Private Labels and Retailer Profitability: Bilateral Bargaining in the Grocery Channel[*]

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Abstract

We examine the role of store branded "private label" products in determining bargaining outcomes between retailers and manufacturers. Exploiting a novel setting in which private label entry coincided with patent expiration, we develop a structural model of demand and supply-side bargaining and seek to quantify the impact of private labels on retailer profits. We find that private label entries mainly affect bargaining leverage of the retailers, while bargaining ability of the retailers stays the same pre- and post- private label entry. We find that the bargaining leverage over private label products affects retailers' gains from private label entry by about 36%. Finally, we find that an average retailer does not benefit from price renegotiation of existing products due to private label entry, whereas retailers with high equity of private label product do.

Keywords: Retail Grocery, Bargaining Models, Private Labels, Store Brands, Demand Estimation.

1   Introduction

Private labels are an important source of retailer revenues and profits. They generated $98 billion in U.S. food and grocery sales in 2012, or 17.1% of total revenues (Schultz, 2012; Nielsen Global Survey, 2012). The impact of private label brands on retailer category profits can come directly from the private label sales themselves or indirectly through improved negotiating positions with national brands. Direct profits increase because private labels can attract new consumers or higher consumption through lower prices; higher margins are another benefit. Indirect profits arise because the store brand can play a strategic role in negotiations with manufacturers and increase the retailers' share of channel profits (Scott Morton and Zettelmeyer, 2004). A private label improves the retailer's bargaining position by reducing the forgone profits if negotiations with manufacturers fail, generating a bargaining benefit via more favorable margins on the competing branded products.[1]

In this paper, we measure the influence of private label entry on bargaining outcomes and quantify the gains of retailers from private label entry that are attributed to bargaining and to the direct profit from simply adding more options. Our empirical analysis exploits a unique setting where private label entry was legally constrained by patent protection that expired during our sample window. Therefore, we are able to observe how retailers and manufacturers behave both with and without competition from private label products, and isolate the factors that drive changes in their conduct. Further, because our data contains many retailers, we observe variation in the quality and positioning of the various private label brands. After the patent expiration, this quality variation yields exogenous variation in the shock to negotiating positions that different retailers experience. To leverage this unique source of variation, we build a model of consumer demand and supply-side bargaining in a hot prepared beverage category. We estimate the model using weekly, chain-level data from 72 retail market areas. We then conduct counterfactual exercises that quantify the impact

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[1]A third benefit argued for store brands is store or store brand loyalty that increases traffic to the store. Our data limits our ability to speak to this potential benefit and so, beyond effects through changes in the draw from the outside good, we do not claim to capture such benefits in this study.

of private label products on bargaining outcomes, comparing the bargaining benefit to the direct category expansion benefit of introducing private labels.

As noted above, our empirical strategy involves exploiting a unique setting.[2] In the focal category, innovation created a new super-premium segment. The category had three existing product segments, all of which have wide penetration of private labels. The dominant brand in the new super-premium segment held a patent that legally foreclosed private label entry into that segment.[3] Competitive entry was essentially blocked until four years into our data period (which tracks the category practically from inception), creating a "before and after experiment." To fully exploit this source of variation, we develop a structural model of demand and supply that can control for confounding factors in the competitive environment (e.g., cost changes, new product entries, continued market expansion, and evolving substitution patterns) and reveal how private labels shaped bargaining outcomes.

While providing a unique setting for analyzing private label competition, the category presents some challenges on the demand side. First, a central dimension of competition in this market is brand variety, so it will be important to include the full set of brands offered. Second, since this was a new innovation with new products (that we observe almost from inception), availability of the products was often limited, especially in the early periods. Finally, product consumption requires a complementary hardware investment. Consumers who did not own this appliance could not consume the products. Ignoring these market features could lead to large biases in our demand estimates. Getting the demand system right is critical, as it drives all subsequent inference. We address all three concerns by extending Bruno and Vilcassim (2008) and developing a random-coefficient, discrete-choice demand system that accounts for availability and ownership by simulating individual consumers and aggregating up to observed shares (availability and ownership are tied to the data via aggregate moments of each). We demonstrate that the model yields flexible substitution

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[2]Due to data licensing agreements, the brands, category, and retailers cannot be revealed.

[3]The dominant brand was also the "category captain" in many retailers, adding to its dominant position (Nijs et al., 2013). The category captain coordinates with the retailer to manage the selection and display of a given product category. It is typically one of the leading national brands.

patterns that capture key market features, including substitution between the super-premium segment and other segments and variation in the private label brand equities.

Turning to the supply side, we must first recover wholesale prices, as these are not observed in the data. To do so, we assume that retailers behave as monopolists and then use the first order conditions from the retailer's profit maximization problem to solve for the wholesale prices that rationalize retailer decisions (Bresnahan, 1987; Werden and Froeb, 1994). We find that these recovered wholesale prices decline in the period after the patent expiration as one would expect if the bargaining benefit were meaningful.

These inferred wholesale prices are then the focus of our bargaining model. We further assume that retailers and manufacturers bargain over linear contracts that determine these "transfer prices." Following the recent literature, we model the retailer-manufacturer vertical contracting relationship as a 'Nash in Nash' bargain, focused on determining the wholesale price that splits the gains from trade. Using the inferred wholesale prices, we recover the bargaining power (ability) parameters and manufacturer cost parameters that rationalize the observed outcomes. To do so, we compute both the profits that each party achieves under agreement and the profits that would obtain should they fail to reach one. The observed wholesale prices maximize the Nash product, as indexed by the power parameters. Private label products provide a key source of variation in the disagreement payoffs that define the gains from trade.

To estimate this bargaining model, we modify the empirical approach developed by Grennan (2013), which allows us to recover the distribution of bargaining parameters for each retailer-manufacturer pair. We find that retailers' bargaining ability is relatively low against manufacturers and also does not change significantly after the patent expiration (private label entry). Thus, we find that bargaining outcomes are driven primarily by the bargaining leverage (position) of the retailers. We then conduct counterfactual exercises that quantify the retailers' gain from private label entry attributed to their bargaining position. We find that bargaining positions over private label products (i.e. who manufacturers the private

label product) have a substantial impact on the retailers' gains from private label entry. In the scenario in which retailers have to rely on the branded firm to manufacturer their private label product, the retailers' gain from private label entry is lower by 36%, compared to the scenario in which retailers use independent suppliers to manufacturer their private labels. Regarding bargaining positions over existing, branded products, we find that price renegotiation of existing products due to private label entry will not benefit an average retailer. We find that when wholesale prices are adjusted due to private label entry, retailers' gains from private label entry is lower by about 14.3% on average, compared to the scenario of no price renegotiation. We find substantial heterogeneity around the average, however, and retailers with higher equity of private label products tend to gain more from bargaining thanks to the higher disagreement payoffs that the popular private label product provides.

Our research relates to several streams of literature in both marketing and economics. First, we contribute to the literature on private labels, which includes seminal papers by Hoch and Banerji (1993) and Dhar and Hoch (1997) that identified and cataloged the determinants of private label success, and sought to explain why their penetration varied across retailers. Hansen et al. (2006) investigate whether consumer tastes for store brands are correlated across categories, or are driven more by category-specific factors. They find strong evidence of the former relative to the latter. Sayman et al. (2002) study how private labels are positioned vis-a-vis national brands, and Scott Morton and Zettelmeyer (2004) show how private labels allow the retailer to carry closer substitutes to national brands than otherwise and that this arises because of the incentives national brands face in negotiating with retailers.

A few papers have studied questions more directly related to the bargaining benefit of private labels per se. Pauwels and Srinivasan (2004) examine the impact of store brand entry on the relative margins of retailers and suppliers, as well as their role in shifting consumer demand. They examine four categories in the Dominick's Finer Foods retail chain and find that retailer margins improve, but that category sales only rarely expand upon store brand entry. Similarly using Dominick's data on the oats category, Chintagunta et al.

(2002) empirically analyze how private labels change conduct in the channel, as well as how this conduct translates through to retailer pricing decisions. They find that post entry manufacturers' accommodate so that Dominick's average weekly margin increased by around 3%, but that consumers tastes do not change post entry. Meza and Sudhir (2010) again use Dominick's data, but for the breakfast cereal market, and examine how private labels affect bargaining power, and ask whether and how retailers can use prices to strategically influence this negotiation. They find that bargaining power increases as evidenced by lower wholesale prices on imitated national brands, but that strategic pricing is less clearly evidenced in the data. We add to this literature along three key dimensions. First, our setting lets us exploit the patent expiration to evaluate behavior with and without exogenous private label exclusion. Second, we implement a full bargaining model specification that allows us to generate counterfactuals to investigate the causal effects of private labels and isolate the bargaining component of the private label benefit. Third, we expand the investigation from a single retailer to 54 different retailer banners and 72 different retail market areas, allowing us to describe the distribution of private label bargaining and category expansion benefits across varying private label brand qualities.

Our bargaining model draws upon the theoretical literature on bilateral Nash bargaining (Nash, 1950; Rubinstein, 1982), which includes the theoretical development of the 'Nash in Nash' bargaining solution for most applied work by Horn and Wolinsky (1988) and recent developments by Collard-Wexler et al. (2019). In doing so, we contribute to the growing stream of empirical literature on bargaining models, which includes papers by Misra and Mohanty (2006), Ho (2009), Draganska et al. (2010), Crawford and Yurukoglu (2012), Grennan (2013), Ho and Lee (2017), Gowrisankaran et al. (2014), and Crawford et al. (2018). This work is also related to a broader empirical literature on vertical contracting, which includes important contributions by Villas-Boas (2007) and Bonnet and Dubois (2010), among several others. Noton and Elberg (2018) model bargaining between retailers and manufacturers in the Chilean market for low and ground coffee, focusing on the impact of supplier

size on the split of channel profits. Contrary to conventional wisdom, they find that small suppliers often attain shares of the channel surplus on par with the largest supplier. In the paper most closely related to ours, Draganska et al. (2010) empirically model the bargaining problem between retailers and manufactures in the German market for ground coffee, seeking to quantify the sources of heterogeneous bargaining power and determine whether they have shifted over time. They find that store brand entry, per se, does not increase bargaining power, but that store brands positioned closer to national brands tend to have stronger bargaining power. They also find that bargaining positioning has little impact on profits.

Our contribution to the broader bargaining literature goes well beyond a new application of the model. Our unique setting of the patent expiration allows a test of sorts of the bargaining model itself. Specifically, we are able to evaluate how well the model captures the way private labels shift bargaining *position* as compared to needing to capture the change in bargaining outcomes through bargaining *power (ability)*, a shift that seems unlikely to actually occur at the point of the patent expiration. We find that indeed the bargaining model can capture the change through bargaining position with changes in the average bargaining power before versus after the patent expiration being very small and insignificant. This provides new evidence that bargaining models can capture fundamental aspects of supply behavior under even large exogenous shifts in the supply arrangements.

The paper is organized as follows. In section 2, we describe the data used in our empirical study and provide an overview of the context, which is disguised due to licensing restrictions. The model and estimation are described in section 3. We present the results of our estimation in section 4 and conduct counterfactual exercises in section 5. Section 6 concludes.

2 Data and Setting

The data are drawn from IRI's point of sale (POS) database and cover a period of over 6 years in the 2000's and 2010's. The data cover 72 U.S. retailer-market areas (RMAs) and include 54 distinct retail banners. Retailer-market areas are geographic trading areas defined by IRI in conjunction with the retailer, and roughly correspond to retailer divisions. Retailer divisions are usually organized around regional distribution centers, which typically serve up to a few hundred individual stores. The data we have access to contain information only about the retailer and not other competing retailers in the market area.

For each RMA, we observe weekly, SKU-level data on sales, price per serving and merchandising variables, each aggregated up from the individual store level to the RMA. Rather than working with individual SKUs, we aggregate up to the product segment-brand level. With this aggregation, a brand with products in more than one segment has multiple options, one for each segment. We include four segments, which we label: low (L), main (M), premium (P), and super-premium (S). Although the segments are primarily differentiated vertically, both the top and bottom product segments also have some horizontal differentiators related to convenience.

The super-premium product segment is dominated by one manufacturer (the patent-holder). The dominant brand (also labeled brand D) operates a number of sub-brands with common pricing and promotion schedules. In the analysis we have aggregated these to a single brand. In addition, in the super-premium segment, the dominant brand has various relationships with legacy brands (with existing positions in the low, main and premium segments) that otherwise appear distinct to the consumer. We categorize the brands into four relationships: owned, licensee, partner, independent.

To construct our market definitions and to handle elements of our model addressing choice sets, we include some additional data. In particular, we use the standard volume (ACV) weighted product distribution measure, our key proxy for product availability at the RMA-level. In addition to the aggregate POS data, we include cross-tabulations drawn

from the IRI individual panelist data. We use the panelist cross-tabs in two ways related to market defitions. First, the panel provides an estimate of the number of shoppers in each RMA. We use this to construct our measure of market size. We define the size of the market to be the number of shoppers times the number of days per week (7) times a scaling factor related to per capita purchases in the focal category in that RMA, which we obtain from the average daily purchases in that market per shopper. Second, we develop a proxy for ownership of the complementary appliance based on the annual percent of shoppers (in each RMA) who have purchased any products from the super-premium category in the previous 12 months. We then use these yearly values from the panelist data to impute weekly observations of ownership at the RMA-weekly level. The details of this imputation are available in appendix A.

Finally, we obtain information on relevant input prices. These prices are available at the monthly level. Because most of the input prices are highly correlated, we include two inputs. Input 1 is priced slightly higher than input 2. During the observation period, both input prices increase and then fall, with the peak prices occurring a three years into the sample period. These input prices serve as shifters for the manufacturing costs.

Our final sample is selected to include RMA-week-segment-brand cases with a reasonable level of distribution. Details of the sample construction are presented in appendix A.

2.1 Category Description

Figure 1a shows the evolution of the four product segments over time. The horizontal axis is delineated in weeks, starting at the beginning of our sample. The vertical axis is national dollar sales. While there is clear seasonality in sales over the course of any given year, the stability of the three traditional segments (L, M, and P) is clear. Main and premium command relatively equal dollar shares of the overall market, while low lags far behind. The most dramatic feature of the graph is the meteoric rise of the super-premium segment, which starts essentially from scratch, yet becomes the largest overall segment by the end of the
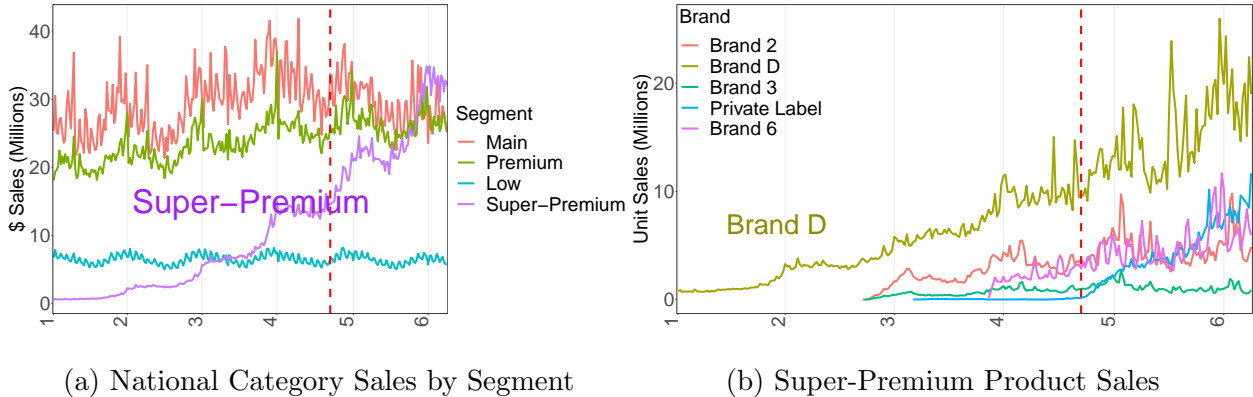
(a) National Category Sales by Segment   (b) Super-Premium Product Sales

Figure 1: Category Sales

sample period.

