Demand-based pricing versus past-price dependence:
The role of retailer category objectives, costs and benefits of pricing tactics

Shuba Srinivasan, Koen Pauwels, and Vincent Nijs

May 14, 2006

1 Associate Professor and University Scholar, The A. Gary Anderson School of Management, University of California, Riverside, CA 92521, Phone: (909) 787-6447, Fax: (909) 787-3970, E-mail: shuba.srinivasan@ucr.edu.

2 Associate Professor, Tuck School of Business at Dartmouth, Hanover, NH 03755, Phone: (603) 646 1097, E-fax: 1 502 396 5295, E-mail: koen.h.pauwels@dartmouth.edu.

3 Assistant Professor, Kellogg School of Management, Northwestern University, Phone: (847) 491 4574, Fax: (847) 491 2498, E-mail: v-nijs@kellogg.northwestern.edu.

The authors are listed in reverse alphabetical order and are grateful to the Dominick’s project at the Graduate School of Business, University of Chicago for making the data available. Shuba Srinivasan acknowledges the financial support received from the University Scholar Award from the University of California, Riverside.
Demand-based pricing versus past-price dependence: The role of retailer category objectives, costs and benefits of pricing tactics

Abstract

Recent research has found that retailers’ dynamic pricing practices often fall short of sophisticated demand-based pricing models, and has demonstrated that much money is left on the table in the process. Why then would a retailer not engage in demand-based pricing for each category and brand? We examine the circumstances under which demand-based pricing versus past-price dependence is more prominent in dynamic retail pricing.

We develop a conceptual framework of the strategic objectives and costs and benefits to retailers of changing prices over time. First, we argue that the strategic role of the category in the retailer’s portfolio matters in terms of retailer overall profit objectives: Staples (high penetration and frequency) are more important than fill-ins (low penetration and low frequency). Second, the costs of demand-based pricing are likely to be higher for categories with many SKUs. Third, we expect that retailer benefits of demand-based pricing are higher for growing categories, for storable products, for brands with broader product lines, for high-share brands, in categories where private labels have a strong position, and when consumer demand is very sensitive to price. In contrast, past-price dependence offers benefits for expensive products, but is costly when manufacturers offer frequent discounts.

We use metrics of demand-based pricing and past-price dependence and relate these to the variables in our conceptual framework. We show that category purchase frequency is the strongest positive determinant of demand-based pricing, followed by price sensitivity of brand demand and brand product-line breadth. In contrast, category SKU proliferation strongly reduces the retailer’s propensity to use demand-based pricing. Past-price dependence is most prominent for expensive products, and least prominent for storable products.

Understanding and formalizing the antecedents of the price drivers will allow manufacturers to use trade deals strategically and will allow retailers to identify problem areas and re-allocate scarce marketing resources in order to get the biggest bang for their buck. Moreover, understanding the supply-side benefits and costs of retail-price changes adds to the rich marketing literature on consumer effects of purchase frequency, product storability, and assortment complexity.

Key words: Demand-based pricing, past-price dependence, retail-price drivers, time-series models, generalized forecast error variance decomposition.
1. Introduction

Retailers face the complicated task of setting and changing prices for the many items they carry. A typical grocery store in the United States now carries around 31,000 items in hundreds of product categories (Kahn and McAlister 1997). Each week, a retailer changes prices on over 4500 items (Levy et al. 1998). Besides the sheer number of price change possibilities, the considerations that enter the retailer pricing decisions have become very complex. Sophisticated demand forecasts based on scanner data, a wide variety of manufacturer discounts, the push towards category management, and marketing intelligence on competing retailers’ prices may all matter, and have been incorporated in recent analytical research (e.g., Basuroy et al. 2001, Kim and Staelin 1999, Wedel et al. 2004). However, empirical studies of retail price changes conclude that retailers often do not change prices in the face of the above considerations (Dutta et al. 2002), leading to past-price dependence and lower profits (Krishna et al. 2001). Most recently, Nijs, Srinivasan, and Pauwels (2006) find that when retailers rely on past prices to set future prices (i.e., past-price dependence, price stickiness, or price inertia) lower category margins are observed, while demand-based pricing is associated with higher category margins.

Current literature attributes the prominence of past-price dependence to several causes including: Lack of detailed information about market demand (Business Week 2000) as well as good tools for making pricing decisions (AMR Research 2000), decision anchoring (Krishna et al. 2001), high managerial and physical costs of considering and executing price changes (Levy et al. 1997), and legal and customer goodwill considerations (Bergen et al. 2003). These causes mainly pertain to the general occurrence of past-price dependence, not to the circumstances that lead a retailer to rely on past prices for some categories and brands, but not for others. Nijs et al. (2006) found high variance in past-price dependences across brands and categories. In this
context, “it is unfortunate that so little attention has been given to characterizing the circumstances that give rise to high versus low nominal levels of price inertia” (Andrew Caplin, quoted in Levy et al. 1998, p. 81). Building on previous work in this area we aim to address the following key research problem: When do retailer-pricing tactics reflect a higher degree of demand-based pricing versus past-price dependence?

To this end, we develop a conceptual framework of the strategic role of the category in the retailer’s portfolio and the costs and benefits of demand-based pricing and past-price dependence in the next section. Section 3 introduces the methodology, and we report the results of our analysis in section 4. We conclude with managerial implications and suggestions for future research in section 5.

2. Antecedents of demand-based pricing and past-price dependence

Within the grocery retail context pricing strategies and tactics play a critical role in determining bottom-line profits. While setting price levels and strategies (e.g., EDLP versus High-low) has received considerable research attention, far less is known about the tactics of weekly price changes, despite the observation that “pricing is all about price changes” (Bergen et al. 2003, p. 668). Recent research by Nijs et al. (2006) has quantified the relative importance of various price drivers as determinants of retailer pricing over time. Specifically, they find that competitive retailer prices, store traffic, and category management considerations together account for less than 10% of the over-time variation in retail prices. Instead, past-price dependence, brand demand, and wholesale price are the main drivers of retail-price variation over time, accounting for 90% of the variation. More importantly for our research focus, the first two factors are key determinants of retailer performance: While past-price dependence hurts category profits,
demand based pricing enhances category profits (ibid). However, no explanation was provided for the high category and brand-level variation in the prominence of these two drivers. Therefore, we set out to identify and conceptualize the circumstances under which past-price dependence and demand-based pricing are more or less prominent.

