Grocery Retailer Behavior in the Procurement and Sale of Perishable Fresh Produce

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Abstract

This study examines retailer pricing behavior for iceberg lettuce shipped from California and Arizona, mature-green and vine-ripe tomatoes shipped from California and Florida, and lettuce-based fresh salads. A switching regression model is used to examine oligopsony power. Market power over consumers is inferred from selling price, selling and acquisition cost, and estimated price elasticities of demand. Evidence suggests buyers are often able to exercise oligopsony power in procuring fresh produce commodities. Unilateral monopoly power granted by geographic and brand differentiation allows retailers to exercise market power over consumers, in the sense of marking up prices in excess of full marginal costs.

Keywords: Supermarket, grower-shippers, lettuce, bagged salads, tomatoes, market power, oligopsony, oligopoly, switching regression model, fresh produce.

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Table of Contents

List of Tables

List of Figures

Introduction

This study is part of an investigation by the U. S. Department of Agriculture, Economic Research Service (ERS) into competition and pricing practices in the fresh fruit and vegetable (produce) industries. We focus on iceberg lettuce shipped from California and Arizona (CA-AZ), mature-green and vine-ripe tomatoes shipped from California and Florida, and lettuce-based fresh salads. The companion report by Richards and Patterson (RP) analyzes similar issues for Washington apples, California fresh grapes, California fresh oranges, and Florida fresh grapefruit.

A key factor motivating the investigation is the wave of mergers in food retailing that have led to increasing concentration in the sector.[1] A concern is that this concentration may manifest itself both in terms of retailer oligopoly power, in selling to consumers, and oligopsony power, in buying from commodity shippers and food manufacturers. The concerns about oligopsony power are magnified in the produce sector, because the selling side of these markets is in most cases unconcentrated, relative to the buying side. In addition, most produce commodities are highly perishable, meaning that supply at any point in time is very unresponsive (inelastic) to price (Sexton and Zhang (SZ), 1996). The disparity between numbers of sellers and buyers and the need to move product to avoid losses from spoilage limits shippers' bargaining power in dealings with retailers.

Understanding retailer market power is critical to the assessment of various emerging practices in the produce sector, such as retailers' requests that shippers pay slotting fees or provide various services (see Calvin *et al.*, 2001). If retailers possess little or no market power, then fee and service requests must have an efficiency motivation, and are not an appropriate focus of policy concern. If market power exists, fees and services may be a symptom of that market power, but the appropriate policy remedies do not necessarily focus on mitigating use of fees and services. Rather, the focus of policy should be on the market power itself. If retailers possess oligopsony power in dealings with grower-shippers, banning the use of particular fees and/or services would most likely simply cause the market power to be manifested in other dimensions, such as lower acquisition prices, and at the cost of reduced efficiency.

Our investigation of retailers' behavior in the procurement and sale of iceberg lettuce, mature-green and vine-ripe tomatoes, and lettuce-based packaged salads focuses on 20 retail grocery chains in six U. S. metropolitan markets over the two-year period from January 1998 through December 1999. The market areas include Albany, NY (two chains), Atlanta (three chains), Chicago (three chains), Dallas (five chains), Los Angeles (four chains), and Miami (three chains). In several instances, the same retail chain was studied in multiple cities. By agreement with the data vendor, we are unable to reveal the chain names. Thus, retail chains are identified by their city and by number, e. g., Chicago 1, Chicago 2, Miami 1, etc.

The methods utilized in this study differ in several respects from those employed in the RP companion study due in part to differences in types of commodities analyzed in each study. Whereas fresh lettuce and tomatoes are highly perishable, the fruits investigated by RP can generally be stored for some months with proper refrigeration. Thus, the supply of the highly perishable commodities can be treated as perfectly inelastic for all prices in excess of harvest costs, but the quantity supplied of RP's semi-perishable fruits will depend upon current period price, given the opportunity to move product into and out of storage.

RP chose to work with an integrated econometric model that enables them to simultaneously estimate the degree of oligopsony (buyer) market power and oligopoly (seller) market power exercised by retailers. RP's model also allows the data to reveal discrete shifts in the pricing regimes, based upon a theory that retailers' behavior in some periods may be characterized by collusive pricing and, in other periods, by more competitive pricing intended to "punish" deviations from the collusive agreement.

The methods utilized in this study are somewhat simpler, due, in part, to the perishable nature of the commodities investigated here. We look separately at retailers' behavior as buyers from grower-shippers and as sellers to consumers for the aforementioned commodities. To examine possible oligopsony power, we utilize the switching regression model developed by Sexton and Zhang (SZ, 1996) to investigate pricing for perishable commodities. The analysis of retailers' behavior as sellers relies upon the observation that any seller's markup of a commodity's price over its marginal

[1] See Kaufman (2000) and Kaufman *et al.* (2000) for recent summaries of mergers and acquisition activity in U.S. grocery retailing.

cost for acquisition and selling is determined by the elasticity of demand the seller faces for the commodity and a parameter to indicate the extent to which the retailer is exercising the market power indicated by the demand curve. We are able to observe selling price and most aspects of selling and acquisition cost, and can estimate the price elasticities of demand from the data. This information can be used to infer the underlying pricing behavior.

Throughout the analysis, the focus is on the implications of retailers' behavior for price and economic welfare of producers. The impact of retailer behavior on consumer welfare is also an interesting and important question. However, this question must be analyzed in the context of a broad cross section of items in the store, not merely for a few produce items.

Prior Research on Food Retailer Market Power

Rising concentration and consolidation of sales among large supermarket chains in the United States have made retailer market power in the food industry a topical issue. At a conceptual level, there should be broad agreement that two basic factors give grocery retailers some degree of market power, in the sense of being able to influence prices. First, as several authors have noted, the spatial dimension of retail food markets is important, because consumers are distributed geographically and incur nontrivial transaction costs in traveling to and from stores. [2] This condition leads to a spatial distribution of grocery stores, and gives a typical store a modicum of market power over those consumers located in close proximity to the store and, hence, the ability to influence prices at least somewhat. [3] Second, retailers have the ability to differentiate themselves through the services they emphasize, advertising, and other marketing strategies. The question, thus, is not whether retailers have the ability to influence price, but, rather, the extent and implications of that influence.

Oligopoly power in food retailing is not amenable to the application of some methods used by economists to examine market power questions, because modern groceries sell a vast number of different products – an average of 30,000 or more items for U. S. supermarkets. The structure-conduct-performance (SCP) approach is useful, however, because prices can be observed readily and aggregated into indices. [4] These studies seek to explain grocery prices as a function of demand, cost, and market structure variables. Studies such as Hall, Schmitz, and Cothern (1979), Lamm (1981), Newmark (1990), Marion, Heimforth, and Bailey (1993), and Binkley and Connor (1998) have examined average retail food price relationships, using cities as the unit of observation.

Marion *et al.* (1979), Cotterill (1986), Kaufman and Handy (1989), Cotterill and Harper (1995), and Cotterill (1999) focused upon the behavior of individual stores, giving them the opportunity for increased precision and relevance in construction of explanatory variables relative to earlier studies. Cotterill (1986) studied food retailer monopoly power in Vermont, a sparsely populated state, which provided an almost ideal setting to delineate relevant geographic markets for identifying concentration. Concentration variables (four-firm and one-firm concentration rates and the Herfindahl index) were positively associated with price and were statistically significant. [5] A parallel study of Arkansas supermarkets by Cotterill and Harper (1995) and Cotterill (1999) reached similar conclusions as to the impacts of retailer concentration on food prices. [6] MacDonald (2000) argues that observed pricing patterns at retail for food items with a strong seasonal component are consistent with models of oligopoly rivalry among retailers.

However, not all studies of grocery retailing have found a positive association between concentration and price. Kaufman and Handy (1989) studied 616 supermarkets chosen from 28 cities selected at random. Both firm market share and a four-firm Herfindahl index were negatively but insignificantly

[2]For discussions of food retailing from a spatial economics perspective, see Faminow and Benson (1985), Benson and Faminow (1985), Walden (1990), and Azzam (1999).

[3]Market power due to location is inevitable when consumers are distributed geographically and incur nontrivial transportation costs. Even when large numbers of sellers exist in a market, any one seller competes actively with only its nearest rival(s). In the absence of barriers to their doing so, retailers will enter a geographic market until economic profits are driven to zero. Prices will exceed marginal costs on average, however, based upon the fixed costs of entry.

[4]The structure-conduct-performance approach is an empirical methodology based upon a loose conceptual framework which posits that conduct and, in turn, performance in an industry are determined by structural conditions in the industry, such as degree of concentration, entry barriers, and extent of product differentiation.

[5]Four-firm concentration ratio is the share of market sales made by the four largest sellers, one-firm concentration ratio is the share for the market leader, and the Herfindahl index is the sum of the squares of market shares for all sellers in the market.

[6]Studies conducted at the city level finding a positive structure-price relationship include Hall, Schmitz, and Cothern (1979), Lamm (1981), and Marion, Heimforth, and Bailey (1993).

correlated with price. Newmark (1990) also obtained a negative and insignificant coefficient on four-firm concentration in a study of the price of a market basket of goods for 27 cities. Binkley and Connor (1998) suggest one explanation for the conflicting results in terms of the product coverage in the price variable. They found a positive and significant concentration-price correlation for dry groceries, but a negative and insignificant correlation for fresh and chilled food items.

Cotterill's (1993) part 5 contains a debate on the issue of market power in grocery retailing, and Connor (1999) and Wright (2001) provide recent critiques of research into the concentration-price relationship in grocery retailing. To the extent that the positive correlation between pricing and concentration found in the majority of studies is a robust conclusion, it lends credence to the aforementioned concerns that the recent wave of grocery mergers is apt to cause adverse price effects on producers and/or consumers.

Other investigations into food retailer pricing have focused on the transmission of prices from the farm to retail for commodities. This research has emphasized two primary issues: the “stickiness” of retail prices relative to farm prices, and potential asymmetries in the transmission of price from farm to retail. Of particular concern is the allegation that retail prices tend to respond more quickly and fully to farm price increases than to farm price decreases. To the extent that such behavior occurs, it is harmful to producer interests. If the FOB price decreases due to a large harvest, but the decrease is not transmitted to consumers, the additional sales needed to absorb the increased production are not achieved, exacerbating the decrease in the FOB price.

The empirical evidence on asymmetry in price transmission is mixed. Kinnucan and Forker (1987) for dairy products, Pick, Karrenbrock, and Carman (1990) for citrus, and Zhang, Fletcher, and Carley (1995) for peanuts found evidence that retail prices and margins were more responsive to farm price increases than decreases. More recently, Powers and Powers (2001) found no asymmetry in the magnitude or frequency of price increases, relative to price decreases, for CA-AZ lettuce, based on a sample of 40 grocers for 317 weekly observations from 1986-92.

The implications for competitiveness of food retailing from the research on rigidity of retail prices and asymmetry of transmission of farm-level price changes are not clear. Rotemberg and Saloner (1987) have shown that sellers with market power are more likely to maintain stable prices in response to changing costs than are competitive firms. The incentives are reversed for price changes due to demand shifts, but Rotemberg and Saloner showed that the cost effect dominates, when both cost and demand are subject to fluctuations. [7] Re-pricing or menu costs also contribute to explaining retail price rigidities. Changing prices is costly for retailers, so a product’s price will be fixed unless its marginal cost or demand changes by a sufficient amount to justify incurring the cost of re-pricing. Carlton (1989) summarizes research on this topic, and Azzam (1999) presents an application to food retailing.

Moreover, from a marketing strategy perspective, a plausible pricing strategy in grocery retailing is to stabilize prices to consumers by absorbing shocks in farm-level and wholesale prices for certain frequently-purchased, staple commodities. For example, 6 of the 20 retailers in our sample did not change the chain’s price for iceberg lettuce over the entire sample period of 104 weekly observations. As we demonstrate subsequently, this type of pricing behavior by retailers is probably harmful to grower/shippers, but viewed in isolation, it can hardly be construed as evidence of market power, as opposed to simply representing a marketing strategy by the retailer to attract and retain customers.

Asymmetry of price transmission, wherein farm price increases are passed on to consumers more quickly than farm price decreases, is less readily explained. In a standard model of monopoly or oligopoly pricing, the optimal price change in response to a given increase or decrease in marginal costs may not be symmetric, and depends upon the convexity/concavity of consumer demand (Azzam, 1999). This consideration, however, does not explain a delay in responding to a price decrease, relative to a price increase.

To date, very little research has been conducted on the topic of food retailers’ oligopsony power as buyers from food shippers and manufacturers. To an important extent, the issue has surfaced only recently, in response to concerns over slotting and related fees charged by retailers. The issue is quite difficult to address because prices paid by retailers

[7] The fundamental intuition is that as the extent of competition increases, individual sellers perceive an increasingly elastic demand. This makes price changes more beneficial because some of the benefits are derived at the expense of competitors.

to shippers or manufacturers are typically not revealed. Retailers' selling costs are also generally confidential and, moreover, almost impossible to apportion to individual products, given the multitude of products sold in the store. Produce commodities provide one of the better opportunities to examine retailer buying power because farm-level prices are typically reported, as are shipping costs to major consuming centers, and sales are often direct from grower-shippers to retailers. SZ (1996) examined pricing for CA-AZ iceberg lettuce from January 1988 to October 1992 and concluded that retailers were successful in capturing most of the market surplus generated for that period, essentially consigning grower-shippers' economic profits to near zero over the time period analyzed.

Data Sources and Data Issues

The source of all retailer data used in this study is Information Resources International (IRI). IRI provided detailed weekly data on a wide selection of produce commodities and packaged salads for the 2-year period from January 1998 through December 1999, 104 observations in total, for 20 retail chains in 6 U. S. cities. [8] These cities were selected strategically (not randomly) to obtain broad geographic coverage and size diversity. The data are organized by universal product classification (UPC) code or price lookup (PLU) code. For each retailer and each product code, IRI provided weekly sales volume, listed selling price, and the number of stores within the chain selling the product in the given metropolitan area. Note that the reported selling prices are the same for all of a chain's, that stores in a given city. Weekly farm-level data on production and FOB price, weekly terminal (wholesale) price data for major terminal markets, and transportation costs from producing areas to the six consuming regions in the study were provided by the USDA Federal-State Market News Service (F-SMNS). [9]

We encountered some fundamental problems in working with the IRI data. The fresh tomato and lettuce categories feature PLU codes, rather than the more standardized UPC codes. The PLU is typically a four-digit code that is punched into the register as the product is checked at retail. PLU codes were originally not standardized among retailers, but a standardization program has been pursued through the auspices of the Product Electronic Identification Board. However, usage was not fully standardized during the time period investigated here. The problem was particularly acute for tomatoes, where reliable industry sources indicated, for example some retailers classified vine-ripe tomatoes in the code (4064) reserved supposedly for mature-green tomatoes, instead of the normal (3151) vine-ripe code.

A further problem for both the iceberg lettuce and fresh tomato data is that retailers may assign multiple PLU codes for essentially the same product, based on differences in point of origin, size, or variety, but there is no standardization among retailers as to this practice. Through conversations with personnel in the industries and with are the data vendor, and through careful analysis of the data, we were able to resolve many of the issues concerning the PLU codes. Ultimately, however, we cannot have the degree of confidence working with the PLU codes as with standardized UPC codes.

A second concern in working with the IRI data was unexplained, large shifts from period to period in sales volume for several chains. Investigation revealed various possible explanations. In cases where multiple PLU codes were being used for the same basic commodity, sales may vary extensively for particular codes based simply upon how the product is classified. Proper aggregation across PLU codes addresses this issue. A low reported sales volume might be due to "stock outs" in a particular code for some time periods. IRI generates unit sales by dividing sales revenue by per-unit price. Thus, any errors in reporting the per-unit price due, for example, to failure to reflect discounts to consumers who purchase with membership cards, or failure to update computers to reflect sale prices, will cause variations in sales revenue that will be attributed incorrectly to variations in volume.

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[8] As noted, in many cases, a particular retail chain is represented in multiple cities. For example, Chain J in City X may have the same corporate ownership as Chain K in City Y. We are precluded from making this type of connection when discussing results, because to reveal the cities where a particular corporate chain is operating, in many cases would result in revealing the chain's identity.

[9] We were not able to obtain shipping cost information for all of the metropolitan areas. When data were unavailable, we substituted data for a nearby city.

Table 1—Summary of FOB and Retail Prices by Commodity

	FOB Price		Retail Price[1]	
Commodity	Mean	Variance	Mean	Variance
CA iceberg Lettuce (per head)	$0.2820	0.1297	$1.1322	0.1313
CA vine-ripe tomatoes (per lb.)	0.3065	0.0745	1.5818	0.3353
CA mature-green tomatoes (per lb.)	0.2597	0.1196	1.8311	0.3516
FL mature-green tomatoes (per lb.)	0.4261	0.1597	1.6223	0.3775

[1]The values reported in the table are the averages across the chains.

Ultimately, if we were not confident in the reliability of the data for a commodity in a given chain, that commodity-chain was omitted from the analysis. Thus, for each commodity the analysis is based on considerably fewer than the original 20 retail chains for which IRI provided data.

Table 1 provides summary information on FOB and retail prices. Notice that the average variance in the retail prices among the chains in our sample is larger than the variance in the FOB price for each commodity. The *relative* variability, measured in terms of the coefficient of variation, is, however, always greater for the FOB price. 10 Conventional wisdom, as noted, is that retail prices are less variable. Three observations worth making, however. First, retail prices sometimes may vary because the product is being heavily promoted by retailers, and used as a loss leader. The variance is not necessarily the right measure of stability when the time series of retail prices is very stable with a few observations considerably lower. Second, although we have tried to omit instances where the wrong PLU code was used, we may still occasionally be overestimating the variance of retail prices, due to incorrect definition of the product. Third, the tendency of retailers to follow a variety of strategies calls into question the conventional wisdom concerning relative stability of retail prices. The prices at the FOB and retail levels compared in many of the studies already noted are averages across many firms; relative variances in averages are not necessarily informative about the same comparison when individual retailers are used. As already noted, the price series from some of our retailers exhibit no variation at all, and the remaining retailers thus have average variances somewhat higher than the combined averages reported in the table. Thus, it is not clear how closely individual retailer data for perishable commodities should comport with the conventional wisdom.

[10]The coefficient of variation is the sample standard deviation divided by the sample mean.

How Market Power Affects Producers and Consumers

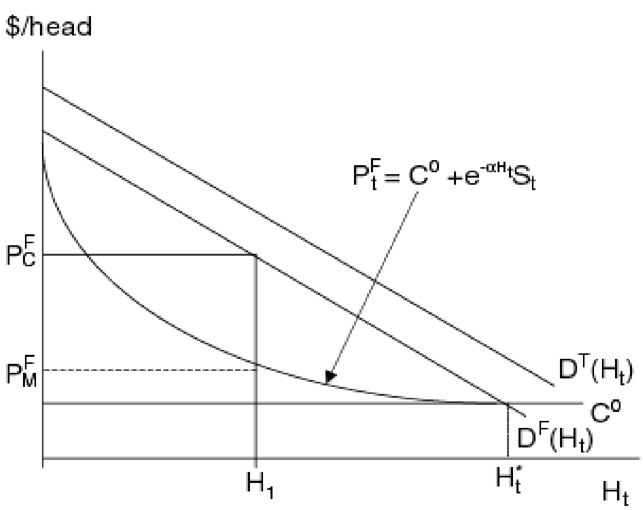
SZ (1995, 1996) developed a model of price determination for perishable produce commodities that allows for imperfect competition. When a commodity is perishable, it must be sold in the current market period. Thus, total supply is fixed (i. e. , perfectly inelastic) for all prices in excess of the per-unit cost of harvesting. This scenario is depicted in Figure 1, for per-unit harvest cost C^0. Aggregate demand for the commodity is depicted as $P^T = D^T(H_t)$; final-product value, P^T, is a decreasing function of the total harvest volume, H_t. The function $P^F = D^F(H_t)$ is final demand less per-unit shipping and handling costs. It seems reasonable to treat these per-unit costs as constant with respect to total volume shipped; hence the shift from D^T to D^F is parallel. Under conditions of perfect competition in procurement, D^F represents the farm-level demand for the commodity. D^F intersects C^0 at the harvest volume H^*. Under any form of competition, the farm price, P^F, must fall to the level of per-unit harvest costs for crops of magnitude H^* or greater. Thus, C^0 represents a floor below which the farm price will not fall. For all harvests when $H_t < H^*$, a per-unit "surplus" exists, $S_t = P^F – C^0$, which is inversely related to the size of the harvest.

Under perfect competition, the surplus is captured entirely by the grower-shippers as owners of the asset in fixed supply, namely the available harvest. Thus, for example, harvest H_1 generates per-unit surplus $P^F_C – C^0$, which is captured entirely by growers through market price P^F_C, where the C subscript denotes the competitive outcome. Under imperfect competition in procurement, the surplus will be divided between grower-shippers and purchasers (e. g. , retailers and food service buyers), based on relative bargaining power. The less aggressive the competition among buyers to procure the product, the greater the share of the surplus they will capture, resulting in a lower farm-level price.

Note from Figure 1 that the magnitude of per-unit surplus is decreasing in the size of the harvest. Thus, under an arrangement where buyers captured a constant percentage of the market surplus, the farm-retail price spread would be a decreasing function of the harvest. SZ (1995, 1996), however, hypothesized that grower-shippers' share of the available surplus would also be a decreasing function of the harvest, because a large harvest of a perishable commodity should diminish sellers' bargaining power relative to buyers'. In that case, the farm-retail price spread could increase with increases in harvest, if grower-shippers' share of the surplus fell sufficiently. SZ quantified their hypothesis by expressing farmers' share, ($_t$, of the market surplus through the function $\gamma_t = e^{-\alpha H_t}$ 0 [0,1], so that farm price is given by the function under imperfect competition, farm price given harvest H_1 is P_M^F, and the market surplus is shared, with growers capturing $P_M^F - C^0$ and buyers capturing $P_C^F - P_M^F$.

Because supply of the commodity in any period is inelastic at prices in excess of the per-unit harvest cost, oligopsony power in the short run affects only the distribution of the surplus between buyers and sellers. Any increase in the degree of oligopsony power will depress returns to growing the commodity, and, in the long run, this result will cause some resources to exit the industry. Thus, oligopsony power will have the long-run effect of reducing supply, which will cause higher retail prices and a reduction in consumer welfare.

Figure 1
The short-run produce pricing model



Consider now the specific behavior of food retailers in procuring and selling produce commodities. Denote retail prices and quantities with the superscript 'R'. Then aggregate inverse retail demand is $P^R = D^R(Q^R)$, where Q^R is the volume of the product sold at retail. Denote demand for all other uses of the commodity as $Q^S = D^S(P^S)$. 11 We assume that these users (e. g., processors and institutions) procure and sell the commodity competitively. 12 Then we can define a residual supply function, $Q^R(P)$, for the commodity to food retailers as the total harvest less the secondary-market demand:

$$
\begin{aligned}
&Q^R(P_t) = H_t - D^S(P_t) \quad \text{if } P_t \geq C_0 \\
&Q^R(P_t) = 0 \quad \text{otherwise.}
\end{aligned} \tag{1}
$$

Effective oligopoly power is exercised when a retailer marks up the commodity in excess of its full marginal costs of acquisition and sale, i. e., farm price, shipping cost, and selling cost. By raising price above marginal cost, a retailer reduces sales of the commodity in its stores. Because the total supply is fixed in any given market period, the result of oligopoly power in selling the commodity at retail is to force the diversion of a greater share of the volume into secondary and lower-value market outlets, such as the food service, institution, and processing sectors.

