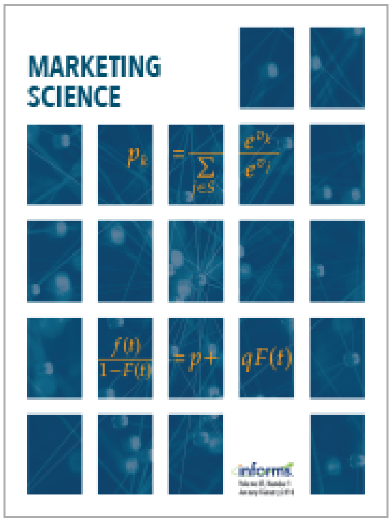

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Consumer Preferences and Product-Line Pricing Strategies: An Empirical Analysis

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Firms often differentiate their product lines vertically to capture consumers' differential willingness to pay for quality. Additionally, many firms offer products varying not in quality but in characteristics such as scent, color, or flavor, that relate to horizontal differentiation. For example, in the yogurt category, each manufacturer carries several product lines differing in quality and price, but within each line there is an assortment of flavors that is uniformly priced.

To better understand these product-line pricing strategies, we address two key issues. First, how do consumers perceive product-line and flavor attributes? Second, given consumers' preferences, is the current strategy of pricing product lines differently, but offering all flavors within a product line at the same price, optimal?

We find that consumers value line attributes more than flavor attributes. Our analysis reveals that firms exploit these differences in consumer preferences by using product lines as a price discrimination tool. However, firms' profits would not significantly increase if they were to price flavors within a product line differently. Therefore, the current pricing policy of setting different prices for product lines, but uniform prices for all flavors within a line, appears to be on target.

Key words: product-line pricing; competitive strategy; product assortment
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1. Introduction

The number of consumer goods and services offered in the marketplace has been steadily increasing over the last decades. According to the Marketing Intelligence Service, 31,510 new consumer SKUs (stock-keeping units) were introduced in the United States in 2003, which is about the total number of SKUs stocked in an average supermarket. Colgate, which sold two types of toothpaste in the early 1970s, today offers 19. Häagen Dazs was launched in 1961 with only three flavors of ice cream: vanilla, coffee, and chocolate, but has continually grown its product line to include 36 flavors in 2004. This proliferation is not limited to packaged goods. The credit card industry, which offered a handful of cards in the 1960s and 1970s, makes tens of thousands of distinct card offers daily.

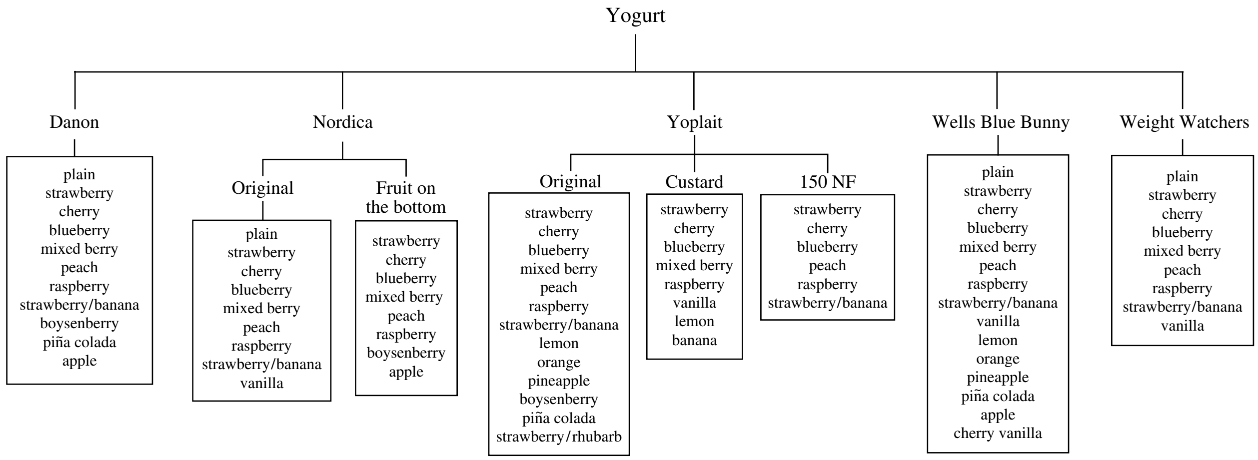
A common strategy for firms extending their product lines is to differentiate their offerings vertically, i.e., to provide different quality levels at different prices to capture the differential willingness to pay for quality among consumers. For example, a typical desktop product line includes CPUs with clock speed ranging from 2.2 GHz to 2.8 GHz, memory from 256 MB to 2 GB, and so on.

There are also categories, however, where firms offer a line of products that vary not in quality but in other characteristics. For example, Coca Cola carries Diet Coke, Decaffeinated Coke, Diet Decaffeinated Coke, Cherry Coke, Vanilla, etc. Characteristics such as scent, color, or flavor relate to horizontal differentiation. Typically, the items within product lines that vary only along a horizontal dimension are priced the same.

A good example of both strategies is the yogurt category (see Figure 1 for an overview). In this category, each manufacturer carries several product lines. Yoplait, for instance, offers Yoplait Original, Yoplait Custard, and Yoplait 150 Nonfat. These product lines differ in quality (as measured by fat/sugar content) and price, i.e., they are vertically differentiated. Within each line items are horizontally differentiated: There is an assortment of flavors that are all offered at the same price. Such pricing strategy begs two questions: (1) *Do firms price-discriminate across the product lines they carry*? (2) *Would discriminating across flavors within a product line lead to an increase in profits*?

Related to the pricing of a product line is a firm's assortment decision. Firms have the option to introduce new lines and/or new flavors. Dannon, for

Figure 1 **Structure of the Yogurt Category**



example, had a few product lines in the 1980s, with a larger number of flavors in each line. Now they have moved to offering more distinct lines with fewer flavors per line. A recent visit to their website revealed that their current assortment consists of 14 distinct product lines. To understand a strategy shift like this, we need to understand how consumers perceive the differences between lines and flavors and how manufacturers can best price their product line(s) to extract consumer surplus.

