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Comments on "Pricing a Product Line"

The traditional study of markets viewed products as commodities. Each product was identical in every respect. It made sense to assume a common market price for all products because it could be argued that consumers would choose the lowest-priced product. Modern studies of markets have determined that the resulting uniform price can lead to intense price competition. However, there are ways of avoiding such competition. Firms without some permanent production advantage can seek to develop some monopoly power for themselves by making their product different. As a result, the product would compete in a different market where the product had less competition. This strategy can exist as long as specific types of consumer heterogeneity in tastes exist and specific cost structures exist that allow differentiated products to exist. Although only special forms of heterogeneity are consistent with differentiated product markets, we do clearly observe such differentiation and, hence, we must conclude that many markets do have the required special structures.

However, we observe also that firms frequently offer a variety of products, often called a product line. One reason may be production economies in the manufacturing of the products. Perhaps shared costs across products give firms offering a variety of products a cost advantage over individual firms offering only one product. Another reason may be the additional consumers attracted by variety. These consumers may find some advantage in doing all their shopping with one firm. These consumers may be willing to pay a premium for variety and, hence, to provide firms with an incentive to carry a product line. Still another reason for carrying a product line may be to balance risks or seasonal demand. Investigation of these fundamental motivations behind the existence of a product line will definitely provide important topics for future research.

"Pricing a Product Line," by Shmuel Oren, Stephen Smith, and

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Robert Wilson (in this issue), provides an important beginning for this research. Although the paper does not attempt to explore the fundamental existence questions, it does formulate an important but limited problem about pricing a special type of product line. This problem involves the optimal price schedule for a series of products that differ in their cost of production. Some products have higher variable costs, while others have higher fixed costs. It is assumed that consumer utility is only a function of the quantity of the product consumed and no other characteristics on which the products may differ. However, it is assumed that consumers differ on the marginal utility associated with various quantities of the product and hence consumers will choose different quantities at the same price. This difference allows a nonlinear (i.e., nonconstant) price to extract more profits than a linear price. Although the paper never compares the profits associated with a constant price and the profits associated with a nonlinear pricing schedule, we suspect that the later schedule would provide more profits because of the added flexibility that a nonlinear schedule provides. Future research must determine whether the additional flexibility of a nonlinear pricing schedule does justify the added transaction costs.

If we assume that a nonlinear pricing schedule is appropriate, a firm can sell different quantities of a particular product to different consumers at different per unit costs. This event will occur when consumers differ on the marginal utility for quantity. Moreover, under some special situations, this single-product pricing problem can be interpreted as a product-line problem. The paper comes to this interesting conclusion by noting that if several identical products were priced using different nonlinear pricing schedules, all products could simultaneously exist in a market. The result is a product line where each product should be purchased at a different quantity. For example, product x might be cheapest when 1 unit is desired while product y might be cheapest when 2 units are desired. Of course, the number of units desired depends on the prices charged. Hence, a product line pricing problem exists which is solved by the authors.

Consumers, who in this case are only concerned with the quantity consumed, will purchase the product that offers the lowest per unit cost. However, the per unit cost is a function of the quantity consumed and, hence, the derivation of an optimal pricing schedule is nontrivial. In fact, the pricing problem is quite complex. Nevertheless, the paper makes a series of clever simplifying assumptions—which probably hold for a large variety of situations—which are able to make the problem tractable. For example, by analogy with a copying machine that supplies a standard copy, each consumer's purchase can be treated as a separate purchase and the cost of producing units for that purchase—in this case, a quantity of standard copies—is independent

of the quantity purchased by other consumers. In other words, each consumer's copies are produced by a different copy machine. Hence, the cost of producing copies for one consumer is independent of the number of copies made by other consumers. This important property of the analogy elegantly solves the cost interdependency problem and allows the resulting formulation to be concerned only with how much of the product each individual purchases rather than the total quantity of the product purchased across individuals.

