
10 Product line pricing

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Abstract

A firm in modern economy is more likely to sell a line of products than a single product. Product line pricing is a challenging marketing mix decision as products in a line demonstrate complicated demand and cost interdependence. In the last three decades researchers from different disciplines have made significant progress in addressing various issues relating to the topic of product line pricing. In this chapter, I discuss the literature on product line pricing with the focus on recent research development.

The discussion starts with a general framework of the product line pricing problem and a brief description of the decision support models for product line pricing. It is then followed with extensive discussions on the pricing of vertically differentiated product lines and the pricing of horizontally differentiated product lines respectively. Finally, I conclude the chapter with a discussion on future research directions.

1. Introduction

A firm in modern economy typically sells a line of products rather than a single product. For example, cars are offered with different powers, yogurts are offered with different flavors, online shopping is offered with different delivery options, and wireless phone service is offered with different plans. This chapter reviews the academic research on product line pricing. Its purpose is to provide a comprehensive discussion on the topic with both the experienced and new researchers as the intended audience. I shall focus on recent research development in this area. Good reviews on the early literature on this topic can be found in Rao (1984, 1993).

To be more precise about the scope of this review, I define a product line as a set of products or services sold by a firm that provide similar functionalities and serve similar needs and wants of customers. This definition sets the topic of product line pricing apart from the more general topic of multi-product pricing. For example, research on bundle pricing, razor-and-blade pricing, and loss-leader pricing in the context of retail assortment management is beyond the scope of this review according to the above definition of a product line.

In addition, to avoid the potential overlap with other chapters in this *Handbook*, I exclude the following topics from this review, even though they can be somewhat related to product line pricing: pricing multiple generations of products, pricing new products with the existence of used goods market, retailer's pricing of a category of products consisting of national and private brands, and quantity discounts. However, some overlap will still occur. This is often inevitable and even desirable because it can be beneficial to look at the same issue from different perspectives. For example, the pricing of different delivery options by an online retailer can be viewed as a problem of product line pricing but also a problem of pricing services if the service aspect is emphasized. Combining the views can provide marketing managers and researchers with more comprehensive understanding on this issue.

Because this chapter contributes to a handbook of pricing research, my discussion will

concentrate on the pricing issues conditional on the configurations of product lines. The optimal design of a product line is an important topic but it is beyond the scope of this review. Nevertheless, whenever applicable, I will try to base the discussion on the optimal or equilibrium configurations of product lines as shown in the literature.

The optimal pricing decision of a product line is critically dependent on the relations of the products in the line. In general, products in a line can be vertically differentiated, horizontally differentiated, or both. A product line is vertically differentiated if products in the line are differentiated along a dimension (product attribute) in which consumers have the same preference ranking on each level. That is, all consumers prefer to have more (or less) of the attribute. Such a dimension is typically interpreted as product quality in the literature (Moorthy, 1984; Mussa and Rosen, 1978). Examples of vertically differentiated product lines include iPods with different memory capacities and printers with different speeds. A product line is horizontally differentiated if the products in the line are differentiated along dimensions in which consumers have different preference rankings due to their taste differences. Examples of such product lines include ice creams with different flavors and clothes with different colors. In practice, it is common for a product line to be vertically differentiated along some dimensions but horizontally differentiated along others. For example, a line of automobiles may be vertically differentiated on gas-mileage but horizontally differentiated on colors. In this review, I classify previous studies based on their focus on vertically differentiated or horizontally differentiated product lines and discuss the pricing issues for these two types of product lines respectively in two sections. For papers applicable to both vertically differentiated and horizontally differentiated product lines, I discuss them in either section, depending on their emphasis and main contributions.

The objective of this chapter is to provide a comprehensive review of important research developments in product line pricing. However, due to space and knowledge limitations, this review is far from exhaustive. Readers who are interested in any specific topic of product line pricing research are encouraged to conduct more extensive literature search in that area.

The rest of the chapter is organized as follows. In the next section, I present a general framework for the product line pricing problem and briefly discuss the decision support models for product line pricing. I discuss the pricing of vertically differentiated product lines in Section 3 and horizontally differentiated product lines in Section 4. Finally, I conclude the chapter in Section 5 with a discussion on future research directions.