Figure 1b focuses on the super-premium segment alone, revealing the dominant brand's sales position relative to its other partners and licensees (before patent expiration) as well as the sharp growth of the private label brands that entered when the patents expired (week 246 in the figure).

While private labels were nearly uniformly available in all segments apart from the super-premium segment, private label entry in super-premium was restricted prior to patent expiration. We present the timing of entry by private label brands in Figure 2a, which contains a histogram characterizing the timing of private label entries over the sample period. The vast majority of entries occurred within plus or minus four weeks of patent expiration, with the ones entering just before the patent expiration being manufactured by the dominant brand (i.e., the owner of the dominant brand manufactured the private label for the retailer). Note also that there is another group of retailers that chose to launch private labels about a year later instead and yet another group that entered long before patent expiration, apparently in violation of the patent. In the data, these early entrants withdrew the products shortly after entry, with press reports indicating that at least one of these firms faced litigation. In total, all but seven RMAs launched a private label during our data period. Note that because our study answers the primary research question by evaluating the counterfactual if the private label were not launched, this implies limited scope for selection concerns regarding the

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decision of whether to launch a private label.

2.2   Weekly Data for Demand Estimation

In total our data contain 72 retail market areas and 54 unique grocery banners. The data span 326 weeks, but some RMAs are missing in the first year. As a result, we have 22,116 weekly RMA observations. The number of segment-brands varies across weeks from 16 to 57 and generally increases over time, as new super-premium brands are added to the product mix. In total, we have 615,424 observations at the RMA-week-segment-brand level.

Table 1 presents summary statistics for prices and sales in the super-premium segment. The information is split into the year before, and after, the patent expiration. The first row contains all brands, so that the number of brands differs between the pre and post patent period. Both a large growth in sales as well as an overall decline in prices is clear. The second row drops the private label, which suggests that the average price decline is not simply due to the private label itself. The third row considers a set of brands that were in the market at least half the year before the patent expired. In this way, the set of brands is constant. Again, prices fall and sales increase, though both changes are further muted. The next set of rows examine sample individual brands; specifically, the ones included in the the "Same Brands Pre/Post" row. Most of these brands decline in price and increase in sales.

Table 2 presents information about the distribution of the number of super-premium brands across RMAs during the two-year window bracketing patent expiration. The first row corresponds to all super-premium brands and reveals that the average number of brands that sold super-premium products the year before the patent expired was 6.9, whereas after it was 12.8, so that more than 6 brands were added on average. The next three rows consider the number of brands in three price tiers: low being less than 60 cents, mid between 60 and 75 cents, and high greater than 75 cents. Brand entry was somewhat concentrated in the lower price tiers, with on average 2.9 brands added to the lowest tier, 1.5 to the middle tier, and 1.4 to the top tier. The lower tier added the private label as well as some brands that shifted

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down market over time. Beyond these changes in products and their positioning, we also note that the amount of merchandising (display) did not meaningfully change between the pre and post periods, with the median slightly decreasing and the mean slightly (approximately 1 percentage point) increasing and that the level of display is very modest with an average around 7-8%.

	Pre		Post		% Change In	
	Weekly Sales	Avg. Price	Weekly Sales	Avg. Price	Weekly Sales	Avg. Price
All Brands	18,641	0.69	32,270	0.65	73%	-6%
All Brands Except PL	18,611	0.69	29,383	0.66	58%	-4%
Same Brands Pre/Post	18,400	0.69	25,559	0.67	39%	-2%
Brand D	9,419	0.66	13,284	0.63	41%	-4%
Brand 1	1,097	0.69	793	0.74	-28%	6%
Brand 2	3,442	0.66	4,584	0.64	33%	-4%
Brand 3	927	0.67	1,240	0.64	34%	-4%
Brand 4	1,313	0.69	993	0.73	-24%	6%
Brand 5	283	0.56	430	0.53	52%	-6%
Brand 6	2,255	0.89	4,235	0.84	88%	-6%

Table 1: Avg. Super-Premium Weekly Unit Sales and Sales Weighted Prices for Pre and Post Patent Expiration.

	Pre			Post		
	1st Quart.	Mean	3rd Quart.	1st Quart.	Mean	3rd Quart.
All Price Tiers	6	6.9	8	11	12.8	14
Price <0.60	0	0.9	1	2	3.8	4
Price in (0.60,0.75)	4	4.5	5	5	6.0	7
Price >0.75	1	1.5	2	2	2.9	4

Table 2: Distribution of Number of Super-Premium Brands Across RMAs for Pre and Post Patent Expiration

2.3 Quarterly Data for the Bargaining Model

In this section, we first briefly describe the estimation sample for the supply side estimation before providing some description of that data. We aggregate to the quarterly level to better match the decision frequency of the negotiations over wholesale prices. We focus on the period of stable distribution among super-premium products (quarters 7 to 17) and include only super-premium products in our bargaining analysis to reduce the computational complexity. Although some substitution exists between the super-premium segment and the other segments, this substitution is relatively small. Finally, we drop some cases due to problems in the quarterly aggregation (e.g., too few observations in a quarter). The details

of the sample construction are provided in appendix A.

The final sample retains 5,755 observations (retailer-market-brand-quarter cases), which is 92% of the potential super-premium bargaining observations in the sample period. We note that these observations largely come from markets that have between 3 and 10 brands (74%) and more than 50% are from markets that have between 3 and 6 brands. Because over time more brands generally entered most markets, the market-periods with less than 3 brands occur largely in the first year of the sample (74%) and all of the cases with more than 10 brands occurs after the patent expiration.

Since our main interest lies in identifying the wholesale price that results from negotiations between retailers and manufacturers, we focus on regular price as our primary outcome variable.[4] The POS data do not distinguish between regular and promotional prices, so we proxy for the regular "shelf" price by computing the 90th moving quantile of quarterly prices and treating this as the regular price. The remaining measures are constructed as averages.
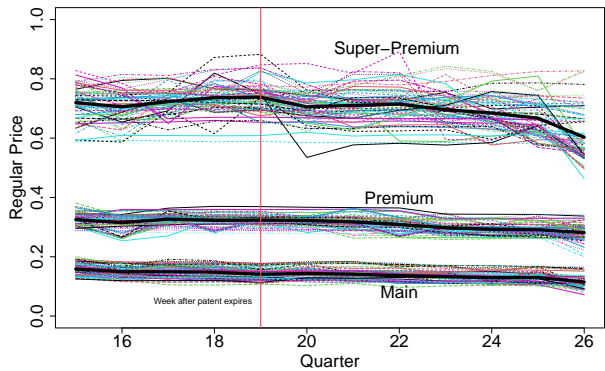
Figure 2b shows the regular price series for the leading brand in each of the three primary segments (super-premium, premium and main). The figure contains one price series for each retailer (RMA) in each category. Although we focus on bargaining in the super-premium segment, we show the regular prices for the other segments as reference points, for instance, to gauge the influence of common cost factors on retail prices. From this figure we can ascertain three facts. First, the figure depicts the clear vertical separation of the segments. Second, retailers' regular prices display a reasonable amount of variation. Third, by comparing across segments, we are able to see that prices in the super-premium segment decreased after patent expiration (quarter 19 in the figure, corresponding to the vertical line) more than the other segments. Moreover, super-premium prices continue to fall for the remainder of the sample, as additional private label and independent brands continue to enter the market.[5]

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[4]See Nijs et al. (2010) on the role of manufacturer trade promotions.

[5]Using a difference-in-difference analysis between the super-premium segment and the other segments for the pre- versus post-patent expiration periods and including controls for time trends, quarter of year dummies and RMA fixed effects, we find that the interaction representing the diff-in-diff for the immediate decrease from quarter 19 to 20 is significant (coef=-0.034, se=0.006, n=432), and so is the total decrease in the post patent expiration (coef=-0.024, se=0.003, n=2592).

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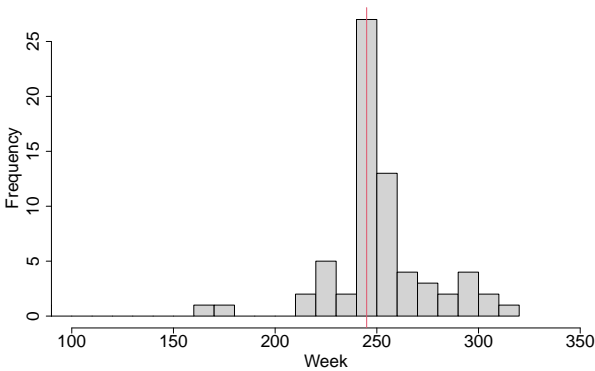
(a) Private Label Entry Timing   (b) Regular Prices of Leading Brand

Figure 2: Descriptive Results

3 Model and Estimation

On the demand side, we specify a relatively standard discrete choice, random coefficient model of consumer demand (aggregated to the market share level) using the framework developed by Berry et al. (1995). To accommodate the rapid expansion of the super-premium segment (particularly the limited early distribution/availability in many grocery chains) and also to account for the hardware requirement, we employ methods developed by Bruno and Vilcassim (2008) to simulate consumers with choice sets that are consistent with these market features.

On the supply side, we assume that retailers set monopoly prices at the retail level (abstracting away from retailer to retailer competition).[6] Using the first order conditions (FOCs) of the monopoly pricing problem, we then 'back out' the implied marginal costs the retailer pays for each product (Werden and Froeb (1994); Nevo (2000a)). These costs are assumed to be the wholesale prices charged by manufacturers to the retailers that carry their products. We do not have any additional data on the wholesale prices themselves. For all products carried by a given retailer, we assume that these wholesale prices are negotiated

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[6]Given our full estimation set-up, this is not as restrictive as it might seem. We include six-month product intercepts for all products, so that the outside good is effectively able to change every half year. Hence, the only cross-store effects we do not capture with our demand system are short term price promotions and merchandizing. Of course, the monopolist assumption ignores strategic interaction among retailers.

via the 'Nash in Nash' bilateral bargaining protocol (with passive beliefs) proposed by Horn and Wolinsky (1988). In particular, we assume that the parties bargain bilaterally over a purely linear transfer price, enforcing the assumption that firms do not believe that other contracts will be renegotiated should they fail to reach agreement in this bargain. We are directly ruling out the existence of more complex nonlinear contracts, slotting fees, quantity discounts or full-line forcing arrangements that may be empirically relevant (O'Brien and Shaffer, 2005).[7]

3.1 Demand Model and Estimation

We assume that consumers are in the market every week, though we set the market size to account for the target population that consumes the product and the amount consumed per week. Consumer i is characterized by a vector of taste parameters which includes price sensitivity and segment specific tastes, as well as a vector of local product availabilities, a_{it}, and an ownership indicator for the required complementary good, m_{it}. The ownership and availability variables determine which products are in the current choice set of a given consumer, as will be precisely detailed below. For consumer i in market r at time t, the utility for product j (segment-brand) is then given by

$$u_{ijrt} = \alpha_i log\left(p_{jrt}\right) + \gamma_{it} X_{jrt} + \xi_{jrt} + \epsilon_{ijrt} \tag{1}$$

The individual level utilities are defined as follows:

$$\begin{pmatrix} \alpha_i \\ \gamma_{it} \end{pmatrix} = \begin{pmatrix} \bar{\alpha} \\ \bar{\gamma}_t \end{pmatrix} + v_i \tag{2}$$

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[7]Although these are admittedly strong assumptions (albeit ones that are maintained throughout almost the entire empirical bargaining literature), we have some ability to test their restrictiveness in two ways. First, if specific kinds of non-linear contracts are in place, we would identify that as a corner case in our model (see below). Second, we can focus on the small set of firms that publicly and categorically refuse to enter into such arrangements.

where v is assumed to be distributed multivariate normal with mean zero and diagonal covariance matrix, and, as typical in structural demand estimation, we assume the ϵ_{ijrt} are distributed according to a type-I extreme value error distribution. Following Nevo (2001), utility can be re-written parsimoniously as $u_{ijrt} = \delta_{jrt} + \mu_{ijrt} + \epsilon_{ijrt}$. The first term, $\delta_{jrt} \equiv \bar{\alpha} log\left(p_{jrt}\right) + \bar{\gamma}_t X_{jrt} + \xi_{jrt}$, represents the common component of utility that is shared by all individuals, while the two remaining terms, μ_{ijrt} and ϵ_{ijrt} are heterogeneous across them. The μ_{ijrt} is simply $v_i \left(log\left(p_{jrt}\right), \tilde{X}_{jrt}\right)'$, in which v_i are often referred to as the 'nonlinear parameters' and $\tilde{X}_{jrt}$ is the subset of variables in X_{jrt} that have random coefficients. We note that in our setting X_{jrt} contains product-six-month fixed effects and month-in-year time effects for each RMA, along with a coefficient for percent ACV display.[8]. For the non-linear parameters, we include a random coefficient on $log(p_{jrt})$, and coefficients on the $\tilde{X}_{jrt}$, which contains segment dummies.

The availability and ownership variables constrain choices by excluding or including options from the consumer's choice set. The availability vector contains a binary variable for each time period for each product. These variables take the values 1 or 0, indicating whether the product is available for that consumer in that week. The machine ownership variable, m_i, has elements for each week, for each individual, taking values 1 if the individual owns the appliance and 0 otherwise. When $m_{it} = 0$, the availability for all super-premium products are then set to 0; we denote this modified availability vector $\tilde{a}_{it}$. Note that none of these variables are observed to us, but will instead be simulated from the aggregate distribution, from which we are able to extract moments.

We normalize the outside good utility to 0, so that the individual probability of purchase can then be computed as

$$s_{ijrt} = \frac{\tilde{a}_{ijrt}e^{\delta_{jrt}+\mu_{ijrt}}}{1 + \sum_k \tilde{a}_{ikrt}e^{\delta_{krt}+\mu_{ikrt}}}. \tag{3}$$

Estimation proceeds via the generalized method of moments (GMM) as described by

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[8]Recall that availability and ownership are handled directly in the simulation and do not appear as variables in X_{jrt}

Nevo (2000b) with the main distinction being the additional simulation and integration over the availability and ownership terms (based on Bruno and Vilcassim (2008) and Tenn and Yun (2008)). To help identify the nonlinear parameters (associated with price and tastes for each segment), we use the instrumenting strategy proposed by Gandhi and Houde (2015), which generalizes and extends the methods originally suggested by Bresnahan et al. (1997). Note that we are not instrumenting for price; we treat prices as conditionally exogenous given the large number of time-varying product dummies already included in the demand system.[9] The instruments that we do include are needed here to identify the nonlinear parameters that characterize the consumer heterogeneity. The design of these instruments is intended to capture how isolated a product is in product space, which should, in principle, give it more market power. The particular instruments we employ are 1) the number of brands in a set of price-difference bins, 2) the number of brands in the various price-difference bins within the product's own segment, and 3) the sum of the price differences in the product's own segment. In addition, we include the full cross of the average segment prices by the segment identities.

