Strategic Vertical Pricing in the U.S. Butter Market

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Abstract:

This article develops a methodology for empirically analyzing vertically strategic interactions in a multi-level supply channel. The model is used to analyze the vertical channel for U.S. butter manufacturing and retailing. Aggregating products to the firm level and using a nonlinear AIDS demand system under alternative strategic pricing assumptions is estimated using full information maximum likelihood (FIML) for seven geographic markets from 1998-2002. The market demand for butter was found to very price elastic. Furthermore, cross price elasticities between private labels and the two large national brands were also very elastic. The selected market structure was one indicating category profit maximization of national brands (separate from private label) at the retail level, Vertical Nash competition in the vertical channel, and Bretrand competition at the manufacturing level. Our results strongly suggest that the retail market for food products is impacted by the underlying vertical structure. The study provides useful measures of imperfect competition in the retail manufacturing sector.

Keywords: Vertical interaction, market structure, strategic pricing, market power, AIDS model, butter.

JEL Codes: L13, L22, L66

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I. Introduction

Empirically evaluating vertical market structures in a multi-level supply channel is especially challenging because of analytical complexities and lack of wholesale prices. Consequently, modelers in the past have obtained parameter estimates using simplifying assumptions about vertical channel relationships and relying linear or approximated demand specifications. Their empirical work also tended to focus on a small number of brands (e.g. Sudhir 2001[1]) and employ multi-step estimation procedures (e.g. Villas-Boas 2006). In this paper, we develop a methodology that overcomes some of these shortcomings and is motivated primarily along practical lines for empirical research.

One of the main applications of channel studies has been modeling the competitive interactions between national brands and private labels (i.e. store brands).[2] Over the past several decades, private label products have made substantial inroads in the food industry in terms of increasing market shares, shelf location, and the number of product offerings. The nature of the vertical competitive structure between large food retailers that own the private labels and manufacturers that own national brands has been a primary concern for policymakers and antitrust agencies. Thus, understanding the way in which the vertical food markets are structured and how costs and/or market power are translated to retail prices represents an important research topic for public policy.

Various simplifying assumptions have been imposed in past studies trying to evaluate the impact of vertical channels on prices. Some common vertical market structural assumptions have included: Manufacture Stackelberg (MS), Vertical Nash (VN), and nonstrategic proportional (i.e. mark-up) pricing rules. However, little empirical work has been done to examine the suitability of these assumptions before they are used. Choi (1991) specifies three pure strategy vertical games (Manufacturer Stackelberg (MS),

[1] Sudhir points out that: “While it is possible to extend the model development to additional brands, solving for the optimal vertical strategic reactions becomes computationally cumbersome”

[2] Unlike competition between two national brands, there are often more vertical complexities between retailers and manufacturers in a competition interaction between national brands and store brands.

Vertical Nash (VN), and Retailer Stackelberg (RS)), and theoretically shows the important effects of demand specifications on the equilibrium results. To overcome tractability and convergence issues in complex vertical aligned market models, it was common to presume linear or linearized demand functions. Such restrictions on consumer behavior are not supported by demand theory, the restrictions may not hold empirically, and thus model results at likely to be fragile. Indeed, Cotterill and Putsis (2001) empirically reject linear demands in favor of more flexible forms (LA-AIDs model), and suggested that “future theoretical and empirical research addressing channel issues should avoid the linear form wherever possible.”

In this paper, we begin by developing a modeling methodology for empirically analyzing vertically strategic interactions in a multi-level supply channel. The approach in this paper is particularly appealing for several reasons. It overcomes some of the problematic tractability concerns present in past multi-level channel studies while allowing for the usage of complex demand functions. It can be applied to multi- retailer cases, and, like several previously developed channel approaches, (e.g. Sudhir 2001), it does not require wholesale price information.

Our estimation methodology is motivated by a two recent papers (Dhar, Chavas, Cotterill and Gould (2005) and Wang, Stiegert and Dhar (2008)), who made complex demand functions more accessible to competitive analysis among national brands in single-level marketing studies. This methodology is then extended to analyze beyond the the retail market to consider strategic vertical market structures including horizontal manufacturing competion. The model is fitted for retail and production butter market data for seven demographic market areas. Over the past few decades, the U.S. butter sector has evolved into a market with highly concentrated oligopolies both at the processing and retail level. Furthermore, private labels (i.e. store brands) in the butter market have captured a sizable market share (53% in 2005). The prominent position of private labels in a market with few branded products and oligopolistic manufacturing provide for an interesting case study of pricing strategies in a vertical sector.

The empirical analysis in this paper makes use of IRI scanner data for the markets from January 1998 to June 2002. We examine some of the central assumptions commonly used in the literature on vertical interactions. Market structure and strategic pricing are then investigated under best-fitting assumptions. We estimate a flexible nonlinear almost ideal demand system (AIDS) across a menu of alternative pricing models using full information likelihood maximization (FIML). The menu of market alternatives include possible structural outcomes at the retail level, the manufacturing level and in the vertical channel: (1:retail) individual brand profit maximization, three other sub-category profit maximization rules, (2:vertical channel) MS, VN and single market level, (3:manufacturing) Bertrand pricing and tacit collusion two national brands and tacit collusion of among all national brands. In total, the best-fitted model was selected from 24 estimated models.

Our results show that manufactures followed Bretrand pricing, retailers maximized national brands as a complete category separate from private labels and that the vertical channel was most consistent with VN conduct. Moreover, we rejected the use of retailers' proportional mark-up assumption. These results suggest that models simply assuming one-marketing stage or vertical "Manufacturer Stackelberg" game in the channel may not accurately reflect market reality. To our knowledge, this is the first structural analysis of the U.S. retail butter market that considers both vertical and horizontal strategic interactions, and is the first study to use a flexible nonlinear AIDS model in examining vertical strategic models. Our econometric results lend broad support to the findings of previous research, and have important implications for both national brand and store brand butter marketing managers.

