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Supermarket Pricing and Promotional Behavior: Evidence from the San Luis Obispo Market

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Abstract

We collected price and promotional data from seven supermarkets operating in San Luis Obispo, CA, for one year, from 2017 to 2018. Using the data, we created a series of variables to measure prices and promotional activity. These variables were subjected to an exploratory regression analysis. The research uncovered a number of findings that help explain price variation in supermarkets and motivate future research. Average prices, price variation, promotional frequency, and promotional depth are all interrelated in important, and in some cases unexplored, ways.

Keywords: food prices food retail, pricing behavior, retail behavior

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Introduction

Supermarket pricing behavior is studied across multiple disciplines for diverse reasons. Retail food prices have direct implications for consumer welfare and the nature of price pass-through helps to shine light on the structure and functionality of the food supply chain. Many more examples abound throughout the fields of marketing, policy, and industrial organization. We seek to contribute to the literature on the empirical nature of supermarket pricing and promotional behavior, while raising questions to help motivate future research on the topic.

This study uses price and promotional data collected directly from seven supermarkets operating in San Luis Obispo, CA, to conduct a descriptive analysis of the degree to which price levels, promotional activity, and price variation are interrelated. We studied 30 distinct product categories in order to create a dataset that captures the meaningful variation within the supermarket. Product categories vary considerably in terms of their purchase penetration (the share of households purchasing items) and frequency (how often items are purchased) (Dhar, Hoch, and Kumar, 2001), as well as other factors such as the number of competing brands, storability, positioning in the supermarket, and promotional activity.

The variables of interest in the study are price levels, price variation, the price differences among national brands (NBs) and private labels (PLs) within product categories, and promotional frequency and depth. These variables partially comprise the so-called "marketing mix," or the key measurements of retailer marketing behavior and strategy.[1] We describe and discuss each in turn below. This study sought to measure how these factors vary across supermarket categories and the extent to which they are associated with one another. Each of these topics has been studied considerably, but they are typically not considered in conjunction with each other. The primary goal of our study was to provide broad insights into supermarket strategy and to inform future studies that seek to identify causal relationships connecting pricing and promotional behavior with store and category characteristics.

Food prices and variation therein are surely the two most studied aspects of retailer strategy. Our study is in the vein of Hosken and Reiffen (2004), Nakamura and Steinsson (2008), and Richards, Hamilton, and Allender (2016) in that we sought to measure and describe average food prices and price dispersion, rather than identify the determinants of these factors. Understanding and measuring retailer behavior via pricing provides insights into the study of price rigidity, input price pass-through, competitive action, and other aspects of retailer behavior.

The remainder of the paper proceeds as follows: We discuss a general background for supermarket pricing strategies, hypotheses that were evaluated in this study, the data collection process, the resulting dataset, and the stores visited for the study. We describe our methodology and present our results. We discuss our results and the extent to which our findings conformed to the hypotheses evaluated in this study. We conclude with the limitations of our study and ideas for future research.

[1]The marketing mix is typically said to include product placement, which is not a factor measured or included in our study.

Background

Nearly all supermarkets carry a mix of both NBs and PLs. The former are available in identical format across competing retailers, while the latter (also known as store brands) are marketed as being unique to the retailer at which they are being sold. The price difference between NBs and PLs within product categories are of interest for multiple reasons. This margin is often thought of as a measure of the relative quality of PLs, with wider NB/PL margins indicating stark quality differences and narrow margins indicating more comparable quality among products. Both Bontemps, Orozco, and Réquillart (2008) and Ward et al. (2002) studied the NB/PL margin as a measure of PL sales penetration and found that NB prices rise, on average, as PL market share increases. Volpe (2014) showed that the NB/PL margin varies with economic conditions, narrowing as average food prices rise. In an extensive review of the literature on PLs, Olbrich, Hundt, and Jansen (2016) recommend price gaps between NBs and PLs as one of the four most important research areas on PLs, looking forward.

Supermarkets set prices based on pricing strategies, and nearly all retailers use either high/low pricing (HLP), everyday low pricing (EDLP), or a combination of both (Ellickson and Misra, 2008). The key difference between the two is that the former relies on the use of promotions, or temporary and advertised price reductions. The academic literature on supermarket promotional activity is vast, with many studies seeking to measure the impact of promotions on sales and profitability. McColl, MacGilchrist, and Rafiq (2020)'s study is one recent example, demonstrating that promotions in large supermarkets often lead to cannibalization, or the increase in sales of one brand at the expense of others within product categories. Another is Budd et al. (2017), who used experimental design to demonstrate that promotions targeting healthy foods can increase the sales of these options. We followed the marketing literature (e.g., Bogomolova et al., 2015) and quantified promotional activity using frequency and depth. These are measured as the share of weeks that the items are on promotion and the percentage discount offered by promotions, respectively. Both of these measures have been studied in the context of their impacts on sales. However, little is known about how they interact with product characteristics or other aspects of retailer pricing strategy.

Hypotheses

While this study was exploratory in nature, extant economic and marketing research leads to a number of expectations with respect to associations among our marketing mix variables. The HLP strategy is associated with higher average prices (e.g., Bell and Lattin, 1998); therefore, we expected higher average shelf prices to be associated with promotional frequency and depth.

This phenomenon has been observed across stores and retail formats but, to our knowledge, has not been studied across products or categories. We expected promotional frequency and promotional depth to be inversely associated. Marketing scientists have shown that retailers and consumers alike perceive a tradeoff between promotions that are frequent and shallow and promotions that are infrequent and deep (Sivakumar, 1996; Sheehan, Hamilton, and Chellappa, 2019).

