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Empirical Analysis of Competitive Interaction
In Food Product Categories

By William P. Putsis, Jr.

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Abstract

This paper provides an overview of recent research on estimating competitive interaction in food product categories. In particular, the focus of this review is on research using scanner data conducted at the disaggregate (*e.g.*, store, chain or local market) level, including empirical studies of vertical (*i.e.*, within-channel) conduct. Studies addressing the competitive interaction on price, as well as non-price variables (*e.g.*, in-store display and feature advertising) are considered.

The author first describes the methodologies available for measuring the competitive interaction between firms and then briefly summarizes recent empirical developments. Given the complexity of the interactions that take place in practice, it is argued that much of the richness of actual competitive behavior is lost in aggregate analysis. Competitive interaction is the result of a complex set of variables and influences–demand side factors, market and industry structure, firm "personality," and category characteristics all interact in a complex fashion to determine strategic behavior of retailers and manufacturers.

Keywords: Competition, Competitive Strategy, Channel Behavior

1. Introduction

A central characteristic of competition is that firms are mutually dependent–the outcome of an action by one firm depends to some extent on the reaction of its competitors. To further complicate matters, the game being played between firms within a strategic group may be very different from a game being played across strategic groups. For example, Coke and Pepsi may cooperate with each other when it comes to determining their promotion schedules but compete fiercely with any marketing response from a member outside the strategic group (*e.g.*, a private label).[1] Further still, both vertical and horizontal elements of conduct play important roles–not only can channel behavior significantly affect market equilibria, but seemingly innocuous assumptions on retail level demands can implicitly place rather restrictive assumptions on the types of conduct permitted (Genesove and Mullin 1998, Cotterill, Putsis and Dhar 1998, Lee and Staelin 1997).

Despite the fact that much of the "action" in many product categories occurs between individual market players and/or at the local market level, much of the recent empirical IO research has been conducted at the aggregate level. For example, using a New Empirical Industrial Organization (NEIO) framework, Gasmi, Laffont and Vuong (1992) and Gasmi and Vuong (1991) examine collusive behavior in the soft drink market over the period 1968-1986 employing quarterly data aggregated at the national level. Genesove and Mullin (1998) examine market power in the sugar industry 1890-1914 using aggregate U.S. data. Bhuyan and Lopez (1997) take a similar approach in examining oligopoly power in forty food and tobacco categories at the national four-digit SIC level.

In this review, we argue that understanding and assessing the competitive interaction that exists in the marketplace requires careful attention to the interaction that occurs at the disaggregate level (*e.g.*, between individual food manufacturers, between individual retailers selling national brands and private labels, and between the retailers and food manufacturers within the channel). While there may be value in understanding "average" overall industry conduct using national data, there are severe limitations of such an approach. For example, analysis conducted at the national level can miss much of the richness of the interaction that occurs between individual market players discussed above. In addition, recent work has demonstrated that the biases associated with measuring market response using data aggregated at the national level can be severe (Christen, *et al.* 1997). Further, this is exacerbated by the use of linear demand schedules in many NEIO studies (see, *e.g.*, Genesove and Mullin 1998, Cotterill, Putsis and Dhar 1998). Today, scanner data at the firm, chain level and local market level are widely available. These data generally contain very detailed information on retail marketing decisions, market structure characteristics and local market demographics, often broken down by individual store or chain. Further, the availability of wholesale price data, which can aid in the attribution of market power between channel members (see, *e.g.*, Kadiyali, Chintagunta and Vilcassim 1998), is becoming more common. Recent studies have used scanner data to infer within channel conduct with (Kadiyali, Chintagunta and Vilcassim 1998) and without (Cotterill, Putsis and Dhar 1998) wholesale price data.

In most instances, observed market conduct and the source of market power (*e.g.*, manufacturer versus retailer) can be an important consideration managerially. While it may be interesting to know, for example, that market power in an industry has grown over the past 25 years, this finding in and of itself has little managerial relevance. Since the outcome of a firm's action depends at least partly upon the behavior of its rivals, it is important for firms to understand the nature of the game being played, not just the aggregate market outcome. In the extreme, failure to account for these differences can call into question the validity of results obtained by aggregating across market players.

Although competitive response can be understood along several different dimensions (*e.g.*, Ramaswamy, Gatignon, and Reibstein 1994; Bowman and Gatignon 1996), an important first step in this direction requires an understanding about the *type* of interaction that actually occurs. Thus, the objectives of this paper are simple ones –to *describe* the methodologies available for the empirical estimation of competition and to summarize recent developments assessing the types of competitive interaction that exists in the market. In particular, our focus is on the direction of the reaction in practice–is it a retaliatory move, accommodating in nature, or leader-follower in nature? In doing so, this work relies heavily on two recent papers by this author (Putsis and Dhar 1998a, Cotterill, Putsis and Dhar 1998).

1. Spiller and Favaro (1984) make a similar argument, distinguishing across two groups, one a "dominant" and the other a "fringe" group.

The paper proceeds as follows. First, we describe the methodologies available for estimating competitive interaction. Next, we focus on recent developments in estimating competitive interaction–a reaction function approach based on LA/AIDS demands (Cotterill, Putsis and Dhar 1998) and conjectural variations approaches (Kadiyali, Chintagunta and Vilcassim 1998, Kadiyali, Vilcassim and Chintagunta 1998, Putsis and Dhar 1998a, 1998b). We also discuss recent developments concerning demand functional form and vertical versus horizontal conduct. The paper concludes with suggestions for future research.

