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# *Food Marketing Policy Center*

## **Assessing the Competitive Interaction Between Private Labels and National Brands**

By Ronald W. Cotterill,  
William P. Putsis, Jr. and Ravi Dhar

Food Marketing Policy Center  
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University of Connecticut  
Department of Agricultural and Resource Economics

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## Abstract

In contrast to single-equation cross-sectional studies of private label share, developing a complete understanding of the nature of the competitive interaction between national brands and private labels requires an understanding of the determinants of *both* demand and strategic pricing decisions by firms. Consequently, we estimate a simultaneous system of share and price for private labels and national brands. From the empirical results, two measures of market response are derived. The unilateral demand elasticity measures the pure “own” demand response, while the residual (or “total”) elasticity also captures the impact of competitive price reaction (Baker and Bresnahan 1985). When taken together, these provide important strategic insights into the pricing interaction between national brands and private labels.

In our empirical analysis, we employ a flexible, non-linear demand specification, the Linear Approximate Almost Ideal Demand System (LA/AIDS, Deaton and Muellbauer 1980a), and specify the price reaction equations derived under the LA/AIDS demand specification. Incorporating LA/AIDS demands into a structural equation framework represents an important departure from previous demand specifications in competitive analysis. Using the proposed LA/AIDS framework, we perform a detailed intra-category analysis using data on six individual categories: bread, milk, pasta, instant coffee, butter and margarine. In addition, in an attempt to generalize the results to a broader set of categories and in order to enable us to compare our results to previous cross-section studies, we also estimate using a sample pooled across 125 categories and 59 geographic markets.

Consistent with our objectives, we find that consumer response to price and promotion decisions (demand) and the factors influencing firm pricing behavior (supply) jointly determine observed market prices and market shares. Further, estimates of residual demand elasticities suggest that examination of partial demand elasticities alone may provide an incomplete picture of the ability of brands to raise price. Managerial implications, limitations and suggestion for future research are discussed.

*Keywords:* Competition; Competitive Strategy; Private Labels; Pricing

## 1. Introduction

The nature of competitive interaction between “national brand” and “private label” products has been a primary concern of marketing managers in the food industry for some time now. Over the past decade, this has taken on greater urgency as private label products have made substantial inroads in a number of product categories. For example, in 1996, private label sales in food stores increased 6.3% versus manufacturer brand growth of just 1.3% (*Progressive Grocer*, November 1996). Overall, private label brands in U.S. supermarkets reached an all-time high unit market share of 20.8% in the third quarter of 1997 (*BrandWeek*, 11/24/97). Alternatively, private label sales have declined in some categories as national brands have effectively responded to private label competition (*BrandWeek*, 5/29/95, *New York Times* 6/11/96). Yet, despite the increasingly intense competitive interaction between private labels and national brands, surprisingly little research has been conducted addressing this issue.

Most previous empirical research has focused on the variation in market share of private label products across categories (Sethuraman 1992; Sethuraman and Mittelstaedt 1992; Hoch and Banerji 1993). Sethuraman (1992), for example, identifies twelve marketplace factors as potential determinants of private label success. These factors include retail sales volume, average retail price, price differential between the private label and national brands, retail private label price promotion and brand promotion. These cross-section approaches, however, have produced some counter-intuitive findings. For example, a consistent yet surprising finding is that there is a *negative* relationship between national brand-store brand price differential and store brand market share (McMaster 1987; Raju and Dhar 1991; Sethuraman 1992). This implies that the *larger* the price differential between national brands and private labels, the *lower* the private label share. Raju, Sethuraman and Dhar (1995a), suggesting that cross-category analysis is inappropriate for assessing the true relationship between private label share and price differential, demonstrate that analysis of a single category over time produces the expected positive relationship. We show that the previous counter-intuitive results may also be due to the failure of cross-sectional studies to address the simultaneity of demand and competitive interaction between market players.

While early work addressing private label-national brand interaction used static structural measures of competition (e.g., Connor and Peterson 1992), recent research has begun to address the simultaneous estimation

of demand and competitive interaction for private label products. For example, Kadiyali, Chintagunta and Vilcassim (1998), using data on wholesale and retail prices, investigate pricing power in manufacturer-retailer interactions for a local analgesics market. Also, Putsis and Dhar (1998a) describe the *pattern* of interaction that exists between private labels and national brands across on 58 categories. Employing linear demands within a conjectural variations framework, both papers suggest that a richer set of questions can be addressed when demand and competitive response are considered simultaneously.

We build on prior research on private labels in two fundamental ways. First, we maintain that developing a complete understanding of the interaction between private labels and national brands *requires* an understanding of the determinants of *both* demand and strategic pricing decisions by firms. As an example, recent price cuts in the ready-to-eat cereal category by Post and Nabisco in response to pressure from private label resulted in a consumer response that increased its market share from about 16 percent to over 20 percent, while decreasing private label shares. In response, Kellogg's announced a 20 percent across the board price cut due to declining shares of its major brands. Other national brand and private label cereal manufacturers also reduced prices (Cotterill and Franklin 1999). Clearly share responds to price, while the price setting behavior of firms depends upon the game being played by interdependent agents. While this is certainly not new, we maintain that the counter-intuitive findings inherent in much of the cross-sectional research on private labels can easily be explained by simultaneously addressing demand and price setting behavior, even when conducting a cross-sectional analysis.<sup>1</sup>

Second, we analyze the strategic price interaction between national brands and private labels, which enables us to assess differences in the ability of national brands and private labels to raise price across categories. Previous examination of demand response has generally focused the concept of partial own demand elasticity within a Marshallian demand curve (see, e.g., Tellis' 1988 Meta analysis). This measure of price response has often been criticized for its *ceteris paribus* assumption, explicitly

1. It is well known that OLS applied equation by equation to jointly endogenous variables (e.g., price as a function of share and share a function of price as explained above) will produce inconsistent parameter estimates (see, e.g., Intriligator 1978 or Judge, 1985). Simultaneous equation approaches to estimation have a long history in marketing (Bass 1969; Schultz 1971; Hanssens, Parsons and Schultz 1990; Neslin 1990; Bayus and Putsis 1999).

assuming all other prices are held constant (see, *e.g.*, Werden 1998). In reality, most price changes are met with some sort of competitive response (see, *e.g.*, Leeflang and Wittink 1992). Since a firm's price change is likely to be met by a change in the prices charged by its rivals, the observed demand effect will be attenuated or exaggerated by the competitive response and related cross-price demand response. Accordingly, estimates of partial demand elasticities alone may provide managers with inadequate information regarding the impact of a given price change. Consequently, in the empirical analysis below, we examine the *total* (or “*residual*”) *demand elasticity*. The residual demand elasticity measures the net demand response once competitor reactions and cross-price demand effects are taken into account. Consequently, it not only can be an important part of understanding the pricing relationship between private labels and national brands, but can also be a useful managerial tool for assessing the net impact of a price change (see, *e.g.*, Baker and Bresnahan 1985, Cotterill 1994).<sup>2</sup>

The paper proceeds as follows. In the next section, we describe the theoretical model that guides the empirical specification and the selection of variables. Using LA/AIDS demands, we assume that retailers engage in proportionate mark-up behavior within the channel. Consequently, before we present the results, we provide a test of this assumption and demonstrate that it is indeed supported empirically in the categories studied here. We then describe the methodology used in the empirical analysis in some detail. In discussing the results, we first present estimates of model parameters for the LA/AIDS framework applied to a large cross-category panel data set that includes 125 categories in 59 local markets. We then present the results obtained by applying the proposed framework to six individual categories. Consistent with the objectives stated above, we find that a) the counter-intuitive pricing findings of previous cross section analysis disappear once we account for the simultaneity of demand and supply, and b) there are important differences in the pricing power of private labels across categories implied by residual demand elasticities versus the more commonly

used partial own demand elasticity. We conclude with a discussion of the study's limitations and suggestions for future research.