The remainder of this article is organized as follows: In section 2, we introduce the new methodology and derive estimable first order conditions under different vertical model assumptions. In section 3, we describe the data and present our empirical model, followed by the econometric results. Finally, section 4 presents conclusions.

II. Theoretical Framework

In this section, we explain our approach in deriving the estimable profit maximizing first- order conditions for a channel. When modeling a pricing strategy in a multi-level supply channel, one needs one to be concerned about the vertical as well as the horizontal nature of competitive interactions. Therefore, we first derive optimal decision rules for the retailer and the manufacturing stages, and then we model the interactions between manufacturers and retailers under different forms of presumed vertical conduct. Finally, we derive first order conditions for the entire supply channel.

For the simplicity of exposition, we can assume that a vertical sector has one retailer and three manufacturers A, B and C as depicted in figure 1. Manufacturer A produces one national brand (brand1); Manufacturer B produces two national brands (brand 2 and brand 3); Manufacturer C produces a store-brand (brand 4) under the management of the retailer.

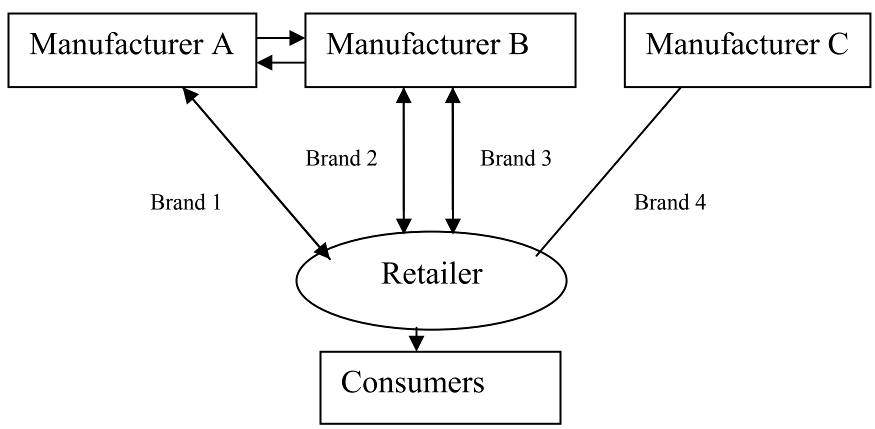

Figure1. Vertical Market Structure

II.a The Retailer

We are interested in modeling different types of the retailer's pricing rules. In the case of category-profit-maximization, the retailer maximizes category profits (π) by choosing retail prices (p_i) for given wholesale prices (W_i, for national brands 1,2 and 3) and constant marginal cost (c_4, for store-brand 4).

Max $\pi = (p_1 - w_1)x_1 + (p_2 - w_2)x_2 + (p_3 - w_3)x_2 + (p_4 - c_4)x_4$

The retailer's FOC equations can be derived as ($\forall i$ =1...4):

$$\text{Brand } i : \frac{\partial \pi}{\partial p_i} = x_i + (p_1 - w_1)\frac{\partial f_1}{\partial p_i} + (p_2 - w_2)\frac{\partial f_2}{\partial p_i} + (p_3 - w_3)\frac{\partial f_3}{\partial p_i} + (p_4 - c_4)\frac{\partial f_4}{\partial p_i} = 0$$

These FOCs can be rewritten as follows:

$$\begin{pmatrix} TR_1 \\ TR_2 \\ TR_3 \\ TR_4 \end{pmatrix} = (I + \Psi)^{-1}\Psi \begin{pmatrix} TW_1 \\ TW_2 \\ TW_3 \\ TC_4 \end{pmatrix} \tag{1}$$

where $\Psi = \begin{pmatrix} \varepsilon_{11} & \varepsilon_{21} & \varepsilon_{31} & \varepsilon_{41} \\ \varepsilon_{12} & \varepsilon_{22} & \varepsilon_{32} & \varepsilon_{42} \\ \varepsilon_{13} & \varepsilon_{23} & \varepsilon_{33} & \varepsilon_{43} \\ \varepsilon_{14} & \varepsilon_{24} & \varepsilon_{34} & \varepsilon_{44} \end{pmatrix}$. Note that the equation (1) nests different types of retailers' pricing rules. For instance, in the case of the retailer's brand-profit maximization, the matrix Ψ becomes $\Psi = \begin{pmatrix} \varepsilon_{11} & 0 & 0 & 0 \\ 0 & \varepsilon_{22} & 0 & 0 \\ 0 & 0 & \varepsilon_{33} & 0 \\ 0 & 0 & 0 & \varepsilon_{44} \end{pmatrix}$. And in the case of the retailer's "national brand versus private label" pricing rule, the matrix Ψ would then become $\Psi = \begin{pmatrix} \varepsilon_{11} & \varepsilon_{21} & \varepsilon_{31} & 0 \\ \varepsilon_{12} & \varepsilon_{22} & \varepsilon_{32} & 0 \\ \varepsilon_{13} & \varepsilon_{23} & \varepsilon_{33} & 0 \\ 0 & 0 & 0 & \varepsilon_{44} \end{pmatrix}$. If the retailer imposes a non-strategic proportional margin, the equation (10) would become $\begin{pmatrix} TR_1 \\ TR_2 \\ TR_3 \\ TR_4 \end{pmatrix} = \begin{pmatrix} m_1 & & & \\ & m_2 & & \\ & & m_3 & \\ & & & m_4 \end{pmatrix} \begin{pmatrix} TW_1 \\ TW_2 \\ TW_3 \\ TW_4 \end{pmatrix}$, where

$m_i > 1, \ \forall i$.