Previous literature in marketing acknowledges that several forces may influence whether or not retailers adapt prices based on demand, cost, and other considerations. When one acknowledges that considering and executing price changes is costly (e.g., Bergen et al. 2003), the benefits of doing so should outweigh the costs (Levy et al. 1997, McAlister 2005). Moreover, effective pricing by retailers requires that they understand where to allocate their scarce pricing resources in order to get the biggest bang for their buck. Specifically, the extent to which the retailer uses demand-based pricing would depend on the category’s role in the store’s overall portfolio, and the costs versus the potential benefits of using such sophisticated pricing.

First, we consider the category’s role in the store’s overall portfolio. A key aspect of the pricing strategy is that the retailer must decide on the role each category plays in the overall portfolio and then execute towards those goals (Dhar et al. 2001). Whether the retailer achieves these objectives will likely depend on the role the category plays in the consumers’ portfolio. An accepted classification scheme proposed by the Food Marketing Institute (FMI, Category Management, Guide #1, 1995) utilizes the consumer-based category roles defined according to the percentage of households that buy the category, i.e., penetration, and the frequency with which it is purchased (i.e., average number of times per year the category is purchased). Categories generally fall into one of four groups: (1) staples (high penetration, high frequency), (2) niches (low penetration, high frequency), (3) variety enhancers (high penetration, low frequency), and (4) fill-ins (low penetration, low frequency). Since consumer motivations to
purchase staples are different from fill-ins, retailers’ pricing tactics will differ also. Furthermore, since higher penetration and higher frequency categories are more likely to be in a shopper’s market basket, retailers will tend to use staples as traffic builders and fill-ins as profit generators (Dhar et al. 2001).

Second, costs and benefits are likely to play an important role in determining the extent to which the retailer uses sophisticated demand-based pricing tactics versus past-price dependence. In this study, we hypothesize that the costs and benefits associated with pricing are likely to be a function of category and brand characteristics. These characteristics may influence the prominence of demand-based pricing and past-price dependence in either the same (i.e., both positive or both negative) or opposite directions. We develop the conceptual framework below.

2.1 Category’s role in overall store portfolio

Category penetration. As argued by McAlister (2005), retailers have scarce resources to engage in sophisticated pricing across hundreds of categories and thousands of products. The larger the proportion of households that purchase in the category, the more important sophisticated demand-based pricing is likely to be (Fader and Lodish 1990). First, categories with high penetration are important to the retailer’s bottom line as they drive store traffic. Second, customers are more likely to respond to pricing efforts in categories they already tend to buy. As such, we expect less dependence on past prices in high penetration categories.

H1: In setting prices of brands in categories with higher penetration rates, retailers place a) higher emphasis on demand-based pricing and b) lower emphasis on past prices.

Purchase frequency. When customers purchase frequently in a category they are more alert and knowledgeable about pricing, more likely to notice the dynamic week-to-week changes, and
better able to learn established pricing patterns and anticipate promotions (Alba et al. 1999, Briesch et al. 1997). As a result, the retailer’s returns for demand-based pricing are higher and past-price dependence is more detrimental than in categories with low purchase frequency (Fader and Lodish 1990). Moreover, the retailer’s number of opportunities to enhance/limit category volumes and margins are higher and more immediate in frequently purchased categories. Therefore, we expect that:

H2: In setting prices of brands in categories with higher purchase frequency, retailers place a) higher emphasis on demand-based pricing and b) lower emphasis on past prices.

As an illustration of how the category’s strategic role may affect retail-pricing tactics, Figure 1 contrasts the prominence of demand-based pricing versus past-price dependence in the toothbrush category and the cheese category (from results table 4 in Nijs et al. 2006).

--- Figure 1 about here ---

For toothbrushes, only 4% of the over-time variation in retail price is driven by brand demand considerations. In contrast, demand-based pricing accounts for 17% of retail price variation in the cheese category. As we know from IRI’s Marketing Factbook, the toothbrush category has much lower purchase frequency than the cheese category (less than 4 times a year versus more than 11 times a year) and lower penetration rates (under 40% versus over 98%). Hence, to the retailer, each category serves a different strategic objective in the overall store portfolio. For cheese, a staple category (higher penetration and purchase frequency), the retailer places higher emphasis on brand demand in changing retail prices, while for toothbrushes, a non-staple category, there is more past-price dependence. Evidently, these categories and brands may also differ on other dimensions, which we discuss next.
2.2 Costs of using demand-based pricing

Category SKU proliferation. Sophisticated demand-based pricing involves costs to the retailer that can be quite substantial, such as the set-up and execution of scanner data analysis and the material, managerial, and labor costs of changing prices (Bergen et al. 2003, Levy et al. 1998). Some of these costs (e.g., the set-up costs of scanner data analysis) are incurred at the organizational level (Levy et al. 1997) or are unlikely to vary much by brand and category. However, the sheer number of SKUs does vary substantially by category, making it costly for the retailer to dynamically adapt prices even in the presence of (temporary) demand impulses (McAlister 2005). For instance, in a Dominick’s store in the Chicago area the oatmeal category has 96 SKUs while shampoo has more than 2500 SKUs. Given the pricing complexity in the latter category we expect the retailer to adhere to established pricing patterns. Moreover, the impact of sophisticated demand-based pricing may be diluted in crowded categories with a large number of competing SKUs given the complexity of the purchasing decision for consumers (Chernev 2003). As such, it is less likely that an individual price can stand out and influence category purchase (Srinivasan et al. 2004).

H3: In setting retail prices of brands in categories with larger number of SKUs, retailers place a) lower emphasis on demand-based pricing and b) higher emphasis on past prices.

