Money-Back Guarantees and Market Experimentation

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Abstract:

We study the use of money-back guarantees as a form of market experimentation in a market for experience goods with repeat purchases. We show that extending the customer base in the second period by using a money-back guarantee can be optimal only if a monopolist faces an uncertain distribution of buyers. Within the second period, a money-back guarantee allows the monopolist to discriminate between new and repeat purchasers while a pure price reduction does not. Thus, whenever money-back guarantees are feasible, an optimal experimentation strategy includes a money-back guarantee in the second period but not necessarily a price reduction. (*JEL* D42, D83, L15)

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I. Introduction

It is common for a monopolist to introduce a new product in the market at a high price, which later declines. For the durable good case, a declining price path is consistent with several models, the intertemporal price discrimination and quality signaling ones being the most frequently cited. For repeatedly purchased experience goods, however, none of these arguments is valid.[1]

Despite the lack of theoretical predictions of a decreasing price path for repeatedly purchased experience goods, several recently introduced products that fall into this category have exhibited such paths. For instance, Schering-Plough launched its blockbuster antihistamine drug Claritin in May of 1993, and within less than a year lowered its retail price by 13%. A similar strategy was used in the late 1990's while marketing Rogaine Extra Strength, a treatment for male baldness. In that case the price of the product remained relatively stable, but after a year on the market its producer, Pharmacia & Upjohn, started offering a money-back guarantee to unsatisfied buyers.

When searching for motivating real-world examples, we turned to the pharmaceutical market because it provided us with clean examples for which existing models of intertemporal pricing do not offer a satisfactory explanation. First, for pharmaceutical products the prior probability of treatment success is usually known in

[1] The idea of intertemporal price discrimination (Stokey, 1979) is first to extract surplus from high-valuation buyers, and only after that to sell the good to others. This argument falls apart if the good can be purchased repeatedly. As for the signaling argument, in a single-period model high quality is normally signaled through high prices. See Bagwell and Riordan (1991). In the presence of repeat purchases, signaling is done through low introductory prices that allow a high-quality producer to increase future revenues by attracting more customers early on. See Milgrom and Roberts (1986).

advance, which eliminates the incentive for the seller to signal quality in the conventional sense. Second, the outcome of a specific trial is purely individual, hence the information about any individual outcome has no value for other prospective buyers. This fact allows us to stay away from reputation issues. Finally, each individual outcome is easy to observe, and in some cases can even be verified by third parties, which justifies the symmetric information assumption we make in our paper. In many other examples, the point we are making is muddied by interaction with other effects[2].

An important feature the two aforementioned examples have in common is that, while different instruments (price variation and a money-back guarantee, respectively) were used, in both cases the set of targeted customers was extended after the product had been in the market for some time. In our paper, we analyze both instruments and focus on two issues. First, why was the promotion not offered along with the introduction of the good itself, as one might expect? Second, why in some cases is a money-back guarantee chosen over a price reduction, and vice versa? After answering these questions, we discuss several variations of the model, thus contributing to a general understanding of the factors that determine a firm's choice of an intertemporal pricing strategy for experience goods in the presence of repeat purchases.

The strand of literature closest to our research is the literature on monopoly experimentation, which also makes use of the assumption of the seller being uncertain

[2] For instance, it is a common practice to market new brands of beer as premium ones. Later, if such an attempt fails, the seller usually resorts to various kinds of promotions. See Chura (2001a,b) for a few examples. While the idea behind such practices is very similar to the one discussed in our paper, the examples from the beer market are not as clean due to such confounding factors as the structure of the market, stronger subjectivity of quality judgments, and reputation effects.

about the demand parameters.[3] However, all the existing work in this field assumes random and exogenous changes in demand over time. Such a setup is reasonable for the case in which the purchases made in consecutive periods are independent, which is clearly not the case for experience goods. A second strand of literature related to our research shows the optimality of penetration pricing for experience goods with repeat purchases in the case when the seller knows demand with certainty. The low initial price allows more potential customers to try the product early and learn its value. The prices therefore rise over time as buyers learn the quality.