## 2. Theoretical Framework

Several approaches to estimating competitive interaction have been suggested in the literature. One approach to estimating competitive interaction requires specifying, *a priori*, the various forms of competitive interaction to be considered (hence it is often referred to as a “menu” approach). Non-nested hypothesis tests are used to ascertain which type of competition best fits the data (see, *e.g.*, Gasmi, Laffont and Vuong 1992, and Kadiyali, Vilcassim and Chintagunta 1996). Alternatively, conjectural variations (CV) approaches allow a researcher to estimate the competitive interaction directly without the need to specify the interactions *a priori* (see, *e.g.*, Putsis and Dhar 1998a, 1998b and Kadiyali, Vilcassim and Chintagunta 1998). This entails deriving each player's first order conditions as a function of the conjectures each player has about its rival's actions; these first order conditions and the demand functions are estimated directly. Alternatively, the reaction function approach that we present here contrasts with the CV approach in that it solves the first order conditions for each player, expressing each decision variable as a function of rival's decision variables, as well as demand and cost shift variables (see, *e.g.*, Martin 1993). This provides a researcher with a functional form specification based upon each player's “best response” given the underlying demand structure and competitive environment. As pointed out by Liang (1987) and Tirole (1988), the reaction coefficients are generally a complex function of the demand coefficients and the conjectures.<sup>3</sup>

Following work by Choi (1991) and Besanko, Gupta and Jain (1998), we begin with a category-level model of manufacturers operating in a duopoly, with one producing a national “branded” product and the other producing a

2. Following Baker and Bresnahan (1985) and Cotterill (1994), and using a duopoly for illustration, the residual or total demand elasticity is defined follows:  $\eta_1^R = \eta_{11} + \eta_{12} \xi_{21}$ , where  $\eta_{11}$  denotes the (own) “partial” demand elasticity,  $\eta_{12}$  denotes the cross-price demand elasticity of demand (both estimated directly from the demand equation), and  $\xi_{21}$  denotes the price reaction elasticity (estimated directly from the reaction functions). We will use the terms residual demand elasticity (Baker and Bresnahan 1985, Werden 1998) and total demand elasticity (Tomek and Robinson 1981) interchangeably throughout.

3. We note that for consistent conjecture models, the CV and reaction function approaches produce identical estimates of competitive interaction. If a model is a consistent conjecture model, then firm one's (two's) conjecture about changes in  $P^2$  ( $P^1$ ) when it changes  $P^1$  ( $P^2$ ) would be equal to the observed price reaction of  $P^2$  ( $P^1$ ) to  $P^1$  ( $P^2$ ). See Putsis and Dhar (1998a) for a discussion of the various approaches taken for estimating competitive interaction and Kadiyali, Chintagunta and Vilcassim (1998) or Bresnahan (1989) for a discussion of the interpretation of CV parameters.

“private label” product.<sup>4</sup> Each manufacturer sells to a local retailer by specifying a wholesale price, with the retailer setting the retail price. Following the rationale set forth by Besanko, Gupta and Jain (1998), we assume that each retailer acts as a “local monopolist.”<sup>5</sup>

Since a key objective of this paper is to explore the implications of the demand specification for assessing the competitive interaction between market players, we begin by concentrating on the demand-side specification. Empirical demand analysis and functional form specifications have been well developed in the economics literature (see, e.g., Deaton and Muellbauer 1980a or Phlips 1983). Numerous forms have been proposed that possess theoretical advantages over a linear specification, including the Linear Approximate Almost Ideal Demand System, or LA/AIDS (Deaton and Muellbauer 1980b). Advantages of the LA/AIDS functional form include the fact that it is derived from the underlying choice axioms in utility theory, individual behavior can be aggregated to consistently estimate demand parameters from market level data, and that it gives a first-order approximation to any “true” demand system functional form (Deaton and Muellbauer, 1980b). It is also a flexible non-linear form with well-known properties. Thus, for our purposes, it provides a convenient contrast to linear forms.

We begin by presenting the general LA/AIDS demand specification and then derive the associated reaction functions. The general LA/AIDS functional form for national brands, originally introduced by Deaton and Muellbauer (1980b), is given by equation (1):

$$S_{ij}^1 = a_{10} + a_{11} \ln P_{ij}^1 + a_{12} \ln P_{ij}^2 + a_{13} \ln (E_{ij}) + a_{14} D_{ij} \quad (1)$$

where, for category i and market j:

4. In the empirical analysis that follows, we will use composite national and private label brands. Accordingly, we will focus on one national brand and one private label brand in the presentation below. However, it should be noted that the model and analysis could easily be extended to include multiple brands.

5. Besanko, Gupta and Jain (1998) provide a strong rationale for this assumption, which is also made by Choi (1991). They cite the work of Slade (1995), who interviewed grocery chain managers “who reported that the vast majority of households (over 90%) *do not* engage in comparison shopping by visiting several stores” to seek out the best deal. This suggests that “competition takes place across brands *within* a store rather than *across* stores in a local market ...” (italics added). Slade (1995), empirically demonstrates that sales within one chain are unaffected by prices at other chains, suggesting pricing *independence* across rival chains within a category. This is also consistent with the work of Walters and Mackenzie (1988), who use data across all grocery items sold by two retailers.

$S_{ij}^1$  = dollar market share of the national brand,

$P_{ij}^1$  = retail price per unit volume of the national brand,

$P_{ij}^2$  = retail price per unit volume of the private label brand,

$E_{ij}$  = total per capita expenditure divided by Stone's price index, which is equal to  $S_{ij}^1 \ln P_{ij}^1 + S_{ij}^2 \ln P_{ij}^2$ ,

$D_{ij}$  = vector of retail demand shift variables, which includes measures of retail promotion, local market characteristics and private label distribution.

The per capita expenditure variable ( $E_{ij}$ ) is a deflated (real) measure of per capita expenditures and its coefficient provides an estimate of the impact of changes in total category expenditure on demand. Contrasting with many attraction-type market share models (see, e.g., Cooper 1993), the LA/AIDS functional form is derived from the consumer's cost function and, consequently,  $S_{ij}^1$  and  $S_{ij}^2$  are expressed as share of expenditure. From the basic formulation in (1), the usual demand restrictions of symmetry, homogeneity, and adding up can be imposed. Further, all (quantity) demand elasticities can be recovered from the demand specification.<sup>6</sup> The private label demand equations follow by analogy.

