Retail product-line pricing strategy when costs and products change

Steven M. Shugan\textsuperscript{a,\*}, Ramarao Desiraju\textsuperscript{b}

\textsuperscript{a}Marketing Department, University of Florida, Warrington College of Business Administration, Gainesville, FL 32611, USA

\textsuperscript{b}Department of Marketing, University of Central Florida, Orlando, FL 32816, USA

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Abstract

Rapid changes in technology can have a sudden and differential impact on cost components of variants within product lines such as computers, printers, digital cameras and cellular phones. How should retailers react to such changes? We address this issue by answering three questions. First, when the costs of specific product components change (perhaps, precipitously), how should retailers adapt their prices in the affected product lines? Second, what will be the impact on profit margins, the range of prices and average price of the line? Finally, if a product variant is either added or removed from the line, how should the retailer adjust the other prices in the line? Our analysis reveals that the nature of interaction between the variants of the product line plays a central role in determining the appropriate retailer response to cost shocks. We also provide empirical support for our analysis. © 2001 by New York University. All rights reserved.

1. Introduction

Retailers often face dramatic cost-changes from their suppliers for reasons such as technological advances, learning-curve effects and price shifts in raw materials markets. Decreases in computer chip prices, for example, affect the prices of many products from cellular phones to alarm clocks; increases in wages impact most services from health care to banking; and, oil price shocks dramatically impact many products from automobiles to home insulation.

* Corresponding author. Tel.: +1-352-392-1426, ext. 1236.
E-mail addresses: shugan@dale.cba.ufl.edu (S. Shugan), rdesiraju@bus.ucf.edu (R. Desiraju).
Retailers must know how to adjust their prices in response to various types of cost shocks. One strategy for dealing with cost change calls for a corresponding price change; for example, wholesale cost increments (decrements) result in higher (lower) retail prices. Such strategies, however, may not consider the interactions among the variants of a retail product line (Mason and Milne 1994). It is vital for the retailer to consider the impact of a variant’s price both on that variant’s profits as well as the profits of the other variants in the line (Blattberg and Neslin 1990; Levy and Weitz 1995; Hauser and Shugan 1983; Shugan 1984; Zenor 1994). In juxtaposition with this emphasis on product line interactions, one interesting empirical finding has recently emerged: demand in product lines tends to exhibit some asymmetric patterns (Blattberg and Wisniewski 1989; Blattberg and Neslin 1990). This means that consumers may be more resistant to trading off some quality to obtain a better price than accepting a higher price to get better quality.

This article’s primary objective is to provide general guidelines for retailers who carry lines of product variants that vary in quality. We provide these guidelines with the help of mathematical analysis. Our analysis examines pricing implications when the product variants exhibit either symmetric competition or, as suggested by recent empirical research, asymmetric competition. A main purpose is to derive implications about how retailers should adjust prices when facing cost shocks from many factors including changes in raw material prices, technology and labor costs. Finally, cost changes and related factors sometimes lead to the removal or addition of a product variant from the market (Padmanabhan, Rajiv and Srinivasan 1997). We also examine the impact of these removals or additions.

On the supply side, variants within a line often vary in quality. Quality differences are often caused by differences in components or ingredients. Sometimes, cost changes have a disproportionate impact on higher quality (lower quality) variants. For example, increases in the price of diamonds might have a disproportionate impact on the higher quality variants of the jewelry lines (e.g., watches, earrings, necklaces, and bracelets) because, for such variants, a greater percentage of the cost comes from diamonds. Lower quality jewelry variants may contain few or no diamonds. Similarly, decreases in the prices of nickel cadmium batteries may have more impact on lower quality electronic devices (e.g., camcorders, CD players, cordless telephones, and some laptop computers) because higher quality devices use other types of batteries (e.g., manganese lithium). In yet other instances, cost changes are felt proportionally throughout the line. For instance, increases in alcohol taxes can have a proportional impact on the cost of liquor products. The cost of each wine bottle, for example, may increase by 10%.

Changes in costs can also lead to changes in assortments. Previous research shows the importance of considering the impact of assortment on optimal prices. For example, in a study of sixty-five different retail outlets, Shugan (1987) found that the price of a variant varies with retail assortment. We, too, are concerned with the impact of assortment on prices.

To highlight the research questions we study, consider the following:

(1) Suppose that a retailer, such as Service Merchandise, carries coffee makers including the Hamilton Beach 784, the Proctor Silex Auto Drip and the Norelco HB 5123. Suppose further the manufacturer of the Proctor Silex offers a trade promotion (essentially, a decrease in the retailer’s cost). The existing literature (e.g., Skinner
1970) suggests that Service Merchandise should lower the retail price of the Proctor Silex. The literature, however, provides no guidance to the retailer on whether or how to change the prices of the Hamilton Beach 784 or the Norelco HB 5123.

(2) A computer retailer carries a computer line comprised of low-quality laptops with nickel-cadmium batteries and high-quality laptops with manganese-lithium batteries. For simplicity, suppose there are two types of potential customers: low-end buyers and high-end buyers. The laptops with the lithium batteries provide performance features demanded by high-end buyers who pay a premium price to obtain these products. The low-end buyers are more price-sensitive—they buy the high-quality product variants if the price is low enough; otherwise, they relinquish the lithium features for the lower priced laptops. Now suppose the cost of nickel decreases so that the cost of the low-quality laptop decreases. Clearly, the price of the low-quality laptops should decrease, but it is unclear how to adjust the price of the higher quality laptops. Analogously, if the cost of lithium increases, the cost of the higher quality laptops should increase leading to higher prices. Should the prices of the lower quality laptops increase or decrease?

(3) There are three grades of gasoline: high-octane gas, medium-octane gas, and low-octane gas. Suppose the cost of oil goes up. What will be the impact on the prices of the three grades of gasoline?

(4) Suppose a sudden cost increase or shortage of foodstuffs (e.g., a fruit) leads to the discontinuation of some food products containing this ingredient. How should the retailer adjust the price of other food variants (e.g., bakery goods, jams, and jellies) when some variants are removed from the line?

(5) We know that margins and price ranges impact a variety of marketing decisions. Given that, how will changes in costs and line-composition affect the margins and the range of prices in the line?

Our analysis answers these questions. For example, we find that when a cost decline disproportionately impacts the lower-quality variants, the price of the lower quality variants should decrease while the prices of the higher quality variants should increase. Hence, in the preceding laptop example, when the cost of nickel-cadmium batteries decreases, the retailer should raise the price of high-quality laptops with manganese-lithium batteries and decrease the price of laptops with nickel-cadmium batteries. We also explain the rationale for such recommendations.

The remainder of this article is organized as follows. The next section briefly reviews the relevant literature on asymmetric competition and product line pricing. Subsequent sections present our general mathematical model, discuss the implications of asymmetry, and investigate the impact of various types of cost shocks on a product line that exhibits asymmetric competition. The penultimate section provides empirical support for our analysis and the final section summarizes our conclusions.

2. Literature review

This section reviews the literatures on asymmetric within-line competition and product line pricing, in turn.
The concept of asymmetric line competition has now been documented in many contexts. Blattberg and Wisniewski (1989) popularized the concept, suggesting that quality tier competition is asymmetric. They provided empirical evidence that although lower quality brands were vulnerable to higher quality brand’s price reductions, high-quality brands did not show this vulnerability. They observed many more consumers “switching up” to higher quality brands than “switching down” to lower quality brands. Asymmetric line competition is now documented in both in-store experiments (Bemmaor and Mouchoux 1991) and household-level purchasing panel-data (Kamakura and Russell 1989).