Our contribution is in combining the seller and buyer side learning.[4] This endogenizes the changes in demand faced by the seller. In our two-period model, not only does the monopolist gather information about the demand parameters through first-period sales, but also consumers learn the value they can attain from the product based on first-period trials, and adjust their behavior accordingly. The rate of such learning in turn depends on the monopolist's actions in the first period. Hence, there is an additional factor the monopolist has to take into account when choosing its optimal experimentation strategy. The other contributions of this paper to the research on monopoly

[3] See Grossman et al. (1977), Aghion et al. (1991), Mirman et al. (1993), and Trefler (1993), to name a few.

[4] To the best of our knowledge, the only other paper that implements a similar idea of bilateral learning is by Vettas (1998). He studies the effect of two-sided learning on the entry of new firms in the market, whereas we use a similar framework to see how the incentives to experiment affect the intertemporal pricing strategy of a monopolist.

experimentation include the introduction of heterogeneity among buyers[5] and the introduction of an additional tool, a money-back guarantee (MBG), for the firm.[6]

In our new setting with buyer and seller learning, we start by reconfirming the optimality of penetration pricing when the distribution of buyers is known: when the monopolist knows the distribution of buyers with certainty, a declining price path is never optimal. The specifics of our demand dynamics do not change this result. However, we also show that, when the distribution of buyers is uncertain, the seller's incentive to obtain information about demand characteristics may dominate the incentive to penetrate the market with initially low prices. In these cases, which are more likely as uncertainty about demand increases, a declining price path or a late MBG offer may become optimal as part of an experimentation strategy for the monopolist.[7] We derive formal conditions for the optimality of experimentation and show that if MBG's are allowed and an

[5] This is different from the works by Shapiro (1983) and Bergemann and Valimaki (2000), where the initial point expectation and the actual realization of product value are the same for all buyers. In our model, we make a more realistic assumption of heterogeneous prior expectations and different realizations of product value across buyers, thus differentiating them horizontally.

[6] The existing theoretical studies of money-back guarantees interpret them as a risk-sharing instrument (Heal, 1977) or a tool for signaling product quality (Moorthy and Srinivasan (1995), Shieh (1996)). In our paper, we take a different approach and show that money-back guarantees can also serve as part of an optimal experimentation strategy.

[7] The firm's uncertainty about demand parameters plays an important role in other existing literature on intertemporal pricing. For instance, a number of models of intertemporal price discrimination show that a seller's uncertainty about demand parameters may call for a decreasing price path. See Harris and Raviv (1981), Conlisk et al. (1984), Landsberger and Mejlijson (1985), and Sallstrom (2001). However, this argument is valid only for durable goods and fails to explain our examples.

experimentation strategy is optimal, then it includes late introduction of an MBG but it may not include a price reduction.

The next section outlines the model. Section III contains the analysis of the case in which money-back guarantees cannot be used, so the firm's only instrument is price variation over time. In Section IV the ability of the firm to use money-back guarantees is added. Section V discusses the robustness of the findings to several modifications of the model and concludes.

II. The Basic Model

In each of two periods a risk neutral, expected profit maximizing monopolist sells an experience good to two types of risk neutral buyers, H and L. The total mass of infinitesimal potential consumers[8] of the good is fixed and normalized to 1, and the sizes of the two groups are N_H and $N_L = 1 - N_H$, respectively. In each period, each buyer consumes either zero or one unit of the good, and we assume that the product cannot be stored between periods. The firm is unable to price discriminate across buyers at any point in time. There are no production costs,[9] and neither the seller nor buyers discount future periods. Therefore, each buyer's payoff is the sum of her first and second period net utilities while the seller's payoff is the sum of first and second period revenues minus

[8] Since buyers are infinitesimal while the seller observes only aggregate sales and refunds, no single buyer has an impact on any other player, and a buyer updates her information, q, based on her own product trial only. This allows us to treat the buyers as "price takers" while working through the model and to focus on the choices made by the seller.

[9] The results for the positive costs case do not qualitatively differ from the results here. See Nizovtsev (2001).

first and second period refunds if refunds are offered. In the first period, the seller and all potential buyers correctly anticipate the choices that will be made in subsequent stages.

