Two-Stage Oligopoly Pricing with Differentiated Product: The Boston Fluid Milk Market©

By

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(Draft Prepared for the American Agricultural Economics Annual Meeting, Long Beach, California, 2002)

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"People of the same trade seldom meet together, even for merriment and diversion, but the conversation ends in a conspiracy against the public or in some convenience to raise prices…."

> -Adam Smith (1937): An Inquiry into the Nature and Causes of the Wealth of Nations, ed. by Edwin Cannan. New York: The Modern Library.

Introduction

The US fluid milk market is going thorough rapid changes, not only due to major modifications and rationalizations in the Federal Milk Marketing Order (FMMO) system but also due to consolidation of processing and retailing firms in the milk-marketing channel. Although there is a substantial amount of research on fluid milk markets, little research has been done from the perspective of industrial organization. More importantly, most research assumes a competitive market channel; as a result, policy implications drawn from these studies are not relevant to the present, because fluid milk market channels have evolved into highly concentrated oligopolies both at the processing and at the retailing level. In terms of product definition, most of the early studies on fluid milk assume homogeneous products. The present study will try to overcome this shortcoming by studying the fluid milk market using the framework of differentiated product oligopoly.

To keep the research agenda manageable and focused however, the present study will concentrate on the strategic interactions between processors and retailers in a major US city. Rather than studying the fluid milk market at the state or national level, this study focuses on a regional milk market that is the Boston Retail market area. This area is large enough to serve as a geographic market area for milk processing and small enough to capture, in serviceable fashion, strategic interaction among supermarket retailers. Empirically this is the first study of the fluid milk market that specifies a structural differentiated product oligopoly model with flexible demand and cost specifications.

The present study uses disaggregated retail chain level data from Boston to analyze conduct and performance at the retail and processor level. Due to the uniqueness of the disaggregated data in this study it was possible to differentiate milk between branded and private label milk.

The other reason for studying the Boston market is to measure the impact of the North East Dairy Compact (Compact). In July of 1997, the North East Dairy Compact Commission began instituting an over-order price premium for dairy farmers. The Compact affected the blend price that farmers receive by effectively establishing a price floor for the Class-I milk in the New England milk market. The announcement of the over-order premium generated a significant amount of media attention and encouraged a great deal of speculation about its impact on retail fluid milk prices. Since the Boston market is the largest city market within the Compact area, a study of the Boston milk market is critical in understanding the impact of the Compact. Compared to other studies on the Compact, this is the first study to use structural new empirical industrial organization (NEIO) framework.

By specifying a structural model, the present study estimates different indicators of competitiveness of the fluid milk market, namely average and marginal cost, average profits and price-cost margins for the whole, and pre and post Compact period. Our study covers the period from March 1996 to July 2000.

Boston Fluid Milk Market

To analyze the competitive structure of the channel it is very important to start with a description of the Boston market. At the retail level the Boston supermarket industry is one of the most competitive and largest on the East coast. Our model is based on brand level sales milk by the major retailers and processors in Boston and the top four retailers and processors controlled 80% of the milk sale. The top four retailers in Boston market are: Stop & Shop, Shaw's, Star Market and DeMoulas. For the purpose of analysis, we club the rest of the smaller retail chains in the database as 'Residual Chains (RC)'.

In terms of brands, the Boston fluid milk market is dominated by three brands, Private label (Store Brands), Garelick and Hood. Most of the other brands, with very small market shares (less than 1% in most cases) are basically residual and specialty (such as milk for lactose intolerant and organic milk) brands. In terms of within-the-chain market share of brands, private label brands dominate except in the case of Residual Chains; where Garelick dominates.

Regarding processors, the parent of the Garelick brand, Suiza Foods is the largest followed by Hood. During the period of this study, Stop & Shop is the only retailer that had its own processing plant and processed all its private label milk. Also under a special deal, Hood milk sold through its stores was also processed in this plant.[i] The private label milk of the other three chains in recent times has been processed by Suiza Foods.

Data Description

The present research uses unique retail chain level scanner data from the IRI-Infoscan database. [ii] The database provide detailed marketing and retail price related information for the aggregate and 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 period-city-store-brand.

Regarding input costs of processing and packaging milk, the farm level milk price is the most important cost in the retail packaged fluid milk market. There are two price series the Federal Milk Marketing Order (FMMO) provides that measure the input cost of farm level milk price: the announced Class-I price and the announced Cooperative Class-I price. The difference between the two is the over order premium received by the cooperatives. For the pre-Compact period we opted for the first price series because the over order premium is not paid by all processors. In fact the over order premium is to a large extent a service fee rather than a true premium, because the cooperative performs the milk assembly function and balancing services over time. Also, this premium is usually fixed for a long period of time. So, from the perspective of econometrics, over order premium is a scale factor and should not affect the overall results significantly. The post Compact farm level milk price is the higher of the FMMO and the Compact Commission announced price.