2.3 Benefits of demand-based pricing

Category growth. High growth categories offer larger retailer benefits for demand-based pricing. As a result, the retailer is more likely to pay close attention to pricing decisions and how they affect demand. Moreover, the returns of demand-based pricing will grow with the category. Furthermore, new product introductions occur frequently in growing categories and customers
are in the process of developing preferences (Carpenter and Nakamoto 1989). As such, the retailer will selectively target and allocate scarce pricing resources to growing categories. We propose that:

H4: In setting retail prices of brands in high-growth categories, retailers place a) higher emphasis on demand-based pricing and b) lower emphasis on past prices.

Category storability. For storable goods, the retailer has to deal with substantial consumer stockpiling following price discounts, which may keep a consumer out of the category or even out of the store for an extended period (Mela et al. 1998). Consumers may even buy ‘deal to deal’ if they can accurately anticipate promotions (Krishna 1992, Neslin 2002). Therefore, simply extending past pricing patterns will hurt performance. In contrast, the retailer can benefit from carefully analyzing dips and spikes in demand and pricing accordingly.

H5: In setting retail prices of brands in storable categories, retailers place a) higher emphasis on demand-based pricing and b) lower emphasis on past prices.

Private label share in the category. An important part of a retailer’s business is the private label program. Some retailers (e.g., Wegman’s) successfully use store brands as a means of differentiation and as a store traffic driver (Dhar et al. 2001). For others the private label offers increased category profits due to higher percentage margins and increased bargaining power versus national brand manufacturers (e.g., Pauwels and Srinivasan 2004). As the retailer reaps the full rewards for private label performance, categories with a higher retailer private label share tend to get more pricing attention. Therefore, we expect higher use of demand-based pricing and less dependence on past prices.
H6: In setting retail prices of brands in categories with greater share of the retailer private label, retailers place a) higher emphasis on demand-based pricing and b) lower emphasis on past prices.

*Brand product-line breadth.* Retailers may be less willing to engage in demand-based pricing for categories with many SKUs, but they are more likely to expend pricing resources on brands with a broad product-line. Indeed, such brands will enjoy more power in the category vis-à-vis brands with narrow product lines (Kekre and Srinivasan 1990). Powerful brands tend to have both wider distribution (Reibstein and Farris 1995) and better shelf space due to their strong position relative to the retailer (Corstjens and Corstjens 1995).

In the toothpaste category of a Dominicks’s store, Crest has 167 SKUs while Aquafresh has only 5 SKUs. As such, the former brand has a stronger position within the retailer’s portfolio than the latter. Given the prominence of brands with more extensive product lines, it will be in the retailer’s best interests to engage in sophisticated demand-based pricing strategies rather than rely on past-price dependence, despite the complexity and cost of implementing price changes for the brand’s many SKUs. Therefore, we propose that:

H7: In setting retail prices of brands with greater product line breadth, retailers place a) higher emphasis on demand-based pricing and b) lower emphasis on past prices.

*Brand market share.* Both analytical models (e.g., Lal et al. 1996) and empirical evidence (Chevalier and Curhan 1976, Pauwels 2006, Walters 1989) suggest that retailers are more willing to change prices for high-share brands versus smaller brands. Leading brands enjoy higher consumer awareness and familiarity (Keller 1993), which creates a larger customer base that may
be affected by the retail-price change. Thus, promotions on leading brands have the power to expand the category (Bronnenberg and Mahajan 2001) and even increase store traffic (Moorthy 2005). Given the strategic importance of these brands to retailers, there are significant benefits associated with demand-based pricing strategies and consequently larger costs of past-price dependence.

H8: In setting retail prices of high-share brands, retailers place a) higher emphasis on demand-based pricing and b) lower emphasis on past prices.

*Price sensitivity of brand demand.* Logically, the benefits to demand-based pricing are higher in categories where demand is very sensitive to prices and price changes. Therefore, the retailer may decide to adapt prices based on perceived changes in consumer preferences and willingness-to-pay (Levy et al. 1998), even without manufacturers’ financial support (Blattberg and Neslin 1990). Therefore, we hypothesize that:

H9: In setting retail prices of brands with higher demand sensitivity, retailers place a) higher emphasis on demand-based pricing and b) lower emphasis on past prices.

2.4 Benefits and costs of past-price dependence

*Category expensiveness.* Expensive categories are likely to include more premium products for which consumer purchases are less likely to be driven by price. Offering price discounts may undermine the quality image of these products (e.g., Rao et al. 1989), to the detriment of category performance. Therefore, manufacturers and retailers may establish guidelines to keep prices consistently at a relatively high level and limit use of discounts. Thus, the observed past-price dependence is the result of careful consideration of the long-term pros and cons of pricing
consistency.

H10: In setting retail prices of brands in expensive categories, retailers place a) lower emphasis on demand-based pricing and b) higher emphasis on past prices.

Manufacturer promotional frequency and depth. When manufacturers offer frequent discounts the retailer is stimulated to pass-through cost decreases to the consumer. Therefore, price changes tend to reflect cost considerations rather than demand or past prices. Indeed, Levy et al. (1998) report that the retail-price decision maker typically looks weekly at a variety of information, including manufacturer wholesale price changes and the latest store information on the item, such as last week’s sales, prices, and promotions. An abundance of manufacturer discounts requires the retailer to carefully consider the pass-through decision, and thus the attractiveness of a price change. Indeed, retail pass-through increases in the frequency of manufacturer promotions (Armstrong 1991). Kumar et al (2001) explain this phenomenon in an analytical model of retailers’ strategic considerations, consumer discount expectations, and heterogeneity in travel costs and product valuation. When trade promotions are less frequent, consumers are more likely to believe that there is no ongoing trade promotion when they observe the regular retail price. Consequently, when trade promotions are infrequent, consumers have little incentive to travel for a better deal, which enables the retailer to charge a higher regular price. The retailer will then prefer to change retail prices less often when the frequency of manufacturer promotions is low. High manufacturer discount frequency breaks this pattern and leads to higher retail pass-through as consumers’ incentives to search are enhanced and the retailer risks losing the consumer if the trade deal is not passed on.

