Fresh Vegetable Price Linkage Between Grower/Shippers, Wholesalers, and Retailers

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This study focused on the transmission of price adjustments between grower/shippers and wholesalers and between wholesale handlers and retailers of nine fresh vegetables (only the results associated with bell peppers are reported in this paper). Results among the nine vegetable products were not consistent with respect to the magnitude of adjustments or the time periods involved in the adjustments. In response to wholesale price changes, upward price adjustments at the retail level occur more quickly than do downward price adjustments. Price transmission relationships also varied among the vegetable products between the wholesaler and grower. Overall, the results indicate that factors in addition to changes in upstream prices are impacting retailers' and wholesalers' pricing decisions.

Average farm prices have been trending upward; however, average retail prices have risen faster than average shipping point prices, resulting in a larger retail-farm spread (Waterfield). For example, the farm share of the retail cost of fresh produce fell from .29 in 1987 to .23 in 1992 (USDA, Agricultural Statistics). This has many participants within the vegetable industry concerned that the retail sector quickly responds with higher prices when faced with declining product supply, but, when product supply is increasing and grower returns are declining, retailers are less responsive in downward retail price adjustment.

Past studies have tried to explain price movements within the vegetable industry in order to allow vegetable producers, wholesalers, and retailers to make more precise production, pricing, and inventory decisions (Granger; Hansmire and Willett; Heien; Kinnucan and Forker; Powers; Ward; Ward and Zepp). A major weakness of these studies has been the use of average monthly prices to determine how prices throughout the marketing channel adjust to a change in price at one exchange point. Because of the perishable nature of fresh vegetables and relatively volatile nature of supplies entering the marketing system, planning horizons for retailers and wholesalers are much less than one month, which probably leads to a change in pricing and inventory strategies several times each month. Weekly data for fresh produce are more consistent with planning horizons for participants in the fresh produce marketing channel. However, until recently it has not been feasible to capture weekly retail-level fresh produce price data. With the advent of retail scan-data technology, weekly price data on variable weight items such as fresh produce, can now be gathered and tracked at some locations (Eastwood).

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Objectives

The overall goal of this project was to provide vegetable producers and other industry participants with insight about the pricing behaviors of shippers (growers), wholesalers, and retailers and the resulting price transmissions for specific commodities. Of particular interest was the possibility of differences in the adjustment process to price increases versus price decreases and the amount of time required for the adjustments to take place. Visualizing the flow of product from the farm gate to the retail consumer as a stream, upstream and downstream relationships exist. Six specific objectives were to analyze:

1) downstream price increases in relation to upstream price increases,
2) downstream price decreases in relation to upstream price decreases,
3) symmetry in the amounts of price changes transmitted for falling versus rising upstream prices,

4) lag periods in which upstream price increases are transmitted,
5) lag periods in which upstream price decreases are transmitted, and
6) symmetry between the lag periods used to transmit rising and falling upstream prices.

Vertical Price Linkage Models

By examining the relationships between exchange points in the distribution channel, the vertical price linkages between levels can be estimated and used to evaluate how downstream prices move in relation to upstream changes. In an effort to estimate fresh vegetable price linkages, Ward used Granger's causality test, which presumes that causality may flow in either direction between two variables. Using this information, Ward and Zepp estimated symmetry conditions for nine fresh vegetable relationships using Wolffram's asymmetric models to accomplish their objectives. Price increases and decreases were hypothesized to move in a parallel (symmetric) manner, although the length of the lag at the retail level was longer. However, they found asymmetric relationships and price movements that may or may not be related to a change in price by the price leader, which existed between the shipper and wholesaler and between the wholesaler and retailer. The conclusion was that as wholesale prices rise, retailers are reluctant to increase their prices for fear of an inability to move the perishable items. On the other hand, as wholesale prices fall, retailers move quickly to pass their savings on to consumers, and grower prices fall at a more accelerated rate than grower prices rise when wholesale prices are increasing.