2. A general framework for product line pricing

Assume a firm sells a product line consisting of m products. The firm's optimal pricing problem can be formulated as

$$\text{Max}_{p_1, p_2, \dots, p_m} \pi = \sum_{i=1}^m \pi_i = \sum_{i=1}^m D_i(p_i, P_{-i}, P_c, X, X_c) p_i - \sum_{i=1}^m C_i(D_i, D_{-i}) \quad (10.1)$$

where

- π is the total profit of the product line,
- π_i is the profit of the i th product in the product line,
- D_i is the demand of the i th product,

D_{-i} is a vector of demand of the products other than the i th product in the line,
 p_i is the price of the i th product,
 P_{-i} is a vector of prices of the products other than the i th product in the line,
 P_c is a vector of prices of the products from competing firms,
 X is a vector of the firm's marketing mix variables other than prices on all products in the line,
 X_c is a vector of the marketing mix variables other than prices from competing firms, and
 C_i is the cost of selling D_i units of the i th product

Equation (10.1) reveals two significant differences in pricing a product line as compared to pricing a single product. The first difference comes from the demand interdependence of the products in a line. Unlike the demand in the single-product case, the demand of product i in a line is not only a function of its own price but also a function of the prices of the other products in a line. The second difference comes from the cost interdependence of the products in a line. On the one hand, the economies of scale may reduce the production cost of each product as the number of products in a line decreases. This is because a shorter product line leads to more sales for each product in the line. On the other hand, the economies of scope may lower the cost of each product when more products are added into the product line.

Generally, demand interdependence leads to the cannibalization effect. That is, lowering the price of one product steals the demand from the other products in the line. This is because products in a line are partial substitutes, by our definition of product line. However, under some circumstances, demand among the products in a line can be complementary even though they are substitutes in functionalities. For example, a low price for a product in the line may attract consumers to the line and they may end up buying other products in the line through the 'bait and switch' mechanism (Gerstner and Hess, 1990). As another example, setting a very low price to a product in a line may increase the sales of a high-priced product in the line due to the 'compromise effect', well documented in the consumer behavior literature (Kivetz et al., 2004; Simonson and Tversky, 1992).

The presence of demand and cost interdependence for products in a product line makes the optimal pricing decision a challenging one. There are two main difficulties. First, it is hard to come up with precise specifications of the demand and cost interdependence and estimate their parameters, especially when the number of products in a line is large. Second, it is hard to simultaneously solve for the optimal prices of all products given the complexity of demand and cost interdependence.

Researchers have proposed various mathematical programming and decision support models to obtain optimal prices based on the general framework given in equation (10.1) (Chen and Hausman, 2000; Dobson and Kalish, 1988, 1993; Little and Shapiro, 1980; Reibstein and Gatignon, 1984; Urban, 1969). Generally, the decision support models on product line pricing follow a three-step procedure. The first step is to specify the functional forms of demand and cost. The second step is to estimate parameters in the demand and cost functions. The data source can be sales records, conjoint analysis output and operation/production records. Finally, the third step is to solve the optimization problem mathematically. Given the challenging nature of the product line pricing problem,

typically a number of simplifying assumptions have to be imposed in the specifications of demand and cost functions, and heuristic algorithms have to be used in optimization. Some commonly adopted simplifying assumptions include (1) ignoring reactions from the competitors and (2) ignoring interactions between prices and other marketing mix variables. In addition, cost interdependence tends to be ignored or modeled in a less sophisticated fashion than demand interdependence in those models. The primary reason, as stated in Dobson and Kalish (1993, p. 171), is that '(t)he cost structure of a firm can in many cases be very complicated and hard to measure'.

Moreover, the optimization problem as formulated in equation (10.1) is itself a simplified version of the product line pricing problem in general. Two important considerations are ignored in equation (10.1). First, the unit price of each product is assumed to be independent from the number of units purchased. Thus the practice of nonlinear pricing is not taken into account. Second, equation (10.1) is a static model and the potential intertemporal demand and cost interdependence is ignored. If we extend equation (10.1) to consider the issues of nonlinear and dynamic pricing, more complicated decision support models will be required to provide heuristic solutions to the pricing problem.

Besides mathematical programming and decision support models, researchers have also developed various analytical models on product line pricing with stylized assumptions on demand and supply. While the purpose of the decision support models is to obtain optimal prices explicitly based on demand and cost estimations, the objectives of the stylized analytical models are to identify key economic effects that influence the optimal prices and provide directional guidance for optimal product line pricing. We review the analytical models in the literature along with the empirical studies in the next two sections.

3. Pricing vertically differentiated product lines

Recall our definition of vertical differentiation from the Introduction. Examples of the dimension in this case are the power of cars, the processing speed of computers and the purity of chemicals. In the product line pricing literature, researchers typically assume that products are vertically differentiated along a single dimension and interpret such a dimension as product quality.

