Estimating Market Power and Pricing Conduct for Private-Label and National Brands in a Product-Differentiated Oligopoly: The Case of a Frozen Vegetable Market

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This paper develops two brand-level demand models, where prices are treated as endogenous, to estimate unilateral market power in a representative product-differentiated oligopolistic food market. The results are estimated using point-of-purchase scanner data and are used to quantify the impact of a private-label brand on the economic performance of national brands. Specifically, our study calculates demand parameter estimates and returns to retailer vertical coordination for the frozen vegetable market—the third largest private-label food and beverage category in the United States, after ice cream and carbonated beverages. Consistent with broader industry trends, empirical evidence suggests that the private-label brand maintained a slight competitive advantage over Birds Eye and Green Giant.

Introduction

Market growth in private-label goods or store brands, now a $43.3 billion industry annually, has revolutionized food-marketing strategies. Store brands can provide retailers a manner by which to distinguish themselves from their competitors and capture greater profits through vertical coordination. According to a recent Gallup study, three-fourths of consumers attribute similar levels of quality and performance to store brands and national brands, and an even greater percentage (83 percent) purchase store brands on a regular basis (Private Label Manufacturers Association, 1999). This situation can be compared to a 1992 Roper Organization study, which suggested that only 50 percent of consumers claimed private-label quality equal to that of national-brand quality, and a 1993 Food Marketing Institute study in which only one-fifth of all consumers bought some private-label goods (Giblen and Gecel, 1995).

In 1997, the market for private-label foods increased 4 percent, reaching a 20 percent market share, while the food industry as a whole increased only 1 percent (Balu, 1998). The United States is not the only country in which private labels are increasing in popularity. In Canada, private labels account for one-fourth of all sales (Dunne and Narasimhan, 1999). Private labels in Western Europe are even more popular, holding a 43 percent market share in the United Kingdom (UK), 34 percent in Belgium, 28 percent in Germany, and 21 percent in France (*Frozen and Chilled Foods*, 1999). Cotterill (1997) contends that U.S. consumer demand for private labels will continue to grow as the U.S. manufacturer-led model converges with the UK retailer-led model, creating a common organizational structure comprised of global brands, common technology, and similar operating strategies.

While private label is not a new idea (that is, A&P has been selling private-label goods for more than a century), food companies have been actively positioning themselves to further take advantage of this trend. *Progressive Grocer* (1999) claimed that 87 percent of wholesalers cited store brands as a major marketing thrust for 1999. The Kroger Company—which recently purchased Fred Meyer, Inc., making Kroger the number-one food retailer in the United States—stocks almost 25 percent of its shelf space with store brands (*Los Angeles Times*, 1998). Wal-Mart, a major U.S. food-retailing concern, has been manufacturing private-label items since 1993 for distribution worldwide, and the Albertson's 1998 purchase of the Jewell and Lucky chains further increased Wal-Mart's store brand foothold.

The empirical objective of this paper is to estimate unilateral market power in a product-differentiated oligopolistic food market in an effort to quantify the impact of a private-label brand on the economic performance of national brands. Our study calculates brand-level demand

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parameters and returns to retailer vertical coordination for the frozen vegetable market. The frozen vegetable market was chosen because it is the third-largest private-label food category in the United States and is also representative of value-added production agriculture. Our analysis is restricted to this class of oligopolistic markets because it best characterizes the channel in which most final consumer food products are bought and sold. Consistent with the literature, brand-level demand equations—in which prices are treated as endogenous—are estimated using weekly point-of-purchase scanner data. Other parameter estimates in the two empirical demand models, such as cross-price and income elasticities, are reported and discussed. Implications of the retailer's effort to vertically coordinate the market, as well as pricing tactics and strategies, are drawn from the research.

Vegetable Consumption and the Frozen Vegetable Industry

Vegetables represent an increasingly important component of the American diet, with per capita consumption increasing almost 23 percent in the last quarter-century (Putnam and Allshouse, 1997). Frozen vegetable consumption increased at a rate of 87 percent during the same period and now makes up more than one-fifth of all consumed vegetables (Figure 1). These statistics, however, mask some of the challenges faced by the \$2.3 billion frozen vegetable industry during the last decade. Since 1990, the annualized growth rate in industry demand was only 2.5 percent (Putnam and Allshouse, 1997); consequently, many firms have struggled to survive. Wisconsin-based private-label processor Stokely USA, Inc. divested its frozen vegetable business, blaming its financial woes on depressed selling prices and flat demand (Gibson, 1996). Similarly, Green Giant shut down its flagship vegetable processing plant in LeSueur, Minnesota. More like a "hot potato" than a frozen vegetable brand, Birds Eye has been sold twice in the last five years—from Kraft General Foods to the Dean Foods Company in 1993 and, more recently, from Dean Foods to Agrilink Foods, Inc. in 1998. The financial problems observed in this industry are representative of many other mature, processed food markets (*Standard and Poors*, 1996).