Evidence from multiple streams of research suggests that “...higher-quality competitors are more resistant to attacks from lower-quality brands than lower-quality competitors are resistant to attacks from higher-quality brands” (Heath and Chatterjee 1995). It appears that “within retail product lines ... substitution patterns are asymmetric... high price/quality variants steal sales from low price/quality variants, but the converse is not true (Mulhern and Leone 1991)”. “High-quality brands are less vulnerable to losses when prices are increased. ... competition among brands in different quality tiers can be asymmetric both in choice (what) and in category choice (whether) (Sivakumar and Raj 1997)”.

Theories have been proposed to explain these asymmetries. Psychological theory suggests that these asymmetries occur from individual behavior because individuals view price and quality differently resulting in asymmetries in behavior (e.g., Nowlis and Simonson 1997, Carmon and Simonson 1998, Luce, Payne and Bettman 1999). Simply put, “...consumers generally seem to be more resistant to trading off some quality to get a better price than accepting a higher price to get better quality.” (Bettman, Luce and Payne 1998) These responses could be rational (Wernerfelt 1995).

Other researchers suggest that asymmetry is the result of differences between individuals. For example, buyers may have differential preference strengths for higher-quality and lower-quality products (Blattberg and Wisniewski 1989). Consider, for example, a camera product line consisting of two cameras of different quality. The higher-quality camera has digital editing capabilities while the lower quality camera does not. Buyers for the higher-quality camera (call them segment H) may have a strong preference for digital editing, while buyers of the lower-quality camera (call them segment L) may not. In this case, a price reduction on the higher-quality camera may attract segment L. The reverse fails to occur because, despite the lower price, segment H still finds the lower-quality camera to lack an essential feature. In general, buyer heterogeneity may cause asymmetries and can be thought of as “consequence of aggregating probabilities with nonlinear functional forms (Chintagunta, Jain, and Vilecassim 1991)”.

Since the empirical discovery of asymmetric line competition, researchers are beginning to explore potential implications. Recent research investigates the implications for marketing planning (Carpenter, Cooper, Hanssens and Midgley 1988), developing public policy (Guiltnan and Gundlach 1996) and predicting the decision outcomes of individual consumers (Simonson and Tversky 1992). Our interest lies in the implications for product line pricing.

Researchers in both the economics and marketing literatures have studied product line pricing (Monroe and Bitta 1978) as well as the traditional impact of costs on a single product’s price (Skinner 1970; Bulow and Pfleiderer 1983) when product lines fail to exhibit asymmetric line competition. The focus in economics literature is on two issues: (1) how
product lines price discriminate among potential buyers and (2) the resulting social welfare loss. For instance, Katz (1984) describes conditions that motivate firms to provide the socially desirable line breadth. Mussa and Rosen (1978) show that firms can use product lines to sort customers and engage in imperfect price discrimination. Each customer self-selects so that the quantity of the purchased product reveals the customer’s price sensitivity. Several authors including Srinagesh and Bradburd (1989) have extended the Mussa-Rosen model. However, this work focuses principally on regulation rather than on product line management.


Given sufficient time, resources and data, it is theoretically possible to estimate the optimal price of every variant in every store at every time. In practice, however, a dynamic environment often requires an immediate strategic response. Retailers must often make immediate price changes for a large number of variants without the benefit of detailed analysis. Under such conditions, general findings, such as those discussed herein, are more likely to be helpful.

3. The general linear model

We model product lines consisting of variants with well-defined price-quality orderings. Higher-priced variants may have additional features, performance or general quality. Product lines fitting this description are numerous and include cellular phones, laptop computers, alarm clocks, binoculars, calculators, cameras, radar detectors, answering machines, coffee-makers, microwaves and so on. Higher quality surge protectors, for example, may protect against more severe voltage spikes. Product lines not fitting this description often differ on variety rather than quality and include books, charms, earrings, yogurt, and bed sheets (Shugan 1989).

Without loss in generality, we order variants from lowest to highest quality. Denote the $i^{th}$ variant within a product-line $\alpha$ as $A_i$ where $A_i$ has a quality level greater than $A_{i-1}$ for $i=2,3, \ldots, V$, where $V$ is the number of variants as well as the variant of highest quality. For
example, when \( V = 2 \), we have two variants, \( A_1 \) and \( A_2 \), with lower quality and higher quality, respectively. Perhaps, \( A_2 \) has many more features, better components or more expensive materials. Consider a line of compact 35mm cameras. The variants could be the inexpensive Olympus AF Super (about $40) and the expensive Olympus Infinity Stylus (about $80). Finally, let \( F_a \) be the fixed cost associated with carrying the line \( \alpha \) and assume \( \theta \) for all variants \( i \). We set prices to maximize total profits given by Eq. (1) for the entire line \( \alpha \) with \( V_a \) variants.

\[
\pi_\alpha = \sum_{i=1}^{V} (p_i - c_i) D_i - F_a
\]

For notational simplicity, we suppress \( \alpha \). See Table 1 for notation.

To isolate the impact of asymmetric competition, consider a simple two variant product line, \{A1, A2\}. Let \( D_i \) denote \( A_i \)'s demand which is a function of prices \( p_i \) and \( p_k \) where \( \frac{\partial D_i(p_i, p_k)}{\partial p_i} < 0 \) and \( \frac{\partial D_i(p_i, p_k)}{\partial p_k} > 0 \), for all \( i \neq k \) and \( i, k = 1, 2 \). To add additional structure let the demand be linear in prices, that is, all second partials are zero: \( \frac{\partial^2 D_i}{\partial p_i \partial p_j} = 0 \) for all \( i, j = 1, 2, i \neq j \).

We define demand functions exhibiting symmetric line competition as satisfying \( \frac{\partial D_1}{\partial p_2} = \frac{\partial D_2}{\partial p_1} \). Other demand functions are asymmetric. We define BW (i.e., Blattberg-Wisniewski) asymmetry as follows. The lower quality variant’s price \( p_1 \) has no (or far less) impact on the demand of the higher quality variant \( D_2 \) compared with the impact the higher quality variant’s price \( p_2 \) has on the low-quality variant’s demand \( D_1 \). Setting prices to maximize profits yields proposition 1.
3.1. **Proposition 1: impact of asymmetry**

a. When the demand function for a product line is linear and symmetric then, changes in the cost of one variant has no impact on the optimal price of the other variant (i.e., \( \frac{\partial p_1^*}{\partial c_2} = 0, \frac{\partial p_2^*}{\partial c_1} = 0, i = 1, 2 \)).

b. When the demand function for a product line is linear and BW asymmetric then, there is an inverse relationship between the cost of the lower quality variant and the optimal price of the higher quality variant (i.e., \( \frac{\partial p_2^*}{\partial c_1} < 0, \frac{\partial p_1^*}{\partial c_1} > 0 \)).

c. When the demand function for a product line is linear and BW asymmetric then, there is a direct relationship between the cost of the higher quality variant and the optimal price of the lower quality variant (i.e., \( \frac{\partial p_2^*}{\partial c_2} > 0, \frac{\partial p_1^*}{\partial c_2} > 0 \)).

