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Regional Wholesale Price Relationships in the Presence of Counter-Seasonal Imports

Kellie Curry Raper, Suzanne Thornsberry, and Cristobal Aguilar

Counter-seasonal imports of fresh produce facilitate year-round availability in the U.S. and may impact the seasonal structure of market price relationships. Vector autoregression analysis is used to determine the nature and extent of spatial price relationships among four geographically distinct regions in the U.S. fresh peach wholesale market. We evaluate differences in regional spatial price relationships and find statistical evidence that price relationships among regions are different in periods dominated by regional domestic supplies imports compared with periods when counter-seasonal imports dominate the market.

Key Words: counter-seasonal imports, price analysis, regional prices, spatial prices, VAR

JEL Classifications: Q1, Q11, Q13

Counter-seasonal imports facilitate availability of fresh produce when domestic sources are out-of-season, allowing year-round supplies. They may also impact price relationships among domestic markets, including shifting the direction of price influence among regions across seasons or serving to equilibrate prices across regions.

Measurement of spatial price relationships provides insights about the dynamics of these price movements, thus increasing understanding of likely behavior in supply or demand areas of the market (Jordan and Van Sickle). Reichers and Hinson examined lead/lag price relationships for three fresh vegetables across four wholesale markets. They point out that in some markets, counter-seasonal imports will impact price patterns, though they do not

specifically test for this effect. Arnade, Pick, and Gehlhar note that introducing imports impacts the seasonal structure of a market from a demand perspective since market price relationships will be influenced by production cycles of both the import and domestic industries. In an earlier study, Arnade and Pick apply seasonal unit root tests in fruit industries where seasonal cycles may be shifting due, at least in part, to counter-seasonal imports.

From a producer, wholesaler, and retailer perspective, knowledge of differing market and price lead/lag relationships are important when the market transitions between domestic production and import seasons. Knowledge of which regions lead price, the degree to which market shocks move prices among regions, and the regional market reaction time can all be useful in designing market strategy. In addition, it is useful to know whether such price relationships are consistent across the year or whether those relationships change when primary supply source changes seasonally.

The U.S. fresh peach market offers an interesting example of bimodal supply sources with distinct regional production areas complemented by counter-seasonal imports. It is

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certainly logical that driving forces behind such prices change from the import (winter) season to the domestic (summer) season. The fresh peach supply from June to November is virtually all grown domestically, while the fresh peach supply from December through April is virtually all imported. In addition, fresh peach production in the U.S. consists of four primary growing areas with distinct climatic conditions and varying harvest seasons. Lack of domestic production during the winter marketing season may result in greater equilibration of market prices among regions. Summer market prices should exhibit greater spatial differences among regions, including greater independence, due to local supply influences.

The overall objective of this study is to determine the nature and extent of spatial price relationships among four geographically distinct U.S. fresh peach production regions in the presence of counter-seasonal imports. Specifically, we seek to (1) determine the direction of price influence among regions and associated sensitivity to regional shocks, (2) test whether prices among regions exhibit long run market integration, and (3) determine whether differences exist in regional spatial price relationships in seasons dominated by domestic supplies versus counter-seasonal imports.

We conduct vector autoregressive analysis (VAR) on weekly prices from the primary fresh peach wholesale markets of four U.S. regions. We evaluate the three basic questions by using forecast error variance analysis and impulse response functions together with Granger causality tests to measure short-term directional relationships between regional prices; by conducting long-run market integration tests between price pairs, and by using block exogeneity tests combined with seasonal dummy variables to evaluate whether seasonal differences exist.

Overview of the Fresh Peach Sector

The supply source for the U.S. fresh peach market is bimodal due to the seasonal nature of domestic production. Fresh peaches produced in the southern hemisphere are imported from December to May when there is little or no domestic production to meet U.S. demand.

Chile is the major supplier of fresh peaches during the winter season, accounting for 98% of imports (USDA-ERS 2005, 2007). The primary entry points for fresh peach imports are Philadelphia and Los Angeles, with 67% and 25% of imports, respectively (U.S. Census Bureau). Since 2002, a seasonal import tariff of 0.2 cents per kilogram for fresh peaches has been imposed from June to November corresponding with the U.S. peach harvest season (Brunke). No tariff exists for imports from December through May.

While the USDA defines the fresh peach marketing season as May 1 to October 31, U.S. fresh peach production and sales volumes are concentrated during the months of June to September with 83% of the yearly domestic volume marketed during this period (USDA-NASS 2004). At least some price variation within the fresh peach marketing season may be attributed to shifting areas of domestic production. That is, some regions begin marketing earlier in the year and have longer harvest seasons than other regions. These supply influences are revealed in prices. Average farm and wholesale prices tend to be higher in May and September when fewer regions are marketing fresh peaches as compared to June through August when most regions are active in the market (USDA-NASS, various years). Though the supply of imports and domestic production overlap at the beginning and end of the domestic marketing season, overall supply is sufficiently thin relative to demand during these periods to drive prices upward. These thin market periods do present some opportunities for producers who can adjust their supply season accordingly.

California produces nearly half of the nation's fresh peaches (48.7%) and virtually all the nation's processing peaches (USDA-NASS 2004). South Carolina and Georgia (commonly known as the "Peach State") rank second and third in fresh peach production with 11 and 8% of U.S. production, respectively (Table 1). Total volume of domestic production has remained steady at about 2.4 million pounds since 1994. Production also occurs in U.S. regions not generally recognized as part of the "fruit belt." For example, Michigan ranked 9th

Table 1. State Rank in Fresh Market Peach Production (2004), Regional Marketing Season and Corresponding Nearest Wholesale Market Region

State	Production		Marketing Season		Cost Estimates ^a		
	Fresh Market Peaches (Tons)	Share of U.S. Fresh Peach Production (%)	Regional Marketing Season ^b	Nearest Wholesale Region ^c	Estimated Production Cost per Acre (\$)	Estimated Average Yield (Pounds)	Estimated Cost per Pound (\$)
California	305,000	48.71	June 1 – September 30	West	11,29 ^d (2004)	27,000	0.42
South Carolina	67,500	10.78	May 20 – August 31	South	3,224 ^e (1998)	6,960	0.56
Georgia	52,500	8.39	May 20 – August 31	South	3,224 ^e (1998)		0.56
New Jersey	32,500	5.19	July 1 – September 30	East	3,129 (1996)	7,250	0.53
Pennsylvania	23,000	3.67	July 1 – September 30	East			
Washington	21,500	3.43	July 1 – September 30	West			
Alabama	14,000	2.24	June 1 – September 30	South			
Colorado	13,000	2.08	June 1 – September 30	West	8,410 (2005)	21,840	0.39
Michigan	12,500	2.00	July 1 – September 30	Midwest			
Texas	12,200	1.95	June 1 – September 30	South	3,500 (2003)	3,600	0.97
Other States	72,410	11.57	Varied				
Total	626,110	100.00					

Sources: National Agricultural Statistics Service, USDA; National Information System for USDA Regional IPM Centers; California Department of Food and Agriculture; Day, et al.; Fresno County Agricultural Commissioner; Sharp and Cooley

^a Production cost estimates for fresh peaches in selected states where data are available.

^b USDA defines the overall marketing year for fresh peaches as May 1 to October 31. Regional marketing seasons are reported here.