The wage rate ($/hr) data used in the cost function specification has been obtained from the Econbase data base prepared by the Wharton Econometrics Forecasting Associates from the Bureau of

Labor Statistics raw data series, available at the University of Connecticut Library web site. Data on industrial electricity rate ($/kilowatt-hour) for Massachusetts has been obtained from the Energy Information Administration, Department of Energy (EIA-DOE) database available at the DOE web site.[iii]

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. To keep the estimation routine manageable and tractable we assume that retailer's only variable cost is the wholesale price.[iv]

Choice of Demand Specification:

Our flexible characteristic based Nested Logit demand specification is similar to Berry (1994) and Besanko et al. (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), with Nested Logit it is possible to derive analytically the exact form of the first order condition.

Another advantage of Nested Logit model is that computationally it is simpler than the random coefficient model as used by Nevo (1997) and Berry et al. (1995). Also, empirically in a recent comparative study, Wojcik (2000) has shown that, although the random coefficient approach to demand specification theoretically is more desirable when modeling differentiated product market, empirically the Nested Logit model performs much better.

Since the success of the estimation of the Nested Logit demand system depend critically on an empirically reasonable product nesting structure, next we describe the nesting structure used in this study.

Unlike any other previous studies of differentiated product markets, we differentiate fluid milk sold through different super market chains at two levels. First milk is differentiated by the brand name under which it is sold. This is 'primary branding'. We have three primary brands in our model: Garelick, Hood and Private label. At the second level milk is differentiated by the store where it is sold. This is termed as 'secondary branding'. For example in our model Garelick milk is sold through all the major retail chains in the Boston market. In this study to capture each retailer's market power, Garelick milk sold through different chains is treated as different brands. Garelick milk at Stop & Shop is different from Garelick milk at Shaw's.

This elaborate nesting structure is an advance. Earlier studies on brand differentiation focused only on primary branding (Cotterill et al., 2000; Nevo, 1997). With just primary branding, retailer market power is explicitly not taken into account. In the recent year's retailer's market power is becoming a very important issue in many market channels including milk. 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).

The specific nesting structure used in this study is presented in Diagram 1. 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.[v] 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.[vi] Empirically aggregating the rest of the retail chains as the Residual Chain is important to keep the model manageable. We assume that the independent effect of these smaller chains in strategic oligopolistic games between the four major retail chains will be insignificant. Together however they may affect the broader market behavior.

On the second level of nodes the choice is between the top three retail brands (Garelick, Hood and Private Label) within a retail chain. As 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.

<u>*Empirical Demand Specifications:*</u>

Nested logit demand system is based on random utility model:

$$u_{hij} = \delta_{ij} + \varepsilon_{hij}$$

where, [1]

$$\delta_{ij} = \beta_{0ij} + X_{ij}\beta - \alpha P_{ij} + \varsigma_{ij}$$

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. 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 value of the unobserved demand characteristics in the RUM. The inclusion of the mean value term ζ_{ij} as a measure of unobservable product attributes follows Berry's (1994) 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 the approach of deriving the Nested Logit demand function using RUM, we derive the following estimable retail demand function:

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

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).[vii] Θ_{RC} is the Variance component term in the second level of nesting (choice between store level brands). And lastly 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. This form of cost specification has been widely used in empirical industrial organization literature (Azzam 1997; Suzuki et al., 1994) for its simplicity and flexibility. From the perspective of the present research objective this specification is flexible enough to capture the farm level milk price and other input cost variations. Nonetheless it is mathematically simple enough to be estimated in a complex non-linear system. So, we specify the following generalized Leontief cost specification (Diewart, 1971):

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

Where C_{ij} is the cost function brand j sold through retailer i. υ_l and υ_m are the price of inputs l and m. Q_{ij} is the level of output. Also, to capture the firm specific unobservable (to econometricians) cost component we use an intercept term in the derived first order conditions. So, my final total cost specification is:

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

Given these demand and cost specifications, we specify two game theoretic models to capture the strategic interactions between retailers and processors. We 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). In a Vertical Coordination game processors and retailers jointly maximizes profit. But in a Vertical Nash game processors and retailers maximize profit simultaneously by deciding, in arms length fashion, on the wholesale and retail price. We chose Vertical Nash game because without any specific information on channel relationships between channel players the Vertical Nash game is preferable (Choi, 1991).

Specification of Processor-Retailer Relationship:

In our Vertical Coordination game we assume each retailer maximizes category profits as if they are owned and controlled the processors that supply them.[viii] 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.

In the case of a Vertical Nash game we need 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 in the case of a Vertical Nash game 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 profit functions to maximize.

The relationships proposed for our model are simplifications of the complex and changing ownership structure that exists in the market. There has been rapid consolidation in the case of processors and retailers of fluid milk in the Boston market. For Garlelick brand we have a single processor (i.e. Suiza Foods). For the Hood brand we have a single processor except in the case of Hood milk sold through Stop & Shop. So, in our Vertical Nash model 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 closest specification because Stop & Shop owns the processing plant.