3.1.1. **Proof**

Taking the derivatives of the demand functions, \( D_i = \beta_{0i} - \beta_{1i}p_i + \beta_{2i}p_j \) for \( i, j = 1, 2 \) \( i \neq j \), with respect to \( p_i \) and \( p_j \) yields optimal prices \( p_i^* \) and \( p_j^* \) which are functions of all variant costs. It is straightforward to show that \( \frac{\partial p_i^*}{\partial c_j} = \frac{\beta_{1j}(\beta_{2j} - \beta_{2i})}{4\beta_{1i}\beta_{1j} - (\beta_{2j} + \beta_{2i})^2} \). Hence, \( \frac{\partial p_i^*}{\partial c_j} = 0 \) when \( \beta_{2j} = \beta_{2i} \). The other results follow. **Q.E.D.**

Proposition 1 implies that, with symmetry, as the lower quality variant’s cost changes, the optimal price of the higher quality variant remains unchanged. Moreover, as the higher quality variant’s changes, the optimal price of the lower quality variant remains unchanged.

In contrast, with asymmetry, as the higher-quality variant’s cost decreases, the optimal prices of both the higher and lower-quality variants decrease. As the higher-quality variant’s cost increases, both the optimal prices of the higher and lower-quality variants increase. Further, with asymmetry, as the lower-quality variant’s cost decreases, the optimal prices of the higher and lower-quality variants move in different directions. When the higher quality variant’s price increases, the lower-quality variant’s price decreases. Lastly, as the lower-quality variant’s cost increases, the higher quality variant’s optimal price decreases while the lower-quality variant’s price increases.

To understand the intuition underlying these results, we need to understand two effects, labeled as the substitution and the margin effects. We begin by considering the substitution effect.

Remember that increases in the cost of a variant tend to increase its optimal price. For example, with only one product facing a linear demand with parameters \( b_{0i}, b_{1i} \), the profit is \((p_i - c_i)(b_{0i} - b_{1i}p_i)\) and the optimal price is \( p_i^* = \frac{b_{0i}}{2b_{1i}} + \frac{c_i}{2} \). Hence, increases in cost \( c_i \) increase the optimal price \( p_i^* \). More generally, when the cost of any variant changes, its optimal price changes in the same direction.
When we have a line of products, a price change for one variant affects the demand for every other variant, because demand functions are interrelated through the cross-elasticities. Essentially, then, as the cost of any variant increases, ceteris paribus, its price increases and tends to cause the demand for the other variants to increase. Similarly, as the price of any variant decreases, ceteris paribus, the demand for other variants tends to decrease. We refer to this as the cross-elasticity or the substitution effect.

Now consider the impact of a change in demand, caused by the substitution effect, on the optimal price of the other variants. We know that higher demand tends to raise the optimal price for a variant. In the single product case, for example, the optimal price of \( p_i^* \)

\[
= \frac{b_{0i}}{2b_{1i}} + \frac{c_i}{2}
\]

increases as the demand parameter, \( b_{0i} \), increases.

Increased demand, due to the substitution effect, then, tends to increase the other variants’ optimal prices. It is possible to characterize the magnitude of such price increments. In the two-variant case, for instance, we can show that the rate of change of the higher quality variant’s price when the lower quality variant’s cost increases is proportional to \( \frac{\partial D_2}{\partial p_1} \).

Now consider the second effect. We noted that a variant’s optimal price increases as its cost increases. Despite that increase, however, the per-unit profit decreases with increased cost. In our single product example, the optimal profit margin of \( p_i^* - c_i = \frac{b_{0i}}{2b_{1i}} \)

\( - \frac{c_i}{2} \) decreases as \( c_i \) increases. Hence, as a variant’s cost increases, that variant’s optimal per unit profit tends to decrease. The variant becomes less profitable and each sale of the variant generates less profit than before the cost increase. Analogously, as the variant’s cost decreases, the variant’s optimal per unit profit increases.

When retailers carry product lines, an incentive exists to shift volume sales to the more profitable variants. Shifting is possible by raising the prices of the less profitable variants and lowering the prices of the more profitable variants. We refer to the incentive to shift sales to higher margin variants as the “margin effect”.

It follows that when the per unit profit margin of one variant increases because of a cost decrease, then that variant becomes more profitable. The “margin effect” now tends to force the prices of the other variants to increase in order to shift unit sales to the now more-profitable variant. Again, it is possible to characterize the magnitude of the price change. In the two-variant case, the rate of change of the higher quality variant’s price when the lower quality variant’s cost decreases is proportional to \( \frac{\partial D_1}{\partial p_2} \).

Clearly, the “substitution effect” and the “margin effect” work in opposite directions. When a variant’s cost increases, its own optimal price increases. The substitution effect then tends to increase the optimal prices of other variants. The margin effect, in contrast, tends to decrease the optimal prices of the other variants because they seek to attract unit sales from the now less-profitable variant.

With symmetric competition among the variants in the category, price changes from the two effects exactly cancel each other. Essentially, this is because the partials, \( \frac{\partial D_2}{\partial p_1} \) and \( \frac{\partial D_1}{\partial p_2} \)
are equal. Consequently, the optimal price of each variant is independent of the cost of the other variant as stated in Proposition 1 (a).

With asymmetric competition, one effect tends to dominate the other. For example, consider two variant lines with one variant of lower quality. Recall that the demand for the higher quality variant is influenced less by the price of the lower quality variant than the lower quality variant’s demand is influenced by the higher quality variant’s price. Consequently, when the cost of the lower quality variant goes up, the substitution effect is dominated by the margin effect and the price of the higher quality variant goes down. When the cost of the higher quality variant increases, the substitution effect dominates the margin effect and the price of the lower quality variant goes up.

Clearly, the nature of within line competition does impact pricing strategy. The next section derives those implications in more detail for multiple variant lines.

4. Multiple variant lines

Earlier, we outlined several scenarios and raised questions about the impact of cost and assortment changes on profit margins, price ranges, average prices and product line pricing strategy in general. This section develops some answers to the following three questions. First, when the cost of specific product components or ingredients change (perhaps, precipitously), how should retailers adapt their prices in the affected product lines? Second, what will be the impact on profit margins, the range of prices in the line and on the average price of the line? Finally, if a product is either added or removed from the line, how should the retailer adjust the other prices in the line?

We employ demand functions that display asymmetry, that is, the price of a higher quality variant affects the demand of a lower quality variant, but not vice versa. Specifically, Eq. (2) provides the demand, \( D_i \), for the \( i \)th product variant in an assortment with \( V \)-variants, where \( i = 1, 2, \ldots, V \).

\[
D_i = \begin{cases} 
M(p_{i+1} - p_i) & \text{for } i < V, p_i \leq p_{i+1} \\
M(\theta - p_V) & \text{for } i = V, p_V \leq \theta \\
0 & \text{otherwise}
\end{cases}
\]  

(2)

Here, \( p_i \) is the price of the \( i \)th variant; \( M \) and \( \theta \) are constants. Note that we can interpret \( \theta \) as the maximum buyer reservation price, and \( M \) as a measure of aggregate demand.

Recalling Proposition 1, in the context of a two-variant assortment, the cost of a variant affects the price of another variant only when there is asymmetry. Eq. (2) is a linear demand function displaying, and possibly exaggerating, the “Blattberg-Wisniewski” asymmetric competition, by depicting \( D_i \) as only a function of \( p_i \) and \( p_{i+1} \) but not \( p_{i-1} \).

Let \( \overline{c} = \frac{1}{V} \sum_{i=1}^{V} c_i \) denote the average cost. Let \( \overline{c}_A = \frac{V \overline{c} + \theta}{V + 1} \) denote the adjusted average cost, which is the average of the costs and \( \theta \). Positive demand requires that \( p_i < p_{i+1} \) for all products. A sufficient condition for \( p_i < p_{i+1} \) is that no cost exceeds the adjusted average cost, which we call the regularity condition. Regularity requires:
\[ c_j < \pi_A \quad \text{for} \quad j = 1, 2, \ldots, V \]  

(3)

Define \( c_0 = 0 \). Maximizing retailer profits, that is, \( \pi = \sum_{i=1}^{V} (p_i)D_i - F \), with respect to variant prices yields Proposition 2. Proposition 2 generalizes Proposition 1 to multiple variants.