3.2 Supply Model

The supply model has two stages. In the first stage, the retailer and manufacturer bargain over the wholesale prices. In the second stage the retailer sets retail prices given these wholesale prices. This timing corresponds to the idea that negotiations over wholesale prices occur relatively infrequently compared to retailers' opportunities to adjust retail prices. In our discussion of the supply-side model, we begin with the retailer profits and retail pricing decisions and then turn to the bargaining model.

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[9]In fact, we observe some input costs, but once we condition upon the large number of time-varying dummies described above, these cost instruments have relatively little explanatory power.

3.2.1 Retailer Profit Function and Pricing Decisions

The retailer's pricing objective is a relatively standard multi-product pricing problem (e.g. Goldfarb et al. (2009)). For the set of products carried by the retailer r in period t, m_{rt}, the retailer's profits are given by

$$\Pi_r^{m_{rt}}(\cdot) = \sum_{j \in m_{rt}} (p_{rjt} - w_{rjt}) s_{rjt}^{m_{rt}}(p_{rjt}) M_{rt}, \tag{4}$$

where M_{rt} is the size of the market and $s_{rjt}^{m_{rt}}$ are the shares for product j in retailer r at time t when consumers face as the feasible choice options all products in the set of products m_{rt}. Note that this set of products may be smaller for specific consumers due to their lack of machine ownership or limited local availability.

The optimal retail price decisions take wholesale prices as given and follow a standard monopolist retailer pricing profile (see, e.g., Nevo (2000a)). The optimal pricing policy (in matrix form) is given by $p = w + \Omega(p)^{-1}s(p)$, where $\Omega(p)$ is the relevant matrix of share derivatives. We can then solve directly for wholesale prices as $w = p - \Omega(p)^{-1}s(p)$.

Because this category exhibits some potential to attract store traffic, we adjust the retailer model to capture related incentives. A fully structural model of this incentive is beyond the scope of the current research (see e.g., Thomassen et al. (2017)), but we aim to approximate this incentive of retailers to lower retail price in order to obtain profits from attracting additional store traffic (or alternatively avoid the opportunity cost of lost traffic). In Appendix B, we present details of this approach, which includes small adjustments to the retailer pricing problem and the bargaining solution discussed below as well as a separate estimation of the shadow value of lowering prices to obtain revenues from the rest of the store sales. The impact of this approach on the current research is that the retailer objective function adds a term related to these potential revenues. This term will lower the theoretical retail prices and shrink retailer margins in the focal category (since the retailer trades off category profits for overall store profits).

In our empirical analysis we recover wholesale prices from retail prices using the retailer first order conditions. The bargaining model that we discuss next takes the retail pricing policy as given.

3.2.2 'Nash in Nash' Bargaining

The negotiation between manufacturer and retailer over wholesale prices is formulated as a 'Nash in Nash' bargaining problem. In this problem, each manufacturer and retailer pair bargain over each of the brands' wholesale prices. These bilateral bargains occur simultaneously and without knowledge of the other bargains, but with the participants maintaining passive beliefs regarding the outcomes of those bargains. Note that renegotiation is ruled out here, greatly reducing the computational complexity of the problem.

A central quantity of interest in the bargaining outcomes are the disagreement payoffs, which determine the outside option of each participant in the bargain (and therefore the strength of their bargaining position). As discussed above, the retailer's disagreement payoff is the profit that would be obtained if the product being negotiated was excluded from the product set. This disagreement payoff reflects how much of the demand would be diverted to other products, how the retailer would adjust the prices, and what the margins of those products would then be. For the manufacturer, we assume that bargaining takes place separately for each brand, so the disagreement payoff is the profit made by the manufacturer (from that retailer) for the remaining brands (with the passive beliefs assumption implying that the wholesale prices of those remaining products would not change).

Note that we formulate these bargains as brand specific, so that a given manufacturer bargains with the retailer separately for each brand within their portfolio, taking the other bargains as given.[10] We allow separate bargains for the multiple market areas of a retailer

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[10]Note that an alternative would be for the manufacturer to bargain over all products in their portfolio at once. With our model set-up, this alternative would imply that the retailers would be forced to carry all or none of the brands in the manufacturer's product set. In practice, we in fact observe retailers carrying subsets of the products and find the current assumption preferable. A similar argument (and assumption) is made in Grennan (2013), for similar reasons.

in order to be consistent with the demand estimation as geographies vary in preferences and substitution patterns even within a retail banner. We note that our estimates reveal that the few banners with multiple RMAs largely have similar bargaining power estimates that are not statistically significantly different within banner (i.e. above the expected rate for multiple hypothesis tests).

The Nash product for the bilateral bargaining game between manufacturer f and retailer r over brand k is represented as a function of the wholesale price involved in the current bargain, $w_{r,kt}$, as well as the remaining wholesale prices, $w_{r,-kt}$, which are assumed known under the passive beliefs assumption. The relevant Nash product is given by

$$\left(\Pi_r^{J_{rt}}\left(w_{r,kt},w_{r,-kt}\right)-\Pi_r^{J_{rt}-k}\left(w_{r,-kt}\right)\right)^{\beta_{rkt}}\left(\Pi_f^{J_{rt}}\left(w_{r,kt},w_{r,-kt}\right)-\Pi_f^{J_{rt}-k}\left(w_{r,-kt}\right)\right)^{1-\beta_{rkt}} \quad (5)$$

where $\beta_{rkt} \in \{0,1\}$ is the bargaining power of the retailer and $\Pi_h^m\left(w_{r,kt},w_{r,-kt}\right)$ represents the profits for player $h \in \{\text{Retailer} = r, \text{Manufacturer} = f\}$ and for retailer product set m, which is specific to time period t. These retailer product sets are J_{rt}, denoting the full set of products available in retailer r, $J_{rt} - k$, denoting the same set less brand k. The corresponding manufacturer product sets are f_{rt}, denoting the set of products in retailer r owned by firm f, which includes brand k, and $f_{rt} - k$, denoting the set of products in retailer r owned by firm f, excluding brand k. Note that the profit functions $\Pi_h^m\left(\cdot\right)$ take as retail prices the optimal prices for the given product set given the wholesale prices. As a result, the retail prices differ under agreement and disagreement (and must be computed for each scenario).

This bargaining model has at its extreme values of β_{rkt} specific supply models (see appendix C for details). In particular, if $\beta_{rkt} = 1$ for all k brands in a given retailer r and period t, then the equilibrium behavior coincides with the monopolist retailer that sets wholesale prices equal to the manufacturers' marginal costs, which is the fully-coordinated channel outcome and equivalent prices to the non-linear contracting case that solves the

double-marginalization problem via including a fixed transfer fee in the contract between manufacturer and retailer. In contrast, if $\beta_{rkt} = 0$ for all k brands, then manufacturers offer (linear) wholesale prices accounting for the competing manufacturers and the fact that the retailer sets prices after them. In this sense, the model nests some important supply-side models that are commonly used in the empirical and theoretical literatures (see Iyer and Villas-Boas (2003) for a related discussion with a different utility function).[11]

3.2.3 Manufacturer Profits

We now specify manufacturer profits including two modifications to the standard multi-product form to match our empirical setting. As a starting point, we define manufacturer profits in retailer r and period t with retailer product set m_{rt} and manufacturer product set $f_{rt} \subset m_{rt}$ as given by

$$\Pi_f^{m_{rt}} (\cdot) = \sum_{j \in f_{rt}} \left(w_{rjt} - c_{rjt} \right) s_{rjt}^{m_{rt}} \left(p_{rjt} \right) M_{rt}, \tag{6}$$

where c_{rjt} is the manufacturer's marginal cost of production. This marginal cost is a function of variables $X_{c,rjt}$, indexed by parameters θ_c. In our setting, we use a linear cost function, $c_{rjt} = X_{c,rjt}\theta_c$. We allow costs to vary as a function of the relationship that each brand has with the Dominant Brand (either owned, licensed, partnered, or unlicensed, which serves as the excluded category), the brand's vertical positioning in quality space (either a premium or value offering, which correspond to the highest priced and lowest priced product types), as well as input prices.

To this basic profit set up, we add two additional contractual details that are unique to our setting. First, in both the pre- and post-patent periods, the Dominant Brand had partnering and licensing relationships with many existing national brands. In the pre-patent period,

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[11]Under the assumption of monopoly retailers, in our empirical analysis, we find that the data reject $\beta_{rkt} = 1$, offering some evidence that with our monopolist retailer set-up non-linear contracts are not consistent with the data. Relatedly, Iyer and Villas-Boas (2003) with a different model set-up from ours find that non-linear contracts are not optimal when bargaining is possible.

this was the primary legal avenue by which these national brands could enter the market.[12] In the post-patent period, any firm could enter and produce super-premium products on their own. In both cases, these contractual relationships influence the bargaining outcomes through the construction of the agreement and disagreement payoffs, which are detailed below. Second, post-patent expiration, some retailers contracted directly with the Dominant Brand to produce their private label products, while others utilized an independent third-party manufacturer. This also has important implications for the bargaining leverage.

To address the first issue, we develop a representation of these contractual relationships (partners and licensees) directly in the model. First, the Dominant Brand manufactures the super-premium products for their partners; the Dominant Brand's partners take the product to market themselves (i.e. negotiated directly with the retailers) and pay the Dominant Brand for accrued sales. Abstracting from the details of these unobserved contracts, we model these contracts as offering revenue sharing back to the Dominant Brand net of the Dominant Brand's costs. Hence, while a given partner bargains with the retailers directly in our framework, they must pay a fraction of the wholesale price to the Dominant Brand. Correspondingly, when the Dominant Brand bargains for its wholesale prices (on the products it owns), it considers the side payment it receives from its partners when constructing its agreement and disagreement payoffs.

The modified profits for the partner brands are

$$\Pi_f^{J_{rt}} (\cdot) = \sum_{j \in f_{rt}} \left(w_{rjt}(1 - \kappa) - c_{rjt} \right) s_{rjt}^{J_{rt}} (p_{rjt}) M_{rt}, \tag{7}$$

where κ is the net revenue sharing paid to the Dominant Brand per unit. The Dominant Brand's profit is then,

$$\Pi_f^{J_{rt}} (\cdot) = \sum_{j \in f_{rt}} \left(w_{rjt} - c_{rjt} \right) s_{rjt}^{J_{rt}} (p_{rjt}) M_{rt} + \sum_{j \in J_{p,rt}} w_{rjt} \kappa s_{rjt}^{J_{rt}} (p_{rjt}) M_{rt}, \tag{8}$$

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[12]In fact, there were a few small manufacturers who apparently worked around (or in violation of) the patent, but obtained limited penetration.

where $J_{p,rt}$ is the set of partner brands in retailer r in period t.

In addition to partners, the Dominant Brand also managed super-premium products that held licensed brand names. These licensee brands are manufactured and brought to market by the Dominant Brand. The Dominant Brand pays a licensing fee back to the licensor for each sale. In our model, these licensing fees appear as part of the costs (to the Dominant Brand) for licensing brands.

The second contractual issue noted above concerns the manufacturing relationships for the private label products (post-patent expiration). Note that private label brands are owned by the retailer rather than the manufacturer, so that the retailer can choose amongst multiple manufacturers for the purpose of producing the product. During our study time frame, the set of private label manufacturers was relatively limited. We abstract to two manufacturers–the Dominant Brand and another player that has no national brands in the marketplace (a third party manufacturer). For retailers that have the Dominant Brand as the manufacturer, the bargain is between the Dominant Brand and the retailer, where that bargain internalizes all of the profits from the Dominant Brand's other products (i.e., the Dominant Brand's own, licensing, and partner brands). In contrast, the third party manufacturer has no other products that it internalizes (making its disagreement payoff zero should it fail to reach agreement with the retailer).

3.3 Identification and Estimation

Given this model set-up, we turn now to identification and estimation. For identification, we make use of the first-order condition of the Nash bargaining problem. The first-order condition for bargaining between brand r and retailer j at period t is given by:

$$\frac{dR_{rjt}}{dw_{rjt}}F_{rjt}\beta_{rjt} + \frac{dF_{rjt}}{dw_{r,jt}}R_{fjt}\left(1 - \beta_{rjt}\right) = 0, \tag{9}$$

where F_{rjt} and R_{rjt} denote the difference between the agreement and the disagreement payoffs for the brand and the retailer, respectively.[13] We can write down F_{rjt} and $\frac{dF_{rjt}}{dw_{rjt}}$ as a function of c_{rjt} as follows:

$$F_{rjt} = \sum_{j' \in f_{rt}} (\mu_{1j'} w_{rj't} - \mu_{2j'} c_{rj't})(s_{rj't} - \hat{s}_{rj't}). \tag{10}$$

$$\frac{dF_{rjt}}{dw_{rjt}} = \sum_{j' \in f_{rt}} (\mu_{1j'} w_{rj't} - \mu_{2j'} c_{rj't})\frac{ds_{rj't}}{dw_{rjt}} + \mu_{1j} s_{rjt}. \tag{11}$$

$\hat{s}_{rjt}$ denotes the market share of product j in the disagreement scenario. Substituting out F_{rjt} and $\frac{dF_{rjt}}{dw_{rjt}}$ in expression (9) with expressions (10) and (11), we have

$$\sum_{j'} \mu_{2j'} \left((s_{rj't} - \hat{s}_{rj't}) + \frac{\frac{ds_{rj't}}{dw_{rjt}}}{\frac{dR_{rjt}}{dw_{rjt}}} R_{rjt} \frac{1 - \beta_{rjt}}{\beta_{rjt}} \right) c_{rj't}$$

$$= \sum_{j'} \mu_{1j'} w_{rj't}(s_{rj't} - \hat{s}_{rj't}) + \left(\sum_{j'} \mu_{1j'} w_{rj't} \frac{\frac{ds_{rj't}}{dw_{rjt}}}{\frac{dR_{rjt}}{dw_{rjt}}} R_{rjt} + s_{rjt} \mu_{1j} \frac{R_{rjt}}{\frac{dR_{rjt}}{dw_{rjt}}} \right) \frac{1 - \beta_{rjt}}{\beta_{rjt}}. \tag{12}$$

Note that if we know the demand-side parameters, all of the components in expression (12) are known except for β_{rjt} and c_{rjt}. For identification, we assume that the marginal cost c_{rjt} of a given brand does not vary across retailers in expectation, and that the bargaining power β_{rjt} of a given retailer does not vary across manufacturers in expectation. Then expression (12) is a linear programming problem such that the expected values of $\frac{1-\beta_{rjt}}{\beta_{rjt}}$ and c_{rjt} are identified as a coefficient of the terms observable to the researcher.[14]

For estimation, we parameterize c_{rjt} as a function of brand's observed characteristics as

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[13]Specifically, $F_{rjt} = \Pi_f^{J_{rt}}(w_{r,jt}, w_{r,-jt}) - \Pi_f^{J_{rt}-j}(w_{r,-jt})$ and $R_{rjt} = \Pi_r^{J_{rt}}(w_{r,jt}, w_{r,-jt}) - \Pi_r^{J_{rt}-j}(w_{r,-jt})$.