In general, the elegant way in which the paper models the product line pricing problem provides its greatest contribution. Of course, the paper's approach could be criticized as being too narrow and modeling only problems like the single-product pricing problem. Nevertheless, it is a contribution to show when a product-line problem can be simplified. Furthermore, it is better to solve a simplified problem than to solve no problem at all. In this respect, the paper provides an excellent foundation for future research. Despite these accomplishments, however, many of the key assumptions are hidden in the exposition. For example, in Section II, Oren, Smith, and Wilson state that "we adopt the convention that $\partial u(q, s)/\partial s > 0$," where $u(q, s)$ is the marginal utility of consumer s for quantity q. This statement implies that $\partial^2 U(q, s)/\partial q \partial s > 0$, where $U(q, s)$ is the utility of consumer s for quantity q, which is far more than a convention. The sign of the expression is, of course, a convention. But the assumption that the expression $\partial^2 U(q, s)/\partial q \partial s$ is always a single sign is far more than a convention. The statement assumes that consumers can be ordered; that is, $s = 1, 2, 3, \ldots$, based on their marginal utility for quantity. This assumption is illustrated in figure 1.

Functions shown in figure 2 are not allowed by this convention.

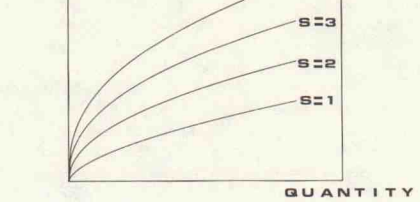

FIG. 1

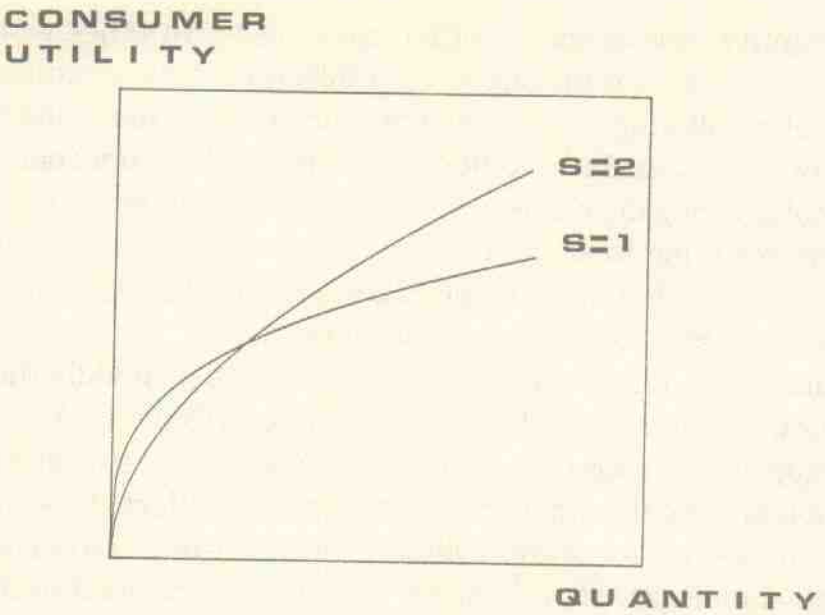

FIG. 2

Hence, not all consumer utility functions are allowed by the convention. The convention precludes a number of situations where light users derive a great benefit for the few copies they obtain. For example, a small law firm may occasionally require a copy of an official document but find little need for a hundred copies of the document. On the other hand, a company reproducing a newsletter may receive little benefit from one copy but obtain a large utility from a thousand copies. Therefore, the paper assumes that the market can be segmented in a special way. The ability to segment the market by marginal utility is, of course, an empirical question. The question has not been adequately studied in the marketing literature. However, it is this reviewer's opinion that although care should be exercised, this assumption is fairly reasonable.

Another important assumption is embedded in equations (1) and (2) of Oren et al. These equations imply that some conditions hold for every value of quantity (see Oren et al., app., for an explicit usage of this assumption). Equations (1) and (2), of course, follow directly from the consumer's optimization. For the equations to hold for all values of quantity, the firm would be required to sell its product at all efficient quantity levels. For example, suppose the product is a copy machine and the machine provides the least expensive per unit cost for two to three copies. Perhaps other machines exist that provide lower per copy cost if only one copy or four copies are required. In this situation, it is required that the firm will sell 2, 2.1, 2.34, 2.46, and every other possible quantity between two and three copies. This requirement restricts the optimal pricing schedule to be concave but less concave than the consumer utility function (across s). Perhaps more profitable pricing schedules exist that are not characterized by a concave function. These