For the rest of the private label milk (Private Labels of Shaw's, Star Market, DeMoulas and Residual Chains) the number of processors changed dramatically over the period of our study and we do not have detailed information on who processed these private labels for most of the period. But from the middle of the study period have most private label milk were processed by Suiza Foods. The change in the ownership of private label processors creates a problem in terms of deriving estimable first order conditions. For the purpose of manageability and tractability in the estimation procedures we assume a single processor of private label milk for the rest of the four retailer and the residual chain. So, in this paper we use the following processor-retailer linkage: [1] For Garelick Brand sold through Stop & Shop, Shaw's, Star Market, DeMoulas and Rest of the Retailers, Suiza is the processor. [2] For Hood brand sold through Shaw's, Star Market, DeMoulas and Rest of the Retailers, Hood Inc. is the processor. [3] For Hood brand sold through Stop & Shop and Private Label of Stop & Shop, Stop & Shop plant is the processor. [4] For Private Label sold through Shaw's, Star Market, DeMoulas and Rest of the Retailers, Suiza is the processor.

<u>Specification of the Empirical Profit Function and Equilibrium Conditions:</u>

The first order condition for the Vertical Coordination can be derived as:

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

where, $Q_{ij} = s_{ij} H$ and H is the exogenously determined market size as defined by Berry (1994).[ix] For the rest of the derivations this condition holds.

By solving equation [5] we will have the following equilibrium first order condition for each of the 15 brands:

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

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 case of Vertical Nash game, at the retail level we assume that the only variable cost is the wholesale price. So, the retail profit function will be the following:

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

by solving equation [7] we will get the following solution:

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

The second term in equation [8] is the difference between the retail price and marginal cost.

At the processor level, in the Vertical Nash game, we assume processors expect retailers to use a linear mark-up over wholesale. This assumption allows the processor to derive his demand curve from the retail demand curve. Our profit maximizing first order condition at the processor level will be the following:

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

By solving equation [9] we will get the following solution:

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

We plug equation [8] in [10] and get the following estimable equation for the Vertical Nash game:

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

Compact Specification:

Here we derive the estimable first order condition only in the case of Vertical Nash game. The derivation in the case of vertical coordination is similar. Our first order conditions contain marginal cost and the usual mark-up term (the difference between the price and marginal cost). Due to the flexibility of our cost specification, our model should be able capture the effect of the non-strategic change in the farm level milk price on retail price. But to capture any other effect (unobservable to econometricians) related to strategic oligpolistic game such as the Compact implementation, we specify a Compact binary. The effect of the Compact can be both positive and negative in the strategic pricing games of the oligopolistic players in the market and the effect can come from players at any stage of the channel. Due to this unspecific nature of the Compact effect, specifying a binary variable for the Compact was the most flexible approach in modeling the Compact. Our modeling of structural shift with binary is similar to Porter (1983). So, the final estimated first order condition is of the following form:

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

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

As a result of the derivations mentioned above in both the Vertical Coordination and Vertical Nash game we will have 15 demand functions (i.e., equation [2]) and 15 first order conditions (i.e., equation [12]) defining the profit maximizing equilibrium conditions. To capture all the cross brand variations in the market, a 30-equation system (15 demand and 15 first order conditions) is estimated for each game: Vertical Nash and Vertical Coordination.

Variable Description:

Here we describe all the demand and cost side variables used in our analysis.

Demand Side:

To specify the Random Utility Model (RUM), we use a linear combination of variables to specify the characteristics space of the products (i.e. Retail Fluid Milk). Of these characteristics in our model, retail price is endogenously determined and the rest of the variables are assumed to be exogenous. Following variables describe the characteristics space of our demand system: *retail price, volume per unit, ratio of whole milk to skim/low fat milk, weighted average price reduction (of any price reduction), percentage volume merchandising (of any merchandising)*.

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. 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 players (Stop & Shop, Shaw's and Star Market) and DeMoulas and Residual Chains. Highest average price reduction was in Shaw's (27%) followed by Stop & Shop (26%), Star Market (23%), DeMoulas (3.3%) and Residual Chains (3%). In terms of milk sold 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%), DeMoulas (6.6%) and Residual Chains (3.5%).

Our most important supply side variable is the farm level 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 FMMO and Compact announced price.

To capture the effect of energy cost, on processing fluid milk we use the electricity rate in Massachusetts ($ per Kilo Watt-Hour). 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 of USA. Data for Massachusetts or the Northeast US 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 Farm level milk price is about 8.5 cents and in terms of percentage increase it is a 5.67% rise from the Pre-Compact period. Also note that 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 the Post-Compact period. They declined from the beginning of 1999 to the end of the study period. On the other hand the wage rate increased steadily in both the Pre- and Post-Compact period.

Regression Results[x]

We use non-linear three-stage least square (N3SLS) to estimate the two 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 for the estimation procedure.

We use Vuong test (Gasmi, Laffont and Vuong, 1992) to select the best-fit model. Since we use N3SLS, our estimate of the log likelihood function value comes from the conrecentrated log likelihood function estimated with the help of the final parameter values. The test statistic finds no significant difference between the two models; but given the positive sign of the test statistic, the Vertical Nash model is more appropriate. Also, given the values and signs of the estimated parameters, the conclusions that can be drawn from the two models are very similar; so subsequent sections focus on parameter estimates for the Vertical Nash model.