H11: In setting retail prices for products with frequent discounts from the manufacturer,
retailers place a) lower emphasis on demand-based pricing and b) lower emphasis on past prices.

In contrast, deeper (versus shallower) manufacturer promotions may induce the retailer not to change the price to the consumer. Indeed, the observed likelihood of obtaining any retail pass-through is decreasing in the depth of discount (Armstrong 1991). One rationale is that, while manufacturers like deep discounts to stimulate brand demand, retailers perceive limits on the ability to increase category demand (Gupta 1988, Srinivasan et al. 2004). Another rationale follows from Kumar et al.’s (2001) model: a deeper discount increases the retailer’s margin from maintaining the regular price and pocketing the manufacturer promotion. Therefore, it is in the retailer’s best interest to target consumers with a high product valuation rather than seeking to maximize overall demand. Therefore, we expect:

H12: In setting retail prices for products with deep discounts from the manufacturer, retailers place a) lower emphasis on demand-based pricing and b) higher emphasis on past prices.

Table 1 presents an overview of our hypotheses.

--- Table 1 about here ---

3. Methodology

Estimates of demand-based pricing and past-price dependence were provided by Nijs et al. (2006). The authors used weekly store-level scanner data from the Dominick's retail chain for 24 product categories in 85 stores. Results are available for the top three brands in each category in each store. Generalized Forecast Error Variance Decomposition (GFEVD) was used to quantify the extent of demand-based pricing and past-price dependence (Pesaran and Shin 1998). In
essence, GFEVD measures the relative impact over time of shocks originating in the individual endogenous variables in a VARX model. Analogous to a ‘dynamic $R^2$’, GFEVD gives the percentage of variation in retailer pricing for a brand that can be attributed to both contemporaneous and past changes in each of the endogenous variables in the VARX model. Specifically, GFEVD was determined using the following equation:

$$
\theta_{ij}(t) = \frac{\sum_{l=0}^{t} \psi_{ij}^g(l)^2}{\sum_{l=0}^{t} \sum_{j=1}^{m} \psi_{ij}^g(l)^2}, \quad i, j = 1, \ldots, m.
$$

(1)

where $\psi_{ij}^g(l)$ is the value of a Generalized Impulse Response Function (GIRF) following a one standard-error shock to variable $j$ on variable $i$ at time $l$ (for details on the calculation of GIRFs see, for example, Dekimpe and Hanssens 1999).

The relative importance of the drivers is derived from the GFEVD values at 26 weeks to reduce sensitivity to short-term fluctuations. The accuracy of the GFEVD estimates was determined using Monte Carlo simulations. We report summary statistics per category in Table 2. Demand-based pricing and past-price dependence account for 11.4% and 49.6% of the dynamic variation in retail prices, respectively.²

--- Table 2 about here ---

We test our hypotheses by linking demand-based pricing and past-price dependence to the antecedents identified in our conceptual framework. Measurement details on these variables are provided in Table 3.

--- Table 3 about here –

We estimate the following equations:
\[ DBP_{ijk} = \gamma_0 + \gamma_1 CPEN_k + \gamma_2 PFREQ_k + \gamma_3 CSKUP_{jk} + \gamma_4 CG_{jk} + \gamma_5 CSTOR_k + \gamma_6 PLS_{jk} + \gamma_7 BPLB_{ijk} + \gamma_8 BMS_{ijk} + \gamma_9 PSBD_{ijk} + \gamma_{10} CE_{jk} + \gamma_{11} MPFRQ_{k} + \gamma_{12} MPDPT_k + \mu_{jk} \] (2)

\[ PPD_{ijk} = \beta_0 + \beta_1 CPEN_k + \beta_2 PFREQ_k + \beta_3 CSKUP_{jk} + \beta_4 CG_{jk} + \beta_5 CSTOR_k + \beta_6 PLS_{jk} + \beta_7 BPLB_{ijk} + \beta_8 BMS_{ijk} + \beta_9 PSBD_{ijk} + \beta_{10} CE_{jk} + \beta_{11} MPFRQ_{k} + \beta_{12} MPDPT_k + \epsilon_{ijk} \] (3)

where \( DBP_{ijk} \) indicates the extent of demand-based pricing for brand \( i \) in category \( k \) in store \( j \) and where \( PPD_{ijk} \) captures the degree of past-price dependence for brand \( i \) in category \( k \) in store \( j \). \( \mu_{ijk} \) is the error term for equation (2) and \( \epsilon_{ijk} \) is the error term for equation (3). The covariates are \( CPEN \) (category penetration), \( PFREQ \) (purchase frequency), \( CSKUP \) (category SKU proliferation), \( CG \) (category growth), \( CSTOR \) (category storability), \( PLS \) (private label share in the category), \( BPLB \) (brand product-line breadth), \( BMS \) (brand market share), \( PSBD \) (price sensitivity of brand demand), \( CE \) (category expensiveness), \( MPFRQ \) (manufacturer promotional frequency), and \( MPDPT \) (manufacturer promotional depth). In addition we allow for store and category fixed effects in both equations.

Estimation of equations (2) and (3) by OLS (\( \theta^{OLS} \)) will provide consistent parameter estimates (see Murphy and Topel 1985). However, the standard errors of these parameters may be biased since demand-based pricing (DBP), past-price dependence (PPD), and price sensitivity of brand demand (PSBD) metrics are estimated quantities. We use a bootstrap algorithm to generate unbiased standard errors (see the technical appendix for details).

4. Results: Antecedents of Retail-Price Drivers

The considerable variation in the importance of price drivers allows us to assess our hypotheses.
developed in section 2 and examine the antecedents of demand-based pricing versus past-price dependence in Table 4.