II.b The Manufacturer

The two national-brand manufacturers maximize their profit (π) by choosing values of wholesale prices (w_i):

Max $\pi_1 = (w_1 - c_1)x_1$, for firm A,

Max $\pi_2 = (w_2 - c_2)x_2 + (w_3 - c_3)x_3$, for firm B.

Where c_i is the constant marginal cost of different brands.

Using a conjecture variation approach[3], we can assume that the manufacturers form conjecture is such that each brand's wholesale price is a function of the competing brands' wholesale prices (i.e. $w_1(w_2, w_3), w_2(w_1), w_3(w_1)$). The corresponding first order conditions (FOCs) can be derived as follows:

Brand 1: $\dfrac{\partial \pi}{\partial w_1} = x_1 + (w_1 - c_1)(\dfrac{\partial f_1}{\partial w_1} + \dfrac{\partial f_1}{\partial w_2}\dfrac{\partial w_2}{\partial w_1} + \dfrac{\partial f_1}{\partial w_3}\dfrac{\partial w_3}{\partial w_1}) = 0$

Brand 2: $\dfrac{\partial \pi}{\partial w_2} = x_2 + (w_2 - c_2)(\dfrac{\partial f_2}{\partial w_2} + \dfrac{\partial f_2}{\partial w_1}\dfrac{\partial w_1}{\partial w_2}) + (w_3 - c_3)(\dfrac{\partial f_3}{\partial w_2} + \dfrac{\partial f_3}{\partial w_1}\dfrac{\partial w_1}{\partial w_2}) = 0$

Brand 3: $\dfrac{\partial \pi}{\partial w_3} = x_3 + (w_2 - c_2)(\dfrac{\partial f_2}{\partial w_3} + \dfrac{\partial f_2}{\partial w_1}\dfrac{\partial w_1}{\partial w_3}) + (w_3 - c_3)(\dfrac{\partial f_3}{\partial w_3} + \dfrac{\partial f_3}{\partial w_1}\dfrac{\partial w_1}{\partial w_3}) = 0$

Note that they can be alternatively expressed as[4]:

$$TW_1 + (TW_1 - TC_1)(\varepsilon^w{}_{11} + \varepsilon^w{}_{12}\eta^w{}_{21}\frac{w_1}{w_2} + \varepsilon^w{}_{13}\eta^w{}_{31}\frac{w_1}{w_3}) = 0 \qquad (2)$$

$$TW_2 + (TW_2 - TC_2)(\varepsilon^w{}_{22} + \varepsilon^w{}_{21}\eta^w{}_{12}\frac{w_2}{w_1}) + (TW_3 - TC_3)(\varepsilon^w{}_{32} + \varepsilon^w{}_{31}\eta^w{}_{12}\frac{w_2}{w_1}) = 0 \qquad (3)$$

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[3] Conjecture variation models nest many non-cooperative games (Dixit 1986).

[4] First order conditions in terms of elasticity are first used in Dhar, Chavas, Cotterill and Gound (2005).

$$TW_3 + (TW_2 - TC_2)(\varepsilon^w{}_{23} + \varepsilon^w{}_{21}\eta^w{}_{13}\frac{w_3}{w_1}) + (TW_3 - TC_3)(\varepsilon^w{}_{33} + \varepsilon^w{}_{31}\eta^w{}_{13}\frac{w_3}{w_1}) = 0 \qquad (4)$$

Where TW_i denotes total wholesale dollar sales, TC_i is total variable cost. ε^w is the wholesale price elasticity of demand, and $\eta^w{}_{ij}$ is the brand j 's conjecture of brand i 's price response, i, j =1,2,3. This conjecture variation model nests different types of games between the manufacturers (Dixit 1986). For instance, in the case of Nash Bertrand game, all conjectural variation would equal to zero, and the FOCs would become:

$$TW_1 + (TW_1 - TC_1)\varepsilon^w{}_{11} = 0$$

$$TW_2 + (TW_2 - TC_2)\varepsilon^w{}_{22} + (TW_3 - TC_3)\varepsilon^w{}_{32} = 0$$

$$TW_3 + (TW_2 - TC_2)\varepsilon^w{}_{23} + (TW_3 - TC_3)\varepsilon^w{}_{33} = 0$$

II.c Vertical (retailer-manufacture) interaction

In absence of wholesale price information, we need a way to combine the FONCs of the retailer and manufacturers into one estimable supply side equation. Specifically, this means that we have to transform the manufacturer's FONCs ((2) (3) (4)) to obtain: a) a total wholesale margin of the manufacturer as a function of variables with observable information, and b) a vertical interface that correctly tracks our presumed vertical behavior. Our procedures follow a) and b) sequentially.

When selling products through the retailer, manufacturers face derived demand functions:

$$x_i = f_i(p_1(w_1, w_2, w_3, c_4), p_2(w_1, w_2, w_3, c_4), p_3(w_1, w_2, w_3, c_4), p_4(w_1, w_2, w_3, c_4))$$

$\forall i$ =1...4. Where $f_i(.)$ is given by the demand model. Therefore, we can present wholesale price elasticities as follows: $\varepsilon^w{}_{ij} = w_j \upsilon_{ij}$, where, $\upsilon_{ij} = \sum_{k=1}^{4} \varepsilon_{ik} \frac{\partial p_k}{\partial w_j} \frac{1}{p_k}$.