A study of the California lettuce industry by Powers provided the analytical basis for the price-linkage model used in this study. If firms are competitive, fresh vegetables are produced by combining the farm commodity with marketing inputs in fixed proportions. The marginal cost of producing the vegetables, then, remains constant regardless of the amount produced, and the rule linking each city's wholesale price to the shipping-point (grower) price for the i^{th} commodity is:

(1) $W_i = a_{1,i} S_i + a_{2,i} X_i$,

where, W is the city's wholesale price, S is the FOB shipping point price, X is the price of marketing inputs, and $a_{1,i}$ and $a_{2,i}$ are coefficients representing the marketing technology (Powers, p. 2-3). Coefficient $a_{1,i}$ indicates the number of units of the i^{th} vegetable at the shipper/grower level it takes to provide one unit of the same vegetable at the wholesale level. Since vegetables are perishable, $a_{1,i}$ is expected to exceed 1. Coefficient $a_{1,i}$ also indicates the amount the wholesale price would change based on a one unit change in the shipping-point price.

The vertical relationship in equation 1 is based on three assumptions. First, firms are competitive. This seems to be a reasonable assumption for fresh produce grower/shippers and wholesalers. Because of their large numbers and the lack of a government program to limit production or shipments, growers and packer-shippers are unable to manipulate the FOB price of vegetables. Terminal markets are "dominated by many small-volume buyers and sellers with diverging interest," which prevents groups of wholesalers from exerting any control over a city's wholesale price (Powers). While retailers do not seem to operate in a competitive environment, Holloway found that retail market deviations from competitiveness during 1955-83 were relatively insignificant. The second assumption is that fresh vegetables are combined with fixed proportions of marketing inputs. The lack of substitutability of marketing inputs in the short run and the relatively fixed nature of technology for marketing and distributing fresh vegetables support the validity of this assumption. Finally, the third assumption is that except for transportation, marginal marketing costs are constant. Since fees for cooling, packing, and selling usually remain constant during the year this assumption seems to be reasonable.

Although the total response of downstream prices to upstream prices is probably nearly symmetrical in the long run, initial price responses may be asymmetrical and price changes may not be fully passed through during the week in which the initial price change occurred. To accommodate this, equation 1 was revised to allow for asymmetric price responses and gradual price adjustment by using Houck's approach for specifying non-reversible functions and including lags for increases and decreases in upstream grower/shipper prices and in hauling cost (HC) between the production area and the wholesale markets. The resulting equation, which specifies the change in the i^{th} wholesale price due to rising (R) and falling (F) grower/shipper prices and hauling costs is:

$$(2)\quad WP_{i,t} = \sum_{j=0}^{LR} \delta_{1,i,t-j} SR_{i,t-j} + \sum_{j=0}^{LF} \delta_{2,i,t-j} SF_{i,t-j} + \delta_3 HCR_{i,t} + \delta_4 HCF_{i,t} + e_{i,t}\ ,$$

where:

$$WP_{i,t} = W_{i,t} - W_{i,0}\ ,$$

$$SR_{i,t} = \sum_{k=0}^{t} \Delta S_{i,k} \text{ with } \Delta s_{i,k} = S_{i,k} - S_{i,k-1} \text{ if } S_{i,k} > S_{i,k-1},\ 0 \text{ otherwise,}$$

$$SF_{i,t} = \sum_{k=0}^{t} \Delta S_{i,k} \text{ with } \Delta s_{i,k} = S_{i,k} - S_{i,k-1} \text{ if } S_{i,k} < S_{i,k-1},\ 0 \text{ otherwise,}$$

$$HCR_{i,t} = \sum_{k=0}^{t} \Delta HC_{i,k} \text{ with } \Delta HC_{i,k} = HC_{i,k} - HC_{i,k-1} \text{ if } HC_{i,k} > HC_{i,k-1} \text{ and 0 otherwise, and}$$

$$HCF_{i,t} = \sum_{k=0}^{t} \Delta HC_{i,k} \text{ with } \Delta HC_{i,k} = HC_{i,k} - HC_{i,k-1} \text{ if } HC_{i,k} < HC_{i,k-1} \text{ and 0 otherwise.}$$