^c As defined in this study.

^d San Joaquin Valley-South (includes Fresno County).

^e Production costs for South Carolina and Georgia estimated jointly.

among states in fresh peach production in 2004. Although a relatively small player in the marketplace, contributing only 2% of national production with farm level value of \$10.3 million, 2 of the top 10 U.S. peach-producing counties are located in Michigan.

Table 1 provides some insight into general cost and yield relationships in fresh peach production across regions. California has relatively high production costs per acre. However, yields are also significantly higher than in other major peach production states, resulting in a low cost per pound for fresh peaches. By contrast, production costs per acre are relatively low for Texas, but corresponding yields are also quite low, resulting in relatively high average costs per pound. Colorado presents an interesting case. Average yields in Colorado are comparable with those of California as are production costs per acre. However, the variance of yields in Colorado is higher and is likely a limiting factor to industry growth in that region.

Although notably absent from the list of top ten peach production states, Florida presents an

interesting example of strategy. During the primary domestic marketing season (summer), peach production in the state is hindered by persistent summer rains that create disease problems. Florida's marketing advantage lies in an early spring combined with improved cultivars possessing a short bloom to harvest period and lower winter chilling requirements (Williamson et al.). This results in early season marketing (April and May) before California, Georgia, and South Carolina have peaches available. Consequently, Florida producers receive a higher price per pound than do producers who are unable to market until later in the season.¹

¹ Fresh peaches grown in California fall under a marketing order that specifies quality, size, maturity, and packaging of fruit sold from April 1 to November 27. One outcome of the marketing order is that less premature fruit is marketed to consumers, thus lessening the demand impact of consuming poor quality early harvest fruit. Other peach producing areas of the U.S., however, are not covered by this marketing order. (See <http://ecfr.gpoaccess.gov>.)

Some regions of Texas also hold an early marketing advantage due to the adoption of low-chill cultivars (Fuller, Bello, and Shafer). However, Texas' advantage lies primarily in the strong sense of regionalism displayed by consumers as most Texas peaches are consumed within the state and consistently bring a premium over non-Texas fruit throughout the harvest season (Kamas et al.). This behavior is consistent with the brand strength hypothesis which states that geographic origin will have a stronger impact on consumer purchase decisions for products with weak brand name recognition (Perouty et al.). This condition certainly holds for most fresh produce items, where branding is not common. Still if the region itself holds significant collective reputation stock, price influence from other regions may be somewhat buffered.

Consumption data for fresh peaches suggests that this is a mature market in the U.S., although there does appear to be growth potential for exports which have recently expanded (USDA-ERS 2007). Domestic per capita consumption has remained steady at approximately 10 pounds per year since the 1980s, while consumption of processed peaches has fallen from seven pounds per capita in the 1970s to 4.2 pounds per capita in 2002 (Brunke).

Retail prices for fresh peaches increased 80% between 1993 and 2003 (USDA-AMS). By contrast, farm and wholesale fresh peach prices have risen only slightly during the last decade. Farm-

level season average fresh peach prices from 1995 to 2004 ranged from 24.4 cents per pound to 30.7 cents per pound (USDA-NASS, various years). An exception is 1996 when prices rose to 33.1 cents per pound due to a short peach crop. Wholesale prices have remained relatively constant as well and averaged more than double the farm gate price at 67 cents per pound during the 2003 production year. The apparently strong relationship between farm and wholesale prices is illustrated in Figure 1.

Modeling Spatial Price Relationships

These production and market characteristics increase the likelihood that regional price relationships differ across seasons in the U.S. fresh peach wholesale market. Two pricing issues particularly relevant are directional market segmentation and long-term market integration. Market segmentation tests, which rely on the concept of Granger causality, can be used to indicate the direction of price influence in spatial markets. The null hypothesis of market segmentation implies that prices occurring in one region do not influence prices received in another market. In the context of price leadership, unidirectional segmentation may imply that prices in one region "lead" prices in another region, but not vice versa.

According to Ravallion, "measurement of (spatial) market integration can be viewed as basic data for an understanding of how

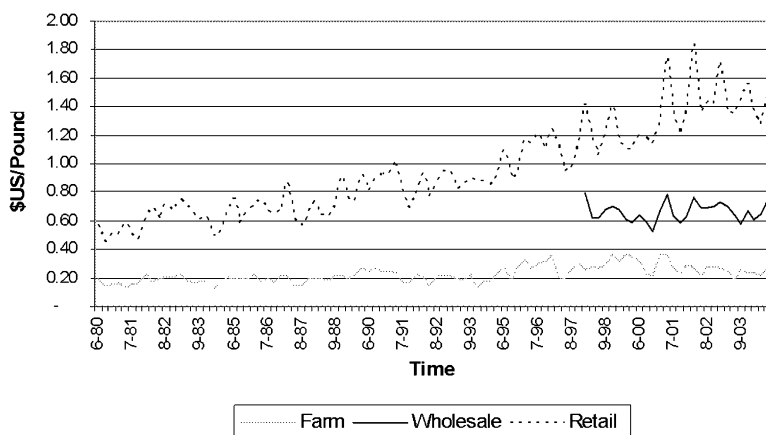


Figure 1. U.S. Average Monthly Fresh Peach Prices at Farm, Wholesale and Retail Level (Source: USDA-AMS)

specific markets work" (p. 103). Integration implies greater interdependence among prices of different regions such that every price contributes to explain the evolution of the others. Realistically, markets are not likely to be perfectly segmented nor perfectly integrated since price arbitrage is often imperfect. That is, a price shock in one region may not be reflected completely through prices in other regions that are engaged in trade, particularly in the short run (Ardeni). Thus, a rejection of perfect market integration does not necessarily imply that prices in regional markets are unrelated.

Long-run market integration requires that a change in price in region x is fully reflected in region y prices over time. However, the existence of long-term market integration does not imply the existence of short-run market integration nor does it indicate the direction of influence in the relationship (Ravallion). As integration increases, markets likely form prices based on information from other markets, that is, bidirectional causality should be present (Rapsomanikis et al.). However, as discussed by Fackler and Goodwin, the degree of market integration may not be symmetric.

We use VAR analysis to determine the nature and extent of spatial price relationships in fresh peach wholesale markets among four U.S. regions.² A VAR model allows examination of all possible spatial price relationships among the regions, since variables are defined by their own lags and the lagged values of all other variables. Modeling price relationships using VAR allows us to directly test the hypotheses of lead/lag relationships as indicated by directional market segmentation tests and to test the hypothesis of long-run perfect market integration. Forecast error variance (FEV), one component of a typical VAR analysis, contributes to the analysis of interdependence among markets. Some have criticized VAR analysis of prices in studying spatial

market relationships as lacking theoretical foundation (McNew; McNew and Fackler; Barrett; Barrett and Li; Lence and Falk). However, when price data alone is available, VAR analysis can be a useful tool for examining the price adjustment process and providing evidence of spatial price relationships (Vollrath and Hallahan).

Given the bimodal nature of the U.S. fresh peach market with respect to supply sources, we hypothesize that the domestic supply season and the import season exhibit differing price relationships among regions. The use of wholesale-level rather than farm-level prices enables us to examine the marketing year in its entirety. We consider three marketing seasons: (1) the full year, (2) the "summer" (domestic supply) season, defined as the third week of April through the second week of November, and (3) the "winter" (import) season, defined as the third week of November to the second week of April.