We begin by estimating a demand system at the line-flavor (SKU) level. The question addressed hereby is *whether consumers perceive different product lines or different flavors across lines as closer substitutes*. We investigate this issue in two ways. First, we compare different nested-logit model specifications to determine which structure best describes consumer preferences for lines versus flavors in the yogurt category. Second, we look at the estimated line-specific and flavor-specific effects. By comparing the ranges of these fixed effects of lines and flavors we can determine the relative impact of lines and flavors on consumer purchase decisions. Based on the parameter estimates, we develop a summary measure of the value of all flavors in a product line. This measure, the *inclusive value*, can be used to assess the relative contribution of additional flavors to a product line.

The parameter estimates also allow us to shed light on the ability of firms to engage in second-degree price discrimination using different product lines. That is, *can firms exploit differences in consumers' willingness to pay in order to increase their profits*? Suppose, for example, that consumers value line attributes more than flavor attributes. Then, firms have a lot to gain by pricing their product lines differently, whereas they have little to lose from pricing all flavors within a line the same. In this sense, comparing the estimated fixed effects of lines with those of flavors implicitly tests for the presence of price discrimination.

A related question that arises in this context is the following. *Given the structure of the market, is the current pricing policy of offering all flavors in a product line at the same price optimal*? Depending on whether consumers' choice is driven by line or by flavor attributes, the answer can vary. In the yogurt category, consumers frequently purchase multiple flavors, but they usually buy from one line. As evident from Table 1, 82% of the purchase occasions (28,431 out of 34,577) are of a single product line, but 56% (19,312) involve the purchase of multiple flavors. If consumers' choice is indeed driven by flavors, firms might be better off pricing popular flavors low to attract buyers (loss-leader strategy). If, however, consumers perceive all flavors within a line to be fairly similar, then having the same price for all flavors makes more sense.

To study firms' product-line pricing strategies, we specify a supply-side model where manufacturers set prices for all lines they carry (one price for each line), taking into consideration the interdependencies within and across product lines. The channel structure

Table 1 **Purchase Pattern in the Yogurt Category**

	1 product line	2 product lines	3 product lines	4 or more	Total
1 flavor	15,068	186	10	1	15,265
2 flavors	6,769	1,865	42	1	8,677
3 flavors	4,028	1,679	159	4	5,870
4 flavors	1,737	994	145	20	2,896
5 flavors	499	430	104	14	1,047
6 flavors	247	219	58	19	543
7 flavors	57	82	22	6	167
8 flavors	14	34	11	5	64
9 flavors	5	9	9	3	26
10 or more	7	3	7	5	22
Total	28,431	5,501	567	78	34,577

is captured by a vertical Nash model. We conduct a "what-if"-type experiment to investigate whether the current pricing policy is optimal by determining how much a firm can gain by setting different prices for different flavors.

Our findings indicate that consumers value line attributes more than flavor attributes. Furthermore, the value of a product line is not merely a function of the number of flavors it includes: The calculated inclusive values reveal that more flavors do not always result in increased utility for consumers and hence higher market shares.

In light of consumer preferences for lines versus flavor attributes, the current pricing policy of setting different prices for product lines, but uniform prices for all flavors within a line, appears to be on target. The counterfactual analysis we conduct confirms that firms' profits would not significantly increase if they were to price flavors within a product line differently. This does not mean that firms fail to exploit differences in consumer preferences. On the contrary, firms seem to use product lines as a price discrimination tool. Overall, our analysis suggests that firms have a good understanding of consumers' preferences and devise their pricing strategies accordingly.

The remainder of the paper is organized as follows. Section 2 develops a discrete-choice model on the demand side and a model of Bertrand competition between oligopolistic manufacturers who sell through a strategic retailer on the supply side. In §3 we describe the data used for the empirical analysis. We discuss the results in §4 and conclude in §5 with directions for future research.

2. Model Formulation

We start by formulating a discrete-choice model of demand where consumers choose among the available line-flavor combinations in the market. Then we turn our attention to the supply side. We specify the channel structure by considering competing manufacturers who sell through a retailer. The retailer sets prices to consumers for all product lines in the category (Choi 1991, Sudhir 2001).

2.1. Demand Model

All products are grouped in mutually exclusive sets, with the outside good being the only member of group 0. To obtain insights into consumers' preferences for lines and flavors, we use a nested-logit model (Berry 1994, Cardell 1997) and compare different nesting structures to determine which one best describes the data: (1) *line-primary structure*: all flavors are grouped by line, i.e., consumers perceive different flavors within a line to be closer substitutes than different product lines offering a specific flavor; (2) *flavor-primary structure*: all lines that offer a particular flavor form a group, i.e., consumers perceive different product lines offering a specific flavor to be closer substitutes than different flavors within a given line.[1] Below we derive the line-primary logit in detail. The flavor-primary nested logit is defined analogously.

Let $l = 1, \ldots, L$ denote lines (e.g., "Dannon Lowfat") and $f = 1, \ldots, F$ flavors (e.g., "strawberry"). Let F_{lt} denote the set of flavors offered by line l in period t. We assume that at each consumption occasion, consumer h selects the line-flavor combination that maximizes his/her utility (Nevo 2001) or decides to not consume anything, in which case his/her utility is $U_{0t}^h = \epsilon_{0t}^h$.

The utility of flavor f in line l is given by

$$U_{lft}^h = a_{lf}^h + \beta_f^h f_{lt} + \beta_d^h d_{lt} + \beta_p^h p_{lt} + \xi_{lft} + \epsilon_{lt}^h + (1-\sigma)\epsilon_{lft}^h, \quad \sigma \in [0, 1), \tag{1}$$

where f_{lt}, d_{lt}, and p_{lt} denote feature, display, and price for line l in period t, and β_f^h, β_d^h, and β_p^h are the respective response parameters. We allow for household-specific variation in these response parameters to capture consumer heterogeneity. Note that all marketing-mix variables are uniform across all flavors within a product line. We explicitly acknowledge the existence of attributes such as national advertising and shelf space that affect consumer utility but are unobserved by the researcher by including the term ξ_{lft} (Berry 1994, Besanko et al. 1998). The idiosyncratic demand shock $\epsilon_{lt}^h + (1-\sigma)\epsilon_{lft}^h$ is i.i.d. extreme value distributed. The parameter σ captures the within-group (nest) correlation. For $\sigma = 0$ we obtain the standard multinomial logit model.