Similarly, oligopsony power is exercised when retailers, as buyers, recognize their ability to influence the acquisition price for the commodity. Under oligopsony power retailers pay less to acquire the product than its marginal value at retail less marginal shipping and selling costs and, thereby, capture a share of the aforementioned market surplus.

[11]Based upon conversations with industry sources, we estimate that 60-65 percent of lettuce sales are to retail and 35-40 percent to the food service sector. For fresh tomatoes, the approximate percentages are 45-50 percent to retail and 50-55 percent to food service.

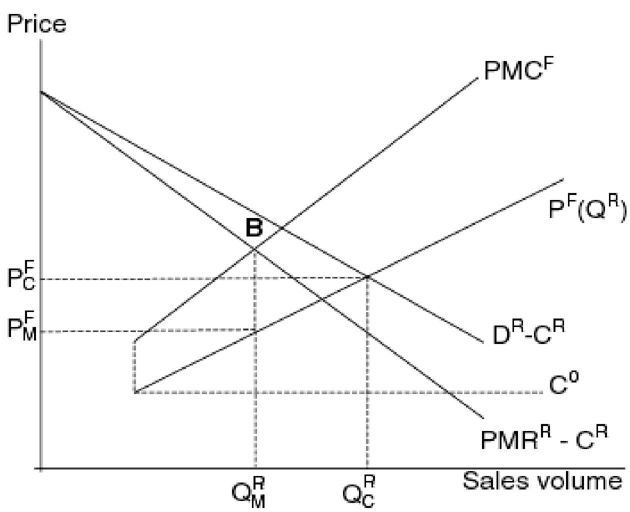
[12]This assumption is not central to the analysis but seems quite reasonable. None of these buyers are large relative to the market, and sales to secondary purchasers are often made through various terminal markets, long regarded as quintessential competitive markets.

Figure 2 illustrates an oligopoly-oligopsony equilibrium. Technical details on the model illustrated in Figure 2 are provided in Alston, Sexton, and Zhang (1997) and Sexton and Zhang (2001). The retail industry marginal revenue curve is $MR^R = \partial [P^R Q^R]/ \partial Q^R$, and the curve labeled $PMR^R = \xi MR^R + (1-\xi)P^R$ represents the "perceived marginal revenue" curve for the food retailing industry (Melnick and Shalit, 1985), with the parameter $\xi \in [0,1]$ indicating the extent of oligopoly power exercised by the industry. For example, if the retailing industry sells the commodity competitively, then $PMR^R = P^R$ and $\xi = 0$, or if the retailing industry acts as a pure monopolist or cartel, then $PMR^R = MR^R$, i. e., $\xi = 1$. Within the interval (0,1), higher values of ξ represent greater levels of retailer oligopoly power. $PMR^R = >MR^R + (1-\xi)P^R$ thus represents the gross value of an incremental unit of the farm commodity to the industry. To obtain the net value, we subtract per-unit shipping and handling costs, C^R, as illustrated in Figure 2 by the curve $PMR^R - C^R$.

If retailers procured the commodity competitively, then grower-shippers would be paid a price based on the net PMR^R schedule: $P^F(Q^R) = PMR^R(Q^R) - C^R$, depending upon the volume of product marketed at retail. If retailers exercise oligopsony power in procurement, the actual farm price will be less than indicated by the $PMR^R - C^R$ function. The function $P^F(Q^R)$ in figure 2 denotes the inverse form of the residual supply function derived in (1).

Figure 2

Produce market equilibrium under retailer oligopsony power



Applying Melnick and Shalit's logic to the market for acquisition of the farm commodity, we define the industry's marginal cost of procuring the commodity as $MC^F = \partial [P^F Q^R]/ \partial Q^R$ and the perceived marginal acquisition cost function as $PMC^F = \theta MC^F + (1-\theta)P^F$. Similar to the interpretation afforded the oligopoly power parameter, ξ, the parameter θ denotes the degree of oligopsony power and ranges in the unit interval, with $\theta = 0$ denoting perfect competition in procurement, i. e. , $PMC^F = P^F$, and $\theta = 1$ denoting pure monopoly or a perfect buyer cartel, i. e. , $PMC^F = MC^F$. Within the interval (0,1), larger values of θ denote greater levels of oligopsony power.

If the retailing industry both procured and sold the produce commodity competitively, the market equilibrium would occur at point A in figure 2, with volume of sales Q^R_C and producer price P^F_C. The difference between the harvest volume, H, and the volume, Q^R_C, sold at retail is diverted to processing and foodservice uses. When retailers exercise both oligopoly and oligopsony power in procurement and sale of the commodity to the degree illustrated by the PMR and PMC curves in figure 2, the market equilibrium occurs at point B and involves sales of Q^R_M and producer price P^F_M. As noted, market power exercised by retailers will cause relatively more of the total production, $Q^R_C - Q^R_M$, to move through processing and food service outlets.

It is important to emphasize that *either* oligopoly or oligopsony power reduces the welfare of producers.[13] Producer welfare is an increasing function of the volume of product moved through retail channels, and either type of market power reduces this movement and diverts more product into alternative outlets.

[13]It also reduces the welfare of consumers, considering the particular commodity in isolation. From consumers' perspective, reduced movement of product at retail results in higher volumes moved through alternative market channels. Nonetheless, consumer welfare is diminished, because oligopoly and/or oligopsony in one of the market channels results in a failure to equate consumers' marginal valuation of the product across the alternative market channels, a necessary condition for consumer welfare maximization. However, as noted, examining only a single or a few commodities is an inappropriate basis to evaluate the effects of retailer behavior on consumers.

Analyses of Farm-Retail Price Spreads

In this section, we report on some statistical analyses of the behavior of the farm-retail price spread (or margin) for the commodities under investigation. Under any theory of pricing from farm to retail, variations in the margin over time will be due, at least partly, to changes in the marginal costs of transporting the product from shipping points to the retail location and selling it. Indeed, under conditions of perfect competition, variations in the margin should be explained fully by variations in the seller's marginal cost. However, under a more general model of pricing from farm to retail, additional factors may help to explain the margin.

Of particular interest is the effect of shipments and sales volumes on the margin, given the hypothesis that, under oligopsony power, large shipments reduce producers' relative bargaining power and, hence, share of the market surplus. Conversely, under perfect competition in the procurement of a produce commodity, the volume of shipments would have an effect on the margin only to the extent that marginal costs of marketing and selling the commodity were related to the volume shipped and sold. The margin would be an increasing (decreasing) function of shipments if industry marginal costs were an increasing (decreasing) function of shipments. Although we lack hard evidence on this point, it is not likely that industry marginal costs would rise with the volume sold. Most produce commodities are shipped by refrigerated truck, and no single industry is a major user of refrigerated shipping, to the point where its actions would affect shipping rates. A similar conclusion applies to retailing costs. A retailer's handling costs likely rise with the volume handled, but the increase would, at most, be proportional to the increase in volume handled. Thus, based upon consideration of marketing costs, we would expect, under conditions of competition, that the total volume of shipments would have no effect on the margin, or, possibly, an inverse effect, if greater movement brought about handling economies for retailers.

Under the SZ hypothesis discussed previously, producers' relative bargaining power is an inverse function of the magnitude of the harvest. This hypothesis presents the possibility that the margin will be an increasing function of the harvest. This outcome will result only if the impact of the larger harvest on sellers' relative bargaining power dominates its negative effect on the magnitude of per-unit surplus that is available. Thus, a finding that the farm-retail price spread is increasing as a function of the harvest volume represents rather strong evidence that buyers are exercising market power in procurement of that commodity.[14]

We estimated the following models of the farm-retail price spread for the chains in the sample:

$$(2)\ M^{1}_{i,t} \quad (P^{R}_{i,t} \quad P^{F}_{t}) \quad {}_{i\,0} \quad {}_{i\,1}H_{t} \quad {}_{i\,2}S_{i,t} \quad {}_{i\,3}T_{i,t} \quad {}_{i,t,}$$

$$(2'),\ M^{2}_{i,t} \quad (P^{R}_{i,t} \quad P^{F}_{t})/(P^{R}_{i,t} \quad C^{0}) \quad b_{i\,0} \quad b_{i\,1}H_{t} \quad b_{i\,2}S_{i,t} \quad b_{i\,3}T_{i,t} \quad e_{i,t,}$$

where $M^{j}_{i,t}$, j=1,2, is measured in $/unit (heads of lettuce and lbs. of tomatoes), H_t is the volume in ten million lbs. of the farm commodity shipped during week t, $S_{i,t}$ is the cost per truckload ($000) of shipping the product from the producing location to chain i's city in week t, $T_{i,t}$ is a time trend, and $\varepsilon_{i,t}$ and $e_{i,t}$ are error terms to capture unexplained variation in $M^{1}_{i,t}$ and $M^{2}_{i,t}$, respectively.[15] The time trend is included to capture secular changes in the margin, due to changes over the sample period in retailer selling costs or the extent of market power.[16]
Equation (2) is the traditional price-spread formulation, which expresses the absolute mark- up of the farm price as a function of total harvest volume, shipping costs, and trend. We experimented with alternative specifications for the farm production variable, including decomposing H_t by points of origin (e. g. , California vs. non-California production) to determine whether the

[14] RP set forth a related hypothesis in their work on this project. They argue that retailers' bargaining power is inversely related to the amount of the commodity that the retailers need to procure in a given time period. For example, if a large percentage of retailers is promoting a particular commodity and, thus, anticipating higher sales, the retailers' relative bargaining power is diminished and, thus, the margin may be a declining function of the total volume of sales of the product. As RP note, this hypothesis makes more sense in the context of the semi-perishable commodities they examine, where higher prices can stimulate movement of product from storage, than for the highly perishable products analyzed here.

[15] The USDA F-SMNS reports daily FOB prices for lettuce and fresh tomatoes. Prices are typically reported in a high-low range. The FOB price, P^{F}_{t}, utilized for purposes of this study is the weekly average of the midpoint of the daily price range.

[16] We conducted tests for unit roots in the three price series, FOB, wholesale, and retail, and for the price-spread series utilized in the study. Unit roots were rejected in all cases, implying that the series are stationary and justifying analysis in the levels of the data.

source of production, as opposed simply to the overall level of production, had an effect on the margin.[17]

Equation (2') expresses the markup as the retailers' share of the total market surplus. Equation (2') directly embodies the Zhang-Sexton hypothesis regarding the effect of harvests on growers' relative bargaining power. For parsimony of presentation, only the results from estimating equation (2) are presented in detail. Detailed results from estimation of (2') do not differ appreciably and are available from the authors.

Equations (2) and (2') were estimated for each of the basic commodities in the study (iceberg lettuce, mature-green tomatoes, and vine-ripe tomatoes) using seemingly unrelated regressions (SUR).[18] Note that equations (2) and (2') are not subject to simultaneity bias, because H_t is determined by planting decisions made months previously. Notably we lack data on retailers' selling costs. This omission introduces a specification error only if retailers' costs were nonconstant over the two-year period analyzed in this study. Given the low rate of overall inflation during this time and the short time period, retailers' selling costs likely were very stable. The omission of retailing costs causes the estimated coefficients to be biased only if retailing costs are correlated with the explanatory variables included in the model, a prospect that we consider unlikely, especially given that shipments in (2) and (2') are measured in aggregate, not at the chain level.

CA-AZ Iceberg Lettuce

Figure 3 illustrates the farm-retail price spread for iceberg lettuce for a sample of the retail chains included in the study. The margin is expressed as dollars per head and plotted by week, for the 104 weeks in the sample. Panels (a) and (b) exhibit margins for a chain in Miami and Dallas, respectively. These figures illustrate the volatility in the margin that is typical. By way of contrast, panel (c) illustrates the margin for a Los Angeles chain. The price spread in this case is stable for most periods, but does experience occasional, wide fluctuations. Finally, panel (d) illustrates the price spread for a chain that maintained a constant retail price throughout the study period. Because the FOB price varied widely through this time period, a constant selling price at retail results in a price spread that exhibits periodic wide fluctuations.

The results of estimating margin equation (2) for CA-AZ iceberg lettuce are contained in table 2. Six of the 20 chains in the sample maintained a constant retail price throughout the sample period. These chains were excluded from the lettuce margin analysis.[19] Two other chains were excluded because we had serious questions about the reliability of the data.[20]

The coefficient on the total volume of iceberg lettuce shipments is positive for 11 of the 12 cases and statistically significant at the 90% level in seven of those cases.[21] The only negative coefficient is not statistically significant. These results support the notion that the farm-retail price spread increases with the volume of shipments, and are thus consistent with the Sexton-Zhang hypothesis that large shipments of a perishable commodity diminish sellers' relative bargaining power.[22]

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[17] For example, a plausible hypothesis to test when examining the price spread for a California commodity is whether the spread is increasing in the magnitude of production emanating from outside of California. This outcome could occur if retailers used the prospect of obtaining the product elsewhere to force price concessions from the California shippers. However, in most cases we could not reject the hypothesis that the effect of shipments volume on the margin was the same regardless of the source of the shipment.

[18] Using SUR, the store-level margin equations for each commodity are estimated as a system of equations. SUR gains efficiency, relative to single-equation estimation, by taking into account correlation in the error terms across equations.

[19] Given that P^R is a constant, estimating the margin for these stores is equivalent simply to estimating an equation to determine the level of the farm price. The implications for producer welfare from retailers maintaining constant or stabilized retail prices are investigated later in the paper.

[20] Some of the equations included in the system for iceberg lettuce exhibit autocorrelation, when single-equation results are examined. The same is true for results we report subsequently for vine-ripe and mature green tomatoes. We obtained a separate set of results for every equation in the system, correcting for autocorrelation on a single-equation basis. The results are comparable to what we report; particularly, the relationships between the margins and the harvested volume are unaffected. The other results are somewhat weaker, and the signs are not consistent across all equations, as is the case with the results we do report. A test for contemporaneous correlation of the residuals does support the SUR system estimator. That evidence, combined with the fact that no qualitative conclusions depend on the choice of estimator, led us to prefer reporting the systems results. Given occasional missing observations for which we would have to correct, there seemed to be no payoff from attempting to incorporate autocorrelation corrections into our SUR results. The single-equation results corrected for autocorrelation are available upon request from the authors.

[21] Similarly, the shipment variable in (2'), the margin-share equation was positive and significant for each of the 12 stores, meaning that the retailer's share of the market surplus was an increasing function of the shipments volume in each instance.

[22] A plausible alternative specification of the margin is as the difference between a retail price at time t and the farm price in the previous week, period t-1, i.e., $M_{i,t} = P^R_{i,t} - P^F_{t-1}$. This specification allows a one-week lag in transmission of farm prices to retail. Re-estimating equation (1) for iceberg lettuce with this definition of $M_{i,t}$ weakens, but does not eliminate, the impact of shipments volume on the margin. Eight of 12 coefficients were positive under this specification, with five of them being statistically significant. Only one of the four negative coefficients was statistically significant.

Figure 3
CA-AZ Iceberg Lettuce: Farm-Retail Price Spreads for Selected Retail Chains

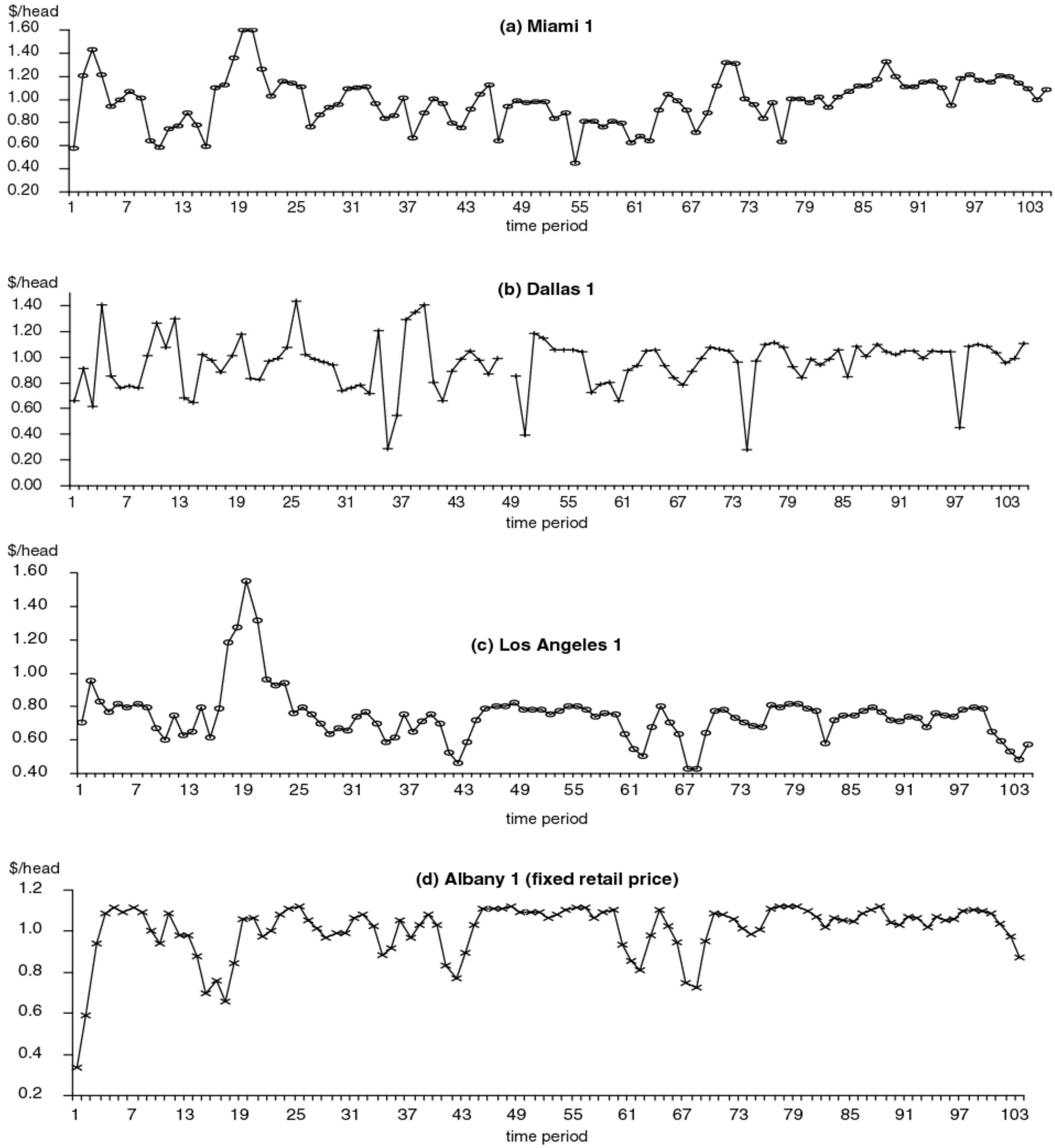


Table 2—Farm-Retail Price-Spread Equations for CA-AZ Iceberg Lettuce

City/Chain	Constant[1]	Total volume[1]	Shipping cost[1]	Trend[1]
Atlanta 1	0.082	0.0765	0.0394	0.0021
	(0.460)	(3.453)*	(1.109)	(3.329)*
Chicago 1	0.352	0.0503	0.0546	0.0013
	(2.611)*	(3.042)*	(1.860)*	(2.817)*
Albany 1	0.822	0.0240	-0.0357	-0.0011
	(4.869)*	(1.191)	(1.468)	(1.976)*
Dallas 1	0.807	-0.0013	0.0652	0.0005
	(3.986)*	(0.052)	(1.121)	(0.758)
Dallas 2	0.446	0.0172	0.0541	-0.0009
	(3.959)*	(1.240)	(1.757)*	(2.199)*
Dallas 3	0.3831	0.0299	0.1989	-0.0031
	(2.025)*	(1.282)	(3.826)*	(4.671)*
Miami 1	0.1003	0.0854	0.0528	0.0012
	(0.545)	(3.791)*	(1.642)	(1.899)*
Miami 2	0.5588	0.0082	0.0477	-0.0005
	(5.190)*	(0.615)	(2.253)*	(1.371)
Los Angeles 1	0.6817	0.0355	-0.106	-0.0019
	(3.993)*	(1.725)*	(0.457)	(2.229)*
Los Angeles 2	0.2135	0.0619	-0.130	0.0007
	(1.539)	(3.702)*	(0.674)	(0.969)
Los Angeles 3	0.2680	0.0815	-0.265	-0.0005
	(1.953)*	(4.926)*	(1.375)	(0.668)
Los Angeles 4	0.1125	0.0470	0.634	-0.0019
	(0.690)	(2.386)*	(2.625)*	(2.254)*

Absolute t-statistics are in parentheses.
*Denotes statistical significance at the 90% level.

Increases in shipping costs are associated with an increase in the margin in eight of the 12 cities, although the effect is significant in only five of the cases. None of the four instances where the margin was negatively related to shipping costs was significant. Higher shipping costs should lead to higher margins under either competition or buyer market power. However, whereas increases in shipping costs are reflected fully in the margin under perfect competition, buyers with oligopsony power rationally absorb a portion of this type of cost. Thus, the general failure of shipping costs to have a significant effect on the margin may reflect retailers' absorption of a large portion of those costs. In addition, shipping costs comprise a rather small part of total acquisition and selling costs for lettuce. Retailers who prefer, as part of an overall marketing strategy, to offer relatively stable prices to their customers may elect simply to not pass on most changes in shipping costs.

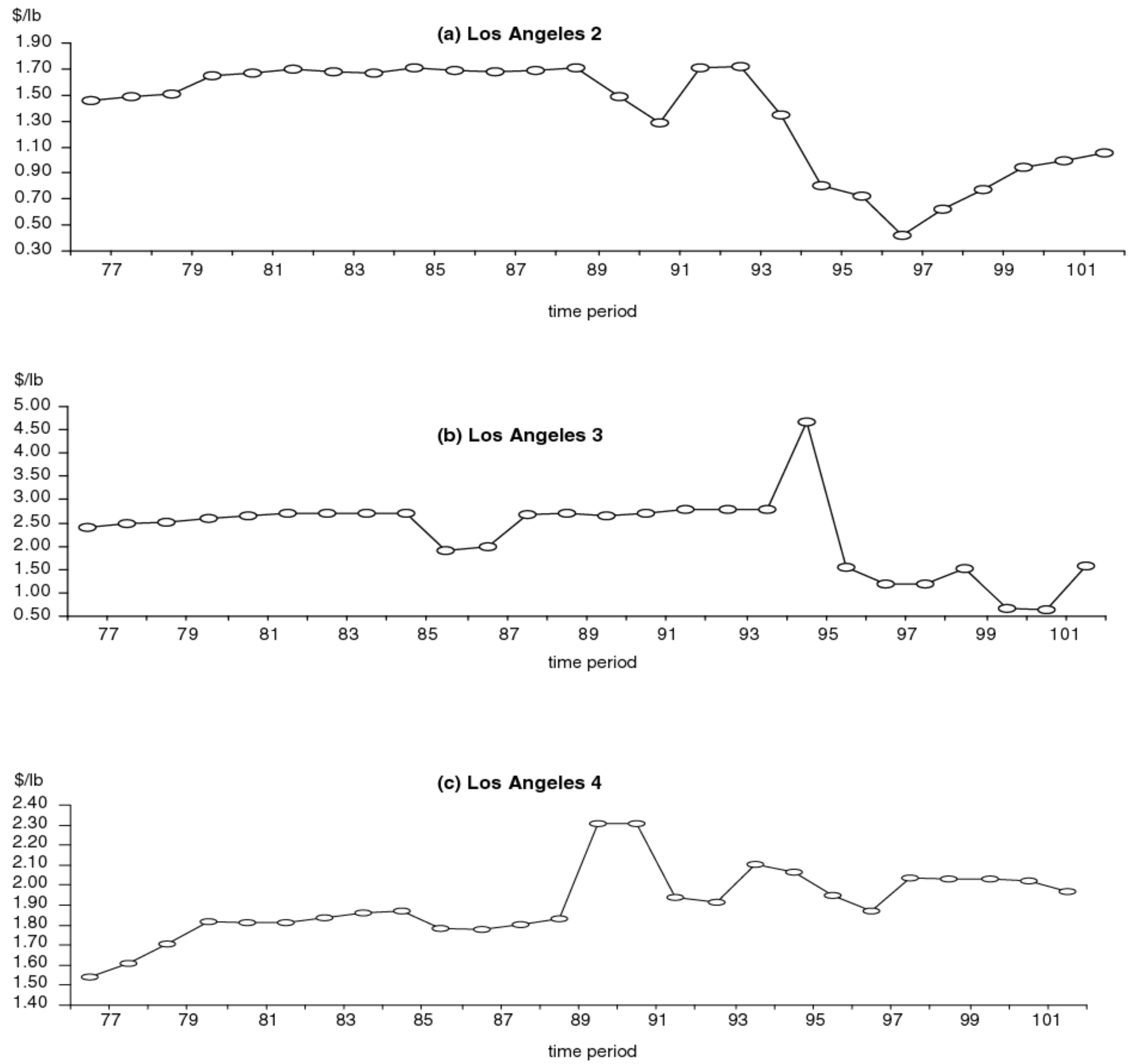
Finally, the regressions do not indicate any consistent underlying trend across chains in the margin over the short, 2-year period of the data set. Seven of the 12 trend coefficients are negative, and 5 of them are statistically significant. Three of the five positive trend coefficients are statistically significant.