$WP_{i,t}$ is the difference between the city's wholesale price for commodity i in week t and the price in week 0, the initial week; $SR_{i,t}$ is the sum of all week-to-week increases in the i^{th} FOB price from its initial value in week 0 to week t; $SF_{i,t}$ is the sum of all week-to-week decreases in the i^{th} FOB price from its initial value in week 0 to week t; HCR_{it} is the sum of all week-to-week increases in the i^{th} truck hauling costs from its initial value in week 0 to week t; $HCF_{i,t}$ is the sum of all week-to-week decreases in the i^{th} hauling costs from its initial value in week 0 to week t; LR is the lag length for rising prices; LF is the lag length for falling prices; $\delta_{1,i,t-j}$ (j=0,1,2,...,LR) are the LR + 1 estimated coefficients corresponding to the LR + 1 $SR_{i,t-j}$'s; $\delta_{2,i,t-j}$ (j=0,1,2,...,LF) are the LF + 1 estimated coefficients corresponding to the LF + 1 $SF_{i,t-j}$'s; $\delta_{3,i}$ is the estimated coefficient for HCR_I; $\delta_{4,i}$ is the estimated coefficient for HCF_i; and $e_{i,t}$ is the random error term. Because every variable appears as a deviation from its previous or initial value, there is no intercept term in equation 2. Initially, Powers included lags of hauling costs and average U.S. hourly earnings for nonsupervisory workers in wholesale grocery and related products, but neither factor explained any additional variation in wholesale prices; therefore, they were omitted from his model. Likewise, after estimating the model in this study with some fabricated transportation data (the interested reader is referred to Carver), unsatisfactory results prompted the removal of hauling costs from the equations used in this study.

For each wholesale city's equation, LR and LF were found by specifying lag lengths of seven weeks and estimating the equation. The last lag was then eliminated if its estimated coefficient was not statistically different from zero at the .20 level, and the equation was re-estimated. This procedure was followed until the last lag remaining in the equation was statistically different from zero. A longer lag period indicates that price changes are distributed over a longer period of time (Powers).

$\sum_{j=0}^{LR} \delta_{1,i,t-j}$ and $\sum_{j=0}^{LF} \delta_{2,i,t-j}$ represent the total response of a city's wholesale price to an increase or decrease, respectively, in the i^{th} price at the shipping point. Because of product shrinkage, these values should slightly exceed one for the price changes to be fully passed through. If these values greatly exceed one, price changes at the FOB level more than completely pass through, and, if these values are less than one, price changes are only partially passed through.

If $\sum_{j=0}^{LR} \delta_{1,i,t-j} = \sum_{j=0}^{LF} \delta_{2,i,t-j}$, then the wholesale price response to rising and falling FOB prices is symmetric.

In order to examine the relationship between wholesale prices and retail prices, a similar equation was used,

(3)

$$RP_{i,t} = \sum_{j=0}^{LR} \delta_{1,i,t-j} WR_{i,t-j} + \sum_{j=0}^{LF} \delta_{2,i,t-j} WF_{i,t-j} + e_{i,t}$$

where $RP_{i,t}$ is the difference between the i^{th} retail price in week t and this price in week 0, the initial week.

Data Sources

Nine fresh vegetables were selected for this study: green beans, broccoli, cabbage, sweet corn, cucumbers, okra, green peppers, squash, and tomatoes. Shipping point price data were collected by personal contact with two major grower/shippers in the region and are presumed to reflect the average weekly prices received by grower/shippers. However, due to the relatively short harvest season for this region, the data sets for some vegetables have a small number of observations. Bell peppers had the largest number of Tennessee shipping point price observations, and results reported here are for this commodity.[1] Price data for wholesale markets were acquired from the Market News Service (USDA, 1988-1993) for four markets considered important to Tennessee producers (Best and Brooker). The reported wholesale market prices in Atlanta, Baltimore, Chicago, and Cincinnati were used to represent the average weekly wholesale market prices for the selected vegetables at each location. Except for Baltimore, the wholesale prices are dated for each Saturday and represent the average price (sometimes a range) that was dominant during the preceding week. Baltimore's dates are for Mondays and represent the average price for the week that follows.