Accordingly, the FOCs for producers' profit maximization (2) (3) (4) can be alternatively expressed as:

$$\begin{pmatrix} TW_1 \\ TW_2 \\ TW_3 \end{pmatrix} = -\Gamma^{-1} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} + \begin{pmatrix} TC_1 \\ TC_2 \\ TC_3 \end{pmatrix} \qquad (5)$$

Where $\Gamma = \begin{pmatrix} \upsilon_{11} + \upsilon_{12}\eta^{w}{}_{21} + \upsilon_{13}\eta^{w}{}_{31} & 0 & 0 \\ 0 & \upsilon_{22} + \upsilon_{21}\eta^{w}{}_{12} & \upsilon_{32} + \upsilon_{31}\eta^{w}{}_{12} \\ 0 & \upsilon_{23} + \upsilon_{21}\eta^{w}{}_{13} & \upsilon_{33} + \upsilon_{31}\eta^{w}{}_{13} \end{pmatrix}$

Substituting equation (2) into (1) gives the following estimable equations for the supply channel:

$$\begin{pmatrix} TR_1 \\ TR_2 \\ TR_3 \\ TR_4 \end{pmatrix} = (I + \Psi)^{-1}\Psi \begin{pmatrix} -\Gamma^{-1} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} + \begin{pmatrix} TC_1 \\ TC_2 \\ TC_3 \end{pmatrix} \\ TC_4 \end{pmatrix} \qquad (6)$$

Note that the matrix equation nests MS and VN conducts. These conducts are characterized by different values of v, depending on individual manufacturer's beliefs on the retailer's pricing rules. For instance, in a MS equilibrium of all brands, $\upsilon_{ij} = \sum_{k=1}^{4} \varepsilon_{ik} \frac{\partial p_k}{\partial w_j} \frac{1}{p_k}$, and in a VN equilibrium, $\upsilon_{ij} = \frac{\varepsilon_{ij}}{p_j}$.

In comparison with approaches in previous channel studies, this method simplifies the calculation process of estimable first-order conditions, and allows the usage of flexible demand functions that have closed- form analytical elasticity estimates such as in the case of the AIDS model. [5] Also, the equations are shown to be in terms of observable data and estimated model parameters. Like several prior models of the vertical channel (e.g, Sudhir 2001) this approach steps around the need to collect wholesale price information. If wholesale prices are someday more accessible, the model itself could be easily adapted by using the derived formulae for wholesale prices as additional estimation equations. Finally, although this approach is introduced in a one-retailer context, it can

[5] In absence of wholesale price data, the traditional approach to obtain the manufacturer's first order condition involves using the chain rule by calculating the derivative of consumption with respect to retail price and then using the vertical link $[\partial p / \partial w]_{i \times i}$. As discussed earlier, such calculations can be intractable in complex game settings.

also be applied to multi-retailer cases by differentiating brands by retail chains and by manufacturers[6].

Note that, when category profit maximization of the retailer is defined in a single-retailer model, $I + \Psi$ matrix becomes singular due to the Cournot aggregation condition. As a result, this case of pricing rule of retailer can not be estimated. However, a multi-retailer model is not subject to this restriction and can be used for the cases of retailer's category profit maximization.

Given the complex nature of vertical models, channel studies have explained vertical conduct in ways consistent with observed behavior. One common approach uses a time sequencing argument (i.e. "leader-follower" or "first mover-second mover") for the manufacturer's and retailers pricing behavior under MS and VN assumptions. Under MS conduct, manufacturers announce their price as a first mover, and retailers choose their retail price as a follower. And in a VN conduct, manufacturers and retailers are assumed to make pricing decisions simultaneously. There are also some other studies that explain VN as a conduct in which manufacturers and retailers ignore each other's actions.

We suggest a different way to interpret behavior in the vertical setting. In particular, we believe the critical difference between MS and VN relies not on the timing of pricing decisions but rather the manufacturer's beliefs (or information) about the retailer's pricing rules. We explain MS as a vertical conduct that features manufacturers having full information about the market and retailer's pricing rules, and explain VN as a conduct with manufacturers believing (or guessing, not necessarily correctly) that retailers use arms-length pricing rules.

II.d Demand and Cost specifications

In this section, we specify a nonlinear, Almost Ideal Demand System (AIDS) model (see Deaton and Muellbauer, 1980). The AIDS model is well-known for being consistent with economic consumer theory and being fully flexible in demand estimations. Also, the use of the demand specification highlights the generic nature of our

[6] See Dhar and Cotterill (2003) for more about differentiating brands by retailer and manufacturer.

methodology. Our literature survey shows that this is the first study to use a flexible nonlinear AIDS model in estimating vertical strategic models.

The AIDS function can be stated as:

$$W_{ilt} = \alpha_i + \sum_{j=1}^{N} \gamma_{ij} \ln(p_{jlt}) + \beta_i \ln(\frac{M_{lt}}{P_{lt}}) \tag{7}$$

Where $p= (p_1, \dots , p_N)$ is a $(N \times 1)$ vector of prices for x, M denotes expenditure on the N goods, $w_{ilt}= (p_{ilt}\, x_{ilt}/M_{lt})$ is the budget share for the ith brand consumed in the lth city at time t. The term P can be interpreted as a price index defined by $\ln(P_{lt}) =\delta+\sum N_{m=1}\alpha_m \ln(p_{mlt}) + 0.5 \sum N_{m=1}\sum N_{j=1}\gamma_{mj} \ln(p_{mlt}) \ln(p_{jlt})$.

The demand system imposes symmetry restrictions:

$\gamma_{ij} = \gamma_{ji}$ for all $i \neq j$

and homogeneity restrictions: (8)

$$\sum_{i=1}^{N} \alpha_{0i} = 1,\ \sum_{i=1}^{N} \gamma_{ij} = 0,\ \sum_{i=1}^{N} \gamma_{ij} = 0,\ \forall j$$

$$\sum_{i=1}^{N} \beta_i = 0$$

The parameter δ is often set to some predetermined value (Deaton and Muellbauer 1980a), For the present analysis, we follow the approach suggested by Mischine, Moro and Green and set δ =0.