2. Estimating Competitive Interaction

Previous theoretical research on competition has typically employed non-cooperative game theory under Nash equilibrium (*e.g.*, Lal 1990, Raju, Srinivasan and Lal 1990). In such models, the form of competitive interaction between firms is assumed (*e.g.*, Stackelberg leader-follower behavior in Raju, Sethuraman and Dhar 1995 and Narasimhan and Wilcox 1998). While the assumptions of firm interaction in theoretical models of competition are reasonable, there is limited empirical evidence regarding the type of competitive interaction that actually occurs between firms in the marketplace. Empirical research assessing competitive interaction, which did not even begin until the late 1970's and early 1980's (*e.g.*, Gollop and Roberts 1979, Bresnahan 1981; see Bresnahan 1989), suggests that there is significant variation in the competitive interaction observed across categories and marketing mix instruments (Slade 1995). For example, Roberts and Samuelson (1988) find that cigarette advertising is cooperative, while Gasmi, Laffont and Vuong (1992) reject cooperative behavior in the soft-drink market. Slade (1995) finds that advertising in the market for saltine crackers lies somewhere between the two.

Empirical estimation of competitive interaction entails some simplifications of the games being played and or the players involved in the game. For example, we can specify a n-firm game across multiple strategic decision variables and we can often solve for closed form solutions for decision variables. However, identifying such a game empirically is another matter. Consequently, one way of simplifying empirical analysis entails examining only two firms in a market. In the case where the market can be represented reasonably well by a duopoly (*e.g.*, Coke versus Pepsi in Gasmi, Laffont and Vuong 1992), such a simplification is reasonable. However, very few markets can be appropriately characterized as a duopoly. Focusing on only two firms in an oligopoly or in a monopolistically competitive industry is often inappropriate since it necessary entails assuming that the reactions and/or conjectures of all other firms are zero. One way of resolving this issue is to distinguish between how firms compete between versus across strategic groups in an industry (Spiller and Favaro 1984, Porter 1985, Putsis and Dhar 1998a, 1998b). For example, competition between national "branded" and store "private label" products has increased dramatically in recent years. Market leaders like Procter & Gamble and Eastman Kodak have decreased prices and altered promotional strategies in response to increased private label penetration in their markets (*Business Week*, May 2, 1994). Similarly, firms within a strategic group (*e.g.*, two national brands) can also compete fiercely with each other.

Previous research assessing the competitive interaction between firms has essentially taken on four forms: non-nested model comparisons, conjectural variation approaches, reaction function and time-series causal approaches. Non-nested model comparisons entail deriving equilibrium conditions under the *assumption* of a certain type of firm behavior (*e.g.*, Nash or Stackelberg). Using non-nested hypothesis tests of the type introduced by Vuong (1989), the objective is to test which form of non-cooperative behavior best fits the data (since the equilibrium conditions are typically non-nested, non-nested hypotheses tests are needed). Examples of research of this type include Gasmi and Vuong (1991), Gasmi, Laffont and Vuong (1992) and Kadiyali, Vilcassim and Chintagunta (1996). Since a researcher infers firm behavior based upon the choice of which form of interaction fits the data best from a menu of competing possibilities, this approach is often referred to as the "menu approach."

By contrast, the conjectural variations approach treats firm conduct as a continuous parameter to be estimated (see, *e.g.*, Bresnahan 1989 and Kadiyali, Vilcassim and Chintagunta 1998, Putsis and Dhar 1998a, 1998b). Based on early work by Iwata (1974), and more recent work by Gollop and Roberts (1979), Spiller and Favaro (1984) and Gelfand and Spiller (1987), this approach entails the estimation of a conjectural variation or "*conduct*" parameter, which essentially measures deviation from Nash behavior.[2] That is, if both firms in a

2 . Note that Nash behavior is typically *defined* by the absence of a competitive response. For example, Nash-Bertrand behavior implies the absence of a price response.

duopoly have estimated conduct parameters equal to zero, then Nash (or "independent") behavior is inferred. If only one firm had an estimated conduct parameter greater than zero, then a leader-follower relationship is inferred (we present a typology of interaction below). An advantage of this approach is that it does not assume a specific type of market interaction, rather it allows the research to let the data describe the market interaction (via the estimated conduct parameter). In addition, marginal costs and price-cost margins are estimated directly from the data. Since this approach entails the simultaneous estimation of the first order conditions directly, it is not identical to estimating each firm's reaction function. Kadiyali, Vilcassim and Chintagunta (1998) provide a useful discussion regarding the interpretation of the conduct parameters, while Gasmi, Laffont, and Vuong (1992) employ both non-nested model comparisons and a conjectural variation approach. The interested reader may also want to look at the classic papers by Iwata (1974) and Bresnahan (1989).

Reaction function approaches of the sort used in Cotterill, Putsis and Dhar (1998) 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. This provides a researcher with a functional form specification based upon each player's "best response" given certain assumptions about 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.[3] As with a CV approach, marginal costs and price cost margins can be estimated directly from the data.

Time series causal approaches employ time series data and causality tests such as Granger causality to infer causality in interaction. The intuition is simple: if firm two reacts to changes in firm one's marketing actions, then firm two's reaction will be observed after firm one's behavior. These time-sequenced sets of events imply that firm one is the leader and firm two the follower. Leeflang and Wittink (1992) use causality tests to infer firm reactions across marketing instruments. One potentially valuable use of causality tests is in inferring and confirming leader-follower relationships estimated by either a menu or a conjectural variations approach. An example of a recent study employing Granger causality is work by Raju and Hanssens (1994). Hanssens, *et al.*, (1990, Chapter 5) present an excellent overview of causality tests.