[14]The expected value of $\frac{1-\beta_{rjt}}{\beta_{rjt}}$ is identified by the variation of $\left(\sum_{j'} \mu_{1j'} w_{rj't} \frac{\frac{ds_{rj't}}{dw_{rjt}}}{\frac{dR_{rjt}}{dw_{rjt}}} R_{rjt} + s_{rjt} \mu_{1j} \frac{R_{rjt}}{\frac{dR_{rjt}}{dw_{rjt}}} \right)$ across brands for a given retailer, and the expected value of $c_{rj't}$ is identified by the variation of $\mu_{2j'} \left((s_{rj't} - \hat{s}_{rj't}) + \frac{\frac{ds_{rj't}}{dw_{rjt}}}{\frac{dR_{rjt}}{dw_{rjt}}} R_{rjt} \frac{1-\beta_{rjt}}{\beta_{rjt}} \right)$ across retailers for a given brand.

follows

$$c_{rjt} = X_{jt}\theta_c + \varepsilon_{rjt}^c. \tag{13}$$

where X_{jt} consists of brand-specific intercepts, as well as time dummies (common across brands) that capture any systematic intertemporal fluctuation in marginal costs. Conditional on the brand-specific intercept and the time fixed effects, the marginal cost may vary across retailers and across time due to the idiosyncratic shock, ε_{rjt}^c. We assume that ε_{rjt}^c follows a Normal distribution with mean zero and standard deviation σ_c.

We also parameterize the bargaining power of each retailer as follows.

$$\log\left(\frac{\beta_{rjt}}{1 - \beta_{rjt}}\right) = X_{rt}\theta_r + \varepsilon_{rjt}^r. \tag{14}$$

For ease of estimation, we assume that the bargaining power is distributed such that its log-odds-ratio is determined by observed characteristics of the retailer as well as an idiosyncratic shock, ε_{rjt}^r, which is Normally distributed with mean zero and standard deviation σ_r. We include in X_{rt} a constant term, time fixed effects, a dummy variable that is one for post-PL introduction periods for retailers that has a PL product, and a dummy variable that is one for pre-PL introduction periods for PL retailers. These dummy variables capture any systematic differences in bargaining power between retailers that have a PL product and retailers that don't. The dummies also capture how the introduction of a PL product affects the bargaining power of the retailer. We also include in X_{rt} a measure of brand equity of the PL product associated with the retailer in X_{rt}. This term aims to capture the possibility that a retailer that can produce a higher quality PL product may have greater bargaining power.[15]

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[15]The measure of brand equity we use is the deterministic component of utility $(\delta - \alpha p)$ for the PL product that the retailer has in the premium (i.e. non-patented) segment. This measure captures the retailer's ability to introduce a high quality PL product. Note that because the measure is constructed from the market share of the retailer's PL product in other product segments, the measure is not perfectly collinear with the demand of the PL product in the premium segment.

For estimation, we adopt a Bayesian Monte-Carlo approach. Specifically, we use a Metropolis-Hastings (MH) algorithm that proceeds as follows.

1. The parameters of interest are $\{\theta_c, \theta_r, \sigma_c, \sigma_r\}$. We set a diffused prior for θ_c and θ_r. We assume that σ_c and σ_r both follow $IG(1,1)$. We also draw our initial guess of $\log\left(\frac{\beta_{rjt}}{1-\beta_{rjt}}\right)$ vector. We update our guesses of $\{\theta_r, \theta_c, \sigma_r, \sigma_c\}$ and the log-odds-ratio during the iteration process.

2. From a candidate distribution (which is a Normal distribution centered around $\log\left(\frac{\beta_{rjt}}{1-\beta_{rjt}}\right)$ with step size flexibly adjusted during the process), draw a new candidate of $\log\left(\frac{\beta'_{rjt}}{1-\beta'_{rjt}}\right)$. Using the MH algorithm, we either accept or reject the new guess. The criteria is the likelihood that corresponds to the residuals of expression (13) and expression (14), evaluated at the current guess of θ_c and θ_r. To evaluate expression (13), we convert the log-odds-ratio to β'_{rjt}, and compute the corresponding values of c'_{rjt} using expression (12) evaluated at the current value of θ_c.

3. With the updated draws of $\log\left(\frac{\beta_{rjt}}{1-\beta_{rjt}}\right)$, evaluate expression (14) and update θ_r and σ_r via Bayesian least squares.

4. Convert the log-odds-ratio to β_{rjt}, and use expression (12) to derive a vector of c_{rjt} associated with β_{rjt}. Evaluate expression (13) and update θ_c and σ_c via Bayesian least squares.

5. Repeat the process until it converges.

As we noted above, R_{ft} and $\frac{dR_{ft}}{dw_{r,ft}}$ terms can be fully pre-computed using the demand-side estimates. Further, the quantities F_{rt} and $\frac{dF_{rt}}{dw_{r,ft}}$ can be pre-calculated up to the cost parameters θ_c. Note that these pre-calculations involve several steps. First, to calculate the quantities related to the retailer profits, we need to compute the disagreement payoffs. Because these payoffs involve counterfactual sets of products, we need to solve for the optimal prices under the reduced product set $J_{rt}-k$. Since we have assumed a monopolist retailer, this

problem has a unique solution that is recovered by successive approximation (e.g., see Judd (1998)). Second, for each bargain, we need to simulate the shares for both the agreement and disagreement product sets, as well as their prices. Third, for each agreement payoff, we need to simulate the first and second derivatives of the shares. Finally, we need to compute the solution to the system of total derivatives of optimal price by wholesale prices based on equation (50) provided in Appendix D.

4   Empirical Results

In this section, we discuss results from the structural demand estimation and then the structural supply model.

4.1   Demand Model Estimates

Table 3 presents parameter estimates for the main parameters of interest, namely those relating to price and heterogeneous substitution effects. Recall that the model includes many additional controls, omitted here for brevity. The price coefficient is negative and significant and yields an average own price elasticity of -2.89. This own price elasticity is in line with other CPG categories, and is very similar to alternative specifications (robustness tests) based upon simpler models that do not capture substitution between brands as well, including a log shares-log price regression (-3.06) and a model with no heterogeneity or ACV and installed base correction (-3.10). The model reveals substantial heterogeneity in tastes for three of the segments, namely super-premium, main and low, whereas tastes for the premium segment are relatively homogeneous. The model reveals significant, but modest heterogeneity in price sensitivity. This modest heterogeneity may be due to the presence of segment heterogeneity, since these segments exhibit a sharp degree of vertical differentiation.

Figure 3 shows how the 'brand intercepts' compare between private label products and the leading national brand for each segment in each of the 72 RMAs. The figures contain

Variable	Estimate	Std. Err.	Signif.
Mean Price	-3.006	(0.001)	**
SD Price	0.109	(0.022)	**
SD Low	4.693	(0.028)	**
SD Main	1.472	(0.020)	**
SD Premium	0.012	(0.099)	
SD Super-Premium	1.218	(0.033)	**

Table 3: Estimates of Non-linear parameters

the average (over all of the six-month time periods) brand intercept estimates for the corresponding brands in each RMA. To present these values on a single graph, each brand intercept is normalized by subtracting the mean of it's segment's leading national brand intercept (i.e., the leading national brand's mean intercept is zero). Looking first at figure 3a, we can see that, while the median brand intercept of the leading national brand is greater than that of the private label, the distributions do overlap, particularly in the premium and super-premium segments. Figure 3b, which presents the same comparison, using differences instead of levels, illustrates that the overlap is not simply due to common market shifts, but rather due to some private labels achieving brand equity levels near those of the national brands. Although we cannot reveal identities of retailers, the relative ordering of the private brand intercepts are closely related to our understanding of the private brand programs of the retailers. This suggests that the products do share similar positions in vertical quality space (for at least some retailers), and as a result, compete for the same consumers. Moreover, it also demonstrates that there is heterogeneity (across retailers) in the degree to which they do so, providing a key source of variation for the supply-side bargaining problem.

In addition to the variation in brand intercepts, our supply-side model builds on the substitution patterns captured in the demand model. In particular, our interest is in capturing aspects of the vertical segmentation (along price dimensions) within the super-premium segment. To illustrate these substitution patterns, in Table 4 we present cross-price elasticities for a subset of brands and private labels for RMAs, which we label RMA 1-4. The pattern of

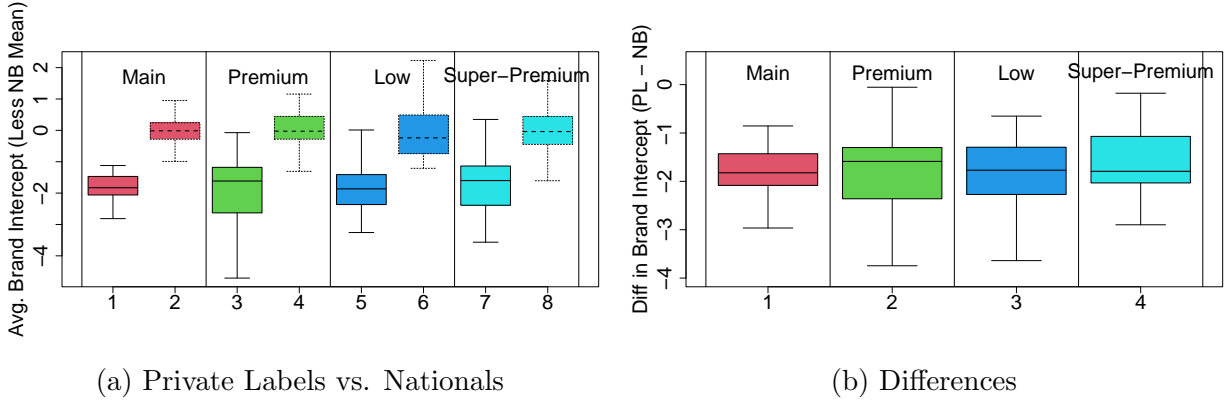(a) Private Labels vs. Nationals

(b) Differences

Figure 3: Private Label Brand Qualities

cross-price elasticities is sensible. Brands that are positioned vertically close to one another have higher elasticities, and brands positioned further apart have lower elasticities. Private labels have meaningful variation because of their price positions and brand equity (and the resultant market shares). For example, RMA 1, an upscale retailer, has higher elasticity to Brand 8 (a high priced brand) and lower to Brand 5 (a low priced brand), whereas RMA 2 and 3 both have lower quality private labels, and so have lower elasticities to Brand 8. Finally, RMA 4 has a much higher private label share than most other private labels and as a result has much higher cross-elasticities. This is consistent with its strong private label program and positioning as a retailer.

Brand	Brand 5	Brand 7	Brand 2	Dominant Brand	Brand 6	Brand 8
National Brands						
Brand D	0.392	0.305	0.295	-2.722	0.306	0.286
Brand 2	0.074	0.080	-2.895	0.101	0.109	0.074
Brand 6	0.065	0.069	0.089	0.087	-2.904	0.115
Brand 7	0.081	-2.945	0.056	0.057	0.057	0.051
Private Labels						
RMA 1 (upscale retailer)	0.094	0.141	0.141	0.141	0.140	0.173
RMA 2 (low-end retailer)	NA	0.114	0.109	0.109	0.108	0.083
RMA 3 (low-end retailer)	NA	0.122	0.133	0.135	0.134	0.094
RMA 4 (upscale, largest PL)	0.766	NA	0.764	0.765	0.762	0.762

Table 4: Cross-Price Elasticities for Select National and Private Label Brands. Rows are the brand that increases price and columns the brand that is impacted. NA indicates the brand is not available in that retailer

We next examine whether the basic implications of an improved bargaining position are apparent in the wholesale prices we recover from the monopolist pricing assumption. Specifically, we consider for the same brands as presented in Table 1 (those available at least six months prior to the patent expiration) whether the wholesale prices decrease on average in the four quarters after the patent expiration versus the four quarters before the expiration. Table 5 presents the analysis.

Brand	% Δ in $\hat{w}$	Est. Change	S.E.	t-stat	Obs. Pre	Obs. Post
Brand D	-6.1%	-0.024	0.004	-6.06	275	280
Brand 1	2.4%	0.011	0.005	2.047	206	214
Brand 2	-4.0%	-0.016	0.003	-4.47	282	284
Brand 3	-3.9%	-0.155	0.004	-3.91	163	173
Brand 4	3.3%	0.014	0.005	2.68	267	266
Brand 5	-6.7%	-0.021	0.008	-2.59	46	77
Brand 6	-3.3%	-0.019	0.004	-4.34	200	279

Table 5: Percent and Level Changes in $\hat{w}$ for the year before versus after patent expiration for brands available at least 6 months before the patent expiration

The estimated differences are all negative except in two cases, the same brands that were found in Table 1 to increase the retail prices following the patent expiration, suggesting a shift upmarket. For the remaining brands, the decreases are between 3% and 7% with the second largest difference being for the Dominant Brand, the leading national brand. Although consistent with past research (Meza and Sudhir, 2010) that suggests the improved bargaining leverage that the private label provides can lead to lower wholesale prices, we cannot at this stage rule out other changes (e.g. declining marginal cost trends). Our supply-side estimation and analysis further calibrates the magnitude of this bargaining benefit in the context of the value of the private brand and other changes that could be occuring.

4.2 Supply-side Estimates

The supply-side estimation aims to recover two sets of parameters. The first, $\{\theta_c, \sigma_c\}$, characterize the cost function, while the second, $\{\theta_r, \sigma_r\}$, characterize the bargaining power

of the retailers. We first discuss the cost parameter estimates and then turn to the bargaining power parameters.

Variable	Estimate	Std. Err.	Signif.
Constant (Largest brand)	0.358	0.005	*
Std.deviation of the residual (σ_c)	0.044	0.001	*
Brand FE		✓	
Time FE		✓	

Table 6: Estimates of Cost Parameters- *: p-value<.01

Marginal Costs   Table 6 presents the point estimates for the cost parameters. The constant, which represents an average per-serving cost for the largest supplier, is 35.8 cents, suggesting a modest per-serving cost for the product. In Figure 4a, we show the distribution of marginal costs across brands. We find that most brands incur a per-serving cost of between 30 and 40 cents. In Figure 4b, we show how marginal cost of the largest brand evolves over time. We find a declining trend: marginal cost of the largest brand starts at 35.8 cents in period 7 (the third quarter of 2011), and it goes down to 30.9 cents within two years and a half.
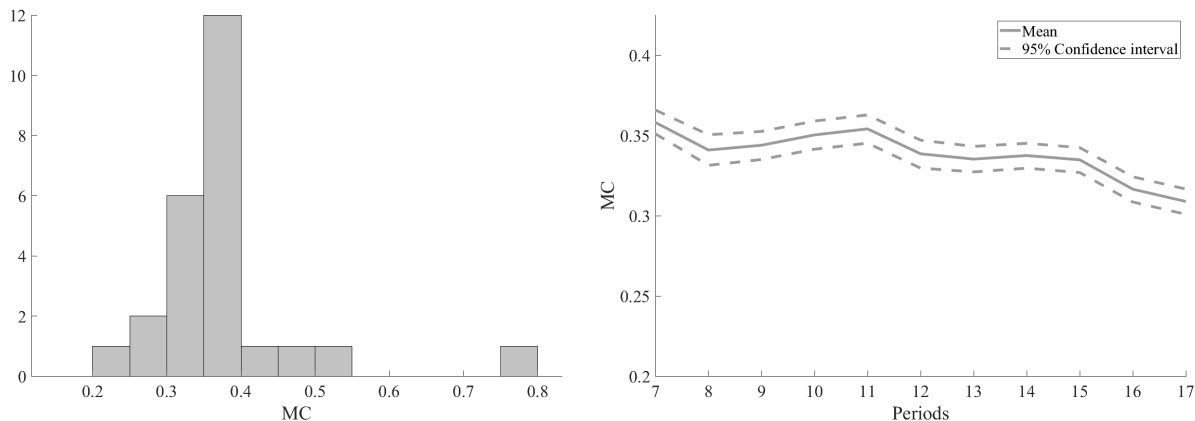
(a) Distribution across brands   (b) Evolution of largest brand's MC

Figure 4: Marginal costs

Overall, we find reasonable variation in costs across brands, with the standard deviation

being 8.9 cents, the interquartile range covering 8.6 cents, and the total range covering 77.9 cents.