Firms offer vertically differentiated product lines because consumers are heterogeneous in their willingness to pay for product quality. This gives firms the incentive to conduct second-degree price discrimination, which is achieved by offering a set of products with different quality and prices. In general, there are two possible causes of demand interdependence in a vertically differentiated product line: consumer self-selection and the context effect. Consumer self-selection refers to the fact that each consumer chooses the product to buy that maximizes her net surplus. As a result, the price of one product affects the demand of other products in the line. The context effect refers to the fact that consumers' preferences toward a product can be influenced by the prices of the other products in the line. For example, Petroshtus and Monroe (1987) showed that the price range of the products in a line could affect consumers' evaluation on individual products in the line. Simonson and Tversky (1992) showed that the consumers tend to avoid extreme options. Therefore, adding a high price product into a line may increase the demand of a product with a mid-level price.

While the findings from behavioral research on the context effects are interesting and important for product line pricing, most of the studies are descriptive in nature. The analytical and empirical studies on product line pricing have primarily focused on the impact of consumer self-selection. In the rest of this section, I discuss the previous research relating to consumer self-selection and product line pricing in detail.

3.1 *Consumer self-selection and product line pricing: the basics*

The primary consideration in the literature on pricing a vertically differentiated product line is the demand interdependence resulting from consumer self-selection. The basic modeling framework that captures the self-selection effect is as follows. Suppose a monopoly firm sells a high-quality product (H) and a low-quality product (L). Product H is designed to target consumers with high willingness to pay for quality (the H -type) and product L is designed to target consumers with low willingness to pay for quality (the L -type). If the price of H is too low, then the L -type may want to purchase product H . Similarly, if the price of L is too low, then the H -type may want to purchase product L . Generally speaking, a monopoly firm will not be able to extract consumer surplus fully because the prices of products H and L have to be set to induce consumers to ‘self-select’ into buying the designated products.

The above idea was formally modeled in the seminal papers by Mussa and Rosen (1978) and Moorthy (1984). While both papers assumed a monopoly seller, the former assumed a continuous distribution of consumer types and the latter assumed a discrete distribution of consumer types. The main insights of both papers are that under general conditions: (1) only the consumers with the highest valuation for quality get the efficient quality (i.e. the quality that would be chosen by a social planner for that segment) and all other segments get lower than the efficient qualities; and (2) the consumers with the lowest valuation for quality are charged with their willingness to pay for the product they buy and other consumers are charged below their willingness to pay for the products they buy. In addition, as pointed out by Verboven (1999), the pricing outcome given in Mussa and Rosen (1978) and Moorthy (1984) implies that the absolute price–cost margins increase with product quality but the percentage price–cost margins typically decrease with product quality.

To illustrate the results from Mussa and Rosen (1978) and Moorthy (1984), let us consider the following numerical example. Suppose that the market consists of one H -type consumer and one L -type consumer, and further assume that the reservation price of the H -type consumer is $3q$ and the reservation price of the L -type consumer is $2.5q$, where q is the product quality. The unit production cost is assumed to be $0.5q^2$. If a monopoly firm sells product H with quality q_H at price p_H to the H -type consumer and sells product L with quality q_L at price p_L to the L -type consumer, the profit of the firm is

$$\pi = (p_H - 0.5q_H^2) + (p_L - 0.5q_L^2) \quad (10.2)$$

If there is no demand interdependence, i.e. the H -type (L -type) consumer can only access product H (L), it will be optimal for the firm to set prices at the reservation prices of the consumers. Therefore the optimal prices are $p_H^* = 3q_H$ and $p_L^* = 2.5q_L$. Then, from (10.2), it is easy to obtain that the optimal quality levels are $q_H^* = 3$ and $q_L^* = 2.5$, and they are socially efficient. Consequently, we have $p_H^* = 9$ and $p_L^* = 6.25$ in this case.

In the situation where consumers have access to both products in the product line, each consumer can choose the one that maximizes her net surplus. In such a case, the demand of the two products becomes interdependent as a result of this consumer self-selection. Notice that the self-selection condition for the H -type consumer to choose product H over product L is

$$3q_H - p_H \geq 3q_L - p_L \quad (10.3)$$

and the condition for the L -type consumer to choose product L over product H is

$$2.5q_L - p_L \geq 2.5q_H - p_H. \quad (10.4)$$

From equations (10.3) and (10.4), we can see that the demand of each product is affected by the prices of both products. Following Moorthy (1984), it is easy to verify that (10.3) has to be binding for profit maximization but (10.4) is not binding. In addition, $p_L^* = 2.5q_L$ still holds. Then, from (10.2), we can obtain that $q_H^* = 3$ and $q_L^* = 2$.¹ Consequently, $p_H^* = 8$ and $p_L^* = 5$. We can see that the consumer with the high valuation for quality still gets the efficient quality but the other consumer gets lower than the efficient quality, and the consumer with the low valuation for quality is charged at her willingness to pay for the product purchased, but the other consumer is charged below her willingness to pay for the product purchased. The above results from the numerical example demonstrate the insights from Mussa and Rosen (1978) and Moorthy (1984). It is also straightforward to verify that the absolute price–cost margins increase with product quality but the percentage price–cost margins decrease with product quality in this case as pointed out by Verboven (1999).²