On the supply side, in a game where price is the strategic variable, manufacturers choose wholesale prices  $w_{ij}^1$  and  $w_{ij}^2$ , respectively. While we typically don't observe  $w^i$ , if we assume that retailers follow a (known) proportional markup rule for pricing decisions (e.g.,  $P_{ij}^l = m^l w_{ij}^l$ ), then it becomes possible to derive first-order

6. Following Green and Alston (1990), estimates of the national brand's own price and cross-price (here, with respect to private label price) elasticity of demand are:

$$h^{11} = -1 + \frac{a_{11}}{\bar{S}^1} + a_{13} \quad h^{12} = \frac{a_{12}}{\bar{S}^1} + a_{13} \frac{\bar{S}^2}{\bar{S}^1},$$

respectively, where  $\bar{S}^1$  and  $\bar{S}^2$  are sample average market shares or any other market share value. Thus, these demand elasticities vary as market shares vary and are local or point estimates of the elasticities. The expenditure elasticity and the elasticities for variables,  $d^k$ , in the vector of exogenous demand shift variables are:

$$h^{13} = 1 + \frac{a_{13}}{\bar{S}^1} \quad e^k = \frac{a_{14}^k}{\bar{S}^1} \bar{d}^k,$$

respectively, where  $k=1, \dots, m$  is the index for the number of variables in the  $D$  vector and  $\bar{d}^k$  is the average value of  $d^k$ . For variables expressed in logarithmic form, this elasticity formula has the inverse of  $d^k$  rather than  $d^k$ . The price reaction elasticity for national brands, which gives the present change in brand price for a one percent change in private label price, is  $b_{11}$  in equation 5. Private label equations and elasticity formulae can be expressed analogously.

approximations to the price reaction curves expressed in retail prices that capture horizontal manufacturer interactions consistent with LA/AIDS demands. Define  $C^1_{ij}$  to be a vector of supply-side cost shift variables for national brands and  $C^2_{ij}$  to be a vector of supply-side cost shift variables for private labels. In our empirical analysis,  $C^1_{ij}$  and  $C^2_{ij}$  will include two cost shift variables, one representing the *retailer's* ability to raise price over (wholesale) costs (reflecting  $m^1$  and  $m^2$ ) and one that captures *manufacturer* cost differences related to package size. As Choi (1991) notes, deriving closed form solutions for the first order conditions under nonlinear demands are generally not possible. Here, employing LA/AIDS demands (equation 1), we can solve the first order conditions for  $P^1_{ij}$  and  $P^2_{ij}$ , respectively, using a Taylor series expansion to obtain a linear approximate retail reaction function that allows empirical analysis. This produces the following price reaction function for the national brand manufacturer, with the specific variables to be included in the  $D_{ij}$  and  $C_{ij}$  vectors detailed in the next section:

$$\ln P^1_{ij} = b_{10} + b_{11} \ln P^2_{ij} + b_{12} \ln D_{ij} + b_{13} E_{ij} + b_{14} \ln C^1_{ij} \quad (2)$$

The corresponding functional form for estimation of the private label reaction function is:

$$\ln P^2_{ij} = b_{20} + b_{21} \ln P^1_{ij} + b_{22} \ln D_{ij} + b_{23} E_{ij} + b_{24} \ln C^2_{ij} \quad (3)$$

It is important to note that the price reaction elasticity for national brands (the percent change in national brand price for a one- percent change in private label price,  $\beta_{11}$  in equation 5), does not depend on the retailer's proportional markup. The national brand demand function (1), and the logarithmic form of the reaction functions (equations 5 and 6) comprise the three-equation system to be estimated. The fourth equation in the system (the private label demand equation), and its associated demand elasticities, are recovered via the adding up property of the demand system.

Incorporating a flexible demand functional form is not without its tradeoffs. Choi (1991) used simulation to explore the theoretical properties of channel models with non-linear demand forms that did not have closed form solutions. Here, we examine the empirical properties of one such model by using a logarithmic first order (Taylor series) approximation to the reaction functions to produce estimable supply-side relations. While the use of such approximations is not uncommon in econometric analysis (e.g., the non-nested P-E test proposed by Davidson and MacKinnon 1981 relies heavily on the same Taylor series

approximation), this means that we cannot impose cross-equation constraints between the demand and reaction equation parameters. The implication is that we cannot estimate the conjectural variations that are embedded in the reaction coefficients. However, we are able to estimate the price reaction elasticities, which enable us to generate estimates of unilateral versus residual demand elasticities, a focal point of our analysis of horizontal pricing behavior. Moreover, using only data on actual retail prices, we can solve for price-cost margins and manufacturer marginal costs (as is possible with the corresponding CV approach), so that the loss in estimation detail due to the supply-side approximation is minimal. Finally, we perform our analysis across data consisting of supermarket operations in 59 markets across 125 categories, including an intra-category analysis of six individual categories. We believe that this provides for some degree of generalizability and at the same time bridges the gap between detailed intra-category studies of competitive interaction (e.g., Kadiyali, Chintagunta and Vilcassim 1998) and the cross section studies on private label pricing discussed earlier.

### 3. Empirical Estimation

#### 3.1 Data

The data used in this study are IRI market-level data on food products across 59 geographic markets and 211 categories for 1991 and 1992. Categories were excluded from the analysis if they contained missing data or if they were categories where private labels have not been introduced. This left 125 categories in the sample for an average coverage of 54 cities in a typical category. National brand volume (dollar) share averaged .721 (.775) in 1992.

These data were merged with independent data from *Progressive Grocer* on the demographic characteristics of the IRI geographic markets. Thus, we have two principal dimensions on which the data vary—across categories and across geographic markets. Consistent with previous work in the private label area (e.g., Sethuraman and Mittelstaedt 1992; Hoch and Banerji 1993; Slade 1995), aggregate branded and private label variables were created for the 125 product categories and 59 markets. Brand price, feature, display, and price reduction variables are volume market share weighted averages.<sup>7</sup>

7. Consistent with some previous work on private labels (e.g., Slade 1995), aggregate private label and national brand variables were created for share, price and price reduction. Private label (national brand) share is sum of all private label (national) brands in the  $i$ th market,  $j$ th category. Private label (national brand) price is the volume-weighted average price of

### 3.2 Empirical Specification

We define the set of variables used in the empirical analysis to follow directly from the theoretical model above (Chart 1 lists the variables used in the empirical analysis). Based upon previous research, we specify the demand shift vector,  $D_{ij}$ , to include three sets of variables: i) variables capturing retail promotion activity, ii) local market characteristics, and iii) private label distribution. Let us address each set of variables one at a time. First, similar to Kadiyali, Chintagunta, and Vilcassim (1998), we specify a series of endogenous trade promotion variables in the demand shift vector. These variables include measures of the percent of volume sold on display, the percent of volume sold with a local newspaper feature advertisement, and temporary percent price reduction (BRDISPLAY, BRPRICEREDN and PLPRICEREDN).<sup>8</sup> Second, following Hoch, *et al.* (1995), who found that local market characteristics affect the observed demand response, we also include two variables representing PLDISPLAY, BRFEATURE, PLFEATURE, local market demographics (INCOME, AGE). Third, since the total demand for private labels and national brands in a geographic area will clearly be affected by private label coverage, we also include private label distribution (PLDISTN) as a demand shift variable. All of this implies:

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all private labels (national brands) in the  $i$ th market,  $j$ th category. The two price reduction variables are volume-weighted percent price reduction for all private label and branded products, respectively. Thus, for price and share, we have four aggregate variables: total branded share, total private label share, volume-weighted average price of national brands, and the volume-weighted average price of private label products.

8. We address the endogeneity of the trade promotion variables through the use of instrumental variables. The principle is similar to the approach taken by Berry, Levinsohn and Pakes (1995). Specifically, each promotional vehicle for market  $i$ , category  $j$ , is expressed as a function of the promotional activity in each of the other  $j$  ( $j \neq i$ ) markets, using the fitted value as the instrument. Note that in order for this approach to eliminate the endogeneity bias, the equation errors for each promotion instrument have to be independent. This requires that display and feature decisions, for example, are made on a market by market (or chain by chain) basis.