With respect to the NB/PL price differences, expectations were largely unclear in our setting. The bulk of the research on NB/PL competition and dynamics focuses on market share within product

categories. Brüggemann, Olbrich, and Schultz (2020)'s study is a recent example of research in this arena that informs expectations for our purposes. The authors found that more NBs within categories, higher NB promotional activity, and lower NB prices were all associated with higher NB market share. Therefore, we expected that larger product categories and those with higher promotional frequency would be associated with higher NB/PL price differences, indicative of lower PL market share and potentially lower PL quality.

We expected both store size and category size to share associations with retail prices. Research on several fronts has shown that food prices are lower in larger stores and retail formats, likely due to efficiencies and scale (e.g., Chung and Myers, 1999; Saitone, Sexton, and Volpe, 2015). Thus, we expected that store size would be negatively associated with average prices. Very little empirical work has linked category size, as measured by shelf space, brand count, or product count, with food prices or promotional activity. Standard industrial organizational theory posits that product categories with more brands will see lower prices and increased promotional activity, as there is stronger competition for market share.

Finally, the literature on price rigidity offers some expectations with respect to the marketing mix. Much of the research on price variation and rigidity in food retail focuses on the impacts of upstream costs. Supermarkets face high menu costs (i.e., costs associated with changing prices). One of the advantages of the EDLP strategy is fewer price changes and, therefore, reduced menu costs (Levy et al., 1997). Thus, we expected that promotional activity, particularly promotional frequency, would be positively associated with price variation over time.

Data

A research team at Cal Poly collected price and promotional data directly from seven supermarkets in San Luis Obispo, CA, via weekly visits.[2] The stores included Vons, Ralphs, Smart and Final, Trader Joe's, Whole Foods, California (CA) Fresh Market, and Food 4 Less. The relative locations of the stores studied are shown in Figure 1. The average driving distance among the stores, examining them pairwise, is 2.63 miles. Vons and Ralphs are traditional supermarkets and are banners in national retail chains, owned by Albertsons and Kroger, respectively. Food 4 Less and Smart and Final are both warehouse format supermarkets, focusing on low prices and limited customer service. Trader Joe's is a limited assortment supermarket, selling its own PL brand nearly exclusively for most product categories. Whole Foods is a natural/gourmet supermarket, emphasizing fresh and organic foods and a high degree of customer service. It also features a limited availability of NBs. Finally, CA Fresh Market is a three-store independent grocer without a PL option in most product categories. The stores visited, as well as descriptive characteristics of these stores, are included in

[2]The research team consisted of six undergraduates, forming two teams of three each. One team collected price data from October 2017 through June 2018, then again from September 2018 through October 2018. The other team collected price data from June 2018 through September 2018. Within each team, one research assistant was assigned three stores to visit, while the other two were assigned two each. Each week, students visited their assigned stores unless travel or other obligations required team members to substitute for one another. One research assistant, Nicole Tedjasaputra, remained involved in the project and is a coauthor of the study.

Table 1. We also include demographic data, as drawn from the census tracts, to show that these stores operate in diverse environments, as defined by the nearby household characteristics.

Figure 1. Location of the Stores Included in the Analysis

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Table 1. Store Characteristics

Store	Square Footage[a]	Num. Registers	Num. Aisles	Pricing Strategy	Median HH Income[b]	Number of Households	Unemployment Rate
Trader Joe's	12,000	8	4	EDLP	$91,641	1,315	1.81%
Vons	45,000	11 (4 self-checkout)	11	HLP	$91,641	1,315	1.81%
Ralph's	45,000	7	21	HLP	$41,921	2,831	3.18%
CA Fresh Market	18,000	6	8	EDLP	$41,921	2,831	3.18%
Food 4 Less	50,000	10	15	HLP	$91,641	1,315	1.81%
Whole Foods	30,000	8	14	EDLP	$70,642	2,815	3.31%
Smart and Final	40,000	6	23	HLP	$40,292	1,832	5.63%

Notes: [a]These numbers are approximate and are based on estimates provided by employees. The authors are responsible for any errors. [b]Demographic data were drawn from the American Community Survey (ACS) 2016 5-year estimate. The unemployment rate is an estimate calculated as the number of unemployed persons over age 16, divided by the total number of persons over the age of 16.

The authors visited each store once per week, on Tuesday, to ensure that price and promotional changes were captured in the week they occurred. The dataset includes 30 product categories. The categories were selected largely out of convenience. We consulted marketing literature and visited the stores in question to identify product categories that were available in identical or similar formats across all stores, were easily visible for the researchers to find, and spanned all of the major supermarket departments. For each category, we sought to record data on the leading NB (as determined by availability across all seven stores) and the store's comparable PL, if applicable in both cases. In some cases, it was not possible to measure NBs and PLs within categories. For example, Trader Joe's is a limited assortment supermarket with few to no NBs, and CA Fresh Market is an independent supermarket with relatively few PL offerings. For simplicity, we characterize all fresh produce as "bulk" and are unconcerned with brands, to the extent they are labeled for consumers. Table 2 summarizes the dataset according to product categories.