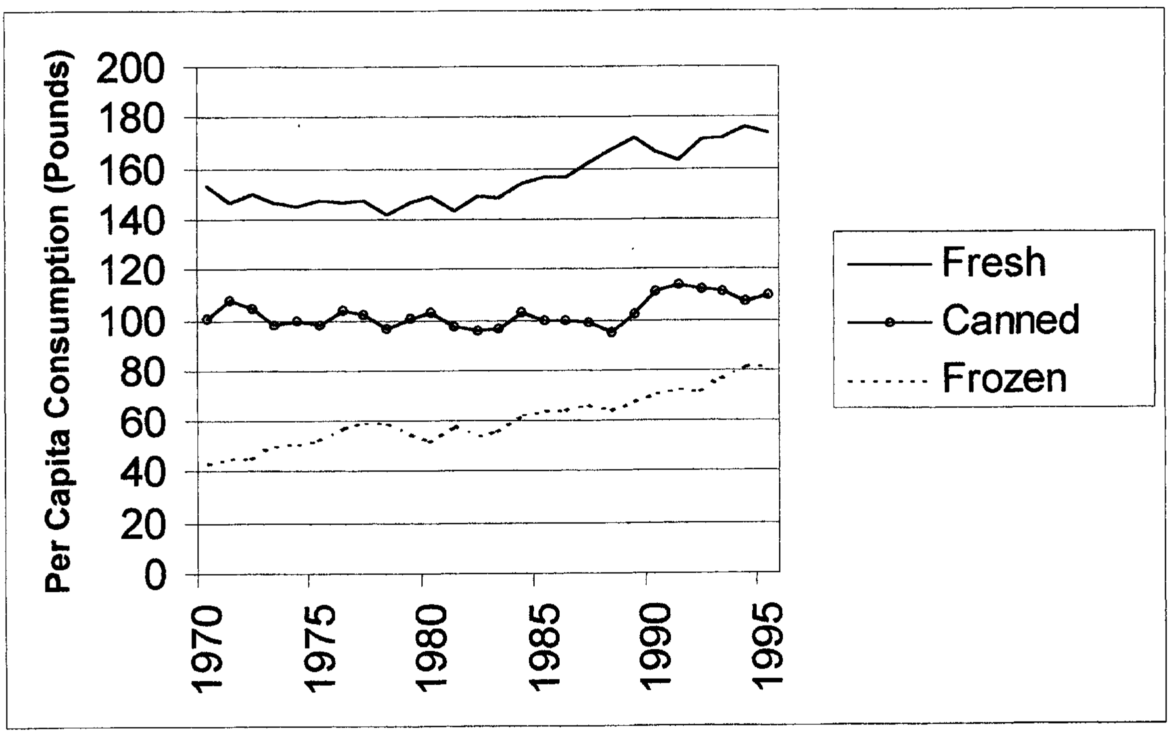

Figure 1. U.S. Per Capita Vegetable Consumption (Pounds), Disappearance Data, 1970–95.

Source: Putnam and Allshouse (1997).

Literature Review

The measurement of brand-level market power in a product-differentiated food or beverage market is becoming more sophisticated in the literature as better data become available and as marketing researchers begin to recognize the importance of this class of markets to consumers. Baker and Bresnahan (1985) are usually credited with the seminal, new empirical industrial organization (NEIO) work on combining demand and industrial organization theory (that is, residual demand analysis) to obtain market power estimates for three brands of domestic beer. Liang (1989) extended the work of Baker and Bresnahan by specifying a structural system of linear demands and linear Bertrand price reaction functions. The latter not only endogenizes price but also quantifies price interdependence. Liang also tested for consistent price conjectures at the brand level in the ready-to-eat (RTE) breakfast cereal industry. Cotterill (1994) improved the demand-side specification of Liang's model and developed several new measures of market power and pricing conduct for nine brands sold in the regular carbonated soft drink industry. Vickner and Davies (1999) refined Cotterill's specification by more precisely controlling for the effects of merchandising, using weekly time series data, and empirically separating rivalrous pricing behavior from pricing conduct associated with shipping costs. They investigated five brands in the domestic spaghetti sauce market and provided a more detailed critique of the previous articles in the literature.

The apparent financial success of private-label brands in the food industry has not gone unnoticed in empirical marketing research circles. Industrial organization economists are intrigued with the notion of vertical coordination and its impact on the economic performance of the food industry. Given the structure of food markets in which private-label brands compete, the NEIO approaches described earlier are entirely applicable to address their impact. Like any other brand in the model, the private-label brand has its own demand equation. Depending on the quality of the data and the empirical objectives of the paper, endogeneity may be handled using a variety of instrumental variable (IV) techniques.

The literature on vertical coordination in food retailing tends to be theoretical and is based on Spengler's (1950) "double marginalization" problem (Bontems, Monier-Dilhan, and Requillart, 1998; Mills, 1998; Allain, 1998; Giraud-Heraud, Soler, and Tanguy, 1998). Fewer empirical studies have investigated the impact of private-label brands on national brands. Connor and Peterson (1992) explained private-label and national-brand price differences based on the structural characteristics of the market. Cotterill and Putsis (1998), and Cotterill, Putsis, and Dhar (1999) utilize the above NEIO framework to explain price-cost margin differences between national brands and private-label brands in food markets. The separate national brands were aggregated together and compared to the respective private-label brand for a variety of food product categories; results for only six separate product categories were highlighted.

In an effort to achieve our principal objective of estimating the market power that a private-label brand may exercise relative to a national brand, our research departs from these earlier studies in three important ways. First, we do not aggregate the national brands, Birds Eye and Green Giant, in the model to capture differences in their demands. Second, we use disaggregate weekly, store-level data to capture any temporal and cross-sectional variation in our parameter estimates. Vickner and Davies (1999, 2000) have argued that disaggregate time series is critical in measuring brand-level behavior. In fact, in some food product categories, the effects of merchandising (that is, price changes) are short-lived and may only last several weeks. Finally, we analyze the frozen vegetable market, which is the third-largest, domestic, private-label food and beverage market.