Vine-Ripe Tomatoes

Equations (2) and (2') were estimated for vine-ripe tomatoes for 9 of the 20 chains contained in the sample. In all cases, the FOB price is for California, the primary source of domestically supplied vine ripes. Chains were excluded when we were unable to discern definitively the PLU codes pertaining to sales of vine-ripe tomatoes. USDA F-SMNS began reporting FOB prices for California vine-ripe tomatoes in 1999. This factor plus seasonality in shipments resulted in only 26 weekly observations being available to estimate the vine-ripe tomato margin equation. F-SMNS does not separate tomato shipments by vine-ripe and mature-green categories. Thus, the shipments variable, H_t, is total domestic shipments of fresh tomatoes, as reported by F-SMNS.

Figure 4 illustrates the price spread for vine-ripe tomatoes for three Los Angeles retail chains, and figure 5 provides the same information for selected chains from other cities. Figure 4 illustrates how pricing strategies for produce commodities can vary among chains even within the same city. Chains 2 and 3 in Los Angeles maintained stable but high margins through the summer and most of the fall in 1999, but then each experienced a sharp

Figure 4
Vine-Ripe Tomatoes: Farm -Retail Price Spreads for Los Angeles Chains

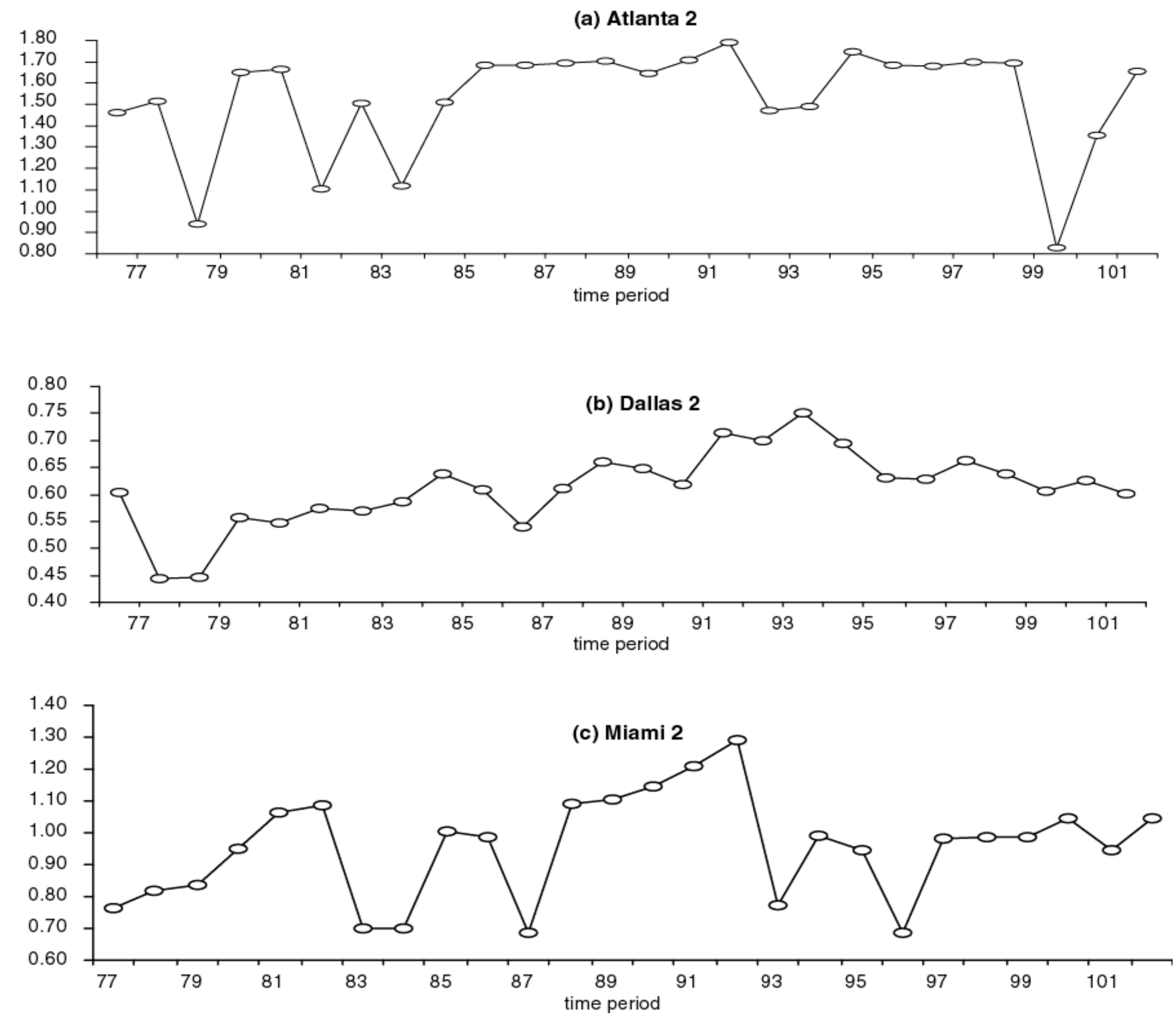


drop in the margin. Chain 4 conversely exhibited a slowly rising margin throughout the time period and did not join the sharp decline in margins initiated by its competitor chains. In figure 5, note that Dallas chain 2 has a rather stable margin and one that is much smaller than exhibited by any of the three LA chains illustrated in figure 4. Conversely, the margin is larger absolutely and more volatile for chain 2 in Atlanta and chain 2 in Miami. Even in these cases, however, the margins are smaller than for the LA chains, despite the likelihood that costs are lower for the LA chains, given their proximity to California production.

Table 3 summarizes the estimation results. The volume of shipments has a positive effect on the margin in seven of the nine cases, although the effect is statistically significant in only four of those cases.[23] Neither of the two negative coefficients is significant at the 90 percent level. Similar to the case for iceberg lettuce, shipping costs have no consistent effect on the margin – the effect is positive in four instances and negative in the other five. Except for two cases, the effect is not statistically significant. Similarly, there is no

[23] Shipments volume had a positive and statistically significant effect on the retailers' share of the market surplus (equation (2')) in each case.

Figure 5
Vine-Ripe Tomatoes: Farm-Retail Price Spreads for Selected Retail Chains



overall pattern to the trend over the short time series at hand. The trend coefficient is positive in five cases and negative in the other four. The effect is statistically significant in five of the nine total instances.

Mature-Green Tomatoes

Mature-green tomatoes are produced domestically in both California and Florida. Florida tomatoes compete seasonally with imports from Mexico. Florida tomatoes are shipped predominantly to eastern and midwestern markets, with the western half of the country served predominantly by tomatoes from California and Mexico. The California marketing season runs from May to December and complements the Florida season, which runs from October through June. See the ERS report by Calvin *et al.* (2001) for additional description of the industry.

We estimated the price-spread equation separately for shipments emanating from California and Florida. Satisfactory data were available to estimate the model for 11 chains for California tomatoes and 3 chains (all in the southeast) for Florida tomatoes. Fifty-two weekly observations were available for California, and 69 observations were available for Florida. Figures 6 and 7 illustrate the farm-retail price spread for mature-green tomatoes for selected chains. Figure 6 presents a comparison of the behavior of the price spread for California mature greens for three Dallas chains, while figure 7 presents the price spreads for Florida mature greens. Figure 6 further illustrates the differences in produce-pricing practices even

Table 3—Farm-Retail Price-Spread Equations for California Vine-Ripe Tomatoes[1]

City/Chain	Constant	Total volume	Shipping Cost	Trend
Atlanta 2	-0.828	0.0583	0.0978	0.0157
	(0.494)	(1.844)*	(0.450)	(1.333)
Chicago 1	1.759	0.0066	-0.0797	-0.0035
	(3.429)*	(0.694)	(0.983)	(1.047)
Albany 1	-1.746	-0.0257	0.3296	0.0188
	(1.168)	(1.166)	(1.795)*	(2.049)*
Dallas 2	-0.220	0.0238	-0.0322	0.0071
	(1.036)	(4.104)*	(0.783)	(4.657)*
Dallas 4	2.498	-0.0381	-0.0377	-0.0054
	(2.958)*	(1.684)	(0.225)	(0.904)
Miami 2	-2.308	0.0214	0.3299	0.0225
	(2.308)*	(1.067)	(2.603)*	(3.173)*
Los Angeles 2	4.884	0.0275	-0.894	-0.0363
	(3.341)*	(0.687)	(0.820)	(4.141)*
Los Angeles 3	1.316	0.2813	0.1034	-0.0252
	(0.441)	(3.378)*	(0.047)	(1.377)
Los Angeles 4	0.071	0.0384	-0.416	0.0188
	(0.124)	(2.390)*	(1.024)	(5.313)*

[1]Absolute t-statistics are in parentheses.
*Denotes statistical significance at the 90% level.

within a city. Chain 2 exhibits a rather stable price spread of about $0. 70/lb, except for two brief spikes in the spread. Chain 3's margin is higher on average (about $1. 10/lb) and much more volatile. Chain 4's margin is also quite stable, but it averages $1. 58/lb, more than double the margin for chain 2. Conversely, the pricing behavior for the chains selling Florida mature greens is quite comparable. The mean spread ranges from $1. 03/lb (Miami 1) to $1. 40/lb (Atlanta 1), and the degree of volatility in the spread is quite similar across all three chains.

Table 4 reports the results from estimation of the margin equation. Mature greens provide an interesting comparison, because Florida grower-shippers are organized, whereas their California counterparts are not. In particular, Florida tomatoes are marketed through the auspices of a Federal marketing order, and most grower-shippers belong to a marketing cooperative, which handles over 90 percent of fresh tomatoes sold in Florida and whose activities are coordinated with the marketing order. An example of the industry's coordination in marketing was its attempt to enforce a price floor during the 1998 and 1999 marketing seasons, in conjunction with voluntary export restrictions implemented by Mexico, as part of an agreement to suspend the U. S. Commerce Department's investigation into dumping allegations lodged by Florida against Mexican tomato exporters.

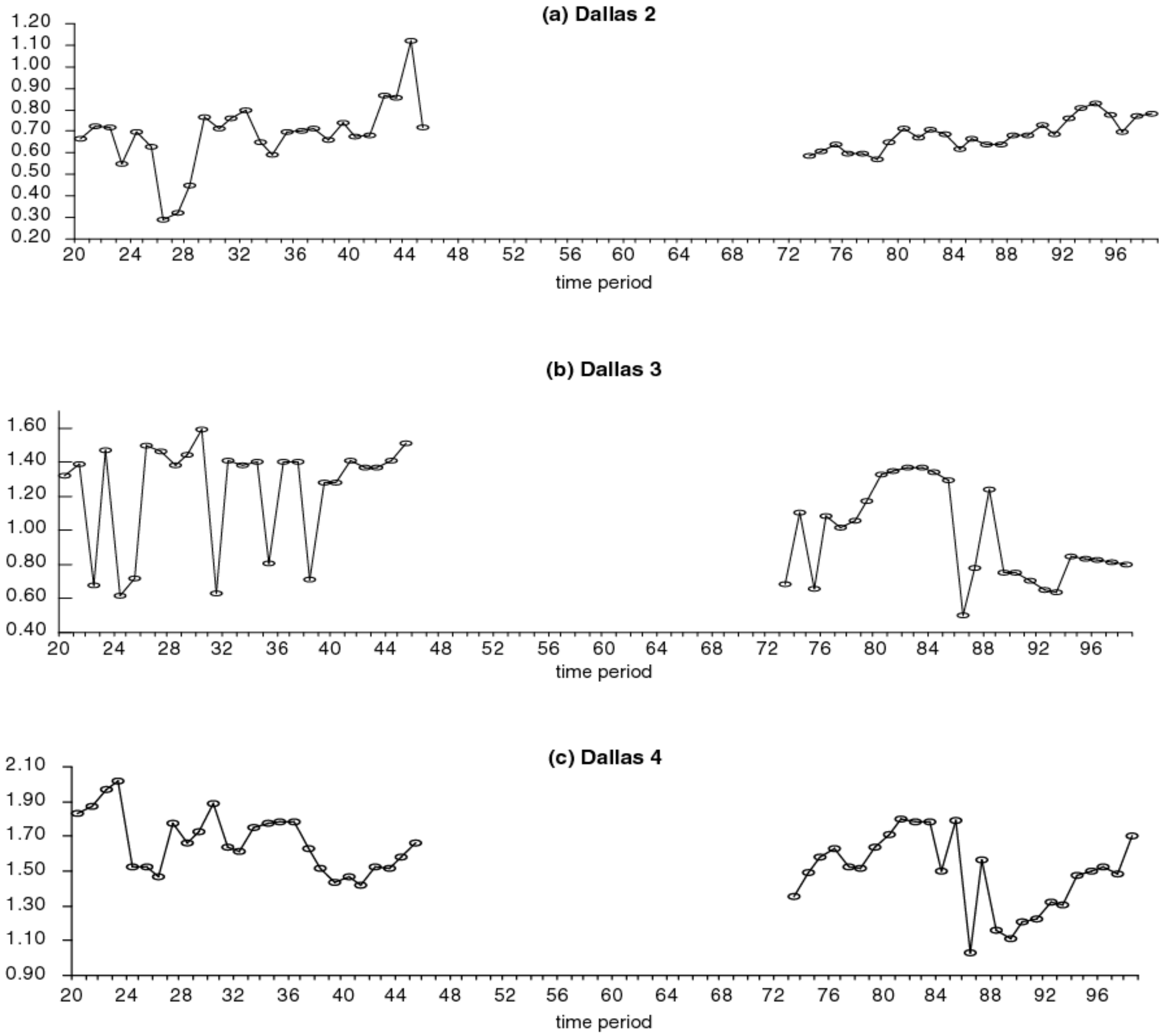
The volume of shipments increases the price spread for California mature greens in all 11 cities. The effect is statistically significant in seven of those cases. Conversely, the volum of shipments has no consistent impact on the price spread for Florida mature greens.[24] The coefficient is negative in two of the three cases, and the one positive coefficient is small and not statistically significant. Although it is hard to state a definitive conclusion based on these limited results, the evidence does suggest that perhaps the Florida grower-shippers' organization and coordination in marketing affords them a degree of protection against retailers' efforts to bid farm prices down during periods of relatively high supply.[25]

As in the previous cases, shipping costs have little consistent effect on the margin. The direction of the effect is (paradoxically) negative in 11 of the 14 total cases, but is significant in only four of those cases. Again, failure of shipping costs to play an important role in determining the margin may reflect rational absorption of a portion of any changes in shipping costs by retailers with market power and/or retailers' wish to stabilize consumer prices for staple produce commodities.

[24]The retailers' share of the market surplus from equation (2') was an increasing and statistically significant function of the shipment volume in each instance for California mature greens. The shipments coefficient was positive in all cases for Florida mature greens as well, but the effect was statistically significant in only one instance.

[25]Specifying the margin with a one period lag (see footnotes 22 and 24) had little effect on the Florida results. The effect of shipments on the California margin continued to be positive in 10 of the 11 cases, but the effect was significant statistically in only three of those cases.

Figure 6
California Mature-Green Tomatoes Farm-Retail Price Spreads for Dallas Chains



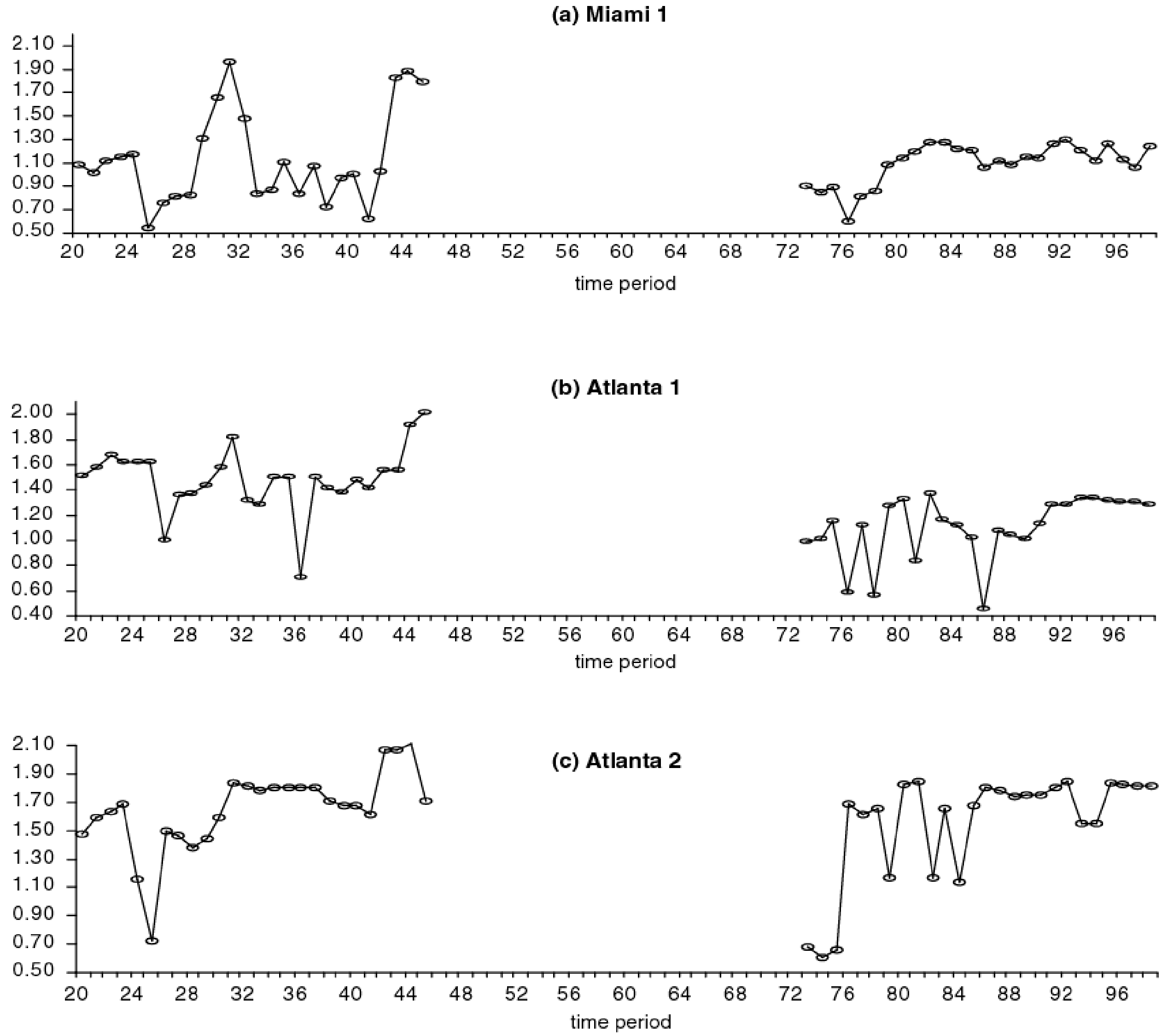
The trend coefficient, interestingly, was negative in all 11 cases for California mature greens and was significant in six of those cases. The trend in the margin was negative and significant in one of the three cases for Florida mature greens. The coefficient was positive but not significant in the other two cases. A possible explanation for the trend in California is the increasing consolidation among California tomato grower-shippers. Calvin *et al.* estimated that the top four shippers controlled 43 percent of the market in 1999 and the top eight controlled 70 percent. As the larger shippers increase their market share, their relative bargaining power may also increase.

Summary of Margin Analysis

Tables 5, 6, and 7 summarize the main results of the analysis of farm-retail price spreads. Table 5 contains the means and variances for the price spreads analyzed in this section. Table 6 is a correlation matrix of the price spreads for selected cities, while table 7 reports the elasticity of the price spread with respect to the total volume of shipments.

Tables 5 and 6 combine to demonstrate the considerable independence that retailers have in setting prices for produce commodities. Because the farm price for a given commodity is assumed to be identical across retailers, differences in the price spread among retailers are due to differences in setting prices at retail. Table 5 shows that, even

Figure 7
Florida Mature-Green Tomatoes: Farm-Retail Price Spreads



within a city, there is considerable variation in the markup for a commodity. For example, the Dallas 1 retail price for a head of CA-AZ iceberg lettuce reflected on average about a \$0. 95 markup, whereas Dallas 2 had an average \$0. 64 markup. The markups for California mature-green tomatoes among the Dallas chains ranged from \$0. 68 in Dallas 2 to \$1. 58 in Dallas 4. The differences in markups are somewhat less among the Los Angeles chains. Iceberg lettuce average markups ranged only from \$0. 67 to \$0. 80, while mature green markups ranged from \$1. 01 to \$1. 50 per lb. There is, however, a wide difference, \$1. 35 vs. \$2. 29, in how the Los Angeles 2 and Los Angeles 3 chains marked up a pound of vine-ripe tomatoes.

