Oligopoly Pricing with Differentiated Products: The Boston Fluid Milk Market Channel [Ψ]

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Abstracts: We model Boston fluid milk market after taking into account strategic interactions of the processors and retailers and estimate it using monthly propriety retail scanner data and other data from public sources from 1996 to 2000. Market demand is modeled using flexible nested logit demand system and processor level cost is modeled using flexible generalized Leontief cost function. Our modeled is flexible enough to capture the nature of competition between brands within store and across stores. We find that the brands compete much more vigorously within store and than across stores. This structure of competition fits squarely with Slade's (1995) assumption on retail competition. We also explore strategic implications of the North East Dairy Compact on retailers and processors using emerging methodologies of antitrust simulation. The predictions from the antitrust simulation analysis are consistent with the concept of 'focal point pricing' at the Compact implementation, suggesting an increase of market power in the fluid milk marketing channel. Our estimated brand level total channel price cost margins also show that the margins increased after the Compact implementation.

Keywords: Nested Logit demand system, generalized Leontief cost function, fluid milk, marketing channel, North East Dairy Compact.

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Introduction

Fluid milk market channels in many milksheds have evolved into highly concentrated oligopolies both at the processing and at the retailing level and milk is no longer a homogeneous commodity. Brands, including supermarket private labels, and differentiated pricing are common. Little quantitative research on the milk-marketing channel has been done from the perspective of industrial organization. Exceptions include Kawaguchi et al. (1997), and Suzuki and Kaiser (1997) however, that work assumes milk is a homogeneous product, and focuses upon Cournot quantity competition models at the aggregate market level. Most studies of brand level differentiated product pricing in other industries, such as Nevo (2001) and Hausman and Leonard (2002) use panel data techniques to estimate only the demand surface. Recently Besanko et al. (1998) and Cotterill et al., (2000) estimate differentiated product demand systems jointly with first order conditions that specify exogenous cost shift variables, as instruments. All of these studies assume a single stage in the marketing channel.

In this paper, we specify a structural differentiated product oligopoly model at both the processing and retailing stages with flexible demand at retail and flexible costs for processing. We estimate brand level marginal costs jointly with the brand level demand surface. This is the first study to use key account data from Information Resources Inc. to estimate the demand for different brands of a food product at each of several chains that compete in a market.[1] This disaggregate approach allows us to evaluate consumer switching among supermarket chains as well as among brands in a chain. Consequently we can extend the US Department of Justice antitrust simulation model (Hosken et al., 2002; Werden and Froeb, 1994) to analyze market power at the retail chain level as well as at the brand/processor level.

Antitrust simulation is hypothetical, i.e. ex ante, because it predicts how the conduct of a profit-maximizing firm would change if an event such as a merger were to occur. In this study we also analyze, ex post, the impact of an event, the creation of the Northeast Dairy Compact on channel firm conduct. Work by Schelling (1960) and Verboven (1997) suggests that a focal point event such as the Compact can facilitate tacit collusive pricing. Commencing in July 1997 the Compact established a price floor for Class-I milk in the New England milk market. If the federal milk market order price for Boston dropped below \$16.94/cwt (\$1.46/gallon) processors were required to pay the difference, effectively ensuring that farmers received the \$16.94/cwt. price. Compared to other studies of the Compact, Balagtas and Sumner (2003), Lass, Adanu and Allen (2001), and Cotterill and Franklin (2001), this is the first study to use a structural, new empirical industrial organization (NEIO) framework. We estimate different indicators of competitiveness for firms in the Boston fluid milk market, namely average cost, marginal cost, and price-cost margins for the pre- and post-Compact periods. We find wider margins in the post-Compact period and estimate the corresponding change in total profits by brand and supermarket chain.

Model Specification and Variable Description

For empirical estimation we will use a nested logit retail demand system. On the cost side we specify a generalized Leontief cost function for the processors (as in Azzam, 1997). To keep the estimation routine tractable we assume that retailer's only variable cost is the wholesale price.[2]

<u>*Choice of Demand Specification:*</u>

Our flexible characteristic based nested logit demand specification is similar to Berry (1994), and Besanko, Gupta and Jain (1998). Berry uses the variance component structures of the extreme value and logistic distributions developed by Cardell (1997) to derive the nested-logit demand specification. Unlike many other demand specifications such as, LA/AIDS (e.g., linear approximation to almost ideal demand system) and Nonlinear-AIDS, with nested logit it is possible to derive analytically tractable profit maximizing first order conditions. Another advantage of the nested logit model is that computationally it is simpler than the random coefficients model as used by Nevo (2001), and Berry, Levinsohn and Pakes (1994).

The nested logit used in this study has two levels. From the initial node of the nesting tree the choice is between buying milk from any of the major retailers (Stop & Shop, Shaw's, Star Market, DeMoulas, and Residual Chains) or the outside option. In our empirical analysis, the outside option includes residual fluid milk brands (most of these other fluid milk brands hold less than 1% market share), fluid milk derivatives (for example: milk shakes, flavored milk, eggnog etc.) and milk substitutes (like soy milk, Kefir milk etc.) sold in the Boston market.[3] Empirically aggregating the rest of the retail chains as the Residual Chain is important to keep the model manageable (and IRI provides only this residual aggregate). We assume that the independent effect of these smaller chains in strategic games between the four major retail chains is insignificant. Together however they may affect the broader market behavior.

On the second level within a retail chain, the choice is between the three retail brands (Garelick, Hood and private label). As a result of this unique approach to product differentiation, one has 15 brands (5 retail chains with 3 brands in each retail chains) for the Boston market.

This two tier nesting structure is an advance. With large and powerful retailers, marketing mix decisions are not only made by the manufacturers but also by the retailers. Thus products are differentiated by the dual efforts of the retailers and processors (Iyer and Vilas-Boas, 2000). Earlier studies on brand differentiation have focused only on primary branding at the market level because they only had access to market level data (Nevo, 2001; Cotterill, Putsis and Dhar, 2000), or they have focused on store level data in a single chain (Bresanko et al. 1998). Under either approach, retailer interaction and market power is not explicitly measured. In this study we can ask and answer the following question. Would it be profitable for a chain to exercise market power unilaterally, i.e. can a chain without the cooperation of other chains, profitably raise the retail prices of the three brands of milk that it sells?