Model Development

Two competing dynamic demand models are estimated and compared. The first is a double-logarithm specification. Since it is made dynamic with the inclusion of a lagged quantity demanded explanatory variable, both short-run and long-run uncompensated own price elasticities of demand may be obtained (Houthakker and Taylor, 1970). The second approach utilizes demand systems theory (Deaton and Muellbauer, 1980). In particular, we estimate a first-difference, linear approximate/Almost Ideal Demand System (LA/AIDS). Using a demand systems approach, it is possible to determine if the empirical demand model is theoretically consistent; that is, it is possible to test whether the underlying data generation process is consistent with the notions of symmetry and homogeneity.

Double-Logarithm Model

The stylized demand equations for the three brands are given by:

$$(1)\quad \log Q_{kit} = \pi_k \sum_{l=1}^{3} \theta_{kl} \log P_{lit} + \phi_k \log Y_i + \sum_{d \in D_k} \lambda_{kd} M_{dit} + \upsilon_k \log Q_{kit-1} + \mu_{kit},$$

where $k = 1,\ldots,3$; $i = 1,\ldots,3$; and $t = 1,\ldots,56$. For a given brand k, the dependent variable Q_{it} represents per capita quantity demanded (ounces) of frozen vegetables in store i and week t. Thus, this model captures variation temporally, spatially, and across brands. Quantity demanded for a specific brand is hypothesized to be a function of own and rival's prices (P_{it}), per capita disposable income (Y_i), demand shift variables such as race and seasonality (M_{it}), lagged per capita quantity demanded, and a stochastic error term.

It is expected that, for each brand, demand slopes downward. Whether a brand's demand curve is elastic or inelastic is an empirical issue. The cross-price relationships are less clear a priori. It is likely that, for rival brands, the goods are economic substitutes, in addition to being substitutes in use (Caves, 1992). A priori, frozen vegetables are expected to be normal goods with respect to income. Whether the goods are staples or luxuries, again, is an empirical issue. The shift variables are introduced to control for the effects of race and seasonality on the positioning of the demand curve. The set D_k allows these to vary by demand curve. Lagged quantity demanded introduces the possibility of habit formation and consumer inertia into the model (Houthakker and Taylor, 1970). In other words, this week's purchases of a given brand of frozen vegetables are likely to be some positive fraction of last week's purchases of that brand. The dynamic model can then be used to determine both short-run and long-run uncompensated own price elasticities.

LA/AIDS Model

The stylized LA/AIDS market share equations for the three brands are given by:

$$(2)\quad S_{kit} = \alpha_k + \sum_{l=1}^{3} \gamma_{kl} \log P_{lit} + \beta_k \log\left(\frac{E}{P*}\right)_{it} + \varepsilon_{kit},$$

where

$$(3)\qquad \log P_{it}^{*} = \sum_{k=1}^{3} S_{kit} \log P_{kit};$$

$$(4)\qquad \sum_{k=1}^{3} \alpha_k = 1 \quad \sum_{k=1}^{3} \beta_k = 0 \quad \sum_{k=1}^{3} \gamma_{kl} = 0 \quad \forall l;$$

$$(5)\qquad \sum_{l=1}^{3} \gamma_{kl} = 0 \quad \forall k; \text{ and}$$

$$(6)\qquad \gamma_{kl} = \gamma_{lk} \quad \forall k \neq l.$$

In equation (2), for a given brand k, the dependent variable S_{it} represents the dollar market share of frozen vegetables in store i and week t. Market share for a specific brand is hypothesized to be a function of own and rival's prices (P_{it}), per capita expenditures on frozen vegetables (E_{it}), and a stochastic error term. Equation (3) is Stone's price index. Alston, Foster, and Green (1994) have shown that this linear approximation performs well in the presence of price collinearity and generally outperforms competing, more complex price indexes. Equations (4) to (6) represent the adding-up, homogeneity, and symmetry restrictions, respectively. A priori, the expectations regarding qualitative demand behavior in the LA/AIDS model are believed to parallel those in the double-logarithm specification. We use a first-difference or dynamic form of (2), consistent with Deaton and Muellbauer (1980), so that any time-invariant variables would necessarily fall out of the estimation.

Estimation Methodology

Recall that brand-level demand analysis in a product-differentiated oligopoly is complicated because prices are assumed to be endogenous and interdependent at the market level (that is, Green Giant's pricing decisions are a function of the other two brands' pricing decisions). Depending on the quality of the data and the underlying data generation process, the literature offers several approaches to endogenize prices using IV estimation. Several researchers have constructed a structural system of supply-side relations using Bertrand price reaction functions (Baker and Bresnahan, 1985; Liang, 1989; Cotterill, 1994; Vickner and Davies, 1999; Cotterill and Putsis, 1998; Cotterill, Putsis, and Dahr, 1999). Extensive specification testing led us away from this approach, perhaps due to our use of store-level data. On the supply-side, price reaction elasticities were found to be negative in some cases and, when positive, greater than 1. Still, other parameter estimates were not statistically significant ($p>0.10$). Consistent with the literature (Vickner and Davies, 2000), we investigated rich strategic price lag structures, but none was found.