Insights similar to those in Mussa and Rosen (1978) and Moorthy (1984) were also obtained in Maskin and Riley (1984), Katz (1984), and Oren et al. (1984). Following Mussa and Rosen (1978) and Moorthy (1984), the basic idea of pricing a vertically differentiated product line, i.e. maximizing surplus extraction with the quality-based price discrimination under the constraint imposed by consumer self-selection, has been extended into many different contexts. Detailed discussion on the related research is provided below.

3.2 Incorporating competition

A natural extension of the models in Mussa and Rosen (1978) and Moorthy (1984) is to introduce competition into the pricing problem for vertically differentiated product lines. Most papers in this area have focused on the product quality decisions and/or the decisions on the number of products to offer in product lines (Champsaur and Rochet, 1989; De Fraja, 1996; Gilbert and Matutes, 1993; Jing and Zhang, 2007; Johnson and Myatt, 2003). The basic economic force captured by those papers is the tradeoff between product differentiation to mitigate competition and product proliferation along the quality dimension to maximize the benefit from the second-degree price discrimination.

¹ Given the parameter values in the example, it is easy to show that it is optimal to offer two products instead of one.

² The unit costs are 4.5 and 2 for product H and product L respectively.

As a pioneering paper in this area, Katz (1984) introduced competition by assuming that firms are horizontally differentiated, following the idea of Hotelling (1929). As expected, competition lowers firms' prices and profits. As a result, firms may offer products at different quality levels in order to avoid head-on competition.

The basic intuition behind the result of Katz (1984) can be shown using the numerical example presented in Section 3.1. Assume that there are now two firms with the same cost structure competing in the market described in that example. Further assume that each firm can potentially offer up to two products with $q_H = 3$ and $q_L = 2$. If firms simultaneously decide the number of products to offer before their pricing decisions, neither firm will offer both products in the equilibrium. This is because the Bertrand competition on any common product offered by the firms will lead to zero profit for that product for at least one of the firms. Therefore, in equilibrium one firm will offer product *H* only and the other firm will offer product *L* only.³

In an interesting paper by Desai (2001), the competition between firms was also modeled following Hotelling (1929) but consumers' horizontal taste differences toward the two competing firms were allowed to be different for the *H*-type and *L*-type. Desai (2001) showed that in this setup it was possible for both firms to offer efficient qualities to both consumer segments in equilibrium. The intuition behind this result is that competition lowers the price of product *H* to the *H*-type. Consequently, it reduces the incentive of the *H*-type to buy product *L*. Therefore firms may not need to lower the quality of product *L* in order to prevent the *H*-type from buying product *L*. Another innovative feature of Desai (2001) was that he allowed the possibility that the market was not fully covered. Under incomplete market coverage, he showed that even a monopoly might offer products with efficient qualities to both consumer segments. This is because the firm in his model faces a downward-sloping demand function instead of a step demand function when the market is not fully covered. As a result, the firm has the incentive to lower its price of product *H* to attract a large portion of the *H*-type. This again reduces the incentive of the *H*-type to buy product *L*.

Another interesting paper in this area is Verboven (1999). This paper studied a special type of vertically differentiated product line consisting of a base product and a premium product which was the base product plus some add-ons. This type of product line is common in the automobile industry. Under the assumption that consumers were only well informed about the base product prices, Verboven showed that the premium products could have larger percentage markups than the base products in equilibrium. This result was different from the standard result in the literature (e.g. Moorthy, 1984) and it was supported by the empirical findings of the paper.