Trading volumes in the U.S. wholesale peach market when supply source transitions from domestic to imports (and vice versa) are comparatively low relative to average trading volumes during the rest of the year. Though the definition of a thin market is somewhat arbitrary (Tomek), for the purposes of this study we define thin markets as weeks where trading volume is less than 10% of the annual average trading volume. The resulting thin market periods are concentrated in April, May, November and December.

The four equation VAR model in standard form is used to examine spatial price relationships in the U.S. fresh peach wholesale market:

$$(1) \quad \mathbf{P}_t = \mathbf{B}_1 \mathbf{P}_{t-1} + \mathbf{B}_2 \mathbf{P}_{t-2} + \dots + \mathbf{B}_m \mathbf{P}_{t-m} + \mathbf{A}_0 \mathbf{Q}_t + \mathbf{A}_1 \mathbf{Q}_{t-1} + \mathbf{A}_2 \text{Thin}_t + \mathbf{u}_t$$

where \mathbf{P}_t is a 4×1 vector of weekly (time t) regional wholesale peach prices, defined in this study as P_{West} , P_{Midwest} , P_{East} , and P_{South} ; \mathbf{B}_1 through \mathbf{B}_m are 4×4 matrices of coefficients, each associated with a different time lag $i = 1, 2, \dots, m$, such that

$$\mathbf{B}_i \mathbf{P}_{t-i} = \begin{matrix} b_{i,11}P_{Wt-i} & b_{i,12}P_{MWt-i} & b_{i,13}P_{Et-i} & b_{i,14}P_{St-i} \\ b_{i,21}P_{Wt-i} & b_{i,22}P_{MWt-i} & b_{i,23}P_{Et-i} & b_{i,24}P_{St-i} \\ b_{i,31}P_{Wt-i} & b_{i,32}P_{MWt-i} & b_{i,33}P_{Et-i} & b_{i,34}P_{St-i} \\ b_{i,41}P_{Wt-i} & b_{i,42}P_{MWt-i} & b_{i,43}P_{Et-i} & b_{i,44}P_{St-i} \end{matrix}$$

\mathbf{Q}_t is the weekly total fresh peach shipments (in pounds) for the U.S. (included as an exogenous

² Directed Acyclic Graph (DAG) and Event Studies are among alternative methods which could be used to analyze spatial price relationships. We chose VAR analysis since it can illustrate issues of price direction, but is also better suited to handling periods of thin markets and the complex seasonality which are characteristic of our data.

variable); \mathbf{A}_0 and \mathbf{A}_1 are the associated 4×1 coefficient vectors; $Thin_t$ is a dummy variable taking a value of 1 during thin market periods as defined above and 0 otherwise; \mathbf{A}_2 is the associated 4×1 coefficient vector; and \mathbf{u}_t is a 4×1 vector of white noise disturbance terms.³

Following Donovan et al., the optimal VAR lag length can be determined by using criteria such as Akaike's Information Criterion (AIC), Schwartz Criterion, or the sequential likelihood ratio test. Ivanov and Kilian argued that the AIC produces the most accurate impulse response for monthly VAR models. Several studies have also used the AIC in determining lag length for weekly data (Balaban and Kunter; Darrat and Zhong; Vickner and Davies).

Equation (1) reflects the "full year" marketing season mentioned above with no distinction between supply sources. When we instead consider that summer and winter may be separate marketing seasons, values are not included during the out-of-season weeks. We adopt the approach of Ward by incorporating lagged dummy variables (D_{s1} through D_{sm}) that indicate which lag enters the model. We also append the model in Equation (1) with summer marketing season dummy variables (S_t) to evaluate whether price response differs between winter and summer marketing seasons among regions. The resulting equation is:

$$\begin{aligned} \mathbf{P}_t = & \mathbf{B}_1 \mathbf{P}_{t-1} D_{s1} + \mathbf{B}_2 \mathbf{P}_{t-2} D_{s2} + \dots \\ & + \mathbf{B}_m \mathbf{P}_{t-m} D_{sm} + \mathbf{A}_0 \mathbf{Q}_t + \mathbf{A}_1 \mathbf{Q}_{t-1} \\ (2) \quad & + \mathbf{A}_2 Thin_t + \mathbf{B}_{1s} \mathbf{P}_{t-1} S_t D_{s1} + \mathbf{B}_{2s} \mathbf{P}_{t-2} S_t D_{s2} \\ & + \dots + \mathbf{B}_{ms} \mathbf{P}_{t-m} S_t D_{sm} + \mathbf{A}_{0s} \mathbf{Q}_t S_t \\ & + \mathbf{A}_{1s} \mathbf{Q}_{t-1} S_t + \mathbf{u}_t \end{aligned}$$

where $D_{s1} = [0, 1, 1, 1, \dots, 1]$, $D_{s2} = [0, 0, 1, 1, \dots, 1]$, and $D_{sm} = [0, 0, \dots, 0, 1, 1, \dots, 1]$ are dummy variable series with D_{sm} taking the value of 1 beginning at observation $m + 1$, but a value of 0 when including the lag would mean adding a lag from a different season; with each D_s sequence restarting at zero when the

marketing season changes from summer to winter or vice versa; and where $S_t = 1$ for weeks that fall in the summer marketing season and 0 otherwise. This dummy variable structure ensures that the first m values in a marketing season are not lagged to the last m values of the previous season or to the previous counter-season (e.g., summer/summer or summer/winter).

Following Jordan and VanSickle and Ravallion, we use VAR results to examine the spatial price relationship hypotheses of market segmentation and long-run market integration.⁴ In contrast to Ravallion's radial model and to Jordan and VanSickle, we do not presume the existence of a central market, but rather let the data reveal any existing spatial relationships among markets. Recall that unidirectional market segmentation implies that prices occurring in one region do not influence prices received in another market. In the context of the model presented above, this is tested by:

$$(3) \quad H_0: b_{i,xy} = 0 \quad \text{for } i = 0, 1, 2, \dots, m.$$

Here, $b_{i,xy}$ is the estimated regression coefficient for the lagged price of region y on prices in region x , at lag i . If $b_{i,xy} = 0$ across all lags, lagged prices in region y do not contribute to price variation in the dependent region x , (i.e., lags of P_y do not Granger cause P_x) indicating that the market in region x is segmented from region y .⁵ From Equation (1), unidirectional long run market integration,⁶ or the idea that

⁴ Co-integration methods are typically used for market integration testing. However, unit root tests indicate that the data are stationary in levels (I(0)). That, combined with strong seasonality and shifting supply patterns, implies that standard co-integration methods of analyzing price relationships are not sufficient in this case.

⁵ This is a measure of directional price influence. Pure market segmentation requires that a price neither receives nor leads another region's price and would require a joint test of $b_{i,xy} = 0$ and $b_{i,yx} = 0$ for every i . Since we are primarily interested in the direction of price influence, we do not conduct the joint test.

⁶ Equation (4) represents conditions that are sufficient for testing one direction of price influence. A test of bidirectional long-run market integration would require a joint test of Equation (4) with the corresponding equation representing how changes in region x 's price are reflected in prices for region y . Since we are primarily interested in direction of price transmission, we do not conduct such tests here.