Given the poor performance of the structural simultaneous equations approach, we obtained consistent parameter estimates for each demand model using a two-stage generalized least-squares (GLS) technique. Cotterill and Haller (1997) used a two-stage generalized least-squares (GLS) procedure developed by Hausman, Leonard, and Zona (1994) to recover consistent estimates of unilateral market power in the RTE breakfast cereal industry. In the cereal industry application, first, the price of one brand (say Post Raisin Bran) in one market was regressed on Post Raisin Bran prices from the other nine markets in their study. Hence, the effects of the rivals' pricing strategies in that market were purged from Post Raisin Bran's price series. This process was repeated until each brand's price in each market was replaced with a predicted price series free of endogeneity. Second, the instrumented price data were re-stacked in the appropriate way and substituted into their respective demand equations for the final consistent estimation.

In our study, the three spatially dispersed stores are located within the same, but relatively large, geographic market. The instrumentation process was adapted without loss of generality to this case. For example, the price of private-label frozen vegetables in one store was regressed on private-label frozen vegetable prices from the other two stores in the study. Thus, the effects of the national brands' pricing strategies within that store were purged from private-label's price series. This process was repeated until each brand's price in each store was replaced with a price series free of endogeneity. The prices again were re-stacked in the appropriate way and used in the demand estimation process.

This estimation procedure should not be confused with traditional two-stage least-squares (2SLS), where the instrumentation process relies on the use of reduced-form equations. Recall, in the first stage of 2SLS, that every instrument—either strictly exogenous variables or lagged endogenous variables—is used in a reduced-form regression equation to predict the value of an endogenous variable in the system; there is a reduced form equation for each endogenous variable in the system. In the second stage of 2SLS, these predicted values of each endogenous variable are substituted into the structural system, and the estimation process is completed with another application of ordinary least-squares.

Data Description

A large food retailer for three spatially dispersed stores in the Denver, Colorado market compiled the point-of-purchase, store-level scanner data. This type of data is consistent with other scanner-data studies at the store-level (Green and Park, 1998; Jones, Mustiful, and Chern, 1994). Sales (ounces/week) and price (cents/ounce) data for three brands were collected for 56 weeks from January 29, 1994 through February 18, 1995. Descriptive statistics for quantity, price, and dollar market share are catalogued by brand in Table 1a. Information regarding displays and feature ads was not available in the data set; however, for this retailer, lobby or end-aisle freezer cases did not exist, so there is no loss of explanatory power from the omission of a display measure. Since feature ads accompanied the temporary price reductions in the product category, all of the information regarding in-store merchandising was adequately captured by the price series alone.[1]

Birds Eye, Green Giant, and private label are the three brands of frozen vegetables in this sample of stores. The firms sell packages of a single vegetable, such as corn, peas, or broccoli; mixtures of three or more vegetables marketed under themes like "California Style" or "Italian Style";

[1]Due to limitations in the data set, we did not have information on the number of square inches of feature ad print devoted to the sale product. Also, it was not possible to determine if a sale product was accompanied by a photograph or if it was just described by printed text. Finally, since our data were collected weekly, we were not able to determine the duration, measured in number of days, of an in-store feature ad merchandising event.

Table 1a. Descriptive Statistics of Selected Continuous Variables in Double-Logarithm and LA/AIDS Demand Models.[a]

Variable	Mean	Standard Deviation	Coefficient of Variation	Minimum	Maximum
Quantity[b]					
Private Label	13,901	4,485	32.26	6,583	28,713
Birds Eye	1,662	1,067	64.20	522	7,588
Green Giant	1,853	805	43.45	481	4,320
Price[c]					
Private Label	6.96	0.89	12.79	4.39	8.26
Birds Eye	9.32	1.31	14.10	6.10	11.56
Green Giant	12.98	0.61	4.67	11.21	14.27
Market Share[d]					
Private Label	71.17%	6.07%	8.53	52.05%	87.10%
Birds Eye	11.26%	4.79%	42.57	4.55%	30.15%
Green Giant	17.57%	5.10%	29.02	5.43%	40.21%

[a] Calculations based on 168 observations in the panel data set.
[b] Ounces/week.
[c] Cents/ounce.
[d] Based on dollar sales.

and minimal-preparation convenience meals (that is, a stir-fry meal or stew) that include more vegetables, like pea pods or mushrooms, as well as sauces, pasta, or rice. Industry-wide, mixtures and minimal preparation meals are the strongest growth category, but packages of single vegetables still make up the majority of category sales (Boehning, 1996). Given the empirical objective of measuring the impact of retailer vertical coordination efforts on the economic performance of national brands, product mix issues within and between brands and stores are omitted.

The per capita disposable income and race series, deemed time-invariant in this study since their values did not change weekly, were obtained from the 1990 U.S. Decennial Census for the three zip codes in which the stores were located. Since food retailers strategically locate their stores in a specific area to capture a local consumer base, it is reasonable to use demographic data that are representative of that area to explain demand shift behavior. The demographic data may be found in Table 1b. A trigonometric function was constructed to capture seasonality present in the data (Doran and Quilkey, 1972). The periodic function equals 1 in the middle of winter and -1 in the middle of summer, consistent with the weekly frozen vegetable consumption patterns found in this database.

Empirical Results

Since the data consist of pooled time series and cross-sectional observations on frozen vegetable consumption, we considered a set of competing single-equation, linear estimators: one-way random effects; one-way fixed effects; seemingly unrelated regression (SUR); and a classic pooled regression using two-stage GLS. Each pooled-regression technique offers degrees of freedom advantages compared to pure time series approaches, given the data is stacked. In the case of the error-components or one-way random effects model, we failed to reject the null hypothesis of a zero variance for the unobservable individual effects (that is, the three stores), hence rendering that approach inappropriate (Judge et al., 1985). The dummy variable or one-way fixed effects model could not be used because the unknown parameters for the time-invariant per capita disposable income and race variables are not estimable in the presence of the three fixed effects (Hausman and Taylor, 1981). Thus, meaningful economic information could have been lost. The SUR approach was also abandoned since there were no efficiency gains to be realized, given the symmetry of the design matrix.