--- Table 4 about here ---

4.1 Category’s role in overall store portfolio

Category penetration. In categories with higher category penetration, the extent of past-price dependence is lower, consistent with hypothesis H1b ($b = -.113$, $p < .05$). Categories with many buyers will receive more week-to-week pricing attention from the retailer and thus show less dependence on past prices.

Purchase frequency. In support of hypotheses H2a ($b = .387$, $p < .01$) and H2b ($b = -.098$, $p < .05$), retailers place higher emphasis on demand-based pricing and a lower emphasis on past prices in categories with high purchase frequency. These results are consistent with higher returns of demand-based pricing when shoppers can regularly observe and act on price changes (Alba et al. 1999, Briesch et al. 1997). Based on the standardized coefficients reported in Table 4, purchase frequency is the strongest positive determinant of demand-based pricing.

4.2 Costs of using demand-based pricing

Category SKU proliferation. In categories with a large number of SKUs, retailers are less likely to use demand-based pricing, consistent with H3a ($b = -.205$, $p < .01$). This confirms theoretical arguments and previous empirical observations (Bergen et al. 2003, Levy et al. 1998) that changing prices involves substantial managerial and physical costs to the retailer. Consequently, retailers are less likely to dynamically adapt prices in categories with a large number of SKUs as the sheer complexity prohibits detailed weekly consideration of prices (McAlister 2005).
4.3 Benefits of demand-based pricing

Category growth. High growth categories exhibit a greater extent of demand-based pricing, consistent with H4a ($b = .090, p < .01$). We infer that retailers selectively target and allocate scarce managerial resources to high-growth categories, allowing more sophisticated demand-based pricing tactics.

Category storability. The retailer places a higher emphasis on demand-based pricing and a lower emphasis on past prices for storable goods, consistent with H5a ($b = .058, p < .05$) and H5b ($b = -.213, p < .01$). Given the potential for consumer stockpiling, retailers benefit from close inspection of dips and spikes in demand and consequent price changes and suffer from past-price dependence. In fact, storability is the most important factor reducing the extent of past-price dependence in our study.

Private label share in the category. In support of H6a ($b = .063, p < .01$) and H6b ($b = -.140, p < .01$), retailers place a higher emphasis on demand-based pricing and a lower emphasis on past prices in categories where the retailer’s private label commands a larger share. Clearly, private labels are an important part of the store’s overall portfolio since they differentiate the retailer’s offerings and drive store traffic, leading the retailer to use demand-based pricing tactics.

Brand product-line breadth. For brands with a broader product line, retailers are more likely to use sophisticated demand-based pricing, consistent with H7a ($b =.130, p < .01$). These brands have wider distribution (Reibstein and Farris 1995), better shelf space (Corstjens and Corstjens
can satisfy the needs of heterogeneous consumers (Kekre and Srinivasan 1990), and enjoy more retailer attention in the form of demand-based pricing due to their brand power. Moreover, this finding puts our result on category SKU proliferation into perspective: the negative impact of category SKU proliferation on demand-based pricing most likely comes from having many brands with several SKUs rather than a few brands with many SKUs.

Brand market share. In setting retail prices of high-share brands retailers place a higher emphasis on demand-based pricing and a lower emphasis on past prices, consistent with H8a ($b = .110, p < .01$) and H8b ($b = -.128, p < .01$). High-share brands are of greater strategic importance to the retailer both as drivers of top-line revenues and store traffic. By incorporating demand considerations into retail pricing decisions retailers acknowledge the essential relationship between the success of high-share brands and their own overall performance.

Price sensitivity of brand demand. Brands with high demand sensitivity elicit more demand-based pricing and less past-price dependence, consistent with H9a ($b = .159, p < .01$) and H9b ($b = -.118, p < .01$). Clearly, retailers are well attuned to the important relationship between demand and price. Price sensitivity to brand demand is second only to purchase frequency as the strongest enhancer of demand-based pricing.

Category expensiveness. In setting the prices of brands in expensive categories, retailers place lower emphasis on demand-based pricing and higher emphasis on past prices, confirming hypotheses H10a ($b = -.098, p < .01$) and H10b ($b = .120, p < .01$). Since price may serve as a signal of quality for expensive products (Rao and Bergen 1992), frequent tinkering with prices
may harm the consumers’ quality perception. Therefore, the retailer may prefer pricing consistency resulting in higher past-price dependence. Category expensiveness is the most important enhancer of past-price dependence in our study.

*Manufacturer promotional frequency and depth in the category.* Our results confirm that in setting retail prices in categories with frequent manufacturer discounts, retailers place lower emphasis on demand-based pricing and lower emphasis on past prices, in support of H11a ($b = -0.109, p < .01$) and H11b ($b = -0.088, p < .01$). This result is consistent with Levy et al.’s (1998) observation that the retail price decision makers pay attention to manufacturer wholesale price changes in their weekly meetings. It also fits with Kumar et al.’s (2001) model implications that retailer pass-through is increasing in the frequency of manufacturer promotions. In addition we find that retailers rely less on demand-based pricing when manufacturers offer deeper discount ($b = -0.063, p = .07$), consistent with H12a.

Overall, our empirical findings support the hypotheses as summarized in Table 5.

--Insert Table 5 about here---

### 5. Conclusions and Managerial Implications

In this paper we develop a conceptual framework of the factors that determine the retailer’s reliance on two key price drivers. Specifically we examine the circumstances under which demand-based pricing versus past-price dependence is more prominent in dynamic retail pricing. First, the strategic role of the category in the retailer’s portfolio matters in terms of retailer overall profit objectives: Staples (high penetration and frequency) are more important to store
performance than fill-ins (low penetration and low frequency). This suggests that the retailer is less likely to rely on past prices in categories that are critical to the retailer’s overall profit objectives. Second, the costs of demand-based pricing are higher for categories with many SKUs. Given the pricing complexity, the retailer is more likely to stick to established pricing patterns. Finally, retailer benefits of demand-based pricing are higher for growing categories, storable products, brands with greater product-line breadth, high-share brands, categories with a strong private label, and when consumers are very sensitive to price. In contrast, the benefits of past-price dependence are higher in expensive categories. The relative importance of these effects is as follows:

- Purchase frequency, a key determinant of the strategic role of the category in the retailer’s portfolio, is the strongest positive determinant of demand-based pricing, followed by demand sensitivity to price, product-line breadth, and brand share. Category SKU proliferation, on the other hand, most severely complicates the implementation of demand-based pricing.

