# Promotional Timing for Substitutes and Complements at Major US Supermarkets 

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#### Abstract

The purpose of this study is to investigate empirically the major determinants of the supermarket manager's decision rule for placing products on promotions. Specifically, I examine the roles of substitutes and close complements as well as the potential interaction between national brands and private labels in determining promotional timing. The results expand upon the literature by demonstrating that complementary considerations, both within stores and among competitors, are highly significant determinants of promotional timing. Additionally, the results indicate that private labels are promoted heavily and that retailers incorporate the promotional timing of private labels when setting national brand promotions. This study provides further evidence that retail sales pricing typically does not conform to theoretical models of pricing.


Keywords: supermarket pricing, price promotions, food prices, private labels, probit models
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## 1. Introduction

This study investigates empirically the determinants of the supermarket manager's decision to place products on promotion, i.e., to offer temporary, advertised reductions in price. Varian (1980) proposed of model of promotional activity wherein retailers use promotions to randomize prices in order to discriminate between informed and uninformed consumers. According to this model, prices would be uncorrelated over time. Pesendorfer (2002), however, found little empirical support for the Varian model. This study extends Pesendorfer's examination into the roles of competition and substitutability on promotional timing in supermarkets. Focusing on a single popular category, ketchup, Pesendorfer showed that retailers take into account the time elapsed since the last promotion for other brands of ketchup, both in-store and at competing stores, when setting promotions.
Literature on retail demand motivates the inclusion of complementary product relationships as well when examining promotional timing. Walters (1991) showed econometrically that the sales of a product in a supermarket are affected not only by changes in own price but also by price changes for close substitutes and complements. Chintagunta and Haldar (1998) demonstrated that price reductions in one product category lead to sales increases not only in the category seeing the reduction, but also in highly complementary product categories.

Moreover, most supermarkets today offer a wide range of private label (PL) products in addition to national brands (NBs). Academic literature (Raju, Setharuman, \& Dhar, 1995; Cortsjens \& Lal, 2000; Steiner, 2004), trade publications (Progressive Grocer, Consumer Reports), and popular press have all documented the rise in popularity, prevalence, and quality of PLs over the past two decades. Ailawadi et al. (2009), in reviewing the literature on promotional decisions, determined that PL promotions constitute an important direction for future research in the field. Volpe (2011) demonstrated that NBs and PLs engage in strong promotional competition within supermarkets. A final motivating factor for PL consideration is that in the data PLs are promoted more frequently, on average, than are comparable NBs. Therefore to expand the set of substitutes and complements pertaining to the products I examine to include PL products to better understand their role, if any, in the promotional decision making process.
While Pesendorfer focused solely on ketchup, I use a unique dataset to examine four distinct pairs of product
categories. The data include the prices and promotions at two major conventional supermarket chains in five metropolitan areas for a $15-$ month period. Three pairs of categories share obvious complementary relationships: hot dogs and hot dog buns, spaghetti pasta and marinara pasta sauce, and peanut butter and jelly. Pasta and sauce were examined by Walters and also Chintagunta and Haldar, and both studies concluded that sales in either category were affected by price changes in the other. The final pair selected for analysis, vanilla yogurt and canned peas, share no readily apparent complementary relationship in purchase or consumption. This pair is included as a check on the validity of the empirical analysis, as these two products should show significantly less cross-category promotional responsiveness than the other three.
Another important distinction between my approach and that of Pesendorfer is the inclusion of multi-week promotions. Promotions lasting longer than one week are very common in my data set, but they are a phenomenon rarely touched upon in the economic and marketing literature. They are more common among PLs but are also prevalent among NBs. The motivation of supermarkets to engage in multi-week promotions has not been discussed in the literature, and Pesendorfer did not include them in his data, citing a lack of theoretical support for their existence. To remove these observations from this analysis would eliminate vast portions of the data set, and therefore I include multi-week promotions in my analysis and provide a discussion of their likely effects on the results.

The econometric results, obtained using probit estimations on the discrete decision of whether or not to promote, clearly indicate that complementarity as well as NB/PL interplay are significant factors on promotional timing. The robustness check on complementarity, as conducting through yogurt and canned peas, confirms that the findings in this respect are not spurious. The results also strongly support those of Pesendorfer with respect to competing brands within product categories and across chains. The findings have implications for consumers, retail managers, and researchers interested in price formation or variation.

## 2. Data and Descriptive Analysis

The unique dataset used in this study consists of weekly prices and promotions at two major supermarket chains, Safeway and Albertsons, both of which operate mostly in the Western US. These are two of the largest chains in the country. In terms of total receipts, Safeway is the fifth largest food retailer in the United States while Supervalu, the parent company to Albertson, is sixth (Supermarket News, 2012). The data come from the companies' respective corporate websites, as both chains engage in online retail. Data on the total sales for each product category come from the 2008 Nielsen Homescan survey.
The data cover the eight product categories mentioned in the above section: beef hot dogs, hot dog buns, spaghetti pasta, marinara pasta sauce, crunchy peanut butter, jelly, vanilla yogurt, and canned peas. The time series of the dataset spans June, 2008 through September, 2009. The metropolitan areas sampled for this analysis are those in which, at the time of collection, both chains were offering online retail and home delivery for groceries. These cities are Las Vegas, Los Angeles, San Diego, Portland, and Seattle. Table 1 provides summary statistics for each of the product-size pairings studied in this analysis, by product category. Promotional frequency (promo freq) is the percentage of time a product is on promotion and promotional depth (promo depth) is the percentage difference by which the selling price is reduced during promotions.
The number of brands reported for each product category represents the number of brands examined due to their availability between Safeway and Albertsons over the entire data time series. The brands included in the analysis are kept hidden to maintain confidentiality, but all are national brands save for the private labels. I consider a single product size within each category, for reasons I will discuss later.

As table 1 shows, there is significant heterogeneity in the degree to which Safeway and Albertsons promote the various product categories. In general, overall promotional activity for the product categories correlates well with their suitability for use as heavily promoted items, or loss leaders, on the part of retailers. Hot dog buns, for example, feature relatively low overall purchase frequency due to the strong seasonality in their demand, and they have only one close complement in consumption. Correspondingly, buns are typically on promotion 34 to 38 percent of the time, which places them at the lower end of the spectrum among the products sampled. At the other end of the spectrum, yogurt is a product featuring high purchase penetration across many consumer demographics and high purchase frequency. It has been noted in the literature for its suitability as a frequently promoted item, and as such, several studies have examined yogurt prices and demand empirically (Vilcassim \& Chintagunta, 1995; Ailawadi \& Neslin, 1998; Ackerberg, 2001). Table 1 shows that a typical yogurt product is on some form of promotion between 78 and 85 percent of the time. Yogurt, in particular, is subject to promotions of great duration that do not conform to any standing economic models of sale pricing.

Table 1. Summary statistics regarding weekly promotions for the product categories, by metropolitan area

| Product Category |  |  | Metropolitan Area |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Las Vegas | Los Angeles | San Diego | Portland | Seattle |
| Hot Dogs (16oz.) | Promo Freq | Mean | 0.3477 | 0.4101 | 0.4193 | 0.5553 | 0.4990 |
|  |  | Std. Dev. | 0.3289 | 0.4002 | 0.3823 | 0.4104 | 0.3988 |
| 4 Brands | Promo Depth | Mean | 0.3562 | 0.3572 | 0.3430 | 0.2346 | 0.2559 |
|  |  | Std. Dev. | 0.1166 | 0.0999 | 0.1160 | 0.1336 | 0.1219 |
| Hot Dog Buns (8ct.) | Promo Freq | Mean | 0.3619 | 0.3552 | 0.3783 | 0.3409 | 0.3833 |
|  |  | Std. Dev. | 0.4450 | 0.4421 | 0.4618 | 0.4257 | 0.4349 |
|  | Promo Depth | Mean | 0.2548 | 0.2639 | 0.2377 | 0.2261 | 0.2582 |
| 2 Brands |  | Std. Dev. | 0.0879 | 0.0918 | 0.0875 | 0.0793 | 0.0816 |
| Pasta (16oz.) | Promo Freq | Mean | 0.6322 | 0.6364 | 0.6382 | 0.6905 | 0.6956 |
|  |  | Std. Dev. | 0.4461 | 0.4452 | 0.4379 | 0.4170 | 0.4296 |
| 3 Brands | Promo Depth | Mean | 0.2788 | 0.2964 | 0.3070 | 0.2726 | 0.2580 |
|  |  | Std. Dev. | 0.1019 | 0.0987 | 0.0948 | 0.1037 | 0.0899 |
| Pasta Sauce (26oz.) | Promo Freq | Mean | 0.5572 | 0.5384 | 0.5560 | 0.6135 | 0.6348 |
|  |  | Std. Dev. | 0.4570 | 0.4527 | 0.4636 | 0.4562 | 0.4483 |
|  | Promo Depth | Mean | 0.2681 | 0.2791 | 0.2842 | 0.2705 | 0.2678 |
| 6 Brands |  | Std. Dev. | 0.1176 | 0.1043 | 0.1126 | 0.0979 | 0.1001 |
| Peanut Butter (28oz.) | Promo Freq | Mean | 0.3908 | 0.3764 | 0.3779 | 0.3802 | 0.4211 |
|  |  | Std. Dev. | 0.4590 | 0.4518 | 0.4520 | 0.4536 | 0.4552 |
|  | Promo Depth | Mean | 0.2134 | 0.2198 | 0.1979 | 0.2102 | 0.2237 |
| 3 Brands |  | Std. Dev. | 0.0971 | 0.0855 | 0.0872 | 0.0814 | 0.0800 |
| Jelly (18oz.) | Promo Freq | Mean | 0.3976 | 0.4120 | 0.3981 | 0.4318 | 0.4263 |
|  |  | Std. Dev. | 0.4459 | 0.4394 | 0.4482 | 0.4427 | 0.4466 |
| 5 Brands | Promo Depth | Mean | 0.1946 | 0.2135 | 0.2117 | 0.2296 | 0.2348 |
|  |  | Std. Dev. | 0.0911 | 0.0938 | 0.0897 | 0.1036 | 0.1031 |
| Yogurt (320z.) | Promo Freq | Mean | 0.7918 | 0.8119 | 0.7845 | 0.8014 | 0.8472 |
|  |  | Std. Dev. | 0.3536 | 0.3522 | 0.3598 | 0.3312 | 0.2847 |
| 3 Brands | Promo Depth | Mean | 0.2388 | 0.2273 | 0.2412 | 0.2318 | 0.2036 |
|  |  | Std. Dev. | 0.0808 | 0.0786 | 0.0819 | 0.0835 | 0.0855 |
| Canned Peas (15oz.) | Promo Freq | Mean | 0.3941 | 0.3658 | 0.3888 | 0.4926 | 0.4589 |
|  |  | Std. Dev. | 0.4487 | 0.4375 | 0.4461 | 0.4404 | 0.4488 |
|  | Promo Depth | Mean | 0.2478 | 0.2345 | 0.2097 | 0.1888 | 0.1919 |
| 2 Brands |  | Std. Dev. | 0.0922 | 0.1024 | 0.1113 | 0.1089 | 0.0991 |