Similarly cross equation restrictions were found to generate the best fit model in the case of the Compact binary. So, in the final model, we estimate three Compact binaries: one each for Garelick, Hood and Private label.

We compute a system wide weighted R^2 following McElroy (1977).[xi] For our Vertical Nash game it is 0.73. For the Vertical Coordination game it is 0.72. High values of the system R^2 suggest that our models do fit well with the data.

We estimate 64 parameters using N3SLS and of these 48 are statistically significant. Most of the statistically insignificant parameters are from the cost specification. Demand side parameters seem to have more explanatory power than the supply side parameters. Nevo (1997) also found that this to be true.

Elasticity Matrix:

In this paper due to space limitations we do not provide detailed estimates of elasticities.[xii] Due to the assumption of exogenous market size ($s_{ij}H=Q$) price elasticity estimates in terms of market share and quantity sold are equal. So, estimated elasticities presented here can be interpreted both ways. For purpose of maintaining consistency, the analysis presented here interprets elasticities in terms of market share.

Due to the elaborate nesting structures of our model, we can decompose elasticity of any brand into the following components:[xiii]

$$\eta_{ij} = \eta_R + \eta_{j/R} + \eta_{i/jR} \qquad [10]$$

where η_{ij} is the overall elasticity and η_R, $\eta_{j/R}$, and $\eta_{i/jR}$ are the conditional elasticities. Such that η_{ij} is the percentage change in market share (s_{ij}) due to 1% price change of brand i sold through retailer j. η_R is the percentage change in market share of the five retailers (s_R) due to 1% change in price of brand i sold through retailer j. $\eta_{j/R}$ is the retailer j's percentage change in share ($s_{j/R}$) due to 1% price change of brand i sold through retailer j. And $\eta_{i/jR}$ is the percentage change in share of brand i ($s_{i/jR}$) due to 1% price change of that brand.

Table 1 presents the overall elasticity matrix for all brands of milk (η_{ij}). The estimated elasticity presented here measures the percent market share change due to 1% percent change in price. In terms of signs, they are as expected: all the own price elasticities are negative and all the cross price elasticities are positive. Within a retail chain the brand cross price elasticities are higher than the brand cross price elasticities across stores implying consumers prefer switching brands within a retail chain rather than moving to a different store for the same brand.

Such inelastic demand across chains suggests significant market power at the chain level. Individual chain can profitably raise price. Any unilateral price increase by a processor will lead significant switch to other brands within stores, resulting in significant market share loss for the processor. But a retailer can increase price of all the brands it sells and lose very little in terms of market share to any of the other retailers. Moreover this result supports Slades (1995) assumptions that for products in a particular category such as milk, a chains store is a local monopoly.

Analysis of the North East Dairy Compact

In this section first we concentrate on analyzing the effect of the Compact on retailers and processors rather than estimating the effect on consumers. To understand the Compact related issues, we explore farm and retail price movements and use estimated mark-ups and profits for different brands.

Exploratory Analysis of the Compact:

Due to the Compact, the average farm level milk price rose from $1.42 to $1.51 per gallon an increase of 8 cents. If the Compact were not there and the FMMO price was the effective price for the full study period then the price change would have been from $1.42 to $1.39, a decrease of 3 cents. So the Compact did increase the pay price received by dairy farmers of New England. This was one of the objectives (Federal Register 30, 1997).

Although the Compact increased raw milk price it decreased raw milk price variation. This decreased input cost risk for processors and retailers. With the Compact, the standard deviation of the farm level milk price decreased from 0.12 to 0.08. Traditional economic analysis would suggest that some of the benefits of the decreased input cost variation could be passed on to the consumers. This was the other objective of the Compact (Cotterill and Franklin, 2001). But in the Boston milk market we find the contrary. The spread between farm and retail price increased significantly for all the brands during the post Compact period (Cotterill and Franklin, 2001). This increased retail prices above and beyond any increase in the farm level price. They also showed that even after taking into account other increases in input costs, the increase in the spread is rather disproportionate.

In view of all the findings presented, it seems useful to use the present model with its explicit flexible cost and demand functions to analyze this unusual increase in the farm to retail price spread.

Average and Marginal Cost:

Table 2 presents estimated marginal and average cost of all the brands. Private label milk has the lowest average and marginal processing cost. Garelick has a cost advantage over Hood. For all the three brands at the 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 if the plants have excess capacity This result is also consistent with the empirical findings of Olley and Pakes (1996), who find that oligopoly results in an inefficient allocation of output across existing plants (even while increasing average productivity by allowing for the entry of productive new firms).

Interestingly just after the Compact when the retail milk price overshot the increase in farm level milk price due to the Compact, the average and marginal cost actually declined for almost all the brands (compare Pre-1997 to Post-1997 in Table 2). For example: in the case of Garelick-Stop & Shop pre Compact-1997 average cost (marginal cost) was 2.16 (2.13) but it dropped to 2.14 (2.12) for the post Compact-1997 period. This strongly suggests the purely strategic nature of the price rise at the time of the Compact implementation. Next we explore profit margins and profit estimates to explore the effect of the post Compact cost increase on channel players' bottom lines.