Table 2. Product Descriptions and Average Prices Across All Stores

Product Category	Brand	Avg Shelf Price	Avg Promo Price	Average NB/PL Difference
Soda (6-pack cans)	Coca-Cola	$2.05	$1.39	43.29%
	Private label	$1.32	$0.91	
Coffee (12 oz.)	Folgers	$7.56	$5.10	48.52%
	Private label	$4.61	$2.42	
Tuna (5 oz.)	Bumble Bee	$1.52	$1.11	17.24%
	Private label	$1.28	$1.13	
Cereal (12 oz.)	Cheerios	$4.15	$2.57	47.18%
	Private label	$2.57	$1.00	
Potato chips (8 oz.)	Lays	$3.24	$2.26	27.78%
	Private label	$2.54	$1.56	
Macaroni and cheese (7.25 oz.)	Kraft	$1.55	$1.13	63.04%
	Private label	$0.81	$0.76	
Pasta sauce (26 oz.)	Prego	$2.91	$2.03	34.54%
	Private label	$2.05	$1.16	
Peanut butter (16 oz.)	Jif	$3.55	$2.18	29.17%
	Private label	$2.65	$1.76	
Cookies (13 oz.)	Chips Ahoy	$3.27	$2.17	41.68%
	Private label	$2.14	$1.40	
Hazelnut spread (13 oz.)	Nutella	$4.82	$3.90	46.93%
	Private label	$2.99	N/A	

Table 2. (continued)

Product Category	Brand	Avg Shelf Price	Avg Promo Price	Average NB/PL Difference
Ketchup (20 oz.)	Heinz	$3.18	$2.09	50.61%
	Private label	$1.90	$1.42	
Pancake mix (40 oz.)	Bisquik	$3.69	$2.49	30.82%
	Private label	$2.47	$1.36	
Eggs (dozen)	Egglands	$3.53	$2.16	13.81%
	Private label	$3.07	$2.10	
Milk (gallon)	Alta Dena	$4.78	$3.51	32.28%
	Private label	$3.45	$2.37	
Almond milk (1/2 gal.)	Almond Breeze	$3.50	$2.51	5.84%
	Private label	$3.30	$2.14	
Orange juice (1/2 gal.)	Simply Orange	$4.38	$3.00	29.91%
	Private label	$3.24	$2.37	
Cheddar cheese (2 lb.)	Tillamook	$9.68	$6.62	31.51%
	Private label	$7.05	$4.27	
Butter (1 lb.)	Land O'Lakes	$5.98	$3.64	36.65%
	Private label	$4.17	$2.76	
Ice cream (1/2 gal.)	Breyers	$4.52	$3.90	29.56%
	Private label	$4.09	$2.22	
Frozen waffles (12.3 oz.)	Vans	$3.07	$2.17	31.44%
	Private label	$2.23	$1.52	
Frozen broccoli (10 oz.)	Birdseye	$2.75	$1.94	51.25%
	Private label	$1.63	$1.21	
Chicken breasts (1 lb.)	Foster Farms	$5.39	$2.58	28.38%
	Private label	$4.05	$1.33	
Bacon (1 lb.)	Oscar Mayer	$8.31	$4.89	35.84%
	Private label	$5.78	$2.99	
Ground turkey (1.25 lb.)	Jennie-O	$5.16	$2.37	14.80%
	Private label	$4.45	$2.37	
Fuji apples (1 lb.)	Bulk	$1.34	$1.07	
Russet potatoes (1 lb.)	Bulk	$1.00	$0.95	
Baby carrots (1 lb.)	Bulk	$1.50	$1.00	
Zucchini (1 lb.)	Bulk	$1.84	$1.26	
Romaine lettuce (head)	Bulk	$1.42	$0.95	
Bananas (1 lb.)	Bulk	$0.67	$0.54	

The research team collected the data over a one-year period, from October 2017 through October 2018. Each week, the shelf price was recorded, as well as a binary indicator reflecting whether the product in question was on promotion. If on promotion, the promotional price was also recorded.[3] Using the raw price and promotional data, we created the variables to be used in our analysis. These are reported and defined in Table 3, along with summary statistics. Most of the marketing mix variables are calculated using the primary price data, as collected by the authors. The authors estimated category size by measuring the length of the shelves within product categories and multiplying by the number of shelves. It does not take into account the depth of shelves and is, therefore, an estimate. Brand count is a count taken by the authors during store visits and does not include product variations within companies (e.g., flavor or package size differences by brand). Square footage is an estimate of the selling space, per store, and is based on estimates made by store employees, shared in conversation with the authors. We created the dummy variable for HLP pricing at the product level, rather than the store level. Ellickson and Misra (2008) studied more than 17,000 supermarkets and found that 38% of them used a combination of HLP and EDLP, meaning that pricing strategies vary by department or product categories. If a product has a promotional frequency of 10% or greater, it is classified as HLP in our dataset.[4]

[3]For Ralphs and Vons, shoppers are required to have membership cards, which are free to obtain, in order to redeem promotional prices.

[4]We experimented with 5% and 15% as thresholds as well, given that we could find no widely accepted point of delineation between HLP and EDLP in the literature. Using these alternate thresholds does not change the results.

Table 3. Summary Statistics and Variable Definitions

Variable	Definition	Mean	Std Dev	Minimum	Maximum
Average shelf price	The average weekly nonpromotional price, across all stores.	3.38	2.08	0.19	12.90
Normal shelf price	The normalized weekly average shelf price, calculated as the average shelf price divided by the average of all products' shelf prices, by store.	1.00	0.60	0.07	3.51
Coefficient of variation shelf price	The coefficient of variation of the shelf price, calculated as the standard deviation divided by the mean.	0.45	0.13	0.00	0.67
Average promotional price	The average weekly promotional price, across all stores. This is only reported during promotions and is blank otherwise.	2.99	1.76	0.49	10.15
Coeffience of variation promotional price	The coefficient of variation of the promo price, calculated as the standard deviation divided by the mean.	0.29	0.21	0.00	0.89
Promotional frequency	The share of weeks that a product was on promotion during the data collection period.	0.35	0.36	0.00	1.00
Promotional depth	The average percentage difference between the shelf price and the promotional price.	0.19	0.13	-0.55	0.57
NBPL shelf difference	The average percentage difference between national brand and private label shelf prices within product categories.	0.28	0.13	-0.03	0.57
Brand count	The estimated number of unique brands offered, by product category and store.	8.57	7.90	0.00	44.00