3. Possible Forms of Competitive Interaction

Previous research has attempted to classify or categorize competitive interaction. For example, Raju and Roy (1997) define three forms of competitive interaction: independent (Nash), leader-follower (Stackelberg) and collusive. Under *independent* behavior, each player takes its rival's strategic actions as given and acts to maximize its own profits. Under *leader-follower* behavior, one firm acts as the leader (*i.e.*, it does not react to it's rival's actions), while its rival follows changes in the leader's strategic behavior. Under *collusive* behavior, firms act to maximize joint profits. Kadiyali, Vilcassim and Chintagunta (1998) characterize competitive pricing behavior according to *Nash* (independent), *cooperative* (positive conduct parameters, *i.e.*, both firm's pricing actions move together) and *competitive* behavior (negative conduct parameters). Ramaswamy, Gatignon, and Reibstein (1994) recognized an inherent asymmetry in the inferred interactions: while simultaneous price *increases* might be evidence of coordinated behavior, simultaneous price *cuts* might be indicative of "retaliatory" behavior.

We build on this research and divide competitive interaction into patterns that are symmetric versus those that are asymmetric.[4] In doing so, we expand on much of the previous research that has primarily addressed price interaction by considering both price and non-price (*e.g.*, in-store display and feature advertising). Further, we differentiate between "regular" price versus "temporary" price reductions. These are important distinctions since, as we will see shortly, there is likely to be significant

We will generally use the term "independent" in this paper, although Nash and independent can be used interchangeably in this context (as in Raju and Roy 1997).

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).

4. In our attempt to categorize competitive interaction below, we have tried to be as descriptive as possible, while also following previous research (*e.g.*, Ramaswamy, Gatignon, and Reibstein 1994, Raju and Roy 1997, Kadiyali, Vilcassim and Chintagunta 1998). Note that non-cooperative interaction can be consistent with both the "retaliatory" and "cooperative" behavior suggested by Ramaswamy, Gatignon, and Reibstein (1994).

variation in the type of competitive interaction observed across marketing mix variables.

For illustration, imagine a differentiated duopoly, with each firm producing one product and facing strategic promotion decisions. Symmetric interaction implies both firms respond to actions by its rival in a similar fashion. For example, *cooperative* promotions imply that promotional decisions are made in a coordinated fashion – if one firm increases its promotional intensity, the other *cuts* its promotional intensity to accommodate. Examples of this type of interaction might include the famed Coke-Pepsi alternating promotions. Alternatively, *non-cooperative* promotions imply that an increase (decrease) in the promotional intensity of one firm is met by an increase (decrease) in the promotional intensity of its rival. Two firms competing for end of year market share via extensive coupon drops would constitute non-cooperative behavior.[5] Finally, note that a lack of a response by both rivals is also symmetric. Thus, we will include a third form of symmetric behavior, *independent* (sometimes referred to as Nash), which implies a lack of response by both rivals. Independent behavior might be expected, for example, in markets where demand substitutability is weak. Here, since there is little or no cross-promotion response, the competitive response is also likely to be quite small.

We also consider two forms of asymmetric behavior. *Leader-follower* (Stackelberg) behavior implies that one firm reacts to changes in it's rival's actions (the "follower"), while the other (the "leader") does not. Often, private labels are thought to follow national brands' marketing efforts, although we allow for private labels to be a leader as well as a follower below. The final form of interaction allows for the case where two firm's competitive strategies may be opposite in direction, *i.e.*, where one firm behaves cooperatively, while the other competes in a non-cooperative fashion. For example, one firm may simply follow the actions of a stronger rival. A weaker, or "fringe" firm, may simply not be willing to take the dominant firm on directly, hence accommodating its larger rival's promotional efforts. However, firms with a "dominant" share position might fiercely defend its market position, taking on a non-cooperative stance. We will refer to this form of interaction as "*dominant/fringe-firm*" behavior (Spiller and Favaro 1984).

Let us define things a bit more formally. Imagine that the two firms in this duopoly have multiple marketing instruments at their disposal: regular price (P_1 and P_2), temporary price reductions (γ_1 and γ_2), and non-price promotions (*e.g.*, feature and/or display, denoted by μ_1 and μ_2). Quantities are represented by Q_1 and Q_2, respectively. We will denote the competitive response of firm 1 to a change in firm 2's actions by the relevant partial derivative. For example, $\partial\gamma_1 / \partial\gamma_2$ denotes the response of firm 1 to firm 2's temporary price reduction. Although cross-promotion response is certainly possible (Leeflang and Wittink 1992), we focus on like-instrument response here in the interest of parsimony. We also note that cooperative price promotion, for example, does not necessarily imply cooperative non-price promotions. In practice, it may often be the case that firms compete vigorously on price (for example), but accommodate changes in the feature advertising of their rivals. Table 1 details the categorization discussed above in the context of the conduct parameters to be estimated. Note that since temporary price reductions are expressed as an average price *reduction*, the signs for this variable in Table 1 are opposite that of regular (non-deal) price.

Using this characterization, it is possible to begin to put together a more complete picture of strategic response using promotion response as an example. Given a firm's decision to promote, competitive behavior and demand interacts as depicted in Figure 1. On the consumer side, issues such as cross-category effects, the ability to stockpile a promoted item for future use, and how salient the item is all influence the demand response. In addition, the firm's rivals will likely respond according to one of the responses characterized above. It is only after the demand and supply side responses are put together that we can get a complete picture of market behavior. The key empirically is to be able to identify and estimate each separately. The focus of much of the work discussed in this review is to do precisely this.

4. Assessing Competitive Interaction–Research to Date

So, given this discussion of models of strategic interaction, what do we currently know about the nature of competition between firms? Recent research suggests that there is significant variation in the competitive interaction observed across categories (Slade 1995) and across marketing mix instruments (*e.g.* price versus in-

5. We note that for price decisions, these definitions will be reversed. That is, *cooperative* pricing implies that prices rise and fall together, while *non-cooperative* pricing implies that they move in opposite directions. Also, note that each form of symmetric interaction is symmetric in direction, but not necessarily in magnitude.

store displays). For example, Roberts and Samuelson (1988) find that cigarette advertising is cooperative, while Gasmi, Laffont and Vuong (1992) reject cooperative pricing in the market for soft drinks. Kadiyali, Vilcassim and Chintagunta (1996) find Stackelberg leader-follower pricing in laundry detergent.

