Shlomo Kalish*
University of Rochester

Comments on "A Simulation Model for the Evaluation of Pricing Strategies in a Dynamic Environment"

Clarke and Dolan's paper deals with the general problem of managing innovations over time. More specifically, it looks at the pricing of new products over time. This general problem is certainly important, as evidenced by the increasing interest in these issues among the business community in the last decade (see, e.g., Porter 1980). Academic interest in this subject has also increased in recent years.

This problem differs from traditional pricing problems because of several factors that cause intertemporal interactions; that is, the profit at period t depends not only on price and quantity sold at time t but also on past quantities sold. Therefore, the static marginal pricing rule that marginal revenues equal marginal cost has to be altered. The modified rule is that at each point in time, marginal cost equals marginal revenues plus the marginal present value of future profits.

The factors causing intertemporal complications are as follows: On the supply side, there is the concept of learning by doing (or the "experience curve"), where the average unit cost declines as more experience in production is gained (see Alchian [1959] for an excellent discussion of the issues and Henderson [1980] for a recent popular exposition). The implications of this phenomenon have been studied extensively in economics (see, e.g., Arrow 1962; Porter 1980; Rosen 1972; and Spence 1981). The basic idea is fairly simple. Given that cumulative production reduces production costs, the firm has an incentive to overproduce (or price lower), as compared with the myopic case, where only immediate profit counts. This is true for the monopolist and certainly for situations where there are threats of entry, or in the case of oligopoly, since cost reduction implies an improved competitive position.

A similar phenomenon exists on the consumer side. For several

* I would like to thank Subrata Sen for numerous useful comments. The usual disclaimer applies.

(*Journal of Business*, 1984, vol. 57, no. 1, pt. 2)

0021-9398/84/5712-0022$01.50

reasons (see below), the conditional demand for a new product increases as more units are sold and as it gains market share. These reasons include the diffusion of information about the product's existence (awareness diffusion); reduction in uncertainty and learning about the product's experience attributes through recommendations from existing users; and other factors, associated with penetration, such as service availability. While marketing scholars have dealt with these issues extensively, they have essentially been ignored by economists.[1] The effect of these factors on price is similar to that of cost reductions. Because of the increase in demand as a result of more units' being sold, it is worthwhile to reduce price and sell more. Future demand and, therefore, one's competitive position are improved (see Kalish [1983*a*] and the references cited there for a review and summary of these results).

A third complication arises in the case of durable goods. Durable goods provide services during their economic lifetime. The demand for their services is supplied by the total existing stock in the market. Therefore, the demand for new units depends not only on price but also on stock, which is related to past prices. Moreover, consumers develop expectations about future prices and modify their behavior accordingly. This is particularly important in markets with frequent innovations, where price typically declines over time and consumers trade off the benefit of using the product now against the expected savings incurred by delaying the purchase (e.g., in the case of microcomputers). If consumers act in a myopic manner, that is, without expectations, then a monopolist would price the durable high at introduction and proceed to reduce price as the "high bidders" buy, until price equals marginal cost. However, even with consumer foresight, there are those who are willing to buy at a high price immediately while others wait until the rate of price decline equals the rate of benefit loss. Therefore, even in this case, we expect decreasing price over time.

When all the factors described above exist simultaneously (typically true of a new durable product), then optimal price could take several forms depending on the relative intensity of these factors. This problem for the monopoly case has been studied and is summarized in Kalish (1983*a*).

The inherent dynamics of supply and demand makes the modeling of competition a difficult problem. Some of the interesting questions are, When will competitors enter? How will current policy affect the competitive entry? How is the uncertainty regarding competitive entry and technological breakthroughs handled? Are there spillovers of learning in cost and market reputation to competitors?

Several recent papers have looked at some aspects of the problem.

1. Schmalensee (1982) and Gould (1970) are two exceptions.

Spence (1981) and Eliashberg and Jeuland (1982) look at simplified situations, where there is only one factor present (cost decline for Spence, and a durable good for Eliashberg and Jeuland), and derive analytical and numerical solutions. In both situations the monopolist faces a sure entry at some known future time (several entries in the first case). Teng and Thompson (1981) consider several of the factors described above and solve numerically the open loop equilibrium with several firms competing. The model they use, however, was criticized as unrealistic by Jeuland (1981).

Clarke and Dolan's objective is to have a realistic model. Because of the complexity of the situation, they choose to simulate the market rather than solve for the optimal solution. The monopolist is facing a sure entry at a known future time. (This is somewhat unrealistic, because it is independent of the leader's policy or cost and marketing advantages). Production costs decrease with experience, in a realistic way, where the initial costs and rate of cost decline for each competitor are specified by the user of the model. The market is composed of different segments, characterized by their reservation prices for the leader's and follower's products. Product durability is another user-specified parameter, that is, the number of periods it takes for the product to be consumed, so that buyers reappear on the market. However, consumption rate is independent of price. Consumers do not have price expectations and their choice is based on maximizing the difference between reservation price and actual price for the two products. The learning on the consumers' part is modeled in a peculiar way. For those who have not adopted yet, the reservation price increases as the number of adopters increases. However, the reservation price for those who have tried already remains constant once they have tried.