Table 3. (continued)

Variable	Definition	Mean	Std Dev	Minimum	Maximum
Category size	The estimated square footage of product categories, by store. This is calculated as the estimated length of product shelves by the number of shelves.	47.29	59.24	0.75	333.33
Square footage	The size of the stores visited for this study, as measured by retail space square footage, and estimated by store employees, in thousands.	36.84	12.41	12.00	50.00
Registers	The number of checkout aisles, or registers, by store. This includes self-checkout.	8.07	1.86	6.00	11.00
HLP	A dummy variable equal to 1 for store/product combinations that are on promotion more than 10% of the time, or follow the high-low pricing strategy.	0.55		0.00	1.00

As a starting point in our empirical analysis, we calculated averages for all variables by store. The results are reported in Table 4. The highest average shelf prices are at CA Fresh Market and the lowest are at Trader Joe's. However, the objective of this study was not to rank or categorize retailers according to average price levels. Comparing average prices for food baskets is problematic for multiple reasons. First, in the calculation of average prices, relatively more expensive items are given disproportionately more weight than cheaper items. Second, without purchase data, it is impossible to determine how well these prices reflect what prices consumers actually pay, on average. And finally, many of these comparisons are not exact across stores. For example, Trader Joe's sells only PLs, which are nearly always cheaper than NBs.

Table 4. Sample Means of Variables Included in Estimated Regressions by Store

Variable	California Fresh Market	Food 4 Less	Ralphs	Smart and Final	Trader Joe's	Vons	Whole Foods
Average shelf price	$3.99	$3.37	$3.17	$3.03	$2.66	$3.93	$3.50
Normal shelf price	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Coefficient of variation shelf price[a]	0.51	0.51	0.51	0.47	0.09	0.48	0.51
Average price	3.50	$2.76	$2.76	$2.72	N/A	$3.39	$2.69
Coefficent of variation promotional price	0.27	0.39	0.26	0.30	N/A	0.40	0.05
Promotional frequency	0.31	0.67	0.25	0.25	N/A	0.55	0.03
Promotional depth	0.22	0.23	0.19	0.14	N/A	0.18	0.22
NBPL shelf difference	N/A	0.27	0.32	0.28	N/A	0.24	0.25
Brand	11.46	6.35	11.17	8.17	1.54	10.04	8.51
Count category size	34.28	49.51	66.30	41.13	14.17	66.04	31.86

[a]CV is the coefficient of variation, measured as the standard deviation divided by the mean.

Shelf price variation is consistent across stores. The coefficient of variation (CV), which is the sample standard deviation divided by the sample mean, is equal to 0.51 for CA Fresh Market, Food 4 Less, Ralphs, and Whole Foods. It is only slightly less for Smart and Final and Vons. The CV is nearly zero for Trader Joe's, which practices strict EDLP and rarely changes prices. Therefore, excluding promotions, food prices in the sample varied similarly throughout the sample. This may reflect consistent responses by retailers to changes in market fundamentals and warrants further investigation.

Promotions were commonplace at five of the seven retailers in the sample. No promotions were observed at Trader Joe's during the data collection, and very few were observed at Whole Foods. However, the average product in the sample was on promotion 67% of the time at Food 4 Less and 55% of the time at Vons. We do not claim that our sample of products is accurately representative of the entire product mix at the respective stores, but it is worth noting that this intensity of promotional activity exceeds that measured by studies using scanner data (e.g., Hosken and Reiffen, 2004). At Ralphs, Smart and Final, and CA Fresh Market, the average product in the sample was on sale between 25%-31% of the time. On average, Smart and Final, which featured relatively low average shelf prices, had the lowest average promotional depth, at 14%. The deepest promotions were at Food 4 Less, with an average depth of 23%. Therefore, Food 4 Less engaged in the heaviest promotional activity out of all the sampled retailers.

The average NB/PL shelf price difference, in percentage terms, was also fairly consistent across stores. The difference ranged from 24% at Vons to 32% at Ralphs. The averages in the sample corroborate those of Volpe (2011), who measured the NB/PL price difference across hundreds of product categories for Safeway and Albertsons (before they merged) and found an average of 23%.

Finally, the sampled stores exhibit considerable variation with respect to average brand counts and category size. The data indicate that with more brands, category size increases, as expected. Trader Joe's, focusing primarily on its own PL, features fewer than two brands per sampled category, on average. Alternatively, CA Fresh Market, Ralphs, and Vons all average more than 10 brands per category. One motivating factor behind sampling a variety of stores and product categories is that elements of retail strategy and pricing behavior depend on the breadth and depth of product categories.

Given the exploratory and descriptive nature of this study, we calculated pairwise correlations for all of the continuous variables in our analysis. In doing so, we were able to examine whether the associations among our variables corroborate empirical evidence to date, and also identify potential elements of supermarket pricing and promotional behavior that is worth exploring in future research. We report the correlation coefficients for selected variables in Table 5.