Table 4—Farm-Retail Price-Spread Equations for California and Florida Mature-Green Tomatoes

City	Constant[1]	Total volume[1]	Shipping Cost[1]	Trend[1]
		--California Tomatoes--		
Atlanta 1	1.821	0.0367	-0.171	-0.0068
	(5.959)*	(1.650)	(2.273)*	(4.621)*
Atlanta 2	1.474	0.0701	-0.181	-0.0015
	(3.737)*	(2.603)*	(1.773)*	(0.827)
Dallas 1	1.076	0.0430	-0.0354	-0.0029
	(7.180)*	(4.143)*	(0.675)	(4.269)*
Dallas 2	0.644	0.0395	-0.1593	-0.0005
	(4.670)*	(4.589)*	(3.058)*	(0.958)
Dallas 3	1.544	0.0299	-0.0030	-0.0047
	(6.053)*	(1.910)*	(0.030)	(4.578)*
Dallas 4	1.471	0.0223	-0.1190	-0.0058
	(3.404)*	(0.875)	(0.710)	(3.466)*
Miami 2	0.588	0.0617	-0.0169	-0.0014
	(1.859)*	(2.446)*	(0.244)	(0.832)
Los Angeles 1	1.098	0.0422	0.5611	-0.0068
	(3.004)*	(2.083)*	(0.975)	(3.431)*
Los Angeles 2	0.818	0.0217	0.0690	-0.0013
	(3.199)*	(1.389)	(0.179)	(0.923)
Los Angeles 3	0.156	0.0300	2.089	-0.0057
	(0.388)	(1.313)	(3.347)*	(2.581)*
Los Angeles 4	1.602	0.0281	-0.524	-0.0015
	(5.139)*	(1.686)*	(1.050)	(0.909)
		--Florida Tomatoes--		
Atlanta 1	1.976	0.0183	-0.870	-0.0034
	(4.756)*	(0.803)	(2.222)*	(2.488)*
Atlanta 2	2.138	-0.102	-0.766	0.0005
	(4.138)*	(0.361)	(1.573)	(0.311)
Miami 1	2.010	-0.0551	-0.622	0.0011
	(4.733)*	(2.366)*	(1.554)	(0.823)

[1]Absolute t-statistics are in parentheses.
*Denotes statistical significance at the 90 percent level.

The variances of the price spread in parentheses in table 5 also present an interesting story. A chain that applied a constant markup to a commodity and merely passed along changes in its acquisition costs would exhibit a low variance in the margin. Chains that varied prices strategically, e. g. , for sales, would exhibit a higher variance. Variances in the price spreads for iceberg lettuce were quite similar, ranging from 0. 015 for Dallas 2 to 0. 051 for Dallas 3. The price spreads for fresh tomatoes were more variable on balance, and differences in price-spread variances were more pronounced among the chains. For example, Chicago 1 had a variance of only 0. 006 in its price spread for California vine-ripe tomatoes, whereas variance in the vine ripe price spread for Los Angeles 3 was 0. 704.

The correlation coefficients in table 6 measure the extent to which the price spreads move together over time. Such coefficients range from –1. 0 (perfect negative correlation) to 1. 0 (perfect positive correlation). Correlation coefficients for chains within a particular city are highlighted in boldface type. In a prototypical competitive market, we would expect to see a high positive correlation among the price spreads, because all chains face similar shocks in the costs of procuring and marketing a commodity. The reality, however, is that the price spreads are not highly correlated, even within a city. For iceberg lettuce, the correlations for the three Dallas chains range from 0. 14 to 0. 26. Correlation in lettuce price spreads is somewhat higher for the Los Angeles chains, ranging from 0. 31 to 0. 68. There tends to be even less co-movement among the price spreads for fresh tomatoes. The two Dallas chains exhibit a negative correlation (-0. 32) in their spreads for California vine ripes, and, similarly, two of the three coefficients are negative for the three Los Angeles chains analyzed for vine ripes. Negative correlations are also present for both Dallas and Los Angeles chains for mature-green tomatoes.

Table 5—Means and Variances for Farm-Retail Price Spreads

City	CA Iceberg Lettuce[1]	CA Vine-Ripe Tomatoes[1]	CA Mature-Green Tomatoes[1]	FL Mature-Green Tomatoes[1]
Atlanta 1	0.9114		1.2957	1.3979
	(0.0434)		(0.1016)	(0.1484)
Atlanta 2		1.5266	1.5991	1.1939
		(0.0661)	(0.1181)	(0.1031)
Chicago 1	1.0038	1.3051		
	(0.0235)	(0.0057)		
Albany 1	0.8287	0.9401		
	(0.0310)	(0.0377)		
Dallas 1	0.9495		1.2854	
	(0.0437)		(0.0212)	
Dallas 2	0.6409	0.6119	0.6840	
	(0.0148)	(0.0494)	(0.0156)	
Dallas 3	0.8367		1.1019	
	(0.0509)		(0.1066)	
Dallas 4		1.5029	1.5780	
		(0.0318)	(0.0458)	
Miami 1	0.9881		1.1148	1.0252
	(0.0445)		(0.0949)	(0.1098)
Miami 2	1.0038	0.9543		
	(0.0217)	(0.0275)		
Los Angeles 1	0.8048		1.4815	
	(0.0353)		(0.0686)	
Los Angeles 2	0.6711	1.3527	1.0144	
	(0.0217)	(0.1695)	(0.0324)	
Los Angeles 3	0.7437	2.2910	1.3998	
	(0.0249)	(0.7038)	(0.0708)	
Los Angeles 4	0.7470	1.9082	1.4971	
	(0.0314)	(0.0317)	(0.0412)	

[1]Variances are indicated

The elasticities in table 7 represent the estimated percent change in the margin due to a one-percent increase in the level of shipments. All elasticities are evaluated at the means of the data. Elasticities based upon significant coefficient estimates are denoted with an asterisk. For the CA-AZ commodities, the elasticity is positive in 29 of 32 cases and is based upon a significant coefficient in 18 of those cases. Thus, the evidence is quite strong that larger shipment volumes are associated with a widening of the margin for the CA-AZ commodities. The margin for Florida mature-green tomatoes appears to behave differently based upon our limited observations. Shipments volume is associated with an increase in the margin in only one of the three cases, and the effect is not statistically significant. Specifying the margin to allow a one-week lag in transmission of farm prices to retail tended to weaken but not eliminate the impact of shipment volume on the margin.

Although the preceding results do not speak directly to the issue of retailer market power in procuring and selling perishable produce commodities, they do indicate the considerable independence among the retailers in setting prices and margins for these commodities—independence that does not exist in a quintessential competitive market. Similarly, the pervasive widening of the margin in response to higher shipment volumes supports the hypothesis that large volumes of these perishable commodities are used as a tool to bid down FOB prices and, thus, widen the margins.

Analysis of Retailer Oligopsony Power in Fresh Produce Procurement

In this section we report on an analysis of buyer power in procurement of iceberg lettuce and fresh tomatoes based upon the methodology reported in Sexton and Zhang (SZ, 1996). Figure 1 gave a graphical summary of the model. The SZ model applies to perishable produce commodities, in which supply in any market period can be regarded as perfectly inelastic for all prices in excess of the per-unit harvest costs. If the available harvest is sufficiently large, relative to demand, the farm price will fall to the level of harvest cost (C^0 in

Table 6—Correlation Coefficients for Farm-Retail Price Spreads in Selected Cities

(a) **CA Iceberg Lettuce**

	Dallas 1	Dallas 2	Dallas 3	LA 1	LA 2	LA 3	LA 4
llas 1	1.0000						
llas 2	**0.1368**	1.0000					
llas 3	**0.1577**	**0.2577**	1.0000				
1	-0.0253	0.1765	0.3969	1.0000			
2	0.1960	0.2781	0.2768	**0.3143**	1.0000		
3	0.0669	0.1704	0.4294	**0.5862**	**0.6460**	1.0000	
4	0.1380	0.1060	0.3432	**0.5039**	**0.5230**	**0.6806**	1.0000

(b) **CA Vine-Ripe Tomatoes**

	Dallas 2	Dallas 4	LA 2	LA 3	LA 4
Dallas 2	1.0000				
Dallas 4	**-0.3221**	1.0000			
LA 2	-0.2372	-0.1024	1.0000		
LA 3	0.1144	-0.3197	**0.4797**	1.0000	
LA 4	0.5716	-0.2508	**-0.3790**	**-0.0376**	1.0000

(c) **CA Mature-Green Tomatoes**

	Dallas 1	Dallas 2	Dallas 3	Dallas 4	LA 1	LA 2	LA 3	LA 4
Dallas 1	1.0000							
Dallas 2	**0.5384**	1.0000						
Dallas 3	**0.2956**	**-0.1138**	1.0000					
Dallas 4	**0.2172**	**-0.0835**	**0.5040**	1.0000				
LA 1	0.4827	0.2424	0.1931	0.0762	1.0000			
LA 2	0.5446	0.3422	0.0643	0.1803	**0.2625**	1.0000		
LA 3	0.1026	0.1388	-0.2183	-0.0966	**-0.0492**	**0.4023**	1.0000	

(d) **FL Mature-Green Tomatoes**

	Miami 1	Miami 2	Atlanta 1
Miami 1	1.0000		
Miami 2	**0.0281**	1.0000	
Atlanta 1	0.4135	0.4244	1.0000

Table 7—Elasticities of the Margin With Respect to Shipment Volume

City	CA Iceberg Lettuce	CA Vine-Ripe Tomatoes	CA Mature- Green Tomatoes	FL Mature- Green Tomatoes
Atlanta 1	0.672*		0.303*	0.138
Atlanta 2		0.429	0.474*	-0.067
Chicago 1	0.422*	0.052		
Albany 1	0.232	-0.307		
Dallas 1	-0.011		0.358*	
Dallas 2	0.215	0.437*	0.619*	
Dallas 3	0.285		0.217	
Dallas 4		-0.285	0.203*	
Miami 1	0.692*		0.592*	-0.485*
Miami 2	0.091	0.252		
Los Angeles 1	0.353*		0.305*	
Los Angeles 2	0.739*	0.229	0.229	
Los Angeles 3	0.879*	1.378*	0.230	
Los Angeles 4	0.501*	0.226*	0.201*	

* indicates that the elasticity was computed from a coefficient that was statistically significant at the 90 percent level.

Figure 1) under any form of competition, but will not normally fall lower, because price must be sufficient to cover the marginal costs of harvesting. A correctly specified econometric model of price determination for produce commodities must incorporate the fact that in some periods farm price will be determined by the level of per-unit harvest costs.

When the harvest-cost constraint does not bind (i. e. , for harvest levels less than H^*, in Figure 1), the farm price is determined by (a) consumer demand for the commodity in its various final-product forms, (b) costs of shipping, handling, and selling the product, and (c) the extent of competition in the market. If buyers compete aggressively, the farm price will be bid up to the level of final product value less all costs of marketing and selling—the schedule $D^F(H)$ in Figure 1. However, if buyers have market power, they will be able to capture some of the market surplus, S, for the commodity, defined as the final product value, P^R, minus per-unit costs for harvest (C^0) and for marketing and selling (C^R): $S_t = P^R_t - C^0_t - C^R_t$.

Economic theory provides little guidance as to how S_t will be shared between buyers and sellers, under conditions of imperfect competition. The hypothesis advanced by SZ was that buyers' bargaining power would be positively related to the size of the harvest, because large harvests of a perishable commodity diminish sellers' bargaining power, through the pressure created to move the perishable crop to market. Let ($_t$ denote the share of market surplus captured by producers in period t. The hypothesis of perfect competition in procurement is then H_0: $\gamma_t = 1$. The SZ (1996) hypothesis of an inverse relationship between γ_t and H_t can be depicted through a variety of functional forms. They found that a simple exponential relationship best fit the data: $0 \leq \gamma_t = e^{-\alpha H_t} \leq 1$, where $\alpha = 0$ corresponds to $\gamma_t = 1$ and perfect competition, and $\alpha > 0$ indicates the presence of buyer market power.

Let 8 denote the probability that the FOB price is constrained in any period by the level of harvest costs, C^0_t. Then the process describing FOB price determination for a perishable produce commodity, under possible imperfect competition, is summarized as follows:

$$(3) \quad \begin{aligned} P^F_t &= C^0_t && \text{with prob} = \lambda \\ P^F_t &= C^0_t + e^{-\alpha H_t}(P^R_t - C^R_t) && \text{with prob} = (1-\lambda). \end{aligned}$$

For estimation purposes, functional forms must be chosen for the retail demand, marketing cost, and harvest-cost functions. Following SZ (1996), we specified the following linear system with additive error terms:

$$(4) \quad P^R_{i,t} = a - (1/b_i)H_{i,t} + \varepsilon^1_t, \varepsilon^1_t \sim N(0, \sigma^2_1), i = 1, \ldots., n,$$

$$(5) \quad C^R_{i,t} = c + dT_{i,t} + \varepsilon^2_t,\ \varepsilon^2_t \sim N(0, \sigma^2_2), i = 1, \ldots., n,$$

$$(6) \quad C^0_t = C^0 + \varepsilon^3_t,\quad \varepsilon^3_t \sim N(0, \sigma^3_t).$$

Equation (4) specifies inverse demand in n consuming markets, with final product price in market i, $P^R_{i,t}$, specified as a linear function of consumption, $H_{i,t}$, in market i. All other determinants of demand are assumed to be constant over the two-year sample period, and their effects are contained within the intercept, a.[26] In particular, equation (4) presumes the absence of important substitutes for iceberg lettuce. Our analysis of chain-level demand functions for iceberg lettuce, discussed later in this report, investigated green-leaf and romaine lettuce as possible substitutes for iceberg lettuce and found their effect to be generally insignificant.

In equation (5) all costs of marketing, $C^R_{i,t}$, except for shipping costs $T_{i,t}$ are assumed to be constant over the sample period, and their effects are reflected in the intercept term, c. Finally, per-unit harvest costs are assumed to have a constant mean C^0 over the sample period. Given the short sample period and relatively stable prices during the time, these assumptions seem to be quite reasonable. SZ (1996) describe aggregation of (4) – (6) to the industry level to obtain the following empirical specification of the price-determination model in

$$(3)\!: Y1_t \quad P^F_t \quad C^0 \quad \varepsilon^3_t \quad \text{with prob} = \lambda$$

$$(3')\ Y2_t \quad P^F_t \quad C^0 \quad \varepsilon^3_t \quad e^{-\alpha H_t}\ A - \ H_t \quad dT_t$$

$$\varepsilon^3_t \qquad {}_t\ \varepsilon^1_t \quad \varepsilon^2_t \quad \varepsilon^3_t \qquad \text{with prob} = 1 - \lambda.$$

$$Y_t \quad \max\ Y1_t, Y2_t\ .$$

In (3’), H_t is the total harvest, T_t is a quantity-weighted average of shipping costs across the n consuming markets, and Y_t is the farm price net of mean per-unit harvest costs.[27] In the absence of the constraint that price cannot fall below the harvest cost, farm price would be determined by the equation for Y2. However, since no harvest would occur in that event, farm price net of mean harvest cost is the greater of $Y1_t$ and $Y2_t$. Based on (3’), in weeks in which the potential supply, H_t, exceeds H^*, the harvest-cost price, Y1, exceeds Y2, and farm price is determined by the level of harvest costs. When $H_t < H^*$, a per-unit surplus exists in the market, and Y2 > Y1 determines the farm price.

The system in (3’) defines a nonlinear switching regression model with heteroskedastic errors. The model was estimated via maximum likelihood using GAMS. See SZ (1996) for construction of the likelihood function. Data for the model include farm price net of mean per-unit harvest costs, $Y_t = P^F_t - C^0$. Farm price was measured for each commodity in \$10/carton as the weekly average of daily FOB prices reported by the USDA, F-SMNS. Estimates of per carton harvest costs were obtained from either the University of California or the University of Florida Cooperative Extension Service. Weekly shipments were measured in units of 40,000,000 lbs. , as reported by the F-SMNS. For shipments emanating from California or Arizona, the weighted average shipping cost, T_t, in \$1,000 per truck load, was derived as the population-weighted average of truck rates reported by F-SMNS to ship CA-AZ lettuce to five U. S. cities: Atlanta, Chicago, Dallas, New York, and Los Angeles. For shipments emanating from Florida, T_t was based on shipping costs from Florida to Atlanta, Chicago, and New York. The parameters to be estimated include A = a – c – C^0, ∀, ∃, d, $(\sigma_1^2 + \sigma_2^2)^{0.5}$, and Φ_3.

CA-AZ Iceberg Lettuce

Figure 8 shows the weekly FOB price per carton and the estimated per-carton harvest cost, C^0 =\$4. 45/carton, for CA-AZ iceberg lettuce. Noteworthy is that the FOB price is near the harvest-cost minimum for a rather large number of the 104 weekly observations.

Estimation results for the general model, and a restricted model with ∀ constrained to equal zero (i. e. , perfect competition in procurement) are reported in table 8. The point estimate of ∀ for the general model is $\hat{\alpha} = 0.833$, with standard error 0. 322. The estimate is statistically significant, and the restricted model of perfect competition is thus rejected in favor of the general model. Consistent with the results reported by SZ (1996), this result supports a conclusion that buyers are able to capture a large share of available market surplus for CA-AZ iceberg lettuce and that, in many periods, the FOB price is constrained to the harvest-cost minimum. Producers’ estimated share of the surplus is $\hat{\gamma}_t = \exp\{-0.833 H_t\}$. For the sample period from 1998-99 the range of $\hat{\gamma}_t$ is [0.

[26] The specification of final product demand further assumes that the price elasticities of demand, evaluated at a given price level, are identical across consuming markets. This assumption facilitates aggregation of the model across markets.

[27] Although the consumption levels in individual markets, $H_{i,t}$, are clearly endogenous, the aggregate production, H_t, can be considered exogenous for all prices greater than the level of per-unit harvest costs. Expected price contributes to determining the acreage committed to a produce commodity. However, once acreage is committed, the distribution of H_t depends primarily upon weather shocks. Except when price falls to the level of per-unit harvest costs, it seems unlikely that weekly demand fluctuations determine the corresponding weekly harvests. As long as the variation from week to week, due to demand and weather, dominates the variation from year to year in acreage commitments, our approach should produce the most reliable estimates, given the inherent difficulty in estimating any model of supply response based upon two years of data.

Figure 8
CA-AZ Iceberg Lettuce FOB Price and Harvest Cost: 1998-1999

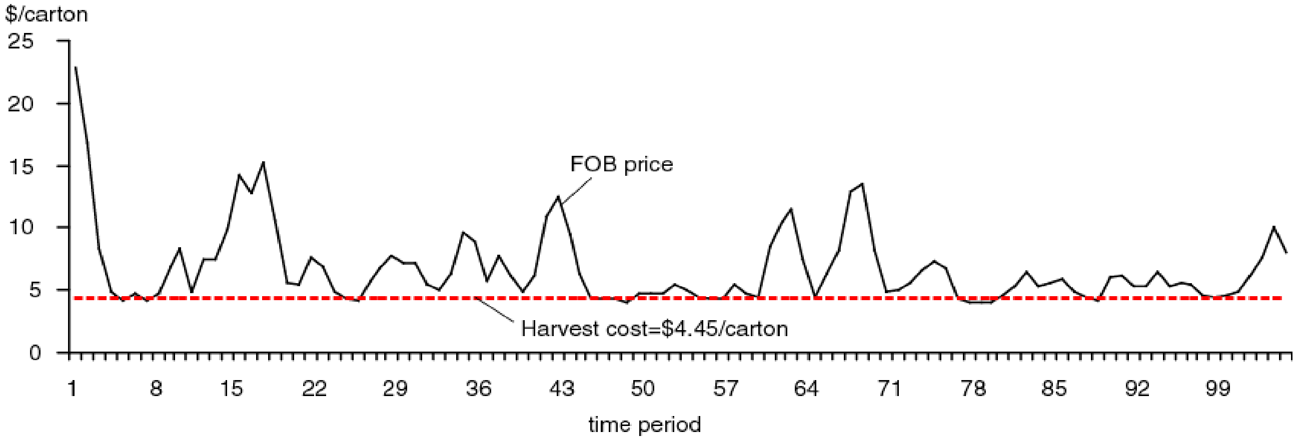


Table 8—Estimation Results for CA-AZ Iceberg Lettuce

Parameter	General Model Estimate	General Model Std. Error	Restricted Model: α = 0 Estimate	Restricted Model: α = 0 Std. Error
α	0.833	0.322		
A	4.549	2.526	1.607	0.403
β	0.780	0.923	0.509	0.195
D	0.895	0.781	0.182	0.113
$(\sigma_1^2+\sigma_2^2)^{0.5}$	1.831	1.174	0.387	0.039
σ_3	0.035	0.007	0.041	0.011
log likelihood	26.458		22.945	

138, 0. 330], with a mean value of 0. 194, i. e. , producers capture on average approximately 20% of the market surplus. These surplus estimates are somewhat higher than were obtained by SZ for the period from January 1988–October 1992, which ranged from 0. 031 to 0. 145, with a mean value of 0. 0649.

Both the aggregate demand slope parameter, β , and the shipping cost parameter, d, have the hypothesized positive signs, but neither parameter was estimated with much precision. The estimated flexibility of the FOB price with respect to the total volume of shipments evaluated at the sample means is –2. 301 for the general model, implying an elasticity of farm-level demand of approximately –1/2. 301 = -0. 433. [28]

Following Kiefer (1980), the probability that each observation is derived from the harvest-cost regime is P_t = prob{$Y1_t > Y2_t * Y_t$} (i. e. , P_t is the probability that we are observing $Y1_t$, given knowledge of Y_t). Figure 9 shows the estimated values of P_t. The rule that minimizes the probability of misclassifying observations between regimes is $Y_t = Y1_t$ if the estimated ψ_t is greater than 0. 5. Based upon this rule, 38 of 104 or 36. 5 percent of the observations of the FOB price for 1998-99 (the ones above the ψ_t = 0. 5 line in figure 9) are estimated to have resulted from the harvest-cost regime.

California Vine-Ripe Tomatoes

Analysis for California vine-ripe tomatoes was limited to the 1999 marketing year (26 weekly observations) because USDA F-SMNS did not report FOB prices for vine ripes prior to 1999. Figure 10 shows the path of 1999 FOB prices and the per-unit harvest cost, estimated to be $4. 25/carton. F-SMNS does not disaggregate fresh

[28] The price flexibility is the percent change in price due to a one percent increase in shipments. Thus, at the data means, a one- percent increase in shipments is estimated to cause about a 2.3 percent decrease in FOB price, when price is not constrained to the harvest cost regime. The ratio of one over the estimated flexibility is a consistent, although biased, estimate of the price elasticity of demand.