Profit Margins and Total Profit:

Table 3 presents the total channel profit margins for all the brands.[xiv] In terms of total profit margin private labels (27.97) are the most profitable brands, followed by Garelick (22.48) and Hood brands (16.27). When one compute profit margin by retail chain, private label dominated: DeMoulas has the highest channel profit margin (23.75) and Star Market has the lowest (19.94). The superior performance of the private label milk corroborates the recent surge in private labels across supermarket grocery product categories.

The profit margin for the smaller Hood brand is significantly lower than the other two brands. In terms of millions of gallon sold by each processor and retailer per month this margin difference can detract from total brand profit unless it contributes to a substantial expansion in the quantity sold. For this reason we need to examine total channel profits for each brand.

In terms total channel profit largest retail chain stop & Shop brands make the highest amount of profit ($40.19 million) followed by the number two chain Shaw's brands ($30.61 million). Interestingly for the rest of the retailers ranking in terms of total profit do not follow their ranking in market share. DeMoulas with it's huge private label sales makes more channel profit than Star Market and the Rest of the Retailers. For all five chains private label brands made more channel profits than the other two brands and compared to private label and Garelick, Hood is the distant third. Cotterill and Franklin (2001) document that Hood clearly was competing on price and accepting lower profit to expand market share during this period.

In terms of the total channel profit margins for all the brands (except Hood in Shaw's), the post-Compact estimated profit margins are always higher than the pre-Compact margins. Depending on the brand, price-cost margins rose from 1 to 4 percentage points. These rises in mark-ups across all brands confirm that the Compact facilitated the exercise of market power within the channel.

To see if higher mark-ups led to higher profits we also estimate the average channel profit per period for each brand. Profit estimates are important because with increased price and mark-ups, total profit might decline due to a decrease in sales. Our estimated total channel profit per period for all brands rose, except for the Garelick in Shaw's and Residual chains, and private label for Residual chains. Even for these brands the decline in profit is not so large to make the aggregate channel profit for the market to be lower during the post Compact period than in the pre Compact period.

Unobservable Compact Effect: Estimated Compact Binaries:

The estimated parameters for the three Compact binaries capture the unobservable effect of the Compact on retail price after controlling for changes in costs including changes in the farm level milk price. Consequently it shows the profit enhancing effect of the Compact announcement. All estimated coefficients for the three Compact binaries are positive and significant (Table **). For Garelick brands of milk the Compact has added 12 cents per gallon to retail price, for Hood brands, 7 cents, and for private label milk it is about 17 cents. Interpretation of these numbers will need a broad framework, so we defer further discussion on the Compact binary in the next section, which deals exclusively with the Compact related issues. Also, cost and profit issues related to the Compact are discussed there.

As mentioned in the previous section for Garelick brands this profit enhancing effect is about 12 cents per gallon, for Hood brands 7 cents and for private label milk it is about 17 cents. Due to modeling limitations it is not possible to disaggregate this positive unobservable effect, such that we know how much of the benefit goes to the processors and to retailers. But based on the premium that the Compact generated during the post Compact period, we can calculate the total dollars of excess profits that all channel players received. These benefit numbers are presented in Table *. The marketing channel firms after controlling for all cost increases in response to the Compact, generated $25.05 million of excess profit, with private label cornering almost $18.35 million of it.

Exploratory Reasoning for Post Compact Pricing

The large effect of the Compact on profit does suggest that the Compact as an event has increased market power of the channel players. Structurally this can be construed as a classic market for tacitly collusive behavior. The industry is highly concentrated both at the processor and retail level. The supply side of the industry is highly regulated (at least for fluid milk) through the FMMO and other state and regional regulations. Processing technology is quite similar across processors. Also the very high cross price elasticities between brands in a store require tacit collusion or some other form of coordinated pricing to elevate margins. Given that there can be and is a need for tacit collusion in fluid milk channel, if one seeks to elevate profits, we need to establish the reason for using the Compact as the vehicle exercising market power within the channel. The reason may lie in the concept of 'focal point pricing'

(Chua, 2000). A concept first used by Schelling (1960). According to Schelling's focal point theorem, certain strategy profiles in any game are focal points. Implementation of the Compact in July 1997 was a clear and pre-defined focal point. The public relations and political battles that preceded it, crystallized that date as a critical date for changing prices and focused industry attention on the exact Compact premium that would be imposed, 18 cents per gallon. Before this time channel players did not add any exact increase in the farm price to the retail price in any time period.