Table 1b. Values of Time-Invariant Variables Used in Demand Models.[a]

Variable	Store 1	Store 2	Store 3
Per Capita Disposable Income	$22,936	$10,954	$18,847
Race[b]	84	70	93
Population	19,112	27,007	27,075

[a] Data was assembled for the geographic area defined by each store's zip code. Variables are considered time-invariant as they do not change by week.
[b] Percent of Caucasians in population.

Source: USDOC.

The two-stage GLS estimation approach used in this paper closely follows that used in other market power studies of product-differentiated oligopolies (Hausman, Leonard, and Zona, 1994; Cotterill and Haller, 1997). To conserve space, the results of the first stage of the estimation are not reported but are available upon request from the authors. It is noted that, despite the stores residing in separate zones and maintaining different product mixes, the predicted price equations fit the data extremely well. The second-stage point estimates and standard errors associated with the unknown parameters in equations (1) and (2) are catalogued in Tables 2a and 3a, respectively. An analysis of the elasticities may be found in Tables 2b and 3b, respectively.

Table 2a. Brand-Level Parameter Estimates in Double-Logarithm Demand Model.[a]

	Dependent Variable: Per Capita Quantity Demanded		
Variable	Private Label	Birds Eye	Green Giant
Intercept	7.590***	1.551	3.347*
	(1.171)	(1.926)	(1.772)
Instrumented Price			
Private Label	-1.428***	-0.006	0.435**
	(0.117)	(0.211)	(0.186)
Birds Eye	0.034	-1.568***	0.090
	(0.092)	(0.198)	(0.153)
Green Giant	-0.621*	-0.557	-2.967***
	(0.353)	(0.662)	(0.635)
Per Capita Income	0.717***	0.180***	0.521***
	(0.052)	(0.066)	(0.084)
Race[b]	-0.809***	0.419**	0.419**
	(0.134)	(0.168)	(0.168)
Seasonality	0.061**	-0.011	0.069**
	(0.024)	(0.039)	(0.034)
Lagged Quantity Demanded[c]	0.172***	0.432***	0.420***
	(0.055)	(0.056)	(0.064)
R^2	0.855	0.685	0.815

[a] ***=1% significance level, **=5% significance level, *=10% significance level; standard errors are in parentheses.
[b] Parameter estimates on Race variable restricted to equality between Birds Eye and Green Giant demand equations.
[c] One-week lag.

Table 2b. Short-Run and Long-Run Own Price Elasticity Estimates from Double-Logarithm Demand Model.

Brand	Short-Run	Long-Run[a]
Private Label	-1.428	-1.725
Birds Eye	-1.568	-2.761
Green Giant	-2.967	-5.116

[a] Long-run elasticity equals the uncompensated, short-run own price elasticity η_{kk}^{DL} given in table 2a divided by 1 minus the parameter estimate on the respective lagged quantity demanded variable, or $\eta_{kk}^{DL}/(1-\upsilon_k)$.

Table 3a. Brand-Level Parameter Estimates in Dynamic LA/AIDS Model.[a]

	Dependent Variable: Change in Market Share	
Variable	Private Label	Green Giant
Change in Instrumented Price		
Private Label	-0.134***	0.077***
	(0.033)[b]	(0.028)
Birds Eye	0.057*	-0.027
	(0.031)	(0.029)
Green Giant	0.077***	-0.051
	(0.028)	(0.039)
Change in Real Expenditure	0.018	-0.027*
	(0.019)	(0.015)
R^2	0.101	0.100

[a] ***=1% significance level, **=5% significance level, *=10% significance level; standard errors are in parentheses.
[b] Symmetry and homogeneity restrictions imposed.

Table 3b. Brand-Level Price Elasticities from Dynamic LA/AIDS Model.

	Private Label	Birds Eye	Green Giant
Compensated[a]			
Private Label	-0.477	0.192	0.284
Birds Eye	1.215	-1.152	-0.062
Green Giant	1.152	-0.040	-1.112
Uncompensated[b]			
Private Label	-1.207	0.077	0.104
Birds Eye	0.446	-1.274	-0.252
Green Giant	0.551	-0.135	-1.260

[a] Elasticities are read from left to right. Compensated elasticities are given by $\tilde{\eta}_{kl}^{LA/AIDS} = -\Delta_{kl} + \left(\gamma_{kl}/\bar{S}_k\right) + \bar{S}_l$, where the Kronecker delta equals 1 for $k = l$ and 0 otherwise. Average dollar market shares $\left(\bar{S}_K\right)$ are used.

[b] Uncompensated elasticities are given by $\eta_{kl}^{LA/AIDS} = -\Delta_{kl} + \left(1/\bar{S}_k\right)\left(\gamma_{kl} - \beta_k \bar{S}_l\right)$.