Putsis and Dhar (1998a) studied the competitive interaction between private label (*e.g.*, store brands) and national brand grocery products across 58 product categories. Scanner data was used from grocery retailers in the United States. The coverage included 59 geographic market in the United States in 1992. Employing a conjectural variations approach, each product category was categorized into the five distinct forms of competitive interaction discussed above for each of four marketing mix variables (regular price, temporary price reductions, display and feature advertising). The Appendix presents the model used in the approach, including the set of first order conditions that gave rise to the estimated CV parameters.

Table 2 summarizes the results originally reported by Putsis and Dhar (1998a). A look at the table reveals that there are significant differences across categories and across promotional instruments, which is consistent with the broader literature. At least with respect to the competitive interaction between private labels and national brands, the results in Table 2 suggests that national brand leadership is indeed the most common form of interaction for each marketing mix variable. However, it characterizes only 19 out of 58 categories for regular price, and 16, 19, and 15 out of 58 categories for temporary price reduction, feature and display, respectively. In fact, private label price leadership characterized three categories (milk, frozen plain vegetables and fresh breads) and 6, 1 and 7 categories, respectively for temporary price reduction, feature and display. Not surprisingly, a number of categories (16) were characterized by non-cooperative price interaction. Aggregating across the four marketing mix variables, national brand leadership was the most common form of interaction (69 observations), independent behavior the next most common (42), followed by non-cooperative interaction (40), dominant-fringe firm relationships (37), cooperative interaction (27) and private label leadership (17), respectively.

Contrasting with this broader analysis, other research has focused on a single individual category in detail. For example, Kadiyali, Vilcassim and Chintagunta (1998) use a NEIO framework to investigate the impact of a line extension in the yogurt category. Specifically, they employ store-level scanner data on weekly sales in the yogurt category over 155 weeks. In the 59th week of observation, Yoplait introduced a line extension, Yoplait Lite. Using a simultaneous system of demand and supply (cost) and a conjectural variations approach, they examine the competitive interaction between the two dominant players in the market, Yoplait and Dannon. They find that in both the pre- and post-extension situation, the observed pricing interaction is “softer” than implied by one-shot Bertrand-Nash behavior. Prior to the line extension, Dannon and Yoplait price cooperatively with one another, resulting in price-cost margins higher than those that would be implied by Bertrand-Nash pricing. Dannon was estimated to have a lower price-cost margin that Yoplait, but was less “vulnerable” to Yoplait pricing than was Yoplait to Dannon (based on the cross-price demand elasticities). Providing both demand and cost-based explanations for the shift, Kadiyali, Vilcassim and Chintagunta find that the introduction of the line extension shifts power to the parent brand, Yoplait. Post-extension, Yoplait’s pricing is non-cooperative. This is consistent with the findings of Narasimhan and Wilcox (1998), who find that private label introductions can have similar impact on the within-channel power of retailers. Such dynamics could only be uncovered by disaggregate analysis of this type.

Essentially all of the previous research assessing competitive interaction (including Kadiyali, Vilcassim and Chintagunta 1998) has assumed linear demands due to the lack of closed form solutions using non-linear functional forms (see Besanko, Gupta and Jain 1998 for a notable exception). One exception to this is the use of the flexible non-linear LA/AIDS form incorporated by Cotterill, Putsis and Dhar (1998). Using a reaction function approach, Cotterill, Putsis and Dhar (1998) assess both horizontal and vertical interaction between private label and national brands. Specifically, begin by presenting the general LA/AIDS demand specification and then derive the associated reaction functions. The general LA/AIDS functional form, originally introduced by Deaton and Muellbauer (1980), is given by equation (1):

$$S^{1}_{ij}=a_{10}+a_{11}\, lnP^{1}_{ij}+a_{12}\, lnP^{2}_{ij} + a_{13}\, ln(E_{ij})+a_{14}D_{ij} \quad \mathbf{(1)}$$

Where, for category i and market j:

S^{1}_{ij} = dollar market share of the national brand,

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

P^{2}_{ij} = 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 $S^1_{ij} \ln P^1_{ij} + S^2_{ij} \ln P^2_{ij}$,

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

From the basic formulation in (1), the usual demand restrictions, symmetry, homogeneity, and adding up can be imposed. Further, all relevant demand elasticities can be recovered from the demand specification.

On the supply side, employing LA/AIDS demands as in equation (1), they solve the first order conditions for P^1 and P^2, respectively, using a Taylor series expansion to obtain a linear approximate retail reaction function that allows empirical analysis. This produced the following price reaction function for the national brand manufacturer:

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

where C_{ij} denotes a vector of brand-level cost-shift variables. The corresponding functional form for estimation of the private label reaction function is:

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

The price reaction elasticity for national brands, b_{11} in equation 5, gives the percent change in brand price for a one percent change in private label price.

Using this framework, Cotterill, Putsis and Dhar (1998) explore the strategic implications of the non-linear demand specification for both vertical and horizontal interaction, focusing on the competitive interaction between private label and national brands. A series of intra-category analyses were conducted using scanner data on six individual categories: bread, milk, pasta, instant coffee, butter and margarine. In an attempt to generalize the results to a broader set of categories, they also estimated the system (1) through (3) above using a sample pooled across 125 categories and 59 geographic markets.