Closely related empirical work in this area is quite scarce. A noticeable empirical research by Sudhir (2001) examined the competitive product line pricing behavior in the US auto market. He found more-competitive-than-Bertrand pricing behavior in the minicompact and subcompact segment, cooperative pricing behavior in the compact and

³ In this case, there is no pure strategy equilibrium in prices if firms set prices simultaneously. If firms set prices sequentially, the pure strategy equilibrium will be $p_H = 5.5$ and $p_L = 3$ when the first mover produces product *H* and the second mover produces product *L*, or $p_H = 5.5$ and $p_L = 2.5$ when the first mover produces product *L* and the second mover produces product *H*. We can see that the prices and profits of the firms are lower than those in the monopoly case.

midsize segment and Bertrand pricing behavior in the full-size segment. These findings can be explained by firms' ability to cooperate, which is high in the segment with high concentration, and by firms' motivation to compete, which is high in the segment for entry-level customers (the minicompact and subcompact segment) because firms try to build customer loyalty for long-run probability as those entry-level customers eventually move up to buy large cars. The findings of the paper indicate the importance of the dynamic consideration in firms' product line pricing decisions. Remarkably, such a consideration has been largely ignored in the analytical models.

3.3 *Interactions with other marketing mixes*

As indicated in equation (10.1), the product line pricing decision is influenced by other marketing mix variables chosen by a firm and its competitors. Recent research on pricing vertically differentiated product lines has examined the interactions of product line pricing with other marketing mixes. Villas-Boas (1998) studied a manufacturer's product line decisions when it sells through a distribution channel with a single retailer. His results show that the main conclusions from Mussa and Rosen (1978) and Moorthy (1984) are reinforced in the channel setting. In fact, the quality of the low-end product is even more distorted than in the case without the retailer. This result is obtained because double marginalization in the channel increases the price to the *H*-type while the *L*-type is always charged with the reservation price. Consequently, this increases the incentive of the *H*-type to buy the low-quality product. To prevent this from happening, the manufacturer has to distort the quality level of the low-end product further down.

As to the interaction between product line decision and advertising, Villas-Boas (2004) studied the situation where the function of advertising is to create product awareness. He showed that in general a monopoly firm would charge a lower price for the high-quality product and a higher price (accompanied by higher quality) for the low-quality product when advertising was costly than when it was costless. The basic intuition is that a low-end consumer is unlikely to buy the high-end product if the high-end product is the only one she is aware of, but a high-end consumer will buy the low-end product if she is only aware of the low-end product. Therefore, when advertising is costly a greater proportion of sales will come from the low-end product. Then the firm has an incentive to increase the price of the low-end product by increasing its quality. To prevent the high-end customer from buying the low-end product when she is aware of both products, the price of the high-end product has to be lowered.

A recent paper by Lin and Narasimhan (2006) studied the interaction between product line decision and persuasive advertising. They suggested that persuasive advertising might increase consumers' willingness to pay for quality. Consequently, they showed that the prices and quality levels of both high- and low-quality products would increase when a firm adopted persuasive advertising strategy.

3.4 *Cost-related issues*

Researchers have also studied various impacts of cost and cost interdependence on product line pricing. Gerstner and Hess (1987) offered explanations for the empirical phenomenon of quantity discount and quantity premium observed for products in large packs. A product line with the same product sold at different pack sizes can be viewed as a special type of vertically differentiated product line if free disposal is assumed. The authors

showed that consumers' storage costs and transaction costs played significant roles in determining quantity discount versus quantity premium for products in large pack sizes. In particular, quantity premium prevails when customers differ only in their storage costs but quantity discount prevails when customers differ only in their transaction costs.

Balachander and Srinivasan (1994) examined the product line pricing by an incumbent firm that used prices to signal its cost advantage in order to deter entry. They found that credible signaling required the firm to offer higher quality and higher price of each product in the line than in the perfect-information case. The intuition is that it is prohibitively costly for a firm without cost advantage to mimic the high quality level of each product in the line. Thus, high quality credibly signals the cost advantage. In contrast to the result from the standard model (e.g. Moorthy, 1984), the quality of the lower-end product can be distorted to a higher than efficient level when quality and price are used to signal cost advantage.

Shugan and Desiraju (2001) studied the optimal adjustments of product prices in a line given the cost change of a product. Somewhat different from the standard assumptions made in the literature (e.g. Moorthy, 1984), their assumptions on demand interdependence were based on the empirical findings by Blattberg and Wisniewski (1989), who suggested that competition between quality tiers was asymmetric. That is, consumers are more likely to switch up to buy the high-quality product when it cuts price than switch down to buy the low-quality product when its price is reduced. Shugan and Desiraju (2001) found that when the cost of high-quality product declined, the prices of all products in the line should decrease. But when the cost of low-quality product declined, the prices of the high-quality product should increase while the price of the low-quality product should decrease. The driving force behind those results is that the high-quality product is mostly immune to the price cut by the low-quality product, so that preventing the *H*-type from switching down is not a major concern as in the standard case (e.g. Moorthy, 1984).