Source: Safeway.com and Albertsons.com and author's calculations.
There appears to be little variation across cities in terms of promotional activity. Promotional frequency tends to be somewhat higher in the Portland and Seattle metropolitan areas, particularly for hot dogs and canned peas. It is worth noting that Safeway is the market leader in both Portland and Seattle by wide margins and that Safeway promotes products more frequently, on average, than does Albertsons. Hot dog price promotions can be as deep as approximately 35 percent off the posted shelf prices, but for all other products the average promotional depth is between 20 and 30 percent.
For this analysis, it was important to select products for each brand analyzed within a category that are roughly the same size, as promotional patterns can differ significantly among product sizes in order to target different demographics, e.g, large versus small families (Note 1). Therefore, for each product category, the product size examined in this analysis is that which features the largest assortment of brands, and in turn the brands selected within each product size are those that were available to consumers consistently throughout the entire time period across all five metropolitan areas.
Given that the substitutability or complementarity of these product categories is central to this analysis, it is worthwhile to examine the promotional patterns of these products in light of the research that has been conducted on the topic. Chintagunta and Haldar (1998) showed that it is suboptimal for retailers to promote close complements simultaneously, for in doing so retailers forgo profits on products which consumers would have purchased at full price in light of a single promotion. Hosken and Reiffen (2004) argued that retailers should not promote two NBs within a product category simultaneously, as this practice is also suboptimal from a profitability standpoint. Table 2 summarizes how the promotional patterns of the product categories examined in this study match up with these key recommendations from the literature, taking into account the promotions of

PL products.
Table 2. The extent of simultaneous promotions for the examined product categories, by chain


Note: Total number of NB products examined is in parentheses.
Source: Safeway.com and Albertsons.com and author's calculations.
Table 2 demonstrates clearly that both chains frequently promote close complements as well as NB products within categories simultaneously. Considering only NB products, the lowest degree of simultaneous promotion between close complements is 21.70 percent for the case of hot dogs and buns at Albertsons. That is, at least one NB hot dog product and one NB bun product were jointly on promotion for approximately 15 weeks out of the 15 month time series. The greatest degree of joint complementary promotions occurred for pasta and pasta sauce, for which simultaneous promotions were run between the two categories 97 and 86 percent of the time for Safeway and Albertsons, respectively. The degree of cross-complement promotions is the lowest, on average, for hot dogs and buns, the pair posited to have the greatest degree of complementarity. However pasta and sauce are jointly on promotion significantly more often than even the pairing of yogurt with canned peas, which is assumed to have zero complementarity in consumption. This suggests that retailers do not take the overall complementarity of pasta with sauce to be a consideration in setting promotions, either because the high storability of the products greatly diminishes the relationship or because consumers exhibit very strong brand loyalty in this market. Examining the overall prevalence of cross-complement promotions, it is clear that certain other factors, such as competitive considerations, are at play in the determination of retailers' promotional decisions.
Likewise both retailers frequently set simultaneous promotions within product categories for NB products. This practice is relatively rare for hot dogs, buns, and peanut butter, where it occurred between five and 20 percent of the time. However for pasta, sauce, and yogurt it was observed consistently across the time series. Frequent, simultaneous promotions for substitutes within product categories may be indicative of overlapping trade promotions from manufacturers, but once again, competitive considerations on the part of supermarkets are likely to be a factor, as they are the single largest determinant of supermarket price changes (Levy et al., 1998).
Table 2 suggests that these supermarkets are making more of an effort to avoid these practices for the top two most popular brands in each product category, as measured by quantity sales via Nielsen Homescan data (Note 2). For example, the top two brands of pasta are only on sale simultaneously 17 percent of the time, though at least two NB pastas are on sale simultaneously 78 percent of the time. The incidence of simultaneously pasta
sauce promotions drops from 95 and 75 percent to 27 and 11 percent for Safeway and Albertsons, respectively, when considering only the top two NBs. In general, the incidence of simultaneous promotions for complements falls dramatically as well. A consumer could expect to find some leading peanut butter and jelly products on sale simultaneously 55 percent of the time at Safeway or 65 percent of the time at Albertsons, but considering only the two largest brands sampled, these number fall to six and 12 percent, respectively. However even limiting the focus to these top brands, for which retailers have the greatest incentive to carefully manage promotions, both of these practices occur regularly. Only for the case of top jelly brands at Albertsons do theoretically suboptimal promotions never occur, while the top pasta and top sauce brands at Safeway are jointly on sale 50 percent of the time.

Finally, all of the figures pertaining to promotional simultaneity are almost certainly underestimating the extent to which Safeway and Albertsons engage in these practices, as these statistics only account for those products included in the formal econometric analysis below. For every product category examined in this study, there were additional NB products and sizes that were not available consistently across time or for all five of the metropolitan areas.
Rao, Arjuni, and Murthi (1995) (hereafter RAM), examining NB ketchup products, found that brands within product categories were promoted independently and identical brands were promoted independently across chains. Lal and Villas-Boas (1998) as well as Hosken and Reiffen (2004) found no justification for such independence in theory, and Pesendorfer's findings on NB ketchup rejected both types of independence. I performed Chi-squared tests for overall independence among NBs within categories and between identical brands across chains. The results, particularly the number of times the null hypothesis of independence is rejected per product category, are summarized in table 3 .

Table 3. Test results for independence in promotions within categories and across chains ( $\mathrm{H}_{0}$ : independence)

|  | Independence of NB Promotions within Product Categories |  |  | Independence of Promotions for Identical Products across Chains |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | Pairwise Comparisons | Safeway | Albertsons | Pairwise Comparisons |  |
| Hot Dogs (16oz.) | 3 | Reject 1 (33\%) | $\begin{aligned} & \text { Reject } 1 \\ & (33 \%) \end{aligned}$ | 3 | Reject 2 (67\%) |
| Hot Dog Buns (8ct.) | 1 | Do Not Reject | $\begin{aligned} & \text { Reject } 1 \\ & (100 \%) \end{aligned}$ | 2 | Do Not Reject |
| Pasta (16oz.) | 6 | Reject 4 (67\%) | Reject 5 (83\%) | 4 | Reject 3 (100\%) |
| Pasta Sauce (26oz.) | 15 | Reject 9 (60\%) | $\begin{aligned} & \text { Reject } 13 \\ & (87 \%) \end{aligned}$ | 6 | Reject 5 (83\%) |
| Peanut Butter (28oz.) | 3 | Do Not Reject | Reject 2 (67\%) | 3 | $\begin{aligned} & \text { Reject } 1 \\ & (33 \%) \end{aligned}$ |
| Jelly (18oz.) | 10 | Reject 2 (20\%) | $\begin{aligned} & \text { Reject } 5 \\ & (50 \%) \end{aligned}$ | 5 | Reject 3 (60\%) |
| Yogurt (320z.) | 3 | Reject 3 (100\%) | $\begin{aligned} & \text { Reject } 3 \\ & (100 \%) \end{aligned}$ | 3 | Reject 1 (33\%) |
| Canned Peas (15oz.) | 1 | Reject 1 $(100 \%)$ | $\begin{aligned} & \text { Reject } 1 \\ & (100 \%) \end{aligned}$ | 2 | Reject 1 (50\%) |

Source: Safeway.com and Albertsons.com and author's calculations.