The monopolist's problem, given the market characteristics and the entry time of the competitor, is how to price the product over time so as to maximize the net present value of cash flow. However, the pricing strategies are somewhat restricted. First, once the entry occurs, the firm becomes myopic, and the competition takes a Stackelberg leader-follower form (the authors also look at another situation of price matching by the follower, which results in a price that a myopic monopolist would set). Moreover, in the monopoly period the price is restricted to one parameter, Z. That is, the price path is restricted to be a weighted average between the myopic price and the maximum reservation price in each period (called skimming), or myopic price and marginal cost (called penetration), where Z is the weight placed on the myopic price. The problem is to find one weight for the whole monopoly period, so that the total net present value is maximized. The authors then report on the results of the simulations under different scenarios.

In what follows I shall comment on the results of the simulations.

Consistent with Spence (1981), the authors find that the rate of decline in cost has a unimodal effect on profits of the leader; that is, for intermediate rates of cost decline, the "optimal" net present value is the highest. Other than this general conclusion, the authors do not find any simple relationships between the parameters of the problem and profits. This is, perhaps, not surprising given the restrictive strategies considered. In a recent paper (Kalish 1983*b*) I have examined optimal pricing policies by a monopolist, using a similar consumer model. I show there that, for frequently purchased goods, price will always be below the myopic price. For durable goods, however, price will be above the myopic price, except at introduction, when it can be below the myopic price in order to stimulate penetration. Restricting the price either below or above the myopic price for the entire period will mask this effect. In the light of this, it is also not surprising that the durability of the product is the most significant factor for determining whether a "skimming" strategy is profitable. Similarly, the "diffusion" parameter is significant, since the higher the learning on the consumer's side, the greater the likelihood of having penetration pricing at introduction.

While the results mentioned above were derived for the monopoly case, the qualitative nature should be similar here as well. This is certainly so for the case where the follower matches the leader's price, since in this case the firm essentially prices as a monopolist, except that it only gains a fraction of the total profits in the competitive period. Therefore, the postentry period is discounted relative to the preentry period, but within each period it is a monopoly situation. In the Stackelberg leader-follower case, the problem is equivalent to two optimization problems. One is the monopoly period, with an end constraint on the number of adopters; the other is the competitive period. The qualitative nature of the results mentioned above holds also for the constrained monopoly case and, therefore, they apply here as well.

In conclusion, while the Clarke-Dolan model is an interesting building block toward the understanding of pricing policies over time, I would be very cautious in recommending the model for normative purposes. It is suggested that future research should focus on a more realistic modeling of the competitive situation, incorporation of "smarter" consumers, and a richer set of pricing strategies. Although this is a difficult task, it certainly carries significant rewards.

References

Alchian, A. 1959. Costs and outputs. In M. Abramovitz et al., *The Allocation of Economic Resources*. Stanford, Calif.: Stanford University Press.

Arrow, K. J. 1962. The economic implications of learning by doing. *Review of Economic Studies* 29 (June): 155–73.

Eliashberg, J., and Jeuland, A. P. 1982. New product pricing strategies over time in a developing market: How does entry affect prices? Working Paper. Chicago: University of Chicago, Graduate School of Business.

Gould, J.P. 1970. Diffusion processes and optimal advertising policy. In Edmund S. Phelps et al., *Microeconomic Foundations of Employment and Inflation Theory*. New York: Norton.

Henderson, B. 1980. *Henderson on Corporate Strategy*. Cambridge, Mass.: Abt Books.

Jeuland, A. P. 1981. Parsimonious models of innovation. Part B. Incorporating the variable of price. Working Paper. Chicago: University of Chicago, Graduate School of Business.

Kalish, S. 1983*a*. Monopolist pricing with dynamic demand and production cost. *Marketing Science* 2 (Spring): in press.

Kalish, S. 1983*b*. New product diffusion model with price, advertising, and uncertainty. Working Paper. Rochester, N.Y.: University of Rochester, Graduate School of Management.

Porter, M. 1980. *Competitive Strategy*. New York: Free Press.

Rosen, S. 1972. Learning by experience as joint production. *Quarterly Journal of Economics* 86 (August): 366–82.

Schmalensee, R. 1982. Product differentiation advantages of pioneering brands. *American Economic Review* 72 (June): 349–65.

Spence, A. M. 1981. The learning curve and competition. *Bell Journal of Economics* 12 (Spring): 49–70.

Teng, J., and Thompson, G. L. 1981. Optimal pricing and advertising policies for new product oligopoly models. Working Paper. Pittsburgh: Carnegie-Mellon University.