4.1. Proposition 2: characteristics of the optimal solution

When the demand functions for a product line are BW asymmetric (Eq. (2)) and regularity holds (Eq. (3)), then:

a. The optimal price for variant \( A_i \) (\( i = 1, 2, \ldots, V \)) increases with the cost of higher-quality variants and decreases with the cost of the lower-quality variants. More precisely, 
\[
p_i^* = \sum_{k=0}^{i-1} (\pi_A - c_k).
\]
b. The optimal margin for variant \( A_i \) increases with the cost of higher-quality variants and decreases with both the costs of the lower-quality variants and variant \( A_i \). More precisely, 
\[
m_i^* = \sum_{k=0}^{i-1} (\pi_A - c_k).
\]
c. The optimal price range for the line decreases with the cost of every variant in the line except the highest-quality variant. More precisely, 
\[
p_V - p_{V+1}^* = \theta - 2\pi_A + c_V.
\]
d. The average optimal price for the line: (1) increases with the cost of a variant, \( A_i \), if 
\[ i > \frac{V}{2} \]  
and (2) decreases with the cost of a variant, \( A_i \), if 
\[ i < \frac{V}{2} \]. More precisely, 
\[
\frac{1}{V} \sum_{i=1}^{V} p_i^* = \frac{1}{2} \theta + \sum_{i=1}^{V} \left( \frac{i}{V} - \frac{1}{2} \right) c_i.
\]
e. The optimal price of any variant increases with its cost, the price of the adjacent higher-quality variant, and the margin of the adjacent lower-quality variant. More precisely, 
\[
p_i^* = \frac{p_{i+1}^* + c_i + m_{i-1}^*}{2}, \]  
where \( m_0 = c_0 \) and \( p_{V+1} = \theta \).

4.1.1. Proof

Setting the derivative, with respect to \( p_i \), of 
\[
\sum_{i=1}^{V} (p_i - c_i)(M(p_{i+1} - p_i)) - F = 0
\]  
equal to zero yields 
\[
p_{i-1} - c_{i-1} + p_{i+1} - 2p_i + c_i = 0 \quad \text{where} \quad p_0 = c_0 = 0 \quad \text{and} \quad p_{V+1} = \theta.
\]
Solving that system of equations, for \( i = 1, 2, \ldots, k, \ldots, V \), yields optimal prices 
\[
p_i^* = \sum_{k=0}^{i-1} (\pi_A - c_k).
\]
It follows that optimal margins are 
\[
m_i^* = p_i^* - c_i = \sum_{k=0}^{i-1} (\pi_A - c_k) - c_i.
\]
Direct substitution yields 
\[
p_V^* - p_1^* = \sum_{k=0}^{V-1} (\pi_A - c_k)\quad \pi_A = \theta - 2\pi_A + c_V.
\]
The average line price becomes 
\[
\frac{1}{V} \sum_{i=1}^{V} p_i^* = \frac{1}{V} \sum_{i=1}^{V} \sum_{k=0}^{i-1} (\pi_A - c_k) = \frac{1}{2} \theta + \sum_{i=1}^{V} \left( \frac{i}{V} - \frac{1}{2} \right) c_i.
\]
Finally,
rearranging $p_{i-1}^* - c_{i-1} + \frac{p_{i+1}^*}{2} = \frac{p_{i+1}^* + c_i + p_{i-1}^* - c_{i-1}}{2} = p_{i+1}^* + c_i + m_{i-1}^*$. Q.E.D.

From the results in Proposition 2, we can address the questions raised in the introduction. For example, when $V = 5$, then, $\bar{c}_A = \frac{\theta + c_1 + c_2 + c_3 + c_4 + c_5}{6}$, $p_1 = \bar{c}_A$, $p_2 = 2\bar{c}_A - c_1$, $p_3 = 3\bar{c}_A - c_1 - c_2$, $p_4 = 4\bar{c}_A - c_1 - c_2 - c_3$, and $p_5 = 5\bar{c}_A - c_1 - c_2 - c_3 - c_4$.

From these price expressions, we can see that as $c_1$ decreases, the optimal price of $A_4$, for example, increases because $p_4 = 4\bar{c}_A - c_1 - c_2 - c_3 = \frac{2(c_4 + c_5)}{3} - \frac{c_1 + c_2 - c_3}{3} + \frac{2\theta}{3}$. Next, suppose the cost of $A_5$ increases. Then, $\bar{c}_A$ increases, raising the prices of $A_1$, $A_2$, $A_3$, $A_4$ and $A_5$. Finally, suppose there is a proportional increase in costs. For example, if the cost of every variant doubles, then all prices do not necessarily change in the same direction. $A_1$’s price goes up, but $A_4$’s price decreases when $2(c_4 + c_5) < 3(c_1 + c_2 + c_3)$.

It is also worth noting that at optimality, Proposition 2 implies that the demand for the entire line is $D_{total} = M(\theta - \bar{c}_A)$. So as the adjusted average cost increases, optimal sales decrease.

In general, as the average cost of all variants of higher quality than $i$ increases, the price of variant $i$ also increases. If we substitute higher quality variants for lower quality variants, holding constant the number of variants, the price of variant $i$ increases. By varying the average quality, that is, changing all costs by some factor $r$, many useful implications can be obtained. See Table 2. Note, for example, the table shows the impact of a variant’s cost increase.

Note also that Proposition 2 implies $m_{i+1}^* > m_i^*$ because $\bar{c}_A > c_{i+1}$. Hence, in our model, unit profit margins increase as products increase in quality in the line. This finding is consistent with general retail practice because variants with either higher quality or more features have a greater carrying cost requiring them to contribute more money per unit to the retailer (see e.g., Levy and Weitz, 1995).

Thus far we held $V$ constant. Now consider removing variant $A_i$ from the line. Then, $\bar{c}_A$ changes by $\frac{\sum_{i=1}^V c_i + \theta - c_s}{V} = \frac{\sum_{i=1}^V c_i + \theta - (V + 1)c_s}{V(V + 1)}$, which is positive because of the regularity condition. Hence, removing a variant always increases the adjusted average cost. For variant $A_i$, $p_i^* = \sum_{k=0}^{i-1} (\bar{c}_A - c_k)$; so the removal of a higher quality variant increases $\bar{c}_A$ and, therefore, increases $p_i^*$. The removal of a lower quality variant has the opposite effect. Table 3 summaries the implications of Proposition 2 for assortment changes.

Table 3 shows that, for example, if variants at the bottom of the line are discontinued, the price of lowest-quality variant increases, the highest-quality variant’s price decreases, the lowest-quality margin increases, the highest-quality margins decrease and the range of prices in the line decreases. The opposite occurs with the removal of a high-quality variant.

The intuition behind this result is straightforward. Product lines perform two functions that single products cannot. The first is price discrimination. When higher priced variants serve
relatively price-insensitive customers, the lower priced variants can serve the relatively price-sensitive customers. Second, by offering a greater breadth of variants (along with a range of prices), product lines function to serve more customers. Removing variants from the line diminishes the line’s ability to perform each function.