Overall, the tests for independence in promotional activity reflect findings more in line with Lal and Villas-Boas than with RAM. For example, independence within product categories is soundly rejected for pasta, pasta sauce, and yogurt. Across all comparisons across chains for like products, independence was more likely to be rejected than not. However there are several instances in which independence could not be rejected, and this finding serves as a caution against drawing store-wide implications from the results of empirical tests performed on a single product category. For example, NB promotions of peanut butter at Safeway are wholly independent, and across chains peanut butter promotions are independent for all but one brand. Peanut butter shares several attributes with ketchup, in that it has high penetration among consumer demographics, is highly storable, and is frequently used as a condiment or as an ingredient in recipes. Hence an empirical paper aimed at testing for the extent of independence among promotions using these data and only peanut butter products would likely also conclude that promotions are largely independent, while table 3 shows that the answer to the question depends heavily upon the product categories being examined. Consistent with the differences uncovered across product categories, Fader and Lodish (1990) and Bell and Lattin (2003) both noted that the scope of most food retail and
marketing studies, in terms of products studied, serves as a limitation on the applicability of the results.

## 3. Methodology and Results

It is evident that Safeway and Albertsons do not follow closely the recommendations prescribed by the literature for optimal promotional activity. However there is a relative dearth of literature on the dynamics of price promotions in a competitive setting. Most studies focusing on price promotions examine consumer response rather than rivalry among sellers. If retailers are not setting promotions to avoid certain practices that appear unprofitable, such as the joint promotion of close complements, the question thus becomes: How do retailers decide when to promote any given product? One possibility, as proposed by Varian (1980), is that retailers set promotions in order to simply randomize prices. However another possibility, one not necessarily mutually exclusive to the Varian model, is that retailers are taking into account substitutability or complementarity in attempts to either bundle or stagger the purchasing decisions of consumers and to respond to competitors' advertised promotions. Steenkamp et al. (2005) and Volpe (forthcoming) have both found direct evidence of retailers responding directly to competitive promotions with advertised promotions in turn.
Building upon Pesendorfer, I model the decision rule for retailers to offer product ion promotion in supermarket $k$ at time $t\left(y_{k t}^{i}=1\right)$ as a function of past promotions on both complements and substitutes at both chains. The decision rule is given by

$$
\begin{equation*}
y_{k, t}^{i}=\gamma^{\prime} Z_{k, t}+\delta^{\prime} H_{k, t}+\beta^{\prime} X_{k, t}+\varepsilon_{k, t} \tag{1}
\end{equation*}
$$

Given that the dependent variable is a binary, equation (1) is estimated as a probit. $Z$ represents a vector of variables measuring the time elapsed since the last promotion for product $i$ and substitutes for $i$ for supermarket $k$ $=$ Albertsons or Safeway. $H$ is a vector of variables measuring the time elapsed since the last promotion for all complements to product $i$ and $X$ represents other explanatory variables intended to control for seasonality and wholesale prices. The $Z$ and $H$ vectors each include squared terms, when possible, to account for nonlinearities in the effect of time elapsed (Note 3). Additionally, the $Z$ and $H$ vectors are each lagged one week. This allows for the coordination and implementation of regional promotional response for the two large chains and precludes simultaneity bias in the estimation. Although shelf prices for certain products vary significantly over the time series, I include only advertised promotions for the purposes of estimating equation (1). The $X$ vector, also following Pesendorfer, consists of binary variables that divide the time series into eight-week periods in order to account for changes in wholesale prices. Table 4 demonstrates how a binary variable pertaining to the promotions for a product of interest is transformed to yield the time-elapsed variable used in this estimation.

Table 4. Sample illustration of the calculation of time-elapsed variables for use in estimating equation (1)

|  | Product name: Leading Breand Franks-16 oz. <br> Chain: Safeway <br> City: Las Vegas, $\mathbf{N V}$ |  |  |
| :--- | :--- | :--- | :--- |
| Date | Promotion (=1 if on sale) ${ }^{\text {a }}$ | Time Elapsed Since Last Promotion | Lagged Time Elapsed $^{\text {b }}$ |
| $\mathbf{0 2 / 0 2 / 2 0 1 0}$ | 1 | 0 | - |
| $\mathbf{0 2 / 0 9 / 2 0 1 0}$ | 0 | 1 | 0 |
| $\mathbf{0 2 / 1 6 / 2 0 1 0}$ | 1 | 0 | 1 |
| $\mathbf{0 2 / 2 3 / 2 0 1 0}$ | 0 | 1 | 0 |
| $\mathbf{0 3 / 0 2 / 2 0 1 0}$ | 0 | 2 | 1 |
| $\mathbf{0 3 / 0 9 / 2 0 1 0}$ | 0 | 3 | 2 |
| $\mathbf{0 3 / 1 6 / 2 0 1 0}$ | 1 | 0 | 3 |
| $\mathbf{0 3 / 2 3 / 2 0 1 0}$ | 0 | 1 | 0 |
| $\mathbf{0 3 / 2 0 / 2 0 1 0}$ | 0 | 2 | 1 |
| $\mathbf{0 4 / 0 6 / 2 0 1 0}$ | 0 | 3 | 2 |

Note: a: When using equation (1) to estimate the decision rule for placing this product on promotion, this is the left-hand side variable. b: When this product is assumed to share complementarity or substitutability with a different product being examined in this analysis, this is a right-hand side variable used in the estimation of equation (1).

Tables A. 1 and A.2, found in appendix A, report the complete probit regression results of estimating (1) for the major NB beef hot dogs available at both chains and the respective PL offerings (Note 4). The binaries included in the $X$ vector are mostly insignificant and they are not reported in appendix A. All remaining regression results are available from the author upon request. In the case of hot dogs and buns, the seasonality vector in (1) includes the July $4^{\text {th }}$ holiday, a time of peak demand for barbeque-related foods, measured as the two weeks prior
to the holiday and one week afterward. In most cases the time elapsed since the last promotion on identical products within chains is positive and significant. However this is less often the case with Albertsons. The majority of the linear coefficients on the time elapsed since own promotions are positive, though several are negative. In nearly every case in which the relationship between time elapsed and the probability of promotions is significant, the signs of the linear and quadratic terms are reversed. That is, following a promotion on a substitute or a complement, the probability of a promotion for a given product initially increases (decreases) but eventually decreases (increases). These patterns, though discussed only in the context of hot dogs, hold true for the remaining seven product categories.
Pesendorfer, examining substitutes only, found almost uniformly initial increases in probability followed by decreases, though I find the opposite case to hold in several instances, not only for hot dogs and buns, but for all product pairings examined in this study. For example, when Safeway sets its PL brand of hot dog buns on promotion, the probability of a promotion on Brand 1 Franks initially decreases and after time increases. Table 5reports the frequency with which the relationships in promotional timing take the two possible directions across all estimations of equation (1) for hot dogs, buns, pasta, sauce, peanut butter, and jelly. I consider only those instances in which the coefficients are statistically significant. Overall, initial increases in probability followed by decreases are somewhat more common among substitutes, numbering 116 total cases compared to 93 for the converse. And initial decreases in probability are more common among complements, by a count of 69 cases to 61. However table 5reveals no striking patterns in the sign of the effect of promotional timing on the promotional decision.

Table 5. The signs of the effect of promotional timing for complements and substitutes on the decision to promote, as estimated using equation (1) ${ }^{\text {a }}$

|  | Positive Linear <br> Negative Quadratic | Negative Linear <br> Positive Quadratic |
| :--- | :--- | :--- |
| Own Substitutes | 56 | 53 |
| Competitor Substitutes | 60 | 40 |
| Own Complements | 33 | 31 |
| Competitor Complements | 28 | 38 |

Note: ${ }^{\text {a }}$ The yogurt and canned peas categories are not included in this table.
Source: Safeway.com and Albertsons.com and author's calculations.

I propose three explanations for the less intuitive, though highly prevalent, findings of initial decreases in the probability of a promotion. Each calls for further empirical investigation in its own right. First, it is important to consider the fact that supermarkets maintain prices and promotions for $30,000-40,000$ products each week. Any optimization problem faced with so many variables would surely be intractable, and hence the Varian model may well hold true for many products, at least some of the time. That is, random promotions on the part of retailers not only enable price discrimination between informed and uninformed consumers but also reduce managerial costs.

The second potential explanation is the incidence of multi-week promotions. Recall that neither Pesendorfer nor the literature in general accounts for this behavior on the part of supermarkets, despite its prevalence. When product $j$ is on sale for consecutive weeks, the time elapsed since the last promotion on $j$ is coded as one until the promotion ends. Hence if product $i$ is more likely to go on promotion during a multi-week promotion for $j$, then the linear effect of promotions for $j$ can very reasonably be expected to be negative, as $i$ is most likely to go on promotion when the time elapsed since the last promotion on $j$ is short.