Central to the objective of this review, two main results were obtained. First, estimates of residual or "total" demand elasticities[6] provided information about *horizontal* pricing interaction. Their analysis suggests that examination of partial or "unilateral" demand elasticities alone provide an incomplete picture of the ability of brands to raise price since the *ceteris paribus* assumption inherent in partial demand elasticities is typically violated–rivals often respond to a firm's price change. Cotterill, Putsis and Dhar (1998) observed substantial variation in the residual and unilateral demand elasticities across categories. In general, the residual elasticity was estimated to be lower (in absolute value) than the unilateral elasticity. In the butter category for example, the estimated elastic unilateral demand elasticity (-1.50) for national brands translated into a mildly inelastic residual elasticity (-0.971). This difference was due to the fact that national brand demand was sensitive to private label price (which followed national brand price closely). For other categories, the difference was even more dramatic. Thus, an individual firm's pricing power depends not only upon demand response, but upon competitive response as well. Second, employing a non-linear flexible functional form provided substantive information on *vertical* strategic behavior since it allows for flexible strategic vertical conduct. For example, the residual elasticity estimates were used to examine private label and national brand passthrough rates–the percent of wholesale price changes that are passed on to the consumer by the retailer. While the estimated national brand passthrough exceeded 100% for five of the six categories (bread, pasta, coffee, butter and milk categories), private label passthrough exceeds 100% for only three categories (coffee, butter and margarine).[7]

6. Following Baker and Bresnahan (1985) 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 η_{11} denotes the (own) "partial" (or "unilateral") demand elasticity, η_{12} denotes the cross-price demand elasticity of demand (both estimated directly from the demand equation), and ξ_{21} denotes the price reaction elasticity (estimated directly from the reaction functions). See also Cotterill (1994) and Werden (1998).

7. We define passthrough in terms of *regular* price as opposed to temporary price reductions, which is more common in the marketing literature. Tellis and Zufryden (1995) and Messenger and Narasimhan (1995) report average retail mark-ups of approximately 25%, which would result in a passthrough rate of 125% as we define it below. Although we estimate the *marginal* passthrough rate of wholesale price changes, we note that marginal passthrough rates of less than 100% can not continue *ad infinitum* since average passthrough rate of less than 100% implies a *negative* price-cost margin. The framework could also easily be extended to estimate trade deal passthrough rates using only retail data. In the case of trade deals, Armstrong (1991) noted that when a retailer does pass a trade discount on to the consumer, it

Once again, these insights could only be obtained by a more disaggregate analysis of the type used here.

5. Demand Functional Form and Aggregation Biases

Thus, empirical analysis suggests that the functional form of the demand equation can potentially play an important role in not only assessing demand response, but vertical and horizontal competitive response as well. This is supported by previous theoretical research that has demonstrated that the form of the demand function has implications for vertical channel behavior. For example, Lee and Staelin (1997) show that "the type of vertical strategic interaction present in a given environment is closely related with the convexity of the demand curve and the level of demand for a given price" (p. 185).

In an empirical IO framework, Genesove and Mullin (1998) note that the linear demands used in prior empirical studies impose strong assumptions on the relationship between retail price and marginal cost. For example, specifying linear demands and constant manufacturer marginal costs under Manufacturer Stackelberg conduct in a monopolistic retail environment (*e.g.*, Choi 1991) implies that exactly 50% of any wholesale price increase is *always* passed through to the consumer by the retailer. More generally, the passthrough rate under linear demands is *always less than 100%* (Harris and Sullivan 1979) regardless of the type of retail competition that exists. The requirement that less than 100% of wholesale price changes (in the linear case) are passed on to the consumer appears to be at odds with actual behavior within the channel and may be overly restrictive. Flexible passthrough rates (which can vary from less than zero to over 100%) exist only for a class of flexible non-constant elasticity demand curves, which includes the LA/AIDS model (Cotterill, Buckhold and Egan 1999). Ideally, one would like to specify a demand functional form that does not restrict retailer's pricing actions to *estimate* the change in retail price that results from wholesale price changes (Cotterill 1998). Clearly, the linear form, used in much of the NEIO work, is not ideal in this regard.

In addition, aggregate analysis suffers from another potentially serious problem. Christen, Gupta, Porter, Staelin and Wittink (1997), using analytic, empirical, and numerical analysis, demonstrate that the estimated demand response from linearly aggregated market-level or national data differ substantially from comparable effects obtained from store-level data. That is, not only do national data provide for biased estimates of the store (or disaggregate) level response, even aggregate models applied to aggregate data provide biased estimates of the *aggregate* response. Further, the bias can be severe– price elasticity estimates using simulated market level data were estimated to be as much as 1232% of the true underlying response. The reason for this is analogous to the temporal aggregation bias discussed in detail in Putsis (1996). In essence, aggregate data are obtained by linearly aggregating disaggregate data. Thus, if the underlying demand response is non-linear then there is a fundamental difference between the demand function evaluated at some "average" level of price and the average of individual demands evaluated at the actual price paid at retail. Through similar rationale, if all consumers faced equal prices, then the bias would be zero. As a result, the general line of reasoning for researchers addressing scanner data is that data aggregated to the chain level is likely to be relatively free of the bias (since prices faced by consumers across different stores within the same chain tend to be the same).

However, certain empirical approaches can minimize the potential for such a bias. For example, the PIGLOG form of the LA/AIDS model allows estimation at various levels of aggregation, minimizing the assumptions necessary to avoid linear aggregation bias (Christen, *et al*. 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.[8] Further, Christen, *et al.* (1997) suggest a debiasing procedure that can be applied to aggregate data. Nonetheless, such methods are not easy to implement in practice and little empirical work has been

generally passes on more than 100% of the deal. Linear demands do not allow for this possibility.

8. This can be shown quite easily. Under a first difference model, all variables are expressed as the change from period t to t+1. Since the marketing mix response in a LA/AIDS specification is log-log in share, first differencing expresses prices, for example, as the log of the ratio of prices in t and t-1. As long as the *relative* prices move together, the ratio of the prices is constant. Thus, if the percent *change* in prices is the same from store to store, the bias is eliminated (this is analogous to homogeneous marketing mix variables in the Christen, et al. 1996 paper). Thus, it is not necessary that all consumers at all stores face the same prices. We would argue that assuming that the relative prices remain the same from one period to the next is more tenable than assuming that all stores have the same prices.

conducted to see how well the bias is actually removed.