Weekly retail prices and product movement were obtained from five Knoxville area retail grocery stores that are part of a national supermarket chain. Prices are for seven-day periods beginning Sunday and ending Saturday. The weekly retail price for each vegetable was multiplied by its volume movement for each store and then summed across the five stores. This value was then divided by the total five-store volume movement for that vegetable to obtain the average weekly retail price. Because vegetables are sold in different quantities at the retail and wholesale levels, the retail prices were adjusted to reflect the prices charged for wholesale quantities (U.S.D.A. Statistical Bulletin No. 616). The data should be a reasonable reflection of retail prices in the Knoxville area because the retail prices and product movement are taken directly from the retail scanner tapes, provided each week by this supermarket chain. While this large supermarket chain does not purchase, except in emergencies, fresh produce supplies from wholesale redistribution markets, the prices were presumed to reflect the prices confronting the chain's produce buyers because the same macro economic forces would be interacting to discover the "same" price at all horizontal points in the marketing chain. In other words, prices on the wholesale markets are a reasonable proxy for prices observed by a chain's buying broker.

Descriptive Statistics

The bell pepper price data used in this study are shown in Figure 1. The shipping-point data are quite limited because of the fairly short harvesting period. The wholesale prices in the four market cities appear to be closely correlated and more volatile than the retail price (Table 1). In fact, the correlation coefficients among the wholesale markets ranged from 0.86 to 0.93. Atlanta prices were less correlated with the wholesale prices in the other three cities, and Atlanta also had the lowest average price. The highest average price was reported for the Cincinnati wholesale market. However, the coefficients of variation for all four wholesale markets are almost identical, ranging from 0.43 to 0.45.

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[1] Interested readers may obtain a copy of the full report on all nine vegetables from the authors (Brooker, et al.)