Demand Parameter Estimates in the Double-Logarithm Model

In Table 2a, each short-run uncompensated own price elasticity estimate (η_{kk}^{DL}) was statistically significant (p<0.01); elastic; and, consistent with a priori expectations, negative. These brand-level elasticities for private label, Birds Eye, and Green Giant were, respectively, -1.428, -1.568, and -2.967. Thus, a 1 percent increase in the price of private-label frozen vegetables leads to a 1.428 percent decrease in its per capita quantity demanded. To determine if these parameter estimates were statistically equal to each other, we constructed several cross-equation F-tests. Given a p-value of 0.54, we failed to reject the null hypothesis that the uncompensated own price elasticity of private label was equal to Birds Eye. However, we rejected the null of equality between private label and Green Giant (p<0.05); Birds Eye and Green Giant (p<0.05); and private label, Birds Eye, and Green Giant (p<0.10).

Elastic demands are not uncommon for studies investigating the demand for durable or storable food products using point-of-purchase scanner data for narrowly defined product markets (Cotterill, 1994; Jones, Mustiful, and Chern, 1994; Cotterill and Haller, 1997; Vickner and Davies, 1999). The storability of a frozen vegetable product may cause it to become an intertemporal substitute for itself; consumers purchase it when the product is sold at a discount and, hence, heighten price sensitivity.

An alternative explanation for the elastic demands stems from the type of data used in this study.[2] Only stores belonging to a single chain were included in the analysis. While a sole retailer only distributes the store-brand frozen-vegetable products, it and other retailers in the market sell the national brands. The exclusion of those other outlets from the analysis may overstate the absolute value of the national brand products' own price elasticities since consumers could purchase those frozen vegetables from other stores when prices rose and vice versa. This fact also has implications for measuring market power based on these elasticity estimates.

Only two uncompensated cross-price elasticity estimates (that is, private label in the Green Giant demand equation and Green Giant in the private-label equation) were statistically significant (p<0.10). The remaining cross-price elasticities were not statistically significant (p>0.10). The three income elasticities were statistically significant (p<0.01) and, as expected a priori, greater than 0, indicating that frozen vegetables are normal goods; since they are less than 1, they indicate staples in this case. Jones, Mustiful, and Chern (1994) found similar results in the RTE breakfast cereal industry, using store-level data where income elasticities were positive for the private-label brand as well as for the top 10 national brands. The other demographic variable—race—revealed an interesting result. In the case of private-label frozen vegetables, per capita quantity demanded decreased as the percent of the Cauca-

[2]The authors would like to thank an anonymous reviewer for this insightful comment.

sian population increased. This relationship was statistically significant (p<0.01). We tested the hypothesis that the parameter estimate on race was equal for both national brands. Given the p-value of 0.59 for the F-statistic of the cross-equation test, we failed to reject the null hypothesis and thus imposed the linear restriction. As the percent of Caucasians in the population increased, per capita quantity demanded increased for both national brands.

The trigonometric seasonality variable was statistically significant (p<0.05) and positive in the private-label and Green Giant demand equations, indicating that demand is relatively higher in the winter and lower in the summer. It is possible that the availability of fresh alternatives influences this relationship. Other orthogonal trigonometric seasonality terms were tested, but they are not found to improve the performance of the model (Doran and Quilkey, 1972). Diagnostically, the models fit the data very well. The percent of variation in brand-level per capita frozen vegetable consumption explained by the specification was quite high for panel data; the R^2 values were 0.855, 0.685, and 0.815 for private label, Birds Eye, and Green Giant, respectively.

Houthakker and Taylor (1970) define the long-run uncompensated own price elasticity of demand to be the short-run uncompensated own price elasticity divided by 1 minus the parameter estimate on the lagged quantity demanded term, or $\eta_{kk}^{DL}/(1-\upsilon_k)$. Alternative lag structures were explored, but the parsimonious single-week lag structure performed well. The parameter estimates on one-week lagged quantity demanded ranged from 0.172 to 0.432, and each was statistically significant (p<0.01). Consequently, the long-run estimates, found in Table 2b, were -1.725, -2.761, and -5.116 for private label, Birds Eye, and Green Giant, respectively. Using similar methodology, Bjorndal, Salvanes, and Andreassen (1992) found the long-run own price elasticity of demand to exceed, in absolute value, the short-run estimate in the French salmon market as it must if this Nerlovian adjustment is appropriate.

Demand Parameter Estimates in the LA/AIDS Model

In the first difference LA/AIDS model, the time-invariant factors—such as race and income—naturally were not included in the estimation process. Seasonality, also excluded as market share, was not significantly correlated (p>0.10) with the appropriate trigonometric variable in each equation, unlike the level of quantity demanded in the previous model. This suggests that each brand's sales level moves together throughout the year, leaving relative shares unchanged.

We tested the symmetry and homogeneity hypotheses to determine if the underlying data generation process was theoretically consistent. In the case of the former, we failed to reject the null hypothesis that the parameter estimate on Green Giant's price in the private-label share equation equaled the parameter estimate on private label's price in the Green Giant share equation. The p-value for that F-statistic was 0.80. The two separate F-tests of homogeneity yielded p-values of 0.89 and 0.72 for the private-label and Green Giant share equations, respectively. In the reported results, the symmetry and homogeneity restrictions were imposed on the model.

The parameter estimates on the prices of private label, Birds Eye, and Green Giant were statistically significant (p<0.10) in the private-label share equation. In the Green Giant share equation, the parameter estimates on private label's price and real expenditure were statistically significant (p<0.10). Since the LA/AIDS model was in first difference form, the R^2 values were not particularly high at 0.101 and 0.100, respectively, for the private-label and Green Giant share equations.