Similarly, on the supply side, the brand level Herfindahl is specified as endogenous, following the methodology suggested by Nevo (1998). Specifically, an instrument is created by forming a weighted average of previous period Herfindahl indices (the weights created by time series regressions). This created an instrument correlated with the current period Herfindahl at over 90%, but which is predetermined in the current period.

$$D_{ij} \equiv \{(BRFEATURE, PLFEATURE, BRDISPLAY, PLDISPLAY, BRPRICEREDN, PLPRICEREDN); (INCOME, AGE); PLDISTN\}.$$

On the supply-side, since we don't observe costs directly, we include cost-shift variables or retailers and manufacturers, respectively. First, prior empirical work on the concentration-price relationship in grocery retailing suggests that the general level of the markup in a local area is related to local retailer concentration (Marion 1979, Cotterill 1986). Consequently, we postulate that the retail mark-ups ( $m^1$  and  $m^2$ ) should be influenced by the local retailer's ability to raise price over (wholesale) cost and, accordingly, specify  $m^1$  and  $m^2$  to be a function of local retail concentration (GROCCR4). Second, we note that Putsis (1997) finds a negative relationship between the brand-level Herfindahl and price. The conclusion drawn there was that the negative relationship was caused primarily by the increased costs associated with a more disperse and fragmented product line, suggesting that manufacturer pricing decisions may be related to brand-level dispersion for cost-related reasons. Finally, we proxy for manufacturer costs by including a measure of package size to capture the hypothesis that smaller package sizes have higher costs per unit. This discussion implies that  $C_{ij}^1 \equiv \{BRVOLPUN, GROCCR4, HERFINDAHL\}$ , and  $C_{ij}^2 \equiv \{PLVOLPUN, GROCCR4, HERFINDAHL\}$ . The Appendix summarizes the predicted signs and presents a more detailed rationale for selected key variables used in the empirical analysis.

### 3.3 Methodology

After substituting in  $D_{ij}$ ,  $C_{ij}^1$ , and  $C_{ij}^2$  as defined above into the LA/AIDS system (equations 1, 2 and 3), we estimated the system directly using three stage least squares. Note that although our model has four equations, however, one of the demand equations is redundant for estimation purposes. Since the market shares of national brands and private labels sum to one, any loss of branded share due to changes in any variable, e.g. private label price, must go to private label share. This general adding up property of a demand system means that we can recover the estimated coefficients and standard errors (t-ratios) for the dropped equation. We drop the private label demand equation and estimate the remaining three equations with three stage least squares.

We began by estimating the LA/AIDS system using a sample pooled across the 125 categories. Conducting the analysis on the pooled data enabled us to carefully examine some of the counter-intuitive pricing results found in previous cross-category research on private labels (e.g., Sethuraman 1992). It is important to note that cross-

category analysis of this type precludes the use of price levels: one cannot compare the price of a pound of cheese to the price of canned soup. Thus, it would be inappropriate to conduct a cross-category analysis focusing on price relationships using data across multiple categories for a given time period (see, e.g., Kelton and Weiss 1989). Consequently, following Kelton and Weiss (1989), we estimated a first difference form on the pooled annual data from 1991 and 1992.<sup>9</sup> Note that when conducting a cross-category study, estimating a first difference model is particularly attractive because it controls for first order fixed effects due to excluded local market and category variables in level regressions.<sup>10</sup> Further, to the extent that product quality is constant from one period to the next, estimating a first difference model eliminates the need for the inclusion of a quality measure for each category since (an assumed constant level of) quality drops out of the analysis when we difference. This is particularly important since quality measurement is such a difficult task when conducting a cross-category analysis (see, e.g., Hoch and Banerji 1993 and Narasimhan and Wilcox 1998).

The focus of our empirical analysis, however, is on intra-category analysis. Consequently, we also estimated the proposed LA/AIDS framework using data for six individual categories: milk, butter, bread, pasta, margarine, and instant coffee. We use these individual category results below to examine the interaction between private labels and national brands in detail on a category-by-category basis. Since individual category-level analysis does not suffer from the same apples-to-oranges comparison that cross-category analysis does, we were able to use the “level” data for each individual category over the 1991 to 1992 time period without needing to take the first difference.

### 3.4 Examination of Model Assumptions

Modeling the interaction between national brands and private labels is especially challenging because the vertical relationship between manufacturers and retailers plays a particularly important role in retail pricing behavior. As a result, one needs to be concerned about the vertical as well as horizontal nature of competitive interaction. In the formulation above, we made two fundamental assumptions: 1) retailers follow a proportional mark-up rule within the channel, and 2) LA/AIDS demands. Given the significance of vertical channel relationships for private label products, it is important that we demonstrate that these assumptions appropriately characterize market behavior before we proceed with estimation. Consequently, in this section, we discuss the results of empirical tests of these assumptions.

In related work (Cotterill and Putsis 1998), we develop tests of channel behavior based upon two well-cited theoretical models of channel structure, Choi's (1991) Manufacturer Stackelberg model and the Raju, *et al.* (1995b) model of private label—national brand interaction. Specifically, we first demonstrate that both models can be represented as specific cases of a more general class of mark-up models. This enables us to derive a set of nested tests for the use of proportional markup behavior within the channel. In the current setting, out of 12 tests for proportional markup conduct (six for private labels and six for national brands), all but one were consistent with proportional markup behavior (all tests are at  $p < .01$ ). Thus, these results are consistent with the supply-side assumptions made in the Raju, *et al.* (1995b) model and provide support for the assumption made in the derivation of the LA/AIDS reaction functions above.

In addition, we examine our assumption of LA/AIDS demands. Specifically, since previous research has generally employed a linear functional form, we compare the LA/AIDS specification to a linear form using a non-nested P-E test (Davidson and MacKinnon 1981). Balasubramanian and Jain (1994) suggest that the choice of non-nested test should be guided by the circumstances surrounding the test (see, e.g., their Table 7 for the appropriateness of using the P-E test in the current application). Jain and Vilcassim (1989) demonstrate that the sample size requirements for the P-E test may be less stringent than that required for Lagrange multiplier tests, suggesting that it is particularly relevant in our application. We employ it as detailed in Greene (1997, pp. 459-462). The results for the demand specification were even more conclusive than those for within-channel structure discussed above. For all six categories, the P-E test *strongly* rejected the null of a linear model at  $p < .01$ .

9. For example, in the first difference equations, BRSHARE is 1992 BRSHARE minus 1991 BRSHARE and BRPRICE is the 1992 LN(BRPRICE) minus the 1991 LN(BRPRICE). Changes in the natural logarithm of price from 1991 to 1992 are percent price changes that can be analyzed across categories. The interpretation of the coefficients in these “differenced” equations is identical to those in the “level” equations.

10. Hausman and Taylor (1981) argue that excluded local market variables in panel data of this type can bias estimation results for level regressions. They show that this can be avoided by specifying a set of city binary variables. These drop out of the model when one takes the first difference. This is also true for specifying a set of category binary variables in level regressions to control for excluded variables in individual categories.

.0001 (except for the bread category, where we reject the linear specification at  $p < .01$ ). Since each of these tests offers support for the three assumptions made in the LA/AIDS derivation above, we proceed to the empirical results.<sup>11</sup>

#### 4. General Results

The results are presented in two stages. First, in this section, we describe the cross category results as well as those for the six individual categories to provide an overall sense of what the analysis reveals. Second, in the following section (Section 5), we discuss the results in relation to the paper's two contributions proposed earlier (simultaneity and pricing interaction).