Trade organizations both at the processor and retail level vehemently opposed the Compact because it raised the raw fluid milk price and thus could hurt their profitability. They openly stated that post Compact retail prices will be increased by any amount that the Compact increases farm price at implementation. Such statements helped cement tacit collusion to raise price and made the Compact the 'focal point'. There is also a behavioral economic reason for an event like the Compact to turn out to be the 'focal point'. Channel players in a market always find it easier to justify higher prices to consumers when publicly announced events like the Compact that raise their cost.[xv] Sullivan (1987) and Chua (1999) also proposed similar behavioral economic reasoning in their studies. Chua (1999) looks at the effect of large increase of the federal beer tax of 1991. She finds that the beer industry's behavior is consistent with firms using the large tax increase as a focal point (Schelling 1960) to institute a collusive price increase. Harris's study (1987) on the federal cigarette tax found a similar effect of tax over shifting.[xvi]

Finally the Compact per-se provided better information on the farm level fluid milk price. As a price floor the post Compact farm price can only go up but cannot go below the Compact announced price thus eliminating month-to-month price level uncertainty in a downswing. Better input price information, available to all firms and more stable input prices can facilitate collusion.

As we have shown the channel firms' fear of decreased profitability due to the Compact has turned out to be not true. In actuality they exercised market power to increase profits and politically attributed retail price increases to the Compact.

Concluding Remarks

Our estimated elasticities matrix not only explains the nature of competition across stores but also within store. The estimates suggest that consumers for a price change of a brand tend to switch brand within store rather than change store for the same brand. Brand level competition is much stronger within a retail chain than is competition across retail chains. Our profit margin estimates across brands suggest higher margin for private labels. Such higher levels of profits may be one of the reasons for the faster growth private labels across chains.

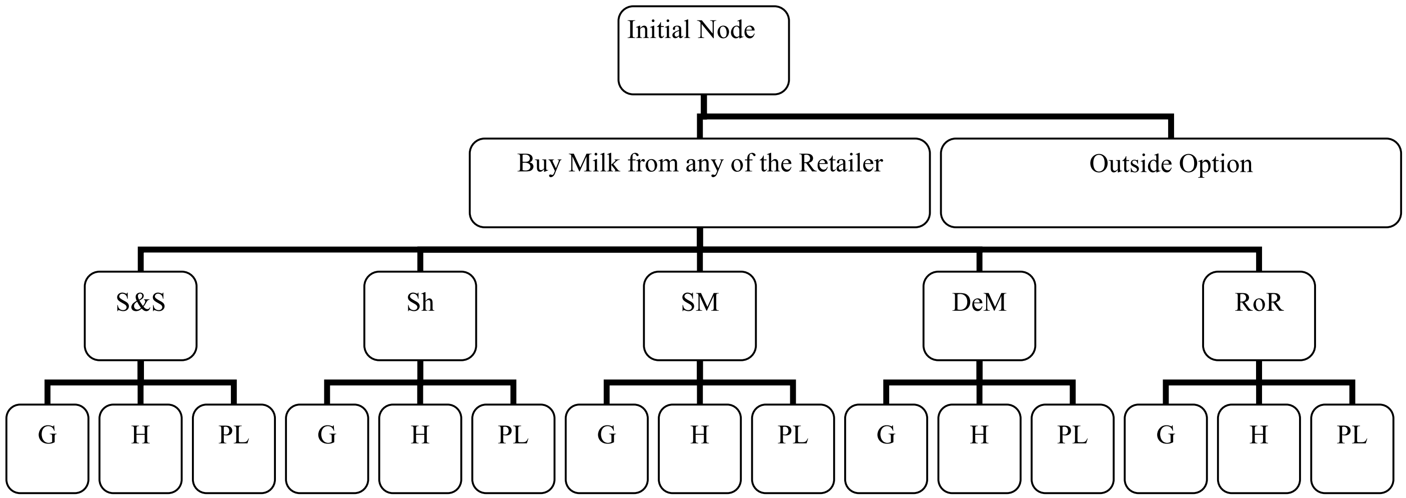
Our review of the literature suggests focal point pricing. Chronological events before and after the compact also suggest that this form of tacit collusion occurred at Compact implementation. Both the estimated Post-Compact margins and the estimated profit per period were higher after Compact implementation. This analysis however does not imply complete elimination of competition. Rather competition between channel players was lessened.

Post-Compact market behavior suggests that in tight oligopolistic markets, policy rules can be used as tools by market channel firms for enhancing profit. Analytical techniques such as those used in this study are now needed for assessing impacts of farm policies. Policy analyses based on competitive market channel will most likely not predict actual outcomes. Also the analysis of the Compact suggest that one needs not only be careful of the about the prevailing information sets within the market but also one needs to build relevant information intensive empirically estimable game theoretic models.

Regarding the Boston fluid milk market, it would be very interesting market to analyze the competition between branded and private label milk. If the current retailer-processor structure persists, then Suiza Foods will remain both the largest processor of branded milk (Garelick) and private labels. In most other product categories dominant brand producers usually do not process the private labels.

Our structural specification is one of the first attempts in modeling the vertical market channel with differentiated products. The models are based on simplifying assumptions such as no horizontal price conjectures, and linear conjectures by processors on retail margins in the vertical dimension. Due to data and modeling limitations we also assume that the only variable cost at retail level is the wholesale price. Future empirical research should relax these simplifying assumptions.

Diagram 1: Nesting Tree for Supermarket Fluid Demand Specification



S&S = Stop & Shop; Sh = Shaw's; SM = Star Market; DeM = DeMoulas; RoR = Rest of the Retailers
G = Garelick; H = Hoods; Pl = Private Label

Table 1: 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 2: Average and Marginal Cost (Pre-C: Pre-Compact; Post-C: Post-Compact.