Empirical Demand and Cost Specifications:

The nested logit demand system is based on the random utility model (RUM):

[1]
$$u_{hij} = \delta_{ij} + \varepsilon_{hij}$$
where,
$$\delta_{ij} = \beta_{0ij} + X_{ij}\beta - \alpha P_{ij} + \varsigma_{ij}$$

Here u_{hij} is the utility level of the representative consumer *h* for brand *ij* (i^{th} supermarket and j^{th} brand). X_{ij} is the vector of characteristics of product *ij* and β is the corresponding vector of coefficients. P_{ij} is the price of product *ij* and *α is the associated parameter to be estimated.* Here δ_{ij} can also be defined as the mean utility level of a consumer, as utility is defined over a representative consumer *h*.

The term ζ_{ij} is the mean value of the unobserved demand characteristics in the RUM. The inclusion of ζ_{ij} as a measure of unobservable product attributes follows Berry's formulation of the discrete choice model. ε_{ij} is the residual error of the RUM with Weibull (extreme value) distribution. Note that ζ_{ij} differs from the idiosyncratic valuations ε_{ij} in that ζ_{ij} is brand-specific but not consumer-specific and that unlike the realizations of ε_{hij}, ζ_{ij} is observed by firms and thus directly incorporated into price setting behavior.

Based on this random utility approach we derive the nested logit retail demand function:

[2]
$$\ln(s_{ij}) - \ln(s_0) = \beta_{0ij} + \beta X_{ij} - \alpha P_{ij} + (1-\theta_R)\ln(s_{j/R}) + (1-\theta_R\theta_{RC})\ln(s_{i/jR}) + \varsigma_{ij}$$

where: s_{ij} is the market share of brand *ij* of the total market (marginal market share). s_0 is the market share of the outside option. $s_{j/R}$ is the market share of retailer *j* given that the fluid milk is brought from any of the five retailers (conditional market share). $s_{i/jR}$ is the market share of brand *i* given that the milk is bought from retailer *j* (conditional market share). P_{ij} is the price of brand *i* in retail chain *j*. Θ_R is the variance component term in the first level of nesting (choice between retailers and outside option). Θ_{RC} is the variance component term in the second level of nesting (choice between store level brands). ζ_{ij} is the regression error term (capturing the effect of unobservable product attributes)

On the supply side, cost specifications need to be specified both at the retail and processor level. At the retail level, the marginal cost of selling fluid milk is assumed to be constant and equal to the wholesale price of milk. At the processor level we specify a generalized Leontief cost function (Diewart, 1971). This cost specification has been widely used in empirical industrial organization literature for its simplicity and flexibility. From the perspective of the present research objective, it is flexible enough to capture the cost impacts of variations in farm level milk price and other input prices. Nonetheless it is mathematically simple enough to be estimated in a complex non-linear system. So, we specify the following processor level cost function:

[3] $$C_{ij}\left(Q_{ij},\upsilon\right)=Q_{ij}\sum_{l}\sum_{m}\delta_{lm}\left(\upsilon_l\upsilon_m\right)^{1/2}+\left(Q_{ij}\right)^2\sum_{l}\gamma_l\upsilon_l$$

where: C_{ij} is the cost function for brand *j* sold through retailer *i*. υ_l and υ_m are the price of inputs *l* and *m*. And Q_{ij} is the level of output.

Also, to capture the brand specific unobservable (to econometricians) cost component we use an intercept term in the derived first order conditions. So, the final total cost specification is:

[4] $$C_{ij}\left(Q_{ij},\upsilon\right)=\chi_{ij}Q_{ij}+Q_{ij}\sum_{l}\sum_{m}\delta_{lm}\left(\upsilon_l\upsilon_m\right)^{1/2}+\left(Q_{ij}\right)^2\sum_{l}\gamma_l\upsilon_l$$

Specification of Processor-Retailer Relationships:

Given these demand and cost specifications, we specify two game theoretic models to capture the strategic interactions between retailers and processors. In both games we initially specify horizontal competition both at the processing and retail level as Bertrand in price with Nash equilibrium. In the vertical channel we try two different games: vertical coordination and vertical Nash (Choi, 1991). With vertical coordination each retailer maximizes category profits as if they owned and controlled the processors that supply them. Therefore, each retailer maximizes profit across the three brands and shares the generated profit with the processors under certain (but unknown to modelers) sharing rules. This is the vertical model in prior research that has assumed a single stage-marketing channel (eg. Nevo, 2001; Suzuki and Kaiser, 1997).

In the vertical Nash game processors and retailers maximize profit simultaneously by deciding, in arms length fashion, on the wholesale and retail price. One needs to know the profit functions of both the retailers and processors. When deriving the first order conditions from them it is important to model the processor-retailer relationships that exist in the market. For example, if there is a single processor for all the brands then we will have a single processor profit function to maximize for all the brands. On the other hand, if a single and independent processor processes each brand then we will end up having 15 processor profit functions to maximize.

Unlike previous research our vertical Nash model captures the complex vertical ownership structure that existed in the market during the 1996-2000 period that our data cover. For the Garelick brand we have a single processor Garelick Farms, which was purchased by an out of market firm Suiza/Dean Foods in July 1997. For the Hood brand we have a single processor except in the case of Hood milk sold through Stop & Shop because Stop and Shop processed all its Hood milk in its own plant under license from Hood (Cotterill and Franklin, 2001, p.18). Therefore we retain the first order condition for Stop & Shop-Hood, derived from the vertical coordination game. Similarly for the Stop & Shop-Private Label, the derived first order condition from the vertical coordination game is the proper specification because Stop & Shop also processed its private label milk.[4] Garelick Farms processed virtually all private label milk for Shaws, Star Market, DeMoulas and Residual Chains.[5]

Specification of the Empirical Profit Function and Equilibrium Conditions:

The first order conditions for the a fully coordinated vertical game can be derived as:

[5] $$P_{ij} = \arg\max\left(\sum_i P_{ij}Q_{ij} - \sum_i C_{ij}\left(Q_{ij}\right)\right)$$

where, $Q_{ij} = s_{ij}H$ and H is the exogenously determined market size as defined by Berry.[6] For the rest of the derivations quantity is determined in this fashion.

When solving equation [5] we assume that horizontal competition among brands is Nash-Bertrand and obtain the following equilibrium first order condition for each of the 15 brands:

[6] $$P_{ij} = MC_{ij}\left(s_{ij}H;\delta,\gamma\right) + g\left(s_{i/j}, s_{i/jR}, s_R;\alpha,\beta,\theta_R,\theta_{RC}\right)$$

These are the estimable supply side relationships for what we will call the vertical coordination game. The first term in equation [6] is the marginal cost term and the second term is the difference between the price and the marginal cost.