The constant a_{lf}^h captures the intrinsic preference for a given line-flavor combination. Because there are too many line-flavor combinations, we focus on the main effects of line and flavor by setting $a_{lf}^h = a_l^h + a_f^h$, where a_l^h denotes the line effect and a_f^h denotes the flavor effect (Fader and Hardie 1996).[2] An additional benefit of this formulation is that it enables us to evaluate new product-line/flavor offerings as long as they are a combination of existing ones. For example, if Dannon were contemplating the launch of

[1] Frequently, the nested logit has been interpreted as implying a sequence of consumer choice decisions. Note that this is not warranted by the model: All we can learn from comparing different nested-logit models is which correlation structure best describes consumer preferences in the data (Cardell 1997). We thank the area editor for drawing our attention to this very important point.

[2] We also did some preliminary empirical analyses, where we compared the directly estimated line-flavor-fixed effects a_{lf}^h to the effects calculated from a main-effects-only model, i.e., $a_l^h + a_f^h$. Our results suggest that the main-effects-only specification yields precise estimates of the line-flavor effects with an average difference between the two estimates of 6.7%.

cherry/vanilla flavor, the utility of this new offering can be computed by adding up the line effect for Dannon and the flavor effect for cherry/vanilla. We need to normalize one line or flavor effect, because line and flavor effects always appear as a sum.

As mentioned previously, we incorporate consumer heterogeneity by allowing the response parameters to vary by household. In particular, we use a discrete-point random coefficients model with K support points as in Besanko et al. (2003), thus assuming that consumers belong to K distinct segments. Each segment k has a different vector of response parameters. In addition to allowing us to incorporate consumer heterogeneity, this demand specification yields more flexible substitution patterns among lines and flavors.

Given the utility specification in Equation (1), the unconditional share for a line-flavor combination within segment k is

$$S_{lft}^k = \frac{\exp\left[\left(\beta_f^k f_{lt} + \beta_d^k d_{lt} + \beta_p^k p_{lt} + IV_{lt}^k\right)/(1-\sigma)\right]}{\left\{A_{lt}^k\right\}^{\sigma}\left(1+\sum_{l'}\left\{A_{l't}^k\right\}^{1-\sigma}\right)}, \quad (2)$$

where

$$A_{lt}^k = \exp\left[\left(\beta_f^k f_{lt} + \beta_d^k d_{lt} + \beta_p^k p_{lt} + IV_{lt}^k\right)/(1-\sigma)\right],$$

and

$$IV_{lt}^k = (1-\sigma)\ln \sum_{f'\in F_{lt}} \exp\left[\left(a_{lf'}^k + \xi_{lf't}\right)/(1-\sigma)\right] \quad (3)$$

is the inclusive value of line l within segment k in period t.

The *inclusive value* represents a summary measure of the impact of all flavors within a given product-line net of the impact of the marketing-mix variables, i.e., the price, feature, and display response. For example, the inclusive value of Yoplait 150 provides a measure of the effect all flavors within this line (strawberry, cherry, blueberry, peach, raspberry, and strawberry/banana) have on consumer utility. Because we use a main-effects-only specification, $a_{lf}^k = a_l^k + a_f^k$, only a_f^k is included in the inclusive value, and the line constant enters the market share expression directly. In this case the inclusive value represents the value of a product-line net of the marketing-mix variables and the quality effects captured by the line intercept.

The total market share of a line-flavor combination in week t is obtained by aggregating over the K segments:

$$S_{lft} = \sum_{k=1}^{K} \lambda^k S_{lft}^k, \quad (4)$$

where λ^k denotes the size of segment k.

In the special case of $K = 1$, we can derive the estimation equation analytically:

$$\ln(S_{lft}) - \ln(S_{0t}) = a_{lf} + \beta_f f_{lt} + \beta_d d_{lt} + \beta_p p_{lt} + \sigma\ln(S_{lft|l}) + \xi_{lft}, \quad (5)$$

where $S_{lft|l}$ is the share of line-flavor combination lf in period t conditional on line l. For $K > 1$, however, we can no longer invert the demand equation analytically to obtain the error term. We therefore use a contraction mapping procedure to compute $\xi_t = (\xi_{lft})_{l,f}$ so that the actual market shares equal the theoretical ones (Berry et al. 1995).

2.2. Supply Model

Manufacturers determine wholesale prices. They sell through retailers who set prices to consumers for all lines in the category. A feature of the data is that all flavors of yogurt in a given line are priced the same.[3] To reflect this phenomenon, we let the manufacturers and the retailer set a uniform price for the entire line. In §4.3 we conduct a "what-if"-type experiment to determine whether this uniform pricing policy is indeed optimal.

Consistent with the findings of Slade (1995) and Walters and MacKenzie (1988), we assume that the retailers are local monopolists, that is, each retailer represents a geographically distinct market. To capture the strategic interactions between manufacturers and the retailer, we use a vertical Nash model (Choi 1991). In this model, manufacturers and the retailer set prices simultaneously, whereby manufacturers take retail margins for their own brand and the retail prices of all other brands as given, and the retailer takes wholesale prices as given when determining the retail price. In an extensive empirical study of six product categories, Cotterill and Putsis (2001) find that vertical Nash conduct best describes the channel interaction.[4]

Note that the manufacturer and retailer objective functions do not include trade deals because, similarly to most previous empirical work, we do not have data to identify such decisions (Sudhir 2001, Besanko et al. 2003). Incorporating trade deals and slotting allowances would lead to a richer model, where we could investigate the bargaining process in the channel and its implications for product-line decisions.

Retailer's Decision. Each period, the retailer chooses prices p_{lt} for all lines to maximize category profits. More precisely, the retailer at time t solves

$$\Pi_t^r = \max_{\{p_{lt}\}_l} M \sum_l (p_{lt} - w_{lt}) S_{lt}, \quad (6)$$

[3] Shankar and Bolton (2004) note a similar pricing policy in a number of other product categories such as mouthwash, bathroom tissue, and waffles.