Variable	Estimate	Std. Err.	Signif.
Constant	-3.183	0.694	*
PL owners (pre-introduction)	-0.141	0.467	
PL owners (post-introduction)	-0.505	0.392	
Brand equity of PL products	0.403	0.145	*
Std.deviation of the residual (σ_r)	2.25	0.216	*
Time FE		✓	

Table 7: Estimates of Bargaining Parameters- *: p-value<.01

Bargaining Powers Table 7 shows the estimates of bargaining power parameters. The dependent variable is the log-odds ratio of bargaining power of each retailer at each period. We find a large negative intercept value, indicating that the bargaining power of a retailer is very small compared to that of a brand. The coefficients for PL owner dummies are negative for both pre-PL and post-PL introduction, indicating that retailers that introduce a PL product have a lower bargaining power than those that don't, although the estimates are not statistically significant. These estimates imply that retailers that introduce a PL product enjoy bargaining power of 0.06 on average, whereas the retailers that never introduced one average 0.11.

Comparing pre- and post-private label introduction, we find that the change in the bargaining power of PL owners is negative, but statistically insignificant and economically small. The average difference of -0.36 (0.141-0.505) in log-odds-ratio translates to the average difference of -0.01 in β_{rjt} between the pre- and post-PL introduction, relative to that of retailers that never introduced a PL product. Our findings suggest that most of the variation in outcomes with versus without the private label is due to changes in the bargaining leverage (disagreement payoffs) of the two parties rather than bargaining power. This bargaining leverage is determined by the nature of demand and the brand equities (intercepts) for the products each retailer carries.

(a) Histogram of bargaining power

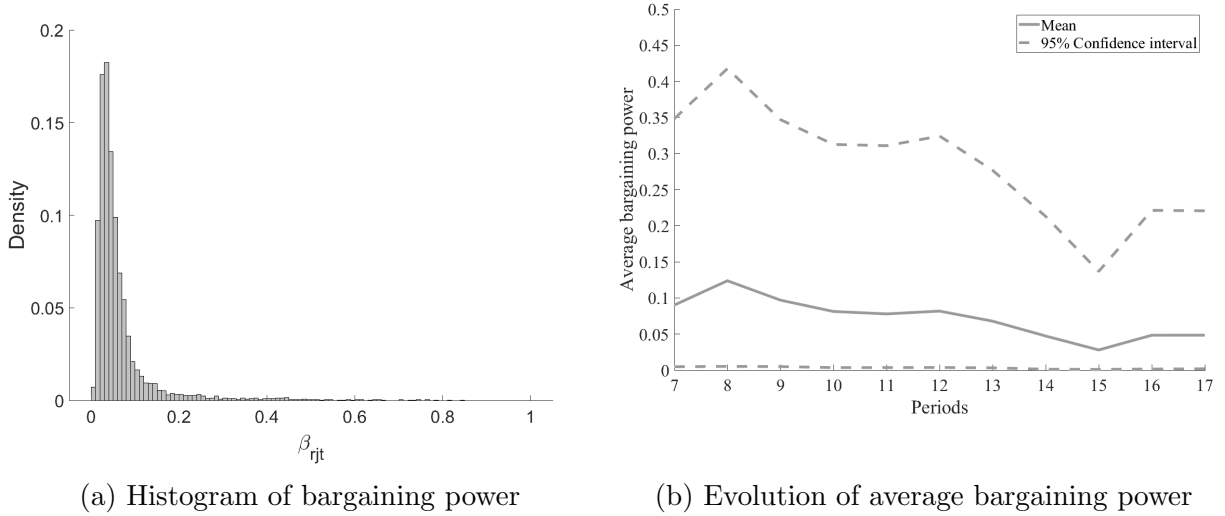(b) Evolution of average bargaining power

Figure 5: Bargaining powers

Figure 5a shows the overall distribution of bargaining power across retailers and periods. The overall bargaining power distribution has a mean of 0.06 and a standard deviation of 0.08. The inter-quartile range is 0.04. Note that low bargaining power does not imply that retailers receive zero payoff out of the negotiation: because retailers choose price after the wholesale price is determined, retailers are always able to add a positive mark-ups over the wholesale prices, even when their bargaining power is zero. Figure 5b shows the evolution of average bargaining power over time. We find a gradual decline in the average bargaining power, though the trend is not statistically significant.

Given the estimated bargaining powers and marginal costs, we compute the margin of each brand. Figure 6 shows its histogram, plotted against the margin of retailers obtained in the previous step. We find that manufacturers gain higher margin than retailers, reflecting their higher bargaining powers. The average margin of manufacturers is 0.35 with a standard deviation of 0.04.
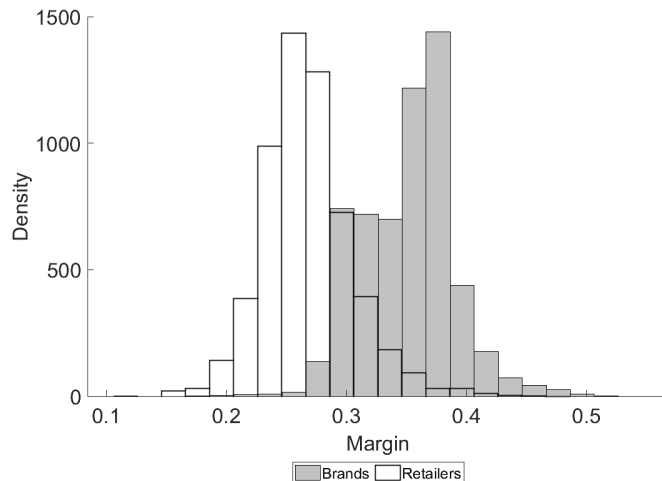
Figure 6: Margin of Brands and Retailers

5   Counterfactual Experiments

In this section, we use counterfactual simulations to isolate and explore the impact of private label entry on market outcomes. Recall that much was changing in the market over this period. The market size was continuing to expand with machine ownership, branded firms that were unaffiliated with the patent holder were entering the market, while new affiliated brands were entering in both periods, and most retailers were launching new private label products. To focus directly on the impact of private label entry and control for other factors, we consider a period after patent expiration and construct counterfactual outcomes for scenarios without private label products, holding other market conditions fixed.

In particular, for each RMA where a private label was actually introduced, we simulate a counterfactual outcome in which the private label product is removed from the market. We compute the equilibrium (bargained) wholesale prices, the corresponding optimal retail prices, and the resulting market shares. We then compare these to the "factual" market outcomes, computed with the private label in the market. Note that both constructs are simulations, with the latter corresponding to the "treatment" that actually occurred (i.e. private label entry) and the former corresponding to the counterfactual "control" condition.

We use percentage changes throughout to maintain a common scale. For the following analyses, we consider 62 RMAs having 346 RMA-period cases with a (factual) private label entry as compared to a (counterfactual) market without the private label. In what follows, we first present the overall gains of retailers from PL entry. We then decompose the effect into category expansion and the change in the margin of existing products. Finally, we discuss how much of the retailers' gains is attributed to their bargaining positions.

5.1 Overall Impact of Private Label on Profits

We begin by quantifying the magnitude of the retailers' total profits generated by the private label products. These total effects are calculated as

$$\Pi_r^F - \Pi_r^{CF} = \sum_j (p_j^F - w_j^F)s_j^F - \sum_{j/PL} (p_j^{CF} - w_j^{CF})s_j^{CF},$$

where p_j is the retail price of product j, w_j is the wholesale price the retailer pays to the manufacturer, and s_j is the equilibrium share of the PL product. Superscripts F and CF correspond to factual and counterfactual cases of PL or no PL product, respectively. To construct a percentage measure, we divide the profit difference by the retailer profit from the super-premium segment without the private label in the market. The distribution of these percentages across retailers is displayed in figure 7. Each observation underlying the density plot is an RMA-quarter. Note that retailers vary quite substantially in this measure of direct profit from the private label. The mean retailer profits from the private label are 10% of the total segment profits without a private label. Some firms earn considerably more, with an RMA that relies heavily on private label products holding the extreme position of around 107%. This case shows both the importance of the private label and that some markets had an under-provision of product options prior to launching the private label. Overall, private labels bring a sizable boost to the retailer profits.
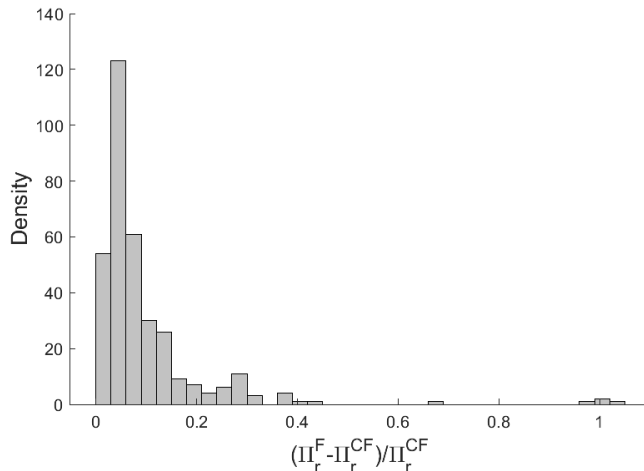
Figure 7: Percent Overall Increase in Profit Due to PL

5.2 Category Expansion and Margin of Existing Products

We now evaluate the amount of profits arising from category expansion due to the presence of the new product, and the change in the margin of existing products. This decomposition helps when we discuss the retailers' gains attributed to bargaining below. We first consider category expansion. Category expansion is the combination of direct profits from the private label product and a loss of shares from the national brands. Profits from category expansion are defined as

$$\Pi_{CE} = \left(p_{PL}^F - w_{PL}^F\right) s_{PL}^F + \sum_{j/PL} \left(p_j^F - w_j^F\right) \left(s_j^F - s_j^{CF}\right) \tag{15}$$

The first term in this sum is the private label direct profits and the second term is the loss in profits due to competitive stealing. To see that the second term is negative, note that the shares of national brands with the private label should on average be lower than those without the private label. Figure 8 presents the direct profit from the PL product as well as the profits lost due to competitive stealing.

Figure 8a shows that direct profit from a PL product accounts for a large increase in the profits relative to the profits attained without the private label. The average is 14%, though there is a large spread. The largest increase indicates a 135% increase in segment profits due to the PL product sales alone. In figure 8b, we show that the lost profits are a meaningful

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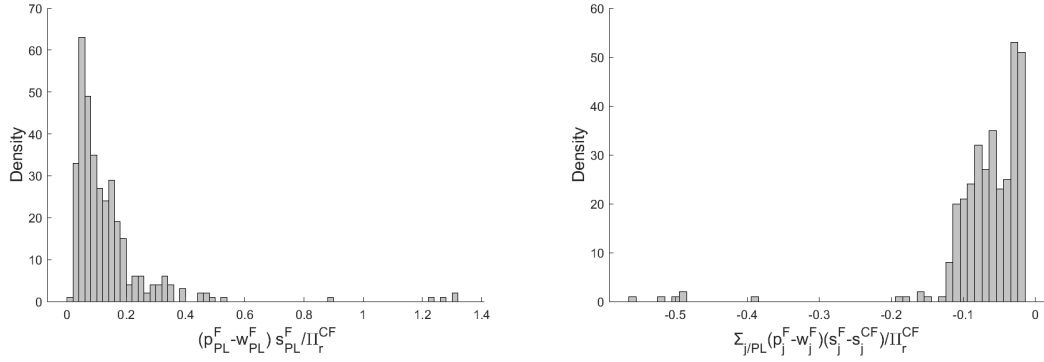
(a) Direct Profit from PL Product as Per-(b) Competitive Stealing Loss as Percentage
centage of Profit without PL of Profit without PL

Figure 8: Category Expansion Effects

proportion of the counterfactual profits without private label, suggesting that of the direct private label profit, a sizable proportion comes from competitive stealing. Most cases fall between an 3% and a 21% loss with the average being a 6.5% loss.
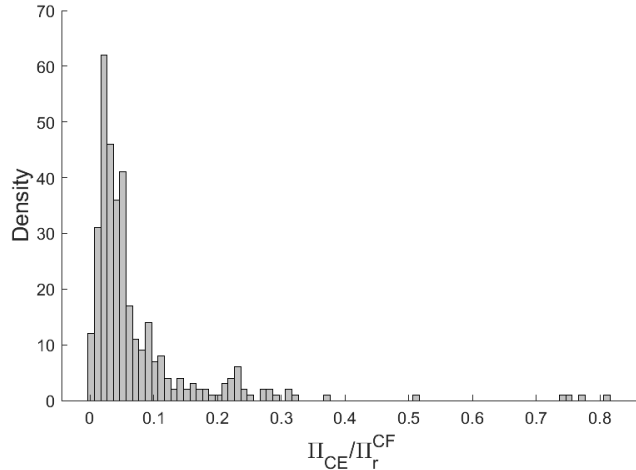

Figure 9: Combined Effects from the Downstream Market

In Figure 9, we show the combined effect. An average retailer sees 7.6% increase in profits from the private label net of the substitution effect, which is about 68.7% of the total gain that the retailer has from introducing a PL product. These results indicate that the private label provides significant benefit that exceeds the loss due to competitive stealing. In particular, this suggests that there is pent-up demand that the private label meets.

We next calibrate how the PL introduction affects the retailers' margin of the existing, branded products. The margin effect is measured as follows:

$$\sum_{j/PL} \left(\left(p_j^F - w_j^F \right) - \left(p_j^{CF} - w_j^{CF} \right) \right) s_j^{CF}. \tag{16}$$

Intuitively, private label entry affects margin of national brand products through two channels. First, PL products give retailers better bargaining leverage (higher disagreement payoffs), lowering the equilibrium wholesale prices. Because retailers set prices taking the wholesale price as their marginal costs, the final prices also go down. Second, because retailers price as monopolists, the introduction of a new product lets them better internalize the cross-product substitution and hence higher market power, which results in a higher final price for the existing products. Because manufacturers will claim some shares of the gain through Nash bargaining, it also raises the wholesale prices. The equilibrium wholesale prices and final prices of the existing products are determined as a result of these two counteracting forces. Note that the margin effect we measure here is not equivalent to the retailers' gains from bargaining, because retailers raise prices of existing products even when the wholesale price remains unchanged (i.e. the latter of the two effects still exists without bargaining). Further exercises to isolate the pure gain from bargaining will be conducted in Section 5.3.