6. Assessing Within-Channel Interactions

Given the implications of demand form for the implied vertical conduct, some recent research has attempted to assess vertical conduct empirically. Cotterill and Putsis (1998), in an initial attempt to examine some of the assumptions made in previous theoretical research (*e.g.*, Jeuland and Shugan 1983, McGuire and Staelin 1983, Choi 1991, Raju, Sethuraman and Dhar 1995), empirically examine the vertical channel assumptions made in two well-cited models of retailer-manufacturer interaction: a) the Choi (1991) Manufacturer-Stackelberg (MS) model, and b) the Raju, Sethuraman and Dhar (1995) Stackelberg model addressing store brands.

Specifically, empirical tests were developed for Manufacturer Stackelberg conduct and the use of proportional mark-up rules within the channel. Their empirical results generally support the assumptions of proportional mark-up behavior by retailers and Manufacturer Stackelberg conduct within the channel. In addition, since the Choi (1991) and Raju, *et al*. (1995) models assumed relatively simple linear demand structures, Cotterill and Putsis (1998) then examined how well these linear demands characterize actual market behavior by comparing them to a flexible non-linear form, the LA/AIDS model. Using non-nested hypothesis tests, linear demands were rejected in a favor of a more flexible non-linear form. When combined with the analytical work of Lee and Staelin (1997), this suggests that additional theoretical and empirical work is needed in order to fully understand the implications of using a linear demand specification.

In related work with available wholesale price data, Kadiyali, Chintagunta and Vilcassim (1998) use weekly store level data from the analgesics category to assess both vertical and horizontal competitive interactions for two retailers (R1 and R2) and two manufacturers (M1 and M2). These interactions are represented in Figure 2 below. Kadiyali, Chintagunta and Vilcassim take an interesting approach. Specifically, they specify a menu of four different possible vertical relationships (Manufacturer Stackelberg (MS), Vertical Nash (VN), Retailer Stackelberg (RS)–see Choi 1991–and an additional proposed model) between manufacturers and retailers. Competitive interactions are estimated using a conjectural variations approach. Based this menu of vertical conduct, they use non-nested hypothesis tests (Vuong 1989) to choose the best fitting game. For the product category studied (analgesics), they find that manufacturer power, as measured by manufacturer mark-up (relative to retailer mark-up) is greater than that of the retailer for the national brands considered. They note that this is consistent with the findings of Cotterill and Putsis (1998) that retailers tend to use proportional mark-ups applied to the wholesales prices charged by manufacturers. It is also interesting to note that out of the three models of vertical interaction previously considered in the literature (MS, VN and RS, as discussed in Choi 1991), the Manufacturer Stackelberg model is the best fitting, also consistent with the findings of Cotterill and Putsis (1998).[9] As with each of the studies discussed above, detailed analysis of this sort cannot be conducted with aggregate industry level data. Thus, these findings provide substantive and managerially useful information that could not be obtained without conducting a detailed intra-category analysis using micro, disaggregate data.

7. Conclusions

It should be clear from the discussion above that no one type of strategic interaction explains competition in all food product category. Further, the pattern of interaction is often quite complex, with significant variation across instruments within any single food product category. Most of the empirical research to date is consistent with the notion that competitive rivalry is not symmetric and that not all marketing mix actions require a similar response.

This suggests that competitive interaction in any category is the result of a complex set of variables and influences. Demand side factors, market and industrial structure, firm “personality,” and category characteristics all interact in a complex fashion to determine strategic behavior, as outlined in Figure 1. Further, each marketing mix instrument is likely to be used as a strategic weapon for different objectives, suggesting that firms may very well take different competitive stances with each instrument. Further, there has been little research that attempts to explain *why* firms act as they do. What determines when a cooperative stance is optimal? What settings encourage independent (Nash) response? In practice, one clear implication is that managers need to take the direction and magnitude of the competitive response into account in evaluating the likely impact of a change in the firm’s marketing mix. In reality, we are just beginning to understand the determinants of strategic

9. We note that their proposed model of vertical conduct fit best overall.

interaction. Nonetheless, there are a variety of methodologies available for addressing the competitive interaction between firms. This review represents an initial attempt to put together a more complete picture of the techniques available and the set of results obtained thus far.

Given the complexity of the interactions that take place in practice, it seems clear that much of the richness of actual competitive behavior is lost in aggregate analysis. Further, even if aggregation biases were not present and aggregate industry level analyses of price-cost margins were able to produce accurate measures of market power and conduct, attributing the source of market power is largely impossible. Given the complexity of the distribution process, cooperative or accommodating behavior (for example) can mean many different things depending upon the vertical market structure and channel behavior. Considerations such as linear aggregation biases and the relationship between the demand form and retail passthrough/channel conduct cannot be ignored in empirical IO analysis. While many of these issues are now being addressed in the literature, it seems clear that future research must be conducted at the more disaggregate level if the analysis is to have any managerial relevance. Fortunately, scanner data that permit such analysis are widely available.