³ While quantity measures are not often included in VAR price models, we include it here as an exogenous variable and a barometer of the national market supply. Potential collinearity issues are minimized since the quantity measure is at the national level and prices are regional measures.

price changes in region x would be fully reflected in region y prices over time, requires that:

$$(4) \quad H_0: \sum_{i=0}^m b_{i,xx} + \sum_{i=0}^m b_{i,xy} = 1$$

Data

Data analyzed in this study are weekly U.S. wholesale prices for fresh peaches from the first week of 1998 through the fourth week of June 2005 (USDA-AMS). The series represents prices received by sellers at U.S. terminal wholesale markets. We construct four regional price series consisting of 390 observations each. We define the four regions based on primary U.S. peach production areas in this study as: West (Los Angeles, San Francisco), Midwest (Chicago, St. Louis, Detroit), East (New York, Boston, Baltimore, Philadelphia) and South (Miami, Atlanta, Dallas, Columbia). Daily shipment information for each market includes the number of transactions and the price for each transaction. Each region's weekly price is constructed as a transaction-weighted average wholesale price of the main cities in the region as listed above, since information on daily or weekly quantities moving through individual markets is not available. All prices are expressed in U.S. dollars per pound. Total weekly fresh peach shipments are also obtained from Agricultural Marketing Service of the USDA and are expressed in pounds. This series is constructed as the sum of weekly volume reported by each U.S. shipment point.⁷

The four series contain some missing values for the second and third weeks of April and November when both domestic production and imports are thin. During these thin market weeks, weekly price information is not reported and some markets have days with no transactions. Since information is inconsistently reported, we estimate missing values for

weekly prices for each city included in the regional market by generating a simple daily average based on the number of transactions and then a simple weekly average that includes only days where shipments were received. The region's weekly price is then calculated as a simple weekly average across the cities included in that region.

Figure 2 plots the relationship of the price series from April 10, 2004 through June 18, 2005. The plot presents evidence that regional prices tend to track more closely together during the summer marketing season than in the winter marketing season. The South exhibits the lowest general price level as well as the smallest price variance across all marketing seasons. The average price in the East is slightly higher than that of the South and has a higher variance, but is relatively stable across marketing seasons. The Midwest and West, in contrast, have higher average prices coupled with higher price variance across seasons.

Results

VAR models are estimated for Equation (1) where separate marketing seasons are not considered and for Equation (2) where dummy variables are employed to separate summer and winter market seasons. Seemingly unrelated regression (SUR) is used for estimation. Dickey-Fuller and Philips-Perron stationarity tests indicate that each of the four regional price series are stationary in price levels when considered under each of the three marketing season scenarios (Pindyck and Rubinfeld).⁸ Based on these results, we are able to estimate the VAR using data in levels rather than in differences and, thus, do not incur losses of the long term information reflected in the data. AIC statistics indicate that a second-order VAR model is optimal for each of the three marketing season scenarios.

Table 2 reports coefficient results, block exogeneity test results, and goodness-of-fit

⁷Note that *shipment points* refer to origin while *terminal wholesale market locations* refer to the end point for those shipments.

⁸For brevity, detailed results of stationarity and optimal lag length are not presented here as they are auxiliary to the analysis.

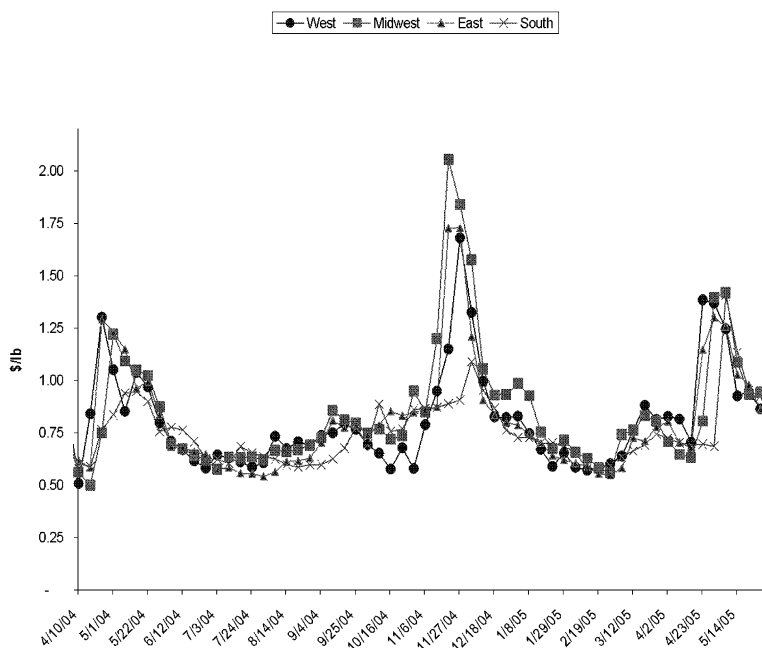


Figure 2. Weekly Regional Wholesale Prices for Fresh Peaches, April 10, 2004 through June 18, 2005 (Source: USDA-AMS)

statistics for each marketing season. Values reported for summer and winter are derived from coefficient estimates from Equation (2).⁹ Adjusted R^2 values range from 0.56 to 0.75. In all three marketing season scenarios, the past week's price of the dependent variable is a significant contributor to the value of the dependent variable (at the 1% level).

Coefficients for total shipments and lagged total shipments are significantly different from zero during summer for each region and the East and South regions when the analysis covers the entire year. These estimated coefficients are not significantly different from zero in any region during the winter season when domestic trading volumes are dramatically lower. During the production season, domestic volumes and regional production can vary greatly from year to year in response to specific

weather events, likely contributing to the importance of shipments during the summer marketing season.¹⁰

As reported in Table 2, block exogeneity is rejected in the case of each dependent variable for each of the three marketing seasons, indicating that, as a group, lags of other regional prices in the system do influence the regional price being considered. Table 2 also reports F -statistics for the null hypothesis that the seasonal dummy variable coefficients for the summer marketing season are jointly zero. A failure to reject H_0 would suggest that overall wholesale price relationships across winter and summer marketing seasons are not statistically

⁹ Separate equations for winter and summer give similar results and are available upon request. Results from Equation (4) were used to test for seasonal differences and are thus reported here.

¹⁰ We included a dummy variable for early harvest dates in the South in versions of the model not reported here. While the South Carolina/Georgia dummy (harvest begins May 20) was insignificant in all markets, the Florida coefficient (harvest begins May 1) was positive and significant for the East and for the Midwest, suggesting that the early Florida harvest influences these two nearby, and later harvesting, regions. Full results from these models are available upon request.

Table 2. VAR Coefficients for the Three Marketing Season Scenarios^{a,b}

Table 2. Continued.