##### 4.1 Cross-Category (Pooled) Results.

Although the focus of our research is on the intra-category analysis, we begin by presenting the pooled cross-category results in an attempt to provide an overview of the findings, as well as a link to previous cross-sectional research on private labels. Tables 1 and 2 present the results using the sample pooled across all 125 categories. Table 1 presents the full set of parameter estimates, while Table 2 presents the associated demand elasticities. We note that all of the coefficients have the hypothesized signs and are statistically significant.

There are two specific results from the cross-category analysis that should be addressed before we proceed to the intra-category analysis. First, in the price reaction equations, we find that the four-firm retail concentration has a significant and positive impact on both branded and private labels prices. The coefficient is 50 percent higher for private label products (.057 versus .028 for national brands), suggesting that the price differential between private labels and national brands narrows in more locally concentrated grocery markets. This is consistent with prior work on the relationship between concentration and price in grocery retailing (Marion 1979, Cotterill 1986), but it represents a significant advance due to the much larger number of categories and markets studied here.

Second, we note that both demand and competitive price response may be related to the existing private label

share in the category. For example, we would expect the national brand price reaction to be greater in categories where private label share was higher, reflecting the greater threat posed by private labels in these categories. In an initial attempt to investigate the impact of varying share levels, we divided the sample into quartiles based upon private label share.<sup>12</sup> Table 3 presents the estimated demand and price reaction elasticities across these quartiles. While there is little change in the own demand response across quartiles, this is not true of cross-price demand response. Whereas national brand demand is *more* sensitive to changes in private label price in high private label share categories, private label demand is *less* sensitive to national brand price. Consistent with this observation, national brand price reaction elasticities also increase across quartiles (in the high quartile in particular), presumably reflecting heightened national brand attention to the increased private label presence. In general, it appears as though price is not an important strategic weapon when private label share is low, but becomes increasingly important in categories where private label share is high. While this may be due in part to a higher degree of price leadership exhibited by private labels in high share categories, it may also be reflective of the idiosyncratic nature of the individual categories. This also highlights the importance of intra-category analysis, to which we now turn.

##### 4.2 Intra-Category Results.

Table 4 presents the estimated demand and price reaction elasticities using the data for the six individual categories. Since traditional  $R^2$  measures are not bounded between zero and one in three stage least squares, Carter and Nagar's (1977) multiple squared coefficient of correlation for simultaneous systems,  $R_w^2$ , was used. All systems fit well, with the system-wide  $R_w^2$  values ranging from a low of 0.932 for bread to a high of 0.998 for instant coffee and margarine.<sup>13</sup>

12. Since share is the dependent measure on the demand-side, it is not possible to include share in the price reaction equation. Thus, quartile stratification represents a direct and parsimonious mechanism for addressing the impact of changing share on the parameter estimates. An advantage of the stratification is that it enables us to allow all parameter estimates to vary across the strata. Most parameter estimates were stable across the quartiles.

13.  $R_w^2$  has a usual  $R^2$  interpretation. Specifically, it measures the percent of system-wide variation in the endogenous variables explained by all independent variables in the system. It is bounded by zero and one. However, we note that this statistic is frequently very high and should be interpreted with caution (see

11. Thanks to the suggestion of an anonymous reviewer, we re-ran each specification using two additional randomly selected categories (mustard and brownie mixes). We again reject linear demands ( $p << .0001$ ), while the tests for channel behavior support proportional mark-up for both private labels and national brands (again  $p < .01$ ). Substantively, the estimated demand elasticities and reaction elasticities were in the range reported in the text for the other categories.

For the individual categories represented in Table 4, the empirical estimation produced results with not only a great deal of face validity, but also results that were consistent with previous research on a number of dimensions. For example, the estimated own price demand elasticities for national brands ranged from -1.03 for instant coffee to -2.05 in the milk category. Tellis (1988) in a meta-analysis of reported demand elasticities, found the mean price elasticity of demand to be equal to -1.71. Further, price response is asymmetric—national brand price cuts are generally more effective in stealing share from private labels (consistent with Allenby and Rossi 1991 and Blattberg and Wisniewski 1989). However, this asymmetry is reversed in the butter category (a category with high private label share at 46%). Bronnenberg and Wathieu (1996) suggest that reversals may occur in categories where private labels have advantageous positions in terms of quality relative to price (also see Hardie, Johnson and Fader 1993).

With respect to the price reaction elasticities, the price reactions of national brands were generally small in magnitude and very close to those reported previously in related research (Lambin 1976, Hanssens, Parsons and Schultz 1990, pp. 201-210). In each of the price reaction equations, own feature and display have strong negative estimated coefficients for both private labels and national brands. It appears as though when price cuts occur, feature advertising and point of sale displays occur more frequently, advertising the price cuts (Mayhew and Winer 1992). However, when national brand display and feature ads are active, private label prices are *lower*. This suggests to us that retailers often respond with price as a strategic weapon in categories where national brand display and feature advertisements are used extensively. This is consistent with recent experience in the breakfast cereal industry (Gejdenson and Schumer 1995, 1996; Angrisani, 1996; Cotterill 1999).

Some additional insight can be gained by looking at individual categories in some depth. For example, private labels competing in the pasta category face consumers who are particularly price sensitive. Both national brand and private label demands are elastic, with estimated demand elasticities of -1.46 and -3.66, respectively. The price differential between national brands (with an average price of 99 cents) and private labels (68 cents) is substantial. Cross-price response is decidedly asymmetric—a 1% change in private label price generates only a 0.42% change in national brand demand, while a 1% change in

national brand generates a 2.9% change in private label demand. National brands, with .81 share, have a dominant market position and compete mildly aggressively on price (the national brand price response elasticity is equal to 0.52). However, consistent with the pooled results, this dominant position erodes in more concentrated retail environments. Contrasting with the pasta category, national brands in the margarine category not only possess a dominant position in terms of share (private label share is just .16), but compete vigorously on price. While the national brand demand elasticity is mildly elastic (-1.39), private label demands are highly price sensitive (with an estimated elasticity of -6.38). Here, however, unlike the pasta category, national brands react strongly to private label price cuts—a 1% reduction in the price of private labels is estimated to produce a 1.5% reduction in national brand price. Such a strategy by national brands is likely to be effective—a 1% reduction in national brand price produces an estimated 3.96% reduction in private label demand. Further, the dominant position enjoyed by national brands in this category is *not* likely to be offset by increases in local retailer concentration (national brand and private label prices increase by approximately the same amount when local retail concentration increases). As a result, private label brands have a particularly difficult time competing through price even when the local market is characterized by strong local retailers. It appears as though national brands use a dominant market position effectively by using price as a strategic weapon in this category.

This discussion suggests that price interaction between national brands and private labels occurs at multiple levels—not only do we need to properly assess the direction of demand and supply reactions, but we also need to be able to understand and assess the nature of the interaction observed. To this we now turn.