In the vertical Nash game, when the only retail variable cost is the wholesale price, the retail profit function is:

[7] $$P_{ij} = \arg\max\sum_i \left(P_{ij} - W_{ij}\right)Q_{ij}$$

When solving equation [7] one obtains the following solution:

[8] $$P_{ij} = W_{ij} + R_{ij}\left(s_{i/j}, s_{i/jR}, s_R; \alpha, \beta, \theta_R, \theta_{RC}\right)$$

The second term on the right side of equation [8] is the difference between the retail price and retail marginal cost as measured by the wholesale price, W_{ij}.

At the processor level, in a vertical Nash game, we assume processors expect retailers to use a linear mark-up over wholesale price (Choi, 1991). This assumption allows the processor to derive the wholesale demand curve from the retail demand curve. Our profit maximizing first order conditions at the processor level are the following:

[9] $$W_{ij} = \arg\max\left(\sum_j W_{ij} Q_{ij} - \sum_j C_{ij}\left(Q_{ij}\right)\right)$$

When solving equation [9] we obtain the following solution:

[10] $$W_{ij} = MC_{ij}\left(s_{ij} H, \upsilon; \delta, \gamma\right) + w_{ij}\left(s_{i/j}, s_{i/jR}, s_R; \alpha, \beta, \theta_R, \theta_{RC}\right)$$

We substitute equation [10] in [8] and get estimable supply side equations for the vertical Nash game:

[11] $$P_{ij} = MC_{ij}\left(s_{ij} H, \upsilon; \delta, \gamma\right) + R_{ij}\left(s_{i/j}, s_{i/jR}, s_R; \alpha, \beta, \theta_R, \theta_{RC}\right) + w_{ij}\left(s_{i/j}, s_{i/jR}, s_R; \alpha, \beta, \theta_R, \theta_{RC}\right)$$

Compact Specification:

Due to the flexibility of our cost specification, our model should capture the non-strategic effect of changes in the raw fluid milk price on retail price. But to capture any other effect (unobservable to econometricians) related to firm conduct changes that persist after Compact implementation, we specify a Compact binary. This variable is zero for pre-Compact and one for post-Compact observations. Our modeling of a shift in strategic conduct is similar to Porter (1983) who estimates the impact of such shifts on railroad freight rates using binaries.

Before July 1997 channel players did not exactly add any increase in the farm price to the retail price in any time period. Retail prices increased at a steady rate more in line with the CPI than the ups and downs of raw fluid milk prices (Cotterill and Franklin, 2001, p. 10). Retail and processor trade organizations openly stated that this would change after the Compact. They threatened that post-Compact retail prices would be increased by an amount equal to the increase in the raw fluid price at Compact implementation (Rosenfeld, 12/19/1996). Such statements may have helped cement a commitment among their members to this price increase that in effect locked in very wide marketing margins (Cotterill and Franklin, 2001, p. 14). In fact retailers posted signs in their stores stating that the 18 cent price increase in July 1997 was due to the Compact increasing raw milk prices 18 cents over June prices (Mass. Dept. of Agriculture as cited in Cotterill and Franklin, 2001, p. 8-9).

According to Schelling's (1960) focal point theorem, certain strategy profiles in any game are potential focal points around which players can signal their objective without formal (such as: verbal or written) coordination. Verboven (1997) has shown that certain price/quantity points can always be used as focal points for collusion by heterogeneous firms. From the discussion above it should be clear that the channel players perceived the implementation of the Compact in July 1997 as a clear and pre-defined focal point. We hypothesize that the coefficient on the Compact binary is positive due to the fact that the advent of the Compact may have been a 'focal point' for the exercise of market power. Prices in the post-Compact period may deviate from Nash-Bertrand conduct in the horizontal dimension at the processor and/or retailer level.

Alternatively the Compact binary may have a negative effect on retail price because the Compact stabilized raw milk prices and thus decreased the variance (risk) of a major input price. Turnovsky (1969) proves that input price risk reduction reduces a competitive firm's profit margin; and, Azzam and Schroeter (1991) have shown the same for an oligopolist's profit margin. Ceteris paribus retail prices should be lower. This in fact was one of the rationales cited by Congress for establishing the Compact (Federal Register, 1997).

In conclusion the Compact, ceteris paribus, may have a positive, negative effect or on balance no effect on retail price levels.

The final estimated first order condition in the vertical Nash game has the following form:

[12]
$$P_{ij} = D_{ij} * Comp + MC_{ij}\left(s_{ij} H, \upsilon; \delta, \gamma\right) + R_{ij}\left(s_{i/j}, s_{i/jR}, s_R; \alpha, \beta, \theta_R, \theta_{RC}\right) + w_{ij}\left(s_{i/j}, s_{i/jR}, s_R; \alpha, \beta, \theta_R, \theta_{RC}\right)$$

where D_{ij} is the coeffient for the Compact binary *Comp*.

To summarize for each game (vertical coordination or vertical Nash) we have 15 demand functions and 15 first order conditions define the profit maximizing equilibrium conditions. To capture all the cross brand interactions in the market, this 30-equation system is estimated for each game.

Variable Description:

The IRI database provides detailed marketing and retail price related information for brands of milk for the aggregate market and for each of the top four supermarket chains in the Boston market from February 1996 to July 2000. Each data point (covering four weeks) in this database is four dimensional specifying time periods, city, chain, and brand.

<u>*Demand Side:*</u>

In the Random Utility Model (RUM), we use a linear combination of variables to specify the characteristics space of the products. The variables are: *retail price, volume per unit, ratio of* *whole milk to skim/low fat milk, weighted average price reduction, percentage volume merchandising.* Volume per unit measures average package size. The last two variables measure the impact of trade promotions including price reductions and advertising of them in local newspapers.

In terms of price, Hood brands are the most expensive brands, followed by Garelick and private label. In terms of market share in each retail chain private label leads, followed by Garelick and Hood. Volume per unit is significantly higher for the private labels than for the other two brands and between Garelick and Hood there are no major differences. This means consumers tend to buy larger sizes (gallons) of private label milk. In the case of the ratio of skim/low fat to whole milk, private labels are lower than the other two brands. In the case of merchandising and price reduction variables, there are significant difference between the top three supermarket players (Stop & Shop, Shaw's and Star Market), and DeMoulas and Residual Chains. Shaws has a very high average price reduction (27%) followed by Stop & Shop (26%) and, Star Market (23%). The smaller players have very low price reductions: DeMoulas (3.3%) and Residual Chains (3%). In terms of milk merchandising Star Market leads (23.1% of all milk sold is sold with merchandising) and followed by Stop & Shop (14.83%), Shaw's (13.1%). Again DeMoulas (6.6%) and Residual Chains (3.5%) are very low. The data clearly indicate that DeMoulas and the Residual Chains are everyday low price (EDLP) chains whereas the other three are Hi-Low merchandisers.