Finally, table 2 showed that retailers place competing NB brands within product categories on promotions simultaneously. The same is true for close complements, as well. It is important to remember that retailers likely engage in these practices intentionally as parts of their promotional strategy. With respect to simultaneous substitute promotions, retailers may be seeking to expand overall category demand by minimizing brand switching. Several studies, including Gupta (1988) and Deighton, Henderson, and Neslin (1994) have shown brand switching, or cannibalization, to be the major component of the sales bump resulting from promotions. By simultaneously promoting brands within categories, retailers are able to substantially increase category sales and rapidly move inventory while reducing shoppers' incentive to simply switch brands.

With respect to complements, supermarkets may decide to offer the combined product of hot dogs with buns on promotion by promoting leading brands of hot dogs and buns in the same week. MacDonald (2000) showed that supermarkets typically reduce the prices of products at the peak of their seasonal demand as an effective
competitive strategy. As an illustrative example in my own data, frozen turkeys as well as several side dishes such as boxed mashed potatoes, stuffing, and cranberry sauce are commonly on promotion simultaneously near Thanksgiving and Christmas. Therefore this practice may be especially common for hot dogs and buns during the summer months and may be used periodically for other close product pairings throughout the year.

Tables 6 through 8 display the results of a number of joint hypothesis tests performed on linear combinations of coefficients in the probit regression results. The null hypotheses are that each of the following promotions, respectively, have no effect on the promotional timing of product $i$ : same-store substitutes, substitutes at competing stores, same-store complements, complements at competing stores, NBs (PLs) when considering PLs (NBs). These hypothesis tests illustrate the most important contributions to the literature resulting from this study. They allow for definitive answers to the major questions pertaining to retailer strategy posed in this study and, for the most part, not explicitly considered in the literature. I will begin with examining the results immediately comparable to those of Pesendorfer and then move on to a discussion of findings addressing questions that have not been addressed in the literature.

Table 6. Hypothesis test results for hot dogs and buns

|  | Brand 1 Beef Franks, 16oz. |  | Brand 2 Beef Franks, 16oz. |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\chi^{2}$ Test | Safeway | Albertsons | Safeway | Albertsons |  |  |
| $\mathrm{H}_{0}$ : Own Hot Dogs $=0$ | 28.24*** | 13.72** | 32.10*** | 19.97** |  |  |
|  | (10) | (5) | (10) | (10) |  |  |
| $\mathrm{H}_{0}$ : Comp. Hot Dogs $=0$ | 15.15* | 8.70 | 9.05 | 17.06*** |  |  |
|  | (10) | (5) | (10) | (10) |  |  |
| $\mathrm{H}_{0}$ : Own Buns=0 | 6.82 | 12.64*** | 5.40 | 16.39** |  |  |
|  | (6) | (3) | (6) | (6) |  |  |
| $\mathrm{H}_{0}$ : Comp. Buns=0 | 9.91 | 4.66 | 7.44 | 8.89 |  |  |
|  | (6) | (3) | (6) | (6) |  |  |
| $\mathrm{H}_{0}$ : NB Effects $=0$ | $43.49 * * *$ | $14.33^{* *}$ | $42.58 * * *$ | $54.24 * * *$ |  |  |
|  | (24) | (12) | (24) | (24) |  |  |
| $\mathrm{H}_{0}:$ PL Effects $=0$ | 12.17** | 17.10*** | 5.67 | 14.66** |  |  |
|  | (8) | (4) | (8) | (8) |  |  |
|  | Brand 3 Beef Franks, 160z. |  | Private Label Beef Franks, 160z. |  |  |  |
| $\chi^{2}$ Test | Safeway | Albertsons | Safeway | Albertsons |  |  |
| $\mathrm{H}_{0}$ : Own Hot Dogs $=0$ | 23.68*** | 32.80 *** | 35.17*** | 13.86** |  |  |
|  | (5) | (10) | (10) | (10) |  |  |
| $\mathrm{H}_{0}$ : Comp. Hot Dogs $=0$ | 14.82** | 10.94 | 30.54*** | 10.75* |  |  |
|  | (5) | (10) | (10) | (10) |  |  |
| $\mathrm{H}_{0}$ : Own Buns $=0$ | 5.89* | 9.82* | 8.91 | 5.52* |  |  |
|  | (3) | (6) | (6) | (6) |  |  |
| $\mathrm{H}_{0}$ : Comp. Buns=0 | 7.53* | 2.94 | 12.56** | 2.76 |  |  |
|  | (3) | (4) | (6) | (6) |  |  |
| $\mathrm{H}_{0}$ : NB Effects=0 | 32.12*** | 44.47*** | 55.45*** | 15.37* |  |  |
|  | (12) | (24) | (24) | (24) |  |  |
| $\mathrm{H}_{0}$ : PL Effects $=0$ | 12.91** | 6.74 | 33.84*** | 11.20** |  |  |
|  | (4) | (6) | (8) | (8) |  |  |
|  | Brand 4 Hot Dog Buns, 140z. |  | Brand 5 Dog Buns, 12oz. |  | Private Label Hot Dog Buns |  |
| $\chi^{2}$ Test | Safeway | Albertsons | Safeway | Albertsons | Safeway (12oz.) | Albertsons (8ct.) |
| $\mathrm{H}_{0}$ : Own Hot Dogs $=0$ | 13.73 | 18.69** | 6.97 | 13.30 | 7.02 | 29.36*** |
|  | (10) | (10) | (10) | (10) | (10) |  |
| $\mathrm{H}_{0}$ : Comp. Hot Dogs $=0$ | 18.41** | 19.58** | 29.74*** | 9.01 | 7.82 | 18.67** |
|  | (10) |  |  | (10) | (10) |  |
| $\mathrm{H}_{0}$ : Own Buns= 0 | 21.21*** | 11.45* | 32.77*** | 22.27*** | 20.83*** | 11.72* |
|  | (4) | (6) |  |  | (6) |  |
| $\mathrm{H}_{0}$ : Comp. Buns=0 | 10.00* | 13.14** | 9.54* | 2.68 | 8.88 | 22.46*** |
|  | (6) | (6) | (6) | (4) | (6) |  |
| $\mathrm{H}_{0}$ : NB Effects $=0$ | 35.56* | 35.09* | 51.19*** | 36.84** | 18.21 | 44.65*** |
|  | (24) | (24) | (24) |  | (24) |  |
| $\mathrm{H}_{0}$ : PL Effects $=0$ | 10.37* | 5.45 | 14.18* | 16.13** | 24.03*** | 20.30*** |
|  | (6) | (6) | (8) | (6) | (8) |  |

Note: *** Significant at the 0.01 level. ** At the 0.05 level. * At the 0.10 level. Degrees of freedom for the hypothesis tests are in parentheses.

Table 7. Hypothesis test results for pasta and sauce


|  | Brand 5 Marinara Sauce, 26 oz. |  | Brand 6 Pasta Sauce Marinara,26 oz . |  | Brand 7 Old World Style Sauce, 26 oz. |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\chi^{2}$ Test | Safeway | Albertsons | Safeway | Albertsons | Safeway | Albertsons |
| $\mathrm{H}_{0}$ : Own Pasta $=0$ | 35.96*** | 5.38 | 27.61** | 7.20 | 11.94** | 5.44 |
|  | (14) | (4) | (14) | (4) | (14) | (4) |
| $\mathrm{H}_{0}$ : Competitor Pasta $=0$ | 3.60 | 27.45*** | 19.61*** | 16.11 | 47.32*** | 20.16* |
|  | (6) | (12) | (4) | (12) | (4) | (12) |
| $\mathrm{H}_{0}$ : Own Sauce $=0$ | 43.69*** | 20.84* | 33.54*** | 21.64* | 48.64*** | 42.74*** |
|  | (14) | (14) | (12) | (14) | (12) | (14) |
| $\mathrm{H}_{0}$ : Competitor Sauce $=0$ | 32.87*** | 24.83** | 33.98*** | 24.43** | 48.64*** | 23.74** |
|  | (14) | (14) | (15) | (14) | (15) | (14) |
| $\mathrm{H}_{0}$ : NB Effects $=0$ | 75.03*** | 40.06 | 55.93** | 57.73** | 68.07*** | 61.35*** |
|  | (40) | (38) | (38) | (38) | (38) | (36) |
| $\mathbf{H}_{0}$ : PL Effects $=0$ | 11.01** | 13.99*** | 2.99 | 8.68* | 13.08** | 3.40 |
|  | (4) | (4) | (4) | (4) | (6) | (6) |

Note: *** Significant at the 0.01 level. ** At the 0.05 level. * At the 0.10 level. Degrees of freedom for the hypothesis tests are in parentheses.