Figure 10a presents the histogram of the margin effect as a percentage of total profits of the retailer without PL. We find that retailers' margin improves with a PL product, but the benefit is quite heterogeneous. On average, retailers derive a benefit of 2.6% of super-premium segment profits due to better margins on branded products. Some firms do substantially better than this (due to the strong positioning of their private label in the marketplace). Finally, figure 10b reveals the magnitude of the margin benefit as a percentage of the overall profit increase due to the private label (i.e., profit with private label minus profit without private label). We find that the margin benefit is quite large, amounting to 31.3% of the overall lift in profits on average. Again, there is significant heterogeneity around
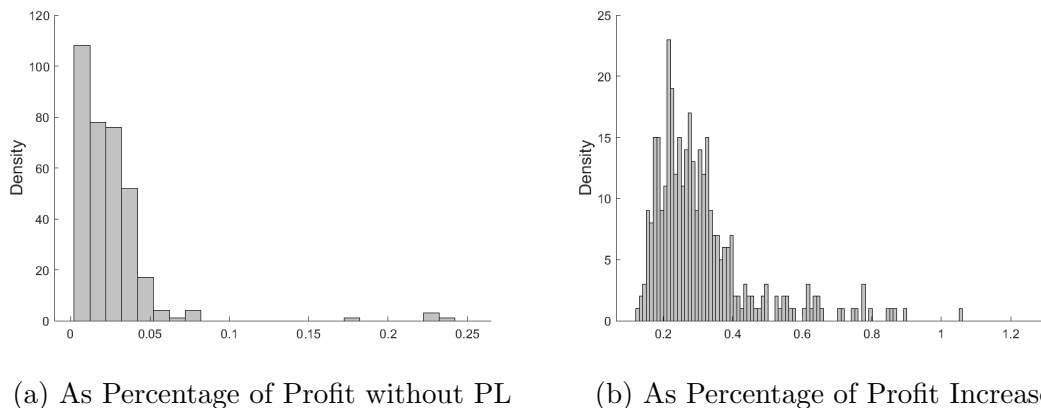
the mean.

(a) As Percentage of Profit without PL   (b) As Percentage of Profit Increase

Figure 10: Margin Benefits

5.3 Isolating Benefits from Bargaining

In this section, we illustrate how much of the retailers' gains from private label entry is attributed to bargaining benefits. Specifically, we consider two sources of bargaining gains: one due to the bargaining position of retailers over the private label products, and the other due to the price renegotiation over the existing, branded products. We construct two sets of counterfactual exercises to isolate out these two factors, holding other factors such as retailers' downstream market power fixed.

In the first set of exercises, we demonstrate that the bargaining position of retailers over the private label products has a substantial impact on the retailers' gains from PL entry. Recall that in reality, some retailers rely on the Dominant Brand to manufacturer their PL product, whereas others utilize an independent manufacturer. Obviously, sourcing a PL product from an independent manufacturer gives the retailer a better bargaining position (because the independent manufacturer has zero disagreement payoff in the Nash bargaining) and hence the retailers' gains from PL entry is larger. Of the 62 retailers that we consider in the counterfactual, 32 retailers (201 retailer-quarter observations) rely on the Dominant Brand, whereas the remaining 30 retailers (145 retailer-quarter observations)

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utilize an independent manufacturer.

To quantify how the retailers' gain depends on their bargaining position over the PL product, we simulate counterfactual market outcomes in which we maintain the PL products in the market, but manipulate their manufacturer. In Table 8, we present gains from PL entry in two counterfactual scenarios. All reported numbers are average across retailer-quarter and are reported as percentage of profits without PL products. The first row corresponds to the scenario in which all retailers rely on the Dominant Brand to manufacture their PL product. This scenario corresponds to the situation where the manufacturers' bargaining leverage over the PL product is largest. We find that because of higher wholesale prices of the PL product, retailers' overall gains from PL entry is about 20% lower than the factual case presented in the third row. Higher wholesale prices are passed on to the final prices and reduce sales, thereby reducing the market expansion effect presented in the second column. On the other hand, outcomes of PL products' bargaining have minor impact on the margins of the existing products (the third column).

In the second row, we present outcomes when all PL products are manufactured by an independent supplier: a situation in which the manufacturer's bargaining position is smallest. The result is symmetric to the first scenario. Retailers' gains are higher by about 20% compared to the factual case, most of which arise from the market expansion. Overall, our findings imply that bargaining positions over the PL product have a substantial impact on the retailers' gains from PL entry (up to 36% of the gains from entry, or 4% of retailers' profit without private label). The results hence highlight the importance of accounting for bargaining positions over private label products.

Scenario	Total gains from PL	Market expansion	Margin effect
All PL supplied by the Dominant	0.080	0.052	0.028
All PL supplied by the independent	0.124	0.099	0.025
Factual (benchmark)	0.101	0.076	0.026

Table 8: Gains from PL Entry under Different Manufacturer Identities

In the second set of counterfactual exercises, we consider how a PL entry affects retailers' gains from bargaining over existing, branded products. In other words, we examine whether or not the wholesale price renegotiation due to PL entry would benefit retailers. To this end, we simulate market outcomes when PL products exist in the market, but the wholesale prices of the branded products are fixed at the level without PL products. This exercise corresponds to a counterfactual simulation of a private label entry, had there not been Nash bargaining in the model. We then take the difference between the predicted total gains of the retailer from the PL product in this counterfactual and those from the counterfactual presented in Section 5.1. The difference represents retailers' pure gain from bargaining over existing products due to PL entry.[16]

In Figure 11a, we present the distribution of retailers' gains from bargaining over existing products. Each unit of observation is retailer-quarter and results are presented in percentage of profits without private label. Positive numbers mean retailers gain from wholesale price renegotiation. We find that, on average, retailers' pure gains from bargaining is -0.007, indicating that an average retailer's gain from PL entry is lower by 0.7% of the retailer's total profit without PL when wholesale prices of existing products are renegotiated (or lower by 14.8% of the retailers' total gain from PL entry). We also find a significant dispersion around the mean: some retailers benefit from bargaining by about 2% of the total profit without PL product, whereas others lose by about 3%.

The fact that the majority of retailers will not gain from bargaining over existing products indicates that the wholesale prices go up in many markets with PL entry. In Figure 11b, we present histogram of the difference in wholesale price of branded products with and without a private label product ($w_j^F - w_j^{CF}$ for $j \neq PL$). Numbers larger than zero mean higher wholesale prices with a private label product. We find that in about 80% of the markets, wholesale prices of the branded products are higher with a private label product in the

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[16]There is degree of freedom regarding what wholesale price to use for the PL product. For this exercise, we assume that the wholesale price of the PL product equals the ones recovered from the demand side (i.e. realized wholesale price).

market, though the overall magnitude of the change is small (for 92% of the markets, the size of the change is less than a cent). In other words, we find that, of the two factors that affect wholesale prices we discussed in Section 5.2, the latter will dominate for the majority of the markets. The better bargaining positions of the retailers from improved leverage (due to PL products) are not enough to offset the upward pressure on the wholesale prices that arise from the improved downstream market power (and that manufacturers also claim its share through Nash bargaining). Therefore, retailers on average lose when wholesale prices are renegotiated.

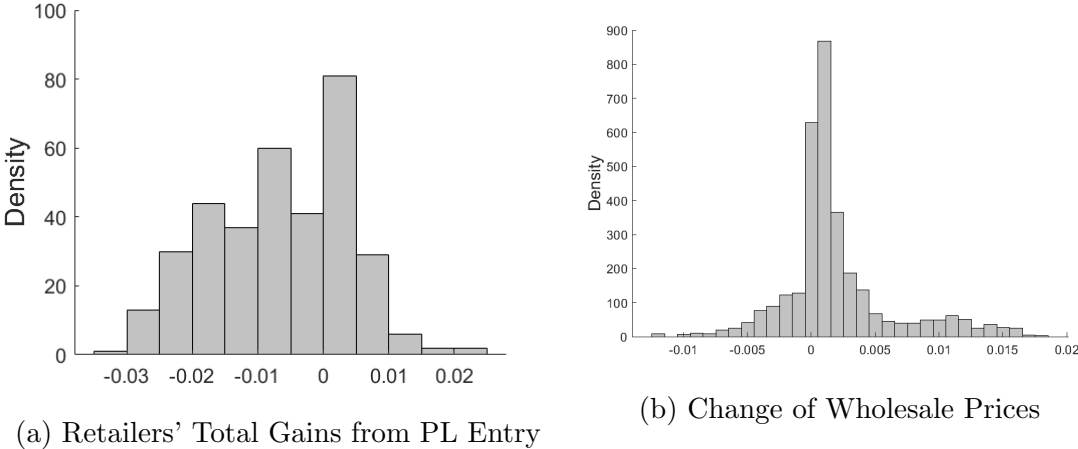(a) Retailers' Total Gains from PL Entry (b) Change of Wholesale Prices

Figure 11: Effects due to Bargaining over Existing Products

To explore the source of heterogeneity in the gains from bargaining across retailers, we consider how the bargaining benefit relates to the private label brand equity of the retailer. In Figure 12, we present scatterplot between retailers' gains from bargaining and their PL product equity. The unit of observation is retailer: to plot the retailer-level gains from bargaining on the Y axis, we average the gains of each retailer obtained above across all time periods. We find positive correlation of around 0.4 between the two measures, indicating that retailers with higher PL equity (i.e. more popular PL product) gain more from bargaining than those with lower PL equity. Our findings are consistent with the story that a stronger PL product provides a better disagreement payoff for the retailer and improves its bargaining position.
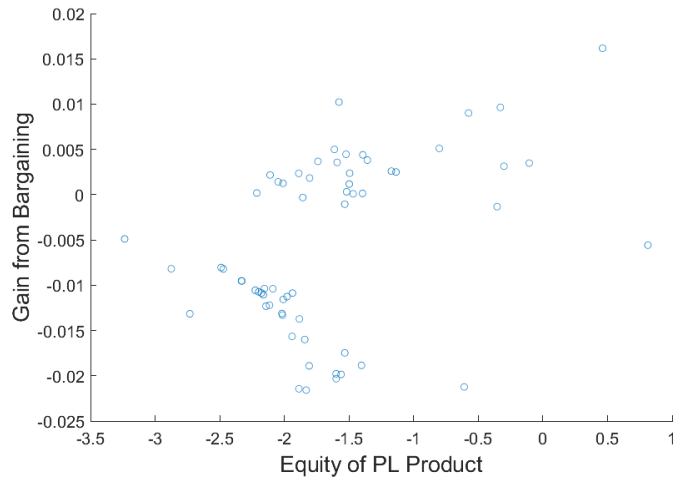
Figure 12: Scatterplot between Gains from Bargaining and PL Product Equity

6   Conclusion

We examine the role of private labels in determining bargaining outcomes in a hot beverage category. We exploit a natural experiment in which private label entry was prevented by patent protection, to reveal how firms behave in the absence of private label competition and how their strategies adapt when entry occurs. We find that bargaining outcomes are driven primarily by bargaining leverage, while bargaining ability remains the same pre- and post-entry of private label products. Moreover, the impact of bargaining leverage is substantial for private label products: retailers' gains from private label entry changes by as much as 36% depending on the identity of the manufacturer of the private label products. We also find that price renegotiation of existing products due to private label entry will not benefit an average retailer: an average retailer's gain from private label entry is lower by about 14.3% when there is wholesale price negotiation, compared to the case of no wholesale price change. However, we also find that retailers with higher equity of private label products tend to gain more from bargaining thanks to the higher disagreement payoffs that the popular private label product provides.

Note that we have abstracted away from competition between rival retailers. Extending the analysis to include these effects is the subject of future research. Future work could

also consider how lump-sum transfers (e.g. slotting allowances and other non-linear contracts) such as those considered in the theory work by Shaffer (2001) or alternative vertical arrangements (e.g. non-cooperative vertical games) would change the analysis.

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A Details of Sample Construction and Key Variables

In this appendix, we provide additional details regarding the sample selection, segment definitions, and key aggregations used in our empirical analyses.

For product segment definitions, we largely follow the IRI definitions with some adjustments to account for mislabeling. In order to construct prices that are comparable across the product segments, we define the equivalent serving size for each segment. For the main and premium products, we apply a universal serving size. For low segment products, we follow the manufacturer's recommendation for each brand to define the equivalent serving size, where available or a universal serving size following industry standards. For super-premium products, we use the manufacturers' recommended serving size, which is standard across brands.

For each segment, we keep the leading national brands based on their total dollar sales in the sample. We keep more brands in the super-premium segment than other segments, since that is the focal segment of this study. For each RMA, we drop segment-brands that only appear once in the entire sample period to avoid singularities when estimating demand. These single period cases are rare and unusual. The remaining sample captures 93.7% of total category sales. Finally, we select the RMA-week-segment-brand observations that have a reasonable level of distribution to better capture representative patterns of demand. First, we drop observations with less than 10% ACV distribution. We found these observations to be more likely to be error-prone and they had little impact on total sales. Second, we drop any segment-brand in an RMA if its median ACV distribution fails to ever achieve 50% (medians are calculated after the censoring). These segment-brands represent relatively small share cases and, with this selection criteria, we retain 87.1% of the remaining observations and 98.3% of remaining dollar sales.

We also note that we group the Dominant Brand owned super-premium brands. In general, these brands' prices and price promotion schedules are closely linked, lending support to the aggregation. We studied a sample of fourteen RMAs in detail to evaluate whether the pricing of these brands were indeed closely linked. We considered the brands that make up 95% of the the Dominant Brand Owned brand sales and that were in the sample at least 52 weeks. We found four such brands. The bulk of the owned sales is actually from a single brand with the rest relatively spread out. We also found that these four brands have TPR promotion schedules that are closely linked with their average prices having sharp dips at the same time and prices are correlated within RMA.

The above describes the sample construction for the demand-side estimation. The supply-side has several additional considerations. First, we aggregate our data to the quarterly level (13 week periods). To do so, we construct a measure of regular prices as the 90th quantile of the weekly price distribution in the quarter and construct averages for the other quantities of interest (e.g., ACV, share). Second, in the supply side estimation, we include only the super-premium products in the bargaining set and don't consider the main, premium, or low product segments. This simplification reduces the computational burden of estimation, focuses on our main interest, and is justifiable because the substitution between super-premium and the other segments is relatively small. Third, we consider a subset of quarters as described in the main text to ensure stability in the distribution and to use data more proximate in time to the private label entries for estimating the cost function.