[4] Our model can be easily modified to capture Manufacturer Stackelberg interactions in the distribution channel. A Manufacturer Stackelberg model may be more appropriate in markets where, unlike in our case, there is a concentration of market power in the hands of a few manufacturers. For example, Sudhir (2001) investigates a yogurt market, where the two major brands have more than 80% of the market share.

where M denotes the total market size, S_{lt} is the market share, p_{lt} is the retail price, and w_{lt} is the wholesale price of product line l in period t. The first-order conditions are given by

$$\nabla_{(L\times L)}(p-w)_{(L\times 1)} = -S_{(L\times 1)}, \tag{7}$$

where ∇ denotes the matrix of derivatives $\partial S_{lt}/\partial p_{lt}$, $l=1,\ldots,L$. Solving for p yields

$$p = w - \nabla^{-1}S. \tag{8}$$

Manufacturers' Decision. Let manufacturer (brand) j carry lines L_{jt} at time t. The profit-maximization problem of the manufacturer is

$$\Pi^m_{jt} = \max_{\{w_{lt}\}_{l\in L_{jt}}} M \sum_{l\in L_{jt}} S_{lt}(w_{lt}-c_{lt}), \tag{9}$$

where c denotes the marginal cost. The FOC is given by

$$S_{lt} + \sum_{l'} \Omega_{ll'} \frac{\partial S_{l't}}{\partial w_{lt}}(w_{l't}-c_{l't}) = 0, \tag{10}$$

where Ω is the ownership matrix defined as

$$\Omega_{ll'} = \begin{cases} 1 & \text{if } l \text{ and } l' \text{ both belong} \\ & \quad \text{to the same brand} \\ 0 & \text{else.} \end{cases} \tag{11}$$

We solve all FOCs simultaneously:

$$\Omega_{(L\times L)} * \Delta_{(L\times L)}(w-c)_{(L\times 1)} = -S_{(L\times 1)}, \tag{12}$$

where $*$ denotes elementwise multiplication and Δ is the matrix of derivatives in equation $\partial S_{lt}/\partial w_{lt}$, $l=1,\ldots,L$. Solving for w yields

$$w = c - (\Omega * \Delta)^{-1}S. \tag{13}$$

Equilibrium Prices. At a Nash equilibrium between manufacturers and the retailer, Equations (8) and (13) hold jointly, so we can add them. The full set of equilibrium retail prices can thus be characterized by

$$p = c - (\nabla^{-1} + (\Omega * \Delta)^{-1})S. \tag{14}$$

The benefit from combining Equations (8) and (13) is that Equation (14) no longer includes the unobserved wholesale prices. It also nicely illustrates the double-marginalization property of the vertical Nash model, i.e., the presence of both a wholesale markup, $(\Omega * \Delta)^{-1}S$, and a retail markup, $\nabla^{-1}S$.

The marginal cost are unknown and need to be estimated from the data. We assume that the cost is the same for all flavors in a given line. Following the literature (Berry et al. 1995), we specify a linear relationship between the marginal cost and input prices:

$$c_{lt} = z'_{lt}\gamma + \eta_{lt}, \tag{15}$$

where z_{lt} includes factor prices (labor, ingredients) along with a line-specific cost constant, γ is a parameter to be estimated, and η_{lt} denotes a cost shock. Substituting Equation (15) in Equation (14) yields the following estimation equations:

$$p = z'\gamma - (\nabla^{-1} + (\Omega * \Delta)^{-1})S + \eta. \tag{16}$$

Depending on the demand model we specify, the matrices of derivatives, ∇ and Δ, will vary. In the case of the random coefficients logit model we have

$$\Delta = \begin{bmatrix} \sum_{k=1}^{K}\lambda^k\beta_p^k S_{1t}^k(1-S_{1t}^k) & -\sum_{k=1}^{K}\lambda^k\beta_p^k S_{1t}^k S_{2t}^k & \cdots\;\cdots & -\sum_{k=1}^{K}\lambda^k\beta_p^k S_{1t}^k S_{Lt}^k \\ -\sum_{k=1}^{K}\lambda^k\beta_p^k S_{2t}^k S_{1t}^k & \sum_{k=1}^{K}\lambda^k\beta_p^k S_{2t}^k(1-S_{2t}^k) & \cdots\;\cdots & -\sum_{k=1}^{K}\lambda^k\beta_p^k S_{2t}^k S_{Lt}^k \\ \vdots & \vdots & & \vdots \\ \vdots & \vdots & & \vdots \\ -\sum_{k=1}^{K}\lambda^k\beta_p^k S_{Lt}^k S_{1t}^k & -\sum_{k=1}^{K}\lambda^k\beta_p^k S_{Lt}^k S_{2t}^k & \cdots\;\cdots & \sum_{k=1}^{K}\lambda^k\beta_p^k S_{Lt}^k(1-S_{Lt}^k) \end{bmatrix}.$$

Recall that the vertical Nash model implies that $\partial p_l/\partial w_l = 1$ and $\partial p_l/\partial w_k = 0$ for $k \neq l$. Hence, ∇ is equal to Δ. The line-primary nested logit has the same derivative matrix. The flavor-primary nested logit is more complicated and numerical methods are needed to obtain the derivatives.

3. Data

Data Sources. We use data on the yogurt category made available for academic research by A. C. Nielsen. The data set spans a period of over two years (from Week 25, 1986 until Week 34, 1988) and consists of weekly data on prices, quantities, features, coupons, and displays for a major supermarket chain in Sioux Falls, SD.[5]

We focus our attention on single-serving yogurt (6 oz. and 8 oz.) because typically only two flavors, plain and vanilla, are available in larger sizes, and these are most often used for cooking as opposed to snacking. While warranted in our case by the nature of the product category, in general the choice of size should be explicitly modeled. Marketers have long shown the importance of jointly considering brand and quantity choice (Chiang 1991, Chintagunta 1993, Zhang and Krishnamurthi 2004). Additionally, size is an important price discrimination tool allowing manufacturers to charge more for the convenience of smaller package sizes (Gerstner and Hess 1987).