Eliminating a variant decreases both the ability to price discriminate and the range of prices, that is, \( p_V - p_1 \). Removing any variant from the line decreases the optimal prices of variants of higher quality than the removed variant; this facilitates the trading-up of former buyers of the removed variant to the higher quality (i.e., margin) variants. Simultaneously, the optimal prices of the lower quality variants increase to take advantage of the less price-sensitive former buyers of the removed variant. Consequently, the optimal price of the

<p>| Table 2 |</p>
<table>
<thead>
<tr>
<th>Impact of Cost Change on Product-Line Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variable</strong></td>
</tr>
<tr>
<td>( p_1^* = \frac{\theta + Vc}{V+1} )</td>
</tr>
<tr>
<td>( p_V^* = \theta - \tilde{c}_A + c_V )</td>
</tr>
<tr>
<td>( m_1^* = \tilde{c}_A - c_1 )</td>
</tr>
<tr>
<td>( m_V^* = \theta - \tilde{c}_A )</td>
</tr>
<tr>
<td>( p_V^* - p_1^* = \theta - 2\tilde{c}_A + c_V )</td>
</tr>
<tr>
<td>( \tilde{p}^* = \frac{1}{2} \theta + \frac{1}{2} \sum_{i=1}^{V} \left( \frac{i}{V} - \frac{1}{2} \right) c_i )</td>
</tr>
</tbody>
</table>

<p>| Table 3 |
| Impact of Assortment on Optimal Product-Line Prices |</p>
<table>
<thead>
<tr>
<th><strong>Variable</strong></th>
<th><strong>Before Removal of ( A_s )</strong></th>
<th><strong>After Removal of Variant ( A_s )</strong></th>
<th><strong>Impact of Removal</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowest-quality Price</td>
<td>( p_1^* = \frac{\theta + Vc}{V+1} )</td>
<td>( p_1^* = \frac{\theta + Vc - c_s}{V} )</td>
<td>Increases</td>
</tr>
<tr>
<td>Highest-quality Price</td>
<td>( p_V^* = \theta - p_1^* + c_V )</td>
<td>( p_V^* = \theta - p_1^* + c_V )</td>
<td>Decreases</td>
</tr>
<tr>
<td>Lowest-quality Margin</td>
<td>( m_1^* = p_1^* - c_1 )</td>
<td>( m_1^* = p_1^* - c_1 )</td>
<td>Increases</td>
</tr>
<tr>
<td>Highest-quality Margin</td>
<td>( m_V^* = \theta - p_1^* )</td>
<td>( m_V^* = \theta - p_1^* )</td>
<td>Decreases</td>
</tr>
<tr>
<td>Price Range of Line</td>
<td>( p_V^* - p_1^* = \theta - 2p_1^* + c_V )</td>
<td>( p_V^* - p_1^* = \theta - 2p_1^* + c_V )</td>
<td>Decreases</td>
</tr>
</tbody>
</table>
lowest-quality variant increases. This results in a smaller price range for the line. Overall, then, the line ends up serving fewer customers than before.

Next, from proposition 2(e), we know\[ p_i = \frac{p_{i+1} + m_{i-1} + c_i}{2}. \]
This formula provides the optimal price of variant \( A_i \) as a function of the optimal price and margins of the immediately adjacent variants. This equation allows prediction of the relative price of a variant across assortments. For example, consider two assortments, \( a \) and \( b \), with at least two common variants, \( A_i \), \( A_i+1 \), where \( a = \{ A_i, A_i+1, \ldots \} \) and \( b = \{ A_i-1, A_i, A_i+1, \ldots \} \), with prices \( p_i^a \), \( p_{i+1}^a \) and \( p_i^b \), \( p_{i+1}^b \). When we observe that \( p_i^b > p_i^a \) and \( m_{i-1}^b < m_{i-1}^a \), then proposition 2 implies that \( p_i^b > p_i^a \) because \( c_{i-2}^b < c_{i-1}^a \), regardless of what other variants are present in either assortment. Similarly, when we observe that \( p_i^a > p_i^b \) and \( m_{i-1}^a < m_{i-1}^b \), then proposition 2 implies \( p_i^a > p_i^b \). Extending this argument yields Table 4.

In stable product lines, where cost and assortment changes are infrequent, retailer experimentation should produce optimal prices consistent with Table 4. That consistency provides a testable implication for our demand model. Our empirical section shows such consistency by comparing line prices across retailers with different assortments. It follows that it will be much more difficult to test the model implications in categories that experience sudden changes.

### 5. Empirical analysis

Although prior empirical work provides evidence of asymmetric line competition that evidence is often limited to frequently purchased consumer nondurables. This section provides evidence that current retail pricing is consistent with asymmetric demand in very stable durable goods categories. Unlike categories with sudden and, perhaps, precipitous technological advances, we expect that prolonged experimentation would effectuate optimal prices in stable categories such as irons and coffee makers.

When a line faces asymmetric line competition, the prior section derived the direction of price adjustments given addition or removal of variants from the line. We can also use those derivations to predict how prices should vary across retail lines because line differences are

---

**Table 4**

<table>
<thead>
<tr>
<th>Result</th>
<th>The Two Assortments</th>
<th>Price in Assortment ( \alpha ) Relationship</th>
<th>Price in Assortment ( \beta )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>( \alpha = { A_i, A_i+1, \ldots } )</td>
<td>If: ( p_{i+1} ) &gt; ( p_i )</td>
<td>( p_i )</td>
</tr>
<tr>
<td></td>
<td>( \beta = { A_i, A_i+1, \ldots } )</td>
<td>Then: ( p_i ) &gt; ( p_{i+1} )</td>
<td>( p_i )</td>
</tr>
<tr>
<td>2</td>
<td>( \alpha = { \ldots, A_i-1, A_i, A_i+1, \ldots } )</td>
<td>If: ( p_{i+1} ) &gt; ( p_i )</td>
<td>( p_i )</td>
</tr>
<tr>
<td></td>
<td>( \beta = { \ldots, A_i-1, A_i, A_i+1, \ldots } )</td>
<td>And: ( m_{i-1} ) &gt; ( m_i )</td>
<td>( m_{i-1} )</td>
</tr>
<tr>
<td>3</td>
<td>( \alpha = { \ldots, A_i-1, A_i, A_i+1, \ldots }, i \geq 1 )</td>
<td>If: ( p_{i+1} ) &gt; ( p_i )</td>
<td>( p_i )</td>
</tr>
<tr>
<td></td>
<td>( \beta = { \ldots, A_i-2, A_i, A_i+1, \ldots }, s \geq 1 )</td>
<td>And: ( m_{i-1} ) &gt; ( m_i )</td>
<td>( m_{i-1} )</td>
</tr>
<tr>
<td></td>
<td>Then: ( p_i ) &gt; ( p_{i+1} )</td>
<td>( p_i )</td>
<td></td>
</tr>
</tbody>
</table>

---

equivalent to additions and removals of variants. When retail prices are optimal in stable product lines, we expect prices to vary across lines as predicted by asymmetric line competition. Comparing the prices of retailers carrying different product lines, and assuming that these prices are optimal, we can check the consistency of these prices with our predictions. Using data from three different retailers, this section's goal is to determine whether the prices of such common variants are consistent with those predicted by asymmetric line competition.

We use proposition 2 to make predictions. For example, suppose we list all possible variants at all stores in order of quality to obtain the set \{A_1, A_2, A_3, \ldots, A_k, A_V\}. Then a line with variants \{A_1, A_3\} should have a higher price for \(A_1\) than a line with variants \{A_1, A_2\} because \(c_3\) is higher in the first line. A line with variants \{A_3, A_5, A_7\} and prices \{p_3, p_5, p_7\} should have a higher \(p_5\) than a line with variants \{A_4, A_5, A_6\} and prices \{p_4, p_5, p_6\} when \(p_3 + p_6\) in the first line is greater than \(p_4 + p_7\) in the second line because \(p_3 + p_7 + c_5 - c_3 > p_4 + p_6 + c_5 - c_4\), as indicated by proposition 2(e). In general, given two lines with some common variants, we can often predict the price of the next highest-quality variant from the immediately adjacent prices and qualities.