Table 8. Hypothesis test results for peanut butter and jelly

|  | Brand 1 Chunky Peanut Butter, 16 oz . |  | Private label crunchy peanut butter, 28 oz. |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\chi^{2}$ test | Safeway | Albertsons | Safeway | Albertsons |  |  |
| $\mathrm{H}_{0}$ : Own PB=0 | 3.67 | 13.97* | 3.67 | 30.65*** |  |  |
|  | (6) | (8) | (6) | (8) |  |  |
| $\mathrm{H}_{0}$ : Competitor $\mathrm{PB}=0$ | 10.97 | 21.30*** | 10.97 | 14.96* |  |  |
|  | (8) | (8) | (8) | (8) |  |  |
| $\mathrm{H}_{0}$ : Own Jelly $=0$ | 11.74 | 25.94** | 11.74 | 27.69*** |  |  |
|  | (12) | (12) | (12) | (12) |  |  |
| $\mathrm{H}_{0}$ : Competitor Jelly= 0 | 6.34 | 27.65*** | 6.34 | 20.65* |  |  |
|  | (10) | (12) | (10) | (12) |  |  |
| $\mathrm{H}_{0}$ : NB Effects $=0$ | 21.16 | $43.83 * *$ | 21.16 | 47.31** |  |  |
|  | (32) | (30) | (32) | (32) |  |  |
| $\mathrm{H}_{0}$ : PL Effects $=0$ | 6.57 | 18.17** | 6.57 | 22.40*** |  |  |
|  | (6) | (8) | (6) | (8) |  |  |
|  | Brand 2 Crunchy Peanut Butter, 28 oz. |  | Brand 3 Chunky Peanut Butter, 28 oz. |  |  |  |
| $\chi^{2} \text { test }$ | Safeway | Albertsons | Safeway | Albertsons |  |  |
| $\mathrm{H}_{0}: \text { Own } \mathrm{PB}=0$ | 22.23*** | $9.80$ | 4.01 | 10.56* |  |  |
|  | (8) | (8) | (8) | (6) |  |  |
| $\mathrm{H}_{0}$ : Competitor $\mathrm{PB}=0$ | 18.25** | 24.11*** | 9.35 | 8.15 |  |  |
|  | (8) | (8) | (8) | (6) |  |  |
| $\mathrm{H}_{0}$ : Own Jelly $=0$ | 17.27 | 17.73* | 14.20 | 11.59 |  |  |
|  | (12) | (12) | (10) | (10) |  |  |
| $\mathbf{H}_{0}$ : Competitor Jelly= 0 | 17.20 | 9.29 | 14.70 | 10.17 |  |  |
|  | (12) | (10) | (12) | (8) |  |  |
| $\mathrm{H}_{0}$ : NB Effects $=0$ | 33.45 | 40.08* | $19.71$ | $16.04$ |  |  |
|  | (34) | (30) | (32) | (26) |  |  |
| $\mathrm{H}_{0}$ : PL Effects $=0$ | 17.95** | 15.15* | 10.63* | 8.05* |  |  |
|  | (8) | (8) | (6) | (4) |  |  |
|  | Brand 4 Strawberry Jam, 18 oz. |  | Brand 5 Strawberry Jam, 18 oz . |  | PL strawberry jelly, 18 oz. |  |
| $\chi^{2}$ Test | Safeway | Albertsons | Safeway | Albertsons | Safeway | Albertsons |
| $\mathrm{H}_{0}$ : Own PB=0 | 21.12*** | 9.98 | 13.23* | 24.60*** | 4.07 | 10.17 |
|  | (8) | (8) | (8) | (8) | (6) | (8) |
| $\mathrm{H}_{0}$ : Competitor $\mathrm{PB}=0$ | $25.47^{* * *}$ | 16.53** | 15.06* | 23.27*** | 10.11 | 15.70** |
|  | (8) | (8) | (8) | (8) | (8) | (8) |
| $\mathrm{H}_{0}$ : Own Jelly $=0$ | 30.16*** | 16.22 | 22.09** | 29.82*** | 14.75 | 30.46 *** |
|  | (12) | (12) | (12) | (14) | (10) | (12) |
| $\mathrm{H}_{0}$ : Competitor Jelly=0 | 26.43*** | 18.06* | 20.94* | 11.90 | 11.61 | 34.42 *** |
|  | (12) | (10) | (12) | (12) | (10) | (12) |
| $\mathrm{H}_{0}$ : NB Effects $=0$ | 37.77 | 31.02 | 41.10 | 44.68** | 20.41 | 44.38** |
|  | (32) | (30) | (32) | (30) | (26) | (26) |
| $\mathrm{H}_{0}$ : PL Effects $=0$ | 24.87*** | 19.56** | 15.96** | 21.00*** | 8.95 | 11.55 |
|  | (8) | (8) | (8) | (8) | (6) | (8) |
|  | Brand 6 Strawberry Jam, 16 oz. |  | Brand 7 Strawberry Preserves, 18 oz . |  | Brand 8 Strawberry Squeeze Jam, 22 oz. |  |
| $\chi^{2}$ Test | Safeway | Albertsons | Safeway | Albertsons | Safeway | Albertsons |
| $\mathrm{H}_{0}$ : Own PB $=0$ | 15.60** | 15.99** | 22.20*** | 19.96** | 19.49** | 13.50* |
|  | (8) | (8) | (8) | (8) | (8) | (8) |
| $\mathrm{H}_{0}$ : Competitor $\mathrm{PB}=0$ | 10.06 | 10.81 | 20.29*** | 14.17* | 18.70** | 14.65* |
|  | (8) | (8) | (8) | (8) | (8) | (8) |
| $\mathrm{H}_{0}$ : Own Jelly $=0$ | 19.03* | 8.27 | 16.87* | 23.52** | 18.53** | 11.65 |
|  | (12) | (10) | (10) | (12) | (8) | (12) |
| $\mathrm{H}_{0}$ : Competitor Jelly=0 | 22.73** | 9.76 | $37.21^{* * *}$ | 20.53** | 20.44** | 14.36 |
|  | (12) | (8) | (10) | (10) | (10) | (12) |
| $\mathrm{H}_{0}$ : NB Effects=0 | 38.37 | 23.93 | 43.88** | 40.14* | 37.49* | 16.11 |
|  | (32) | (26) | (30) | (30) | (28) | (28) |
| $\mathrm{H}_{0}:$ PL Effects $=0$ | 9.09 | 17.69** | 27.03*** | 14.71* | 22.96*** | 15.21** |
|  | (8) |  | (8) |  | (8) |  |

Note: *** Significant at the 0.01 level. ** At the 0.05 level. * At the 0.10 level. Degrees of freedom for the hypothesis tests are in parentheses.

Do retailers take into account same-store promotions for substitutes when deciding when to put products on promotion? These results, like Pesendorfer's, indicate strongly that the answer is yes. For all 14 hot dog and bun products, the test of joint insignificance of time elapsed for same store substitute promotions is rejected at the 10 percent significance level or lower. The same is true for two of the seven pasta products, all 12 sauce products, four of eight peanut butter products, and eight of 12 possible cases for jelly.

Do retailers take into account the promotions of substitutes at competing chains when setting their promotions? Again, the answer from these results is yes. I reject the null hypothesis of insignificance of competitors' promotions for substitute products for five of the eight hot dogs, four of the six buns, three of the seven pastas, 10 of the 12 sauces, four of the eight peanut butters, and eight of the 12 jellies. Therefore it is evident that retailers are taking into account the promotional activity of direct competitors with respect to close substitutes, defined here as products within the same category.

The remaining questions relate to considerations new to this study. Do retailers take into account same store promotions for close complements when making promotional decisions? The answer is yes, although less clearly. For five of the eight hot dogs, two of the six buns, all four NB pastas, five of 12 pasta sauces, three of eight peanut butters, and nine of 12 jellies the results show that retailers are accounting for same-store complementary promotions, again as indicated by rejections of the null hypothesis of joint insignificance. All told, same-store complementary effects constitute significant determinants of promotional timing for 28 of 53 possible cases, or in more than 50 percent of all hypothesis tests. Overall, Albertsons reflects this consideration more strongly than Safeway, as the test of same store complementary independence is rejected more for Albertsons. This observation is in line with the results in table 2 showing that Albertsons is less likely to simultaneously promote pairs of close complements.
Do retailers take into account promotions on close complements at competing stores when setting promotions? This phenomenon is clearly true among buns and much less so among hot dogs. In general it appears that the decision to place buns on promotion is more responsive to hot dog promotional timing than the converse. Only two hot dog products show promotional responsiveness for competitors' buns, while four of the buns are responsive to competitors' franks. Hence, in terms of promotional timing, hot dogs are more likely to be put on promotion independently of complementary considerations than are buns, whose promotions are shown to respond to those of hot dogs. The greater responsiveness of bun promotions to hot dog promotional timing is in line with intuition from the retailer's perspective. Hot dogs are the larger of the two product categories, in terms of shelf space, product assortment, and total sales. Furthermore hot dogs can potentially be paired with other packaged bread products, eaten alone, or used in larger recipes while hot dog buns have virtually no major use beyond complementing hot dogs.

Examining pasta and pasta sauce in table 7 reveals a similar pattern taking shape as that observed with hot dogs and buns, with respect to competitive complementary considerations. The pasta products show no responsiveness to the timing of competitors' sauce promotions, but competitors' pasta promotions are significant for seven of the 12 sauce products. Pasta is therefore the more likely of the two product categories to be promoted independently of complementary considerations. Pasta is able to stand on its own or be used in a variety of manners without red sauce, while pasta sauce has limited culinary applications beyond being paired with pasta and therefore its sales are very closely tied to those of pasta.