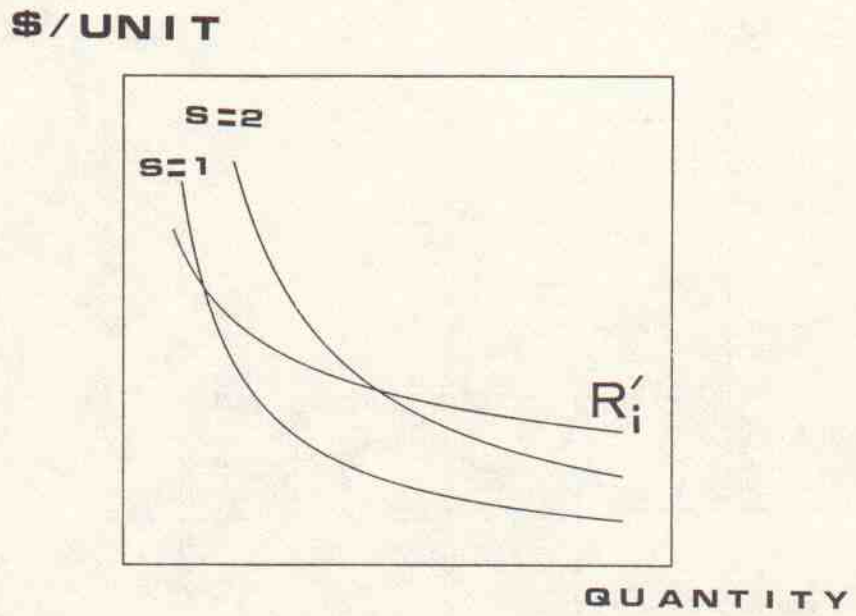

FIG. 3

schedules would imply that at some prices no quantity would be purchased because consumers would find it advantageous to purchase a greater quantity. For example, if at some quantity the pricing schedule were completely flat, consumers would find additional quantity to be free and consumers would, of course, take the free quantity, leaving no consumers purchasing the current quantity. Such flat regions might be desirable when nonlinear costs exist, such as transaction costs or economies of scale. For some products, it might be desirable to have a finite number of sizes available and to allow consumers only to buy quantities of the product in discrete multiples of the available sizes. Hence, the cost function assumed for the product line—that is, the linear function assumed by the paper—is very important. The price schedule, $R_i(q)$ shown in figure 3 (fig. 5 of Oren et al.) might look like the price schedule in figure 4 for some cost functions.

The price schedule in figure 4 creates problems by intercepting the marginal utility curves for consumers s and $\hat{s}$ at two points. Note that the mere existence of nonlinear curves does not necessarily imply that the paper's formulation is not appropriate. For example, figure 5 depicts some cost curves that can be modeled using the paper's formulation. Figure 5 should be contrasted to the linear cost curves shown in figure 6 (also fig. 6 of Oren et al.).

Both figure 5 and figure 6 display cost curves that exhibit a concave efficient lower envelope. The figures do differ in the number of regions in which a product is efficient. Figure 6 shows the paper's formulation where product 1 is efficient below quantity Q_1, product 3 is efficient above quantity Q_2, and product 2 is efficient elsewhere. Figure 5 displays a situation inconsistent with the paper's assumptions, because product 1 is efficient in two regions below Q_1 and above Q_2. However,

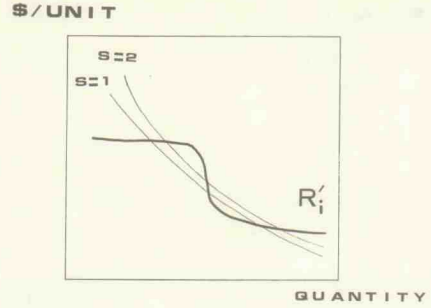

FIG. 4

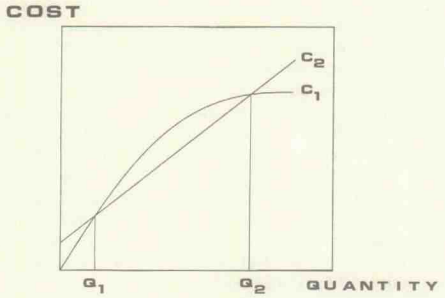

FIG. 5

the paper's formulation might be extended to include the situation described in figure 5 by defining product 1 purchased at quantities below Q_1 as a different product from product 1 purchased at quantities above Q_2. The same trick might be used for payment schedules which look like figure 7.