The brand-level compensated and uncompensated price elasticities for the LA/AIDS mode are summarized in Table 3b. Elasticities are read from left to right in the table for each demand equation. The compensated elasticities are given by $\tilde{\eta}_{kl}^{LA/AIDS} = -\Delta_{kl} + (\gamma_{kl}/S_k) + S_l$, where the Kronecker delta equals 1 for $k = l$ and 0 otherwise. The uncompensated elasticities are given by $\eta_{kl}^{LA/AIDS} = -\Delta_{kl} + (1/S_k)(\gamma_{kl} - \beta_k S_l)$. Average dollar market shares $\bar{S}_K$ are used in the calculations. Each formula employs Chalfant's (1987) simplifying assumption (that is, $\partial \log P^* / \partial \log P_k = S_k$). In repeated sampling experiments, Alston, Foster, and Green (1994) found that these elasticities perform well relative to competing and more complex elasticity formulas. An artifact of their construction, the compensated elasticities are larger than their uncompensated counterparts. Based on the compensated cross-price elasticities, we see that there is a substitute relationship between private label and Birds Eye as well as private label and Green Giant. A complementary relationship appears to exist between Birds Eye and Green Giant. This finding may be due to the product mix of each brand. Birds Eye, at the time the data was collected, did not sell minimal-preparation vegetable-based meals, while Green Giant did not sell packages of single vegetables. Even though private label sells in both of those segments as well as the mixtures segment, a "national brand" consumer would have to purchase both Birds Eye and Green Giant products to have access to all three segments in the category. Moreover, Russell and Kamakura (1994) comment that cross-price elasticities may not conform with a priori expectations when estimated using macro or store-level data. However, the micro or household-level data that they prescribe for this purpose was not available for this study. Russell and Kamakura also concede that micro-level data are plagued with limitations, given household self-reporting problems and the statistical representation of a household sample.

Unilateral Market Power, Price-Cost Margins, and Vertical Coordination

The principal empirical objective of this paper is to determine if a vertically coordinated retailer (that is, one selling a private-label product) can affect the economic performance of the national brands in the frozen vegetable product category. First, we define market power and then link it to a metric of economic performance. Before interpreting the results related to unilateral market power, price-cost margins, and imputed marginal costs, we reiterate that our data are taken from only one chain of stores in one market. Thus, the absolute value of the own price elasticity may be overstated, particularly in the case of national brands, as our model assumes no possibility of inter-chain substitution of purchases. With that caveat in mind, we make inferences from the foregoing demand analyses.

The U.S. Department of Justice and Federal Trade Commission Horizontal Merger Guidelines (USDJ/FTC, 1992) define a non-followship price elasticity to be the change in quantity demanded due to an increase in price when no rivals follow the price increase. It is a measure of unilateral market power and is intuitively linked to the notion of the observed elasticity. Baker and Bresnahan (1985) rigorously derived the now well-known NEIO expression for the observed elasticity η_k^O. It is given by $\eta_k^O = \eta_{kk} + \sum_{l \neq k} \eta_{kl}\eta_{lk}^{PR}$, where η_{kk} is the own price elasticity; η_{kl} is the cross-price elasticity; and η_{lk}^{PR} is the price reaction elasticity (that is, the percent change in the price of brand *l*, given a 1 percent change in the price of brand *k*). When $\eta_{lk}^{PR} = 1$, η_k^O measures demand response under perfect tacit price collusion. When $0 < \eta_{lk}^{PR} < 1$, η_k^O measures demand response under imperfect tacit price collusion. When $\eta_{lk}^{PR} = 0$, η_k^O measures demand response in the absence of any tacit price collusion. This last assumption seems to be consistent with the findings in this study. Recall that a supply side to the model composed of Bertrand price reaction functions was abandoned due to poor econometric performance, but price endogeneity was handled using two-stage GLS. Consequently, there are no empirical estimates of η_{lk}^{PR} in the model. Hence, those parameter estimates are set to 0, leaving $\eta_k^O = \eta_{kk}$, and so, the estimated own price elasticities are the non-followship elasticities by definition. These are summarized in the first row of each section in Table 4 for convenience.

We found mixed results regarding the degree of unilateral market power exercised by the private-label brand. In the first section of Table 4, recall that we were unable to reject the null hypothesis that private label's short-run uncompensated own price elasticity was equal to that of

Table 4. Estimated Price-Cost Margins and Imputed Marginal Costs from Both Demand Models.

Measure	Private Label	Birds Eye	Green Giant
Using Double-Logarithm Model (Short Run)			
Non-Followship Elasticities[a] (η_{kk}^{DL})	-1.428	-1.568	-2.967
Price-Cost Margin[b]	0.700	0.638	0.337
Imputed Marginal Cost[c]	2.09	3.37	8.61
Using Double-Logarithm Model (Long Run)			
Non-Followship Elasticities[a] ($\eta_{kk}^{DL}/(1-\upsilon_k)$)	-1.725	-2.761	-5.116
Price-Cost Margin[b]	0.580	0.362	0.195
Imputed Marginal Cost[c]	2.92	5.95	10.45
Using Dynamic LA/AIDS Model			
Non-Followship Elasticities[a] ($\eta_{kk}^{LA/AIDS}$)	-1.207	-1.274	-1.260
Price-Cost Margin[b]	0.829	0.785	0.794
Imputed Marginal Cost[c]	1.19	2.00	2.67

[a] Defined to be unilateral measures of market power by the 1992 DOJ and FTC Horizontal Merger guidelines. Based on uncompensated elasticities.
[b] For the profit-maximizing firm, the price-cost margin is given by $(p-c)/p=1/|\eta_{kk}|$.
[c] Cents/ounce, calculated using average prices from Table 1a.