Desai et al. (2001) examined the pricing implications where products in a line could share common components, which reduced the production costs due to economies of scope. An interesting finding is that the firm has to increase the price of the low-end product and reduce the price of the high-end product if it lets the low-end product share a premium common component used for the high-end product. This is because the quality of the low-end product increases through sharing. This leads to a price increase for the low-quality product. The price of the high-quality product has to decrease in order to prevent the *H*-type from switching down.

Netessine and Taylor (2007) explored the impacts of production technology and economies of scales on product line decisions. Their model combines the standard product line model as in Moorthy (1984) with the EOQ (economic ordering quantity) production cost model, and allows product line design and production schedule to be optimized simultaneously. They found that the results from their model could be significantly different from the standard results found in Moorthy (1984). The main reason is that, compared to the standard case, a firm is likely to offer fewer products in a line in the presence of inventory costs and economies of scales. This intuition is also obvious from the numerical example discussed in Section 3.1. Given the assumptions made in that example, if the cost of producing the second unit is half the cost of producing the first unit, then only one product will be produced at $q = 2.5$ and $p = 6.25$ with the sales of two units.

4. Pricing horizontally differentiated product lines

Recall our definition of horizontal differentiation from the Introduction. It is interesting that the retail prices for products in a horizontally differentiated product line tend to be uniform. For example, supermarkets typically charge the same price for yogurt with different flavors, department stores typically charge the same price for clothes with different sizes, and video rental stores typically charge the same rental price for new DVDs. Due to the uniform pricing phenomenon, research on pricing horizontally differentiated product lines has focused on the impact of the product line length, i.e. the number of products in the line, or the overall price level of the product line. I discuss this stream of research below, followed by a discussion on the rationales behind the uniform pricing behavior.

4.1 *Product line pricing and product line length*

According to Lancaster (1990), there are three drivers for firms' product line length decisions: the cost consideration, the demand consideration and the strategic consideration.

The main cost consideration in determining the product line length is economies of scale (Lancaster, 1990). Because of economies of scale, an increase in the product line length leads to an increase in cost, as the demand of each product tends to be lower with more products in the line. This argument suggests that a longer product line is associated with higher price because of the increase in cost. However, if we take the product line length decision as endogenous, a high level of economies of scale would lead to a short product line because of the cost consideration. Then a short product line could imply a high price because the observed product line length resulted from high production costs. The empirical evidence on the actual relation between product line length and production costs is not conclusive. Kekre and Srinivasan (1990) examined this issue using PIMS (profit impact of marketing strategy) data and found no negative effects of broadening product line on production costs. Bayus and Putsis (1999) also investigated this issue using data from the personal computer industry. After controlling for the endogenous nature of the product line length decision, they found support for the positive relation between product proliferation and production costs.

The demand consideration also plays a major role in determining the product line length and price. On the one hand, due to the variety-seeking behavior of individual consumers (Kahn, 1995; McAlister, 1982), heterogeneity in consumer tastes and uncertainty in consumer preference, a product line with a large number of varieties is likely to be preferred by consumers (Hoch et al., 1999; Lancaster, 1990). This preference for varieties suggests a higher price for a longer product line. Evidence from both behavioral and empirical research has provided some support for this claim (Berger et al., 2007; Kahn, 1998; Kekre and Srinivasan, 1990; Kim et al., 2002).

On the other hand, a product line with a large number of varieties may increase consumers' costs of evaluating the alternatives (Shugan, 1980; Hauser and Wernerfelt, 1990) because it requires significant effort to evaluate the options provided by the product line. This consequently reduces the attractiveness of a product line with a large number of varieties. To compensate for this effect, price of the product line has to be lowered. Thus a product line with a very large assortment may actually reduce consumers' purchase probability and has to be charged at a low price. Some recent behavioral and empirical studies have provided evidence on the negative effect of product line length on consumer

preference (Boatwright and Nunes, 2001; Chernev, 2003; Dhar, 1997; Iyengar and Lepper, 2000).

Through a set of experiments, Gourville and Soman (2005) showed that product line length could have either positive or negative impacts on consumer preference depending on the assortment type of a product line. They defined two assortment types: alignable and nonalignable. An alignable assortment is one in which the alternatives vary along a single, compensatory product dimension. An example of the alignable assortment is jeans that vary in waist sizes. A nonalignable assortment is one in which the alternatives vary along multiple, noncompensatory product dimensions. For example, a product line consists of a car with sunroof but no alarm system; another one with alarm system but no sunroof can be viewed as a nonalignable assortment. Gourville and Soman (2005) found that product line length had a positive impact on consumer preference if the assortment was alignable. In contrast, product line length can have a negative impact on consumer preference if the assortment is nonalignable because it increases both the cognitive effort and the potential regret faced by a consumer. The authors also showed that simplifying the information presentation and making the choice reversible could mitigate the negative impact of product line length on consumer preference.