There are five major brands in the market: Dannon, Yoplait, Nordica, Wells Blue Bunny, and Weight

[5] Note that because of the age of the data set, our ability to draw conclusions about the current product-line pricing policies in the yogurt market is somewhat limited.

Table 2 Descriptive Statistics: Market Shares and Mean Values of Marketing-Mix Variables

	Nordica Original	Nordica Fruit on the Bottom	Yoplait Original	Yoplait Custard	Yoplait 150	Dannon	Weight Watchers	Wells Blue Bunny	Total
Plain (%)	0.12					1.42	1.71	0.72	3.97
Strawberry (%)	0.84	1.04	1.93	1.48	0.45	2.97	2.67	3.07	14.45
Cherry (%)	0.76	0.28	2.22	0.06	0.48	1.68	1.72	2.38	9.57
Blueberry (%)	0.61	0.58	1.35	0.73	0.47	2.04	1.86	1.82	9.47
Mixed berry (%)	0.61	0.90	1.03	0.94		2.32	1.75	1.25	8.80
Peach (%)	0.51	0.60	0.88		0.66	1.53	2.14	1.45	7.77
Raspberry (%)	0.69	1.01	1.63	0.98	0.64	2.84	2.61	2.33	12.73
Strawberry/banana (%)	0.76		1.29		0.49	2.25	0.37	2.01	7.16
Vanilla (%)	0.19			1.43			1.17	0.05	2.85
Lemon (%)			0.77	0.72				0.98	2.47
Orange (%)			0.91					1.32	2.23
Pineapple (%)			0.61					1.00	1.61
Boysenberry (%)		0.70	1.15			2.57			4.41
Piña colada (%)			0.81			1.59		1.12	3.52
Strawberry/rhubarb (%)			0.62						0.62
Apple (%)		0.57				1.53		1.09	3.18
Banana (%)				1.67		1.45			3.12
Cherry/vanilla (%)								2.08	2.08
Line share (%)	5.08	5.67	15.20	8.01	3.20	24.16	16.00	22.68	100.00
Price	0.0747	0.0753	0.1102	0.1130	0.1125	0.0839	0.0806	0.0562	
Feature	0.0383	0.0482	0	0	0	0.1128	0	0.0659	
Display	0.0143	0.0211	0	0	0.0227	0	0	0.0338	

Note. Reported are the market shares of the "inside goods" prior to normalization with respect to the outside good.

Watchers. There is a private label in the market, but the individual flavors are not identified so we cannot include it in our analysis. Table 2 gives an overview of the product lines that are sold in the market, the flavors they offer, and presents some basic descriptive statistics. As evident from Table 2, Wells Blue Bunny has the longest product line, with 15 flavors, followed by Yoplait Original with 13 flavors and Dannon with 12 flavors. The shortest product line is offered by Yoplait 150 (6 flavors). Among all flavors, strawberry is the most popular (14.45%), followed by raspberry, cherry, blueberry, mixed berry, and peach.

Yoplait has the highest combined market share across lines. Dannon and Wells Blue Bunny have the largest market share as single lines. Interestingly, two high-share brands span the spectrum of prices in the market: Wells Blue Bunny is the lowest-priced line, whereas the Yoplait lines are the most expensive ones. The lines differ greatly in terms of promotional activities. While Weight Watchers, Yoplait Original, and Yoplait Custard have no feature or display activity in the two-year period of the data, the two regional brands, Wells Blue Bunny and Nordica, promote quite heavily using both vehicles. Dannon is the most featured product line.

To calculate the share of the outside good, we first obtain a measure for the total market size. Following Villas-Boas (2004), we multiply the population size with the average weekly consumption of yogurt (in ounces) in the United States.[6]

For the cost shifters in the supply equation we use wage data and the producer price index for fluid milk (main ingredient of yogurt) from the Bureau of Labor Statistics. The monthly series were then smoothed to obtain weekly cost data, following the approach suggested by Slade (1995).[7]

4. Results

Our model explicitly acknowledges the presence of factors unobserved to the researcher that could affect demand, such as national advertising and shelf space allocation. To account for the potential endogeneity of prices due to the presence of these unobserved attributes, we use promotional variables (feature and display) and cost factors—such as wage data and the producer price index for fluid milk—as instruments. We obtain overidentifying restrictions by interacting

[6] From USDA/Economic Research Service, Food Consumption, Prices, and Expenditures Report 1970–1999, the average annual per-capita consumption is 56 ounces, which translates to about 1 ounce/week.

[7] First, the factor price $\tilde{z}_t$ in week t is assumed to be the value of the factor price in the corresponding month. Then the series is smoothed as follows: $z_t = 0.25\tilde{z}_{t-1} + 0.5\tilde{z}_t + 0.25\tilde{z}_{t+1}$. Note that this procedure, while convenient to make the level of temporal aggregation the same for all variables, can lead to overstating the precision for the standard error estimates of the cost shifters. Thanks to an anonymous reviewer for drawing attention to this point.