The buyers within each type are further split into two categories. For one category, the product starts working immediately and works forever, while for the other it never works. The shares of these two categories within each type are q and $1 - q$, respectively, with $0<q<1$, and the value of q is common knowledge.[10] Consumers know their own type but not their category within the type. Hence q represents a prior probability of success for buyers. In order to find out which category she belongs to, each buyer has to try the good once. If a trial results in a failure, then the product is worthless for the buyer. However, if the product works, then her probability of success is updated to 1, and such a buyer of type j gets value $V_j > 0$ from the current as well as all subsequent units of the good. Thus the type j buyer's perceived probability of success, q^*, is initially q but after a single trial is updated to either 0 or 1. We set consumers' reservation utility to zero.

Without loss of generality, we assume that type H values the outcome of a treatment more than type L, or $V_H > V_L$. The values of V_H and V_L are common knowledge.

For later reference we define two functions,

$$S(q,V_L,V_H) = \frac{V_L}{V_H + (1-q)V_L} \tag{1}$$

and

[10] Given the specifics of informational issues in the case of pharmaceuticals, it is natural to assume that the expected probability of success should be the same for both types, and we have made that assumption here. We have also analyzed the case in which the prior probability of success depends on type. This complicates the presentation without adding new insights. The main qualitative results still hold.

$$T(q,V_L,V_H)=\frac{V_L}{V_H} \quad . \tag{2}$$

Note

$$0<S(q,V_L,V_H)<T(q,V_L,V_H)\le 1 \tag{3}$$

for all $0<V_L\le V_H$, $0<q<1$. Henceforth we will suppress the arguments of these functions and write just S or T.

We find it convenient to sort the cases of interest according to the number of types involved in purchasing the good in each period. With common q and $V_H > V_L$ by assumption, it will never be possible to sell to the L-type only, and in each period the firm can sell either to both types (we denote this case A – 'all types') or to the H-type only (denoted H). Hence we get four different sales patterns in regard to the set of buyers served in each of the two consecutive periods – (H,H), (A,A), (A,H), and (H,A).

In the next section we examine the game for the case with intertemporal price changes allowed, but MBG's prohibited. This version of the seller's problem contains fewer possible strategies, which makes it easier to follow. At the same time it will help the reader to relate our results to those of the existing literature on intertemporal pricing, which deals with price variations only and does not consider money-back guarantees.

III. Pure Price Changes Without an MBG

We start with the case in which the prior distribution of N_H is degenerate, so N_H is known to the monopolist with certainty.

In the second period, a buyer of type j with (possibly updated) probability of success q^* will purchase the good if $q^*V_j - p_2 \ge 0$. Knowing this, the monopolist sets its second period price equal to the reservation price of the lowest type it wants to serve: V_H

for sales to experienced H-type, V_L for sales to experienced H- and L-types, or qV_L for sales to inexperienced L-types and experienced H-types. The first five columns of Table 1 indicate the types to which sales are made in each period, the optimal second period prices (p_2), sales (N_2), and second-period payoffs (π_2) for each sales pattern.

The last three columns of Table 1 indicate the optimal first period prices (p_1), sales (N_1), and overall two-period profits (π). All the entries are straightforward except the first period price for sales pattern (H,A). For (H,A), at the start of the second period L-type buyers still have not tried the product. Therefore, the optimal second period price is $p_2 = qV_L$. Knowing that, H-buyers may start buying in the first period and get $U_1^H = q(V_H - p_1 + V_H - qV_L) + (1-q)(-p_1) = q(2V_H - qV_L) - p_1$, or they may wait till the second period and get $U_2^H = q(V_H - V_L)$. The optimal first period price for this strategy is the maximum price that satisfies $U_1^H \geq U_2^H \geq 0$ and induces H-buyers to buy in the first period, $p_1 = qV_H + qV_L(1-q)$.

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Table 1 approximately here

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Proposition 1. If N_H is common knowledge, then reducing the price in the second period is never optimal.[11]

[11] This repeats a well established result for repeatedly purchased experience goods. See, for instance, Farrell (1986) and Milgrom and Roberts (1986). We use this result merely as a starting point in our analysis.