Figure 9
Estimates of the Pricing Regime for CA-AZ Iceberg Lettuce: 1998-99

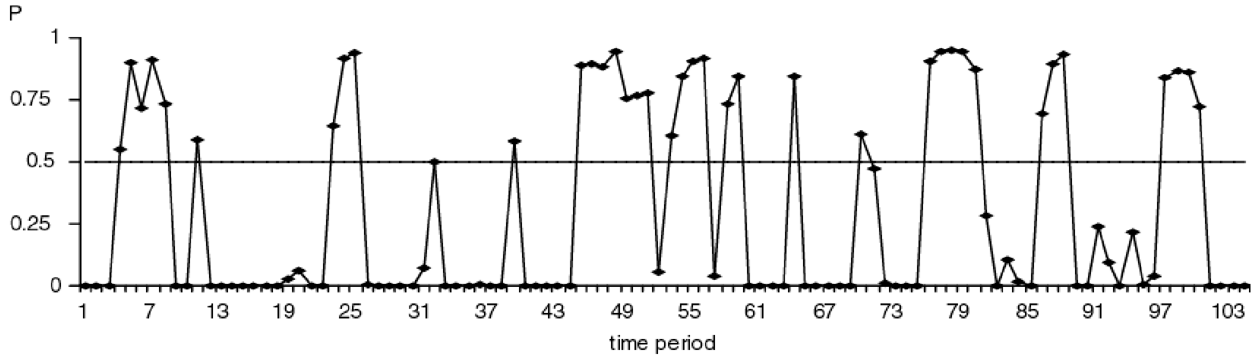
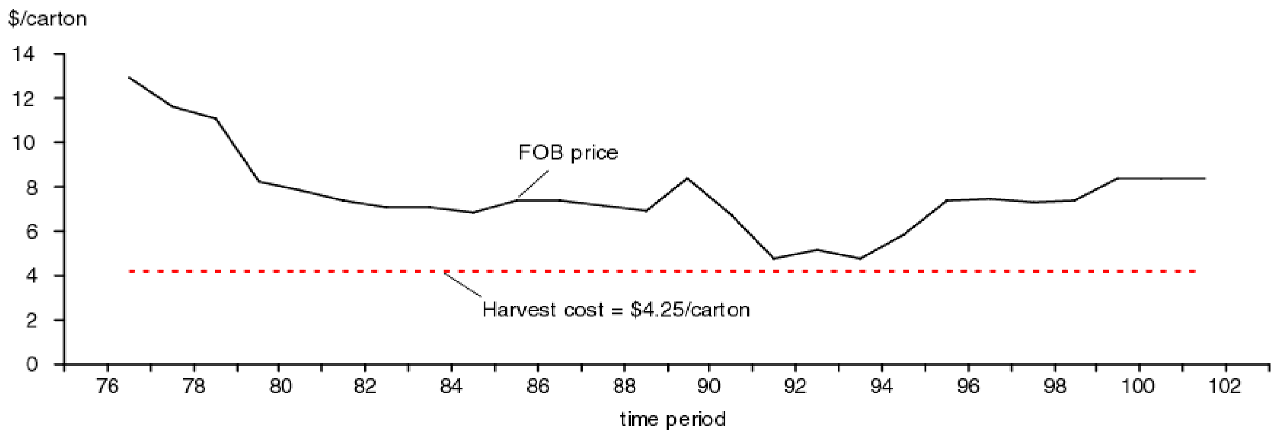


Figure 10
California Vine-Ripe Tomato FOB Price and Harvest Cost: 1998-1999



tomato shipments between vine-ripe and mature-green categories. Thus, H_t is the total weekly shipment of fresh tomatoes in the U. S. Because of the close substitutability between vine-ripe and mature-green tomatoes, use of the combined harvest is probably appropriate, irrespective of the data problem.

Estimation results for the general and restricted model are reported in table 9. The estimated value of α is $\hat{\alpha} = 0.054$, with standard error 0. 013. The estimate is statistically significant, and the restricted model is again rejected in favor of the general model. Although $\hat{\alpha}$ is statistically greater than zero (0), it is quantitatively small, and producers' share of the estimated market surplus is large, ranging from 0. 828 to 0. 902, with mean 0. 861. It appears that retailers exhibited relatively little oligopsony power in pricing vine-ripe tomatoes from California.

The estimates of β and d each have the hypothesized positive signs, although $\hat{d}$ is not statistically significant. The estimated flexibility of the FOB price for California vine ripes with respect to total shipments of fresh tomatoes (i. e. , vine ripes and mature greens) is -1. 067 based on the general model, i. e. , demand is slightly inelastic at the data means. None of the 26 observations for P_t^F is estimated to have resulted from the harvest-cost regime.

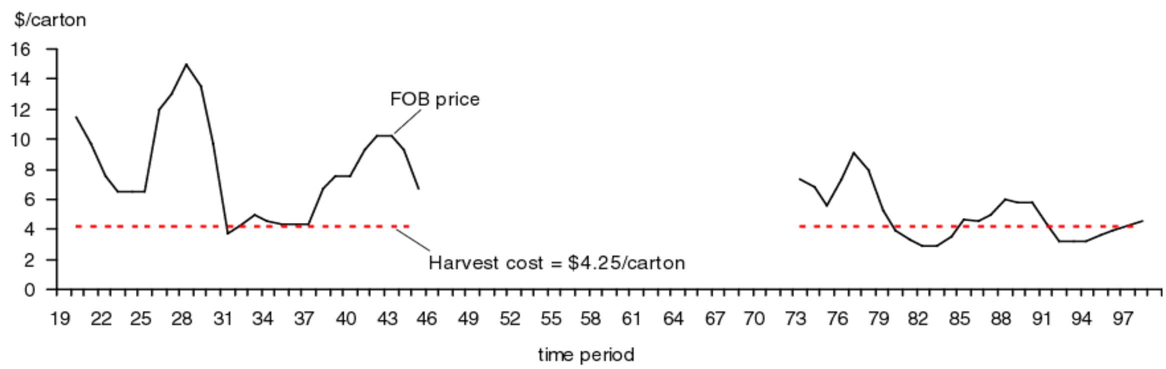
California Mature-Green Tomatoes

Figure 11 depicts the FOB price for California mature-green tomatoes relative to the estimated harvest cost of $4. 25/carton, represented by the dotted line. We experienced some difficulties in estimating the switching regression model for California mature greens. Estimation was successful when the data set was limited to only 1999 observations (26 in total). The estimation results are contained in table 10.

Table 9—Estimation Results for California Vine-Ripe Tomatoes

Parameter	General Model		Restricted Model: $\alpha = 0$	
	Estimate	Std. Error	Estimate	Std. Error
α	0.054	0.013		
A	0.697	0.064	0.189	0.469
β	0.131	0.027	0.179	0.052
d	0.003	0.027	0.677	0.267
$(\sigma_1^2+\sigma_2^2)^{0.5}$	0.001	0.001	0.126	0.048
σ_3	0.509	0.115	0.001	0.071
log likelihood	21.031		8.990	

Figure 11
California Mature-Green Tomato FOB Price and Harvest Cost: 1998-1999



Although the estimate of α is quantitatively large, ($\hat{\alpha}$ = 0. 339), it is imprecise (std. error = 0. 505) and not statistically different from zero (0). Accordingly, the competitive model is not rejected in favor of the general model for California mature greens. The estimates of the producers' shares of the market surplus range from 0. 307 to 0. 475, with a mean value of 0. 404. However, these estimates must be interpreted with caution because of the imprecision associated with the estimate of α. Neither the demand slope nor the transportation cost parameter was estimated with precision, and the transportation cost parameter does not have the anticipated positive sign. Based on the estimate of β, the flexibility of the FOB price with respect to total fresh tomato shipments is estimated to be –12. 86 at the data means. This estimate seems implausibly large, corresponding to a very inelastic demand.

Figure 12 contains estimates of Ψ_t. Based upon the classification rule, 18 of the 26 total observations are estimated to have come from the harvest-cost regime (i. e. , FOB price was constrained to the level of harvest costs for roughly two-thirds of the 1999 observations). Referring to figure 11, we see that the price declined early on during the 1999 season and hovered near the estimated per-unit harvest costs for the remainder of the season. In essence then, the market power parameter α and the demand and transportation-cost parameters are estimated from only the eight observations that did not result from the harvest-cost ratio. Thus, the imprecision in their estimation is not surprising.

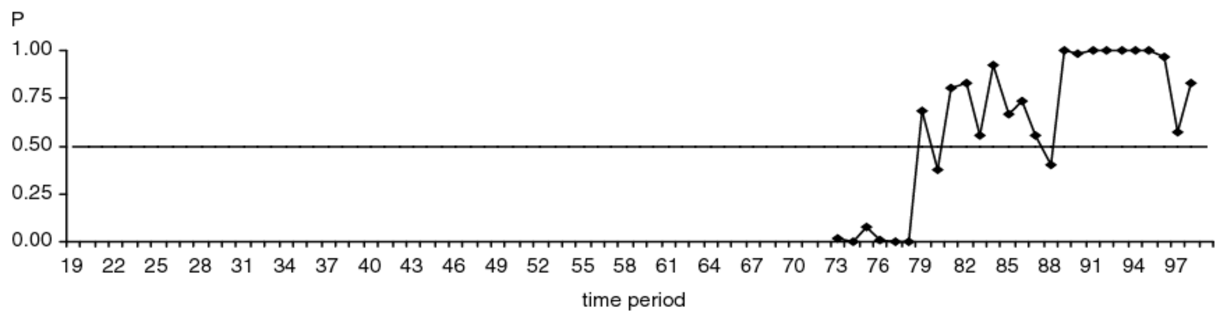
Florida Mature-Green Tomatoes

Florida mature-green tomatoes are marketed under the auspices of a federal marketing order and most grower-shippers are affiliated with a marketing cooperative, which coordinates with the marketing order. The Florida mature-green tomato industry established a voluntary price floor for the 1998-99 and 1999-2000 marketing seasons at $\overline{P}^F$ = $5. 85 per carton, well in excess of harvest costs,

Table 10—Estimation Results for California Mature-Green Tomatoes

Parameter	General Model		Restricted Model: $\alpha = 0$	
	Estimate	Std. Error	Estimate	Std. Error
α	0.339	0.505		
A	-2.992	4.315	-1.285	0.855
β	1.201	1.249	0.633	0.200
d	-2.183	2.619	-1.032	0.343
$(\sigma_1^2+\sigma_2^2)^{0.5}$	0.315	0.342	0.159	0.045
σ_3	0.099	0.019	0.101	0.020
log likelihood	20.021		19.778	

Figure 12
Estimates of the Pricing Regime for California Mature-Green Tomatoes: 1999



estimated to be \$3. 57/carton.[29] Figure 13 depicts the FOB price, the \$5. 85 price floor, represented by the unbroken lines, and the estimated \$3. 57 per-unit harvest cost, represented by the dotted lines.[30] The figure demonstrates that the price floor was quite successful during the sample period. Price dropped in several weeks to around the level of the floor, but it did not drop perceptively below it. Unlike the cases for CA-AZ iceberg lettuce and California mature-green tomatoes, the harvest-cost floor apparently was not a factor at all in establishing the FOB price.

Because it was clear that the industry-established price floor dominated the harvest-cost floor as a relevant factor in establishing price for Florida mature-green tomatoes, we utilized $\overline{P}^F$ instead of the harvest-cost floor in estimating the pricing model. Thus, for Florida mature greens, the model to be estimated was

$$Y1_t \quad P_t^F \quad \overline{P}^F \quad \varepsilon_t^3 \quad \text{with prob} = \lambda$$

$$Y2_t \quad P_t^F \quad \overline{P}^F \quad \varepsilon_t^3 \quad {}_t\; A - \quad H_t \quad dT_t$$

$$\varepsilon_t^3 \quad {}_t\; \varepsilon_t^1 \quad \varepsilon_t^2 \quad \varepsilon_t^3 \quad \text{with prob} = 1 - \lambda.$$

$$Y_t \quad \max\ Y1_t, Y2_t\ .$$

The estimation results are provided in table 11. The estimated value for α is small ($\hat{\alpha} = 0.212$), and is not statistically significant. Thus, the model of competitive procurement is not rejected for Florida mature greens. The estimates of both β and d are positive as expected, but ∃ is estimated very imprecisely. The estimated price flexibility at the data means is 0. 498, implying that demand is

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[29] Enforcement of this price floor was facilitated by the agreement negotiated in 1996 between tomato shippers in Florida and Mexico to suspend the U.S. Commerce Department's investigation into dumping charges lodged by the Florida industry against Mexican tomato exporters. As part of this agreement, Mexican tomato shippers agreed to a price floor of \$5.17 per 25 lb. box. The Mexican floor price was increased to \$5.27 in 1998. The agreement required that exporters representing at least 85 percent of traded tomato volume be signatories and was not binding upon non-signatories.

[30] A voluntary price floor was attempted in marketing California mature-green tomatoes for the 1998 season. The floor was set at \$3.50 plus a handling charge of \$0.50, yielding a total price of \$4.00 per carton. Based on industry sources, only about two-thirds of shippers participated in the agreement. Since \$4.00 is roughly equivalent to the estimate of harvest costs, it is not clear whether the floor had any effect independent of the natural floor price established by the harvest costs (see figure 11).

Figure 13
FOB price, price floor, and per-unit harvest cost for Florida mature-green tomatoes: 1998-99

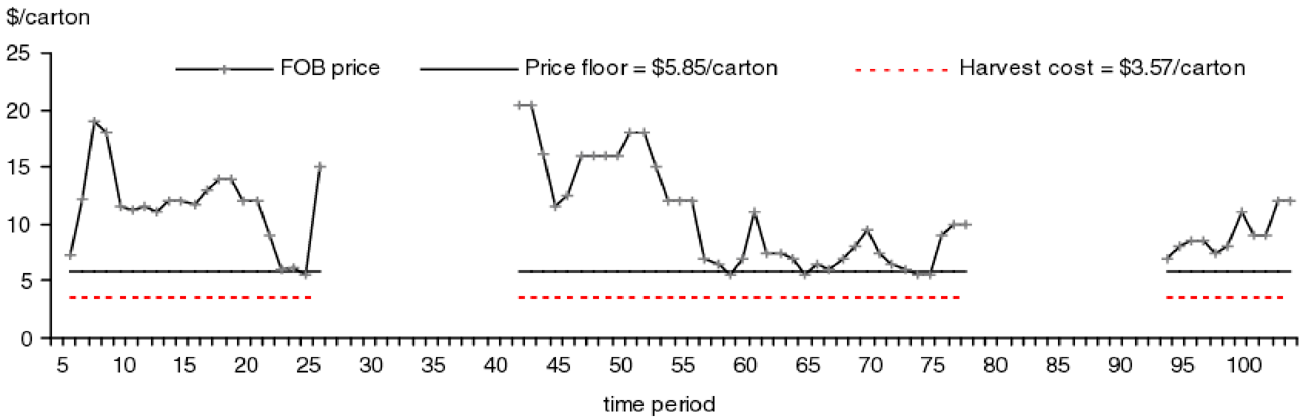


Table 11—Estimation Results for Florida Mature-Green Tomatoes

Parameter	General Model		Restricted Model: α = 0	
	Estimate	Std. Error	Estimate	Std. Error
α	0.212	0.226		
A	3.670	1.697	2.542	0.558
β	0.108	0.243	0.193	0.122
d	1.661	1.008	1.107	0.318
$(\sigma_1^2+\sigma_2^2)^{0.5}$	0.647	0.329	0.410	0.041
σ_3	0.042	0.017	0.047	0.029
log likelihood	-17.304		-17.796	

elastic for Florida mature greens[31]. Based upon the estimated value of α, producers' share of any market surplus in excess of the amount created by the price floor ranged from 0. 514 to 0. 783, with mean value 0. 627. However, because of the imprecision in estimation of α, we cannot reject statistically that producers capture the entire surplus, as they would under perfect competition in procurement.

Figure 14 depicts the estimated probabilities that the voluntary price floor determined the FOB price in each period. Ten of the 69 total observations are estimated to have been determined by the price floor.

[31] Note that Florida tomatoes compete seasonally with imports from Mexico. Thus, due to the competition effect, a relatively elastic demand for Florida mature greens is not surprising.

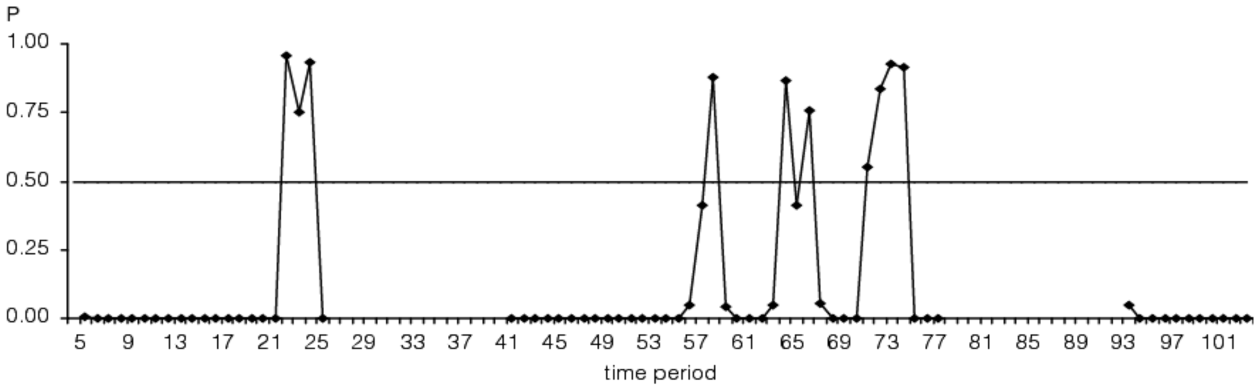
Summary of Oligopsony Analysis

Results of the oligopsony analysis were rather mixed. Results for CA-AZ iceberg lettuce were consistent with earlier results obtained by SZ (1996), and parameter estimates were plausible both with respect to sign and magnitude. Results for fresh tomatoes were less satisfactory. The market power parameter, α, was statistically significant in only one of three instances (California vine ripes) and was quantitatively small in that case, suggesting that producers captured the lion's share of any market surplus. The estimate of α was larger for California mature greens than the estimate for vine ripes, but the former was estimated imprecisely, and we were unable to reject a hypothesis of competitive procurement.

Analysis for Florida mature-green tomatoes demonstrated that the industry's voluntary price floor was successful in maintaining prices well in excess of the harvest-cost minimum. This floor was

Figure 14

Estimates of the pricing regime for Florida mature-green tomatoes: 1998-99



estimated to have determined price in 10 of the 69 total periods. The estimate of α for Florida mature greens pertains to surplus in excess of the price floor, rather than the harvest-cost floor. This estimate was small and not statistically different from zero, meaning that a hypothesis of competitive procurement could not be rejected in this case either. Estimates of the price elasticity or price flexibility of demand for fresh tomatoes varied widely among the alternative cases considered.

The weaker performance of the pricing model when applied to fresh tomatoes could be due to several factors. Available observations were limited in all cases relative to those for CA-AZ iceberg lettuce. For both California mature greens and vine ripes, estimation was based on only a single marketing season. In addition, the availability of only aggregate fresh tomato shipments causes lingering concerns about the appropriateness of the shipments variable in the analyses for tomatoes.

Although the results for fresh tomatoes must be interpreted circumspectively for the reasons just noted, they do tend to suggest that fresh tomato grower-shippers have fared better on average than iceberg lettuce grower-shippers in capturing a larger share of the available market surplus. This result is consistent with the results reported by Calvin *et al.* (2000) that tomatoes was the produce sector that had most been able to withstand retailer requests for services and fees. Available evidence suggests roughly comparable grower-shipper structures in lettuce and fresh tomatoes, although tomato grower-shippers are probably better organized, as we have discussed.[32] Another prospectively important consideration is that tomato grower-shippers deal with repackers, and do not directly face grocery retailers. In the context of the Sexton-Zhang model of price determination for perishable produce, it is quite reasonable to think that repackers are a less potent force in bargaining than are the grocery retailers with whom lettuce grower-shippers deal directly.

Retailer Pricing to Consumers: Constant or Stabilized Retail Prices

We now turn to the analysis of grocery retailers' pricing practices to consumers. In this section, we investigate the implications for producers when some chains hold constant or stabilize retail prices for produce commodities, despite shifts in production and prices at the farm level. We show that, under a rather broad set of conditions, this behavior is harmful to producers. The fundamental point is that, if some share of the sellers of a commodity hold the retail price constant, despite shifts in production and/or aggregate demand, then price must fluctuate more widely for all other sellers, in order for the market to clear. In most cases, this outcome is harmful to producers relative to the alternative where all sellers allow price to fluctuate in response to market conditions. The logic of this argument applies equally to situations where a subset of sellers does not maintain a fixed price *per se*, but instead stabilizes it relative to market conditions

[32] See Sexton and Sexton (1994) for a discussion on the history of CA-AZ iceberg lettuce grower-shippers' attempts to organize.

Figure 15
Impact of constant selling prices on producer welfare

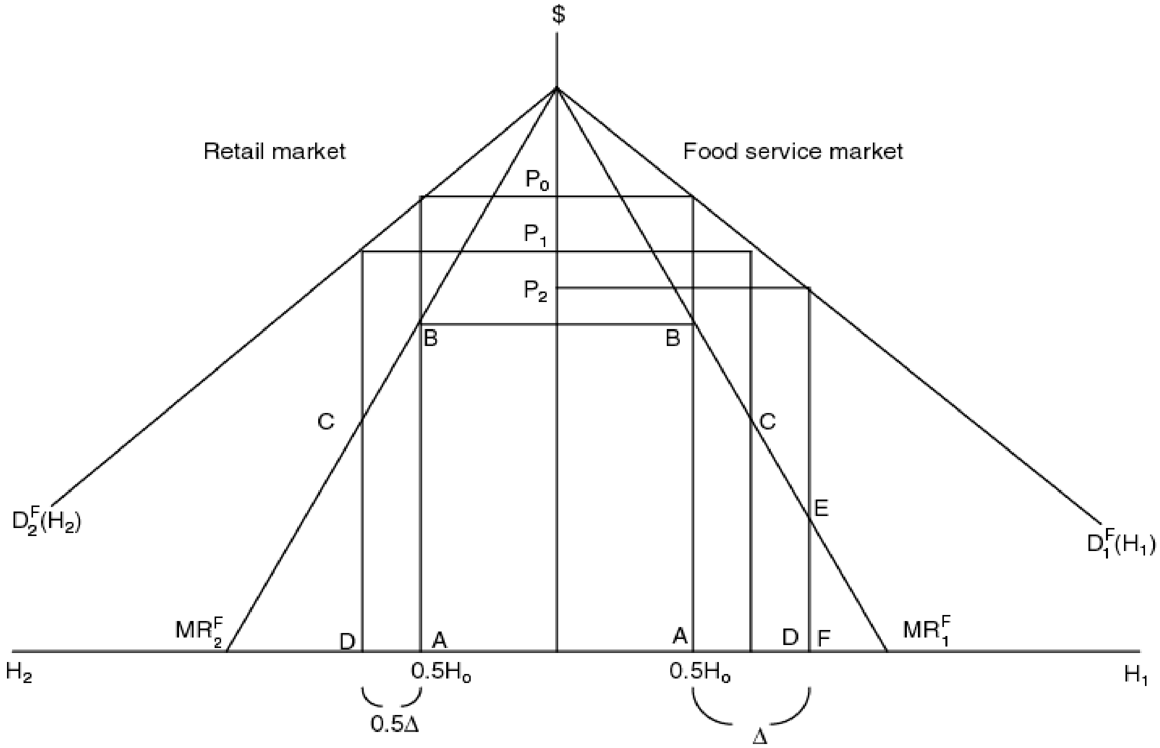


Figure 15 illustrates the basic point for the case of two market outlets. The left quadrant depicts the aggregate retail market, and the right quadrant depicts the aggregate of all other market outlets, and is referred to as "food service". $D_1^F(H_1)$ is final demand in the food service market, less all shipping and marketing costs, and $D_2^F(H_2)$ is final demand in the retail market, less all shipping and marketing costs. For simplicity, $D_1^F(H_1)$ and $D_2^F(H_2)$ are assumed to be identical, and the initial harvest level, H_0, is divided equally between the two markets. Under perfect competition in procurement, $D_1^F(H_1)$ and $D_2^F(H_2)$ are demand curves for the farm product in the respective sectors. Given total harvest H_0, farm price would be P_0 in each market under competition. Under buyer power in procurement, farm price will be less than P_0 as discussed previously and as illustrated in Figure 1.

Suppose that production increases to $H_0 + \Delta$, while demand remains unchanged. If both markets allow price to change in response to the increase in production, each sells $0.5(H_0 + \Delta)$ and price in each market falls to P_1. The increase in producer revenue in each market is the area, ABCD. However, if the retail market maintains a fixed selling price despite the change in production, sales at retail remain at $0.5H_0$, and the per-unit farm value remains P_0 in the retail sector. For the increase in production to clear the market, it must move entirely through the food service market, which now sells $0.5H_0 + \Delta$, with farm value in the food service market falling to P_2.[33] The marginal revenue from the new production is now illustrated by the area ABEF in Figure 15, where ABEF < 2(ABCD).