Among peanut butter and jelly, we see that only two of the peanut butter products, both of the Albertsons chain, display responsiveness to competitors' jelly promotions. However for nine of the jelly products the insignificance of competitors' peanut butter promotions is rejected. I am aware of no clear justification for arguing peanut butter to be promoted more independently than jelly, other than the fact that annual peanut butter receipts are approximately three times those of jelly. Rather this phenomenon is more likely a result of the fact that jelly is more promotionally responsive in general. The peanut butter and jelly product categories provide further evidence that retailers take into account the promotions of complements when setting promotional calendars.

Do retailers account for PL promotions when setting NB promotions? The results strongly indicate that they do for these product categories. Joint tests for the insignificance of PL promotional timing are rejected for seven of the 10 NB products among hot dogs and buns, seven NBs among pasta and sauce, and 14 NBs among peanut butter and jelly. This finding constitutes a fresh contribution to the growing literature on NB/PL strategy and interaction. Specifically, it supports the notion of intrastore competition between NBs and PLs that Steiner (2004) argued leads to increases in consumer welfare. Volpe (2011) found strong evidence for this competition in terms of promotional timing. A survey of older studies on the retail landscape reveals that it is only recently
that PLs rose to such prominence in food retailing as to consider the nature and economic implications of NB/PL interaction. (Note 5)
Do retailers account for NB promotions when setting PL promotions? The tests of independence reveal that this is true for three of the four PL products among hot dogs and buns, Albertsons Pasta Sauce, and both Albertsons peanut butter and jelly offerings. This serves as further evidence that PLs are now incorporated into managers' pricing strategies and that NB and PL shoppers are not segmented. ANG noted that NB promotional prices are often close to PL shelf prices, a finding generally supported by the data. Therefore one potential explanation for PL responsiveness to NB promotions is the motivation for retailers to maintain strong PL sales despite NB promotions. Price-conscious shoppers will select an NB on promotion if the sale price is lower than the PL shelf price. As shown in table 2, promotions frequently overlap between NB and PL substitutes.

The PL products subjected to this analysis are promoted heavily, in some cases more often than their NB substitutes. Table 9 compares the average promotional frequency for NB and PL products for all eight product categories studied in this analysis and makes this fact clear. The results show that retailers today are incorporating PL promotions carefully into their overall category management strategies. Thus it is evident that PL promotions have become an integral component of supermarkets' competitive strategies. The findings of this study contribute to the empirical evidence that retailers promote PLs, as found by Shankar and Krishnamurthi (2008), and provide evidence to support the implication of the authors' model that PLs should be promoted with high frequencies at HLP supermarkets.

Table 9. Average promotional frequency for national brand and private label products, by product category

| Product Category | NB Promotional Frequency | PL Promotional Frequency |
| :--- | :--- | :--- |
| Hot Dogs | $28.87 \%$ | $22.77 \%$ |
| Hot Dog Buns | $25.00 \%$ | $53.51 \%$ |
| Pasta | $61.78 \%$ | $74.58 \%$ |
| Pasta Sauce | $51.10 \%$ | $75.75 \%$ |
| Peanut Butter | $17.95 \%$ | $35.29 \%$ |
| Jelly | $30.37 \%$ | $45.32 \%$ |
| Yogurt | $64.63 \%$ | $53.70 \%$ |
| Canned Peas | $45.34 \%$ | $56.92 \%$ |

Source: Safeway.com and Albertsons.com and author's calculations.

The final pair of product categories, family-sized yogurt and canned peas, serves as a robustness check on the results. These two product categories share no obvious complementary relationship in consumption. Therefore subjecting these products to the same analysis as the product pairs for which complementarity is a reasonable assumption allows for an investigation into whether or not significant promotional interrelationships have been identified by the sheer virtue of including several products from both product categories in the estimations of equation (1).
Table 10 reports the results of hypothesis testing on yogurt and canned peas. The yogurt and peas product categories are roughly in line with the other three pairs in terms of substitution effects. The yogurt products are promoted heavily, with frequencies generally lower than those of pasta and pasta sauce, and overall they show relatively low promotional responsiveness. However same store substitutes are jointly significant for three of the seven yogurt products and four of the six varieties of peas. Therefore Pesendorfer's findings with respect to the importance of the timing of promotions for substitutes have held up across all eight product categories examined in this study.

With respect to complements, the results indicate almost no significant relationships between the product categories. Canned peas promotions are jointly significant for yogurt in only three cases out of a total of 14 possible, taking into account same store and competitive effects (Note 6). Yogurt promotions are jointly significant in determining the promotional timing of canned peas in only one case out of 12 , also considering both same store and competitive effects. Hence I observe significance in four cases out of a possible 26, which is approximately in line with the expected Type II error rate at the ten percent significance level. There is no evidence of complementary considerations for the promotional timing of any of the Safeway products. All four of the tests suggesting a relationship between yogurt and canned peas promotional activity occur for products sold in Albertsons stores. The results for these Albertsons products may be the simple result of coincidence in promotions over time resulting from an overarching promotional calendar on the part of the chain that results in yogurt and peas promotions appearing to be staggered intentionally.

Table 10. Hypothesis test results for peanut butter and jelly

|  | Mountain High Vanilla Yogurt, 32oz. |  | Dannon Vanilla Yogurt, 32 oz . |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\chi^{2} \text { test }$ | Safeway | Albertsons | Safeway | Albertsons |  |  |
| $\mathrm{H}_{0}$ : Own Yogurt $=0$ | 24.97*** | 22.90*** | N/A | 10.71 |  |  |
|  | (6) | (8) |  | (8) |  |  |
| $\mathrm{H}_{0}$ : Competitor Yogurt $=0$ | 3.86 | 2.64 | N/A | 10.35* |  |  |
|  | (8) | (8) |  | (6) |  |  |
| $\mathrm{H}_{0}$ : Own Peas=0 | 1.53 | 14.33** | N/A | 9.68 |  |  |
|  | (4) | (6) |  | (6) |  |  |
| $\mathrm{H}_{0}$ : Competitor Peas=0 | 1.99 | 9.20 | N/A | 5.42 |  |  |
|  | (6) | (6) |  | (6) |  |  |
|  | Glen Oaks Drinkable Yogurt, 32 oz. |  | Private label vanilla yogurt, 32 oz. |  |  |  |
| $\chi^{2}$ test | Safeway | Albertsons | Safeway | Albertsons |  |  |
| $\mathrm{H}_{0}$ : Own Yogurt $=0$ | 1.88 | 10.91 | 9.53 | 28.73*** |  |  |
|  | (6) | (8) | (6) | (8) |  |  |
| $\mathrm{H}_{0}$ : Competitor Yogurt $=0$ | 4.19 | 17.45** | 17.76** | 15.99** |  |  |
|  | (4) | (7) | (8) | (8) |  |  |
| $\mathrm{H}_{0}$ : Own Peas=0 | 6.63 | 2.77 | 10.30 | $30.73 * * *$ |  |  |
|  | (6) | (6) | (6) | (6) |  |  |
| $\mathrm{H}_{0}$ : Competitor Peas=0 | 6.41 | 5.40 | 7.55 | 26.09*** |  |  |
|  | (6) | (6) | (6) | (6) |  |  |
|  | Del Monte Sweet Peas, 15oz. |  | Green Giant Sweet Peas, 15 oz. |  | Private Label Canned Peas, 15 oz. |  |
| $\chi^{2}$ Test | Safeway | Albertsons | Safeway | Albertsons | Safeway | Albertsons |
| $\mathrm{H}_{0}$ : Own Yogurt $=0$ | 8.95 | 11.55 | 5.28 | 2.49 | 2.13 | 28.47*** |
|  | (6) | (8) | (7) | (6) | (7) | (6) |
| $\mathrm{H}_{0}$ : Competitor Yogurt $=0$ | 9.70 | 12.00 | 4.89 | 10.00 | 6.79 | 7.21 |
|  | (6) | (7) | (8) | (7) | (6) | (7) |
| $\mathrm{H}_{0}$ : Own Peas=0 | 5.08 | 30.43*** | 13.88** | 12.39* | 5.61 | 14.42** |
|  | (6) | (6) | (6) | (6) | (6) |  |
| $\mathrm{H}_{0}$ : Competitor Peas=0 | 20.90 *** | 17.08*** | 27.89 *** | 3.37 | 15.01** | 10.20 |
|  | (6) | (6) | (6) | (6) | (6) | (6) |

Note: *** Significant at the 0.01 level. ** At the 0.05 level. * At the 0.10 level. Degrees of freedom for the hypothesis tests are in parentheses.

## 4. Conclusions

The results of this study support the notion that supermarket chains are closely monitoring and responding to one another. From summary statistics such as those presented in tables 2 and 3 it is evident that retailers are engaging in practices that have been labeled unprofitable based upon results in the literature, such as promoting NBs simultaneously or promoting close complements simultaneously. However previous studies examining the profitability of promotions, as summarized by Blattberg, Briesch, and Fox (1995), have not accounted for the role of substitutability or complementarity. The accompanying results of the probit estimations show that retailers are explicitly accountingfor complementarity and substitutability in both the interstore and intrastore cases.
Taken in sum, the decision rule estimation results are fully in line with those of Pesendorfer (2002) with respect to the importance of the pricing of substitutes in determining promotional timing. The study provides further evidence that the Varian (1980) model of pricing does not fully account for retailers' competitive considerations. Price promotions over time are dependent on the timing of other promotions and hence are not entirely random or unpredictable. For all eight product categories examined, the effect of substitute promotions is significant for both same store and competitive products. Furthermore, the results show that the complementarity of products, both within stores and at competing stores, is a significant component of the decision making process for retailers when setting price promotions. Promotional response across chains and product categories is the strongest for the pairing of hot dogs and buns, which I posit to feature the strongest complementarity of the four pairs examined in this study.