Draganska and Jain (2005) examined the impact of product line length on consumer preference empirically, taking into account product line competition among firms. They developed and estimated a structural model based on utility theory and game theory. In their empirical application for the yogurt category, they found evidence that consumer utility was in an inverse-U relation with the product line length of a firm. This result reconciles the findings in the aforementioned literature that documented either the positive or the negative relation between product line length and consumer preference.

The joint impact of cost and demand factors on optimal product line length and price can be demonstrated with a simple example. Suppose that a firm sells to a unit mass of consumers who are uniformly distributed along a circle of unit length. The product line is also positioned on the circle. The location of a consumer on the circle reflects her preference. If a product is at distance x from a consumer, the consumer's reservation price for the product is $1-x$. The marginal production cost is assumed to be zero but the firm incurs a fixed cost F for adding a product to the line. Given those assumptions, if the length of the product line is n , it is optimal for the firm to position its products evenly around the circle. It can be shown that the optimal price for the product line is $p = 1 - (1/2^n)$. The market is fully covered at this price, i.e. every consumer purchases the closest product, and the total profit of the firm is $\pi = 1 - (1/2^n) - nF$. In this example, the price and profit of the product line increase with its length thanks to the demand effect (as reflected by the term $1/2^n$), but the total profit of the product line can also decrease with its length due to the cost effect (as reflected by the term nF). The optimal length of the product line is determined by the tradeoff between the demand and cost effects. It can be obtained by maximizing the total profit with regard to n .

In addition to the cost and demand considerations, the strategic consideration by firms can have a significant impact on product line length and formation. The strategic consideration can be from three aspects. First, firms' decisions on product line length and formation are influenced by their competitive behavior. On the one hand, firms facing heterogeneous consumers may want to expand their product offerings in order to gain positioning advantage. On the other hand, firms may want to restrict the length of their

product lines in order to avoid head-on competition. Theoretical models on competitive product line positioning and pricing generally admit multiple equilibria (Shaked and Sutton, 1990). Brander and Eaton (1984) showed that firms' products could either be positioned in a compartmentalized fashion, with each firm focusing on a segment of the market, or in an interlaced fashion, with competition in every fraction of the market. The price of each firm's product line is expected to be higher in the first case than in the second. The authors further showed that both cases could be Nash equilibrium if firms made product decisions simultaneously, but the first case would be at equilibrium if firms made product decisions sequentially. The model in Brander and Eaton (1984) assumed that each firm was selling a fixed number of products. This assumption was relaxed in Martinez-Giralt and Neven (1988). Their theoretical model showed that firms would shorten their product line to avoid intense price competition. Therefore a shorter product line can be associated with higher price in a competitive setting.

In an empirical study on competition between Procter and Gamble and Lever Brothers in the laundry detergent market, Kadiyali et al. (1996) found that firms seemed to behave in a coordinated way in their product line pricing behavior, with each firm positioning its strong product as the Stackelberg leader in its strategic interaction with the rival's weak product. In their empirical study on the yogurt category, Kadiyali et al. (1999) also found accommodating behavior in product line competition. They showed that a product line extension gave the firm price-setting power in the market but the prices and profits of both the extending firm and its rival increased after the product line extension.

Second, the product line length decision can be made strategically by firms selling through channels. In an interesting paper by Bergen et al. (1996), they showed both theoretically and empirically that offering a large number of branded variants could reduce competition among retailers and lead to high prices and profits for both the manufacturer and the retailers. The intuition of this result is that consumers incur high shopping costs when they compare brands across retailers that carry a large number of branded variants. As a result, fewer consumers engage in comparison-shopping across retailers as the number of branded variants increases. Consequently, the competition among retailers is softened.

Finally, product line length and formation can be used as a strategic tool for entry deterrence, as suggested by Schmalensee (1978). This strategic role of product line length implies a higher price for a longer product line as a long product line deters potential competitive entry. However, Bayus and Putsis (1999) found that the entry deterrence role of product proliferation was not supported by the data used in their empirical study.

4.2 Rationales for the uniform pricing of a product line

As mentioned at the beginning of this section, the products in a horizontally differentiated product line are typically charged with a uniform price, at least at the retail level. This is surprising because one would expect both the demand elasticity and the marginal production costs to be different for different products in a line. Some explanations have been offered in the literature for this puzzling phenomenon. On the supply side, firms may incur large menu costs (Levy et al., 1997) by setting different prices for different product variants. This discourages firms from setting non-uniform prices if the gain from price discrimination is relatively small. Draganska and Jain (2006) and McMillan (2007) found empirical support for this menu-cost-based explanation as they showed that the profit gained from non-uniform pricing was small.