Proof: The only sales pattern with a price reduction is (H,A). From Table 1, $\pi^{H,A} \geq \pi^{A,A}$ only if $N_H \geq T$, while (H,A) is viable for the second period ($\pi_2^{H,A} \geq \pi_2^{H,H}$)[12] only if $N_H \leq S < T$. Thus (H,A) is never chosen. $\blacksquare$

Now consider the case in which the characteristics of each type (q, V_j, j = H,L) and the total number of potential buyers in the market are common knowledge while the distribution parameter N_H is not. Assume there are two possible realizations of N_H: N_H^1, occurring with probability σ, and N_H^2, occurring with probability $1-\sigma$, where $0<\sigma<1$ and, without loss of generality, $N_H^1 > N_H^2$. Let N_H^* denote the expected value of N_H, $N_H^* = \sigma N_H^1 + (1-\sigma)N_H^2$.

If the firm sells to all types in the first period, then it obtains no information about the value of N_H. The only change to the corresponding entries in Table 1 is that N_H^* replaces N_H. If the firm sells to the H-type in the first period, then it learns the realization of N_H by observing the number of units sold. For the corresponding entries in Table 1, N_H^* replaces N_H in first period terms while the realized value N_H^1 or N_H^2 replaces N_H in second period terms. If $N_H^2 \geq S$, then first period sales to H-types would always be followed by second period sales to H-types and there cannot be a price reduction. If $N_H^1 \leq S$, then first period sales to H-types would always be followed by sales to all types in the second period. But then the same proof as for Proposition 1 (but using

[12] Here as well as throughout the paper, we list A as the optimal choice even when it ties with H. This has no effect on our results.

expectations) shows selling to all types in both periods dominates. Thus no price reduction would occur in this case either.

When $N_H^2 < S < N_H^1$, however, a new, contingent, sales pattern becomes viable. First period sales to H-type would optimally be followed by a contingent strategy of selling in the second period to the H-type only at price V_H if the high value, N_H^1, is realized and to all types at price qV_L if the lower value, N_H^2, is realized, the latter case effectively resulting in a price reduction. We call such contingent strategies "experimentation."

Note that, since $p_2 = qV_L$ occurs only when N_H^2 is realized, it occurs with probability $1-\sigma$. The first period price for sales to the H-type in the experimentation strategy is therefore $p_1 = qV_H + (1-\sigma)(1-q)qV_L$, and the overall expected profit from the experimentation strategy (denoted $\pi_0^{\exp}$) is

$$E(\pi_0^{\exp}) = 2\sigma qV_H N_H^1 + (1-\sigma)qV_H N_H^2 + (1-\sigma)qV_L[1+(1-q)\sigma(N_H^1 - N_H^2)] \qquad (4)$$

We are interested in the parameters of the model that make experimentation optimal for the firm. Experimentation dominates (H,A) and (H,H) if and only if $N_H^2 < S < N_H^1$. Next note (A,H) is never optimal. It dominates (A,A) if and only if $N_H^* > T$ but it is dominated by experimentation unless

$$\sigma V_L \geq \sigma V_H N_H^* + (1-\sigma)V_H[N_H^* - N_H^2] + (1-\sigma)[V_L(1-q)\sigma(N_H^1 - N_H^2)] \text{ .}$$

Since the last two terms on the right-hand side are strictly positive, this condition is satisfied only if $\sigma V_L > \sigma V_H N_H^*$, or $N_H^* < T$. Thus the only additional restriction is obtained by comparing the profit from experimentation to the profit for sales pattern (A,A), $E(\pi^{A,A}) = 2qV_L$. We formalize the result in the following proposition.

Proposition 2. Given uncertainty in the distribution parameters, absence of production costs, and unfeasibility of money-back guarantees, the strategy of charging price $p_1 = qV_H + (1-\sigma)(1-q)qV_L$ *in the first period, and in the second period raising it to* V_H *if* $N_H = N_H^1$*, or reducing it to* qV_L *if* $N_H = N_H^2$ *is optimal if and only if the distribution parameters satisfy the following conditions:*

$$N_H^2 < S, \tag{5}$$

$$\sigma(N_H^1 - T) + (N_H^* - T) + \sigma(1-q)(N_H^1 - N_H^*)T > 0 \tag{6}$$

The condition $N_H^1 > S$ is not listed because it is implied by (6). When $N_H^* \geq T$, (6) is automatically satisfied.