Our most important supply side variable is the raw milk price. For the pre-Compact period we use Federal Milk Marketing Order (FMMO) announced Class-I milk price. And for the post-Compact period we use higher of the announced FMMO and Compact floor price.

To capture the effect of energy cost on processing fluid milk we use the electricity rate in Massachusetts ($ per Kilo Watt-Hour).[7] Milk processing is highly energy intensive not only at the pasteurization phase but also during storage.

We also use the wage rate for the dairy processing industries in the US. Data for Massachusetts or the Northeast were not available. Like energy, labor is a critical factor in processing and handling fluid milk.

The average difference between the pre- and post-Compact raw fluid level milk price is about 8.5 cents per gallon, a 5.67% increase over the pre-Compact period. Not all of the reported price increase is due to the Compact price floor. Part was due to short milk supply and prices above the floor. Also the Compact decreased the farm level class-I milk price variance significantly from 0.12 during the pre-Compact period to 0.088 after the Compact. Electricity rates were lower during part of the post-Compact period. They declined from the beginning of 1999 to the end of the study period, July 2000. On the other hand the wage rate increased steadily in both the pre- and post-Compact period.

Regression Results[8]

We use non-linear three-stage least square (N3SLS) to estimate the alternative vertical Nash and vertical coordination models. As suggested by Berry (1994) retail price and conditional and marginal market shares are the endogenous variables in market equilibrium models. The other marketing mix and cost variables are assumed to be exogenous and used as instruments.

The estimated model contains several cross equation restrictions that aid in estimation. To determine the most appropriate cost and Compact binary restrictions, regression analysis was initiated with the most flexible specification i.e. a minimum number of restrictions on each of the cost functions. Final specification is chosen based on the non-linear three-stage regression optimization criterion. In the final specification, except for the unobservable cost component, all the cost parameters are constrained to be primary-brand specific. For example, for Garelick milk all parameter values of the cost specification are the same and do not change when it is sold by different retailers. This is also the restriction set for Hood and Private Label. Similarly primary brand cross equation restrictions were found to generate the best fit model for the Compact binary. Given the similarity of the costs and characteristics of a brand across retail chains the resulting cross equation restrictions for the pricing equations are not surprising.

In N3SLS, our estimate of the log likelihood function value comes from the concentrated log likelihood function estimated with the help of the final parameter values. A Vuong test statistic (Gasmi, Laffont and Vuong, 1992) finds no significant difference between the two models. The positive sign of the test statistic, however, indicates that the vertical Nash model is more appropriate, so subsequent sections focus on parameter estimates from that model. Nonetheless, the conclusions that can be drawn from the two models are very similar. This result suggests that prior research that ignored vertical channel structure by assuming full vertical coordination under a single maximizing agent may be reasonably accurate.

Table 1 reports vertical Nash estimation results. The system wide weighted R^2 is 0.73, following McElroy (1977).[9] High values of the system R^2 suggest that our model does fit well with the data. Note that 48 of the 64 estimated coefficients are statistically significant.

In the nested logit demand system *price*, measured as $/pint, has a negative and statistically significant impact as hypothesized. The estimated coefficient for the ratio of skim/low fat to whole milk and the weighted average price reduction are both positive as hypothesized and highly significant. The estimated coefficient for volume per unit is significant and negative implying, ceteris paribus, consumers prefer smaller package sizes. For example, if price and characteristics for a gallon of milk are not changed then consumer will prefer to buy two half-gallon containers rather than buying a single one-gallon container.

In the case of variable *ratio of skim/low fat to whole milk,* the estimated coefficient is positive and significant. This variable is used to capture the intra-brand differentiation of fluid milk sold in a store. Most of the enriched milk, organic and other specialty milks are usually processed as skim/low fat categories. This variable also captures the present consumer trend towards low fat diets. This result implies that creation of successful skim/low fat fluid milk products within a brand will help drive market share up.

The sign of coefficient associated with the variable w*eighted average price reduction (of any price reduction)* is positive and significant as expected. Price reduction leads to higher market share for any brand.

The estimated coefficient associated with the variable *percentage volume merchandising (of any merchandising)* is negative. The sign of this variable's coefficient in earlier studies has been mixed. Since we are already controlling for price and price reduction, the negative sign implies 'non-price reduction' type merchandising in milk category reduces market share. Such merchandising is trivial in the milk category apparently for good reason. It does not increase market share.

The variance components are both positive as hypothesized and significant. This supports the two stage nesting structure of the model. The brand level intercepts for each of the 15 brands are different and highly significant, as one would expect since the brands have different market shares.

The supply side cost parameters are not as uniformly significant as the demand parameters. Cost intercepts capture the unobservable (to econometricians but not to the channel players) firm specific cost components of the brands. Intercepts are all positive and 9 of 15 are significant. On average across brands unobservable cost is about 44 cents per gallon. For the Garelick brands it is 21 cents; for Hood it is 75 cents; and for private label it is 39 cents. Of the three brands, Hood processes the least amount of milk but it has introduced new product innovations (for example, the light block bottle for fluid milk and vitamin C in milk). Thus Hoods higher unobservable cost may be due to lower processing volume and the costs of newly innovated products.

The estimated coefficients for electricity and wage rates and their interaction coefficients with the market shares are significant. In case of Garelick and Private label brands, farm level milk price does have a positive significant impact on marginal costs. But in the case of Hood brands, none of the estimated coefficients for farm level milk price, or interaction terms with farm level milk price, are significant. Reduced form analysis in Cotterill (2000) also finds a weak relationship between the retail price and the farm level milk price and strong relationships with the wage rate.

Coefficients of the interaction terms between input costs (electricity and the farm level milk price, and electricity and wage rate) also are not statistically significant in most cases. Only one of six interaction coefficient is statistically significant at 5% level.

Finally as reported in Table 1 all estimated coefficients for the three Compact binaries are positive and significant. Scaling these estimated parameters to a per gallon basis, post Compact retail prices for Garelick milk are 12 cents higher than in the pre Compact period. For Hood post compact prices are 7 cents higher, and for private label milk prices are 17 cents higher. Since the model controls for changes in input prices these higher prices are not due to changes in costs.

We will further evaluate the impact of the Compact on channel price conduct after analyzing brand level elasticities and simulations for the potential exercise of market power.