- Category penetration, purchase frequency, private label share, brand-share, and demand sensitivity all substantially lower the prominence of past-price dependence. Storability most strongly diminishes the retailer’s reliance on past-pricing dependence, while category expensiveness is the only significant enhancer of this retailer pricing behavior.

**Implications for Manufacturers:** Our study helps manufacturers get a better understanding of retail pricing and how trade deals influence the pricing process. While there is much debate about the level of pass-through to consumers (Besanko et al. 2005), our findings suggest that active use of deals can limit the reliance on both past prices and demand-based pricing. Therefore, smaller brands may be able to break through ‘sticky’ pricing patterns by increasing the frequency with which they offer deals to the retailer. In contrast, market leaders with a broad
product line may actually consider reducing the number of deals. Since retailers are inclined to promote leading brands more heavily (Pauwels 2006), maintaining established pricing patterns would be in their best interest. Of course, expected price reaction by competing manufacturers may preclude both leading and smaller brands from executing these changes.

Our findings also help manufacturers identify scenarios where pass-through may be difficult to achieve due to the retailer’s reliance on past pricing. Smaller brands face such pass-through jeopardy, consistent with Pauwels (2006). Moreover, retailers are more likely to rely on past-pricing patterns for perishable products and in expensive categories with low price sensitivity. This establishes an additional hurdle that manufacturers must overcome before the retailer is willing to pass-on trade discounts to the consumer.

Implications for Retailers: Recent research has shown that past-price dependence is associated with lower retailer profits (Nijs et al. 2006). We classify the conditions under which retailers rely more on demand-based pricing and past prices respectively. Our insights offer an opportunity for retailers to evaluate their pricing structure. They may wish to diminish their reliance on past prices and enhance the use of demand-based pricing in specific instances. An extremely valuable area for future research will be to establish exactly how much money the retailer is ‘leaving on the table’ by relying on past prices in the circumstances we have identified (e.g., categories with high SKU proliferation). Furthermore, do higher profits from demand-based pricing outweigh the full price change costs to the retailer, which amount to .7% of revenues and 35% of net margins (Levy et al. 1997)? Using in-house cost information retailers may re-evaluate the appropriateness and cost-effectiveness of their pricing approaches in different categories.

Contributions to Marketing Theory: Our analysis adds to the growing body of research on retail pricing and its performance implications across categories (e.g., Bolton 1989, Fader and Lodish
1990). Our findings indicate that the retailer is paying more attention to demand-based pricing in categories with high purchase frequency. In contrast, SKU proliferation may not only confuse consumers – as to which item to choose (Chernev 2003) – but also retailers as to which items to promote and how to price them. Omitting supply-side effects of assortment complexity underestimates the cost to society of having large assortments relative to the benefits of increased choice. Our results also contribute to the ongoing debate in economics and marketing on the rationality of observed past-price dependence. While Krishna et al. (2001) and Nijs et al. (2006) point to the negative profit impact of this practice, our findings indicate that the retailer may well be rationally weighing the costs and benefits of demand-based pricing versus adhering to past-pricing patterns (Carlton 1986). This finding is consistent with friction models of price changes (Desarbo et al. 1987), which show that decision makers do not change their price unless the pressures to do so exceed certain thresholds. The support for our conceptual framework suggests that these threshold levels depend on identifiable circumstances related to the perceived benefits and costs of demand-based pricing and past-price dependence.

Overall, our findings raise several questions for future research. First, as mentioned above, there is significant value to both retailers and manufacturers in establishing exactly how much money is ‘left on the table’ by past-price dependence. Second, when retailers seem unwilling to allocate scarce managerial resources to weekly pricing decisions, how can retail price decision-making be improved for small brands and in categories with low penetration and shopping frequency?

In conclusion, retailer-pricing actions differ systematically across categories. Our research sheds light on how (1) the strategic role of the category in the retailer’s portfolio and (2) costs/benefit tradeoffs determine the relative importance of demand-based pricing versus past-
price dependence in the retailer’s pricing decisions. Understanding and formalizing the antecedents of the price drivers allows manufacturers to use trade deals more strategically and retailers to identify problem areas and re-allocate scarce marketing resources in order to get the biggest bang for their buck.
<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Demand based pricing</th>
<th>Past-Price Dependence</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1 In setting prices of brands in categories with higher penetration rates, retailers place a) higher emphasis on demand-based pricing and b) lower emphasis on past prices.</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>H2 In setting prices of brands in categories with higher purchase frequency, retailers place a) higher emphasis on demand-based pricing and b) lower emphasis on past prices.</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>H3 In setting retail prices of brands in categories with larger number of SKUs, retailers place a) a lower emphasis on demand-based pricing and b) higher emphasis on past prices.</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>H4 In setting retail prices of brands in high-growth categories, retailers place a) a higher emphasis on demand-based pricing and b) lower emphasis on past prices.</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>H5 In setting retail prices of brands in storable categories, retailers place a) a higher emphasis on demand-based pricing and b) lower emphasis on past prices.</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>H6 In setting retail prices of brands with greater share of the retailer private label, retailers place a) a higher emphasis on demand-based pricing and b) lower emphasis on past prices.</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>H7 In setting retail prices of brands with greater product-line breadth, retailers place a) a higher emphasis on demand-based pricing and b) lower emphasis on past prices.</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>H8 In setting retail prices of high-share brands, retailers place a) a higher emphasis on demand-based pricing and b) lower emphasis on past prices.</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>H9 In setting retail prices of brands with higher demand sensitivity, retailers place a) a higher emphasis on demand-based pricing and b) lower emphasis on past prices.</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>H10 In setting retail prices of brands in expensive categories, retailers place a) lower emphasis on demand-based pricing and b) higher emphasis on past prices.</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>H11 In setting retail prices for products with frequent discounts from the manufacturer, retailers place a) lower emphasis on demand-based pricing and b) lower emphasis on past prices.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>H12 In setting retail prices for products with deep discounts from the manufacturer, retailers place a) lower emphasis on demand-based pricing and b) higher emphasis on past prices.</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>
Table 2: Extent of demand-based pricing and past-price dependence across categories*