Tables 5, 6, 7 and 8 provide actual prices for three retailers: Service Merchandise, W. Bell & Co., and McDade & Company, for two product categories, coffee makers and irons. We denote the lines at the three retailers as \{a, b, d\}, respectively. Using suggested retail prices and manufacturer product descriptions, the tables order the variants from the lowest quality to highest quality. Hence, \(A_1 = \) the Hamilton Beach Mini-Drip, \(A_2 = \) Hamilton Beach 784, \(A_3 = \) Proctor Silex Auto Drip Beverage and so on.

The lowest-quality coffee maker at Service Merchandise and Bell is \(A_1\) and the lowest quality coffee maker at McDade is \(A_2\). Let \(p^k_{A_j}\) denote the price of variant \(A_j\) at retailer \(k\). The prices for the lowest-quality variants are \(p_{A_1}^a = \$14.83\), \(p_{A_1}^b = \$14.83\) and \(p_{A_2}^d = \$14.98\). These prices are for the Hamilton Beach Mini-Drip at Service Merchandise, the Hamilton Beach Mini-Drip at Bell and Hamilton Beach 784 at McDade.

The model can determine the relative prices for some of the common variants. Consider \(A_3\), for example, the Proctor Silex Auto Drip. All three retailers carry it. Using the formula

\[
p_i^* = \frac{p_{i+1}^* + p_{i-1}^* + c_i^* - c_{i-1}^*}{2} \quad \text{(see proposition 2e)},
\]

the prices at each respective retailer are \(p_{A_3}^a = \frac{22.97 + 14.83 + c_3 - c_1}{2} = \frac{21.90 + 13.90 + c_3 - c_1}{2}\) and \(p_{A_3}^d = \frac{19.98 + 14.98 + c_3 - c_2}{2}\), respectively. Given that \(c_2 > c_1\), the model implies \(p_{A_3}^a > p_{A_3}^b > p_{A_3}^d\). Table 5 reveals that at \(p_{A_3}^b = \$19.97\), \(p_{A_3}^a = \$19.90\) and \(p_{A_3}^d = \$18.99\), respectively, which is consistent with the model.

Before proceeding, we note three assumptions used in our empirical analysis. First, as shown in this example, we sometimes must assume a cost ordering (e.g., \(c_2 > c_1\)). Given the limited overlap between the lines at the three retailers, a cost ordering based on suggested retail prices and features allows additional testing. That ordering increases the number of cases predicted by our theory. In this example, we can predict \(p_{A_3}^b > p_{A_3}^d\) and \(p_{A_3}^a > p_{A_3}^d\) in addition to \(p_{A_3}^a > p_{A_3}^b\).
Second, the three retailers we studied were discount showrooms. Each had multiple outlets in similar markets and each outlet provided an almost identical environment and range of product categories. Since the outlets share similar characteristics, we assume that each retail outlet faces a similar demand function (i.e., similar first derivatives with respect to prices). This seems reasonable given a similar positioning for the outlets, similar site selections and the similar demographics of customers. We also assume that each outlet has similar variable costs, since by law, manufacturers must offer variants at the same cost.

The third assumption is that each of the three retailers in our study enjoys a reasonable degree of monopoly power. This allows us to empirically evaluate the theoretical work of the previous sections (recall that Proposition 2 was derived in the context of a single retailer). In addition to facilitating our empirical analysis, this assumption can be justified on at least three other reasons.

First, each retailer typically enjoys some degree of monopoly power due to a variety of reasons including location and store loyalty (Oliver, Rust and Varki 1997, Rust, Zahorik and Keiningham 1995). In addition, several empirical studies (Slade 1995; Walters and MacKenzie 1988; Sawyer and Dickson 1990) provide evidence of retail monopoly power. For example, Slade interviewed store managers who reported that over 90% of households do not engage in comparison shopping across stores to seek out the

---

**Table 5**

**Coffee-Maker Prices**

<table>
<thead>
<tr>
<th>Number</th>
<th>Variant</th>
<th>Service Merchandise (α)</th>
<th>Bell (β)</th>
<th>McDade (δ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hamilton Beach Mini-Drip</td>
<td>14.83</td>
<td>13.90</td>
<td>*</td>
</tr>
<tr>
<td>2</td>
<td>Hamilton Beach 784</td>
<td>*</td>
<td>*</td>
<td>14.98</td>
</tr>
<tr>
<td>3</td>
<td>Proctor Silex Auto Drip Beverage</td>
<td>19.97</td>
<td>19.90</td>
<td>18.99</td>
</tr>
<tr>
<td>4</td>
<td>Hamilton Beach 791</td>
<td>*</td>
<td>*</td>
<td>19.98</td>
</tr>
<tr>
<td>5</td>
<td>Norelco HB 5123</td>
<td>*</td>
<td>*</td>
<td>19.99</td>
</tr>
<tr>
<td>6</td>
<td>Mr. Coffee CM-12</td>
<td>*</td>
<td>*</td>
<td>22.97</td>
</tr>
<tr>
<td>7</td>
<td>Norelco Dial-Brew II HB 5185</td>
<td>22.97</td>
<td>*</td>
<td>22.99</td>
</tr>
<tr>
<td>8</td>
<td>Mr. Coffee CMX-500</td>
<td>27.86</td>
<td>21.90</td>
<td>*</td>
</tr>
<tr>
<td>9</td>
<td>GE Coffematic Compact 260</td>
<td>*</td>
<td>27.90</td>
<td>*</td>
</tr>
<tr>
<td>10</td>
<td>GE DCM 14</td>
<td>29.97</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>11</td>
<td>Mr. Coffee-saver</td>
<td>*</td>
<td>33.50</td>
<td>*</td>
</tr>
<tr>
<td>12</td>
<td>Norelco Deluxe Dial-a-Brew 5193</td>
<td>29.97</td>
<td>33.90</td>
<td>29.96</td>
</tr>
<tr>
<td>13</td>
<td>GE Coffematic 10 Cup w/starter</td>
<td>*</td>
<td>35.90</td>
<td>*</td>
</tr>
<tr>
<td>14</td>
<td>Mr. Coffee with Saver</td>
<td>29.97</td>
<td>*</td>
<td>34.96</td>
</tr>
<tr>
<td>15</td>
<td>Proctor Silex 12 Cup Digital A510</td>
<td>39.96</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>16</td>
<td>GE DCM 15</td>
<td>36.97</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>17</td>
<td>Bunn Pour-o-matic</td>
<td>43.97</td>
<td>41.90</td>
<td>42.9</td>
</tr>
<tr>
<td>18</td>
<td>Mr. Coffee, CMX-1000</td>
<td>44.83</td>
<td>*</td>
<td>43.97</td>
</tr>
<tr>
<td>19</td>
<td>GE Digital Brew Starter DCM-50</td>
<td>44.97</td>
<td>42.85</td>
<td>44.89</td>
</tr>
<tr>
<td>20</td>
<td>Mr. Coffee Digital Automatic</td>
<td>*</td>
<td>44.90</td>
<td>*</td>
</tr>
<tr>
<td>21</td>
<td>GE Brew Starter II</td>
<td>*</td>
<td>*</td>
<td>48.98</td>
</tr>
<tr>
<td>22</td>
<td>Mr. Coffee Royal Service</td>
<td>49.83</td>
<td>49.90</td>
<td>*</td>
</tr>
<tr>
<td>23</td>
<td>West Bend Executive</td>
<td>*</td>
<td>57.90</td>
<td>*</td>
</tr>
<tr>
<td>24</td>
<td>Braum Coffee-maker Contemporary</td>
<td>*</td>
<td>69.50</td>
<td>*</td>
</tr>
</tbody>
</table>

* = variant not carried by retailer
lowest priced variant. Such shopping behavior is also consistent with the studies conducted by Walters and MacKenzie and Sawyer and Dickson referenced above.