Table 5. Correlation Coefficients for Selected Continuous Variables Included in the Estimated Regressions

	Avg Shelf Price	**Normal Shelf Price**	**CV Shelf Price**	**Avg Promo Price**	**Promo Freq**	**Promo Depth**	**NBPL Shelf Dif**	**Brand Count**	**Category Size**	**Sq Footage**	**Registers**
Average shelf price	1.00	0.97***	0.09	0.95***	0.27***	0.17**	0.00	-0.04	-0.15**	0.03	0.08
Normal shelf price		1.00	-0.02	0.93***	0.24***	0.17**	0.04	-0.09	-0.21**	0.00	0.00
Coefficient of variation shelf price			1.00	-0.11	-0.19**	0.15**	0.24**	0.13**	0.16**	0.27**	0.00
Average promotional price				1.00	0.17*	-0.12	0.02	-0.04	-0.19***	-0.07	0.07
Promotioal frequency					1.00	0.20***	0.00	0.01	0.24***	0.41***	0.27***
Promotional depth						1.00	0.02	-0.01	0.07	0.09	0.01
NBPL shelf difference							1.00	0.04	-0.08	0.05	-0.17*
Brand count								1.00	0.64***	0.24***	-0.05
Category size									1.00	0.29***	0.09
Square footage										1.00	0.46***
Registers											1.00

Note: ***Indicates that the Pearson correlation coefficient is significant at the 0.01 level, **at the 0.05 level, and *at the 0.10 level.

Some of the estimated correlation coefficients warrant discussion because of their statistical significance and magnitude. The promotional activity variables shared a number of intriguing correlations with other variables in the analysis. Throughout the discussion of correlations, we discuss only those coefficients that are statistically different from zero. As expected, all price measurements share very strong and significant positive correlations. That is, both nominal and normalized shelf prices, as well as promotional prices, are all strongly pairwise correlated, an observation with implications for regression specification design.

Promotional frequency is positively correlated with average and normalized shelf prices, as well as average promotional prices. Therefore, it seems that higher-priced items go on sale more frequently. Frequency is negatively correlated with the CV of shelf prices, which suggests that shelf price rigidity increases with promotional activity, implying that for some products, retailers adjust prices primarily through promotions. The correlations between average and normalized prices with promotional depth are weaker than those with frequency. Importantly, depth is positively correlated with the CV of shelf prices, suggesting some divergence with respect to retailers' use of timing versus depth for sales. Promotional frequency and depth share are positively correlated, which means that at least some products exhibit both deep and frequent promotions. Promotional frequency is positively associated with category size, register count, and store square footage, showing that promotional activity tends to be higher in larger categories and larger stores. Depth shares no significant correlations with category or store characteristics.

The NB/PL price difference shares a positive correlation with the CV for shelf prices. Therefore, on average, the price difference widens between NBs and PLs within product categories as shelf prices become more volatile, and vice versa. The NB/PL price difference is negatively correlated with the register count, meaning that, on average, NB and PL substitutes are priced somewhat closer to one another in larger stores.

The brand count and category size variables both share a number of associations in the data that reflect potential unexplored aspects of retailer strategy and the price-setting process. Not surprisingly, the two variables share a strong and positive correlation, showing that physically larger categories are likely to have more competing brands than smaller ones. Brand count is positively correlated with shelf price CV, meaning that prices change more often in categories with more brands. This may be a function of interbrand competition, including the aforementioned NBs and PLs. Brand count and category size are also positively correlated with square footage, suggesting an intuitive positive relationship between store size and product assortment. The correlation between category size and shelf price CV is also positive, though weaker. Category size is negatively correlated with average and normalized shelf prices, as well as average promotional prices. Taken together, the data suggest that supermarket categories with a greater number of products have lower shelf prices and more intense promotional activity, all of which may also relate to the nature of competition among brands.

As noted, we used both square footage and register count as related, but distinct, measures of store size. The two variables share a positive and significant correlation, but at 0.46, it is clear that larger store footprints do not always result in more registers. Stores exhibit variation in the size and

efficiency of their registers and checkout lanes. Square footage is positively correlated with the CV of shelf prices, suggesting that prices vary more in larger stores, even in the absence of any promotional activity. This is consistent with the notion of cost efficiencies, or that menu costs are smaller in percentage terms for larger stores.

Methodology

To quantify associations among price and promotional variables, we employed a regression framework and estimated a series of ordinary least squares (OLS) regressions. Our goal in this framework was to investigate our hypotheses of interest described in the background section, estimate the magnitudes of associations, and assess significance when possible, not to claim or infer causality. Therefore, we employed a generalized regression model that describes each individual continuous variable of interest as a function of all others. To measure associations, marketing mix variables were modeled as

$$\begin{aligned} Variable_{ij} \\ = f(&Norm\,Shelf\ Price_{ij}, Avg\ Shelf\ Price_{ij,}\ CV\ Shelf\ Price_{ij}, Avg\ Promo \\ &Price_{ij}, \\ &Promo\ Freq_{ij}, Promo\ Depth_{i}\ , Brand\ Count_{ij}, Category\ Size_{ij}, Sq\ Footage_{ij}, \\ &No.of\ Registers_{ij}, HLP_{ij}) + error_{ij} \end{aligned} \tag{1}$$

for product category i and brand j. The purpose of (1) is to measure associations among the full suite of marketing mix variables as well as category and store characteristics, while avoiding evident multicollinearity. Our empirical strategy was to estimate (1) for a the full series of variables of interest, maintaining the righthand side variables consistent, except for the one being used as the dependent variable for each estimation. We experimented with nested versions of (1) for most variables to assess the robustness of our findings, and these results are available from the authors upon request. The data were cleaned of potential outliers to correct any mistakes made in the data collection and entry processes. To account for potential heteroskedasticity, we used robust standard errors that are clustered by store. We calculated the variance inflation factors (VIFs) and conditional index numbers for each estimation of (1) to check for multicollinearity.[5] Average shelf price (Avg Shelf Price) was collinear with normal shelf price (Norm Shelf Price) and average promotional price (Avg Promo Price) in almost all estimated regression specifications of (1).