The Brand Level Price Elasticity Matrix

Given the assumption of exogenous market size ($s_{ij}H=Q_{ij}$) price elasticity estimates in terms of market share and quantity sold are equal. Here we will interpret them in quantity terms. Table 2 presents the partial price elasticity matrix for all brands of milk. As expected, all own-price elasticities are negative, and all cross-price elasticities are positive. Brand level own-price elasticities for Hood and Garelick, the branded products are extremely high. For example a 1% increase in the price of Garelick milk in the Stop & Shop supermarket chain, ceteris paribus, results in a 28.90% decrease in the quantity of Garelick milk sold.

In the top two chains, Stop and Shop and Shaws, own-price elasticities for private label milk are much lower, -10.97 and -11.26 respectively, but still quite elastic. DeMoulas the low priced chain in this study has even lower own-price elasticity for private label, -3.62. Private Label demand becomes less elastic as the price of private label milk falls. When consumers know that the milk is very cheap compared to alternatives they are relatively unresponsive to price changes.

Finally note that the brand cross-price elasticities within a retail chain are much higher than the cross-price elasticities across stores for a particular brand. This documents that consumers prefer switching brands within a retail chain to moving to a different store for the same brand when its price increases.

Conditional Elasticities and the Analysis of Market Power

These high brand level partial own-price elasticities seem to imply that there is very little unilateral market power in the Boston Fluid milk market, however further analysis reveals that this is not the case. Given the nesting structure of our model, we can decompose the elasticity of any brand into the following components:[10]

[13] $$\eta_{ij} = \eta_R + \eta_{j/R} + \eta_{i/jR}$$

where η_{ij} is the overall elasticity and η_R, $\eta_{j/R}$, and $\eta_{i/jR}$ are conditional elasticities. η_R gives the percent quantity lost to the outside option. $\eta_{j/R}$ gives the percent quantity lost to other retailers, and $\eta_{i/jR}$ gives the percent quantity lost to other brands in the store. Their sum is the own price elasticity, η_{ij} .

Table 3 reports selected conditional elasticities that one can use to evaluate unilateral power pricing strategies. Column 1 gives the estimated chain level elasticity ($\eta_{j/R}$) for each chain. These elasticities give the percentage change in quantity of fluid milk sold by a retailer for 1% change in price of each of the three brands sold. For example, if Stop & Shop raises the prices of the three brands by 1% then it loses 1.36% market share to other chains and the outside option. Since all other retailer's prices are assumed constant, these conditional elasticities are a measure of each supermarkets unilateral market power (USDOJ, 1992; Cotterill and Samson, 2002). Such low conditional own price elasticities indicates significant unilateral market power at the chain level. Individual chains can profitably raise price because they lose very little in terms of market share to any of the other retailers or outside options.

The situation is clearly very different for processors. The brand level elasticities in Table 2 indicate that any unilateral price increase of one brand by a processor would lead to a significant switch to other brands within stores, resulting in significant loss of volume and lower profits. However since June 2000 Suiza/Dean Foods effectively controls the processing of

Garelick and all private label milk in the Boston regional market, so one needs to examine the impact on sales and profits of a joint increase in the wholesale prices of these two brands.

The last two columns of Table 3 report the resulting own-price elasticities for that joint price elevation. Suiza/Deans Foods faces the lowest elasticities of demand in DeMoulas's stores. For private label milk it is -2.57 and for Garelick it is -5.35. Therefore after its strategic alliance with Stop& Shop in June 2000 it is interesting to note that Suiza/Dean Foods could have made its strongest price move against DeMoulas., the retailer that sells milk at effectively competitive prices but has the least elastic demand.. In fact near that time DeMoulas switched a major part of its private label procurement to Weeks Dairy (NDH/Crowley), Concord, NH to reduce Suiza/Dean Food's leverage. At the other extreme Star Market, with the most elastic conditional elasticities offers Suiza/Dean Foods the least leverage because these high priced central city stores serve an affluent crowd that readily trades up to Hood.

Given these joint price elasticities would it be profitable for Dean Foods/Suiza to elevate the prices of Garelick and private label milk?[11] To answer this question one needs Suiza/Dean Foods operating profit-sales ratio before a contemplated price increase. Suiza's profit-sales ratio as a company during the late 1990s was approximately 5% (Suiza, 2000). Absent data on Boston our working assumption is that this is the profit sales ratio in Boston before price elevation. A 1 percent retail price increase goes to the bottom line and increases the unit profit margin 20%. For profits to decrease due to a decrease in quantity sold, the own-price elasticities in Table 3 columns 2 and 3 would have to be less than –20. They are not. Even if Suiza/Dean's operating profit-sales ratio in Boston was as high as 10%, an implausibly high rate, the own price elasticities for a joint price elevation would have to be less than -10. They are not. Therefore joint price elevation of Garelick and private label wholesale milk prices is a profitable move for Suiza/Dean Foods.

We conclude that the structure of demand in the Boston market is sufficiently inelastic to reward cooperation of Suiza/Dean and Stop and Shop on pricing of Garelick and private label milk prior to June 2000 and to reward Suiza/Dean Foods on its own after that date when it assumed processing of private label for Stop & Shop. Stop & Shop clearly had a strong incentive to negotiate carefully the long-term contract for wholesale private label milk prices when it closed its plant in June 2000 and entered into a strategic alliance with Suiza/Deans Foods. DeMoulas moved to diversify its sourcing of private label when Stop and Shop formed the alliance with Suiza/Dean. Also at that time Big Y Supermarkets in western New England switched from Suiza/Dean Foods to the Guida Sebert Milk Company, New Britain, CT. for its private label milk because it feared the dominance of Suiza/Dean.[12]

Analysis of the North East Dairy Compact as a Focal Point Event

Our elasticity estimates indicate that supermarket chains and/or Dean Foods Suiza would have found it profitable to raise price. The question that remains is did they in fact raise prices? Our analysis of pricing before and after the Compact indicate that they did at the time of Compact implementation in July 1997. The estimated coefficients for the three Compact binaries capture the effect of the Compact on retail price after controlling for changes in costs including changes in the farm level milk price. As reported in Table 1 each is positive and significant at the 1% level. These results are consistent with elevation of Garelick and private label price by Dean Foods/Suiza as well as the elevation of all three retail prices by chains. Our model cannot identify exactly who raised prices; however, the positive and significant effect of the Compact on prices does suggest that the Compact was a watershed event for the exercise market power by the channel players. Since our data set ends in July 2000 we can not measure any price impacts associated with the Suiza/Dean foods strategic alliance with Stop & Shop.