The intuition behind these conditions goes as follows. When the low realization of the proportion of the high-valuation type in the population is too large, condition (5) is violated, and experimentation is dominated by serving only the H-type in both periods. The left-hand side of condition (6) is a linear combination of N_H^1 and N_H^2, with positive coefficients. If both realizations of N_H are too low, then condition (6) is violated, and serving both types in both periods dominates experimentation. Overall, experimentation is optimal when the two possible realizations of N_H are far enough apart. As an example, the trapezoid shape in the upper-left-hand corner of Figure 1 (after Proposition 4) shows the range of N_H^1 and N_H^2 within which experimentation is optimal when $V_H = 1$, $V_L = 0.4$, $\sigma = 0.5$, and $q = 0.75$.

IV. The MBG case

In addition to price variations, in this section we allow the firm to offer buyers a money refund. The size of the refund offered in period *i* is m_i, $0 \le m_i \le p_i$. If the product works, the refund is not claimed.[13] Otherwise, those buyers whose trials of the product fail claim a refund and stop buying the product. The refund is paid within the same period in which the purchase occurred, and returned units of the product have no salvage value for the seller. We will assume the decision to offer an MBG is made only when the seller strictly prefers an MBG to no MBG.

As in Section III, we begin with the case in which N_H is known to the monopolist with certainty and work backward through the model. For sales patterns (H,H), (A,A), and (A,H), $m_2 = 0$ since all second period purchasers already tried the product in the first period and updated their probability of success to either 0 or 1. The corresponding p_2, N_2, and π_2 entries of Table 1 are therefore unchanged. For sales pattern (H,A), the maximum second period price the seller could charge would be such that an L-type buyer is indifferent between purchasing and not purchasing: $qV_L - p_2 + (1-q)m_2 = 0$, or $p_2 = qV_L + (1-q)m_2$. Raising m_2 and adjusting p_2 appropriately results in a higher price paid by all H-types still in the market. Thus the choices by the seller are $m_2 = p_2 = V_L$,

[13] This implies buyers are being truthful. If this assumption is relaxed, nothing would prevent them from claiming a refund regardless of the treatment outcome. The presence of moral hazard favors policies without an MBG, as pointed out in Shapiro (1983). Further analysis (not included here) shows that, while in a two-period model such an assumption is crucial, if a refund may not be claimed more than once per lifetime, the truthfullness assumption's effect becomes negligible as the number of periods gets large.

with resulting sales $N_2 = qN_H + N_L$ and $\pi_2 = qV_L$. The first six columns of Table 2 summarize the results for the second period. Note that for any of the strategies second period target A is strictly better than H if and only if $N_H < T$.

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Table 2 approximately here

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In the first period, offering an MBG is never justified since it offers no benefit to the seller. The last five columns of Table 2 list the seller's first-period choices and a "name" for the sales pattern to be used for future reference.

We are now able to extend Proposition 1 to the case with MBG's allowed:

Proposition 3. If N_H is common knowledge, then introducing an MBG or reducing the price in the second period is never optimal.

Proof: The only sales pattern implementing a price reduction or late introduction of an MBG is (H,AM). Since it is the only strategy that implements an MBG, it has to be strictly better than any other strategy in order to be chosen. $\pi^{H,AM} > \pi^{H,H}$ if and only if $N_H < T$ while $\pi^{H,AM} > \pi^{A,A}$ if and only if $N_H > T$. Thus (H,AM) is never the optimal choice.■

As in Section III, we next consider the case in which q and V_j are common knowledge while N_H has two possible realizations, N_H^1 and N_H^2 (where $N_H^1 > N_H^2$), occurring with probability σ and $1-\sigma$, respectively.