Figure 15 thus illustrates a market setting where the revenue from additional sales is less when one segment of the market maintains a fixed price, causing the additional volume to be sold entirely through the market outlet(s) that maintain variable prices. This result holds broadly. In particular, a sufficient condition for fixed prices to be harmful to producer welfare is that marginal revenue is a

[33]Because $P_0 > P_2$, standard arbitrage would call for product to move from food service to retail, but these forces are frustrated if retailers insist on holding price at P_0. Only $0.5H_0$ can be sold at retail for price P_0.

decreasing function of sales for all market outlets.[34] Although Figure 15 illustrates a situation with elastic demands (i. e. , marginal revenue is positive in both markets), the conclusion applies equally to markets with inelastic demands. In this case, additional output causes a reduction in total sales revenue, but the reduction is less if all prices are flexible whenever marginal revenue declines as a function of output. The logic illustrated in Figure 15 applies equally to decreases in production. Finally, the presence of imperfect competition in any of the procurement markets does not alter this fundamental conclusion. Under the conditions set forth here, fixing prices in a subset of the market outlets reduces the total surplus accruing to the farm commodity. Thus, farm sector income will be lower due to fixed prices, even if the farm sector captures only a portion of the market surplus.[35]

Estimates of the Impact of Constant Prices on Producer Welfare

How important are fixed retail prices in influencing farm income for a produce commodity? We conducted a simulation analysis to gain some insight into this question. Total demand for the farm commodity was specified in linear form as $Q = a - \alpha P$ and divided between two sectors: a sector that fixes retail price at a mean value and faces demand

$Q_1 = \rho\ (a - \alpha P_1), 0 < \rho < 1,$

and a sector that allows price to fluctuate freely, which faces demand

$Q_2 = (1-\rho)(a - \alpha P_2).$

The parameter ρ measures the share of total demand that is sold through outlets that employ a fixed retail price.

The mean harvest is H_0, which is normalized without loss of generality to be 1. 0: $H_0 = Q_1 + Q_2 = 1.0$. Let Δ_t denote a random shock to harvest, and assume $\Delta_t \sim N(0,\sigma^2)$, i. e. , Δ_t is distributed normally with mean zero and variance σ^2. Similarly, prices are normalized at the mean harvest to be $P_1 = P_2 = 1.0$. Given these normalizations, the relationship among the demand parameters is $a = 1 + \alpha$, and $\alpha = \varepsilon_{Q,P}$, where $\varepsilon_{Q,P} = -(\partial Q/\partial P)(P/Q) = \alpha(P/Q)$ is the absolute value of the price elasticity of total demand evaluated at $(P_1{=}P_2, H_0) = (1,1)$.

To conduct simulations of the impact of fixed retail prices for CA-AZ iceberg lettuce based on the preceding model, we must specify plausible values for the parameters Δ, $\varepsilon_{Q,P}$, and Φ^2. In our sample of retail chains 6/20 or 30 percent employed fixed prices for iceberg lettuce during the 104-week sample period. In addition, we estimate that approximately 60 percent of iceberg lettuce is sold through retail food stores. Thus, a rough estimate of ρ is ρ = 30 percent x 60 percent = 18 percent, assuming that all "food service" outlets have flexible prices. This value for Δ applies only to retailers that maintain a constant selling price. Others, while not fixing price *per se*, clearly stabilize it relative to market conditions. To account in at least an approximate manner for this additional impact, we also conducted a set of simulations assuming that ρ = 30 percent.

As for $\varepsilon_{Q,P}$, SZ (1996) estimated that $\varepsilon_{Q,P} = 0.164$. A somewhat higher estimate, $\varepsilon_{Q,P} = 0.433$, was obtained in the present study. Both values were used in the simulations. The variance, σ_H^2 , of actual California weekly harvests of iceberg lettuce for 1998-99 was used to estimate Φ^2. First, to normalize harvest so that $E[H_t] = 1$, we divide the actual harvest by its mean, $\bar{H}$. Since Var $\{H_t/E[H_t]\} = \sigma_H^2/E[H_t]^2$, a reasonable setting for σ^2, the variance of the normalized shock to harvest $)_t$, is the variance of the actual harvests divided by $\bar{H}^2$.

We simulated a year of harvests by conducting 52 draws of Δ_t from a normal distribution with mean 0 and variance σ^2. The simulated harvest in week t is then $H_t = 1 + \Delta_t$. Given the harvest, price and grower revenue were computed for each week under the alternative scenarios where (a) all sellers had variable prices, or (b) a fraction, ρ, of sellers fixed price at the mean value. Total revenue under scenario (a) is

[34] Let inverse demand in a market j be denoted as $P_j(H_j)$, where H_j denotes sales in market j. Total revenue in market j is $TR_j = P_j(H_j)H_j$. Marginal revenue is $MR_j = dTR_j/dH_j = P_j'(H_j)H_j + P_j(H_j)$, and $dMR_j/dH_j = P_j''(H_j)H_j + P_j'(H_j) + P_j'(H_j)$. Thus, $dMR_j/dH_j < 0$ whenever $2P_j'(H_j) < -P_j''(H_j)H_j$. This condition holds for all concave demand curves, including linear, and also mildly convex demands.

[35] It might be argued that consumers prefer stable prices, so retailers who hold prices constant despite fluctuations in market conditions actually increase demand for the product (Okun, 1981). However, as noted, stabilizing prices in one sector of the market implies even greater price instability in the other sectors, which, under the same logic, would have an adverse effect on demand in those sectors.

$$R_t^{(a)} = 1 + \Delta_t - (\Delta_t / \varepsilon_{Q,P}) - (\Delta_t^2 / \varepsilon_{Q,P}) .$$

Under scenario (b), total revenue is

$$R_t^{(b)} = \rho + \frac{(1-\rho+\Delta_t)[\varepsilon_{Q,P}(1-\rho)-\Delta_t]}{\varepsilon_{Q,P}(1-\rho)} .$$

For each set of parameter values, 100 52-week harvests were simulated. The minimum, maximum, and mean percent loss in revenue from constant/stabilized retail prices for each set of trials are reported in table 12. As was clear from the theoretical analysis, producers' welfare is reduced when a subset of retailers stabilize prices. The relative loss in revenues from fixed/stabilized retail prices is larger the more inelastic is demand and the greater the fraction of product that is sold through fixed/stabilized-price sellers. When $\rho = 0.3$ and $\varepsilon_{Q,P} = 0.164$, the mean loss in revenues was about 3. 5 percent but was only 0. 6 percent when $\rho = 0.18$ and $\varepsilon_{Q,P} = 0.433$. Although not illustrated in table 12, the adverse effect of fixed/stabilized prices on revenue will be greater the more volatile is periodic supply, i. e. , the greater is σ^2.

Retailer Pricing to Consumers: Markups of Price Over Costs

Grocery retailers unquestionably possess some degree of market power, in the sense of having ability to influence prices, both due to spatial differentiation, differentiation in product mix and service levels, customer loyalty, etc. The implications of this power for consumer welfare depend primarily upon conditions of entry into the food-retailing sector. If entry is unimpeded, then the presence of supracompetitive profits in a local market will stimulate entry and lower prices, which will reduce profits towards the competitive level.[36] Long-run equilibrium is attained when no additional entrant can enter profitably. Incumbents in this equilibrium will be charging prices to consumers that exceed marginal costs on average, and some level of supracompetitive profits may persist due to the fixed costs of entry.[37]

Table 12—Simulation Results for Analysis of Constant/Stabilized Retail Prices

	$\varepsilon_{Q,P}$ **= 0.433**	$\varepsilon_{Q,P}$ **= 0.164**
Δ = 0.18	[0.34, 0.84] 0.63	[0.88, 2.89] 1.78
Δ = 0.30	[0.66, 1.84] 1.24	[1.72, 5.65] 3.48

Because it is not possible to analyze the implications of retailer behavior for consumer welfare based upon only a few products, our focus is on the implications of retailer pricing to consumers for producer welfare. Consider the following model setting for food retailing. Consumers and stores are distributed spatially. During each market period, a consumer will visit one or more stores selected from a decision set of stores. Evaluating each store in the decision set, a consumer's decision on whether to visit a store is based upon his/her perception of (a) the total cost for the planned market basket of purchases, (b) the transactions costs associated with the shopping trip, and (c) additional factors, such as the consumer's familiarity with the store, the services and selection offered by the store, perceptions of quality of the store's merchandise (Siroh, McLaughlin, and Wittink, 1998), etc.[38]

Define $Q_{j,t} = N_{j,t}\bar{Q}$, as the total sales of a particular produce item in chain j at time t, where $N_{j,t}$ is the number of customers that visit the chain in period t and $\bar{Q}$ is the average sales per customer. The partial elasticity of sales with respect to the store's price, P_j, can be expressed as follows:

$$\varepsilon_{Q_j,P_j} = \varepsilon_{N,P_j} + \varepsilon_{\bar{Q},P_j} ,$$

where ε_{N,P_j} is the elasticity of customer visits with respect to price of the produce commodity, and $\varepsilon_{\bar{Q},P_j}$ is the elasticity of mean sales of the commodity with respect to its price. $\varepsilon_{\bar{Q},P_j}$ is widely believed to be small in absolute value (demand is inelastic) for produce commodities. Most

[36] Cotterill and Haller (1992) studied entry into U.S. food retailing markets. A key result was that entry was inversely related to the degree of concentration (measured by the four-firm concentration ratio) in the market, leading the authors to conclude that powerful incumbent firms were able to use strategic entry barriers to deter entry. Entry was also inversely related to the presence of strong chains in the market.

[37] For example, 10 geographically dispersed supermarkets in a small city may be able to earn positive economic profits, but entry of an 11th store would cause losses. Thus, 10 stores and positive economic profits would represent the long-run equilibrium.

[38] This consumer-choice framework is very consistent with the model utilized by Messinger and Narasimhan (1997) to study consumers' choice of supermarket formats. Also see Popkowski Leszczyc, Sinha, and Timmermans (2000) for a recent analysis of consumer grocery store choice and switching behavior.

consumers view produce, such as lettuce and fresh tomatoes, as staples in their diets. They are also complementary to many types of meals, and they constitute a small part of most consumers' budgets. Moreover, their perishable nature means that consumers cannot accumulate inventories in response to price promotions.

Not much, however, is known about $\varepsilon_{N,P}$. This elasticity is presumably negative—any increase in a commodity price, *ceteris paribus*, will have a negative impact on visits to a store, but the effect of any one price change is most likely very small, except possibly when an item is on ad, and a very low promotional price is offered.

Thus, the partial elasticity of demand for produce items, such as lettuce and fresh tomatoes, facing a typical retailer is expected to be small in absolute value, implying that the retailer has considerable power to raise produce prices above marginal acquisition and selling costs. However, in terms of a chain's overall pricing strategy, it cannot exercise fully its market power for each commodity it sells. Charging the monopoly markup of price over full marginal cost, C^T, $(P-C^T)/P = -1/,_{Q,P}$, for each product in the chain's stores would cause a large decrease in N, rendering such an action unprofitable.

A retailer's optimal strategy in pricing 30,000 or more product codes is, accordingly, complicated, and, fortunately, not necessary to model, given that our purpose to explore the implications of retailers' pricing strategies for producers of iceberg lettuce and fresh tomatoes. The essence of our approach is illustrated in figure 16. Q_j denotes sales in a representative retail store for a given produce commodity. $P_j(Q_j)$ is the inverse demand function for the store, indicating the *ceteris paribus* relationship between the price, P, charged by the store and its sales volume. $MR_j(Q_j) = \partial[P_j(Q_j)Q_j]/\partial Q_j$ is the store's marginal revenue from sales of the commodity. C^T represents the store's total marginal costs of acquiring and selling the commodity, which consist of the FOB price, per-unit shipping cost, and marginal selling costs. If the retailer elected to set the price of the commodity competitively, it would set $P_j = C^T$ and sell Q^C units per time period. If the retailer elected to exercise fully its monopoly power for this commodity, it would set sales at the output where $MR_j(Q_j) = C^T$ and set $P_j = P^M$, selling Q^M units. As noted, neither strategy is likely to be optimal for a retailer. Competitive pricing contributes nothing *per se* to a chain's profits, although a low price may help attract more customers to the chain's stores. The monopoly price, P^M, contributes to the chain's profits, but the chain likely cannot fully exploit its market power for each commodity without driving most customers away from its stores.

Suppose the price actually observed is P^*, with per-period sales of Q^*. We then construct the perceived marginal revenue function, $PMR_j(Q_j) = \xi MR_j(Q_j) + (1-\xi)P_j(Q_j)$, consistent with the functional forms chosen for $MR_j(Q_j)$ and $P_j(Q_j)$, so that $PMR_j(Q_j)$ intersects C^T at the observed volume of sales, Q^*. The level of market power implied by the retailer's pricing decision is then >. The expression for the relative markup, taking into account the effect of ξ is the following:

$$(7) \qquad (P - C^T)/P = \xi/\varepsilon_{Q,P},$$

i. e. , the markup is always determined jointly by the implied market power and the price elasticity of the demand curve.

As discussed earlier in the paper and illustrated in figure 2, the range for ξ, viewing the commodity Q in isolation, is $\xi \in [0,1]$, with $\xi = 0$ denoting perfect competition and $\xi = 1$ denoting monopoly. These bounds on ξ need not apply in the multi-product context of a grocery retailer. In particular, $\xi < 0$ may be observed when a commodity is on sale and being used as a "loss leader" to attract customers to the chain's stores, and $\xi > 1$ may represent a rational pricing strategy when substitute and complement relationships among products within the stores are considered.[39]

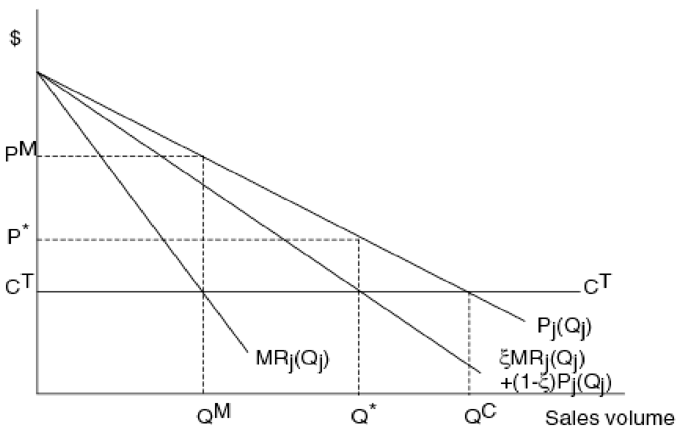
A retailer's sales are a decreasing function of the implied level of market power, ξ, exercised by the retailer, but producer welfare is an increasing function of retailer's sales. Thus, producer welfare is a decreasing function of ξ because market power curtails movement of the product within the retailer's stores and causes diversion of product to lower-valued uses.

The implied values of ξ can be estimated for a retailer and a commodity for each time period,

[39] For example, suppose a retailer wishes to promote sales of its private label brand of a particular product. Clearly, the equivalent national brands will be close substitutes for the private label. In this case, setting a very high markup on the national brand (i.e., $\xi > 1$), rather than a very low markup on the private label, may represent a rational pricing strategy.

Figure 16

Inferring the implied exercise of oligopoly power



given (a) price and sales during that period, (b) an estimate of the demand curve facing the retailer for the commodity, and (c) the retailer's aggregate marginal costs for acquiring, shipping, and selling the commodity. Price and sales per period are available from the IRI data, subject to the caveats about accuracy noted earlier in the paper. Store-level demand functions can be estimated using conventional econometric methods, although problems with accuracy of the data will affect such estimation. As to retailers' costs, FOB prices are observed, as are shipping costs[40] but retailers' selling costs are not observed, nor is it possible to disentangle most of the costs for selling one commodity from the costs associated with the thousands of other commodities the typical retailer sells.

Inability to observe retailers' selling costs was handled in the following manner. We derived an *upper bound* on the implied exercise of a retailer's market power by ignoring these costs, and treating retailer marginal costs simply as the sum of acquisition and shipping costs. For cities where we had multiple chains with usable data for a commodity, we computed a *lower bound* on the implied exercise of market power by assuming that the low-price seller of the commodity in the city sold the commodity on a competitive basis, i. e. , the low-price seller set $P^L = C^T$.[41] Thus, P_t^L was used as a proxy for C^T in computing the implied exercise of market power for all other sellers of the commodity in that city.[42]

An alternative approach is to specify a seller's marginal costs as a function of input prices and estimate a system of equations consisting of an equation for product demand and an equation for seller optimization. Under this approach, information about marginal cost is inferred from the data. Bettendorf and Verboven (2000) provide a recent application of this approach. Applicability of this approach in the present context is very limited for multiple reasons. First, as noted, a retailer's optimization problem involves multiple products and is not easily specified. Second, it is not clear that a reasonable specification can be obtained for the unobserved portion of retailers' marginal costs, namely selling costs. Variable costs associated with selling produce include expenditures for labor and energy (e. g. , for refrigeration). Neither is likely to have varied much over the 2-year period covered by the IRI data, nor do we have access to the prices paid by any of the chains' for these inputs, thus necessitating the use of proxies if this approach were to be utilized.

Store-Level Demand Functions

For each chain and each commodity where we believed the data to be reliable, a demand function of the following form was estimated:

$$Q_t = f(P_t,\ P_t^S), \tag{8}$$

where Q_t and P_t are sales and price, respectively, of the commodity, and P_t^S is the price of a substitute commodity. Sales revenue and product volumes are always reported at the chain level by IRI (i. e. , summed across reporting stores). Because the number of stores reporting information varies across weeks, sales and volume were always converted to a per-store basis. Thus Q_t represents the simple mean of sales for stores in the chain reporting for that period. (P_t and P_t^S, recall, are constant across stores in a chain.) To the extent that sales vary significantly among stores within a chain in a given city, variability in the number

[40] Some error must be acknowledged in the observation of FOB prices and shipping costs. Because FOB prices are typically reported in a range, with high and low prices averaged to construct our FOB price variable, the acquisition costs for a particular retailer may deviate somewhat from what we report.

[41] This approach is similar to the use of competitive "benchmark" prices to measure market power, as discussed by Wann and Sexton (1992).

[42] Although the characterization of P_t^L as an upper bound for C_t^T will generally be valid, it may not be true in periods when the low-price seller offers a promotional price for the commodity and, thus, may set price below C_t^T. Similarly, to the extent that retailers in a given city differ as to their selling costs, error is introduced into the lower bound calculations.

of stores reporting information is another uncontrollable source of error in the analysis.

All other demand determinants (e. g. , consumer income) were assumed to be constant over the 2-year period covered by the data series. For iceberg lettuce, the price of a related lettuce product, either green leaf or romaine, was used for P_t^S . For mature-green and vine-ripe tomatoes, the price of roma tomatoes (the largest selling tomato category after vine ripes and mature greens) was used for P_t^S .

The variables in (8) were specified using the Box-Cox transformation to enable testing for the preferred functional form. The Box-Cox model nests both the popular and convenient linear and double log models, enabling tests to be conducted as to whether the data reject either model. We also conducted a detailed analysis into the structure of the error term in estimating (8), in particular its autoregressive properties. Finally, even among the data series considered most reliable, we still often encountered missing observations and observations on sales that seemed aberrant (see the earlier discussion of the data). Thus, it was important to have systematic testing in place for outliers. Outliers were detected and omitted from the final estimation using the testing procedure described in Belsley, Kuh, and Welsch (1980).

CA-AZ Iceberg Lettuce

The oligopoly power implied by retailers' pricing decisions was analyzed for 12 chains. As noted, six chains maintained constant selling prices throughout 1998-99, making it impossible to estimate a demand function. The implications of this behavior are discussed in the preceding section. Two other chains reported iceberg lettuce sales that we regarded as implausibly low, and, hus, those chains were omitted from the analysis.[43]

Durbin-Watson tests revealed the presence of autocorrelated residuals for each of the 12 chains. In four of the 12 cases, there appeared to be second-order autocorrelation. First-order autocorrelation corrections appeared adequate in the other cases. The Box-Cox tests for functional form generally supported use of the double-log model; it was not rejected in nine of 12 cases.[44] Because of the desirability of utilizing a common model across chains, we elected to work with (8) in the double-log functional form and an AR(2) error structure:

(9) $\ln Q_t = \beta_0 + \beta_1 \ln P_t + \beta_2 \ln P_t^S + \varepsilon_t, \quad \varepsilon_t = \rho_1 \varepsilon_{t-1} + \rho_2 \varepsilon_{t-2} + \rho_t, \quad \upsilon_t \sim N(0, \sigma^2)$.[45]

Table 13 reports results of the analysis of implied oligopoly power for CA-AZ iceberg lettuce. The coefficients in the double log model are elasticities. Thus, $\hat{\beta}_1$ is the estimate of the own-price elasticity of demand for each chain, and $\hat{\beta}_2$ is the estimate of the cross-price elasticity of demand. The estimates of the own-price elasticity of demand for lettuce were statistically significant in 10 of the 12 cases. In 8 of the 12 cases the absolute value of the estimated own-price elasticity was less than 1. 0, indicating an inelastic demand. In three of the remaining cases, the absolute value was between 1. 0 and 1. 1, suggesting that own-price elasticity is nearly unitary for those chains.[46] The coefficient on the substitute commodity price had the hypothesized positive sign in nine of 12 cases, indicating a substitute relationship, but the effect was seldom statistically significant.

[43] The principal PLU codes for iceberg lettuce are 61 and 4061. However, iceberg lettuce may also be assigned to other PLU codes, most notably 4641 and 4634. Choice of product codes for the analysis was done on an individual-chain basis, through detailed analysis of each chain's data.

[44] Hoch *et al.* (1995) also used the double log model to estimate product demand functions for individual grocery retailers.

[45] Some elaboration on the estimation procedure in the presence of autocorrelated errors is necessary.When observations are continuous, estimation methods, such as the Cochrane-Orcutt iterative procedure, are straightforward. Our data sets were discontinuous, both due to missing and outlier observations. Estimation of the models proceeded by first estimating the regression equation by ordinary least squares (OLS) on 104 – m observations, with m denoting the number of omitted observations. $\hat{\rho}_1$ and $\hat{\rho}_2$, were then obtained from the following regression on the OLS residuals, e_t, excluding the first two observations and the two observations following any excluded Greene (1990). The model was then re-estimated on 104 – 2m observations using Q_t^* , P_t^* , and P_t^{S*} . A set of new estimated residuals was then obtained and used to derive updated values of $\hat{\rho}_1$ and $\hat{\rho}_2$. The process was continued until successive estimates of $\hat{\rho}_1$ and $\hat{\rho}_2$ differed by less than 0.001.

[46] Hoch *et al.* (1995) found considerable variation among price elasticities in various food-product categories for individual Dominick's stores in the Chicago area. They showed that about two-thirds of the variation could be explained by demographic and competitive environment variables. Although our results apply to grocery chains within a city, not to individual stores, the arguments posed by Hoch *et al.,* as to why price sensitivities will vary across stores, also apply to our context.