<table>
<thead>
<tr>
<th>Category</th>
<th>Demand-based pricing</th>
<th>Past-price dependence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25th</td>
<td>Median</td>
</tr>
<tr>
<td>Analgesics</td>
<td>7.6%</td>
<td>10.7%</td>
</tr>
<tr>
<td>Beer</td>
<td>11.3%</td>
<td>13.8%</td>
</tr>
<tr>
<td>Bottled juice</td>
<td>7.7%</td>
<td>16.2%</td>
</tr>
<tr>
<td>Canned soup</td>
<td>16.6%</td>
<td>19.9%</td>
</tr>
<tr>
<td>Cereal</td>
<td>11.0%</td>
<td>17.0%</td>
</tr>
<tr>
<td>Cheese</td>
<td>7.2%</td>
<td>21.5%</td>
</tr>
<tr>
<td>Cookies</td>
<td>8.1%</td>
<td>13.5%</td>
</tr>
<tr>
<td>Crackers</td>
<td>10.0%</td>
<td>16.9%</td>
</tr>
<tr>
<td>Dish detergent</td>
<td>2.2%</td>
<td>5.6%</td>
</tr>
<tr>
<td>Fabric softeners</td>
<td>10.4%</td>
<td>13.9%</td>
</tr>
<tr>
<td>Front-end candies</td>
<td>5.2%</td>
<td>7.7%</td>
</tr>
<tr>
<td>Frozen juice</td>
<td>2.4%</td>
<td>5.6%</td>
</tr>
<tr>
<td>Laundry detergent</td>
<td>6.6%</td>
<td>8.8%</td>
</tr>
<tr>
<td>Oatmeal</td>
<td>6.5%</td>
<td>9.6%</td>
</tr>
<tr>
<td>Paper towels</td>
<td>11.4%</td>
<td>15.7%</td>
</tr>
<tr>
<td>Refrigerated juice</td>
<td>15.2%</td>
<td>18.5%</td>
</tr>
<tr>
<td>Shampoos</td>
<td>2.7%</td>
<td>5.4%</td>
</tr>
<tr>
<td>Snack crackers</td>
<td>1.7%</td>
<td>3.7%</td>
</tr>
<tr>
<td>Soap</td>
<td>9.2%</td>
<td>11.8%</td>
</tr>
<tr>
<td>Soft drinks</td>
<td>2.3%</td>
<td>4.2%</td>
</tr>
<tr>
<td>Toilet tissue</td>
<td>2.7%</td>
<td>4.3%</td>
</tr>
<tr>
<td>Toothbrush</td>
<td>9.4%</td>
<td>12.4%</td>
</tr>
<tr>
<td>Toothpaste</td>
<td>2.5%</td>
<td>9.1%</td>
</tr>
<tr>
<td>Tuna</td>
<td>12.3%</td>
<td>19.0%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>6.1%</strong></td>
<td><strong>11.4%</strong></td>
</tr>
</tbody>
</table>

* Note: The remainder of the retail price variation is accounted for by wholesale price (cost), category management considerations, and store traffic, as detailed in Nijs et al. (2006).
<table>
<thead>
<tr>
<th>Variable</th>
<th>Operationalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category penetration</td>
<td>Category penetration is operationalized as the percentage of households that buy this category, obtained from the IRI Marketing Factbook.</td>
</tr>
<tr>
<td>Purchase frequency</td>
<td>Category purchase frequency in days is obtained as 365/purchase cycle time, where we used the purchase cycle time measures reported by the IRI Marketing Factbook, taking the average time reported for each category over the relevant data period.</td>
</tr>
<tr>
<td>Category SKU proliferation</td>
<td>The number of SKUS in the category (Narasimhan et al. 1996) captures the extent of SKU proliferation.</td>
</tr>
<tr>
<td>Category growth</td>
<td>Mean of the first difference of log-transformed category sales (Franses 1998, Steenkamp et al. 2005).</td>
</tr>
<tr>
<td>Category storability</td>
<td>We use storability defined by Narasimhan et al. (1996) to construct dummy variables indicating whether the product category is considered perishable or storable (=1).</td>
</tr>
<tr>
<td>Private label share in the category</td>
<td>This variable is operationalized as the percentage share of the retailer private label brands in the category.</td>
</tr>
<tr>
<td>Product-line breadth</td>
<td>The number of SKUS for each brand captures the extent of the brand’s product-line breadth.</td>
</tr>
<tr>
<td>Brand market share</td>
<td>The brand’s market share is operationalized as the average volume-based share of the brand as in Srinivasan, Pauwels, Hanssens, and Dekimpe (2004).</td>
</tr>
<tr>
<td>Price sensitivity of brand demand</td>
<td>A brand’s demand sensitivity to price is defined as the percentage change in brand sales as a result of a price promotion of one percent.</td>
</tr>
<tr>
<td>Category expensiveness</td>
<td>Following Raju (1992), we first compute the regular price (highest price over the data period) of each brand. The category level expensiveness is calculated by the market share weighted average of the regular prices of the brands in the category.</td>
</tr>
<tr>
<td>Manufacturer promotional frequency</td>
<td>We define promotional frequency as the number of weeks in which negative price-promotion shocks are at least 20% of the brand's regular price. The regular price, in turn, is defined as the maximum price of the brand, following Raju (1992) and Foekens et al. (1999).</td>
</tr>
<tr>
<td>Manufacturer promotional depth</td>
<td>A brand's price-promotion depth is defined as the (percentage) difference between a promotional price (as defined for the frequency count) and the brand's regular price.</td>
</tr>
</tbody>
</table>
### Table 4: Antecedents of past-price dependence and demand-based pricing