## 5. Discussion – Substantive Findings

### 5.1 Previous Cross Section Studies

We noted earlier that previous cross-sectional research (e.g., McMaster 1987; Raju and Dhar 1991; Sethuraman 1992) has, surprisingly, found a *negative* relationship between national brand-private label price differential and private label market share. This suggests that as private label price increases, its share also increases. Raju, Sethuraman and Dhar (1995a) suggested that while such a relationship may be true in cross-section, it is unlikely to hold in time series. In our analysis, we find that the own-price demand elasticities in Table 2 (pooled results) and Table 4 (intra-category results) are all negative as

Berndt 1991, p.468). Further, collinearity may inflate the estimates of  $R^2_w$  throughout.

predicted by theory. Also as expected, all of the price reaction elasticities on the supply side are positive. It is particularly important to note that the pooled analysis is conducted across 125 categories. Thus, we are able to obtain the expected negative demand-side price coefficients and positive supply-side coefficients even in a cross-sectional analysis.<sup>14</sup> In short, there are no free lunches—a *ceteris paribus* price increase results in a loss in share.

### 5.2 Implications for Horizontal Pricing Relationships

As stated earlier, the use of partial own demand elasticity to understand market response has often been criticized for its *ceteris paribus* assumption, explicitly assuming all other prices are held constant (see, *e.g.*, Werden 1998). The previous discussion on price interaction in the margarine category highlights the importance of examining residual demand elasticities for understanding strategic behavior. To illustrate, note that while examination of the private label's own price elasticity of demand in this category (-6.38) alone would suggest that lowering private label price is likely to be an effective way to increase demand, this is simply not the case. As noted above, a 1% reduction in private label price generates a 1.5% change in national brand price, which, in turn, reduces private label demand by 5.9% (1.5 times the cross-price response of 3.96). Thus, the *net* effect of any private label price decrease is likely to be relatively small due to national brand competitive conduct in this category.

Following Baker and Bresnahan (1985) and Cotterill (1994), it is possible to derive two measures of the impact of a price change that provide substantive insights into the ability of a firm to raise price vis-à-vis its competition. The first,  $\eta_{11}$ , is the familiar partial own demand elasticity, which can also be thought of as the *unilateral* (or “non-followship”) demand elasticity since it quantifies the impact of a price change on demand when no rivals follow. As such, it provides a measure of *unilateral market power*—if national brands raised price (without an associated private label price change) and demand fell precipitously, this would suggest that national brands have little ability to raise prices unilaterally. The second measure is the *residual* or *total demand elasticity*. This provides an

estimate of the total impact of a price change given actual market behavior. Focusing on national brands as an example, taking the derivative of the demand equation with respect to price and using the chain rule to take into account strategic interdependence, we can (with some algebraic manipulation) derive the residual (or total) demand elasticity for national brands,  $\eta_1^R = \eta_{11} + \eta_{12} \xi_{21}$ . Here,  $\eta_{12}$  denotes the cross-price elasticity of demand (estimated directly from the demand equation), and  $\xi_{21}$  denotes the price reaction elasticity (estimated directly from the reaction functions).<sup>15</sup> Thus, the second term of this expression ( $\eta_{12} \xi_{21}$ ) provides a measure of the secondary effect of a price change on demand (due to competitive response). If private label prices follow national price changes in a coordinated fashion,  $\xi_{21}$  is positive. Since national brands and private labels are substitutes ( $\eta_{12} > 0$ ), to the extent that coordinated pricing behavior exists, this implies that the total elasticity will be less elastic than the unilateral own price elasticity.

We use the estimates of own-price and cross price demand elasticities, as well as the price reaction elasticities presented above, to provide estimates of the total ( $\eta_{11} + \eta_{12} \xi_{21}$ ) and unilateral ( $\eta_{11}$ ) demand elasticities. Table 5 presents estimates for national brands and private labels across the six categories studied.

The results in Table 5 suggest that there is a substantial variation in the difference between residual and unilateral demand elasticities across categories. In general, the residual elasticity is lower (in absolute value) than the unilateral elasticity, as expected. In the butter category for example, an elastic unilateral demand elasticity (-1.50) for national brands translates into a mildly inelastic residual elasticity (-0.971). In this instance, this is due in large part to the fact that national brand demand is sensitive to private label pricing (the national brand cross-price elasticity equals 1.07). For some categories, the difference is more dramatic. For example, in the margarine category discussed above, the unilateral elasticity (-6.38) implies a considerably larger price response than suggested by the residual elasticity (-0.438). Despite the large own price elasticity for private labels, a 1% price cut by private labels will generate only a 0.437% net change in private label demand. Thus, the viability of any private label strategy aimed at altering price in this category should not be nearly as effective as the unilateral elasticity implies. Similar results are obtained for national brands in this category, although the difference is not nearly as dramatic.

Finally, we note that for a number of categories (milk,

14. We note that these results (unlike those discussed in sub-sections (b) and (c) below) are *not* driven by the demand specification. The correct sign on the price variables on the demand and supply sides are obtained using a linear demand as well. Thus, simultaneity, not demand functional form, is the key to empirically obtaining the proper signs on the price variable in cross-section.

15. For private labels, the analogous expression is  $\eta_2^R = \eta_{22} + \eta_{21} \xi_{12}$ .

bread and instant coffee), the national brand unitary and residual elasticities are essentially identical. This is due primarily to the fact that national brand demand in each of these categories is not sensitive to private label price. Thus, any competitive (price) response by private labels will have little impact on national brand demand. The same cannot be said for private labels in these categories—private label demand is sensitive to changes in national brand pricing behavior. Thus, while examination of unilateral demand elasticities is likely to overstate demand response in general, this is particularly true for private label products.

### 5.3 Methodological Issues

The LA/AIDS framework introduced above provides us with a flexible functional form that performs well on both individual categories and on a larger pooled sample. In addition, the structural equation system provides reasonable fits and parameter estimates for all six categories. Further, the PIGLOG (*Price Independent Generalized LOGarithmic*) form of the LA/AIDS model allows estimation at various levels of aggregation, minimizing the assumptions necessary to avoid linear aggregation bias (Christen, Gupta, Porter, Staelin and Wittink 1997). Specifically, it is easy to demonstrate that any bias in marketing mix response estimates can be eliminated by taking the first difference, provided that *relative* store prices remain the same from one period to the next.<sup>16</sup>

Nonetheless, one needs to be pragmatic about the objectives at hand. The benefits of flexible non-linear forms, such as the LA/AIDS specification, often come at a cost such as analytical intractability. In evaluating the appropriate demand form to use, each of the various tradeoffs should be considered.

Finally, variation from category to category in each of the parameter estimates suggests that while a pooled

analysis might provide estimates of the demand and reaction elasticities that are correct *on average*, they are likely to provide inaccurate estimates of the response for any *specific* category. Although a pooled analysis provides some level of generalizability, the parameter estimates should be viewed as precisely that - general results that may not hold for specific categories. Detailed information on the interaction that occurs for any specific category requires intra-category analysis (Bresnahan 1989).

## 6. Conclusion-Discussion, Limitations and Future Research

Analysis of the IRI data studied here combined with consideration of both demand and supply side influences provide considerably more insight into competitive strategies than do single-equation cross sectional studies. In order to get a more complete view of the strategic implications and in an attempt to produce generalizable results, we have conducted our empirical analysis across a variety of categories and geographic markets.

Based upon the discussion above, there are two main substantive implications:

- *Simultaneity.* Brand managers should expect to face traditional demand relationships regardless of whether they are managing a national brand or a private label - an increase in the price of a national brand (private label) lowers national brand (private label) share. There are no free lunches here - a higher price means a lower share.
- *Horizontal Relationships.* Estimates of residual demand elasticities provide important insights into the marginal impact of pricing decisions. For example, an examination of residual demand elasticities suggests that private labels generally have a more difficult time competing on price than would be implied by unilateral demand elasticities alone. In particular, private labels have an especially difficult time in markets where national brands respond aggressively on price.