Pre and Post-Compact Unit Costs and Price-Cost Margins

Examination of marginal average and costs indicate how the Compact affected the processing cost structure. Table 4-columns1 and 2, present estimated monthly marginal and average and costs per gallon in the pre and post-Compact periods for each of the three brands, Hood, Garelick and private label in each of the five chains. Private label milk has the lowest marginal average and processing cost. Garelick has a cost advantage over Hood. For all brands at equilibrium, marginal cost is lower than average cost. This suggests that by processing more milk, the average cost of processing these brands can be lowered and suggests that plant utilization rates do affect unit costs of processing.

Note that as we expect marginal cost is higher post-compact for all brands except Hood in Shaw's. This anomalous result is due to the fact that Shaw's was dealing only in very marginal quantities of Hood milk during most of the pre Compact period (Cotterill and Franklin, 2001, p. 95). Its introductory prices and costs were very high and dropped dramatically two months prior to the Compact when they moved to full distribution of Hood.

Table 4-column 4 presents the average monthly total channel price-cost margins for each brand during the pre and post-Compact periods.[13] Total channel price-cost margins for all the brands, except Hood in Shaw's, are higher in the post-Compact period. Price-cost margins are on an average 9.88% percentage points higher in the post-Compact period than in the pre-Compact period. Retail prices increased not only because unit costs including raw milk costs increased, but also because the channel unit profit margin increased.

Private labels in table 4 are the most profitable brands, followed by Garelick and then Hood. For private label milk DeMoulas has the highest channel price-cost margin during the post-Compact period (27.18%) and Star Market has the lowest (23.03%). The fact that DeMoulas, the lowest priced chain in our study has the highest post-Compact price-cost margin and that Star Market, the highest priced chain, has the lowest price-cost margin is not entirely surprising given their estimated elasticities in table 3. Also the cost conditions facing these chains drive their pricing and price-cost margins.. DeMoulas average cost for private label is estimated to be the lowest in the study, $1.77 per gallon. At $2.07 per gallon Star Market has the highest unit cost for private label milk. These estimates seem plausible given DeMoulas locations in the outlying suburbs of the Boston IRI market and Star Markets locations in central Boston. The cost estimates clearly are capturing the higher distribution costs for the central city.

Incremental Profits Due to Wider Post-compact Price-Cost Margins

Based on sales and the widened market margins that the Compact generated during the post Compact period, one can calculate the total dollars of excess profits that channel players received. Table 5 reports that marketing channel firms after controlling for all cost increases in response to the Compact, captured $25.05 million of additional profit, with private label accounting for almost $18.35 million of it.[14] Since Stop and Shop processed its private label and Hood milk it captured $6.48 million in increased milk profits during the three year post-Compact period of our study. Garelick milk sold in Stop and Shop earned an extra $1.04 million. Part of this increase may have gone to Suiza/Dean Foods the processor of Garelick. Some of the increased profits captured during the post-Compact period at other supermarket chains may also flow back to processors.

Concluding Remarks

This study is one of the first attempts to model and empirically evaluate a vertical market channel with differentiated products. Detailed brand and chain specific knowledge of vertical relationships allows us to specify two alternative vertical games, full coordination and Nash-Bertrand. Prior research that has ignored processor-retailer channel structure essentially assumes a full coordination game. Our research does not reject this approach, however the Nash-Bertrand model is marginally preferred. Our estimated elasticity matrix not only explains the nature of competition across stores but also within a store. The estimates suggest that consumers tend to switch brands within store rather than change store for the same brand. At the brand level competition is much stronger within a retail chain than it is across retail chains. This structure of competition fits squarely with Slade's (1995) assumption. She specified retailers as 'localized monopolies' when analyzing one of several thousand products sold in the typical supermarket.

Antitrust simulation analyses use the estimated brand level partial demand elasticity matrix to measure market power (Hosken et al. 2002). We report that individual chains possess sufficient market power to unilaterally elevate the prices of milk in a profitable fashion. Dean/Suiza in conjunction with Stop and Shop prior to their joint venture in June 2000, and by itself thereafter, could also jointly elevate the prices of its Garelick and Private label milk in a profitable fashion.

These predictions from the antitrust simulation analysis in fact are consistent with our analysis of focal point pricing at Compact implementation. We estimate that focal point pricing increased the price of private label milk 17 cents, Garelick milk 12 cents, and Hood milk 7 cents per gallon. These price increases are net of changes in costs, including raw milk price increases due to the Compact.

Estimated post-Compact price-cost margins for the channel are higher than pre-Compact margins. This analysis documents a lessening of competition as measured by price cost margins, however it does not always identify how much of the enhanced margin accrues to individual retailers and processors. Since Stop& Shop processed its own private label and Hood milk during the 1996-2000 it captured all of the margin increase on these two brands in its stores, 6.48 million dollars. During the July 1997 to July 2000 post-Compact period consumers in the Boston IRI market area paid $25.05 million more for milk due to a reduction in price competition.

Our models are based on simplifying assumptions such as constant linear conjectures by processors on retail margins in the vertical channel, and variable cost at retail level measured only by the wholesale milk price. If wholesale milk price and retail cost data become available future empirical research should relax these simplifying assumptions.