Dependent Variable	Independent Variable	Full Year		Winter		Summer	
		Coefficient Estimate	p-Value	Coefficient Estimate	p-Value	Coefficient Estimate	p-Value
East	W(-1)	0.061	(0.259)	0.083	(0.170)	0.076	(0.494)
	W(-2)	-0.086	(0.104)	0.116	(0.055)***	0.029	(0.785)
	M(-1)	0.298	(0.000)***	0.381	(0.000)***	0.256	(0.010)***
	M(-2)	-0.242	(0.000)***	0.184	(0.008)***	0.200	(0.038)***
	E(1)	0.507	(0.000)***	0.258	(0.005)***	0.570	(0.000)***
	E(2)	0.149	(0.014)**	0.121	(0.134)	0.170	(0.064)*
	S(-1)	0.019	(0.840)	0.105	(0.465)	-0.141	(0.269)
	S(-2)	0.253	(0.003)***	0.205	(0.119)	0.207	(0.074)*
	Q	-0.00004	(0.074)*	-0.001	(0.486)	-0.00006	(0.019)**
	Q(-1)	0.00004	(0.031)**	0.00009	(0.472)	0.00006	(0.009)***
South	DP	0.126	(0.000)***	0.159	(0.000)***	0.225	(0.000)***
	Adj. R ²	0.56		0.60		0.58	
	H ₀ : Block Exogeneity	F = 12.604	(0.000)***	F = 11.30	(0.000)***	F = 19.189	(0.000)***
	H ₀ : Summer Seasonal Dummy Variable Coefficients are Jointly Zero						
	W(1)	0.033	(0.240)	0.060	(0.071)*	0.0023	(0.969)
	W(-2)	0.037	(0.191)	0.012	(0.745)	0.099	(0.081)*
	M(1)	0.006	(0.840)	-0.029	(0.431)	0.065	(0.211)
	M(2)	0.032	(0.279)	0.072	(0.053)**	0.014	(0.786)
	E(-1)	0.170	(0.000)***	0.161	(0.001)***	0.150	(0.000)***
	E(-2)	0.047	(0.141)	0.117	(0.008)**	0.011	(0.821)
Adj. R ²	S(-1)	0.766	(0.000)***	0.836	(0.000)***	0.686	(0.000)***
	S(-2)	0.043	(0.341)	-0.067	(0.350)	0.077	(0.210)
	Q	0.00004	(0.004)***	0.00008	(0.326)	0.00005	(0.000)***
	Q(1)	0.00004	(0.002)***	-0.00002	(0.805)	0.00005	(0.000)***
	DP	-0.0243	(0.035)**	0.040	(0.039)**	0.055	(0.008)***
	Adj. R ²	0.74		0.75			
	H ₀ : Block Exogeneity	F = 18.70	(0.000)***	F = 7.10	(0.000)***		
	H ₀ : Summer Seasonal Dummy Variable Coefficients are Jointly Zero					F = 3.009	(0.083)***

^a Summer coefficient estimates and p-values are calculated from base model results using estimates for seasonal dummy variable coefficients and winter coefficients.
^b Significance levels denoted by *** = 1%, ** = 5%, * = 10%. Statistically significant coefficient estimates are indicated in bold.

different. Again, results are indicative of regional differences. While we do not reject H_0 for the West and Midwest regions, we do reject H_0 for the East and South regions. These results indicate that, in aggregate, price relationships do not change across marketing seasons for the West and Midwest regions, but do change across marketing seasons for the East and South regions.

Forecast Error Variance Decomposition

FEV decomposition can indicate whether prices received in some regions are more or less likely to determine prices in other regions. The results reported in Table 3 indicate that wholesale prices in the West and South are the most exogenous series of the VAR model. Since the West and South regions are the largest U.S. peach producing regions, this is not a surprising result.

FEV decomposition results reveal further interesting differences among regions. Relatively little of the West region price's FEV is explained by other regions regardless of season, particularly in the shorter time horizons of one and four weeks. Even at the 8 wk lag, the West price's contribution to its own FEV is persistent at nearly 70% and 67% in summer and winter, respectively. It is notable that other regions, to some extent, contribute more to the West's FEV in winter than summer beyond the 1 wk time horizon. This is likely influenced by a substantially lower percentage of counter-seasonal imports entering through California in the winter relative to the dominance of California's production in the summer marketing season.

Though the FEV for wholesale fresh peach prices in the West is not strongly affected by prices in other U.S. regions, the West is the primary contributor to FEV for other regions' prices. During winter, while price changes in the West still explain a large degree of other regions' FEV, the relevance is less than in the summer. During the summer, prices in the West are the primary factor explaining FEV of other regional prices with greater relevance as time horizon increases.

FEVs for East and South region prices exhibit somewhat more influence than other regions in both summer and winter seasons, with slightly

more influence in summer. Still, the South is the only region where West price changes do not have any contemporaneous effect on its own price FEV. This higher degree of autonomy during the domestic supply season likely stems from the South's status as the second largest production region. Another contributing factor may be the reputation of quality that the South has built over time. Consistent with the brand strength hypothesis, that reputation likely insulates the region somewhat from fluctuations elsewhere even though individual suppliers cannot be distinguished by brand.

While patterns in the South region's FEV are similar to those of the West, other regions begin to have relatively more influence beyond the 1 wk time horizon. This early, but deteriorating, autonomy could be associated with the influence of early harvesting subregions within the South. Longer time horizons of 4 and 8 wks reveal that in the summer marketing season, the West exerts the strongest outside influence (17.6% and 31.7%, respectively) while the East also contributes a significant portion of FEV (16.2% and 26.6%).

However, the relationship changes in the winter marketing season with the West and Midwest contributing the most to FEV at the 4 wk time horizon (10.2% and 8.4%, respectively) and still exerting significant and equal influence at the 8 wk time horizon (13.1% each). One explanation for why the Midwest and East increase their influence in the South's market may be related to their relative positions on the supply and demand side of the market in winter versus summer. Midwest production quantities are dwarfed by other production regions during the summer marketing season, while the East is relatively more competitive as a supplier of fresh peaches. However, winter regional marketing relationships appear to be more demand driven which shifts the balance of influence away from domestic production areas.

In the Midwest, own-price influence is strong and persistent in the winter (79% at 1 wk lag and 68% at 8 wk lag), but heavily influenced by other regions' prices after a 1 wk lag during the summer marketing season (85% own-price influence at 1 wk lag but only 41% at

Table 3. Forecast Error Variance (FEV) Decomposition by Region Across Marketing Season

Dependent Region	Time Horizon (weeks)	Standard Error		Winter				Summer			
		Winter	Summer	West	Midwest	East	South	West	Midwest	East	South
		Percent Contribution to Variance									
West	1	0.172	0.172	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
	4	0.034	0.034	78.6	10.0	0.6	10.8	84.5	3.6	11.14	0.7
	8	0.024	0.024	66.6	11.2	1.0	21.2	69.9	6.4	22.02	1.7
Midwest	1	0.178	0.178	20.6	79.4	0.0	0.0	15.3	84.7	0.0	0.0
	4	0.247	0.247	20.9	72.4	1.6	5.1	34.7	54.8	6.8	3.7
	8	0.263	0.263	19.3	67.6	2.5	10.6	37.4	40.8	17.1	4.7
East	1	0.157	0.162	12.5	10.4	77.2	0.0	14.8	5.4	79.8	0.0
	4	0.208	0.240	17.2	25.7	49.7	7.4	24.2	9.9	65.4	0.5
	8	0.227	0.285	16.0	25.3	43.5	15.2	28.0	9.7	61.2	1.2
South	1	0.086	0.084	0.0	1.5	0.7	97.8	0.1	1.2	0.9	97.8
	4	0.152	0.145	10.2	8.4	4.7	76.6	17.6	9.9	16.2	56.3
	8	0.188	0.203	13.1	13.1	3.8	69.9	31.7	11.4	26.6	30.3

8 wk lag). This could be the reflection of more balanced supply during winter, since the Midwest is the only region without an import entrance. The strong own-price influence at 1 wk lag in the summer with sharp deterioration following may be attributed to the fact that though the Midwest has strong subregions of heavy production, its overall production falls far short of the other three U.S. production regions.