Model (1) includes store-level variables reported in Table 1. These include square footage (Sq Footage), number of registers (Registers), and high-low pricing (HLP). Recall that Sq Footage is an estimate drawn from conversations with store employees. Registers is a count of the checkout lanes, taken by the authors during data collection. HLP is the dummy calculated per product and

[5]There is no diagnostic measure agreed upon to investigate potential multicollinearity in OLS models. We employ two of the most common to develop consensus when investigating this potential issue in our estimations. The variance inflation factor is typically thought to represent serious multicollinearity at values of 10 or higher (O'Brien, 2007) .Condition index numbers indicate serious collinearity when two conditions are met-the condition index must be above the threshold of 30, and at least two explanatory variables must individually account for at least 90% of the total variance (Hair et al., 2013).

store combination. We also estimated (1) with store fixed effects, but our preferred estimation results include the store characteristics, as they provide superior model fit (as measured by the adjusted R-squared) in most cases and make our findings more generalizable. The number of aisles was found to be highly collinear with the number of registers in preliminary regressions, and we opted to include only regression using registers due to the heterogeneity of aisle size and length across stores. To assess model fit, we relied on the adjusted R-squared. We also calculated and reported the model F statistics.

Results

We present our regression results in two separate tables, partially to facilitate presentation, but also because we wished to separate the results that speak directly to the retail marketing mix from those that address price variation or rigidity. Given that we measured average prices in two distinct, but related, ways, we estimated (1) for each variable in the marketing mix twice, once using average shelf prices and once using normalized shelf prices. This process intended to lend robustness to the findings. Also, due to multicollinearity, it was never possible to include the average promotional price in (1). Table 6 reports selected regression results for OLS estimations of (1), with marketing mix variables measuring price levels and promotional activity.[6] The estimations on the NB and PL price shelf price differences (NBPL Shelf Dif) were limited in scope, because that variable could only be calculated for a limited number of stores and categories, depending on the availability of PLs. These estimations featured a sample size of 78 and resulted in only CV shelf price (CV Shelf Price) and register count being statistically significant. The correlation between CV Shelf Price and the NBPL price difference was one of the stronger pairwise correlations in the data. Nonetheless, it is important to note that the CV Shelf Price varies relatively little in our dataset. The adjusted R-squared and the F statistics associated with the NBPL Shelf Dif regressions suggest that our model specifications explain very little of the variation of NBPL Shelf Dif, despite having two statistically significant coefficients.

[6]We also experimented with estimating versions of (1) for multiple dependent variables in a system setting using seemingly unrelated regression (SUR). Given our limited sample size, SUR may have yielded efficiency gains in the estimation. However, the results were not qualitatively different from the OLS results. The SUR results are also available from the authors upon request.

Table 6. Regression Results on Prices and Promotions

	NBPL Shelf Dif	NBPL Shelf Dif	Norm Shelf Price	Avg Shelf Price	Promo Freq	Promo Freq	Promo Depth	Promo Depth
Intercept	-0.320	-0.334	2.074*	6.376*	-1.325***	-1.307***	-0.074	-0.061
	(0.287)	(0.330)	(1.123)	(3.951)	(0.459)	(0.459)	(0.227)	(0.227)
Average shelf price	0.005					0.008		0.008**
	(0.007)					(0.009)		(0.004)
Normal shelf price		0.019			0.034		0.033**	
		(0.023)			(0.031)		(0.015)	
Coefficient of variation shelf price	1.152**	1.165**	-1.995	-5.451	1.603*	1.581*	0.434	0.417
	(0.600)	(0.601)	(2.070)	(7.280)	(0.851)	(0.851)	(0.415)	(0.415)
Promotional frequency	0.053	0.051*	0.197	0.552			0.047	0.049
	(0.056)	(0.056)	(0.182)	(0.639)			(0.036)	(0.036)
Promotional depth	0.021	0.018	0.818**	2.648**	0.200	0.208		
	(0.139)	(0.140)	(0.371)	(1.307)	(0.155)	(0.155)		
Brand count	0.001	0.000	0.004	0.017	-0.002	-0.003	-0.002	-0.002
	(0.003)	(0.003)	(0.008)	(0.028)	(0.003)	(0.004)	(0.002)	(0.002)
Category size	0.000	0.000	-0.002**	-0.007*	0.001*	0.001*	0.001**	0.001**
	(0.000)	(0.000)	(0.001)	(0.004)	(0.000)	(0.000)	(0.000)	(0.000)
Square footage	0.003	0.003	0.001	-0.040**	0.001	0.002	-0.001	-0.001
	(0.004)	(0.004)	(0.006)	(0.021)	(0.002)	(0.003)	(0.001)	(0.001)

Table 6. (continued)

	NBPL Shelf Dif	NBPL Shelf Dif	Norm Shelf Price	Avg Shelf Price	Promo Freq	Promo Freq	Promo Depth	Promo Depth
Registers	-0.018**	-0.017**	-0.026	0.133	0.058***	0.057***	0.007	0.005
	(0.008)	(0.008)	(0.028)	(0.100)	(0.011)	(0.011)	(0.006)	(0.006)
HLP	-0.032	-0.032	0.020	0.195	0.456****	0.457***	-0.009	-0.010
	(0.060)	(0.060)	(0.176)	(0.619)	(0.064)	(0.064)	(0.035)	(0.035)
N	78	78	184	184	184	184	184	184
Adj. R-sq.	0.036	0.039	0.017	0.039	0.417	0.416	0.050	0.046
Model F	1.32	1.34	1.40	1.93*	17.38***	17.29***	2.20**	2.10**

Notes: Robust standard errors in parentheses. Standard errors are clustered by store. *Coefficient is significant at the 0.10 level, **at the 0.05 level, and ***at the 0.01 level.