Market-level empirical demand analyses have often ignored expenditure endogeneity issues. These issues arise as a result of expenditure variables (Mit) being correlated with the residual error terms in the demand specification. Blundell and Robin (2000) and Dhar, Chavas and Dhar (2002) found significant effects of the issues on parameter estimates in AIDS. Therefore, similar to Blundell and Robin, we use a reduced form expenditure equation to control for possible expenditure endogeneity:

$$M_{lt} = f \text{ (Time trend, Income),} \tag{9}$$

where household expenditure in the lth city at time t is a function of median household income and a time trend.

Unlike a single-stage marketing research, our channel concerned research needs to specify the cost both at the processing and retail levels. At the retail level, we assume that marginal cost of selling butter is constant and equal to the wholesale price of butter. At the processing level, we plan to use a generalized Leontief cost specification (Diewert, 1971) to capture input cost variations:

$$C_{rh}{}^{k} = Q_{rh}\sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij}(v_i v_j)^{0.5} + (Q_{rh})^2 \sum_{i=1}^{n} b_i v_i$$

Where $C_{rh}{}^{k}$ is the cost of processor k for brand r sold in city h;

Q_{rh} is the level of output for brand r sold in city h;

v_i, v_j are the prices of input i and j for brand r;

i, j = 1….n.

This generalized Leontief cost function has performed well in recent empirical IO literature (e.g. Azzam, 1997; Dhar and Cotterill, 2003) for its mathematical simplicity and flexibility in a complex non-linear system.

III. Empirical Estimation

III.a Discussion of the Data

Our empirical analysis is based on Information Resources, Inc. (IRI) data on butter products across seven local geographic markets[7] in the U.S. Midwest region from January 1998 to June 2002. These markets were selected based on an explorative multivariate analysis (Du, 2008) and data availability. The IRI data provide retail-price related information for 153 main national brands produced by 110 manufacturers. Aggregate information about entire retail butter market and one aggregate all–other national brand is also given. Using the database, we created top branded, aggregate all-other branded and aggregate private label variables across all markets. On the demand side, to incorporate the effect of income differences on butter purchase, we used median

[7] These cities include Des Moines, Kansas city, Milwaukee, Denver, Indianapolis, Minneapolis and Oklahoma.

household income in each city collected from Current Population Survey- Annual Demographic Survey (March CPS Supplement).

These data were merged with independent supply-side data collected from diverse resources[8]. Assuming that production of butter requires three major inputs: cream, labor and energy[9], the farm-level cream price data were obtained from FMMO (Federal Milk Marketing Order) Price Series; the effect of labor is captured by the wage rate of production workers for the dairy manufacturing industries in the U.S. ("Average hourly earnings of production workers-manufacturing-dairy products" from the U.S. Department of Labor. Series ID: EEU32203006(n)-Dairy products (SIC code 202)); and electricity rate (collected from Energy information Administration (EIA)'s Short-Term Energy Outlook Query System) is used to capture the effect of energy cost on processing butter.

The IRI data on retail level butter has one limitation. While it offers a detailed vendor and manufacturer information, it does not give the names of retailers. As a result, we need to specify vertical games under the assumption that there is one single common retailer managing all the brands made by multiple processors in each city.

Here we give a brief description of the markets. Like the entire U.S. butter sector, private label butter in these marketing areas has reached a very high average market share (53%). There are two top national brands (named as brand A and brand B in this paper) in this market. National brand A has a market share of 26%, and national brand B has a market share of 14%. All other national brands have a small share of 6%. In terms of prices, Brand A is most expensive with an average price of $3.25/ lb. Other brands have a similar average price level. (Brand B is $2.27; All other small national brand is $2.45; Aggregate store brand is $2.29)

III.b Empirical Specification

On the demand side, a set of city dummy variables are applied to control for city specific fixed effects for each brand. In addition, a time trend variable is used to each of

[8] The IRI data are reported every 4 weeks. All other data are transformed into the same pattern to match the data.
[9] See Butter processing cost issued by California department of food and agriculture.

the share equations of demand model (7) to incorporate the general consumption trends of this market. To maintain theoretical consistency of the AIDS model, the following restrictions based on (8) are applied to these parameters:

$$a_i = \sum_{r=1}^{7} d_{ir} D_r \ , \ \sum_{i=1}^{4} d_{ir} = 1 \ , \ r = 1 \ldots 7, \ i = 1 \ldots 4 \tag{10}$$

Where:

D_r = the city dummy variable for the r th city.

d_{ir} = the parameter for the i th brand associated with D_r.

The reduced form expenditure function in (9) is specified as:

$$M_{rt} = \delta \ Trend_t + \phi_1 INC_{rt} + \phi_2 INC_{rt}^2 + \sum_{l=1}^{13} S_l \tag{11}$$

Where $Trend_t$ is a linear trend, capturing time specific unobservable effect on consumer butter expenditure; S_l is a group of season dummies, capturing the seasonality of butter purchases; INC_{rt} is the median household income in city r, and is used to capture the effect of income differences on butter purchases.

On the supply side, as mentioned earlier, at the retail level, the marginal cost of selling butter is assumed to be constant and equal to the wholesale price of butter. At the processor level, we use a generalized Leontief cost function (Diewert, 1971) to capture input cost variations. Production of butter is assumed to require three major inputs: cream, labor and energy with substitution possibilities between labor and energy only. We assume all the cost parameters are constrained to be manufacturer specific. All parameter values of the cost specification are the same and do not change when the brands are made by the same manufacturer and when they are sold in different marketing area. So the cost function is:

$$C_{ir}^m = Q_{ir} (a_{11}^m v_1 + a_{22}^m v_2 + a_{33}^m v_3 + a_{23}^m {v_2}^{0.5} {v_3}^{0.5}) + {Q_{ir}}^2 (b_1 v_1 + b_2 v_2 + b_3 v_3) \tag{12}$$

Where:

C_{ir}^m is the cost of manufacturer m for brand i sold in city r.