Finally, the econometric results clearly indicate that NB and PL promotions are far more interrelated than
previous empirical research would suggest. Indeed, for all product categories examined in this study there is evidence that PL promotions affect NB promotional timing and that the converse is also true. Therefore it is evident that PLs today play a major role in the pricing and promotional strategies of conventional supermarket managers and are no longer marketed solely to the demographic of low-income, price-sensitive consumers. Supermarkets place certain PL products on promotions virtually constantly, which is a phenomenon that in itself warrants further exploration. However those PLs promoted less frequently appear to play roles in supermarkets' marketing and competitive strategies that are statistically no different than that of other NB brands within product categories.

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## Notes

Note 1. For certain product categories it was necessary to include potential substitutes that do not match the reported product sizes exactly. Such deviations were performed to incorporate prominent brands whose product sizes varied slightly from the most prevalent size or healthy options that were only sold in a small number of product sizes.
Note 2. For buns, pasta, and jelly the overall biggest seller is the aggregate PLs, and so PLs are used in the complementarity calculations when applicable. The data sharing policy of Nielsen precludes the identification of the top NBs within each category by name.
Note 3. For certain products the inclusion of quadratic terms resulted in model instability, defined by insignificant coefficient estimates of very high magnitudes, due to the low frequency of promotions and thus the estimations for those products include only linear terms.

Note 4. The difference between the closely-related probit and logit estimation techniques for discrete dependent variable models lies in the distributional assumptions of the error term (Griffiths, Hill, and Judge, 1993). Plots of the estimated residuals of several variants on the regressions demonstrated approximate normality on the part of the errors. Moreover, as anticipated, the results from logit regressions on equation (1) (not reported) are very similar to those of the probit estimations.

Note 5. Tellis and Zufryden (1995) argued that retailers should not promote PLs at all, as promotional response
to PLs is very low. However the authors examined only one product category (crackers), and the popularity of PLs has increased significantly in the past 15 years. In the construction of their model of the role of PLs in the channel structure of food retail, Narasimhan and Wilcox (1998) assumed that PLs were not strategic players. Ailawadi, Neslin, and Gedink (2001) (hereafter ANG) used survey data to demonstrate that the best strategy for retailers in general is to promote NBs using the HLP strategy and to price PLs according to EDLP in order to prevent the cannibalization of NB sales during PL promotions.
Note 6. Dannon brand yogurt at Safeway was omitted from the estimation due to the frequency of promotions for the product. Given that it was on promotion for 95 percent of the time series, the regression results for the product yielded meaningless point estimations and precluded all hypothesis testing.
Appendix A: Results of Estimating Equation (1) for Selected Hot Dog and Bun Products
Table A.1. Probit regression results for the promotional timing of Brand 1 and Brand 2 Beef Franks

|  | Brand 1 Beef Franks, 16oz. |  | Brand 2 Beef Franks, 16oz. |  |
| :---: | :---: | :---: | :---: | :---: |
| Chain | Safeway | Albertsons | Safeway | Albertsons |
| Number of sales | 113 | 58 | 104 | 136 |
| Promo Frequency | 37.79\% | 19.39\% | 34.78\% | 45.48\% |
| T_B1Safe | 0.3247* | 0.0099 | -.1784* | -0.061 |
|  | (3.29) | (0.30) | (2.60) | (0.02) |
| T_B1SafeSq | -0.0165 |  | 0.0094 | 0.0225 |
|  | (0.69) |  | (0.36) | (1.74) |
| T_B1Alb | -0.0098 | 0.0336** | -0.0896 | -0.0831 |
|  | (0.01) | (4.32) | (1.09) | (1.00) |
| T_B1Albsq | -0.0011 |  | 0.0079 | 0.0067 |
|  | (0.03) |  | (1.80) | (1.63) |
| T_B2Safe | -0.0787 | 0.0107 | 0.6156*** | 0.2116*** |
|  | (1.07) | (0.62) | (16.26) | (9.33) |
| T_B2SafeSq | 0.0047 |  | -0.0399** | -0.0047 |
|  | (1.61) |  | (6.35) | (1.94) |
| T_B2Alb | -0.1108 | -.1098** | -0.0690 | -0.0847 |
|  | (0.69) | (4.71) | (0.30) | (0.46) |
| T_B2AlbSq | .0215* |  | -0.0035 | 0.0112 |
|  | (2.52) |  | (0.09) | (1.46) |
| T_B3Safe | 0.2652** | 0.0363* | 0.1774** | 0.0874 |
|  | (6.11) | (3.31) | (4.30) | (1.14) |
| T_B3SafeSq | -0.0112* |  | -0.0108** | -0.0042 |
|  | (2.68) |  | (3.76) | (0.56) |
| T_B3Alb | 0.3670** | 0.0596 | 0.0643 | 0.4105** |
|  | (6.00) | (1.72) | (0.19) | (6.34) |
| T_B3AlbSq | -0.0312** |  | -0.0071 | -0.0366** |
|  | (3.90) |  | (0.19) | (4.65) |
| T_B4Safe | -0.2334** | 0.0133 | 0.0942 | 0.1355* |
|  | (4.99) | (0.21) | (1.21) | (2.43) |
| T_B4SafeSq | 0.0148** |  | -0.0051 | -0.0097* |
|  | (4.11) |  | (0.74) | (2.45) |
| T_B4Alb | -0.1517 | 0.0344 | 0.3546** | -0.2080* |
|  | (0.91) | (44) | (6.26) | (2.63) |
| T_B4AlbSq | 0.0233 |  | -0.0373** | 0.0142 |
|  | (1.97) |  | (5.88) | (1.02) |
| T_AlbPLdog | -.1029* | $-0.0568^{* * *}$ | -0.0261 | -0.1381** |
|  | (2.59) | (7.20) | (0.20) | (5.47) |
| T_AlbPLdogSq | 0.0023 |  | 0.0003 | 0.0042*** |
|  | (2.49) |  | (0.07) | (9.06) |
| T_SafePLdog | -0.1971** | -0.0621** | -0.0039 | -0.1319* |
|  | (5.42) | (4.43) | (0.00) | (3.06) |
| T_SafePLdogSq | 0.0121*** |  | 0.0003 | 0.0048 |
|  | (6.69) |  | (0.01) | (1.61) |
| T_AlbPLbun | 0.0822 | 0.0596*** | 0.0371 | 0.0576 |
|  | (1.21) | (10.12) | (0.26) | (0.59) |
| T_AlbPLbunSq | -0.0039 |  | 0.0000 | -0.0009 |
|  | (1.91) |  | (0.00) | (0.11) |


| T_SafePLbun | Brand 1 Beef Franks, 160z. |  | Brand 2 Beef Franks, 16oz. |  |
| :---: | :---: | :---: | :---: | :---: |
|  | -1.7453* | -0.0861 | 1.8463 | 1.1400* |
|  | (2.80) | (0.36) | (1.69) | (2.75) |
| T_SafePLbunSq | 0.6624* |  | -0.7072 | -0.2702 |
|  | (2.55) |  | (1.06) | (1.51) |
| T_B5Safe | 0.0614 | 0.0302* | -0.0138 | 0.0311 |
|  | (1.09) | (3.27) | (0.07) | (0.36) |
| T_B5SafeSq | -0.0026 |  | 0.0005 | -0.0003 |
|  | (1.14) |  | (0.08) | (0.02) |
| T_B5Alb | -0.0029 | 0.0665*** | 0.0266 | 0.0624 |
|  | (0.00) | (8.90) | (0.22) | (1.29) |
| T_B5AlbSq | -0.0016 |  | 0.0016 | -0.0009 |
|  | (0.47) |  | (0.51) | (0.17) |
| T_B6Safe | 0.1177 | -0.0404 | -0.0880 | 0.1496* |
|  | (1.37) | (2.07) | (0.98) | (2.77) |
| T_B6SafeSq | -0.0020 |  | 0.0027 | -0.0126** |
|  | (0.11) |  | (0.20) | (4.58) |
| T_B6Alb | -0.0082 | -0.0015 | -0.1119 | -0.1194** |
|  | (0.01) | (0.00) | (1.46) | (4.58) |
| T_B6AlbSq | -0.0006 |  | 0.0043 | 0.0036 |
|  | (0.02) |  | (1.60) | (0.94) |
| July4th | 1.8516*** | 2.2935*** | 0.6306 | 0.3304 |
|  | (14.01) | (15.46) | (1.03) | (0.59) |
| N | 299 | 299 | 299 | 299 |

Note: Absolute values of $\chi^{2}$-statistics are in parentheses. *** Significant at the 0.01 level. ** At the 0.05 level. * At the 0.10 level.
The explanatory variable names are abbreviations of the product/chain combinations included due to their substitutability or complementarity with the dependent variable. Throughout all right-hand side variables, "Safe" and "Alb" refer to Safeway and Albertsons, respectively. Moreover "Sq" denotes that the variable is a quadratic term. The brand name abbreviations are given as B1-B6 to protect confidentiality, and private label (PL).