In sum, the greatest contribution of Oren, Smith, and Wilson's paper is the transformation of a totally intractable problem into a quite manageable formulation. Of course, the price of any such transformation is a simplification of the original problem by means of several simplifying assumptions. The solution of the simplified formulation will, of course, not be a solution for situations where the simplifying assumptions are

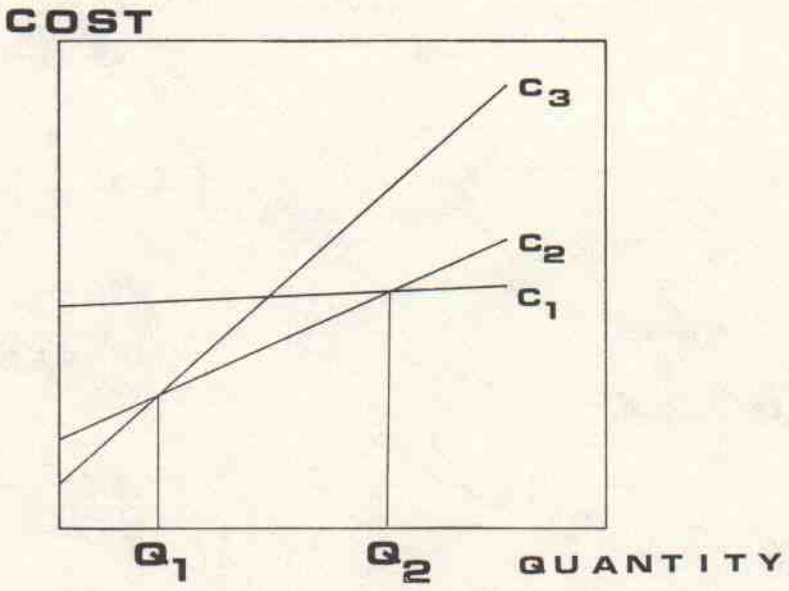

FIG. 6

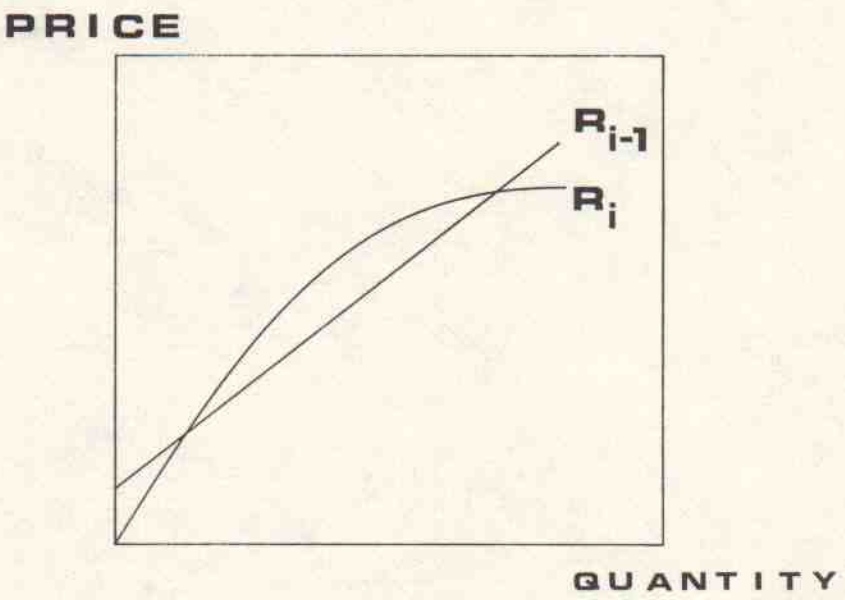

FIG. 7

inappropriate. Nevertheless, the simplified formulation has numerous interesting and managerially relevant applications. Once these assumptions are clearly identified, future theoretical research can gradually relax them, while future empirical research can determine when the assumptions are valid. I hope that the paper's authors will investigate further when nonconcave pricing schedules are desirable and attempt to generalize their formulation. (If one does not look for nonconcave solutions, one does not find them.) I also hope that the authors will continue to explore formally the reinterpretation of the model when product quantity is redefined as product quality.