			March 1996		Pre-C 1997		Post-C 1997		1998		1999		July 2000		Total	
			AC	MC	AC	MC	AC	MC	AC	MC	AC	MC	AC	MC	AC	MC
Garelick	Stop & Shop	Pre-C	2.09	2.07	2.16	2.13									2.12	2.10
		Post-C					2.14	2.12	2.24	2.22	2.45	2.42	2.65	2.60	2.38	2.34
	Shaw's	Pre-C	2.10	2.09	2.18	2.15									2.13	2.11
		Post-C					2.16	2.14	2.26	2.23	2.47	2.44	2.68	2.65	2.40	2.37
	Star Market	Pre-C	2.22	2.21	2.30	2.28									2.25	2.24
		Post-C					2.28	2.26	2.38	2.36	2.59	2.56	2.80	2.76	2.52	2.49
	DeMoulas	Pre-C	2.02	2.02	2.10	2.10									2.05	2.05
		Post-C					2.08	2.08	2.18	2.18	2.39	2.38	2.60	2.58	2.32	2.31
	Residual Chains	Pre-C	1.87	1.82	1.93	1.85									1.89	1.84
		Post-C					1.93	1.89	2.04	1.99	2.25	2.21	2.43	2.34	2.17	2.12
Hood	Stop & Shop	Pre-C	2.46	2.30	2.48	2.31									2.47	2.30
		Post-C					2.47	2.27	2.50	2.29	2.60	2.41	2.74	2.61	2.58	2.39
	Shaw's	Pre-C	2.57	2.56	2.58	2.57									2.58	2.56
		Post-C					2.57	2.50	2.54	2.41	2.64	2.53	2.76	2.69	2.62	2.52
	Star Market	Pre-C	2.63	2.51	2.65	2.54									2.64	2.52
		Post-C					2.66	2.52	2.68	2.53	2.79	2.68	2.92	2.85	2.76	2.64
	DeMoulas	Pre-C	2.36	2.30	2.40	2.35									2.38	2.32
		Post-C					2.42	2.37	2.46	2.40	2.53	2.47	2.62	2.57	2.51	2.45
	Residual Chains	Pre-C	2.32	2.15	2.40	2.30									2.35	2.21
		Post-C					2.38	2.23	2.38	2.18	2.57	2.49	2.66	2.59	2.50	2.37
Private Label	Stop & Shop	Pre-C	1.86	1.80	1.90	1.84									1.87	1.82
		Post-C					1.89	1.83	1.96	1.89	2.11	1.99	2.21	2.08	2.05	1.95
	Shaw's	Pre-C	1.79	1.74	1.83	1.78									1.80	1.75
		Post-C					1.82	1.77	1.90	1.84	2.07	1.99	2.18	2.09	2.00	1.93
	Star Market	Pre-C	1.84	1.82	1.88	1.86									1.86	1.84
		Post-C					1.87	1.85	1.96	1.94	2.15	2.11	2.26	2.23	2.07	2.04
	DeMoulas	Pre-C	1.56	1.51	1.60	1.54									1.58	1.52
		Post-C					1.60	1.55	1.68	1.61	1.84	1.74	1.94	1.84	1.77	1.69
	Residual Chains	Pre-C	1.80	1.78	1.84	1.82									1.81	1.79
		Post-C					1.83	1.82	1.93	1.92	2.11	2.09	2.22	2.19	2.03	2.01

Table 3: Total Channel Profit Margins (%) in the Vertical Nash Game [Pre and Post Compact]

			1996	1997 Pre-	1997 Post-	1998	1999	2000-July	Total
Garelick	Stop & Shop	Pre-Compact	19.75	19.14					19.51
		Post-Compact			23.07	22.37	21.28	19.65	21.58
	Shaw's	Pre-Compact	18.81	18.07					18.52
		Post-Compact			21.97	21.16	19.54	17.88	20.10
	Star Market	Pre-Compact	16.83	16.13					16.56
		Post-Compact			19.94	19.15	17.73	16.24	18.22
	DeMoulas	Pre-Compact	19.43	18.90					19.23
		Post-Compact			22.50	21.70	20.17	18.79	20.74
	Residual Chains	Pre-Compact	20.93	19.00					20.18
		Post-Compact			23.15	21.71	19.47	17.79	20.41
Hood	Stop & Shop	Pre-Compact	12.45	12.65					12.53
		Post-Compact			14.04	13.90	14.83	15.65	14.57
	Shaw's	Pre-Compact	16.01	15.84					15.94
		Post-Compact			16.70	15.20	15.40	15.45	15.54
	Star Market	Pre-Compact	11.49	11.68					11.56
		Post-Compact			13.15	12.67	13.23	13.60	13.11
	DeMoulas	Pre-Compact	15.28	15.71					15.44
		Post-Compact			17.38	17.19	16.88	16.62	17.00
	Residual Chains	Pre-Compact	13.37	14.51					13.81
		Post-Compact			14.99	13.23	15.28	15.55	14.62
Private Label	Stop & Shop	Pre-Compact	19.78	19.70					19.75
		Post-Compact			25.62	24.53	22.64	21.46	23.46
	Shaw's	Pre-Compact	21.38	21.10					21.27
		Post-Compact			26.86	25.52	23.17	21.85	24.22
	Star Market	Pre-Compact	19.65	19.32					19.52
		Post-Compact			25.16	24.09	22.20	21.06	23.03
	DeMoulas	Pre-Compact	25.61	25.59					25.60
		Post-Compact			31.26	28.95	25.48	24.01	27.18
	Residual Chains	Pre-Compact	22.07	21.10					21.69
		Post-Compact			26.42	25.03	22.63	22.08	23.87