Birds Eye. Hence, there exists no statistical difference in unilateral market power between those two brands. However, we were able to reject the null of equality of any other combination of elasticities in that row. The second section of Table 4, summarizing the long-run elasticities also from the double-logarithm model, shows greater differences between the three brands in the study; private label exercises relatively more unilateral market power than the national brands. However, these differences were not tested statistically and may be due to sampling variability. The uncompensated own price elasticities from the LA/AIDS model are given in the third section of Table 4. The differences, again not tested statistically, are miniscule across the three brands.

There is limited evidence in Table 4, which suggests that the private-label brand exercises relatively more unilateral market power than the national brands. Our finding, albeit weak, is consistent with other brand-level non-followship elasticities found in the literature. In Cotterill's (1994) investigation of the regular carbonated soft drink market, he found unilateral market power to be -0.918 for the private-label brand and to range between -1.134 and -2.508 for the national brands. Cotterill and Haller (1997) estimated the non-followship elasticity to be -0.266 for the private-label RTE breakfast cereal brand and to range between -0.603 and -2.949 for national brands. Cotterill, Putsis, and Dhar (1999) found private label to exercise more unilateral market power than national brands in the milk, bread, and instant coffee markets but the opposite in butter, pasta, and margarine markets. In the milk, bread, and instant coffee markets, non-followship elasticities ranged between -0.374 and -0.942 for private-label brands and -1.030 and -2.048 for national brands.

A well-known result from industrial organization theory is that firms exercising market power maximize profits by setting price according to the inverse elasticity rule (Tirole, 1988). Mathematically, the optimal price p satisfies $(p-c)/p = 1/|\eta_{kk}|$, where c is unobserved marginal cost and η_{kk} is the non-followship elasticity. If production of frozen vegetables is assumed to exhibit constant returns to scale, c may also be interpreted as average cost. By calculating the price-cost margin in this way, we implicitly assume that the retailer executes the pricing strategies intended by the national brand manufacturers. That is, observed retail price for a national brand is the national brand wholesale price plus a constant retailer mark-up. Kinsey and Senauer (1997) argue that efficient consumer response (ECR) is responsible for this practice.

The second and third rows in each section of Table 4 show the returns to the retailer's efforts to vertically coordinate the distribution channel and imputed marginal costs, respectively. Imputed marginal costs are calculated using average prices by brand from Table 1a. The results parallel those for market power as the estimates of returns and imputed costs are a function of the measures of unilateral market power. Thus, the same caveat regarding statistically significant differences still holds. In the double-logarithm model, the private-label brand maintained the highest price-cost margin and the lowest marginal costs, followed respectively by Birds Eye and Green Giant. Using short-run (long-run) measures, price-cost margins ranged from 0.337 to 0.700 (0.195 to 0.580) while imputed costs ranged from 2.09 to 8.61 cents/ounce (2.92 to 10.45 cents/ounce). Under the LA/AIDS model, the private-label brand again maintained the highest price-cost margin of 0.829, but the margin was much closer to that of the national brands. In this case, Green Giant maintained a slightly higher price-cost margin (0.794) than Birds Eye (0.785), but it still had a higher imputed marginal cost than its rival (2.67 versus 2.00 cents/ounce).

Concluding Remarks

Industry trends indicate that the threat of private-label products on national brand markets is increasing domestically; it is converging with the UK retailer-led model. The threat is exacerbated by the recent rising concentration ratios in the food retailing industry. This situation has grave implications of both lost market share and profits for national brand manufacturers in many food and beverage product categories. In the frozen vegetable market under investigation, the trends are even more transparent. Private label commands 71.2 percent of the dollar sales in the product category, followed by Green Giant at 17.6 percent, and Birds Eye at 11.2 percent. With an average shelf price of 6.96 cents/ounce, private label has strategically positioned itself as the low-price purveyor of frozen-vegetable products. Birds Eye and Green Giant, respectively, are positioned at 9.32 and 12.98 cents/ounce.

To make matters worse for the two national brands, the battery of analyses in this study indicated that the demand for private-label frozen vegetables is less sensitive to changes in price than its rivals. This result was even more evident with the long-run elasticities in the double-logarithm model and the compensated elasticities in the LA/AIDS framework. Consequently, this exercise of unilateral market power translated into wider retailer price-cost margins and lower imputed marginal costs—the economic spoils of a vertically coordinated distribution channel.

To help mitigate the effects of the private-label threat, the national brand manufacturers in this product category and others have embraced the ECR movement. Under ECR, upstream manufacturers partner with retailers to more effectively manage a category with respect to all aspects of the marketing mix. Although it is recognized that the retailer has the ultimate power to schedule the level of price points and timing of in-store promotions, s/he also has to accommodate an ongoing relationship with manufacturers whose products appeal to a segment of his/her customer base. Additionally, in recent years, Birds Eye and Green Giant have both attempted to further differentiate their products and to de-list those that compete head-to-head with the retailer's core line of packaged, single vegetables. Value-added minimal-preparation vegetable-based meals, such as Birds Eye's Viola line and Green Giant's Create-a-Meal line, are quickly reclaiming shelf space once populated by their lower-priced and presumably lower-margin single vegetable products (Boehning, 1996).

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