Q_{ir} is the level of output for brand i sold in city r.

v_1, v_2, v_3 are input prices for cream, labor and energy respectively.

We examine some of the central assumptions commonly used in the literature on vertical linkages. Market structure and strategic pricing are then investigated under best fit assumptions. Sudhir (2001) emphasizes the need to model and infer vertical interactions simultaneously to accurately estimate the manufacturer's competition when using data at the retail level. So we estimated a series of demand and pricing models (under a variety of assumptions) via full information likelihood maximization (FIML). The assumptions considered are:

(1) MS VN, VI (or single marketing level, or non-linear vertical interactions),

(2) Bertrand game and alternative tacit collusion of manufacturer pricing (between the top two national brands, and among all national brands) [10].

(3) A variety of strategic pricing rules and proportional mark up behavior of retailers[11].

Our approach produces eight equations to be estimated for each model: three demand equations (10), four price reaction equations (6) and one expenditure function (11). Due to the adding- up constraints of the AIDs functions, one share equation on the demand side was dropped. The models are estimated by specifying the FIML concentrated log likelihood function of the system with eight endogenous variables: three quantity demanded variables, four price variables and the expenditure variable.

III.c Empirical Results

We conducted a series of nested and non-nested tests to determine assumptions that fit the data best. Table 1 reports log-likelihoods and Akaike information criterion test statistics for the different models. Examining the log-likelihoods, we find that the best-fitted model is one in which (1) the retailer maximizes category profits for national

[10] The case of collusion among national brands will only be estimated using the vertical conduct identified as the best-fitted model.

[11] Assuming one retailer for each city (see data section in chapter 3), we can not investigate the pricing rule of category profit maximization on the retailer's part (see model limitation in chapter 2). Note that multi-retailer cases are not subject to this limitation.

brands separate from its private label product, (2) the vertical structure is best described as vertical Nash (VN), and (3) manufacturer price under Bertrand competition.

Our finding about the vertical structure suggests that simply assuming one-marketing stage or MS in the channel may be inappropriate. The finding is based on the application of our new modeling methodology and the employment of nonlinear AIDs models. It is consistent with the result of Cotterill and Dhar (2000) for butter category. In Cotterill and Dhar, two aggregated brands (NB and PL) are investigated by using only linear demand functions.

Similarly disconcerting results are found for empirical studies that employ proportional mark-up assumptions. Using our best fitted model, the test for proportional mark-ups behavior of retailer on national brands does not support the use of this assumption by retailers (with Wald statistics = 377.37 and P value <0.001). Our results suggesting that retailers do not appear to employ proportional mark-ups are also consistent with the findings of Cotterill and Dhar (2000) for butter category.

In addition, the results do not show significant evidence of tacitly collusive manufacturer pricing in this market. Bertrand games fit the data generally better than the two collusive cases we investigated.

Parameter Estimates

The econometric results for the best-fitted model can be found in Table 2. In total, 77 of 88 estimated coefficients are statistically significant. On the demand side, 55 out of 60 estimated parameters of the nonlinear Aids model are statistically significant. All estimated parameters of expenditure function are significant and have expected signs; the estimated coefficients associated with seasonal variables captured the seasonality of butter expenditure very well (see Figure 2); the positive estimated income parameters suggest that higher income leads to more butter purchase. On the supply side, cost estimates generally have anticipated signs. Among them, 23 out of 28 parameters are significantly different from zero. And most estimates associated with input factors have the anticipated signs.

In our best-fitted model, all the estimated price elasticities have the anticipated signs (see Table 3). Own-price elasticities for butter brands are elastic with an average of 4.5. In national brands, small national brands competing in the market face consumers who are particularly price sensitive. Own price elasticity for the aggregated small brand (-7.47) is almost twice as much as those for top brands (-3.77 for brand A and -3.38 for brand B). This is consistent with the stronger market positions for the two top national brands. Further, price response is asymmetric among national brands. Brand A has generally less cross-price elasticity with respect to other national brands' prices than vice versa, which reflects its dominative role in the industry. NB B has the least cross effects with other brands. This is consistent with the fact that it is the brand with the lowest average price. When consumers know that this brand is very cheap compared to alternatives they are relatively unresponsive to price changes.

The aggregated store brand has a closely similar level of own-price elasticity with top national brands. This reflects a strong position of private labels in butter market. This result is different from the findings of Cotterill and Dhar (2000), who reported a higher own-price elasticity of store brand than national brands for butter category, but only analyzed national brands as one aggregate brand. In terms of cross-price elasticity, store-brand price cuts are generally more effective in stealing share from national brands. For example, a 1% decrease in the price of store brands results in 1.9% of increase in national brand a demand, while a 1% price change of national brand a generates a 1.6% change in store brand demand. These results are not surprising when we consider the large market share that store brands have reached in butter industry.

Our estimated expenditure elasticities are all positive and vary between 0.39 and 2.65, with store brands being the most inelastic and small national brand being the most elastic brand (see Table 4). This implies that when customers decide to spend more money on butter, they often shift their preference toward national brands, especially to those with lower prices. It also helps explain one circumstance we observed earlier — during holiday sales, store brands often have bigger volume sales but a smaller market share.

Profit Margins and Market Power

Using our best-fitted model, estimated profit margins for the brands are reported in Table 5. National brand B has the lowest channel price-cost margin and small national brands have the highest. At the processing level, small national brands have a cost advantage over top national brands. And hence, small national brand manufacturers have the highest margins. At the retail level, store brands are most profitable with an estimated channel profit margin equals to 0.48. Retailer's profit margins for national brands are lower than store brands with an average of 0.34. This is consistent with the rapid growth of store brands in this market.