More generally, we also find that:

- Both demand and supply-side reactions vary by category. This highlights the importance of understanding the category-specific nature of competition and demand response. Research limited

to one or two categories may not produce sufficient generalizability.

- National brand private label price differential is lower when local retail concentration is high, suggesting that local retail concentration can afford retailers some degree of market power. This may enable retailers with a dominant position in the local market to offset some of the horizontal power afforded national brands.
- Cross price elasticities are decidedly asymmetric with national brand price having a major impact on private label sales, whereas private label price has a considerably smaller impact on branded sales. This is consistent with the work on asymmetric competition and price tiers (Blattberg and Wisniewski 1989; Allenby and Rossi 1991). However, these asymmetries can be reversed (*e.g.*, the bread category), consistent with recent work by Bronnenberg and Wathieu (1996).
- Managers responsible for private labels operating in markets with higher per capita income or categories with a higher level of expenditure will have a more difficult time penetrating the market. More generally, we would expect private labels to suffer during stronger economic times.

The strategic implications for private label brands are numerous. For example, on the demand side (see Table 1), income has the hypothesized impact on both national brand (positive) and private label (negative) share. Further, in terms of price, increases in income benefits national brands most (the coefficient on income is positive and significant in both price reaction equations, but the impact on national brand price is almost twice as large as the impact on private label price). Thus, higher income markets imply a higher national brand share and a larger price premium paid for national brands. While not surprising, this does suggest clearly that higher income markets and stronger economic times represent difficult terrain for private label products. Price is an often used, but not generally effective, tool for private label managers attempting to steal share from national brands in these circumstances.

The results presented above suggest that the effectiveness of any pricing strategy should be viewed within the context of both the residual and unilateral demand elasticities. For example, while traditional (unilateral) measures of demand response for private label products in the margarine category would suggest that

aggressive pricing for private label products would be a successful way to gain share, this would not be the case in practice. Given the aggressive pricing by national brands in this category and the relatively large cross-price response for private labels, such a strategy would be ineffective. In this instance, examination of the residual demand elasticity could be a valuable tool to assist pricing decisions for private label products.

Similar insights can be obtained by examining the impact of wider private label distribution. Increases in private label distribution (see the pooled results in Table 1) has the expected effect of increasing (decreasing) private label (national brand) share. However, higher private label distribution has the unexpected effect of *increasing* national brand price (it has no significant impact on private label price). A closer examination of the data over time suggests that a wider distribution of private label brands appears to push tertiary national brands off the store shelves, thereby increasing both the share of private labels and the price difference between private labels and (the remaining) national brands. However, this varies significantly by category. For example, while increased private label distribution has the effect of increasing national brand price in the pasta category, it has the effect of *decreasing* national brand price in the bread category. This, once again, should not be surprising since the bread category is characterized by a relatively small national brand share and small unilateral demand response. This suggests that increased private label penetration in a fragmented market may only be achieved through aggressive pricing, in effect lowering both private label and national brand price vis-à-vis the intensified price competition. The pasta category, however is characterized by a couple of major national manufacturers, a series of smaller (and lower priced) regional players, and greater price response on the demand side. Thus, a private label strategy of increasing distribution by attacking the small regional players in this category is likely to be effective. It is also likely to result in higher private label share and a larger price differential between national brands and private labels.

The research presented here is not without its limitations. As mentioned earlier, the use of LA/AIDS demands requires tradeoffs in deriving the reaction functions. Future research should examine the implications of the first order approximation in more detail. Further, as pointed out by Genesove and Mullin (1998) and by Cotterill and Putsis (1998), there are a number of implications of the demand functional form chosen for vertical channel relationships. This is consistent with recent theoretical research on channel relationships (Lee

and Staelin 1997). Future research should investigate the vertical implications in more depth. In conclusion, we encourage future research in this area and, in particular, research addressing competitive interaction on a category-by-category basis with the use of disaggregate data.

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**Chart 1. Definitions for Variables Used in the Analysis***(All variables defined for the  $i$ th market,  $j$ th category)**Dependent Variables*

BRSHARE	Aggregate share of category expenditure for branded products
PLSHARE	Aggregate share of category expenditure for private label products
BRPRICE	Natural log of the price of the branded product
PLPRICE	Natural log of the price of the private label product

*Demand Shift Variables ( $E_{ij}$  and  $D_{ij}$ )*

EXPENDITURE	Natural log of per capita category expenditures deflated by Stone's price index
BRDISPLAY	Percent of branded products sold with displays and point-of-sale promotion
PLDISPLAY	Percent of private label products sold with displays and point-of-sale promotion
BRFEATURE	Percent of branded products sold with feature advertising
PLFEATURE	Percent of private label products sold with feature advertising
BRPRICEREDN	Weighted percent average price reduction, branded products
PLPRICEREDN	Weighted percent average price reduction, private label products
INCOME	Natural log of the average household income in the local market
AGE	Natural log of the average age of the local market population
PLDISTN	Private label average distribution (percent of the market's All Commodity Volume (ACV) represented by stores offering a private label in this category).

*Cost Shift Variables ( $C^1_{ij}$  and  $C^2_{ij}$ )*

BRVOLPUN	Natural log of average volume (weight) per package unit sold for the national brand
PLVOLPUN	Natural log of average volume (weight) per package unit sold for private label
GROCCR4	Percentage of all grocery sales by the top four grocery chains
HERFINDAHL	Herfindahl index of brand concentration in the $i$ th market, $j$ th category

Table 1. Estimation Results for Pooled Data: LA/AIDS Model (First Difference)

	Demand Equations		Price Reaction Equations	
	Branded Share	Private Label Share	Branded Price	Private Label Price
BR Price	-0.008 (-2.17)*	0.008 (2.17)*		0.077 (8.55)**
PL Price	0.009 (2.74)**	-0.009 (-2.74)**	0.075 (15.05)**	
BR Price Reduction			-0.106 (-6.34)**	
PL Price Reduction				-0.222 (-12.46)**
BR Volume/Unit			-0.870 (-153.8)**	
PL Volume/Unit				-0.909 (-128.8)**
HHI			-0.002 (-0.21)	-0.049 (-2.95)**
Grocery CR4			0.028 (2.14)*	0.057 (3.11)**
Expenditure	0.054 (15.68)**	-0.054 (-15.68)**	0.229 (38.13)**	0.131 (15.43)**
Br Feature	0.113 (6.49)**	-0.113 (-6.49)**	-0.238 (-8.06)**	-0.015 (-0.36)
Br Display	0.158 (13.38)**	-0.158 (-13.38)**	-0.448 (-22.60)**	-0.046 (-1.58)
PL Feature	-0.024 (-2.28)*	0.024 (2.28)*	0.010 (0.58)	-0.173 (-6.69)**
PL Display	-0.087 (-12.51)**	0.087 (12.51)**	-0.006 (-0.53)	-0.268 (-15.84)**
PL Distribution	-0.188 (-36.24)**	0.188 (36.24)**	0.047 (5.35)	-0.020 (-1.56)
Income	0.021 (3.32)**	-0.021 (-3.31)**	0.113 (10.32)**	0.040 (2.54)*
Age	-0.014 (-0.979)	0.014 (0.979)	-0.161 (-6.45)**	-0.094 (-2.67)**