Figure 1. Bell Pepper Prices

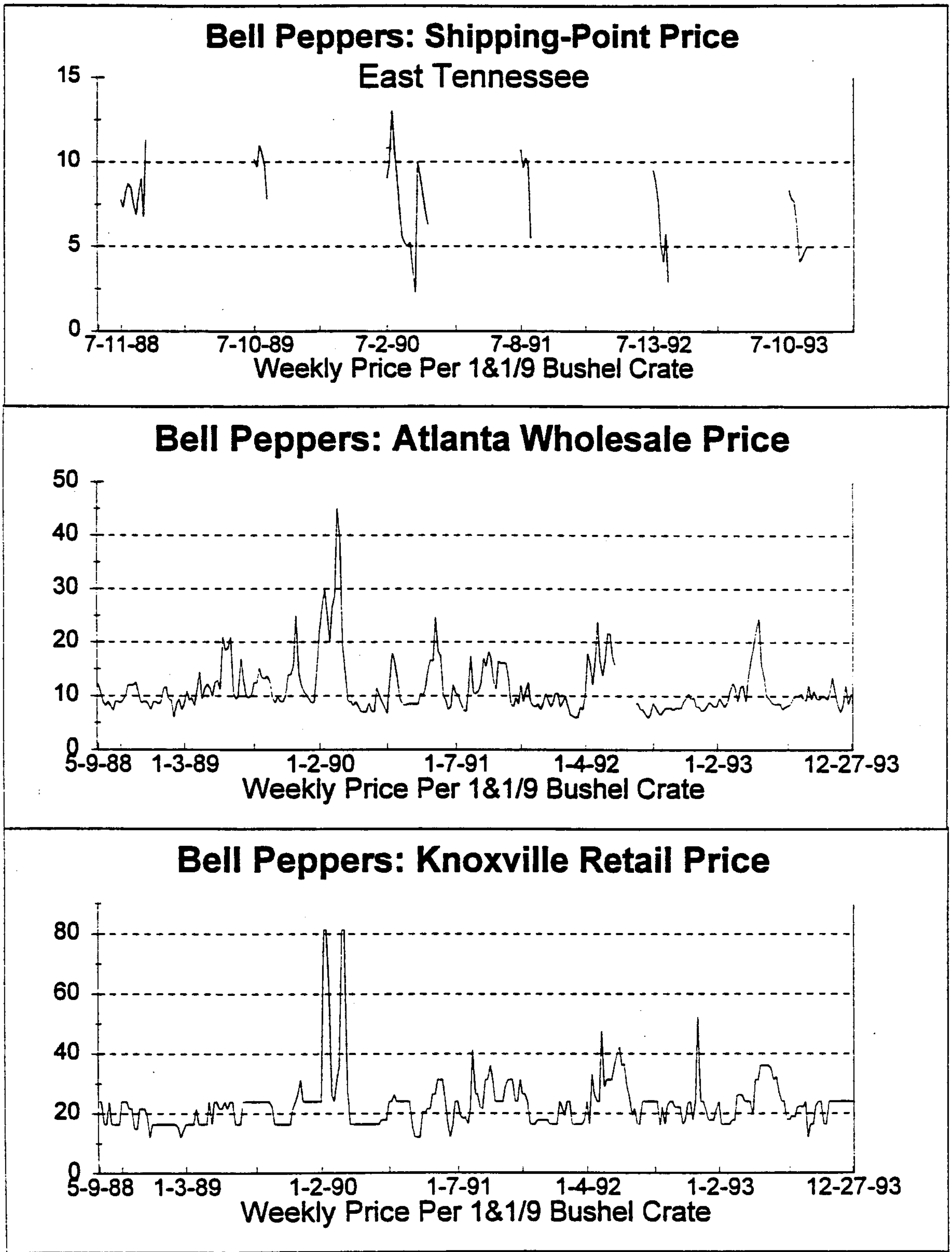

Table 1. Descriptive Bell Pepper Price Statistics

	Price Correlations						Mean Price	Price Range	CV[a]
	Wholesale				Retail	Shipper/	(dollars)	(dollars)	
	Atlanta	Baltimore	Chicago	Cincinnati	Knoxville	Grower			
Atlanta	1.00						11.45	6.00-45.00	0.44
Baltimore	.89	1.00					13.06	6.00-45.00	0.45
Chicago	.86	.91	1.00				12.80	4.75-39.00	0.43
Cincinnati	.89	.93	.93	1.00			14.01	7.25-44.75	0.43
Knoxville	.62	.60	.60	.64	1.00		23.22	12.04-81.38	0.41
Shipper	.55	.70	.61	.62	.37	1.00	7.66	2.26-13.04	0.30

[a] Coefficient of variation.

Correlation coefficients between the retail price and prices at the four wholesale markets varied from 0.60 to 0.64. The overall average retail price was $23.22. The coefficient of variation for the retail price series (.41) was quite close to those obtained for the wholesale prices (0.43 to .45). The lowest coefficient of variation, 0.30, was obtained with the shipper/grower price data, which averaged $7.66 and ranged from $2.26 to $13.04. The correlation coefficient between the retail price series and the shipper/grower price series was lower, 0.37. Two interpretations of the pattern of correlations are 1) that information spreads quickly among the wholesale markets, leading to similar price changes, and 2) for retailers other considerations (e.g., labor, demand elasticity) affect prices.

Results

The results from estimates of equations 2 and 3 are presented in Table 2. The R^2 values for the relationship between the grower/shipper price series and prices at the four wholesale markets ranged from 0.56 in Atlanta to 0.91 in Baltimore. Results obtained with the wholesale to retail equations were lower, ranging from an R^2 of .23 in Chicago to .31 in Baltimore. This is consistent with the pattern of correlations described above.

