Chicago P_{CHt}
	Intercept	0.249**	0.322*	0.254*	0.586*	0.599*
		(1.985)[a]	(2.865)	(2.353)	(6.130)	(7.606)
Guadalajara	P_{GDt-1}	0.425*	0.005	0.043	0.089***	0.065
		(6.611)	(0.102)	(0.788)	(1.817)	(1.609)
	P_{GDt-2}	0.060562	0.124*	0.125*	0.107*	-0.007
		(0.947)	(2.181)	(2.284)	(2.221)	(-0.176)
Monterrey	P_{MTt-1}	0.296*	0.432*	0.196*	0.091	0.006
		(3.971)	(6.471)	(3.057)	(1.612)	(0.130)
	P_{MTt-2}	-0.106	0.152*	-0.013	-0.119	0.002
		(-1.419)	(2.252)	(-0.204)	(-2.085)	(0.044)
Mexico City	P_{CMt-1}	0.138	0.267*	0.504*	-0.082	-0.075
		(1.589)	(3.441)	(6.732)	(-1.240)	(-1.377)
	P_{CMt-2}	0.014	-0.130***	-0.010	-0.093	-0.006
		(0.168)	(-1.658)	(-0.143)	(-1.394)	(-0.116)
Los Angeles	P_{Lat-1}	0.354*	0.390*	0.422*	0.813*	0.597*
		(4.052)	(4.988)	(5.609)	(12.232)	(10.884)
	P_{Lat-2}	-0.301*	-0.467*	-0.332*	-0.233*	-0.229*
		(-3.064)	(-5.313)	(-3.926)	(-3.127)	(-3.719)
Chicago	P_{CHt-1}	0.098	0.094	0.084	0.030	0.453*
		(0.960)	(1.031)	(0.956)	(0.391)	(7.093)
	P_{CHt-2}	-0.132	-0.064	-0.107	0.140*	-0.026
		(-1.445)	(-0.790)	(-1.370)	(2.024)	(-0.468)

[a]/ *t*-statistics are in parentheses.

* 1 percent significance level, ** 5 percent significance level, *** 10 percent significance level

Table 3. Granger Causality Tests for Terminal Market Prices of Mexican Fresh Tomatoes

Causality Direction	One Way Causality Test		Instantaneous Causality Test	
	F-Statistics	P-value	F-Statistics	P-value
Guadalajara → Monterrey	2.846	0.0593	83.052	0.0000
Guadalajara → México City	4.129	0.0168	162.129	0.0000
Guadalajara → Los Angeles	6.453	0.0017	15.820	0.0008
Guadalajara → Chicago	0.249	0.2496	3.619	0.0579
Monterrey → Guadalajara	7.885	0.0004	83.052	0.0000
Monterrey → México City	5.118	0.0064	205.01	0.0000
Monterrey → Los Angeles	2.611	0.0748	64.259	0.0000
Monterrey → Chicago	0.013	0.9867	28.1696	0.0000
Mexico City → Guadalajara	1.661	0.1914	162.124	0.0000
México City → Monterrey	5.961	0.0028	205.011	0.0000
Mexico City → Los Angeles	2.927	0.0548	61.932	0.0000
Mexico City → Chicago	1.222	0.2958	34.689	0.0000
Los Angeles → Guadalajara	9.795	0.0000	3.585	0.0001
Los Angeles → Monterrey	19.744	0.0000	64.259	0.0000
Los Angeles → México City	17.968	0.0000	61.932	0.0000
Los Angeles → Chicago	59.233	0.0000	174.722	0.0000
Chicago → Guadalajara	1.148	0.3181	3.619	0.0579
Chicago → Monterrey	0.628	0.5339	28.169	0.0000
Chicago → México City	1.055	0.3491	34.689	0.0000
Chicago → Los Angeles	2.808	0.0616	174.722	0.0000