Table 3 Parameter Estimates for Different Demand Specifications

	One-segment specification			Line primary	
	Logit	Flavor primary	Line primary	Segment 1	Segment 2
σ		0.36 (0.03)	0.68 (0.03)	0.65 (0.04)	
Price (β_p)	−39.17 (7.12)	−21.64 (6.29)	−42.95 (5.60)	−45.27 (7.47)	−102.27 (24.30)
Display (β_d)	1.04 (0.13)	0.83 (0.11)	1.22 (0.12)	0.82 (0.22)	4.11 (1.58)
Feature (β_f)	1.54 (0.05)	1.28 (0.05)	1.72 (0.05)	0.61 (0.23)	6.07 (1.81)
λ				0.59 (0.12)	
Lines					
Nordica Original	−0.10 (0.15)	−0.16 (0.13)	−0.51 (0.12)	−0.25 (0.18)	−2.18 (0.85)
Nordica Fruit on the Bottom	−0.01 (0.15)	−0.13 (0.13)	−0.36 (0.12)	−0.12 (0.18)	−1.70 (0.78)
Yoplait Original	1.72 (0.38)	0.88 (0.34)	1.96 (0.30)	2.02 (0.48)	6.55 (2.47)
Yoplait Custard	1.71 (0.41)	0.85 (0.36)	1.61 (0.32)	1.65 (0.54)	6.64 (2.63)
Yoplait 150	1.59 (0.40)	0.81 (0.35)	1.35 (0.32)	1.61 (0.43)	
Dannon	0.85 (0.20)	0.39 (0.18)	0.93 (0.16)	1.16 (0.22)	0.69 (0.88)
Weight Watchers	1.04 (0.18)	0.57 (0.16)	0.92 (0.14)	1.08 (0.20)	
Wells Blue Bunny	0	0	0	0	
Flavors					
Plain	−2.84 (0.41)	−3.49 (0.35)	−0.85 (0.33)	−0.19 (0.43)	
Strawberry	−2.45 (0.41)	−2.77 (0.35)	−0.77 (0.33)	−0.09 (0.42)	
Cherry	−2.63 (0.41)	−3.04 (0.35)	−0.81 (0.33)	−0.12 (0.42)	
Blueberry	−2.72 (0.41)	−3.09 (0.35)	−0.82 (0.33)	−0.14 (0.43)	
Mixed berry	−2.66 (0.41)	−3.07 (0.35)	−0.79 (0.33)	−0.11 (0.43)	
Peach	−2.76 (0.41)	−3.20 (0.35)	−0.85 (0.33)	−0.17 (0.43)	
Raspberry	−2.53 (0.41)	−2.87 (0.35)	−0.79 (0.33)	−0.10 (0.42)	
Strawberry/banana	−2.58 (0.41)	−3.11 (0.35)	−0.75 (0.33)	−0.06 (0.43)	
Vanilla	−2.59 (0.42)	−3.43 (0.36)	−0.71 (0.34)	−0.04 (0.43)	
Lemon	−2.88 (0.41)	−3.68 (0.36)	−0.81 (0.34)	−0.15 (0.43)	
Orange	−2.92 (0.41)	−3.76 (0.36)	−0.89 (0.34)	−0.22 (0.43)	
Pineapple	−3.12 (0.41)	−3.98 (0.37)	−0.94 (0.34)	−0.27 (0.44)	
Boysenberry	−2.60 (0.41)	−3.30 (0.36)	−0.80 (0.33)	−0.11 (0.43)	
Piña colada	−2.85 (0.41)	−3.54 (0.36)	−0.83 (0.34)	−0.17 (0.43)	
Strawberry/rhubarb	−3.12 (0.42)	−4.21 (0.37)	−0.92 (0.34)	−0.26 (0.43)	
Apple	−2.82 (0.41)	−3.57 (0.36)	−0.80 (0.34)	−0.11 (0.43)	
Banana	−2.49 (0.41)	−3.32 (0.36)	−0.72 (0.33)	−0.04 (0.43)	
Cherry/vanilla	−2.53 (0.42)	−3.47 (0.37)	−0.71 (0.34)	−0.02 (0.43)	
MSE	4.46	3.76	3.05	2.22	

Note. Standard errors in parentheses.

our original instruments with a full set of brand dummies, as in Villas-Boas (2004).

4.1. Consumer Preferences: Line or Flavor

We start by looking at the demand estimates for three different specifications of the one-segment model: a standard logit model, a line-primary nested logit, and a flavor-primary nested logit. Comparing the mean square errors (MSE) of the different demand models, the standard logit model (MSE of 4.46) is dominated by either of the nested-logit models. Moreover, σ is significantly different from zero, thus allowing us to reject the hypothesis of equivalence between the nested logit and the standard logit model. Comparing the two nesting structures, we see that the line-primary model dominates the flavor-primary model in terms of MSE (3.05 versus 3.76) and plausibility of the parameter estimates. It thus appears that consumers perceive flavors within a line to be more similar than the different product lines offering a particular flavor.

An alternative way of assessing the importance of line attributes relative to flavor attributes in consumer choice is to look at the range of the estimated fixed effects. That is, we calculate the difference between the highest and lowest estimate for the line fixed effects and for the flavor-fixed effects, respectively. Looking at the line-primary model in Table 3, we see that the range for the line effect is 2.47 (the highest estimated line effect is for Yoplait Original, 1.96, the lowest for Nordica, −0.51), whereas the one for the flavor effect is 0.23 (the highest value is for vanilla, −0.71, the lowest is for pineapple, −0.94). This again suggests that line has a greater impact on consumer preferences than flavor attributes.

To capture consumer heterogeneity and obtain more flexible substitution patterns, we estimate a two-segment random coefficients model for our preferred specification, the line-primary nested logit.[8]

[8] Due to the large number of alternatives (line-flavor combinations), we keep the flavor-fixed effects constant across consumer segments

Table 4 Number of Flavors, Inclusive Values, Own and Cross-Price Elasticities of the Product Lines

Product line	Flavors	Inclusive value*	Own	Min. cross	Max. cross
Nordica Original	9	0.05	−3.37	0.07	0.10
Nordica Fruit on the Bottom	8	0.07	−3.41	0.06	0.12
Yoplait Original	13	0.67	−5.67	0.27	0.32
Yoplait Custard	8	0.44	−6.25	0.12	0.17
Yoplait 150	6	0.17	−4.94	0.11	0.14
Dannon	12	0.61	−3.63	0.29	0.37
Weight Watchers	9	0.49	−3.41	0.24	0.34
Wells Blue Bunny	15	0.38	−2.45	0.24	0.30

*Numbers reported are averages across weeks.

As expected, adding random coefficients greatly improves the fit of the model: The MSE drops from 3.05 to 2.22. The right-hand panel of Table 3 reports the parameter estimates. The two segments are of similar size (59% and 41%). All estimated parameters have face validity. In particular, for both segments the price response is negative, whereas the response to feature and display is positive.

The implied own-price elasticities presented in Table 4 range from −2.45 to −6.25. The magnitude of these estimates is quite plausible (all are below −1, consistent with firms being profit maximizers) and in line with previous empirical work in the yogurt category (Draganska and Jain 2004, Villas-Boas 2004). The cross-price elasticities are also in line with our intuition. For example, the values for Nordica Fruit on the Bottom range from 0.06 to 0.12, and for Weight Watchers from 0.24 to 0.34. This considerable variation suggests that our random coefficients specification produced the richer substitution patterns we were looking for.