Relative to the NB/PL estimations, the results for (1) on normalized and average shelf prices, promotional frequency, and promotional depth all featured higher sample sizes, more explanatory power (as measured by the adjusted R-squared), and more statistically significant regression coefficients. For the most part, the significant coefficient estimates correspond to correlations from Table 4 that stood out as reflecting potentially meaningful associations. The OLS results for (1) with price variation, as measured by the CV for shelf prices (CV Shelf Price) and the CV for promotional prices (CV Promo Price), are reported in Table 7. As with the price level and promotional estimations presented in Table 6, these regressions feature multiple significant coefficient estimates, higher adjusted R-squared values, and more statistically significant model F statistics.

Table 7. Regression Results on Price Variation

	CV Shelf Price	**CV Shelf Price**	**CV PromoPrice**	**CV Promo Price**
Intercept	0.529***	0.528***	0.169***	0.169***
	(0.011)	(0.011)	(0.025)	(0.025)
Avgerage shelf price		-0.001		0.003
		(0.007)		(0.002)
Normal shelf price	-0.003		0.008	
	(0.003)		(0.007)	
Promotional	0.013*	0.012*	0.267***	0.266***
frequency	(0.007)	(0.007)	(0.016)	(0.015)
Promotional depth	0.014	0.013	-0.089***	-0.089***
	(0.014)	(0.014)	(0.032)	(0.033
Brand count	-0.002	-0.002	-0.000	-0.000
	(0.003)	(0.003)	(0.007)	(0.001)
Category size	-0.000	-0.000	0.001	0.000
	(0.003)	(0.003)	(0.009)	(0.001)
Square footage	-0.003	-0.003	0.001	0.001*
	(0.002)	(0.002)	(0.001)	(0.000)
Registers	-0.002	-0.000	-0.005**	-0.006**
	(0.001)	(0.001)	(0.002)	(0.002)
HLP	-0.031***	-0.032***	0.134***	0.134***
	(0.006)	(0.006)	(0.014)	(0.014)

Table 7. (continued)

	CV Shelf Price	CV Shelf Price	CV PromoPrice	CV Promo Price
N	184	184	184	184
Adj. R-sq.	0.134	0.132	0.814	0.815
Model F	4.53***	4.48***	101.45***	101.61***

Notes: Robust standard errors in parentheses. Standard errors are clustered by store. *Coefficient is significant at the 0.10 level, **at the 0.05 level, and ***at the 0.01 level.

Discussion

The OLS results suggest a number of potentially meaningful associations among price and promotional variables, which in turn may shed light on components of supermarket behavior and strategy. As discussed above, we calculated both the VIFs and condition index factors for all coefficients in all estimations of (1). The inclusion of any two price variables—average shelf price, average promotional price, or average normalized price—led to multicollinearity in all estimations, therefore we only include shelf or normalized prices separately.[7] We discuss our findings with respect to four sets of estimations of (1): those related to the NB/PL margin, those related to price levels, promotional frequency and depth, and, finally, price variation, as measured by the CV.

NB/PL Price Differences

Price variation measured as CV Shelf Price is found to be positive and significant in both estimations of (1) that feature NBPL Shelf Dif as the dependent variable. A marginal increase in shelf price variation is associated with an increase in the NB/PL margin, within categories, by 1.15 percentage points. Zhao (2006) found, in both a review of the literature and in his own study, that price dispersion within product categories is associated with both the degree of retail competition, as measured by store entry, and consumer heterogeneity. Recall, however, that our regression results suggest our model specifications weakly explain the variation in NBPL Shelf Dif, despite the statistical significance of the coefficient associated with price dispersion. As shown in Table 1, the supermarkets in our study operate in somewhat diverse socioeconomic conditions, despite all being in the same small city. In future research, competition may be approximated using measures, such as the Herfindahl-Hirschman Index (HHI), and shopper heterogeneity may be proxied using demographics. Moreover, studies such as that of Ward et al. (2002), have found that PL penetration and market share have implications for the NB/PL price difference within categories, and we are unable to measure market share or sales in this setting.

The register count is negatively and significantly associated with the NB/PL price difference. Thus, it seems that NBs and PLs are closer in price, on average, in larger format stores. This may reflect higher quality of PL products and established PLs at larger stores that are more comparable to NBs. This finding calls for more research on the relationships between store characteristics and market structure on NB and PL prices.

[7]The full set of multicollinearity results are available from the authors upon request.

Average and Normalized Prices

For both average and normalized shelf prices, we found that Promo Depth has a positive and statistically significant coefficient, while Category Size has a negative and statistically significant coefficient. The finding with respect to Promo Depth suggests that retailers offer larger discounts on relatively more expensive items in the supermarket. Jedidi, Mela, and Gupta (1999) showed that the long-run impact of promotions on sales tends to be negative, though the short-term sales increases can be significant. This finding is observationally consistent with the notion that retailers recognize this phenomenon and offer deeper promotions on more expensive items in order to advertise significant savings to consumers and to maximize the sales boost during promotions.