Table 1: Regression Results from the Vertical Nash Game

Variable Name	Coefficients	Assymp. T-stat
Demand Side		
Retail Milk Price	*-1.2357*	*-7.8045****
Volume Per Unit	*-0.0433*	*-21.706****
Ratio of Skim/Low Fat to Whole Milk	*0.0024*	*4.1164****
Weighted Avg. Price Red. (of Any Price Red.)	*0.0068*	*14.304****
% of Volume Merchandising (of Any Merchandising)	*-0.0014*	*-9.5479****
Demand Intercept: Stop & Shop (Garelick)	*3.4384*	*65.632****
Demand Intercept: Stop & Shop (Hood)	*3.4472*	*64.364****
Demand Intercept: Stop & Shop (Private Label)	*3.4142*	*67.074****
Demand Intercept: Shaw's (Garelick)	*3.3782*	*62.765****
Demand Intercept: Shaw's (Hood)	*3.4209*	*63.536****
Demand Intercept: Shaw's (Private Label)	*3.4983*	*64.439****
Demand Intercept: Star Market (Garelick)	*3.3889*	*62.609****
Demand Intercept: Star Market (Hood)	*3.4031*	*62.842****
Demand Intercept: Star Market (Private Label)	*3.5002*	*65.798****
Demand Intercept: DeMoulas (Garelick)	*3.3601*	*67.05****
Demand Intercept: DeMoulas (Hood)	*3.3497*	*64.857****
Demand Intercept: DeMoulas (Private Label)	*3.5170*	*66.642****
Demand Intercept: Rest of the Retailers (Garelick)	*3.4558*	*66.15****
Demand Intercept: Rest of the Retailers (Hood)	*3.4001*	*65.25****
Demand Intercept: Rest of the Retailers (Private Label)	*3.5335*	*65.313****
Variance Component (Nest Level-1) [1]	0.0328	8.3966***
Variance Component (Nest Level-2) [2]	0.0300	4.7663***
Compact Effect		
Compact Binary: Garelick	0.0073	5.7606***
Compact Binary: Hood	0.0045	4.4374***
Compact Binary: Private Label	0.0109	11.84***
Supply Side		
Cost Intercept: Garelick (Stop & Shop)	0.0124	0.71
Cost Intercept: Hood (Stop & Shop)	0.0502	3.4453***
Cost Intercept: Private Label (Stop & Shop)	0.0307	2.3455**
Cost Intercept: Garelick (Shaw's)	0.0135	0.78
Cost Intercept: Hood (Shaw's)	0.0478	3.2613***

Cost Intercept: Private Label (Shaw's)	0.0257	1.9449*
Cost Intercept: Garelick (Star Market)	0.0207	1.21
Cost Intercept: Hood (Star Market)	0.0579	4.0223***
Cost Intercept: Private Label (Star Market)	0.0276	2.0656*
Cost Intercept: Garelick (DeMoulas)	0.0072	0.42
Cost Intercept: Hood (DeMoulas)	0.0379	2.5915*
Cost Intercept: Private Label (DeMoulas)	0.0121	0.91
Cost Intercept: Garelick (Rest of the Retailers)	0.0009	0.05
Cost Intercept: Hood (Rest of the Retailers)	0.0414	2.8537**
Cost Intercept: Private Label (Rest of the Retailers)	0.0247	1.8253*
Farm Level Milk Price (Garelick)	1.7016	1.47
Electricity Rate (Garelick)	5.8634	4.9241***
Wage Rate (Garelick)	0.0412	4.9678***
Farm Level Milk Price * Electricity Rate (Garelick)	-4.2305	-1.67
Electricity Rate * Wage (Garelick)	-0.6636	-2.9791**
Market Share * Farm Level Milk Price (Garelick)	2.2272	3.1136***
Market Share * Wage Rate (Garelick)	-0.0320	-5.4421***
Market Share * Electricity Rate (Garelick)	1.9191	3.4419***
Farm Level Milk Price (Hood)	0.3662	0.37
Electricity Rate (Hood)	2.3456	2.4246*
Wage Rate (Hood)	0.0204	2.8521*
Farm Level Milk Price * Electricity Rate (Hood)	-0.8859	-0.42
Electricity Rate * Wage (Hood)	-0.2916	-1.55
Market Share * Farm Level Milk Price (Hood)	-2.3885	-0.74
Market Share * Wage Rate (Hood)	0.1144	5.005***
Market Share * Electricity Rate (Hood)	-24.5100	-10.024***
Farm Level Milk Price (Private Label)	2.9762	3.497***
Electricity Rate (Private Label)	4.3864	5.0587***
Wage Rate (Private Label)	0.0205	3.3645***
Farm Level Milk Price * Electricity Rate (Private Label)	-6.2986	-3.3901***
Electricity Rate * Wage (Private Label)	-0.2540	-1.56
Market Share * Farm Level Milk Price (Private Label)	-0.3610	-1.43
Market Share * Wage Rate (Private Label)	-0.0127	-6.5928***
Market Share * Electricity Rate (Private Label)	1.8327	8.3681***
Weighted System R-Square: 0.7283492		

* Significant at 10% Level; ** Significant at 5% Level; *** Significant at 1% Level
1: Nest of Major Retail Chains and Outside Option
2: Nest of Major Retail Chains
Note: Italicized Variables are part of the Random Utility Model

Table 2: Overall Elasticity Matrix at the Median (Vertical Nash Game)

		Garelick					Hood					Private Label				
		S_S	Sh	S_M	DeM	RoR	S_S	Sh	S_M	DeM	RoR	S_S	Sh	S_M	DeM	RoR
Garelick	S_S	**-28.898**	0.082	0.071	0.013	0.155	*4.970*	0.039	0.048	0.017	0.042	*21.144*	0.203	0.095	0.220	0.070
	Sh	0.052	**-26.902**	0.045	0.008	0.101	0.038	*3.775*	0.028	0.010	0.025	0.169	*21.113*	0.060	0.139	0.043
	S_M	0.023	0.022	**-24.988**	0.004	0.043	0.018	0.011	*7.347*	0.005	0.012	0.077	0.058	*15.207*	0.061	0.020
	DeM	0.212	0.248	0.192	**-32.199**	0.367	0.151	0.073	0.106	*1.959*	0.103	0.759	0.582	0.272	*24.621*	0.136
	R_C	0.016	0.016	0.014	0.002	**-13.925**	0.012	0.007	0.009	0.004	*5.619*	0.056	0.043	0.019	0.046	*8.162*
Hood	S_S	*6.449*	0.106	0.094	0.018	0.200	**-31.852**	0.051	0.062	0.025	0.060	*21.144*	0.277	0.125	0.292	0.091
	Sh	0.114	*7.936*	0.098	0.032	0.177	0.101	**-34.981**	0.071	0.036	0.074	0.382	*21.113*	0.134	0.304	0.072
	S_M	0.037	0.039	*11.577*	0.007	0.062	0.029	0.016	**-31.673**	0.009	0.019	0.127	0.098	*15.207*	0.105	0.026
	DeM	0.173	0.173	0.148	*1.450*	0.307	0.135	0.069	0.093	**-34.634**	0.087	0.594	0.429	0.200	*24.621*	0.114
	R_C	0.056	0.020	0.035	0.017	*18.618*	0.054	0.020	0.036	0.018	**-31.324**	0.209	0.144	0.062	0.153	*8.162*
Private Label	S_S	*6.449*	0.021	0.020	0.004	0.042	*4.970*	0.011	0.013	0.005	0.011	**-10.975**	0.056	0.026	0.060	0.019
	Sh	0.018	*7.936*	0.014	0.003	0.032	0.014	*3.775*	0.010	0.004	0.008	0.062	**-11.261**	0.019	0.046	0.014
	S_M	0.015	0.013	*11.577*	0.003	0.027	0.012	0.007	*7.347*	0.003	0.007	0.051	0.038	**-16.953**	0.040	0.013
	DeM	0.012	0.011	0.010	*1.450*	0.023	0.009	0.006	0.006	*1.959*	0.006	0.038	0.029	0.013	**-3.622**	0.010
	R_C	0.038	0.036	0.031	0.007	*18.618*	0.028	0.013	0.020	0.009	*5.619*	0.126	0.098	0.044	0.103	**-24.357**