Generally speaking, FEV results suggest that wholesale price formation in the West and the South is relatively more independent than in the Midwest and the East across both marketing seasons. During the summer marketing season, Midwest region price can be considered as the more endogenous variable in the VAR model with 40.8% of FEV explained by its own error at the 8 wk time horizon. For Midwest growers, assuming symmetric price transmission between wholesale and farm prices, this implies that prices received are determined to a great degree by prices in other regions. This is not surprising since, though Michigan boasts 2 of the top 10 U.S. fresh peach producing counties, the Midwest is the smallest overall production region.

Market Segmentation

We expect that patterns of market segmentation (here, directional price influence as measured by Granger causality) differ across regions and across seasons and the results in Table 4 indicate that this is true.¹¹ In all three marketing season scenarios, short run price variation in the West and South (the major production regions) are explained to a greater degree by own-price changes than by price changes in other regions. In fact, the West is the only region for which standard error of prices decreases across time rather than increasing, suggesting stability as well as a price leadership position relative to other regions. The South appears to maintain the highest level of autonomy among regions regarding the short run

¹¹ Recall that the test in Equation (3) is a unidirectional test of price influence.

influence of other regions' prices on the South's fresh peach wholesale prices. Though not specifically tested in this study, the long-standing tradition and reputation of Southern peach production may be a contributing factor to this phenomenon.

Even though the West is the largest region in terms of production volume, the hypothesis that the South does not influence prices in the West is rejected for the winter and annual marketing season scenarios. However, during summer when domestic peaches are actively marketed, results indicate that prices in the West are not influenced by those in the South or the Midwest. In contrast, West prices are influenced by the South and the Midwest in the winter, but are segmented from the East during the same period. This may be attributed to the fact that though the East is the primary entrance for counter-seasonal imports in the winter, some fresh peach imports do flow through the West (primarily California) as well.

The Midwest presents an interesting case regarding the direction of price influence. Through the summer marketing season, the Midwest market is segmented only from the East, while the West and South influence Midwest wholesale prices (Table 4). Thus, the two largest production regions for fresh peaches are most influential during the marketing season when Midwest has local production competing in the market. Table 4 also reports that in the winter marketing season, the Midwest market is segmented from both the West and the East. In contrast the South exerts influence on Midwest wholesale prices throughout the year.

The East region is the only region for which market segmentation test results suggest no significant influence by other regional wholesale prices during the summer marketing season (Table 4). This may be evidence that "buy local" marketing programs such as Jersey Fresh are performing well. The East is also the only market in which market segmentation test results suggest no significant influence by the West in any marketing season. In the winter, the South and Midwest become contributors to the East's wholesale prices for fresh peaches. Recall that during the winter season the East becomes the "large-volume supplier" as 67%

of fresh peach imports enter the U.S. through Philadelphia, an eastern port (U.S. Census Bureau). Los Angeles, California, is the other primary port of entry with 25% of fresh peach imports during the winter marketing season.

For the South, fresh peach wholesale prices in the West are always relevant. Market segmentation with respect to the West's influence on the South is rejected in each of the three marketing season models. In the summer, the East also becomes a relevant influence, perhaps because of their geographical nearness to the south and large demand centers which serve as markets for the South's summer production. Market segmentation is not rejected in remaining market pairs as related to the South across marketing seasons, suggesting no significant price influences in those cases.

Overall, directional market segmentation tests suggest that during the domestic marketing season, primary U.S. production areas drive wholesale fresh peach prices. Interestingly, the East region is insulated from other regions' price impacts but does influence prices in the other two primary production regions (West and South). When market availability shifts to counter-seasonal imports, regions with large ports of entry (East and West) tend to drive prices.

Long-Run Market Integration

Long-run spatial relationships were also tested to see if a price change at one region is fully reflected over time in the other regions, that is, whether regional markets exhibit integration in the long run. As shown in Table 5, unidirectional long run market integration is rejected for nearly all market pairs. There are notable exceptions. Price changes in the South are shown to be fully reflected in the West in the winter marketing season as well as in the annual scenario, while East region prices are fully reflected in West prices during the summer marketing season. Midwest prices fully incorporate East prices during the winter marketing season when the East becomes the primary supply source, while during the summer marketing season, prices from the South region are fully incorporated into Midwest prices.

Another noteworthy observation is that long-run market integration is rejected for all

Table 4. Testing for Market Segmentation Between Regions Across Marketing Seasons^a

Prices Received in Region X are Influenced by Those Received in Y: X ← Y	Marketing Season									
	Year					Winter				
	Between Regions ^b		All Regions ^c			Between Regions ^b		All Regions ^c		
			Wald	F				Wald	F	
W ← M	0.1153 (0.062)	61.98 (0.00)	20.66 (0.00)		0.157 (0.053)	15.65 (0.00)	5.22 (0.00)	0.058 (0.588)	15.65 (0.00)	5.22 (0.00)
W ← E	0.046 (0.487)				−0.040 (0.694)			0.238 (0.025)		
W ← S	0.289 (0.000)				0.419 (0.000)			0.028 (0.781)		
M ← W	0.005 (0.919)	62.54 (0.00)	20.85 (0.00)		−0.061 (0.391)	13.56 (0.00)	4.52 (0.00)	0.163 (0.078)	18.65 (0.00)	6.22 (0.00)
M ← E	0.185 (0.007)				0.059 (0.391)			0.059 (0.588)		
M ← S	0.299 (0.000)				0.280 (0.001)			0.277 (0.008)		
E ← W	−0.026 (0.601)	29.45 (0.00)	9.82 (0.00)		−0.032 (0.603)	30.64 (0.00)	10.21 (0.00)	−0.105 (0.199)	4.751 (0.19)	1.58 (0.19)
E ← M	0.057 (0.331)				0.198 (0.008)			0.056 (0.567)		
E ← S	0.273 (0.000)				0.309 (0.000)			0.066 (0.476)		
S ← W	0.070 (0.007)	81.52 (0.00)	27.17 (0.00)		0.071 (0.038)	24.29 (0.00)	8.10 (0.00)	0.101 (0.023)	69.35 (0.00)	23.12 (0.00)
S ← M	0.038 (0.216)				0.043 (0.284)			0.079 (0.141)		
S ← E	0.123 (0.000)				0.044 (0.385)			0.161 (0.002)		

^a *p*-values reported in parenthesis. Cases where the null hypothesis of market segmentation is rejected are in bold.
^b $H_0: b_{i,xy} = 0$ for $i = 0, 1, 2, \dots, m$ (Market segmentation); H_a : No market segmentation. For example, 0.1153 (0.062) indicates that the null hypothesis that fresh peach prices in the Midwest do not influence fresh peach prices in the West can be rejected at $\alpha = 0.10$.
^c $H_0: b_{i,xy} = 0$ for $i = 0, 1, 2, \dots, m$ for all y (Market segmentation); H_a : No market segmentation. For example, the Wald statistic of 61.98 (0.00) indicates that the null hypothesis that fresh peach prices in the Midwest, East, and South, do not jointly affect peach prices in the West can be rejected.

market pairs where the West would be the change catalyst, with the exception of the East during the summer marketing season. In contrast, the West seems most influential in the previous analysis and tests presented here. That is, though our earlier analysis suggests that the West has significant influence over prices in other regions, the markets are not fully integrated in the long run. For the South region's prices, market integration is rejected across all regions and all seasons.