Fourth, we use the sample selection rules discussed above and add some additional ones resulting from some measurement concerns due to aggregating to the quarter. We include in the profit calculations only brands that are observed at least 6 of the 13 weeks in the quarter, and include as bargaining observations only those brands that have at least 10 weeks of data in the given quarter. The dropped cases largely are when a brand first enters the market or just before it exits. These cases often have lower ACV, have unusual promotional activity, and our measures for the quarter tend to be poor approximations to rapidly changing shares. In addition to this rule, we identified three other observations where our quarterly measures appeared to have substantial error, and dropped those cases as well. XXXTAKEAKI Need to adjust all descriptions for the smaller sampleXXX After all of these additional sample adjustments, we retain 6,978 observations or 92% of the original bargaining observations (i.e., quarter RMA-brand-retailer pairs). These bargaining observations are spread across the 72 RMAs and 17 quarters. We note that most of the bargaining pair observations have 3 or more brands in the market (86%) and 10 or less (88%).

We use the super-premium category penetration rate (percent households ever purchased in a year) as a proxy for the ownership of the complementary appliance among retailer shoppers. The point-of-sale data starts from the beginning of our sample, yet the penetration rate data are only available starting from three years later.[17] In order to obtain an ownership proxy prior to the observed data, we fit a Bass diffusion curve (Bass, 1969) for each individual RMA with the initial year being when the first product was introduced. The Bass diffusion process is described by the following equation. We estimate the Bass diffusion parameters for each RMA using nonlinear least squares.

$$IB_{jt} = m_j * \frac{1 - \exp\left(-(p_j + q_j) * (t - t_0)\right)}{1 + \frac{q_j}{p_j} \exp\left(-(p_j + q_j) * (t - t_0)\right)} \tag{17}$$

where j represents retailers, t represents year, and $t_0 = 2004$. We then use the fitted value as the end of year ownership throughout the sample (i.e., not only to make up for the missing penetration rates but also the observed values) to smooth out noises from the penetration rate data. In addition, recognizing that the penetration rate likely captures a subset the actual owners among the retailer shoppers (namely, leaving out those who never buy super-premium from that particular retailer), we increase the fitted value by three percentage points.[18] Finally, we interpolate the end of year installed base to end of quarter ones by assigning 13%, 14%, 25%, and 48% increment to each calendar quarter respectively based on quarterly national sales of the complementary good. Weekly installed base levels are interpolated linearly from these quarterly levels.

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[17]Some RMA-years had too few buyers in the IRI panel data to make a projection to the shopper population for that specific RMA-year of the percentage of shoppers that buy any super-premium products. We use the fitted values of a multiple regression to impute the missing values, where the regression includes independent variables the (raw, not projected) observed number of buyers divided by the raw number of shoppers, the share of the super-premium sales out of category sales, total super-premium and total category sales, average dollar sales weighted ACV for super-premium products, the average, minimum, and maximum number of super-premium brands (and polynomials of these), and a cubic function of the year dummies interacted with the category penetration rate.

[18]We determined the 3% value by analyzing the product segment share out of total category to infer a lower bound of the installed base.

(a) Availability by Product Segment

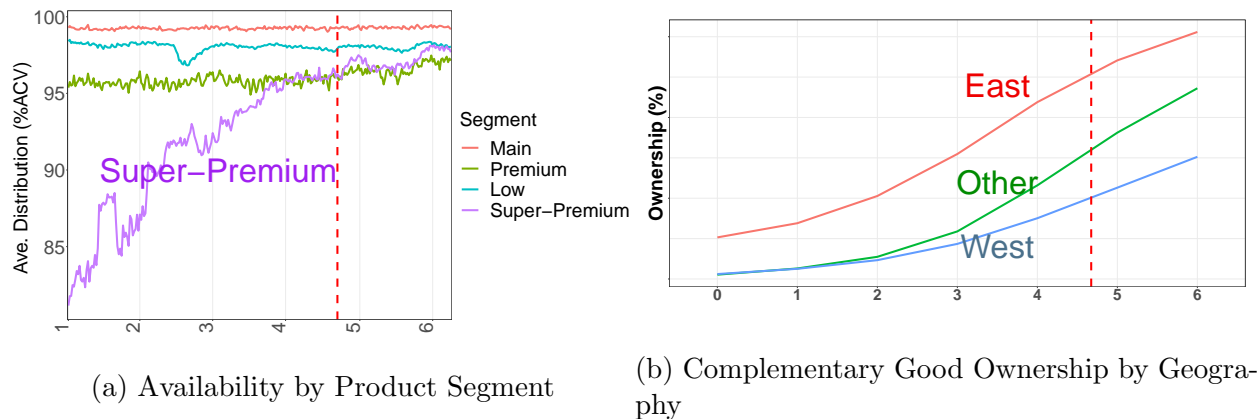(b) Complementary Good Ownership by Geography

Figure A.1: Availability and Complementary Good Ownership

Figure A.1 illustrates how product availability (in all four segments) and ownership of the required complementary good (for the super-premium segment) evolved over the sample period. Figure A.1a shows the sales weighted percent ACV distribution over time for all four categories. From the figure, it is clear that the dominant brands in the main and low segments are essentially carried everywhere, whereas premium, with its more regionally-focused local brands (Bronnenberg et al., 2012), is more heterogeneous (the lower level of average availability in the premium segment mainly reflects variation across chains in what brands they carry, not variation within chains in the products that are carried in particular stores). Note that, even in the premium segment, availability is clearly quite stable over time. In super-premium, however, availability increases sharply for roughly the first two years of the sample, but stabilizes by the end. This is due to the progressive nature of the super-premium roll-out and the large number of new product entries that occurred over this period. Our demand model (presented in section 3.1) has been constructed to account for these features. Figure A.1b shows the evolution of our imputed ownership measure (a proxy for the percent of the population that have access to the required complementary good) aggregated to the regional level.[19] As the figure makes clear, the ownership percentage continued to grow over the sample period, and exhibited substantial geographic variation. These patterns will also be accounted for in our demand analysis. We note that the ownership measure does not have a marked break at the time of the patent expiration (nor do the prices of the required complementary good).

B   Incorporating the Shadow Value of Traffic into Retailer Objective Function

In this section, we provide details of our approach to incorporating the shadow value of attracting additional traffic to the retail store by lowering the prices of the products in the category. Research suggests that the value of these cross-category incentives arising from traffic can be quite high. Thomassen et al. (2017) report an average of 47% of the category

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[19]The actual scale of the installed base is obscured to maintain confidentiality.

price as related to these shadow values when incorporating competition effects. The focal category is one that specifically was considered as potentially drawing meaningful traffic to the store, and because of its premium position that traffic would likely be valuable. Thus, we aim to incorporate into our retailer problem the incentive to lower prices in order to attract traffic and resulting coincidental sales.

Our approach is motivated with micro-foundations of the retailer's problem, but, given the complexity of the fully structural problem, we approximate the additional incentives the retailer faces when setting prices while accounting for the traffic generating potential of a category. In this section, we first introduce the approach and the provide some empirical evidence related to the estimates of these shadow values.

B.1 Micro-foundations

We first present a retailer's profit function where the retailer internalizes profits from all products in the retailer, not only the focal category. Let the set of products in the focal category be m_{rt} and the rest of the products be represented by the set $\tilde{m}_{rt}$. The profit function is then,

$$\sum_{j \in m_{rt}} (p_{rjt} - w_{rjt}) \, s_{rjt}^{m_{rt}} (p_{rt}) \, M_{rt} + \sum_{j \in \tilde{m}_{rt}} (p_{rjt} - w_{rjt}) \, s_{rjt}^{\tilde{m}_{rt}} (p_{rt}) \, M_{rt}, \tag{18}$$

where $s_{rjt}^{m_{rt}}$ and $s_{rjt}^{\tilde{m}_{rt}}$ represent the shares of the corresponding product j in retailer r at time t given the price vector p_{rt}.

Consider the price setting problem for a monopolist retailer r in the focal category. For this problem, the first order conditions for each product j can be represented as

$$\sum_{k \in m_{rt}} (p_{rkt} - w_{rkt}) \frac{\partial s_{rkt}^{m_{rt}}}{\partial p_{rjt}} + s_{rkt}^{m_{rt}} + \sum_{k \in \tilde{m}_{rt}} (p_{rkt} - w_{rkt}) \frac{\partial s_{rkt}^{\tilde{m}_{rt}}}{\partial p_{rjt}} = 0 \tag{19}$$

The first two terms are the standard single category conditions, whereas the latter term represents an effect due to substitution or complements within the store between product j and the products outside of the category. For example, if the product category were breakfast cereal, an obvious complement would be milk and substitutes might include bagels or pancake mix.

The shares implicitly capture the probability of not purchasing in the category, m_{rt}. If category purchase affects traffic (i.e., store visits), then the non-substitutes (including complements and unrelated purchases that are coincident in a visit) will decrease. Thus, the terms related to other categories can also capture the value of store traffic. To simplify, we have formulated the problem as a monopolist retailer facing residual demand so that store traffic could be partially driven by competition.

Solving the general retailer's problem induces significant computational trade-offs. For example, Thomassen et al. (2017) had to aggregate categories to a level of "dry goods" and "drinks," a very high aggregation in order to make the computational challenge of the multi-category model feasible. We argue that retailers generally do not have good detailed

information about their consumers' shopping habits *at other retailers*. Our conversations with retailers suggest they follow more heuristic approaches that account for the need to stay competitive, retain customers, and attract store visits. This motivates us to simplify the above problem to account for the potential shadow value to pricing a product at levels below the monopolist levels, without solving fully the problem in (18).

Our proposed simplification preserves the tension involved in the opportunity costs these other category purchases represent, while retaining the simplicity of data requirements and empirical analysis for our supply side. The next section describes this approximation.

B.2 Approximation to shadow value

To simplify the retailer's problem, we reduce the dimensionality of the value from price changes in two ways. First, we aggregate across products in the other categories to form a single value, λ. Second, we use the inside good share for the focal category as an approximation for the likelihood of buying in other categories in the store. Note that this approximation changes the meaning of λ to also account for the probability of purchases in other categories given a purchase in the focal category. With these two changes, the objective function can be represented as follows:

$$\sum_{j \in m_{rt}} (p_{rjt} - w_{rjt}) \, s_{rjt}^{m_{rt}} (p_{rt}) \, M_{rt} + \lambda \sum_{j \in m_{rt}} s_{rjt}^{m_{rt}} (p_{rt}) \, M_{rt}. \tag{20}$$

$$= \sum_{j \in m_{rt}} (p_{rjt} - w_{rjt} + \lambda) \, s_{rjt}^{m_{rt}} (p_{rt}) \, M_{rt}. \tag{21}$$

Importantly, we now only have data requirements related to the focal category in the retailer objective function, and in line (21) the value of this simplification is clear. This approximation implies that the retailer proxies the impact of product prices on sales in the rest of the store by the share on inside good sales for the store. They value increasing category sales above and beyond the profits in that category and use this as an approximate solution to addressing the need to keep traffic in the store.

The pricing first order condition now becomes,

$$\sum_{k \in m_{rt}} (p_{rkt} - w_{rkt} + \lambda) \frac{\partial s_{rkt}^{m_{rt}}}{\partial p_{rjt}} + s_{rkt}^{m_{rt}} = 0, \tag{22}$$

We drop the r and t subscripts and the (now) unnecessary m_{rt} notation since the subset m_{rt} is now defined as the full set of products in the focal category. The condition can thus be written in matrix form as,

$$p = w - \lambda + \Omega^{-1} s, \tag{23}$$

These first order conditions indicate that as λ increases, retailers will choose lower retail prices as a result of this incentive to attract traffic and the related profits. We also note that

in our empirical analysis, we take retail prices as chosen according to this model and recover wholesale prices. The relevant equation becomes,

$$w = p - \Omega^{-1}s + \lambda. \tag{24}$$

As apparent here, the estimated wholesale prices will be higher as a result of this shadow value.

B.3   Estimating λ

Although in our earlier simplification, we had a constant shadow value, in practice, we allow the shadow value to be relative to the product price. To achieve this, we divide the terms in the first order condition by the price of product j:

$$\frac{p_{rjt} - \Omega^{-1}s_{rjt}}{p_{rjt}} = -\frac{\lambda_r}{p_{rjt}} + \frac{w_{jrt}}{p_{jrt}} \tag{25}$$

We denote $\tilde{\lambda}$ as the relative shadow value and parameterize $\tilde{\lambda}_r = X_r\theta$. The covariates X_r are discussed below. We also rewrite $\tilde{w}_{rjt} = \tilde{w}_j + \tilde{e}_{rjt}$, where $\tilde{w}_j$ represents brand fixed effect that is common across retailers, and $\tilde{e}_{rjt}$ captures the deviation of w_{rjt} from its brand level mean. These brand fixed effects absorb the intercept. We re-write equation (25) as follows and estimate it via linear regression:

$$\frac{p_{rjt} - \Omega^{-1}s_{rjt}}{p_{rjt}} = -X_r\theta + \tilde{w}_j + \tilde{e}_{rjt} \tag{26}$$

We consider two variables in the X_r covariates that are related to the value of traffic that the retailer might attract (or lose) and, in principle, excluded from the theoretical monopolist retailer problem for the focal category. The first variable, *cross-shop percent*, represents the average of the percentage of shoppers of retailer r who also shop at r's top 3 competitors. This measure proxies for the likelihood that lowering prices will increase traffic at the store. To measure this variable, we use panel data and include retail formats that carry a full grocery section such as grocery stores, club stores, and super centers.

The second variable, *cross-shop value*, is the difference between non cross-shopper revenue in the store and cross-shopper revenue in the store per capita. This measure proxies for the average revenue gain available from attracting additional traffic. Here we use the weighted average across the top three competitors weighted by the percentage of cross-shoppers.

We construct both variables using an auxiliary data set, the IRI shopper panel annual aggregates, and take the average of two annual aggregates (the database only provides the latest 2 years of relevant cross-shop data). These two variables measure the degree to which the focal RMA r is facing competition from other retailers, which we contemplate is the main driver of the shadow value in retailer pricing decision. We expect that higher the competition, the higher the shadow value.

The estimates from an OLS regression of equation (26) are presented in table B.1. Both coefficients are positive and significant. The *cross-shop percent* coefficient indicates that

as the percent of shoppers that also shop at the top 3 competing retailers increases, the shadow value increases. The *cross-shop value* coefficient implies that as the revenue difference between loyal and cross-shoppers decreases, the shadow value increases. In other words, our empirical results suggest that higher competition over traffic leads to a higher shadow value incentive in retailer pricing decisions, which is in line with our expectation.

Table B.1: Estimates of Shadow Value Parameters

Variable	Estimate	Std.Err.	Signif.
cross-shop percent	0.025	0.005	***
cross-shop value(/100)	0.101	0.003	***

brand fixed effects are not reported
***: p-value<.01;

The predicted relative shadow value, $\hat{\tilde{\lambda}}_r$, and λ-adjusted wholesale price to retail price ratio $\hat{\tilde{w}}_{rgjt}$ are given by the following equations

$$\hat{\tilde{\lambda}}_r = X_r \hat{\theta}$$

$$\hat{\tilde{w}}_{rgjt} \equiv \frac{\hat{w}_{rgjt}}{p_{rgjt}} = \frac{p_{rgjt} - \Omega^{-1} s_{rgjt}}{p_{rgjt}} + \hat{\tilde{\lambda}}_r$$

The relation between the unadjusted margin, $\hat{\tilde{\lambda}}_r$, and adjusted margin is

$$margin_{adjust} = \frac{p_{rgjt} - \hat{w}_{rgjt}}{p_{rgjt}}$$
$$= 1 - \hat{\tilde{w}}_{rgjt}$$
$$= 1 - \left(\frac{p_{rgjt} - \Omega^{-1} s_{rgjt}}{p_{rgjt}} + \hat{\tilde{\lambda}}_r \right)$$
$$= margin_{unadjust} - \hat{\tilde{\lambda}}_r$$

Based on the above derivation, we can interpret the relative shadow value as the difference between the margin implied by monopoly retailer and the adjusted margin. Calculating these margins without the shadow value adjustment, the monopoly retailer margin is approximately 45% for the super-premium segment on average. The relative shadow value adjusts this margin by approximately 15% downward (by decreasing price). Hence, the adjusted margin is closer to 30%.