4. Concluding remarks

In this research, we developed a new methodology for empirically analyzing vertically strategic interactions in a multi-level supply channel. Our literature survey shows that this is the first study that allows usage of a flexible nonlinear AIDS model in examining vertical strategic models.

The methodology is applied to examine modeling assumptions and analyze strategic pricing for supermarket sales of butter category across seven geographic markets. By employing nonlinear AIDs demand model and full information maximum likelihood (FIML) estimation approach, we find that vertical strategic interactions for the markets seem to be consistent with "Vertical Nash" game. And, we reject the use of retailers' proportional mark-up assumption. These results suggest that models simply assuming one-marketing stage or vertical "Manufacturer Stackelberg" game in the channel may not accurately reflect market reality. These results are consistent with the finding of Cotterill and Dhar (2000) for butter category. In Cotterill and Dhar, two aggregated brands (National brand and Private labels) are investigated by using only linear demand functions.

This is the first structural analysis of the U.S. retail butter market, considering both vertical and horizontal strategic interactions. Based on the discussion above, our econometric results lend broad support to the findings of previous research, and have enormous implications for both national brand and store brand butter marketing managers. For example:

- Price cutting is an effective weapon for store brands to reduce national brand sales. Many prior studies on competition between national brand and store brands showed that price cutting is generally not an effective tool for store brands. However, according to our study, this is not the case here. Store-brand price cuts are more effective in stealing share from national brands. This finding is consistent with the results of Cotterill, Putsis and Dhar (2000) for butter category, who also find the exception of butter category among six food products[12].
- The leading national brand and small national brands are most likely to be affected by private-label discounting.
- The effect of national brand price cuts on store brand sales is less pronounced, but still effective. This implies that both national brand and store brand managers can use discounting to attract the other brands' customers.
- The effect of national brand price cuts on store brand sales are not distributed evenly among national brands. Price cuts by the leading national brands have the biggest effect on private labels.
- When customers decide to spend more money on butter, they are likely to shift their preference toward national brands, especially to those with lower prices. Thus, during holiday sale at each year end, a national brand strategy of increasing sales by price promotions is likely to be effective.
- Managing store brands are more profitable than national brands for butter retailers. At the retail level, store brands are most profitable with an estimated channel profit margin equals to 0.48. Retailer's profit margins for

[12] The six food categories are milk, butter, bread, pasta, margarine and instant coffee.

national brands are lower than store brands with an average of 0.34. This is consistent with the rapid growth of store brands in this market.

One of the shortcomings of this paper is that, due to data limitation, we assumed a single-retailer market structure. When the data permits it, this methodological framework will allow for assessments of vertical markets for multiple retailers.

Table 1: Model log likelihoods and AIC test statistics.

Manufacturers Interaction / Retailer's pricing rule	Bertrand game		Tacit collusion between Brand A and B		Tacit collusion among all National brands		One-level marketing channel/ Nonlinear pricing/ Vertical coordination
	MS	VN	MS	VN	VN		
Case I: Brand Profit Maximization	-20431 (41038)	-19610 (39396)	-20927 (42030)	-21033 (42242)	-20439 (41054)		-20060 (40296)
Case II: Brand a & Brand B / AO/PL	-20130 (40436)	-19703 (39582)	-21747 (43670)	-19591 (39358)	-19920 (40016)		-19909 (39994)
Case III: Brand a & Brand b/ AO & PL	-20254 (40684)	-19598 (39372)	-19764 (39704)	-20209 (40594)	-19901 (39978)		-20032 (40240)
Case IV: All NBs/ PL	-20230 (40636)	**-19513** **(39202)**	-20135 (40446)	-19692 (39560)	-20443 (41062)		-19962 (40100)

NB: National brand;
SB: Store brand;
MS: Vertical Manufacturer Stackelberg;
VN: Vertical Nash.

Table 2: Parameter Estimates for Best-Fitting Model.

Variable Name	Estimates	t value
Demand Side		
Brand A Demand		
Ln(Brand a price)	-0.970	-24.78***
Ln(Brand b price)	0.119	4.8***
Ln(Brand AO price)	0.320	5.24***
Ln(Store Brand Price)	0.532	7.26***
City 1	0.597	2.92***
City 2	0.615	3.06***
City 3	0.526	2.52**
City 4	0.504	2.47**
City 5	0.352	1.88*
City 6	0.254	1.23
City 7	0.246	1.31
Time Trend	0.001	4.05***
Ln(Expenditure/Price Index)	-0.027	-1.6
Brand B demand		
Ln(Brand b price)	-0.300	-15.24***
Ln(Brand AO price)	-0.174	-6.72***
Ln(Store Brand Price)	0.354	11.55***
City 1	-0.975	-10.66***
City 2	-0.941	-10.25***
City 3	-0.916	-9.38***
City 4	-0.968	-9.93***
City 5	-0.821	-9.26***
City 6	-0.521	-5.23***
City 7	-0.598	-6.53***
Time Trend	-0.001	-5.59***
Ln(Expenditure/Price Index)	0.084	11.29***