BR = National Brand, PL = Private Label

Number of Observations = 6717

t-statistics in parentheses

\*\* significant at the 1% level. \* significant at the 5% level

Table 2. Estimated Demand Elasticities for Pooled Data:

LA/AIDS Model (First Difference)

	Branded Quantity	Private Label Quantity
BR Price	-1.065 (-173.52)**	0.225 (10.62)**
PL Price	-0.0046 (-1.078)	-0.984 (-67.06)**
Expenditure	1.070 (239.00)**	0.758 (48.99)**
BR Feature	0.009 (6.49)**	-0.031 (-6.49)**
BR Display	0.023 (13.38)**	-0.078 (-13.38)**
PL Feature	-0.002 (-2.28)*	0.006 (2.28)**
PL Display	-0.013 (-12.51)**	0.045 (12.51)**
PL Distribution	-0.190 (-36.24)**	0.656 (36.24)**
Income	0.699e-06 (3.32)**	-0.241e-05 (3.32)**
Age	-0.0005 (-0.978)	0.002 (0.978)

BR = National Brand, PL = Private Label

t-statistics in parentheses

\*\* significant at the 1% level. \* significant at the 5% level

Table 3. Demand and Reaction Elasticities for Subsets Sorted by Private Label Share: LA/AIDS Model (First Difference)

Quartile (Private Label Market Share)	Low Quartile (0 – 11.1%)	Mid Low Quartile (11.2 - 23.1%)	Mid High Quartile (23.2 - 39.9%)	High Quartile (> 39.9%)
BR Own Price Elasticity	-1.034 (-201.0)**	-1.049 (-145.7)**	-1.110 (-84.05)**	-1.154 (-35.72)**
PL Own Price Elasticity	-0.983 (-19.22)**	-0.837 (-20.18)**	-1.081 (-22.77)**	-1.156 (-19.84)**
BR Demand Cross Price Elasticity	-0.001 (-0.328)	-0.023 (-3.93)**	0.025 (1.70)	0.147 (2.68)**
PL Demand Cross Price Elasticity	0.676 (6.51)**	0.341 (6.80)**	0.351 (8.25)**	0.163 (4.76)**
BR Price Reaction Elasticity	0.070 (9.10)**	0.092 (8.93)**	0.068 (4.03)**	0.195 (6.48)**
PL Price Reaction Elasticity	0.172 (7.24)**	0.047 (3.17)**	0.048 (2.91)**	0.113 (6.33)**
NOBS	1680	1679	1681	1678

BR = National Brand, PL = Private Label

(t-statistics in parentheses)

\*\* significant at the 1% level. \* significant at the 5% level

Table 4. Demand and Reaction Elasticities for Individual Product Categories: LA/AIDS Model

	Milk	Butter	Bread	Pasta	Margarine	Inst. Coffee
BR Own Price Elasticity	-2.05 (-4.45)**	-1.50 (-2.89)**	-1.31 (-6.73)**	-1.46 (-14.53)**	-1.39 (-14.43)**	-1.03 (-58.42)**
PL Own Price Elasticity	-0.942 (-2.44)*	-2.49 (-3.95)**	-0.795 (-2.02)*	-3.66 (-3.96)**	-6.38 (-6.24)**	-0.374 (-1.45)
BR Cross Price Elasticity	-0.120 (-0.152)	1.07 (2.37)**	-0.072 (-0.520)	0.419 (2.88)**	0.525 (5.26)**	-0.030 (-2.42)**
PL Cross Price Elasticity	0.510 (2.28)**	0.700 (0.968)	0.624 (2.11)*	2.94 (4.60)**	3.96 (4.02)**	0.569 (1.56)
BR Price Reaction Elasticity	0.125 (0.846)	0.415 (3.02)**	0.093 (0.722)	0.517 (2.11)*	1.50 (2.11)*	0.106 (2.19)*
PL Price Reaction Elasticity	0.208 (2.30)*	0.497 (1.39)	0.187 (0.926)	0.218 (0.776)	0.893 (2.94)**	0.088 (0.829)
Average BR Share	.30	.54	.62	.81	.84	.94
# Observations	116	112	118	118	118	108

BR = National Brand, PL = Private Label

(t-statistics in parentheses)

\*\* significant at the 1% level. \* significant at the 5% level

Table 5. Unilateral and Residual Demand Elasticities for Individual Product Categories, LA/AIDS Model

	Milk	Butter	Bread	Pasta	Margarine	Inst. Coffee
BR Unilateral Elasticity	-2.05 (-4.45)**	-1.50 (-2.89)**	-1.31 (-6.73)**	-1.46 (-14.53)**	-1.39 (-14.43)	-1.03 (-58.42)
BR Residual Elasticity	-2.07 (-4.97)**	-0.971 (-1.99)*	-1.32 (-7.12)**	-1.37 (-9.61)**	-0.917 (-6.35)**	-1.03 (-62.97)**
PL Unilateral Elasticity	-0.942 (-2.44)*	-2.49 (-3.95)**	-0.795 (-2.02)*	-3.66 (-3.96)**	-6.38 (-6.24)**	-0.374 (-1.45)
PL Residual Elasticity	-0.878 (-2.45)*	-2.20 (-5.04)**	-0.737 (-2.04)*	-2.14 (-2.91)**	-0.438 (-8.07)**	-0.314 (-1.30)

BR = National Brand, PL = Private Label

(t-statistics in parentheses)

\*\* significant at the 1% level. \* significant at the 5% level

## Appendix – Selected Key Variables and Expected Results

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	<i>Variable (Equation)</i>	<i>Expected Effect/Rationale</i>
<b>H1:</b>	BRPRICE, PLPRICE (Demand)	Standard economic theory predicts negative own-price elasticities and positive cross-price elasticities for substitute goods. Further, effects should be asymmetric (Tellis 1988; Blattberg and Wisniewski 1989, Allenby and Rossi 1991).
<b>H2:</b>	BRDISPLAY, PLDISPLAY, BRFEATURE, PLFEATURE, BRPRICEREDN, PLPRICEREDN (Demand)	Increased own promotions have a positive impact on own sales, and a negative impact on rival's sales (Blattberg and Neslin 1990).
<b>H3:</b>	INCOME (Demand)	As per capita income in a market increases, we expect that branded share increases and private label share decreases (Hoch and Banerji 1993).
<b>H4:</b>	PLDISTN (Demand, Price)	As more supermarkets in a local market carry private labels, the share and price of national brands decrease (due to the increased competition), while the share and price of private labels increase due to the increased availability of private label products and the increase in competition.
<b>H5:</b>	BRPRICE, PLPRICE (Price)	The slope of the price reaction curves are positive (Deneckere and Davidson 1985).
<b>H6:</b>	BRVOLPUN, PLVOLPUN (Price)	Increasing average package size lowers cost, thereby lowering market price.
<b>H7:</b>	GROCCR4 (Price)	Increases in grocery firm local market concentration increase prices due to higher margins resulting from increased market power at the retail level (Marion 1979, Cotterill 1986).

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Food Marketing Policy Center  
1376 Storrs Road, U-21  
University of Connecticut  
Storrs, CT 06269-4021

Tel: (860) 486-1927  
FAX: (860) 486-2461  
email: [fmpc@canr1.cag.uconn.edu](mailto:fmpc@canr1.cag.uconn.edu)  
<http://vm.uconn.edu/~wwware/fmktc.html>