Table 4: Average Total Profit per Period (in Millions of $) [Pre and Post Compact]

			1996.00	1997 Pre-	1997 Post-	1998	1999	2000-July	Total
Garelick	Stop & Shop	Pre-Compact	0.09	0.10					0.09
		Post-Compact			0.16	0.13	0.17	0.16	0.15
	Shaw's	Pre-Compact	0.13	0.12					0.12
		Post-Compact			0.14	0.10	0.13	0.10	0.11
	Star Market	Pre-Compact	0.08	0.08					0.08
		Post-Compact			0.12	0.09	0.11	0.09	0.10
	DeMoulas	Pre-Compact	0.02	0.02					0.02
		Post-Compact			0.02	0.02	0.04	0.04	0.32
	Residual Chains	Pre-Compact	0.38	0.30					0.35
		Post-Compact			0.34	0.19	0.17	0.21	0.21
Hood	Stop & Shop	Pre-Compact	0.03	0.03					0.03
		Post-Compact			0.06	0.07	0.12	0.12	0.09
	Shaw's	Pre-Compact	0.01	0.01					0.01
		Post-Compact			0.02	0.03	0.06	0.07	0.04
	Star Market	Pre-Compact	0.03	0.03					0.03
		Post-Compact			0.05	0.04	0.06	0.06	0.05
	DeMoulas	Pre-Compact	0.02	0.02					0.02
		Post-Compact			0.02	0.02	0.04	0.06	0.03
	Residual Chains	Pre-Compact	0.04	0.03					0.04
		Post-Compact			0.05	0.05	0.04	0.07	0.05
Private Label	Stop & Shop	Pre-Compact	0.36	0.40					0.38
		Post-Compact			0.54	0.48	0.58	0.53	0.53
	Shaw's	Pre-Compact	0.35	0.38					0.36
		Post-Compact			0.46	0.35	0.39	0.38	0.38
	Star Market	Pre-Compact	0.14	0.15					0.15
		Post-Compact			0.22	0.17	0.17	0.13	0.17
	DeMoulas	Pre-Compact	0.45	0.46					0.45
		Post-Compact			0.60	0.45	0.41	0.45	0.46
	Residual Chains	Pre-Compact	0.15	0.12					0.14
		Post-Compact			0.16	0.09	0.11	0.13	0.12

Table 5: Total Benefit to Channel Players Due to Compact[1]

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

[1] Millions of $

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End Note

[i] On June 2000 Stop & Shop sold its plant to Suiza and now receives its private label milk from Suiza.
[ii] A Chicago based marketing and consulting firm. They collect data from sample supermarkets with annual sales of more than $2 million dollars located in various size metropolitan areas. Such supermarkets account 82% of grocery sales in the US. In most cities the sample stores covers 20% of the relevant population. Due to the importance of the sample to its customers, IRI makes an effort to make the sample representative.
[iii] The web site address: http://www.eia.doe.gov
[iv] This is not an unrealistic assumption. Given the fact in the short most retailing cost like cost of real estate, refrigeration cost etc. tend to be either sunk or other wise fixed.
[v] The Outside option gives the consumer an option of not to buy any of the brands in our model in the case of a homogenous price increase. Without this option with a homogenous price increase (relative to other products) market shares of the brands in the model do not change negating the possibility that some of the consumers might not buy any of the brands.
[vi] Most theoretical micro economic models predict that residual brands in a market tends to be price takers (Tirole, 1993) and as residual players in the market these brands are not expected to significantly affect the oligopolistic interactions between the dominant brands within a market.
[vii] Role of the variance component in Nested Logit demand specification is explained in details in the Appendix-4.2.
[viii] In micro economic terms this category management implies joint profit maximization of all the brands within a category.
[ix] This is a strong assumption and establishes the 1 to 1 correspondence between market share and quantity sold.
[x] Detailed regression results are available from the authors on request.

[xii] Detailed Tables of elasticity estimates are available from the authors on request.
[xiii] Detailed Derivation is presented in Appendix 4.5.
[xiv] All the profit margins presented in this chapter is based on the following formula:
Profit Margin = (Price - Average Cost) / Price.
[xv] A classic example will be airline ticket price. Most significant rise in ticket price usually takes place just after any announcement of the OPEC oil production cut.
[xvi] In that study, Harris attributes the industry's tacit collusive power on high concentration. Top four firms at that time had 87% of the market share.