To obtain a measure of the contribution of the flavors included in a product line to its overall utility, we calculate the inclusive values of the different product lines as specified in Equation (3). As we can see from the left panel in Table 4, while some of the product lines with a large number of flavors, such as Yoplait Original (13 flavors) and Dannon (12 flavors), indeed have larger inclusive values, the correlation between inclusive value and number of flavors offered is less than perfect (0.57, to be precise). The product line with the highest number of flavors (15), Wells Blue Bunny, has an inclusive value of 0.38, while Yoplait Custard, which offers only 8 flavors, has a value of 0.44. Again, line attributes seem to be a more significant determinant of consumer utility than individual flavors.

and also restrict the line fixed effects for Yoplait 150 and Weight Watchers to be the same. The reason for choosing these two product lines was that they are both diet products, which presumably appeal to a certain segment that is relatively homogeneous in its preferences.

4.2. Firms' Pricing Strategy: Price Discrimination Across Lines

In the yogurt market firms price their product lines differently but keep the price of all flavors within a given product line uniform. So, for example, Yoplait Original is priced differently than Yoplait Custard Style, but strawberry flavor and cherry flavor within each of these lines have the same price. In this and the next section, we explore to what extent this pricing strategy is justified from a profitability point of view.

Given that consumers value line attributes more than flavor attributes, firms have a lot to gain by pricing their product lines differently, whereas they have little to lose from pricing all flavors within a line the same. Hence, comparing the estimated fixed effects of lines with those of flavors implicitly tests for the presence of price discrimination. Based on the demand estimates alone, we can therefore conclude that price discrimination might indeed be present between product lines. However, it could be the case that price differences are explained by cost differences and are not the result of price discrimination on part of the manufacturers. To address this issue, we add a supply-side equation as specified in §2.2 and estimate the marginal costs of the product lines. We use the inferred marginal cost along with the price data to conduct a simple test for price discrimination.

Cabral (2000) suggests that price discrimination is present if the ratio of prices is different from the ratio of marginal costs. We apply this test to the two brands in our data set that carry more than one product line, Nordica and Yoplait. The test statistic is calculated as

$$PD_t = \left(\frac{p_{jt}}{p_{kt}}\right) \Big/ \left(\frac{c_{jt}}{c_{kt}}\right).$$

Because observed prices and the inferred marginal costs vary by week, we report the average, standard deviation, minimum, and maximum of PD_t in Table 5.

Our results provide some evidence for price discrimination. As Table 5 shows, the differences in prices between Yoplait Original and Yoplait 150, and Yoplait Original and Yoplait Custard, respectively, seem too large to be explained by differences in production cost. In the case of Yoplait Original versus Yoplait 150, the average of the test statistic is 0.8467 with a standard deviation of 0.0935. In the case

Table 5 Test for Price Discrimination Between Product Lines

	Nordica Original/ Fruit on the Bottom	Yoplait Original/Custard	Yoplait Original/150	Yoplait Custard/150
Mean*	1.1091	1.0684	0.8467	0.7950
Std. dev.	0.4275	0.0198	0.0935	0.1050
Min.	0.6851	0.9734	0.6896	0.5925
Max.	4.2088	1.1640	1.3235	1.3596

*Numbers reported are price ratios divided by marginal cost ratios.

of Yoplait Custard versus Yoplait 150, the average of the test statistic is even lower, 0.7950 with a standard deviation of 0.1050. This significant difference between the price ratio and the cost ratio can be attributed to price discrimination. In contrast, the average *PD* ratio for Nordica Original and Nordica Fruit on the Bottom, 1.1091, is very close to 1, as is the one for Yoplait Original and Custard, 1.0684. Hence, the differences in prices can be explained by differences in production cost for the two Nordica lines and for Yoplait Original and Yoplait Custard.

Now that we have seen that firms may engage in price discrimination across the product lines they carry, the next question is whether they should also practice price discrimination within their lines.

4.3. Firms' Pricing Strategy: Price Discrimination Across Flavors Within a Line

What would happen to channel profits if manufacturers and the retailer would set different prices for the different flavors? We can use the estimates from the equilibrium model to conduct a what-if experiment to answer this question. We first develop the model for the counterfactual scenario, where prices are set individually for each line-flavor combination. This scenario is then compared to the uniform pricing model in §2.2 to determine how much in profits is lost by the current practice of pricing all flavors within a line the same.

Retailer's Decision. For each period, the retailer chooses prices p_{lft} for all line-flavor combinations to maximize category profits:

$$\Pi_t^r = \max_{\{p_{lft}\}_{l,f}} M \sum_{l,f} (p_{lft} - w_{lft}) S_{lft}, \tag{17}$$

where $S_{lft} = \sum_{k=1}^{K} \lambda^k S_{lft}^k$. The market share with a segment is given by

$$S_{lft}^k = \frac{\exp[(a_{lf} + \beta_f f_{lt} + \beta_d d_{lt} + \beta_p p_{lft} + \xi_{lft})/(1-\sigma)]}{\{A_{lt}^k\}^{\sigma} \left(1 + \sum_{l'} \{A_{l't}^k\}^{1-\sigma}\right)}, \tag{18}$$

where

$$A_{lt}^k = \sum_{f' \in F_{lt}} \exp\left[\left(a_{lf'}^k + \beta_f^k f_{lt} + \beta_d^k d_{lt} + \beta_p^k p_{lft} + \xi_{lf't}\right)/(1-\sigma)\right].$$

The FOC is given by:

$$S_{lft} + \sum_{l',f'} \frac{\partial S_{l'f't}}{\partial p_{lft}} (p_{l'f't} - w_{l'f't}) = 0. \tag{19}$$

Stacking the FOCs and rewriting in matrix notation,

$$\nabla_{(LF \times LF)} (p - w)_{(LF \times 1)} = -S_{(LF \times 1)}, \tag{20}$$

where ∇ is the matrix of derivatives and LF is the total number of line-flavor combinations in the category.