Table 13—Implied Oligopoly Power for CA-AZ Iceberg Lettuce

Chain	Own price Elasticity[1]	Cross price Elasticity[1]	Oligopoly power: upper bound		Oligopoly power: Lower bound	
			Range	Mean	Range	Mean
Atlanta 1	-1.104 (5.603)*	-0.070[2] (0.263)	-0.216, 0.811	0.653	***	***
Chicago 1	-1.503 (3.479)*	-0.055[2] (0.215)	-0.213, 1.119	0.905	***	***
Albany 1	-1.010 (10.679)*	0.123[2] (1.529)	0.218, 0.785	0.557	***	***
Dallas 1	-0.195 (1.930)*	0.242[2] (1.043)	0.021, 0.158	0.124	-0.306, 0.254	0.055
Dallas 2	-1.025 (10.732)*	0.386[2] (2.607)*	-0.031, 0.828	0.540	***	***
Dallas 3	-0.602 (4.524)*	0.035[3] (0.269)	0.189, 0.493	0.358	-0.221, 0.602	0.093
Miami 1	-0.040 (0.128)	0.152[3] (0.477)	0.014, 0.034	0.029	-0.009, 0.018	0.008
Miami 2	-0.300 (1.728)*	-0.172[2] (0.976)	0.110, 0.234	0.202	***	***
LA 1	-0.400 (2.655)*	0.046[3] (0.246)	0.154, 0.327	0.278	-0.616, 0.207	0.039
LA 2	-0.420 (1.632)	0.158[2] (1.047)	0.116, 0.335	0.273	***	***
LA 3	-0.541 (3.542)*	0.001[3] (0.015)	0.115, 0.435	0.310	-0.240, 0.328	0.035
LA 4	-0.164 (1.739)*	0.014[3] (0.508)	0.034, 0.132	0.095	-0.066, 0.078	0.011

[1]Absolute t statistics are reported in parenthesis.
[2]Substitute commodity is romaine lettuce.
[3]Substitute commodity is green-leaf lettuce.
*Denotes statistical significance at the 90% level.
***Denotes the low-price chain or the only reporting chain in the metropolitan area for this commodity.

Table 13 reports both the range across observations and the mean of the implied oligopoly power parameter for both the upper-bound and the lower-bound computation. The largest mean implied oligopoly power is by Chicago 1, with $\hat{\xi} = 0.905$, near the 1. 0 maximum for the single-product case, as an upper-bound calculation. The lowest implied oligopoly power is by Miami 1, with $\hat{\xi} = 0.029$. observation: $e_t = \rho_1 e_{t-1} + \rho_2 e_{t-2} + \upsilon_t$. $\hat{\rho}_1$ and $\hat{\rho}_2$ were then used to transform Q_t, P_t, and P_t^S. For example, $Q_t^* = Q_t - \hat{\rho}_1 Q_{t-1} - \hat{\rho}_2 Q_{t-2}$. In addition, the first two observations in each sequence of continuous observations can be transformed as described, for example, in The mean across chains of $\hat{\xi}$ is 0. 360.[47] The lower-bound computations could be made in only six cases. For the Los Angeles chains, LA 2 had the lowest average price for iceberg lettuce over the sample period. If LA 2 were pricing iceberg lettuce as a perfect competitor, then the market power implied by the other Los Angeles chains pricing is very low, ranging on average over the sample from 0. 011 for LA 4 to 0. 039 for LA 1. Dallas 2 was the low-price seller in the Dallas area. If Dallas 2's price were the competitive price, then the average oligopoly power implied by Dallas 1's and Dallas 3's behavior are, respectively, $\hat{\xi} = 0.055$ and $\hat{\xi} = 0.093$, respectively. The average across the six chains for which we have a mean lower bound on implied oligopoly power is 0. 040.

Our approach generates conservative bounds on the implied exercise of market power. Because marginal selling costs are not zero, the upper-bound calculations are unquestionably high. Similarly, it seems implausible that a retailer would not attach some markup over full marginal cost for a commodity with a relatively inelastic demand, such as iceberg lettuce. Thus, the lower-bound calculations most likely understate the actual

[47] As a comparison to the case of a single-product seller, $\hat{\xi} = 0.36$ is roughly equivalent to the market power that would be exercised by a three-firm oligopoly under Cournot competition.

implied exercise of market power. Thus, we are confident in concluding that most of the chains are setting prices for iceberg lettuce in excess of full marginal costs, but the implied exercise of market power is not especially high for most chains. However, the implications of this conclusion for pricing need to be considered in the context of equation (7). Even modest market power in pricing in conjunction with an inelastic demand can cause a large relative markup of price over full marginal cost. Consider, for example, a hypothetical retailer facing a demand elasticity of $\varepsilon_{Q,P} = -0.609$ (the mean across the 12 chains) and setting price with implied oligopoly power of $\xi = 0.360$ (the mean upper bound). These parameters indicate a relative markup of $(P-C^T)/P = 0.591$, or a price that is more than double full marginal costs.

Vine-Ripe Tomatoes

Data thought to be reliable for vine-ripe tomatoes were available for nine chains. As for iceberg lettuce, Durbin-Watson tests generally indicated the presence of autocorrelated residuals. In five of the nine cases, analysis supported a specification of second-degree autocorrelation. Box-Cox tests supported the double-log specification in seven of nine cases. Thus, for consistency, we again chose to work with the demand model specification indicated in (9)—a double-log model, with second order autocorrelation.[48] In all cases, Roma tomatoes were used as the substitute commodity.[49] Unlike iceberg lettuce, a distinctive wholesaling sector exists for fresh tomatoes. Wholesalers or "repackers", as they are known in the trade, sort tomatoes and check for spoilage, appropriate ripeness, etc. From industry sources, we estimated the repacking charge to be $4. 00 per carton for the period of the analysis. Thus, the upper-bound estimates of implied oligopoly behavior are based on acquisition cost, as measured by the FOB price and repacking costs, including shipping. Because repackers perform functions that otherwise would be performed by retailers, inclusion of these costs for fresh tomatoes increases the accuracy of the upper bound calculations relative to what was possible for iceberg lettuce. When possible, lower-bound calculations on the implied exercise of oligopoly power were also computed, as described previously.

Results of the analysis are summarized in table 14. The estimate of the own-price elasticity of demand is statistically significant in six of the eight cases, and the point estimate indicates an inelastic demand in six of the eight cases. The results suggest that the Roma tomato is not particularly important as a substitute commodity. The coefficient was significant in only two cases, and the hypothesized positive sign, to indicate a substitute relationship, emerged in only five of the eight cases.

The upper-bound estimates of implied oligopoly power vary widely among the chains. The low mean estimate is 0. 09 for Miami 2, and the high mean is 1. 11, i. e. , essentially the equivalent of simple monopoly pricing, for Los Angeles 2. The average of the upper-bound means among the eight chains is 0. 53.[50] Given the limited number of chains in the analysis, we were only able to compute the lower bound estimates for three cases. The mean lower bounds on implied oligopoly power ranged from $\hat{\xi} = 0.057$ (Los Angeles 4) to $\hat{\xi} = 0.333$ (Dallas 4).

Mature-Green Tomatoes

Data considered to be satisfactory were available for 11 chains. We were unable to generate a downward-sloping demand curve for Dallas 3 and, accordingly, it was omitted from the subsequent analysis. The tests for model specification yielded outcomes similar to those obtained for iceberg lettuce and vine-ripe tomatoes—the presence of autocorrelation could not be rejected in all cases with second-order autocorrelation supported in eight of 10 cases. The Box-Cox tests supported use of the double-log model in eight of the 10 instances. Thus, the demand model in (9) was deemed appropriate.

Results of the analysis are summarized in table 15. The estimated own-price elasticity was negative for the remaining 10 chains, and the coefficient was statistically significant in eight of those cases. As was true for vine ripes, Roma tomatoes were not especially effective in the model as a substitute commodity. The estimated cross-price elasticity

[48] The consequence of working with an AR(2) model when the data do not reject an AR(1) specification is a minor loss of efficiency, i.e., an extraneous Δ parameter is being estimated.

[49] Ultimately, Chicago 1 had to be omitted for vine ripes because, despite attempting a variety of model specifications, we were unable to fit a downward-sloping demand function to its data.

[50] As a comparison to the case of a single-product seller, $\hat{\xi} = 0.53$ is roughly equivalent to the market power that would be exercised by a two-firm oligopoly under Cournot competition.

Table 14—Implied Oligopoly Power for Vine-Ripe Tomatoes

Chain	Own price Elasticity[1]	Cross price Elasticity[1]	Oligopoly power: upper bound		Oligopoly power: Lower bound	
			Range	Mean	Range	Mean
Atlanta 2	-0.206	-1.481	0.12, 0.17	0.15	***	***
	(3.808)*	(1.407)				
Albany 1	-1.387	0.440	0.69, 1.01	0.86	***	***
	(9.752)*	(2.632)*				
Dallas 2	-0.971	0.667	0.30, 0.61	0.48	***	***
	(2.547)*	(2.401)*				
Dallas 4	-0.681	-0.005	0.45, 0.54	0.51	0.189, 0.413	0.333
	(1.090)	(0.001)				
Miami 2	-0.145	0.017	0.07, 0.11	0.09	***	***
	(2.538)*	(0.330)				
LA 2	-1.590	0.221	0.58, 1.30	1.11	***	***
	(10.881)*	(1.006)				
LA 3	-0.874	-0.658	0.43, 0.80	0.69	-0.395, 0.688	0.177
	(3.414)*	(1.571)				
LA 4	-0.445	0.019	0.30, 0.37	0.35	-0.146, 0.294	0.057
	(1.731)*	(0.081)				

[1]Absolute t statistics are reported in parenthesis.
*Denotes statistical significance at the 90% level.
***Denotes the low-price chain or the only reporting chain in the metropolitan area for this commodity.

was positive in only six of the 10 cases, and was statistically significant in four of those instances.

The mean upper-bound estimates on implied oligopoly power varied from 0. 076 (Los Angeles 1) to 1. 156 (Dallas 4). The average of the upper-bound means across chains was $\hat{\bar{\xi}} = 0.482$. We were able to compute the lower-bound estimates for six chains. They range from a low of 0. 021 (Los Angeles 1) to a high of 0. 748 (Dallas 4), with a mean value of $\hat{\bar{\xi}} = 0.203$.

Summary of Analysis of Pricing Behavior to Consumers

The implications for consumers from retailers' pricing behavior cannot be discerned from analysis of a few produce commodities. However, the manner in which retailers set prices for these commodities does have implications for producers, and this was the focus of our analysis. Estimation of chain-level demand functions for iceberg lettuce, vine-ripe tomatoes, and mature-green tomatoes revealed inelastic demands in the vast majority of cases. Retailers who face inelastic demands for products have the opportunity to exploit those demands by marking price up in excess of full marginal costs. The extent of this markup reveals the market power implied by the retailers' decision. Because we lacked information on retailers' selling costs, our estimation of the implied market power cannot be precise. Rather, we generated a set of upper-bound and lower-bound estimates.

Even based on the upper-bound calculations, it seems clear that retailers' are not fully exploiting consumers' inelastic demands for produce commodities in their pricing decision. This result is consistent with the intuitive model of consumer shopping behavior set forth here. Consumers' willingness and ability to consider multiple stores to conduct a given shopping trip serves as a brake on retailers' pricing. On the other hand, the estimates indicate that most retailers are setting prices for iceberg lettuce and fresh tomatoes in excess of full marginal costs. The results were rather consistent across the three commodities in the extent of markups indicated. These markups curtail movement of the commodity within the chain and increase the amount of a given harvest that must be diverted to lower-valued uses. Such retailer markups of price are, thus, harmful to producer welfare.

Table 15—Implied Oligopoly Power for Mature-Green Tomatoes

Chain	Own price Elasticity[1]	Cross price Elasticity[1]	Oligopoly power: Upper bound		Oligopoly power: Lower bound	
			Range	Mean	Range	Mean
Atlanta 1	-0.883 (7.617)*	0.020 (0.157)	-0.161, 0.744	0.587	***	***
Atlanta 2	-0.481 (3.926)*	-0.098 (0.382)	0.169, 0.410	0.340	-0.566, 0.327	0.039
Dallas 1	-0.396 (2.027)*	0.091 (0.939)	0.200, 0.396	0.275	0.048, 0.227	0.152
Dallas 2	-0.854 (6.702)*	0.537 (4.458)*	0.080, 0.591	0.403	***	***
Dallas 4	-1.600 (6.672)*	-0.164 (0.625)	0.639, 1.368	1.156	0.249, 1.030	0.748
Miami 1	-0.513 (2.791)*	-0.083 (0.508)	0.050, 0.438	0.321	***	***
LA 1	-0.107 (0.441)	0.162 (1.705)*	0.051, 0.090	0.076	-0.083, 0.079	0.021
LA 2	-1.025 (5.348)*	1.288 (6.391)*	0.036, 0.815	0.627	***	***
LA 3	-1.315 (8.390)*	0.605 (2.912)*	0.386, 1.117	0.906	-0.917, 1.040	0.217
LA 4	-0.174 (0.643)	-0.014 (0.044)	0.070, 0.146	0.125	-0.083, 0.138	0.042

[1]Absolute t statistics are reported in parenthesis.
*Denotes statistical significance at the 90% level.
***Denotes the low-price chain or the only reporting chain in the metropolitan area for this commodity.

Retailer Pricing Behavior for Bagged Salads

Bagged or packaged salads have been a high-growth segment of the produce industry. Calvin *et al.* (2000) report that 462 lettuce-based bagged salad items (i. e. UPC codes) existed in 1999, compared to 202 items in 1993. Sales in the fresh-cut salad category reached nearly $1. 9 billion in 2000, based on A. C. Nielson statistics. The largest selling category is iceberg-based blends, with a cumulative 39 percent market share in 2000. Salad blends, featuring a combination of lettuce types, comprised 30 percent of sales at the same time, with salad kits accounting for 13 percent of sales.

The basic technology to prepare bagged salads is not complicated, and many lettuce shippers entered this segment of the industry during its rapid growth stage during the 1990s.[51] The bagged salad sector has since consolidated. Calvin *et al.* report that the top two sellers (Fresh Express and Dole) held a combined 75. 5 percent share in 1999 of supermarket sales for fresh-cut salads. A third firm, Ready Pac, had a market share near 8 percent, with private-label brands jointly comprising 9. 7 percent.

Our analysis focuses on the traditional iceberg-based (IBB), fresh-cut salad. It remains the largest seller, each of the top three manufactures produces one or more sizes of this product, and we are able to analyze pricing links to the farm input, iceberg head lettuce, which comprises the essential ingredient to producing an IBB salad.

Our analysis for IBB salads necessarily differs from the preceding analysis conducted for iceberg head lettuce and fresh tomatoes, due to differences in the available information. Notably, we lack information on processing costs and on the pricing arrangements between processors and retailers, including fees paid by processors. Thus, we are unable to conduct formal investigations of oligopoly or oligopsony power. Nonetheless, some useful conclusions emerge based on the information that is available.

Table 16 provides an overview of pricing behavior for IBB salads for the 20 retail chains. The table reports mean price per lb. and variance of price (in parentheses) for each brand of IBB salad carried by the chain, including its own private label. Most chains carried multiple sizes of each brand (e. g., 16 oz, 32 oz, 48 oz), and the price reported is a

[51] Thompson and Wilson (1999) estimated the upfront investment costs to process fresh-cut salads to be in the range of $20-30 million.

Table 16—Retailer Mean Price and Variance of IBB Packaged Salads

	Private Label[1]	Fresh Express[1]	Dole[1]	Ready Pac[1]	Head Lettuce[1]
LA 1	1.404 (0.050)				1.087 (0.064)
LA 2		1.526 (0.063)	1.416 (0.029)	1.356 (0.049)	0.953 (0.022)
LA 3			1.486 (0.008)	1.490 (0.007)	1.026 (0.033)
LA 4		1.685(0.005)		1.490 (0.011)	1.027 (0.038)
Dallas 1	1.652 (0.023)				1.233 (0.049)
Dallas 2			1.354 (0.015)		0.923 (0.020)
Dallas 3		1.410 (0.053)			1.121 (0.060)
Dallas 4		1.901 (0.032)			1.253 (0.012)
Dallas 5		1.331 (0.038)	1.943 (0.115)		0.950 (0.000)
Atlanta 1		1.702 (0.041)			1.193 (0.026)
Atlanta 2		1.724 (0.122)			1.252 (0.059)
Atlanta 3	1.636 (0.042)	1.685 (0.121)			1.210 (0.000)
Chicago 1		1.625 (0.044)	1.977 (0.146)		1.237 (0.006)
Chicago 2		1.896 (0.028)	1.931 (0.019)		1.400 (0.000)
Chicago 3		2.035 (0.147)			1.100 (0.000)
Miami 1	1.487 (0.052)				1.270 (0.047)
Miami 2		1.668 (0.080)	1.605 (0.049)		1.004 (0.029)
Miami 3	1.394 (0.003)	1.882 (0.023)	1.520 (0.002)		1.210 (0.000)
Albany 1	1.630 (0.038)		1.619 (0.068)		1.111 (0.044)
Albany 2			1.430 (0.079)		1.290 (0.000)

[1]Variances are indicated in parentheses.

sales-weighted average across size categories. The average and variance for the chain's iceberg head lettuce price is also provided for comparison. An immediate point of interest in table 16 is the variety of behaviors exhibited among the retailers as to how many and which brands of IBB salads to carry. Among our sample chains, only the Los Angeles chains carried Ready Pac IBB salads,[52] and none carried minor brands outside of the top three. Only Los Angeles 2 carried all three leading brands of IBB salads. Seven chains carried two brands—Fresh Express and Dole in five of those cases, with Dole and Ready Pac and Fresh Express and Ready Pac in the others. Six chains carried a private label brand. Among those chains, three carried only their private label brand, two carried their private label and one other brand (Dole, in each case), while the other carried both Dole and Fresh Express. Finally, three chains carried Fresh Express IBBs exclusively, while two carried Dole IBBs exclusively.[53]

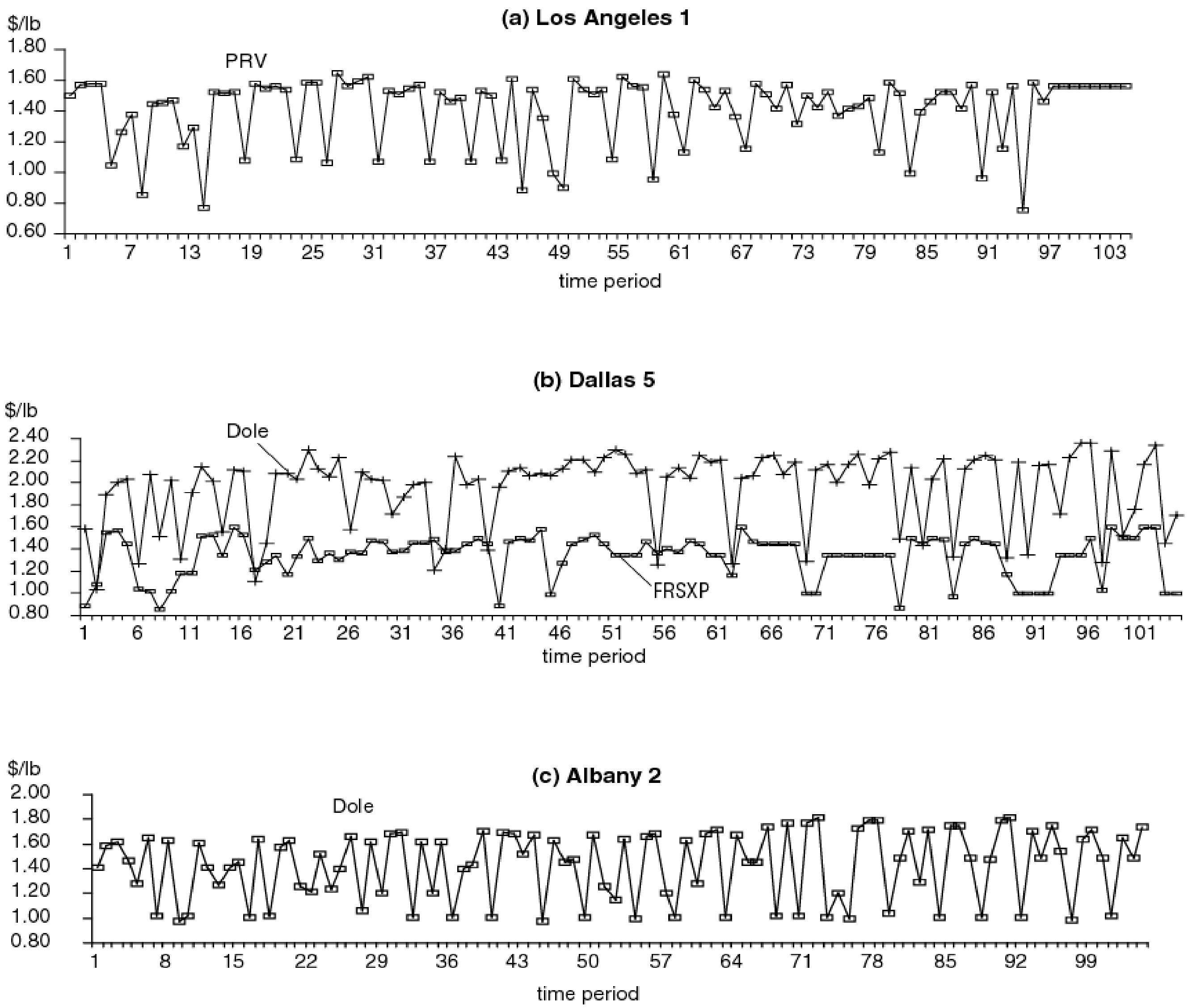
Of similar interest to the decision as to how many and which brands to carry are the decisions as to pricing strategy. Figure 17 illustrates price per pound for 1998-99 for six chains for each IBB salad brand carried by the chain. The six were chosen because they illustrate the range of pricing behaviors practiced by the 20 chains in the sample. Panel (a) illustrates pricing for Los Angeles 1 for its private label, the only IBB salad it carries. While LA 1 charges an average price per lb. that is lower than the price charged by its Los Angeles competitors for the national brands in all but one case (LA 2's pricing of Ready Pac), the price varies considerably from week to week. LA 1 follows a strategy of setting its private label price at about $1. 60/lb for 3-to-5 week intervals, and then offering a promotional price, often less than $1. 00/lb for a 1-week period. Albany 2, illustrated in panel (c), uses a somewhat similar strategy for pricing Dole's IBBs, the only brand it carries.

The converse of the preceding behavior is the every-day-low-price strategy practiced by Miami 3, illustrated in panel (e). Miami 3 carries Dole and Fresh Express, in addition to its own private label. Miami 3 maintained its private label price in the range of $1. 40/lb below the prices it charged for either Fresh Express or Dole. It maintained

[52] Ready Pac tends to specialize in producing salad blends. Several of the chains which did not carry Ready Pac IBB salads carried other product categories by Ready Pac.

[53] It is important to emphasize that this information applies only to IBBs. It was quite common among the sample chains to carry other salad items from a processor, e.g., Ready Pac, even though the chain did not carry the processor's IBBs.