Larger categories with more brands likely feature a greater degree of competition among brands. This notion is consistent with the finding that larger categories, as measured by square footage, are associated with lower shelf prices, and this conforms to our expectations. According to the estimation on average shelf prices, each additional square foot of shelf space is associated with a reduction in shelf price of almost a penny. The economic significance of this relationship, therefore, varies by product category. It would be worthwhile and interesting to use longitudinal data to study the impact of changes in category size, or brand count within categories, on shelf prices as an attempt to measure the competition effects on pricing within stores, rather than between stores.

Also, in line with our expectations, we found that square footage is negatively and significantly associated with average prices. Each additional 1,000 square feet of selling space is associated with a $0.04 decrease in average prices. Therefore, while both store size and category size have inverse associations with shelf prices, store size seems to be economically more important.

Promotional Frequency and Depth

Our findings showed that the CV of shelf prices is positively and significantly associated with both promotional frequency and depth. That is, as shelf prices became more variable in the dataset, we observed more promotional activity. This conformed to our expectations, and it supports the idea that stores with heavy promotional activity change prices more often and are more accepting of menu costs.

Average prices are positively and significantly associated with Promo Depth. We did not find evidence that promotional frequency and depth are inversely related. It is likely that a number of product characteristics are associated with heavier promotional activity, in terms of both promotional depth and frequency. These may include storability and average times between purchases (Narasimhan, Neslin, and Sen, 1996) or product size, bulkiness, and hedonic nature of product prices (Felgate and Fearne, 2015).

Results showed that category size is positively and significantly associated with both Promo Freq and Promo Depth in all estimations, in line with our expectations. Therefore, as total shelf space increases within categories, promotional activity tends to increase. To our knowledge, this exploratory finding is novel. It may relate to our findings with respect to average prices and category size, as it is consistent with the notion that interbrand competition is stronger in larger

categories. Larger categories may also feature more NB products from large manufacturers or distributors, which in turn may exhibit more promotional activity as a result of their larger marketing budgets. The magnitudes of these coefficients are small. For both frequency and depth, an increase in category size of 10 square feet is associated with an increase of approximately 1 percentage point. The association among category characteristics and retail prices and behavior is largely unexplored, beyond the principal elements of category management.

HLP is strongly and positively associated with promotional frequency, which is to be expected, given that promotional incidence is the defining characteristic of the HLP strategy. Interestingly, this coefficient is insignificant in the promotional depth estimations, further demonstrating a lack of association between promotional frequency and depth. In another finding that warrants further research, register count is positively and significantly associated with promotional frequency, implying that larger stores offer promotions more frequently, on average.

Price Variation

For the most part, we did not observe significant regression coefficients in the estimations on price variation. However, we observed a great disparity in model fit when comparing estimations of (1) for shelf price variation versus promotional price variation. The adjusted R-squared values for the CV Shelf Price estimations are about 0.13, but for CV Promo Price they are 0.81. This suggests that most of the shelf price variation is driven by upstream cost changes, which are not included in our study. But promotional frequency and depth, collectively, seem to explain the great majority of the variation in promotional prices. As noted above, researchers have studied price variation in a number of different ways in economic and marketing research. We separated shelf price variation from promotional price variation, and, therefore, did not examine the impact of promotional activity on price changes. We measured how prices, whether shelf or promotional, vary over time for product categories.

Promo Freq and Promo Depth emerged as the two most important variables associated with price variation. As promotional frequency increases, shelf price variation also increases. Therefore, products with more frequent promotions also see more frequent shelf price changes. This is holding HLP constant, which makes this point somewhat nuanced. On average, products exhibiting the HLP strategy see fewer price changes, as measured by the CV. However, marginal increases in promotional frequency are associated with greater shelf price variation. According to the regression results, promotional depth seems not to be associated with CV Shelf Price.

Both Promo Freq and Promo Depth seem to be associated with the CV of promotional prices. Taken together, the results indicate that products with higher promotional frequency (and in general, those abiding by HLP) see more variation in the sale prices offered. However, deeper promotions are more likely to yield promotional prices that vary little over time and are more predictable to consumers. The coefficient on Registers is also negative and significant, lending more evidence to the notion that store size is important for explaining promotional activity. We found that larger stores see less variation in the promotional prices offered.

Conclusions

We conducted an exploratory analysis of pricing and promotional behavior for supermarkets operating in San Luis Obispo, CA, using primary data collected. We used a reduced-form regression framework to identify significant associations among various variables that measured retailer behavior and, in many cases, strategy. In some cases, our results conform to previous research in marketing and economics. But in many cases, we raise questions that merit further research using larger datasets, greater longitude, and an identification strategy that can assess causation.

The most intriguing results from the study, in our view, are those pertaining to the nature of product categories and promotional behavior. Price and promotional activity are both related to category size in a number of significant ways, and it is possible that researchers have emphasized shopper or product characteristics in empirical research while overlooking or undervaluing category characteristics. Promotional activity has been studied extensively, but our findings indicate that there is more to be learned about the links between promotional activity, shelf prices, and store format. Category size, as measured by shelf space or brand count, seems fertile ground for empirical exploration into understanding how and why retailer behavior varies within supermarkets.

As an exploratory study focusing on a single market, our study was not without limitations. We were unable to observe either sales or upstream costs, meaning we could only measure how the marketing mix variables interrelated with one another. The products studied were selected largely based on convenience, given that they were available across different retailers and visible within stores. Without market share data, it is not clear that we always selected the "leading" national brand within categories. It is our hope that the findings of this study and the questions raised by the results spur more research using larger and more diverse datasets.

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