<table>
<thead>
<tr>
<th>Variable</th>
<th>Demand based ((R^2 .36))</th>
<th>Past-price dependence ((R^2 .21))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standardized-Coefficients</td>
<td>Std-error</td>
</tr>
<tr>
<td><strong>Category Role</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category penetration</td>
<td>0.022</td>
<td>0.039</td>
</tr>
<tr>
<td>Purchase frequency</td>
<td>0.387***</td>
<td>0.041</td>
</tr>
<tr>
<td><strong>Costs versus Benefits</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category SKU proliferation</td>
<td>-0.205***</td>
<td>0.026</td>
</tr>
<tr>
<td>Category growth</td>
<td>0.090***</td>
<td>0.022</td>
</tr>
<tr>
<td>Category storability</td>
<td>0.058**</td>
<td>0.027</td>
</tr>
<tr>
<td>Private label share in the category</td>
<td>0.063***</td>
<td>0.019</td>
</tr>
<tr>
<td>Brand product-line breadth</td>
<td>0.130***</td>
<td>0.030</td>
</tr>
<tr>
<td>Brand market share</td>
<td>0.110***</td>
<td>0.027</td>
</tr>
<tr>
<td>Price sensitivity of brand demand</td>
<td>0.159***</td>
<td>0.027</td>
</tr>
<tr>
<td>Category expensiveness</td>
<td>-0.098***</td>
<td>0.023</td>
</tr>
<tr>
<td>Manufacturer promotional frequency</td>
<td>-0.109***</td>
<td>0.026</td>
</tr>
<tr>
<td>Manufacturer promotional depth</td>
<td>-0.063*</td>
<td>0.037</td>
</tr>
</tbody>
</table>

* Significant at the 10% level  
** Significant at the 5% level  
*** Significant at the 1% level

- \( n = 5190 \)
- Store- and category-specific intercepts are not shown due to space considerations
### Table 5: Summary of hypotheses and empirical support

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Demand based</th>
<th>Past Price Dependence</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1  In setting prices of brands in categories with higher penetration rates, retailers place a) higher emphasis on demand-based pricing and b) lower emphasis on past prices.</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>H2  In setting prices of brands in categories with higher purchase frequency, retailers place a) higher emphasis on demand-based pricing and b) lower emphasis on past prices.</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>H3  In setting retail prices of brands in categories with larger number of SKUs, retailers place a) a lower emphasis on demand-based pricing and b) higher emphasis on past prices.</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>H4  In setting retail prices of brands in high-growth categories, retailers place a) a higher emphasis on demand-based pricing and b) lower emphasis on past prices.</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>H5  In setting retail prices of brands in storable categories, retailers place a) a higher emphasis on demand-based pricing and b) lower emphasis on past prices.</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>H6  In setting retail prices of brands with greater share of the retailer private label, retailers place a) higher emphasis on demand-based pricing and b) lower emphasis on past prices.</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>H7  In setting retail prices of brands with greater product-line breadth, retailers place a) a higher emphasis on demand-based pricing and b) lower emphasis on past prices.</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>H8  In setting retail prices of high-share brands, retailers place a) higher emphasis on demand-based pricing and b) lower emphasis on past prices.</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>H9  In setting retail prices of brands with higher demand sensitivity, retailers place a) higher emphasis on demand-based pricing and b) lower emphasis on past prices.</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>H10 In setting retail prices of brands in expensive categories, retailers place a) lower emphasis on demand-based pricing and b) higher emphasis on past prices.</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>H11 In setting retail prices for products with frequent discounts from the manufacturer, retailers place a) lower emphasis on demand-based pricing and b) lower emphasis on past prices.</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>H12 In setting retail prices for products with deep discounts from the manufacturer, retailers place a) lower emphasis on demand-based pricing and b) higher emphasis on past prices.</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>
Figure 1: Plot of demand-based pricing vs. past-price dependence for two categories

- **Demand-based pricing**:
  - Toothbrush: 50%
  - Cheese: 15%

- **Past-price dependence**:
  - Toothbrush: 60%
  - Cheese: 45%
References


Nijs, Vincent, Marnik G. Dekimpe, Jan-Benedict. E.M. Steenkamp, Dominique M. Hanssens


(August), 351-357.


Technical Appendix

*Bootstrap algorithm to correct the standard error bias from OLS-estimation*

To correct the parameter standard error bias introduced when estimating equations (2) and (3) with OLS we use the following bootstrap algorithm:

**Step 1:** Select a sample of size \( n \), with replacement, from the GFEVD estimates provided by Nijs et al. (2006), where \( n \) is equal to the number of observations in the dataset.

**Step 2:** Add measurement error based on monte carlo simulated GFEVD estimates to each data point (Nijs et al. 2006). This step is repeated two hundred and fifty times, each time creating a variation of the dataset obtained in step 1.

**Step 3:** Calculate parameter estimates \( \theta^* \) for equations (2) and (3) for each of the two hundred and fifty augmented datasets created in step 2.

We repeat steps 1 through 3 one thousand times. The standard deviations across the two-hundred and fifty thousand parameter vectors \( \theta^{*1, \theta^{*2, \ldots, \theta^{*250,000}}} \) are the unbiased standard errors for \( \theta^{\text{OLS}} \) (see Bradley and Tibshirani 1993 for details).
Endnotes

1 Demand-based pricing tactics and past-price dependence account for over 60% of the variation in retail prices. The remainder is accounted for by wholesale price, category management considerations, and store traffic, as detailed in Nijs et al. (2006). It is therefore feasible that in our empirical analysis a hypothesis for demand-based pricing is confirmed while the hypothesis for past-price dependence is not, or vice-versa.

2 For an extensive discussion of other price drivers see Nijs et al. (2006).

3 Results are generated using Ox version 4.00 (see Doornik 2002).

4 We are grateful to Scott Neslin for making the storability and impulse-purchase scales available to us.