Manufacturers' Decision. Let manufacturer j offer the line-flavor combinations $LF_{jt} = \{(l, f): l \in L_{jt} \wedge f \in F_{lt}\}$. The profit-maximization problem is then

$$\Pi_{jt}^m = \max_{\{w_{lft}\}_{(l,f) \in LF_{jt}}} M \sum_{(l,f) \in LF_{jt}} S_{lft}(w_{lft} - c_{lt}).$$

The FOC is given by

$$S_{lft} + \sum_{(l',f') \in LF_{jt}} \frac{\partial S_{l'f't}}{\partial w_{lft}} (w_{l'f't} - c_{l't}) = 0. \tag{21}$$

Defining an ownership matrix for line-flavor combination Υ analogously to the brand ownership matrix Ω in Equation (11), the FOCs become

$$\Upsilon_{(LF \times LF)} * \Delta_{(LF \times LF)} (w - c)_{(LF \times 1)} = -S_{(LF \times 1)}. \tag{22}$$

Combining (20) and (22), we obtain the Nash equilibrium prices as

$$p = c - (\nabla^{-1} + (\Upsilon * \Delta)^{-1}) S. \tag{23}$$

We solve numerically for line-flavor specific prices and compute channel profits by line. To do that, we generate prices from the new equilibrium model by re-solving the system of demand and supply equations simultaneously.

Comparing the profits under this scenario to the ones obtained from uniform pricing shows that the gains from nonuniform pricing are minimal (less than 1%). In the new equilibrium, firms do not change their prices although they could potentially do so, which suggests that the current pricing policy is optimal. The average change in prices across flavors is negligible, as is the change in consumer demand (again, less than 1%). There are a number of potential explanations for this result. As suggested by our demand estimates, consumers do not seem to value one flavor over another, making it hard for firms to justify price differentiation within a product line. In addition, because consumers perceive flavors within a line as fairly similar to each other, they may conclude that any price difference is unfair (Xia et al. 2004). In fact, if such fairness concerns are present, we would expect consumer demand to be even lower, and thus profits to decrease. In a study of apparel sizes, another horizontal attribute, Anderson and Simester (2005) demonstrate that nonuniform pricing can lead to a loss in profits of up to 7%. Casual observation suggests yet another possibility: *When it is better to have a different price for certain flavors, firms introduce them as a new product line (e.g., exotic flavors).*

5. Conclusions

In this research we explore the relationship between consumers' preferences for product attributes and firms' pricing policies in the yogurt category. We estimate a demand system at the SKU level, where we account for both consumer heterogeneity and the potential endogeneity of prices. Our empirical analysis reveals that consumers value line attributes more than they do flavor attributes. We also find that the value of a product line is not merely a function of the number of flavors it includes: The calculated inclusive values indicate that more flavors do not always result in increased utility for consumers, and hence higher market shares.

We analyze firms' pricing strategies by specifying a supply-side model with competing manufacturers who sell through a common retailer. The first decision we investigate is firms' pricing strategies across the product lines they carry. While the price differences between product lines appear to be driven primarily by cost differences, in several instances the evidence suggests that manufacturers are using product lines as price discrimination tools. Second, we look at firms' pricing decisions across flavors within a product line. We conduct a "what-if"-type experiment to determine if firms' profits would increase if they were to price flavors individually, and conclude that this is not the case. This finding suggests that firms' strategy of setting equal prices for all flavors within a given product line is indeed optimal.

The proposed methodology can be applied to aid managerial decisions pertaining to product-line pricing and line extensions in various industries. A primary concern for deciding on a line extension is the value of an additional flavor for the overall value of the line, which is readily measured using our approach. More generally, line extensions are but one way to introduce new products. Hence, the decision maker also needs to know the relative merits of adding a flavor and launching a new line.

Our model is fairly detailed and tailored to the specifics of the yogurt category. Therefore, a number of issues need to be considered when the model is applied to support managerial decisions in other product categories. In particular, some key assumptions need to be verified before proceeding.

On the demand side, we have analyzed a specific product category structure, where items within the line only vary by one (horizontal) attribute. However, many products are characterized by a mix between horizontal and vertical attributes, notably in categories such as paper towels or laundry detergent products differ by design/scent (horizontal) and size (vertical). Extending the model to account for this more complex product-line structure is of considerable importance, as it would allow for a wider range of applications.

Another way to generalize the demand model is to incorporate a richer heterogeneity structure. A particularly interesting question is whether segments exist with respect to preference for line versus flavor. One possible approach to accomplish this task would be to extend the framework of Kamakura et al. (1996), who propose an individual-level mixture of nested-logit models to capture differences in the preference structure.

On the supply side, while we believe that the assumptions of Bertrand Nash interaction between manufacturers and vertical Nash interaction between manufacturers and retailer are warranted for the yogurt category, they might be questioned in other markets and should be tested using either conjectural variations or a menu approach (Cotterill and Putsis 2001, Villas-Boas 2004).

Furthermore, underlying our analysis is the assumption that product attributes are given, i.e., a firm does not optimize by choosing which flavors or lines to offer. This is clearly not realistic, but we share this shortcoming with most empirical research to date. Recently, researchers have started looking into the problem of endogenizing product assortment decisions. Bayus and Putsis (1999) and Draganska and Jain (2005) incorporate the endogeneity of product-line length (as measured by the number of options offered) but do not shed light on the decision of which product(s) to offer. In a study of the gasoline market, Iyer and Seetharaman (2003) empirically analyze a firm's decision to price-discriminate by selecting the quality of products to offer (self-serve and/or full-serve) in addition to the price to charge. The emerging literature on endogenous product choice (Mazzeo 2002, Seim 2005) could serve as a starting point in future endeavors to formulate a general model of firms' joint product assortment and pricing decisions.

In sum, this research provides some initial insights into the implications of consumer preferences for firms' product-line pricing strategy. The proposed modeling approach offers a promising tool for the analysis of product-line pricing decisions in a competitive environment, and can be enriched further to capture the realities of the marketplace and the idiosyncratic characteristics of specific industries.

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