Several demand-side explanations were also proposed in the literature. Kashyap (1995) and Canetti et al. (1998) suggested that many firms believe they face a kinked demand curve where marginal revenue is discontinuous at some 'price points'. If the range of prices is narrow under the potential non-uniform pricing strategy, such a range may contain only one of those price points. Then setting a uniform price at such a price point can be optimal. The fairness concern of consumers (Kahneman et al., 1986; Xia et al., 2004) can also force firms to set uniform prices. Consumers may feel that the prices are unfair if product varieties with similar perceived costs are charged with different prices.

Finally, the uniform pricing policy can result from firms' strategic interactions in competition. In the context of multi-market competition (which can be analogous to product line competition), Corts (1998) showed that firms could soften competition by committing to uniform pricing if they have identical costs but the costs of consumers vary across markets. Chen and Cui (2007) suggested that consumers' fairness concern could serve as a commitment mechanism for firms to set uniform prices. In contrast to Corts (1998), they showed that firms could be better off with uniform pricing even if there were no cost variations across product markets. This is because, besides the competition mitigation effect, uniform pricing can have an additional positive effect on firms' profits as it can expand the market under certain conditions if price elasticity varies across products.

5. Future research directions

As discussed in the previous sections, researchers from many different disciplines, such as marketing, economics, psychology and operations management, have investigated various important topics in product line pricing. While much progress has been made in the last three decades, many issues relating to product line pricing remain to be studied. In this section, I discuss some future research directions that are both important and promising in my own opinion.

First, the existing literature on product line pricing has mainly focused on the cases where prices are set on per unit base. In reality, however, the total price of a product can have both a fixed fee component and a variable price (per unit price) component. A prominent example is the price structure of different wireless phone service plans. Danaher (2002) and Iyengar et al. (2007, 2008) conducted some empirical studies in this area but theoretical study on this topic is still scarce. Future research is expected to help us to better understand the issues relating to pricing product line with a sophisticated price structure.

Second, most analytical models on product line pricing are static in nature, even though the intertemporal nature of consumer behavior such as variety-seeking and brand loyalty can be a key driver for firms' product line decisions. The empirical work by Kadiyali et al. (1999) and Sudhir (2001) discussed early in this chapter indicates that the dynamic interactions among firms can have profound impacts on product line pricing. Future analytical research on product line pricing should incorporate some demand- and/or supply-side dynamic features.

Third, behavioral research has offered important insights on consumers' reactions toward product line pricing practices (Gourville and Soman, 2005; Petroschius and Monroe, 1987; Simonson and Tversky, 1992). Future analytical and empirical research can benefit from taking into consideration the behavioral aspects of product line pricing, such as the context effect, consumer fairness concern, regret for forgone choices, etc.

Orhun (forthcoming) has taken some initiative in this direction with the attempt to incorporate the context effect into the model of pricing a vertically differentiated product line.

Fourth, as discussed in this chapter, both demand interdependence and cost interdependence among products are critical to the optimal design and pricing of product lines. This suggests that integrating the research approaches from operations and marketing can be a fruitful research direction (Eliashberg and Steinberg, 1993). As shown in Netessine and Taylor (2007), many new insights could be generated by jointly modeling the demand side and the production side of product line decisions.

Fifth, even though this chapter discussed the research on pricing the vertically differentiated product line and the horizontally differentiated product line separately, in many cases the actual product offerings in a line are differentiated both vertically and horizontally. For example, a line of automobiles can be vertically differentiated on their engine powers but also horizontally differentiated on colors and other attributes. With the exception of Shugan (1989), who showed that fewer horizontal variants are offered for high-quality product than for low-quality product, little research has been done to address the issue of pricing a product line with its products interacting both vertically and horizontally. Future research should fill this gap.

Sixth, the number of empirical studies on product line pricing has been far lower than the number of theoretical studies. This imbalance is expected to change in future as high-quality data from many industries become available to academic researchers.

Finally, technology advance and the emerging of the Internet as a marketing platform have made it cost-efficient for retailers to offer a great number of varieties in certain categories, such as music titles available from iTunes, books available from Amazon.com and DVDs available from Netflix. This phenomenon of having extremely proliferated product lines was coined as the 'long tail' phenomenon by Anderson (2006). It will be interesting for future research to explore the long tail phenomenon and see whether it may lead to new product line pricing implications.

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