B.4 Shadow value implications for the bargaining problem

Turning to the bargaining problem, as in the main body of the paper, dropping the rt subscripts, and noting that R_{fk} represents the retailer r gains of trade (profit with and without manufacturer f's product k and that F_{rk} is manufacturer f's gains of trade (profit with and

without carrying retailer r carrying product k). The Nash-in-Nash objective function can be written as,

$$R_{fk}\left(w_{rk}, w_{r,-k}\right)^{\beta_{rk}} F_{rk}\left(w_{rk}, w_{r,-k}\right)^{1-\beta_{rk}}, \tag{27}$$

where $R_{fk} = \Pi_r^{J_{rt}}\left(w_{r,kt}, w_{r,-kt}\right) - \Pi_r^{J_{rt}-k}\left(w_{r,-kt}\right)$. Specifically, agreement payoff of retailer r

$$\Pi_r^{J_{rt}}\left(w_{r,kt}, w_{r,-kt}\right) = \sum_{j \in J_{rt}}(p_{rjt} - w_{rjt})s_{rjt}(p_{rjt})M_{rt} + \lambda_r \sum_{j \in J_{rt}} s_{rjt}(p_{rjt})M_{rt} \tag{28}$$

$$= \sum_{j \in J_{rt}}(p_{rjt} - w_{rjt} + \lambda_r)s_{rjt}(p_{rjt})M_{rt} \tag{29}$$

$$= M * (p - w + \lambda)' s \tag{30}$$

and similarly, payoff of retailer r without product k

$$\Pi_r^{J_{rt}-k}\left(w_{r,-kt}\right) = \sum_{j \in J_{rt}-k}(\tilde{p}_{rjt} - w_{rjt})\tilde{s}_{rjt}(\tilde{p}_{rjt})M_{rt} + \lambda_r \sum_{j \in J_{rt}} \tilde{s}_{rjt}(\tilde{p}_{rjt})M_{rt} \tag{31}$$

$$= M * (\tilde{p} - w + \lambda)' \tilde{s} \tag{32}$$

The first order condition is then

$$\frac{\partial F_{rk}\left(w_{rk}, w_{r,-k}\right)}{\partial w_{rk}} R_{fk}\left(w_{rk}, w_{r,-k}\right) 1 - \beta_{rk} + \frac{\partial R_{fk}\left(w_{rk}, w_{r,-k}\right)}{\partial w_{rk}} F_{rk}\left(w_{rk}, w_{r,-k}\right) \beta_{rk} \tag{33}$$

The terms in this FOC are mostly the same as the existing calculations. Two main adjustments need to occur. The first is that $\frac{dR}{dw_k}$ becomes the following

$$\frac{dR}{dw_k} = (p - w)'\frac{ds}{dw_k} + \left(\frac{dp}{dw_k}\right)' s - s_k + \lambda \sum_j \frac{ds_j}{dw_k}$$

$$= (p - w + \lambda)'\frac{ds}{dw_k} + \left(\frac{dp}{dw_k}\right)' s - s_k \tag{34}$$

Because the lambda enters the first order condition as an additively separable term, it does not alter $\frac{dp}{dw}$.

C   Corner cases of the bargaining model

The bargaining power parameter in the Nash bargaining model indexes a range of potential supply arrangements. Two corner cases with $\beta = 1$ and $\beta = 0$ correspond to two special cases of retailer-manufacturer games.

The first case, when $\beta = 1$, the retailer has all of the power in the bargaining process. With this bargaining power, the objective function for the bargaining stage becomes

$\left(\Pi_r^{J_{rt}}(w_{r,kt}, w_{r,-kt}) - \Pi_r^{J_{rt}-k}(w_{r,-kt}) \right)$. In other words, the manufacturer's profitability is ignored in the determination of the wholesale price. Since the retailer's profits are decreasing in the wholesale price, the wholesale prices would be set as low as possible, i.e., at the. manufacturer's participation constraint. If this participation constraint for the manufacturer requires non-negative profits, then wholesale prices would be set to the manufacturer's marginal costs. This arrangement produces channel optimal profits because it eliminates the double-marginalization problem. Interestingly, this special case produces wholesale and retail prices that correspond to those from a non-linear contracts setting where the manufacturer makes take-it-or-leave-it offers of a linear wholesale price (at the marginal cost) and fixed fees from the retailer to the manufacturer to make the manufacturer whole. Our current model design cannot identify such fixed fees, but we note that our estimates of bargaining power are all significantly different from 1, suggesting under the monopolist retailer assumption we do not find support wholesale prices that would be consistent with the non-linear contracts setting described above.

The second case is when $\beta = 0$, when the manufacturer has all of the bargaining power. The objective function becomes $\left(\Pi_f^{J_{rt}}(w_{r,kt}, w_{r,-kt}) - \Pi_f^{J_{rt}-k}(w_{r,-kt}) \right)$. As a result, wholesale prices are set to maximize the manufacturer's profits anticipating the retailer will set retail prices optimally. Since our manufacturers are competing with one another, this is consistent with a setting where the competitive manufacturers make linear wholesale price take-it-or-leave-it offers to the retailers. In this case, the prices will not be optimal for channel profits due to the double-marginalization problem. In some sense, then the bargaining increases channel profits and also the share that the retailer obtains as the β increases.

D   Additional Calculations

For simplicity, we drop the krt subscripts and letting w^f and c^f represent the vector of wholesale prices and marginal costs for brands owned by manufacturer f. To accommodate the partner revenue sharing we develop the notation μ_{1j} and μ_{2j}. We let μ_{1j} to be $1 - \kappa$ for the profits for partner brands, κ for the Dominant Brand profits, and 1 otherwise. We let μ_{2j} to be 0 for the Dominant Brand profits and 1 otherwise. With this notation, the manufacturer profits in matrix notation are

$$\sum_{j \in f_{rt}} (w_j \mu_{1j} - c_j \mu_{2j}) s_j^{J_{rt}}(p) \tag{35}$$

We denote the vector of μ_{1j} containing all terms relevant for manufacturer f to be μ_1^f

and likewise for μ_2^f. The derivatives in terms of the wholesale price are then

$$\frac{dF}{dw_k} = \sum_{j \in f} (w_j \mu_{1j} - c_j \mu_{2j}) \frac{ds_j}{dw_k} + s_k \mu_{1k} \tag{36}$$

$$= \left(w^f \cdot \mu_1^f - c^f \cdot \mu_2^f \right)' \frac{ds}{dw_k} + s_k \mu_{1k} \tag{37}$$

$$\frac{dR}{dw_k} = \sum_{j \in J} \left((p_j - w_j) \frac{ds_j}{dw_k} + \frac{dp_j}{dw_k} s_j \right) - s_k \tag{38}$$

$$= (p - w)' \frac{ds}{dw_k} + \left(\frac{dp}{dw_k} \right)' s - s_k. \tag{39}$$

$$\tag{40}$$

We now consider the calculation of the two total derivatives contained in these expressions, $\frac{ds_j}{dw_k}$ and $\frac{dp_j}{dw_k}$. For the former, note that $s_j = s_j (p_1 (w_k), \dots, p_J (w_k))$, so that $\frac{ds_j}{dw_k} = \sum_{l=1}^J \frac{\partial s_j}{\partial p_l} \frac{dp_l}{dw_k}$. In matrix notation, this is $-\Omega \frac{dp}{dw_k}$, where the lth row and jth column of Ω is

$$-\frac{ds_j}{dp_l} = \begin{cases} \text{if } j = 1 & -\int_i \frac{s_{ji}(1-s_{ji})\alpha_i}{p_j} d\theta_i \\ \text{if } j \neq 1 & \int_i \frac{s_{ji} s_{li} \alpha_i}{p_l} d\theta_i \end{cases}, \tag{41}$$

where θ_i represents the set of all individual level variables characterizing heterogeneity, i.e., including tastes, price sensitivity, availability, and machine ownership.

Combining the columns for the derivatives of F and R in terms of w and expressing these derivatives more fully, we have

$$\frac{dF}{dw} = \left(\left(w^f \cdot \mu_1^f - c^f \cdot \mu_2^f \right) \frac{\partial s}{\partial p} \frac{dp}{dw} \right)' + s^f \cdot \mu_1^f \tag{42}$$

$$\frac{dR}{dw} = \left((p - w)' \frac{\partial s}{\partial p} \frac{dp}{dw} \right)' + \left(\frac{dp}{dw} - I \right)' s. \tag{43}$$

For the total price derivative, we must account for the fact that price is the optimal price set by the retailer which satisfies the equation $p = w + \Omega^{-1} s(p)$. To calculate the $\frac{dp_j}{dw_k}$, we

take the total derivative of the pricing equations. This total derivative is

$$\frac{dp}{dw_k} = \frac{dw}{dw_k} + \frac{d\Omega^{-1}}{dw_k}s + \Omega^{-1}\frac{ds}{dw_k} \tag{44}$$

$$\frac{dp}{dw_k} = \frac{dw}{dw_k} + \sum_{l=1}^{J}\left(\frac{d\Omega^{-1}}{dp_l}\frac{dp_l}{dw_k}\right)s + \Omega^{-1}\sum_{l=1}^{J}\frac{\partial s}{\partial p_l}\frac{dp_l}{dw_k} \tag{45}$$

$$\frac{dp}{dw_k} = \frac{dw}{dw_k} - \Omega^{-1}\sum_{l=1}^{J}\left(\frac{d\Omega}{dp_l}\frac{dp_l}{dw_k}\right)\Omega^{-1}s + \Omega^{-1}\sum_{l=1}^{J}\frac{\partial s}{\partial p_l}\frac{dp_l}{dw_k} \tag{46}$$

$$\frac{dp}{dw_k} = \frac{dw}{dw_k} + \sum_{l=1}^{J}\left(\Omega^{-1}\frac{\partial s}{\partial p_l} - \Omega^{-1}\frac{d\Omega}{dp_l}\Omega^{-1}s\right)\frac{dp_l}{dw_k} \tag{47}$$

Further simplifying this expression requires shifting to matrix notation for the quantity in parentheses in the last line above. Specifically, let the lth column of G, be $G_l = \Omega^{-1}\left(\frac{\partial s}{\partial p_l} - \frac{d\Omega}{dp_l}\Omega^{-1}s\right)$. Then we can simplify notation to

$$\frac{dp}{dw_k} = \frac{dw}{dw_k} + G\frac{dp}{dw_k}, \tag{48}$$

which if $I - G$ is positive definite, then the total derivatives are

$$\frac{dp}{dw_k} = (I - G)^{-1}\frac{dw}{dw_k} \tag{49}$$

We combine the columns of the derivatives in terms of w_k and note that $\frac{dw}{dw_k}$ equals 1 for the kth element and 0 otherwise, so that the matrix of derivatives of the wholesale price in terms of the wholesale price is just the identity matrix. The resulting matrix of price derivatives in terms of wholesale prices is

$$\frac{dp}{dw} = (I - G)^{-1} \tag{50}$$

Finally, letting Ω_{jh} be the element in the jth row and hth column, the $\partial\Omega/\partial p_l$ derivatives are defined by

$$\frac{\partial\Omega_{jh}}{\partial p_l} = \begin{cases} \text{if } l = h = j & -\int_i \frac{s_{li}(1-s_{li})\alpha_i((1-2s_{li})\alpha_i-1)}{p_l^2}d\theta_i \\ \text{if } l = j \neq h & \int_i \frac{s_{li}s_{hi}\alpha_i((1-2s_{li})\alpha_i-1)}{p_l^2}d\theta_i \\ \text{if } l = h \neq j & \int_i \frac{s_{li}s_{ji}(1-2s_{li})\alpha_i^2}{p_jp_l}d\theta_i \\ \text{if } l \neq h = j & \int_i \frac{s_{li}s_{ji}(1-2s_{ji})\alpha_i^2}{p_jp_l}d\theta_i \\ \text{if } l \neq h \neq j & -2\int_i \frac{s_{ji}s_{li}s_{hi}\alpha_i^2}{p_jp_l}d\theta_i \end{cases} \tag{51}$$

D.1 Counterfactuals and simulating data

The counterfactuals rely on our ability to simulate data from the bargaining problem. We do so with knowledge of the parameters of the demand and supply side model as well as knowledge of the predetermined variables in the model. We note that in the results in the

paper we use the estimated bargaining parameters (i.e., ignore the bargaining residuals), but that including the bargaining residuals does not substantially change the outcomes, it only adds more variation.

Our main task to run the counterfactuals is to calculate the w and p vectors for each period and market. The optimal p vector can be calculated for any given w by successive approximation on the price first order conditions, $p = w + \Omega(p)^{-1} s(p)$. With the monopolist retailer assumptions, these conditions represent a unique equilibrium.

Our counterfactuals are calculated by proposing the set of products in the bargaining setting and then guessing at the wholesale price, w, and solving for p. With these quantities in hand, we use the first order conditions of the bargaining problem to solve for the w via successive approximation (we have also done this with non-linear solvers). The successive approximation takes the following form:

$$w^{h+1} = c\frac{\mu_2}{\mu_1} - \frac{s\left(w^h\right) + V\left(w^h\right)}{\Psi\left(w^h\right) \cdot \mu_1},$$ (52)

where h indexes the iterations, w, c, and s are the respective Jx1 vectors of wholesale prices, costs, and shares, V is a Jx1 vector that represents the internalization of the profit impact of this bargain on other products the manufacturer controls, and Ψ is Jx1 vector related to a "mark-up" term. The jth element of Ψ is

$$\Psi(j) = \frac{ds_j}{dw_j} + \rho_j s_j,$$ (53)

where ρ_j is defined by

$$\rho_j = \frac{\beta_j}{1 - \beta_j} \frac{\frac{dR_j}{dw_j}}{R_j},$$ (54)

and the diagonal matrix with ρ_j on the (j, j)th element is ρ. V is defined by

$$V = \left(M * (1 - I) * \left(\frac{ds}{dw} + \rho\tilde{s}\right)\right) \cdot (w \cdot \mu_1 - c \cdot \mu_2),$$ (55)

where $\tilde{s}$ is a JxJ matrix with the (j, k) element containing the difference between the share of product k with all products versus the share without product j, where the retail prices are set optimally given the wholesale price and the set of products in the market. The matrices $M * (1 - I)$ are element-wise multiplied and represent the ownership structure with the diagonal elements containing zeros.

The derivation of equation (52) relies on separating the jth (bargained) product from dF_j/dw_j and F_j, moving that to the lefthand side and separating w_j from the other terms.

We note that we have no proof that the bargaining problem has a unique equilibrium. We try multiple starting points in order to evaluate whether multiple equilibria are obtained.