Next, even if the market structure at the retail level is that of an oligopoly, there can be tacit collusion among the competitors. Such collusion allows each retailer to adopt a common product line strategy to local markets, with the exception of the number and type of variants in the line. This is consistent with Bergen, Dutta and Shugan (1996) who show that if different retailers carry different variants, then a greater amount of surplus can be extracted from consumers.

Finally, suppose, in contrast to our assumption, there is noncollusive competition between stores. Such competition usually drives prices down to costs (e.g., McAfee and McMillan 1996). Essentially, as competition increases, each variant’s price becomes more independent of other prices in the line. This causes the predictions of Proposition 2 to be false. Now consider the following null and alternative hypotheses: “H₀: Assortment has no effect on prices; and, H₁: Assortment has an effect on prices as dictated by our theory.” Clearly, the assumption of monopoly power is very conservative since it strengthens the null hypothesis and works against our ability to predict. In other words, given some relationship between prices and assortment, the assumption of monopoly is a harder null hypothesis to reject than the assumption of competition.

Keeping these issues in mind, we now use the pricing data to check the consistency of the model with the data for coffee makers and irons, shown in Tables 5 and 7, respectively. The results for coffee makers and irons data are reported in Tables 6 and 8, respectively. The comparisons reveal that for the hand irons data, our predictions are consistent with observed prices in seven of the nine possible unambiguous comparisons. For the coffee-maker data, our predictions are consistent in eleven of the twelve possible unambiguous comparisons. Overall, our model shows good conformity with existing retailer pricing practices and consistency with pricing under asymmetric line competition.

Table 6
Comparisons For The Coffee Makers Data

<table>
<thead>
<tr>
<th>Number</th>
<th>Variant</th>
<th>Stores</th>
<th>Prediction</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hamilton Beach Mini-Drip</td>
<td>Service Merch./Bell</td>
<td>Higher</td>
<td>Higher</td>
</tr>
<tr>
<td>2</td>
<td>Proctor Silex Auto Drip</td>
<td>Service Merch./Bell</td>
<td>Higher</td>
<td>Higher</td>
</tr>
<tr>
<td>3</td>
<td>Norelco Dial-Brew II HB 5185</td>
<td>McDade/Service Merch</td>
<td>Higher</td>
<td>Higher</td>
</tr>
<tr>
<td>4</td>
<td>Norelco Deluxe Dial-a-Brew 5193</td>
<td>Service Merch./Bell</td>
<td>Lower</td>
<td>Lower</td>
</tr>
<tr>
<td>5</td>
<td>Norelco Deluxe Dial-a-Brew 5193</td>
<td>Bell/McDade</td>
<td>Higher</td>
<td>Higher</td>
</tr>
<tr>
<td>6</td>
<td>Bunn Pour-o-matic</td>
<td>Service Merch./Bell</td>
<td>Higher</td>
<td>Higher</td>
</tr>
<tr>
<td>7</td>
<td>Bunn Pour-o-matic</td>
<td>McDade/Service Merch</td>
<td>Lower</td>
<td>Lower</td>
</tr>
<tr>
<td>8</td>
<td>Mr. Coffee, CMX-1000</td>
<td>McDade/Service Merch.</td>
<td>Lower</td>
<td>Lower</td>
</tr>
<tr>
<td>9</td>
<td>GE Digital Brew Starter DCM-50</td>
<td>Service Merch./Bell</td>
<td>Higher</td>
<td>Higher</td>
</tr>
<tr>
<td>10</td>
<td>GE Digital Brew Starter DCM-50</td>
<td>Bell/McDade</td>
<td>Lower</td>
<td>Lower</td>
</tr>
<tr>
<td>11</td>
<td>GE Digital Brew Starter DCM-50</td>
<td>McDade/Service Merch.</td>
<td>Lower</td>
<td>Lower</td>
</tr>
<tr>
<td>12</td>
<td>Mr. Coffee Royal Service</td>
<td>Service Merch./Bell</td>
<td>Higher</td>
<td>Lower</td>
</tr>
</tbody>
</table>
### Table 7
Iron Prices

<table>
<thead>
<tr>
<th>Number</th>
<th>Variant</th>
<th>Service Merchandise (α)</th>
<th>Bell (β)</th>
<th>McDade (δ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Osrow World Traveler</td>
<td>*</td>
<td>*</td>
<td>12.9</td>
</tr>
<tr>
<td>2</td>
<td>Seamstress II Steam Iron</td>
<td>13.94</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>3</td>
<td>GE Light 'N Easy Steam &amp; Dry Iron</td>
<td>14.9</td>
<td>14.92</td>
<td>14.75</td>
</tr>
<tr>
<td>4</td>
<td>GE Light 'N Easy Compact Steam &amp; Dry Iron</td>
<td>*</td>
<td>15.96</td>
<td>*</td>
</tr>
<tr>
<td>5</td>
<td>GE Light 'N Easy Steam Iron</td>
<td>15.9</td>
<td>16.83</td>
<td>*</td>
</tr>
<tr>
<td>6</td>
<td>Osrow Touch-Up</td>
<td>*</td>
<td>*</td>
<td>17.75</td>
</tr>
<tr>
<td>7</td>
<td>GE Spray/Steam/Dry Iron</td>
<td>17.97</td>
<td>*</td>
<td>18.75</td>
</tr>
<tr>
<td>8</td>
<td>GE Light 'N Easy Spray/Steam/Dry Iron</td>
<td>18.9</td>
<td>17.96</td>
<td>*</td>
</tr>
<tr>
<td>9</td>
<td>Proctor-Silex Spray/Steam/Dry Iron</td>
<td>19.86</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>10</td>
<td>GE Light 'N Easy Surge of Steam, Steam &amp; Dry Iron</td>
<td>22.9</td>
<td>18.82</td>
<td>*</td>
</tr>
<tr>
<td>11</td>
<td>Hamilton Beach Full Size Lightweight Iron</td>
<td>*</td>
<td>18.97</td>
<td>*</td>
</tr>
<tr>
<td>12</td>
<td>GE Instant Spray Non-Stick Iron</td>
<td>*</td>
<td>*</td>
<td>21.9</td>
</tr>
<tr>
<td>13</td>
<td>GE Light 'N Easy Full Size Spray/Steam &amp; Dry Iron</td>
<td>*</td>
<td>22.97</td>
<td>21.9</td>
</tr>
<tr>
<td>14</td>
<td>GE Self-Clean II Iron</td>
<td>*</td>
<td>26.97</td>
<td>*</td>
</tr>
<tr>
<td>15</td>
<td>Hamilton Beach Self-Cleaning Burst of Steam Iron</td>
<td>27.96</td>
<td>*</td>
<td>26.9</td>
</tr>
<tr>
<td>16</td>
<td>GE Travel Iron</td>
<td>*</td>
<td>*</td>
<td>27.9</td>
</tr>
<tr>
<td>17</td>
<td>GE Light 'N Easy Instant Spray, Steam &amp; Dry Iron</td>
<td>*</td>
<td>*</td>
<td>28.8</td>
</tr>
<tr>
<td>18</td>
<td>Sunbeam Comfort Iron I</td>
<td>29.9</td>
<td>29.82</td>
<td>*</td>
</tr>
<tr>
<td>19</td>
<td>Sunbeam Deluxe Self-Cleaning Shot of Steam Iron</td>
<td>*</td>
<td>29.92</td>
<td>29.9</td>
</tr>
<tr>
<td>20</td>
<td>GE Light 'N Easy Self-Clean II Iron</td>
<td>29.96</td>
<td>29.97</td>
<td>*</td>
</tr>
<tr>
<td>21</td>
<td>Sunbeam Self-Cleaning Shot of Steam Iron</td>
<td>34.9</td>
<td>34.86</td>
<td>32.5</td>
</tr>
</tbody>
</table>