*In this elasticity matrix the column label represents the percentage price change and the row label represents the percentage market demand change

* S_S: Stop & Shop; Sh: Shaw's; S_M: Star Market: DeM: DeMoulas; RC:

Table 3: Own Price Elasticities Under Alternative Pricing Scenario

Store	Supermarket Raises Prices of its 3 Brands	The Suiza/Dean Foods Option: Raising Only Garelick and Private Label Prices	
		Garelick	Private Labels
Stop & Shop	-1.36	-7.38	-4.82
Shaw's	-1.46	-5.71	-3.66
Star Market	-1.55	-10.01	-5.72
DeMoulas	-1.34	-5.35	-2.57
Residual Chains	-1.45	-6.09	-5.80
Average	**-1.43**	**-6.91**	**-4.51**

Table 4: Total Channel Marginal Cost, Average Cost, Profit Margin and % Change in Margin

Pocessor/ Brand	Retailer	Total Channel Marginal Cost ($/gal)		Total Channel Avg. Cost ($/gal)		Average Retail Price ($/gal)		Total Channel Price-Cost Margin (%)		% Change in Margin (%)
		Pre-	***Post-***	**Pre-**	***Post-***	**Pre-**	***Post-***	**Pre-**	***Post-***	
	Stop & Shop	2.10	*2.34*	2.12	*2.38*	2.54	*3.07*	19.51	*21.58*	10.59
	Shaw's	2.11	*2.37*	2.13	*2.40*	2.64	*2.99*	18.52	*20.10*	8.53
Garelick	Star Market	2.24	*2.49*	2.25	*2.52*	2.68	*3.08*	16.56	*18.22*	10.07
	DeMoulas	2.05	*2.31*	2.05	*2.32*	2.63	*2.88*	19.23	*20.74*	7.88
	Residual Chains	1.84	*2.12*	1.89	*2.17*	2.41	*2.71*	20.18	*20.41*	1.18
	Stop & Shop	2.30	*2.39*	2.47	*2.58*	2.74	*3.05*	12.53	*14.57*	16.32
	Shaw's	2.56	*2.52*	2.58	*2.62*	3.24	*3.02*	15.94	*15.54*	-2.55
Hood	Star Market	2.52	*2.64*	2.64	*2.76*	2.96	*3.19*	11.56	*13.11*	13.39
	DeMoulas	2.32	*2.45*	2.38	*2.51*	2.83	*3.01*	15.44	*17.00*	10.10
	Residual Chains	2.21	*2.37*	2.35	*2.50*	2.71	*2.93*	13.81	*14.62*	5.86
	Stop & Shop	1.82	*1.95*	1.87	*2.05*	2.33	*2.68*	19.75	*23.46*	18.81
	Shaw's	1.75	*1.93*	1.80	*2.00*	2.32	*2.62*	21.27	*24.22*	13.87
	Star Market	1.84	*2.04*	1.86	*2.07*	2.31	*2.69*	19.52	*23.03*	17.98
Private Label	DeMoulas	1.52	*1.69*	1.58	*1.77*	2.15	*2.42*	25.60	*27.18*	6.18
	Residual Chains	1.79	*2.01*	1.81	*2.03*	2.28	*2.68*	21.69	*23.87*	10.03

** Pre-: Pre Compact; Post-: Post Compact*

Table 5: Total Benefit to Channel Players Due to Post-Compact Margin Expansion: July 1997 - July2000[1]

Brand	Store	Benefit
	Stop & Shop	1.04
	Shaw's	0.93
Garelick	Star Market	0.85
	DeMoulas	0.27
	Residual Chains	1.84
Total for Garelick		**4.93**
	Stop & Shop	0.57
	Shaw's	0.32
Hood	Star Market	0.36
	DeMoulas	0.18
	Residual Chains	0.35
Total for Hood		**1.78**
	Stop & Shop	5.91
	Shaw's	4.32
Private Label	Star Market	1.89
	DeMoulas	4.98
	Residual Chains	1.25
Total for Private Label		**18.35**
Total for All Brands		**25.05**

[1] Millions of $

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Endnotes

[1] IRI Inc.: Chicago based consulting firm that collects retail scanner data from major U.S. cities. Retail data used in this paper was purchased from them. See any annual edition of Trade Dimensions, Inc., Market Scope for a map and detailed demographic and all grocery market share data for the Boston IRI market area.
[2] In the short run many retailing costs including cost of real estate, refrigeration cost etc. tends to be either sunk or otherwise fixed. Labor is probably the main exception.
[3] As residual and specialty products in the market these brands are not expected to significantly affect the oligopolistic interactions between the dominant brands within a market.
[4] At the end of our sample period in June 2000 Stop and Shop closed its plant and entered a long term strategic alliance with Suiza.
[5] Cumberland Farms, the other firm that did private label in New England prior to its 1998 acquisition by Suiza/Dean, supplied no chains in the Boston area (Hasseotes).
[6] This establishes a 1 to 1 correspondence between market share and quantity sold.
[7] Due to high multi-collinearity between gasoline price and electricity rate, we dropped gasoline price from the cost specification.
[8] Detailed regression results not presented in the paper are available from the authors on request.

[10] Detailed derivation is presented in the reviewer's appendix and posted on our website.
[11] Note that our Vertical Nash model assumes a fixed retail markup for a chain so: $\frac{\partial P_R}{P_R} = \frac{w}{P_R} \cdot \frac{\partial w}{w}$

The percent change in retail price equal the ratio of the wholesale to retail price times the percent change in the wholesale price. Thus a one percent change in wholesale price producers less than a one percent change in retail price. This implies that the retail prices elasticities in columns 2 and 3 of Table 3 are more elastic than the actual wholesale elasticities.
[12] Communication to R W Cotterill by Alexander Guida, CEO Guida Sebert Dairy Inc. May 2001
[13] Profit margins presented are based on the following formula: Price-cost Margin = (Predicted Price – Estimated Average Cost) / Predicted Price.
[14] Mathematically, Compact related Profit = Total Post Compact Sales*Compact Binary.