Impulse Response Functions

Figure 3 illustrates impulse response functions from the VAR analysis for each market. Impulse response functions show the reaction to a one standard deviation shock in one region, for example, the West, by that region as well as all other regions in the model. Impulse response functions are shown here only for the Summer and Winter marketing seasons, as it is the differences between these two seasons that present

the most interesting contrasts. In general, the reaction to price shocks is larger and more persistent in the presence of counter-seasonal imports (winter) compared with the domestic marketing season (summer). This is expected since counter-seasonal imports are the only supply source and there is no regional production available to soften potential shocks.

Price shocks in the East region present the most dramatic illustration of this, likely because the East is the primary entrance for counter-seasonal imports. A shock in the East in the summer initially generates a moderate response in nearby Midwest prices, with a slower response from the major production region of the South. Price changes converge at about week 4 and persist through the 10-wk period projected. In the winter marketing season, the initial response of other regions to a shock in East prices is similar, except that the West response is larger than before. The magnitude of response increases more rapidly in the winter and, with the exception of the West,

Table 5. Hypothesis Testing for Long Run Market Integration by Marketing Season^{a,b}

Prices Received in Region X Fully Reflect Price Changes in Region Y: $X \leftarrow Y$	Marketing Season								
	Year			Winter			Summer		
	Test	<i>F</i>		Test	<i>F</i>		Test	<i>F</i>	
	Coefficient	Statistic	<i>p</i> -Value	Coefficient	Statistic	<i>p</i> -Value	Coefficient	Statistic	<i>p</i> -Value
W \leftarrow M	-0.333	30.34	0.000	-0.353	17.30	0.000	-0.325	9.80	0.002
W \leftarrow E	-0.402	27.89	0.000	-0.549	25.41	0.000	-0.145	1.57	0.211
W \leftarrow S	-0.159	5.51	0.019	-0.090	1.053	0.305	-0.355	7.09	0.008
M \leftarrow W	-0.492	61.42	0.000	-0.465	28.05	0.000	-0.301	7.83	0.005
M \leftarrow E	-0.312	21.46	0.000	-0.124	1.123	0.289	-0.404	11.25	0.001
M \leftarrow S	0.802	92.06	0.000	-0.301	7.826	0.005	-0.187	2.02	0.155
E \leftarrow W	-0.370	26.67	0.000	-0.653	43.19	0.000	-0.155	2.14	0.143
E \leftarrow M	-0.288	22.24	0.000	-0.423	28.65	0.000	-0.204	3.68	0.055
E \leftarrow S	-0.072	1.264	0.261	-0.312	9.27	0.002	-0.194	3.96	0.047
S \leftarrow W	-0.206	36.98	0.000	-0.161	13.45	0.003	-0.289	18.90	0.000
S \leftarrow M	-0.238	35.09	0.000	-0.188	11.22	0.001	-0.312	24.27	0.000
S \leftarrow E	-0.153	20.31	0.000	-0.187	11.24	0.001	-0.229	18.50	0.000

^a Recall that H_0 : long run market integration and H_a : No long run market integration. Thus, the first test coefficient of -0.333 with a *p*-value of 0.000 indicates that we reject long run market integration in the direction of Midwest to West. That is, we reject that prices received in the West fully reflect price changes in the Midwest.

^b Market pairs where unidirectional long run market integration is rejected are in bold.

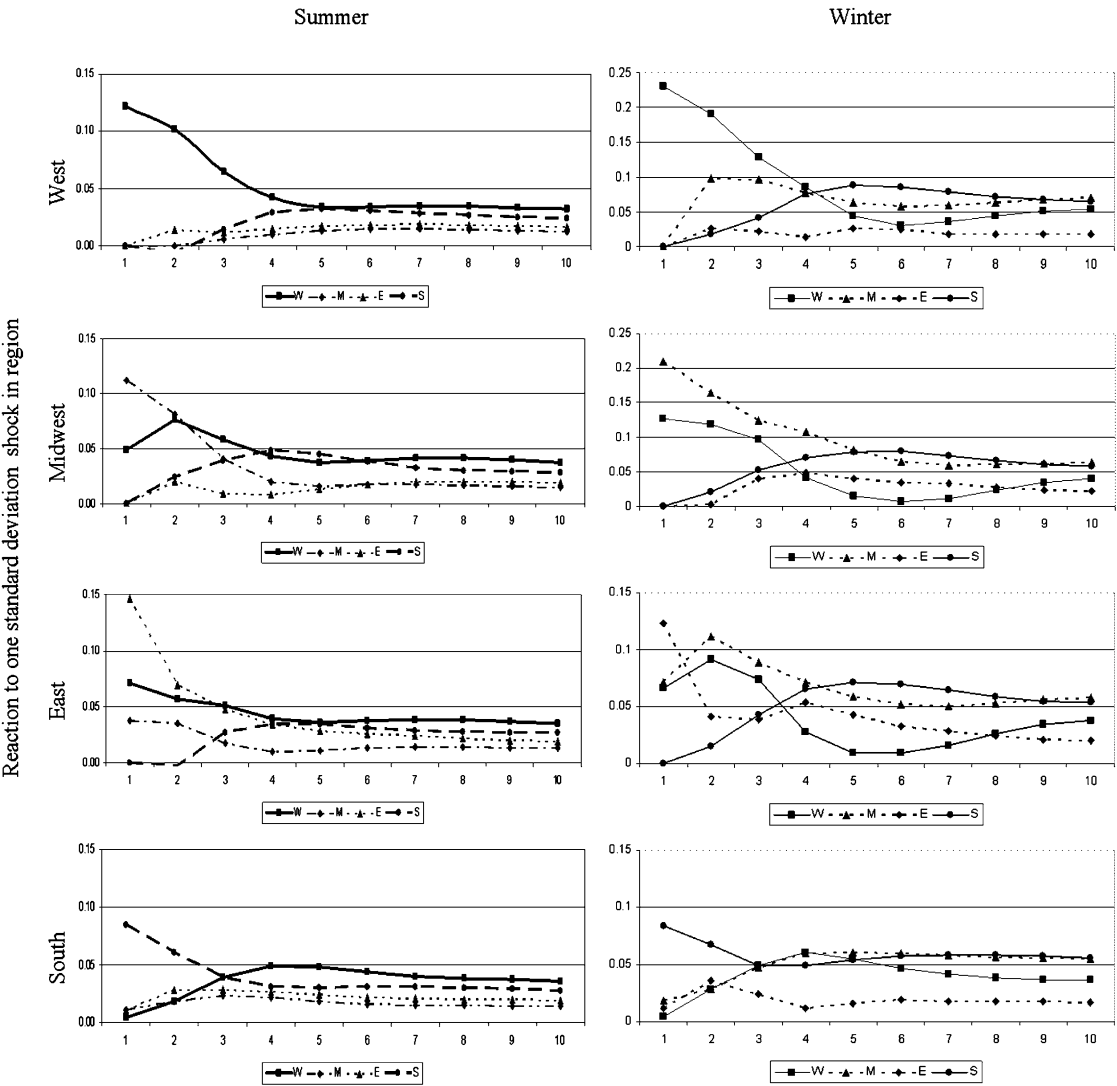


Figure 3. Impulse Response Function Graphs¹²

persists at higher levels for a longer period of time. The own price effect for the East actually falls more quickly in the winter and settles at a lower level than in the summer. By contrast, the impact of a shock to the South has twice the impact on own-price in the winter than in the summer, perhaps an indication of the dampening effect of local supply in the summer marketing season.