Figure 17
Alternative Retailer Pricing Strategies for Fresh-Cut Salads

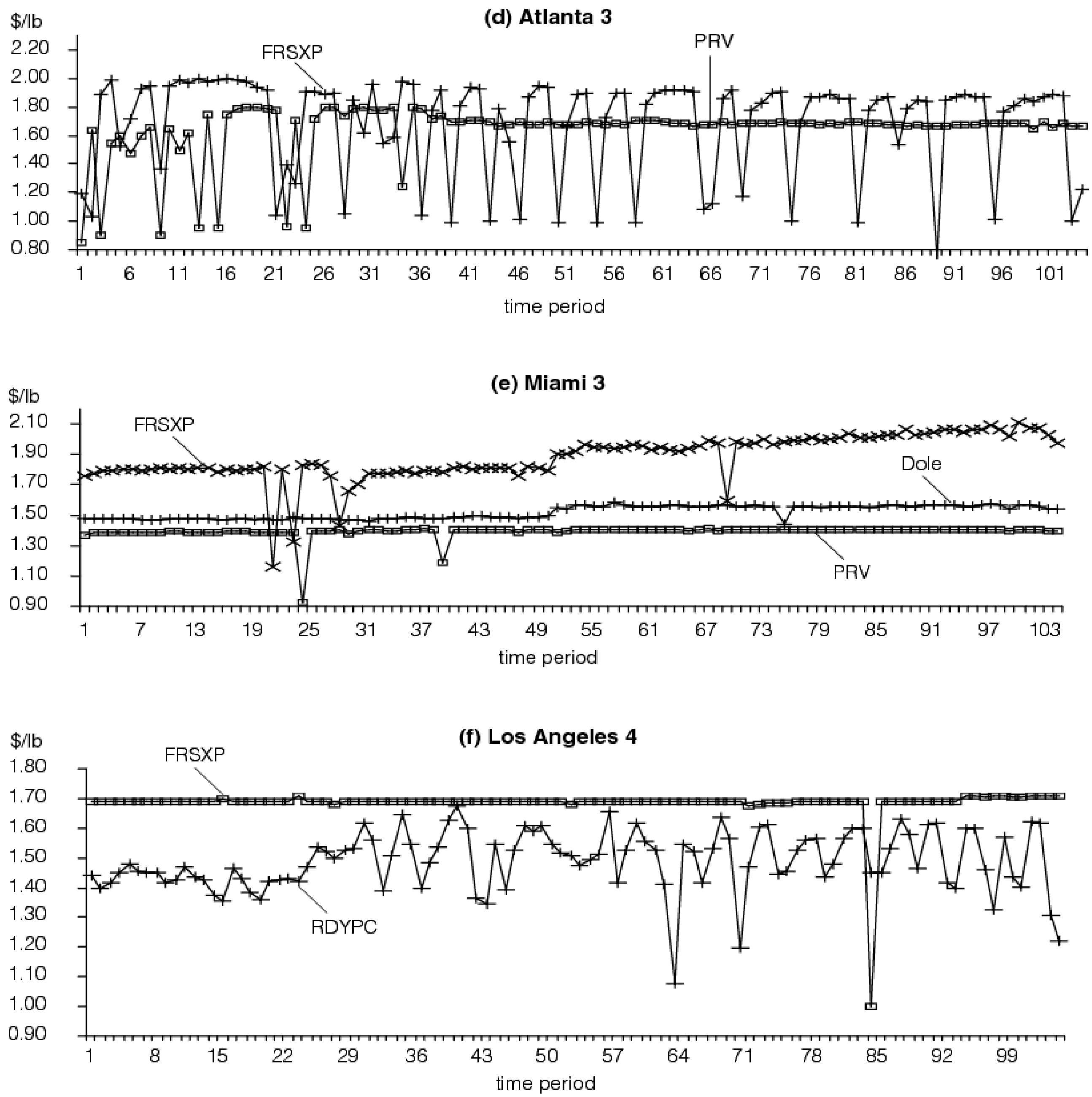


relatively stable prices for these brands as well, although it set a premium price for Fresh Express, on average $0. 26/lb more than it charged for Dole. This price ranking between Dole and Fresh Express is not, however, consistent among retailers. Of the six chains that carried both, Dole had the higher average price in half of the cases. Dallas 5 in panel (b) illustrates a case where Dole commands the premium price relative to Fresh Express, and both items are subject to periodic price promotions.

Atlanta 3 carries its own private label and a single brand, Fresh Express. As illustrated in panel (d), Atlanta 3 has chosen to maintain a rather constant price for its private label of about $1. 60/lb, while using Fresh Express' IBB salad as a promotional item. Although Atlanta 3's price for Fresh Express was higher on average than its private label price, for many weeks during 1998-99 Atlanta 3 set a promotional price of about $1. 00/lb for Fresh Express that was much less than its private label price. Finally, LA 4, depicted in panel (f), illustrates a strategy whereby Fresh Express is sold at a relatively constant premium price, and Ready Pac is offered as a low-price alternative, which is also featured on periodic price promotions.

Figure 17—continued

Alternative Retailer Pricing Strategies for Fresh-Cut Salads



Further insight into the coordination or lack thereof in retailers' pricing decisions for IBB bagged salads is provided in table 17. This table is organized on a city-by-city basis and contains correlation coefficients for the prices charged by each chain in the city for the brands of IBB salads it carries and its iceberg head lettuce price.[54] Correlations of these prices with the FOB iceberg lettuce price are also provided. Several conventions are utilized in the table to highlight key information. Shading is used to highlight blocks of

[54] Albany was omitted from this table because information was available for only two chains, each of which had limited selection of IBB salads.

Table 17—Price Correlations for IBB Salads, Iceberg Head Lettuce, and FOB Price

Dallas

	FOB	Dallas 1 Private Label	Dallas 1 Head	Dallas 5 Fresh Express	Dallas 5 Dole	Dallas 5 Head	Dallas 2 Dole	Dallas 2 Head	Dallas 4 Fresh Express	Dallas 4 Head	Dallas 3 Fresh Express	Dallas 3 Head
FOB	1.000											
Dallas 1 Private Label	0.056	1.000										
Dallas 1 Head	0.388	0.052	1.000									
Dallas 5 Fresh Express	-0.067	0.019	0.031	1.000								
Dallas 5 Dole	-0.274	-0.021	-0.118	0.438	1.000							
Dallas 5 Head	.	.	.	.	.	.						
Dallas 2 Dole	0.078	0.086	-0.088	0.018	**0.056**	.	1.000					
Dallas 2 Head	0.605	0.075	*0.283*	0.091	-0.208	.	0.084	1.000				
Dallas 4 Fresh Express	0.047	0.016	-0.141	**-0.051**	0.004	.	0.039	0.039	1.000			
Dallas 4 Head	0.061	0.009	*0.069*	0.068	0.148	.	-0.242	*0.008*	-0.193	1.000		
Dallas 3 Fresh Express	0.050	0.004	0.078	**-0.062**	-0.063	.	0.187	0.002	**-0.156**	0.382	1.000	
Dallas 3 Head	0.412	-0.010	*0.279*	0.030	-0.038	.	0.051	*0.417*	-0.072	*-0.036*	-0.141	1.000

Los Angeles

	FOB	LA 1 Private Label	LA 1 Head	LA 2 Fresh Express	LA 2 Dole	LA 2 Ready Pac	LA 2 Head	LA 3 Dole	LA 3 Ready Pac	LA 3 Head	LA 4 Fresh Express	LA 4 Ready Pac	LA 4 Head
B	1.000												
1 Private Label	0.110	1.000											
1 Iceberg	0.688	0.073	1.000										
2 Fresh Express	-0.133	0.124	-0.035	1.000									
2 Dole	-0.169	0.015	-0.279	0.389	1.000								
2 Ready Pac	0.103	0.021	0.139	-0.083	-0.063	1.000							
2 Head	0.446	0.174	*0.613*	0.005	-0.238	0.125	1.000						
3 Dole	-0.237	0.015	-0.405	0.179	**0.385**	-0.330	-0.146	1.000					
3 Ready Pac	0.011	0.133	-0.007	0.018	0.216	**-0.349**	0.072	0.137	1.000				
3 Head	0.534	0.029	*0.775*	-0.047	-0.465	0.122	*0.717*	-0.332	-0.078	1.000			
4 Fresh Express	0.033	0.009	0.027	**-0.078**	-0.002	0.065	-0.008	-0.155	-0.027	0.014	1.000		
4 Ready Pac	-0.201	-0.032	-0.280	0.221	0.214	**-0.014**	-0.178	0.058	**0.032**	-0.272	0.028	1.000	
4 Head	0.456	0.063	*0.660*	0.063	-0.268	-0.032	*0.659*	-0.192	0.046	*0.733*	0.019	-0.232	1.000

Miami

	FOB	Miami 1 Private Label	Miami 1 Head	Miami 3 Private Label	Miami 3 Fresh Express	Miami 3 Dole	Miami 3 Head	Miami 2 Fresh Express	Miami 2 Dole	Miami 2 Head
FOB	1.000									
Miami 1 Private Label	0.017	1.000								
Miami 1 Head	0.345	0.049	1.000							
Miami 3 Private Label	0.036	0.043	-0.040	1.000						
Miami 3 Fresh Express	-0.198	0.136	-0.086	0.146	1.000					
Miami 3 Dole	-0.242	0.042	-0.125	0.212	0.710	1.000				
Miami 3 Head	.	.	.	.	.	.	.			
Miami 2 Fresh Express	-0.169	0.095	0.085	-0.054	**-0.050**	0.088	.	1.000		
Miami 2 Dole	0.081	-0.138	-0.019	-0.091	-0.264	**-0.283**	.	-0.130	1.000	
Miami 2 Head	0.742	-0.009	*0.559*	0.128	-0.215	-0.230	.	-0.007	0.032	1.000

Table 17—Price Correlations for IBB Salads, Iceberg Head Lettuce, and FOB Price—continued

Atlanta

	FOB	Atlanta1 Fresh Express	Atlanta1 Head	Atlanta3 Private Label	Atlanta3 Fresh Express	Atlanta3 Head	Atlanta2 Fresh Express	Atlanta2 Head
FOB	1.000							
Atlanta 1 Fresh Express	0.102	1.000						
Atlanta 1 Head	-0.012	0.129	1.000					
Atlanta 3 Private Label	-0.266	-0.122	0.296	1.000				
Atlanta 3 Fresh Express	-0.058	**0.014**	-0.137	-0.005	1.000			
Atlanta 3 Head	.	.	.	.	.	.		
Atlanta 2 Fresh Express	-0.071	**0.011**	-0.017	-0.116	**0.011**	.	1.000	
Atlanta 2 Head	0.472	0.078	*0.243*	0.003	-0.021	.	-0.083	1.000

Chicago

	FOB	Chicago2 Fresh Express	Chicago2 Dole	Chicago2 Head	Chicago3 Fresh Express	Chicago3 Head	Chicago1 Fresh Express	Chicago1 Dole	Chicago1 Head
FOB	1.000								
Chicago 2 Fresh Express	0.016	1.000							
Chicago 2 Dole	0.053	0.249	1.000						
Chicago 2 Head	.	.	.	.					
Chicago 3 Fresh Express	-0.153	**0.046**	0.195	.	1.000				
Chicago 3 Head	.	.	.	.	.	.			
Chicago 1 Fresh Express	-0.028	**0.090**	0.286	.	**0.206**	.	1.000		
Chicago 1 Dole	-0.007	-0.030	**0.055**	.	-0.073	.	0.145	1.000	
Chicago 1 Head	-0.052	-0.077	-0.188	.	0.055	.	0.017	0.025	1.000

correlation coefficients for the prices charged by a given chain. Correlations of prices charged by different chains for a given brand (i. e. , Fresh Express, Dole, and Ready Pac) are indicated by bold face, and correlations of prices for head lettuce across chains are indicated in italics. Empty cells reflect retailers who maintained a constant iceberg head lettuce price throughout the sample period.

Recall that correlation coefficients fall in the range of –1. 0 (perfect negative correlation) to 1. 0 (perfect positive correlation), with values near zero indicating very little correlation between the movements of the particular price pair. The central message of table 17 is that prices within a city for IBB salads tend to exhibit very low levels of correlation. Indeed, in many cases the correlation is negative, indicating prices that move on average in opposite directions.

Correlations of the retail prices with the FOB iceberg lettuce price are provided in the first column of each correlation matrix. In many cases, retailers' prices for iceberg head lettuce are positively correlated with the FOB price for iceberg lettuce. For example, among the Dallas chains, these correlations range from 0. 061 (Dallas 4) to 0. 605 (Dallas 2). However, the correlations between the iceberg FOB price and the bagged salad prices are invariably low, and are often negative. The clear message is that the link between the farm-gate price and the retail price for IBBs is almost completely attenuated, even though iceberg lettuce is the central ingredient in an IBB salad. Consider, for example, the Los Angeles chains. Four of the branded salad prices are negatively correlated with the FOB price, and the highest positive coefficient is only 0. 110 (LA 1 private label).

Further consideration of the price patterns in figure 17 helps in understanding the lack of correlation between movements in the FOB price and the chains' prices for IBB salads. Many chains choose to use IBBs for price promotions. The promotions tend to follow an imprecise, but regular cycle. The correlation coefficients suggest that promotions are not coordinated with movements in the FOB price. The alternative strategy, to maintain stable prices for particular brands of IBBs, also, of course, results in low levels of correlation with the highly volatile FOB price.

Consider now the bold-faced coefficients, indicating correlations between chains' prices for the same brand of IBB. They, too, are invariably low. Three of four instances are negative for the Dallas chains, three of five are negative for the Los Angeles chains, and two of three are negative for Miami. The correlations of prices within brands are positive, but essentially zero, for both Atlanta and Chicago. Clearly there is no coordination among the chains in making pricing decisions for IBB salads in any of the sample cities. The correlations for iceberg head lettuce prices (indicated by italics) within a city are generally higher, but in all cases they are considerably less than 1. 0. Because retailers in the same city face similar or identical FOB prices and shipping costs for iceberg lettuce, the expectation is that retail prices within a city should be highly correlated. The fact that the correlation coefficients are generally in the range of 0. 5 to 0. 7 indicates that there is considerable independence among retailers in pricing iceberg lettuce.

Finally, the shaded portions of table 17 reveal little correlation of prices within a chain for iceberg head lettuce and IBB salads. For example, for the Dallas chains, the correlations of the chain's head lettuce price with its IBB salad price range from – 0. 193 (Dallas 4) to 0. 084 (Dallas 2). It is not clear from a strategic perspective what relationship to anticipate for these within-chain correlations. If a chain were passively setting prices based upon its costs, the prices should all move together, as a function of the FOB price. As table 17 shows, this tends not to happen. The most likely explanation for the near independence of the IBB and head lettuce price movements within a chain is simply that each price is set independently, with little or no attempt made to develop a coordinated pricing strategy across the iceberg products.

To further investigate the relationship between price movements at the farm level for iceberg lettuce and price movements at retail for IBB, we specified regression equations of the following form:

(10)

$$\Delta P_t^R = \beta_0 + \beta_1 \Delta P_t^F + \beta_2 \Delta P_{t-1}^F + \beta_3 \Delta P_{t-2}^F + \beta_4 \Delta P_{t-3}^F .$$

In (10), $\Delta P_t^R = P_t^R - P_{t-1}^R$ is the change in retail price for an IBB salad product, and $\Delta P_t^F = P_t^F - P_{t-1}^F$ is the corresponding change in the FOB price for iceberg lettuce. ΔP_{t-j}^F thus denotes ΔP_t^F lagged j times.

Thompson and Wilson (1999) report that bagged salads have a shelf life of 14-18 days. Allowing up to a week for product to move from the field to the shelf, we have a three to four week window of time over which a price change at the farm level may influence price at retail. Thus, in addition to the contemporaneous change in price at the farm level, we also specify ΔP_t^R as a function of 1-period, 2-period, and 3-period lags of ΔP_t^F.

Equation (10) was estimated for each IBB salad brand carried by each chain. For parsimony of presentation, we present only the results for Fresh Express in table 18. The results for the other national brands and for the private-label brands were very similar to the Fresh Express results. The results in table 18 reveal no consistent relationship between the prices retailers are setting for Fresh Express IBB salads and contemporaneous and lagged movements in the FOB price. Signs are not consistent across chains, most coefficients are not statistically significant, and total explanatory power of the regressions, as measured by the adjusted R^2 statistic is extremely low. The results from estimating (10) reaffirm the fundamental fact that pricing at retail for IBB salads bears essentially no relation to pricing outcomes at the farm level. Because IBBs retain the closest link among bagged salads to a farm product input, we would anticipate that a similar conclusion applies to other bagged salad products, such as blends and kits

Table 18—Price Equations for Fresh Express Bagged Salads[1]

City/Chain	Constant	{delta}P^F_t	{delta}P^F_t-1	{delta}P^F_t-2	{delta}P^F_t-3	Adjusted R^2
Atlanta 1	-0.000	0.381	-0.029	-0.065	0.336	-0.025
	(0.003)	(0.982)	(0.073)	(0.171)	(0.953)	
Atlanta 2	0.003	-0.199	-0.062	-0.096	0.514	-0.027
	(0.068)	(0.331)	(0.102)	(0.163)	(0.937)	
Atlanta 3	-0.004	0.345	0.351	-0.507	0.854	-0.018
	(0.087)	(0.515)	(0.518)	(0.775)	(1.401)	
Chicago 1	0.003	-0.180	-0.303	0.172	-0.380	-0.009
	(0.122)	(0.638)	(1.061)	(0.623)	(1.476)	
Chicago 2	-0.000	0.077	0.315	0.217	-0.127	-0.011
	(0.016)	(0.257)	(1.044)	(0.745)	(0.467)	
Chicago 3	0.008	0.818	-0.377	-0.033	0.316	0.003
	(0.254)	(1.851)*	(0.845)	(0.077)	(0.785)	
Dallas 3	0.000	0.054	0.413	-0.087	0.268	-0.025
	(0.010)	(0.141)	(1.063)	(0.232)	(0.765)	
Dallas 4	0.007	-0.170	0.205	-0.710	0.417	0.024
	(0.309)	(0.559)	(0.666)	(2.392)*	(1.506)	
Dallas 5	-0.006	0.309	0.139	-0.205	0.188	-0.020
	(0.254)	(1.019)	(0.453)	(0.694)	(0.682)	
Miami 2	0.004	-0.366	0.016	0.594	0.737	0.050
	(0.110)	(0.833)	(0.037)	(1.340)	(1.654)*	
Miami 3	0.002	-0.039	-0.089	-0.006	0.106	-0.033
	(0.145)	(0.198)	(0.459)	(0.032)	(0.536)	
LA 2	0.003	0.156	-0.054	0.066	0.017	-0.027
	(0.297)	(1.140)	(0.387)	(0.493)	(0.135)	
LA 4	0.000	-0.040	0.129	-0.145	0.068	-0.025
	(0.008)	(0.292)	(0.940)	(1.102)	(0.552)	

[1]Absolute t statistics are indicated in parentheses.
* Denotes statistical significance at the 90 percent level.

Conclusions

Consolidation among grocery retailers has caused concern about the state of competition in food marketing. This study has investigated grocery retailer behavior in the procurement and selling of iceberg lettuce, fresh tomatoes, and bagged salads. The emphasis throughout has been on the implications of retailers' behavior for the welfare of producers. Knowing the effects of retailer behavior on consumer welfare would require a comprehensive analysis across product categories.

The analysis involved three major components. First, we conducted a detailed analysis of farm-retail price spreads (margins) for California-Arizona iceberg lettuce, vine-ripe tomatoes from California, and mature-green tomatoes from both California and Florida. A central point of the price-spread analysis was to investigate the role of total shipments in influencing the price spread. Under competitive procurement of the aforementioned commodities, there is little reason for the shipment volume to affect the margin. However, under imperfect competition, the hypothesis offered was that high shipments volume for a perishable commodity would diminish the bargaining power of sellers, relative to buyers, and lead to a widening of the margin. This effect was confirmed for each of the commodities studied. An additional result of note from the margin analysis was that transportation costs did not have the effect predicted by a model of perfect competition. Changes in shipping costs tended to have little effect on the price spread. This result is also consistent with imperfect competition in procurement, because buyers with market power rationally absorb a portion of shipping costs. It is also consistent with an objective of retailers to stabilize prices to consumers.

We conducted formal tests for buyer market power in procurement of the fresh produce commodities, based upon the pricing model developed by Sexton and Zhang (1996). Estimation results for iceberg lettuce supported the earlier conclusion of Sexton and Zhang that retailers were able to capture the lion's share (about 80 percent) of the market surplus, whereas under competitive procurement, the entire surplus would go to producers. These results also lend support to the finding from the price-spread analysis that large harvest volumes served to reduce sellers' relative bargaining power. Application of the model to fresh tomatoes yielded rather mixed results. Parameters were generally estimated imprecisely, and a hypothesis of perfect competition in procurement could not be rejected for either Florida or California mature-green tomatoes. Based on the parameter estimates, producers' share of the market surplus is considerably higher for tomatoes than for iceberg lettuce. Florida's mature-green tomato industry, in particular, appeared to have been effective in utilizing collective action to maintain a floor on its selling price and capture a substantial share of the market surplus in excess of the floor.

Retailer market power in selling to consumers is also harmful to producers because it curtails product movement and forces diversion of the product to lower-valued uses. We used a simple framework to develop estimates of retailers' implied oligopoly power in setting prices to consumers for iceberg lettuce and fresh tomatoes. The evidence suggested that retailers are setting prices for these commodities in excess of full marginal costs, but are not exploiting the magnitude of market power available to them, based upon the estimated price elasticities of demand. Also noteworthy was that several retailers maintained constant selling prices for iceberg lettuce throughout our 2-year sample period. Although such pricing may be part of a rational retailer strategy to attract and retain customers, we showed that fixing or stabilizing prices was, in general, harmful to producer welfare, because it leads to greater price volatility in the segments of the market that do not hold prices fixed.

Our analysis for bagged salads revealed a great diversity among retailers as to strategy for this segment of the market. Focusing on iceberg-based salads, we showed that chains differed both in terms of pricing and product selection, including whether to carry a private-label brand. The data revealed no evidence of coordination among retailers in setting prices. The analysis also revealed a nearly complete absence of a relationship between the farm-level price for iceberg lettuce and the prices set at retail for bagged salads.

On balance, we believe that the evidence supports a conclusion that buyers are often able to exercise oligopsony power in procuring fresh produce commodities. This result should not be surprising, given the structural conditions in these markets. The apparent success of the Florida mature-green tomato industry in enforcing a price floor and capturing a significant share of the surplus in excess of the price floor demonstrates the potential benefits to producers through the coordinated behavior allowed them under the law.

The structure of grocery retailing necessarily gives large retailers some degree of market power in terms of an ability to influence price. Ample evidence of this power is the wide variety of pricing strategies that were manifest for the commodities included in this study. However, there was no evidence of coordinated pricing or collusion among retailers in a given city. To the extent that retailers are exercising market power, in the sense of marking up prices in excess of full marginal costs, they are exploiting the unilateral monopoly power they possess through geographic and brand differentiation. The pricing behavior is not the result of coordination with other retailers.

Occasional concerns over data quality, and the wide variety of pricing strategies followed by retailers both limit our ability to make inferences concerning market power. As always, it was necessary to make certain assumptions to facilitate testing hypotheses concerning market power. On balance however, retailers' pricing behavior to consumers probably works to the detriment of produce grower-shippers. Markups of price above cost curtail product movement to the retail sector. Retail prices held constant in the face of fluctuating farm-gate prices also cause diversion of product to lower-valued uses. The timing of sales promotions for produce items bears little or no relationship to prices at the farm level. Retailers thus appear to be acting in their own perceived best interest in making these pricing decisions. Closer coordination appears to be evolving between grower-shippers and retailers, and perhaps this coordination can result in retail pricing decisions that better serve both retailers' and producers' interests.

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