The sums of the significant δs between the grower/shipper and wholesaler levels are greater than 1.0 in every case, except in Atlanta when grower/shipper prices were increasing. All of the pairs of sums of δs for each city are significantly different at the .01 level. And, all of the sums of δs are greater for price decreases than for price increases. This implies that wholesale price adjustments in reaction to price changes at the shipper/grower level are significantly greater when shipper/grower prices decrease than when they increase. So, with bell peppers, there does appear to be asymmetry in price adjustments between grower/shipper and wholesaler levels of the marketing chain.

For the price linkage relationship between the wholesale markets and the retail market, the sums of the deltas indicate the reverse situation. When wholesale prices increased, the retail price increased by 1.77 times as much in Chicago versus 3.79 times as much in Atlanta. However, only in Atlanta did the sums of δs indicate that a 1 percent price decrease would be fully passed through by the retailer. In the other three wholesale market cities the sums of δs were less than 1.0, and even negative in one case. These results indicate that significant asymmetry in price adjustments exists between the wholesale level and the retail level of

Table 2. Bell Peppers: Estimated Sums of δs and Overall Fits

	Grower/Shipper to Wholesale			Wholesale to Retail		
	Increase	Decrease	R^2	Increase	Decrease	R^2
Atlanta	0.90	1.56	0.56	3.76	1.58	0.30
Baltimore	2.14	5.53	0.91	2.26	0.21	0.31
Chicago	1.97	5.41	0.89	1.77	-0.24	0.23
Cincinnati	1.97	6.97	0.85	2.76	0.88	0.27

the marketing chain. Also, the results seem to suggest that other factors not included in the model appear to dominate pricing decisions of the retailer, at least for bell peppers.

The significant lag periods during which price adjustments were made varied among the four wholesale markets (Table 3). For the Chicago market, the wholesalers began adjusting their prices in response to rising and falling shipping-point prices in the following week, referred to as week one. Significant price adjustments continued until week five. For the Atlanta and Cincinnati markets, price adjustments in response to price increases at the shipping point did not begin until the fourth week. Results also varied among the wholesale markets with respect to the adjustments at the retail level in response to changes at the wholesale level. In general, adjustments by the retailer in response to price increases at the wholesale level began in the current week with respect to Baltimore, and began in week one with the other three markets. Except for the results associated with Chicago, it would appear that the retailer adjusts prices upward at a slightly faster rate than downward price adjustments. Comparisons of the grower/shipper-wholesaler versus wholesale-retail lags suggest that wholesalers start adjusting prices downward faster than increases. The two closest markets for East Tennessee growers showed slower adjustment periods for price increases, which may be the results of an asymmetric seasonality effect. That is, when Tennessee prices rise (fall), other growing regions may also tend (not) to supply bell peppers.

Table 3. Significant Lag Periods for Increasing and Decreasing Bell Pepper Prices

	Grower/Shipper to Wholesale		Wholesale to Retail	
	Increasing	Decreasing	Increasing	Decreasing
	----------weeks----------			
Atlanta	4,5	2,4	1,2,3	1,2,4
Baltimore	3,4,5	1,2,3,5	0,1,2,3	0,2,3,4
Chicago	1,3,4,5	1,2,3,5	1,2	0,3
Cincinnati	4,5	1,2,3,5	1,2,3	1,4

Marketing Implications

The wholesale to shipping-point relationship for bell peppers suggests that price information is transferred between these two parts of the distribution channel. With respect to efficiency, the results indicate that price increases are more completely transferred and in less time than price decreases. An interpretation is that wholesalers may use the shipping point increase to justify raising prices in expectation of other marketing costs (i.e., labor) rising. Similarly, a reluctance to lower prices may reflect concerns that other marketing costs are not declining.

The response of the retail price to changes in the wholesale prices led to the supposition of a possible pricing strategy of increasing or decreasing the retail price relative to an average wholesale price level. Such a retail pricing strategy would not be inconsistent with logic, since weekly adjustments of prices may be more costly and bothersome than allowing per unit profits to vary from week to week when the wholesale price is moving within a certain price range.

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