Table A.2. Probit regression results for the promotional timing of hot dog buns

|  | Brand 2 Hot Dog Buns, 14oz. |  | Brand 3 Hot Dog Buns, $120 z$. |  | Private Label Hot Dog Buns |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Chain | Safeway | Albertsons | Safeway | Albertsons | Safeway (12oz.) | Albertson (8ct.) |
| Number of sales | 44 | 76 | 114 | 65 | 167 | 153 |
| Frequency | 14.72\% | 25.42\% | 38.13\% | 21.74\% | 55.85\% | 51.17\% |
| T_B1Safe | -0.3307** | $-0.5039 * *$ | 0.0596 | $-0.4110^{* *}$ | $-0.4618$ | $-0.1494$ |
|  | (4.78) | (6.62) | (0.31) | (4.47) | (0.54) | (1.65) |
| T_B1SafeSq | 0.0203** | 0.0290* | -0.0080 | 0.0138* | 0.0666 | 0.0043 |
|  | (3.81) | (2.89) | (0.86) | (3.47) | (0.26) | (1.16) |
| T_B1Alb | 0.3453* | 0.0866 | 0.1591* | 0.5105** | -0.0923 | -0.1400 |
|  | (2.58) | (0.14) | (3.08) | (5.55) | (0.09) | (1.32) |
| T_B1Albsq | -0.0512** | -0.0086 | -0.052** | $-0.0621^{* *}$ | 0.0037 | 0.0130* |
|  | (5.34) | (0.19) | (5.60) | (5.41) | (0.05) | (3.18) |
| T_B2Safe | -0.0076 | 0.4932** | -0.0069 | -0.2291 | 0.2402 | 0.2068** |
|  | (0.00) | (4.04) | (0.01) | (2.17) | (0.84) | (4.84) |
| T_B2SafeSq | -0.0058 | -0.0499* | 0.0014 | 0.0051 | -0.0078 | -0.0064 |
|  | (0.28) | (2.50) | (0.14) | (0.22) | (0.18) | (2.25) |
| T_B2Alb | 0.3227 | -0.1962 | 0.1340 | -0.1335 | 0.3171 | 0.2838* |
|  | (0.63) | (0.61) | (1.01) | (0.32) | (0.49) | (2.48) |
| T_B2AlbSq | -0.1028 | 0.0106 | 0.0011 | 0.0005 | -0.0131 | -0.034** |
|  | (0.77) | (0.21) | (0.01) | (0.00) | (0.08) | (3.97) |
| T_B3Safe | 0.1756 | 0.2713 | 0.0622 | 0.2050 | 0.4032* | 0.1400 |
|  | (0.59) | (1.06) | (0.44) | (1.18) | (2.48) | (1.41) |
| T_B3SafeSq | -0.0174 | -0.0420* | -0.0050 | -0.0134 | -0.0075 | -0.0070 |
|  | (0.86) | (3.49) | (0.69) | (0.95) | (0.18) | (0.86) |
| T_B3Alb | 0.682*** | 0.710*** | -0.1979** | -0.3809** | -0.4533 | 0.1439 |
|  | (8.75) | (10.15) | (3.96) | (4.11) | (1.35) | (0.53) |
| T_B3AlbSq | -0.071*** | -0.057*** | 0.0108* | 0.0265** | 0.0724 | 0.0210 |


|  | Brand 2 Hot Dog Buns, 14oz. |  | Brand 3 Hot Dog Buns, 12oz. |  | Private Label Hot Dog Buns |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| T_B4Safe | (10.00) | (8.31) | (2.57) | (4.41) | (1.83) | (0.72) |
|  | -0.1589 | 0.3951 | -0.2168 | -0.2297 | 0.0156 | -0.569** |
|  | (0.25) | (1.76) | (2.26) | (0.71) | (0.00) | (4.37) |
| T_B4SafeSq | 0.0523 | -0.0647* | 0.0280* | 0.0400 | 0.0378 | 0.1058* |
|  | (1.27) | (2.93) | (3.49) | (0.67) | (0.38) | (3.37) |
| T_B4Alb | -0.5489** | 0.4642 | -0.1662 | 0.3814 | 0.9779* | -0.2682 |
|  | (3.32) | (2.22) | (1.10) | (1.61) | (2.78) | (0.80) |
| T_B4AlbSq | 0.0686** | -0.1145** | 0.0252 | -0.0361 | -0.136** | 0.0637 |
|  | (5.28) | (5.11) | (1.86) | (1.06) | (4.28) | (1.05) |
| T_AlbPLdog | -0.0996 | 0.1012 | -0.0096 | 0.339*** | -0.0188 | -0.21*** |
|  | (0.20) | (0.58) | (0.02) | (8.32) | (0.01) | (10.97) |
| T_AlbPLdogSq | -0.0003 | -0.0036 | 0.0022* | -0.007*** | 0.0023 | 0.005*** |
|  | (0.01) | (1.27) | (2.47) | (7.69) | (0.49) | (13.24) |
| T_SafePLdog | 0.6570** | -0.0865 | -0.0956 | -0.2393 | -1.5119* | -0.0668 |
|  | (4.31) | (0.19) | (1.31) | (1.94) | (2.94) | (0.28) |
| T_SafePLdogSq | -0.0738* | 0.0308 | 0.0035 | 0.0120 | 0.2938 | 0.0101 |
|  | (2.65) | (1.10) | (0.66) | (2.04) | (2.24) | (1.58) |
| T_AlbPLbun | 0.0881 | 0.6078* | -0.0393 | -0.2633 | -1.736** | 0.2618* |
|  | (0.18) | (3.48) | (0.18) | (1.94) | (6.36) | (3.07) |
| T_AlbPLbunSq | -0.0175 | -0.0246* | 0.0010 | 0.0102* | 0.0834* | -0.0074* |
|  | (1.32) | (2.52) | (0.09) | (2.52) | (3.05) | (2.52) |
| T_SafePLbun | 0.4478 | -0.5506 | 1.9058** | -0.8177 | 5.19*** | 0.7877 |
|  | (1.01) | (0.01) | (6.34) | (0.06) | (16.72) | (1.15) |
| T_SafePLbunSq | -0.0204 | 0.2397 | -0.4656** | 0.0993 | 0.692*** | -0.0078 |
|  | (1.35) | (0.45) | (3.96) | (0.25) | (6.70) | (0.79) |
| T_B5Safe | 1.7647*** | -0.0897 | -0.0499 | -0.0513 | -0.2688 | 0.275*** |
|  | (15.92) | (0.19) | (0.56) | (0.19) | (0.66) | (8.94) |
| T_B5SafeSq | -0.0020 | 0.0535* | 0.0007 | 0.0039 | 0.0288 | -0.0068* |
|  | (1.44) | (3.07) | (0.07) | (0.52) | (0.98) | (2.59) |
| T_B5Alb | 0.1097 | 1.6511*** | -0.0924 | -0.2175** | -0.3579* | -0.0306 |
|  | (0.94) | (8.88) | (1.42) | (4.10) | (2.52) | (0.16) |
| T_B5AlbSq | -0.0093** | -0.0020 | 0.0059 | 0.0066* | 0.0092 | 0.0023 |
|  | (3.78) | (0.54) | (0.03) | (2.90) | (1.92) | (0.58) |
| T_B6Safe | 0.0016 | 0.7616** | 0.9947*** | 0.1132 | -0.3002 | -0.0384 |
|  | (0.00) | (6.50) | (18.98) | (0.46) | (1.02) | (0.09) |
| T_B6SafeSq | -0.0136 | -0.0563* | 0.0090*** | -0.0147 | 0.0165 | -0.0130 |
|  | (1.39) | (3.24) | (8.94) | (1.33) | (0.65) | (1.83) |
| T_B6Alb | 0.0850 | 0.1615 | 0.2281* | 1.6806*** | 0.0450 | 0.5286 |
|  | (0.13) | (0.22) | (3.44) | (13.75) | (0.01) | (1.49) |
| T_B6AlbSq | -0.0141 | -0.0074 | -0.0089** | 0.0007 | 0.0167 | -0.193** |
|  | (1.81) | (0.58) | (3.85) | (0.24) | (0.29) | (4.15) |
| July4th | -0.1664 | -1.2268 | -0.0962 | 0.3791 | 0.6086 | -0.5472 |
|  | (0.06) | (0.79) | (0.04) | (0.33) | (0.11) | (1.16) |
| N | 299 | 299 | 299 | 299 | 299 | 299 |

[^0]
[^0]:    Note: Absolute values of $\chi^{2}$-statistics are in parentheses. ${ }^{* * *}$ Significant at the 0.01 level. ${ }^{* *}$ At the 0.05 level. * At the 0.10 level.