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Appendix–Empirical Estimation (Putsis and Dhar 1998a)

Employing a simple duopoly model and a traditional conjectural variations approach (Iwata 1974, Bresnahan 1989, Gasmi, Laffont and Vuong 1992), the following framework was used as the basis for the empirical analysis. Employing the notation from the text, designating the national brand as firm 1 and the private label as firm 2, and given assumptions made in Putsis and Dhar (1998a) regarding manufacturer-retailer interaction, the set of structural equations can be stated as follows (following Iwata 1974, the equations represent two demand equations followed by the first order conditions for manufacturers and a monopolistic retailer):

$$Q_1 = \alpha_0+\alpha_1 P_1+\alpha_2 P_2+\alpha_3\gamma_1+\alpha_4\gamma_2+\alpha_5\mu_1+\alpha_6\mu_2 \quad \text{(A1)}$$

$$Q_2 = \beta_0+\beta_1 P_1+\beta_2 P_2+\beta_3\gamma_1+\beta_4\gamma_2+\beta_5\mu_1+\beta_6\mu_2 \quad \text{(A2)}$$

$$\begin{aligned} P_1 &= -[Q_1/(\partial Q_1/\partial P_1)] - (MC_1+\gamma_1+\alpha\mu_1) \\ &= -[Q_1/(\alpha_1+\alpha_2(\partial P_2/\partial P_1))] - (MC_1+\gamma_1+\alpha\mu_1) \quad \text{(A3)} \end{aligned}$$

$$\begin{aligned} \gamma_1 &= -[Q_1 / (\partial Q_1 / \partial\gamma_1)] + (P_1 - MC_1 - \alpha\mu_1) \\ &= -[Q_1 / (\alpha_3 + \alpha_4(\partial\gamma_2/\partial\gamma_1))] + (P_1 - MC_1 - \alpha\mu_1) \quad \text{(A4)} \end{aligned}$$

$$\begin{aligned} \mu_1 &= [(P_1 - \gamma_1 - MC_1)/\alpha] - [Q_1 / (\partial Q_1 / \partial\mu_1)] \\ &= [(P_1 - \gamma_1 - MC_1)/\alpha] - [Q_1 / (\alpha_5 + \alpha_6(\partial\mu_2/\partial\mu_1)] \quad \text{(A5)} \end{aligned}$$

$$P_2 = -[Q_2 / (\partial Q_2 / \partial P_2)] - MC_2$$
$$= -[Q_2 / (\beta_2 + \beta_1(\partial P_1/\partial P_2))] - MC_2 \quad \text{(A6)}$$

$$\gamma_2 = [\{-Q_2 + (k_1 P_1 (\alpha_4 + \alpha_3(\partial\gamma_1/\partial\gamma_2)))\}/\{\beta_4 + \beta_3(\partial\gamma_1/\partial\gamma_2)\}] + (k_2P_2 - \beta\mu_2), \quad \text{(A7)}$$

$$\mu_2 = [\{(k_1P_1(\alpha_6 + \alpha_5(\partial\mu_1/\partial\mu_2)))-\beta Q_2\}/ \{\beta(\beta_6+\beta_5(\partial\mu_1/\partial\mu_2))\}] + [(k_2P_2 - \gamma_2)/\beta] \quad \text{(A8)}$$

The set of terms $\{\alpha_0, \ldots, \alpha_6\}$, $\{\beta_0, \ldots, \beta_6\}$, $\{k_1, k_2, \alpha, \beta, MC_1$ and $MC_2\}$ represent parameters to be estimated. MC_1 and MC_2 represent the marginal costs of firm 1 and firm 2, respectively, which are estimated directly. In addition, $\Phi(2\rightarrow1) \equiv \{(\partial P_2/\partial P_1), (\partial\gamma_2/\partial\gamma_1), (\partial\mu_2/\partial\mu_1)\}$ and $\Phi(1\rightarrow2) \equiv \{(\partial P_1/\partial P_2), (\partial\gamma_1/\partial\gamma_2), (\partial\mu_1/\partial\mu_2)\}$ denote the relevant set of conjectural variation or "conduct" parameters.[10] These conduct parameters, continuous parameters to be estimated, represent the "expectations" that a firm has about the reactions of its rivals. Firms hold certain beliefs about their rivals, with these beliefs being realized in equilibrium. Thus, in equilibrium, these conduct parameters are consistent and can be used to infer actual market behavior (Bresnahan 1989).[11]

The objective was to estimate these structural equations directly, thereby obtaining estimates of the conduct parameters above. In doing so, a series of identifying restrictions (following Kadiyali, Vilcassim and Chintagunta 1998) were placed on the system and various instruments were used in order to allow estimation. See Putsis and Dhar (1998a) for details on each player's relevant profit maximization, and on the specific set of identifying restrictions and instruments used in the empirical estimation.

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10. Note that this formulation, expanded to include multiple instruments and the presence of an active retailer, is essentially the same as Kadiyali, Vilcassim and Chintagunta (1998) and Gasmi, Laffont and Vuong (1992), pp. 297-301.

11. Note that the partial derivatives above representing each of the conjectures are identical to the conjectural variation parameters from previous studies (*e.g.*, γ in Iwata, 1974). Using this approach, we do not estimate reaction functions (we estimate the first-order conditions directly), so in this sense, the use of the partial derivatives may seem a bit misleading. We do this for two reasons. First, the notation above accurately represents the fact that we are estimating actual market behavior (or "what firms do as the result of these expectations [about rivals behavior]," Bresnahan 1989, p. 1029). Second, given the number of conduct parameters addressed in the present study, the notation employed above is much more straightforward.