* = variant not carried by retailer

### Table 8
Price Comparison For The Irons Data

<table>
<thead>
<tr>
<th>Number</th>
<th>Variant</th>
<th>Service Merchandise (α)</th>
<th>Bell</th>
<th>Prediction</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GE Light 'N Easy Steam &amp; Dry Iron</td>
<td>14.92</td>
<td>14.75</td>
<td>Lower</td>
<td>Higher</td>
</tr>
<tr>
<td>2</td>
<td>GE Light 'N Easy Steam Iron</td>
<td>15.9</td>
<td>16.83</td>
<td>Lower</td>
<td>Lower</td>
</tr>
<tr>
<td>3</td>
<td>GE Spray/Steam/Dry Iron</td>
<td>17.97</td>
<td>18.75</td>
<td>Lower</td>
<td>Lower</td>
</tr>
<tr>
<td>4</td>
<td>GE Light 'N Easy Spray/Steam/Dry Iron</td>
<td>18.9</td>
<td>17.96</td>
<td>Higher</td>
<td>Higher</td>
</tr>
<tr>
<td>5</td>
<td>GE Light 'N Easy Surge of Steam, Steam and Dry Iron</td>
<td>22.9</td>
<td>18.82</td>
<td>Higher</td>
<td>Higher</td>
</tr>
<tr>
<td>6</td>
<td>Sunbeam Comfort Iron I</td>
<td>29.9</td>
<td>29.82</td>
<td>Higher</td>
<td>Higher</td>
</tr>
<tr>
<td>7</td>
<td>Sunbeam Self-Cleaning Shot of Steam Iron</td>
<td>34.9</td>
<td>34.86</td>
<td>Equal</td>
<td>Higher</td>
</tr>
<tr>
<td>8</td>
<td>Sunbeam Self-Cleaning Shot of Steam Iron</td>
<td>34.9</td>
<td>32.5</td>
<td>Higher</td>
<td>Higher</td>
</tr>
<tr>
<td>9</td>
<td>Sunbeam Self-Cleaning Shot of Steam Iron</td>
<td>34.86</td>
<td>32.5</td>
<td>Higher</td>
<td>Higher</td>
</tr>
</tbody>
</table>
6. Conclusions

Our objective was to provide some general guidelines or pricing strategies for retailers who carry lines of product variants that vary in quality and face component cost shocks. We asked three key questions. First, when the cost of specific product components or ingredients changes, how should retailers readjust the prices of the affected product lines? Second, what will be the impact on profit margins, the range of prices in the line and the average price in the line? Finally, if a product is removed, perhaps suddenly, from the line, how should the retailer adjust the other prices in the line?

We answered these questions for four scenarios: (1) a low-quality variant’s cost changes, (2) a high-quality variant’s cost changes, (3) all variants incur a cost change by some percentage, and (4) a variant is removed from the line. Our analysis revealed how retailers should adjust the prices of all the variants in product lines when costs or lines vary in composition. This information may help retailers more quickly adjust product line prices given a necessary change in the costs.

Table 9 highlights our findings using the first and last product (i.e., highest-quality and lowest-quality products) in the line as an example. The table shows the optimal reaction to four different events, represented by the last four columns in the table. Column (A) represents the optimal reaction to a cost decline in a lower-quality lowest-quality variant in the line: the optimal reaction is to decrease the price of the lowest-quality variant but increase the price of the highest-quality variant. Although prices vary in opposite directions, the margins of both prices increase because the price decrease is less than the cost decrease. Moreover, the price range of the line (i.e., the highest price minus the lowest price) increases. The average of all prices in the line also increases.

Column (B) represents the optimal reaction to a cost decrease in a higher-quality product or the highest-quality product. Column (C) represents the optimal reaction to a proportional cost decrease in all variants in the line. Finally, column (D) represents the reactions to addition/removal of a product from the line.

More generally, when the cost of a variant reflects its quality, we derived the following implications:
• When a variant’s cost decreases, the prices of all lower-quality variants should be decreased.
• When a variant’s cost decreases, the profit margins for lower-quality variants should be decreased.
• When a variant’s cost decreases, the prices of all higher-quality variants should be increased.
• When a variant’s cost decreases, the profit margins for higher-quality variants should be increased.
• When the cost of any variant (except the highest-quality variant) increases, the range of prices in the line should decrease.
• When removing a variant from the line, the lower quality variant prices should be increased.
• When removing a variant from the line, the higher quality variant prices should be decreased.
• When removing a variant from the line, the range of prices in the line should be decreased.

Beyond the implications for pricing strategies, these findings should impact other activities such as promotions and selling efforts because retailers should often allocate more selling efforts to variants with increased margins. As the literature suggests (e.g., Lal and Villas-Boas 1998), margins and price ranges impact a variety of marketing decisions including the allocation of marketing effort. Hence, by prescribing how margins should change, our analysis also prescribes how retailers should reallocate effort. Generally, for example, retailers should allocate more selling and advertising effort to higher margin variants. Therefore, when declining costs have a disproportionate impact on low-quality products, retailer promotions should emphasize the entire line. However, when those cost declines have a disproportionate impact on the high-quality products, retailer promotions should shift emphasis to only the high-quality products.

We explained the intuition underlying our findings with two conflicting effects, the “substitution” and “margin” effect. When a variant’s cost decreases, the substitution effect causes buyers to switch from other variants. This decreases the demand of other variants, which tends to decrease their optimal price. The margin effect, in contrast, tends to increase the per unit profit of the variant with the decreased cost. The higher margin tends to increase the optimal price of the other variants because it becomes desirable to switch buyers to the now higher margin variant. The two effects are exactly equal with a symmetric linear demand function. With an asymmetric demand function, in contrast, the effects do not cancel. The dominant effect depends on whether the cost change is associated with a higher or lower quality variant.

We emphasize that our findings depend on how well our model approximates actual markets and the general applicability of asymmetric line competition. We relied, for example, on both our own and prior empirical work that supports the finding of asymmetric line competition. Future empirical research, of course, must continue to address this issue. Future research should also devote some attention to the pricing implications for a line of services.
Given the unique characteristics of services (see e.g., Desiraju and Shugan 1999), we anticipate additional strategic considerations to arise in that context.

Although our model provides interesting implications, it is only a beginning for developing pricing strategies for product lines. Our analysis focused on recent finding on asymmetric competition and in our model, we only determined the impact of costs and line-composition (i.e., product addition/removal) on the prices of other products in the line. By isolating the effects of line-composition, we hope to have provided some important guidance for pricing decisions. Future research should consider the effect of competition, the effect of dynamics, the effect of various distributions of consumer reservation prices and product lines varying both on quality and variety. All of these factors are important, but considering them simultaneously is beyond the scope of this research.

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References