¹² The y axis represents the magnitude of the price shock and corresponding responses in other regions. The x axis represents the timeline of weeks of impact.

Moreover, any price shock in the Midwest is absorbed by the West region, which reacts in the short run. Assuming symmetric price transmission between wholesale and farm prices, this may have a negative effect on Midwest farm prices. Price shocks in the East and Midwest during the summer have a positive contemporaneous effect on West prices. Since the West is the largest producer, it is expected that West suppliers will react to changes in other regions in order to move significant volumes. The South prices are affected by shocks in the long run, particularly by shocks in the Midwest. Price

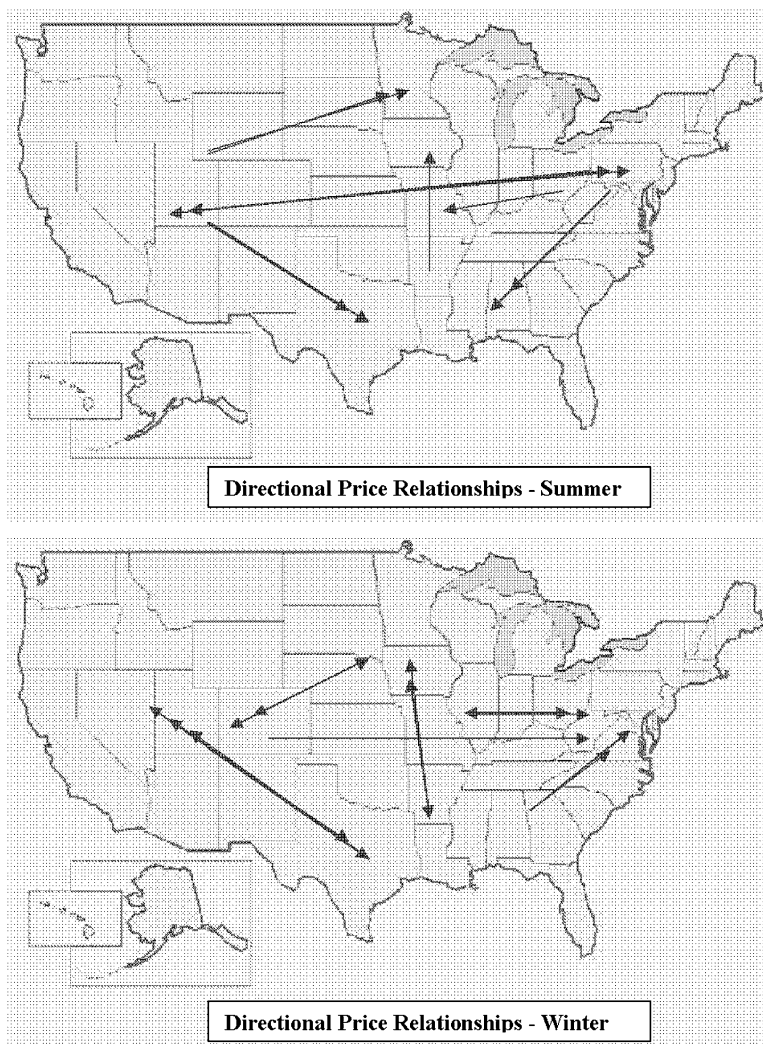


Figure 4. Comparison of Directional Price Relationships across Seasons Based on Synthesis of Results from Tables 3, 4, and 5¹³

changes in the East have short run effects in the Midwest, but the opposite does not happen. During winter, East and Midwest price fluctuations also have an immediate effect on the West, and the effect on the

South is greater in the long run. Midwest prices are drastically affected by price variations in the South in the long run.

Summary and Conclusions

The U.S. fresh peach market offers an interesting example of bimodal supply sources with distinct regional production areas complemented by counter-seasonal imports. When domestic production is available (summer) market prices among regions exhibit greater spatial differences, including greater independence, due to local supply influences while lack

¹³Each arrowhead represents a positive indication of a directional price relationship by one of the three components of the analysis. For example, one arrowhead indicates that only one component of the analysis indicates a directional price relationship while three arrowheads indicates that each of the three components of the analysis indicate a directional price relationship.

of domestic production during the winter marketing season results in greater equilibration of market prices among regions. Summer marketing season prices are led by the two main production regions—the West and South—while the East maintains some degree of autonomy.

Spatial price relationships among regions for the U.S. fresh peach wholesale market reveal less isolation in the winter than in the summer as illustrated in Figure 4. Each arrowhead represents indication of a directional price relationship by test results in Tables 3, 4, or 5. For example, one arrowhead indicates that only one component of the analysis indicates a directional price relationship while three arrowheads indicates that each of the three components of the analysis indicate a directional price relationship.

During the winter marketing season, leadership of the West and South is less preponderant and price influences become more bidirectional. Though not an issue specifically addressed in this study, the influence that these two regions do exhibit during winter may be due to well-established distributional channels for imported peaches. The East, as the primary port of entry for fresh peach imports, reflects substantial influence from the peach deficit by population dense regions of the South and the Midwest.

Wholesale prices for the Midwest and the East can be considered more dependent on prices in other U.S. producing regions than those of the South and West. Both are relatively small regions in terms of fresh peach production. It is unlikely that either region could increase production significantly, given climatological and population pressures. Climatological characteristics of the regions also make it unlikely that varietal changes targeting national marketing windows (e.g., Florida) would be successful. The West and, to some degree, the South, are able to cover any shortage in supply, which leads to lower prices in the Midwest. Efforts focused toward product differentiation through varieties that offer an improved flavor, higher quality, or unique culinary characteristics or through promotion of place of production (e.g., “buy local,” Jersey

Fresh, Select Michigan) may work to lessen the impact of price leadership from the two major production regions during the summer marketing season. Evidence from East region prices during the summer marketing season suggests some success in this arena.

Overall, our results suggest that the market dynamics differ for the domestic (summer) marketing season and the period when counter-seasonal imports dominate the market (winter). During the summer marketing season, locally available supply dampens the impacts of price variations in other regions on a region's own price. However, during the winter months, our analysis suggests that domestic markets become more integrated as the supply source switches to counter-seasonal imports rather than U.S. produced fruit. The West and the East, in particular, see changes in spatial price relationships as they swap the role of major supply region from summer to winter and as peach deficit regions of the Midwest and the South become influential over prices.

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