Table 1 Price and Promotion Response and Implied Market Interactions

Competitive Interaction	Regular Price	Promotion
	Symmetric Interaction	
Independent (Nash)	$\partial P_2/\partial P_1, \partial P_1/\partial P_2 = 0$	$\partial \mu_1/\partial \mu_2, \partial \mu_2/\partial \mu_1 = 0$ $\partial \gamma_1 / \partial \gamma_2, \partial \gamma_2 / \partial \gamma_1 = 0$
Cooperative	$\partial P_2/\partial P_1, \partial P_1/\partial P_2 > 0$	$\partial \mu_1/\partial \mu_2, \partial \mu_2/\partial \mu_1 < 0$ $\partial \gamma_1 / \partial \gamma_2, \partial \gamma_2 / \partial \gamma_1 < 0$
Non-Cooperative	$\partial P_2/\partial P_1, \partial P_1/\partial P_2 < 0$	$\partial \mu_1/\partial \mu_2, \partial \mu_2/\partial \mu_1 > 0$ $\partial \gamma_1 / \partial \gamma_2, \partial \gamma_2 / \partial \gamma_1 > 0$
	Asymmetric Interaction	
National Brand Leader Private Label Follower	$\partial P_2/\partial P_1 \neq 0, \partial P_1/\partial P_2 = 0$	$\partial \mu_2/\partial \mu_1 \neq 0, \partial \mu_1/\partial \mu_2 = 0$ $\partial \gamma_2 / \partial \gamma_1 \neq 0, \partial \gamma_1 / \partial \gamma_2 = 0$
Private Label Leader, National Brand Follower	$\partial P_2/\partial P_1 = 0, \partial P_1/\partial P_2 \neq 0$	$\partial \mu_2/\partial \mu_1 = 0, \partial \mu_1/\partial \mu_2 \neq 0$ $\partial \gamma_2 / \partial \gamma_1 = 0, \partial \gamma_1 / \partial \gamma_2 \neq 0$
National Brand Dominant, Private label Fringe	$\partial P_2/\partial P_1 > 0, \partial P_1/\partial P_2 < 0$	$\partial \mu_2/\partial \mu_1 < 0, \partial \mu_1/\partial \mu_2 > 0$ $\partial \gamma_2 / \partial \gamma_1 < 0, \partial \gamma_1 / \partial \gamma_2 > 0$
Private Label Dominant, National Brand Fringe	$\partial P_2/\partial P_1 < 0, \partial P_1/\partial P_2 > 0$	$\partial \mu_2/\partial \mu_1 > 0, \partial \mu_1/\partial \mu_2 < 0$ $\partial \gamma_2 / \partial \gamma_1 > 0, \partial \gamma_1 / \partial \gamma_2 < 0$

Key: P denotes regular price
γ denotes temporary price reductions
μ denotes non-price promotions (*e.g.*, feature and/or display)

Table 2 Distribution of Estimated Implied Market Interactions Between Private Label (PL) and National Brands (NB) Across 58 Grocery Product Categories

	PRICE	PREDN	FEATURE	DISPLAY
		Symmetric		
INDEPENDENT	4	10	19	9
COOPERATIVE	7	7	6	7
NONCOOPERATIVE	16	10	8	6
		Asymmetric		
NB LEADER	19	16	19	15
PL LEADER	3	6	1	7
NB DOMINANT	8	8	3	9
PL DOMINANT	1	1	2	5

Source: Putsis and Dhar (1998a)

Figure 1. Category Characteristics, Competitive Response and Promotion Response

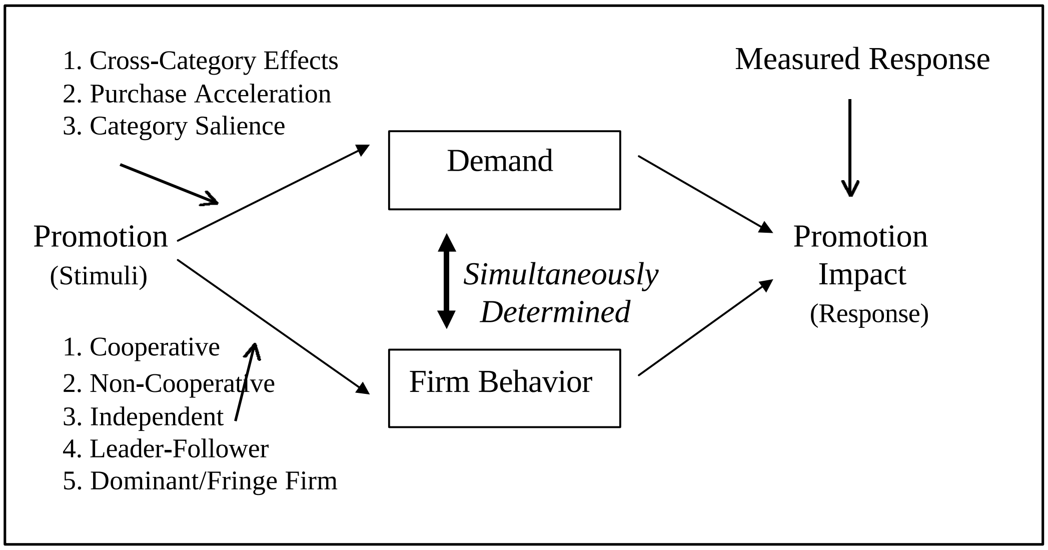
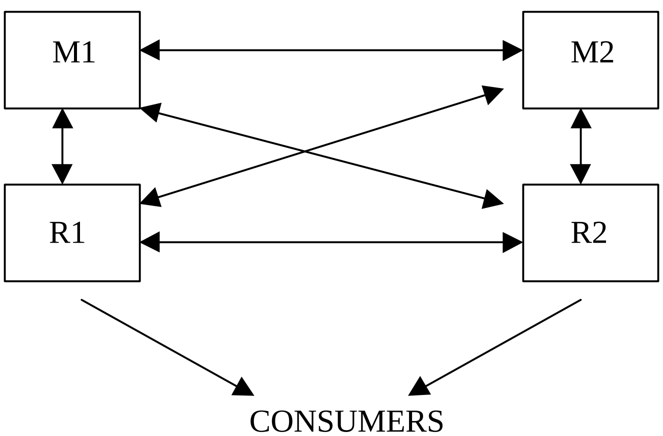


Figure 2. Horizontal and Vertical Interaction as Depicted by Kadiyali, Chintagunta and Vilcassim (1998).



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