Brand AO demand		
Ln(Brand AO price)	-1.414	-12.71***
Ln(Store Brand Price)	1.268	14.03***
City 1	-2.360	-12.93***
City 2	-2.592	-14.33***
City 3	-2.797	-14.69***
City 4	-2.570	-13.81***
City 5	-2.420	-13.44***
City 6	-2.819	-13.99***
City 7	-2.189	-11.17***
Time Trend	-0.001	-1.6
Ln(Expenditure/Price Index)	0.212	14.59***
Store Brand Demand		
Ln(Store Brand Price)	-2.154	-19.18***
City1	3.738	26.52***
City2	3.918	26.73***
City3	4.186	25.65***
City4	4.034	24.75***
City5	3.889	23.05***
City6	4.087	21.31***
City7	3.541	18.6***
Expenditure Function		
Time Trend	0.002	8.15***
Income	3E-4	5.09***
Income^2	-2.40E-09	-4.1***
Seasona1 1	-8.380	-5.63***
Seasona1 2	-8.411	-5.65***
Seasona1 3	-8.375	-5.62***
Seasona1 4	-8.346	-5.6***
Seasona1 5	-8.441	-5.66***
Seasona1 6	-8.476	-5.69***

Seasona1 7	-8.438	-5.7***
Seasona1 8	-8.428	-5.69***
Seasona1 9	-8.382	-5.65***
Seasona1 10	-8.358	-5.63***
Seasona1 11	-8.304	-5.59***
Seasona1 12	-8.229	-5.49***
Seasona1 13	-8.073	-5.41***
Supply Side		
Brand A Cost		
Cream Price	1.752	7.98***
Wage Rate	57.435	5.97***
Elasticity Rate	52.375	5.69***
Wage Rate*Elasticity Rate	-110.057	-5.84***
Market Share*Cream Price	-4.79E-06	-7.3***
Market Share*Wage Rate	-7.46E-06	-3.36***
Market Share*Elasticity Rate	1.10E-05	5.07***
Brand B Cost		
Cream Price	0.491	4.43***
Wage Rate	7.807	2.54**
Elasticity Rate	4.559	1.55
Wage Rate*Elasticity Rate	-11.303	-1.88**
Market Share*Cream Price	-1.18E-06	-3.55***
Market Share*Wage Rate	-3.21E-06	-4.04***
Market Share*Elasticity Rate	4.34E-06	4.52***
Brand AO Cost		
Cream Price	1.334	7.93***
Wage Rate	0.358	0.73
Elasticity Rate	-0.341	-0.76
Wage Rate*Elasticity Rate	-0.792	-0.52
Market Share*Cream Price	-7.40E-06	-2.24**

Market Share*Wage Rate	-1.90E-06	-0.53
Market Share*Elasticity Rate	5.04E-06	1.53
<u>Store Brand Cost</u>		
Cream Price	-1.771	-16.48***
Wage Rate	26.680	3.62***
Elasticity Rate	16.474	2.24**
Wage Rate*Elasticity Rate	-39.992	-2.72***
Market Share*Cream Price	3.38E-06	11.52***
Market Share*Wage Rate	-1.00E-05	-11.74***
Market Share*Elasticity Rate	6.42E-06	6.87***

Note that:
* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level.

Figure2: Seasonal Parameter Estimates and Expenditure (Mil.) on Butter in these markets.

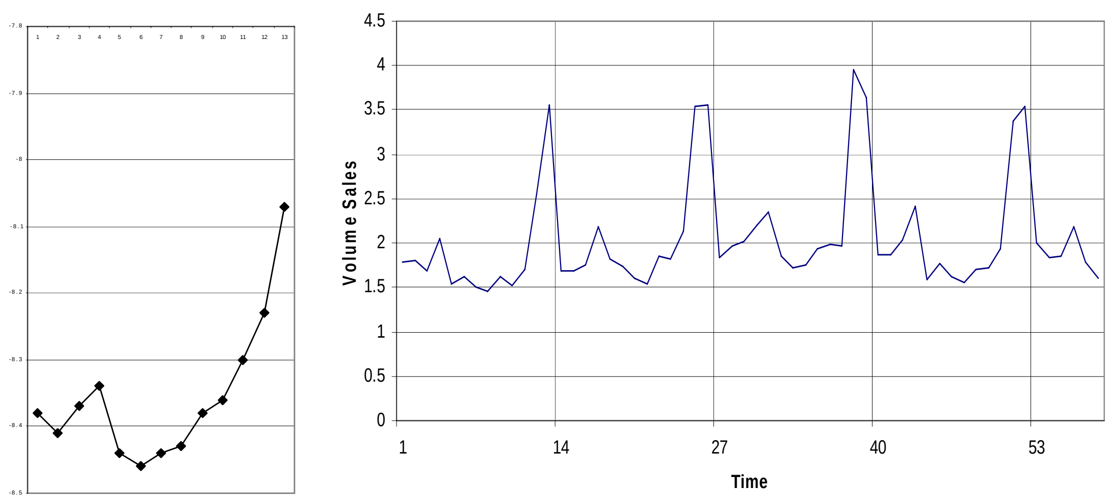

Table 3: Elasticity Matrix.

	Brand A	Brand B	AO	PL
Brand A	-3.768	0.265	0.718	1.862
	(0.102)	(0.035)	(0.07)	(0.105)
Brand B	0.675	-3.388	0.637	0.128
	(0.109)	(0.101)	(0.092)	(0.106)
AO	1.325	0.376	-7.467	3.115
	(0.146)	0.058	(0.477)	(0.379)
PL	1.643	0.164	1.204	-3.397
	(0.091)	(0.024)	(0.117)	(0.119)

Note: Numbers in parentheses are standard deviation.

Table 4: Expenditure Elasticity.

Brand A	0.923
Brand B	1.948
AO	2.651
PL	0.386

Table 5: Channel Profit Margins.

	Channel Profit Margin	Retail Margin	Manufacturer Margin	Retailer Share of Channel Profit	Manufacturer Share of Channel Profit
Brand A	0.559	0.318	0.353	57%	43%
Brand B	0.383	0.372	0.016	97%	3%
AO	0.681	0.345	0.513	51%	49%
PL	0.475				

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