With random N_H, the second period entries in Table 2 are still appropriate as long as the updated version of N_H (N_H^1 or N_H^2 if it has been observed, or the expected value, N_H^*, otherwise) is used. If the seller does not observe the value of N_H, or observes it but does not make her second period target contingent on its realization, then as in Section III, the results for the non-random case carry over to the random case. Hence a price reduction or late introduction of an MBG is possible only when the seller observes N_H and makes her second period target contingent on its realization.

Under the assumptions made, the seller can learn the value of N_H only by observing first period sales to the H-type. The contingent part of the experimentation strategy is to sell to the H-type at price V_H with no MBG when $N_H^1 > T$ is observed and to sell to all types at price V_L with a full MBG when $N_H^2 < T$ is observed. Solving the first-period participation constraint for the maximum price yields $p_1 = qV_H + (1-q)m_1$. Since raising m_1 and adjusting p_1 appropriately has no effect on the seller's payoff, an MBG is not used. Hence in the first period $m_1 = 0$, $p_1 = qV_H$, expected $N_1 = N_H^*$ and expected $\pi_1 = qV_H N_H^*$. The expected profit from experimentation is given by

$$E(\pi_M^{\exp}) = 2\sigma q V_H N_H^1 + (1-\sigma) q V_H N_H^2 + (1-\sigma) q V_L . \tag{7}$$

We are interested in the parameters of the model that make experimentation optimal. We need $N_H^2 < T < N_H^1$ to make the contingent choices optimal in the second period. Just as in the no-MBG case, the only strategy competing with experimentation is (A,A), whereas (A,H) is dominated by (A,A) when $N_H^* < T$ and by experimentation when $N_H^1 > T$ (hence whenever $N_H^* \geq T$).

The conditions for the optimality of experimentation are formalized in Proposition 4.

Proposition 4. Suppose MBG's are allowed and there are no production costs. Given uncertainty in the distribution parameters, the strategy of charging price $p_1 = qV_H$ *in the first period, and in the second period raising it to* V_H *if* $N_H = N_H^1$, *or reducing it to* V_L *and introducing an MBG if* $N_H = N_H^2$ *is optimal if and only if the distribution parameters satisfy the following conditions:*

$$N_H^2 < T \tag{8}$$

and

$$\sigma(N_H^1 - T) + (N_H^* - T) > 0 \tag{9}$$

The interpretation of the conditions is similar to Proposition 2. The condition $N_H^1 > T$ is not listed because it is implied by (9).

Since $S < T$, (8) is less restrictive than (5) in Proposition 2. This is because after sales to the H-type, the second period price V_L will induce all types to purchase when there is a full MBG but the price must be qV_L without an MBG. Thus it is easier for experimentation to dominate (H,H) when MBG's are allowed. The third term on the left-hand side of (6) in Proposition 2 is strictly positive, so (9), which does not include that term, is more restrictive. This means there will be a region in which experimentation is optimal when an MBG is unfeasible but not when it is feasible. To understand why, note $E(\pi_0^{\exp}) - E(\pi_M^{\exp}) = \sigma \cdot q(1-\sigma)(1-q)V_L(N_H^1 - N_H^2) > 0$. This profit difference is positive because, when an MBG is allowed, the seller cannot commit to refrain from using an MBG in the low demand realization. Buyers correctly anticipate that, and the first period price the seller is able to charge decreases. When experimentation is viable in the second period without an MBG, the seller would prefer to have an MBG unfeasible. However, when an MBG is allowed, then a full MBG will be used in the experimentation strategy.

Note that under the experimentation strategy, if N_H^2 is realized, then there is late introduction of an MBG but the product price is not necessarily reduced in the second period, since no assumption was made regarding the relationship between qV_H and V_L.

We now consider a numerical example to compare the cases with and without an MBG allowed. The parameter values are $V_H = 1$, $V_L = 0.4$, $\sigma = 0.5$, and $q = 0.75$. As functions of N_H^1 and N_H^2, expected profits are $E(\pi^{A,A}) = 0.6$, $E(\pi_0^{\exp}) = 0.76875 N_H^1 + 0.35625 N_H^2 + 0.15$, and $E(\pi_M^{\exp}) = 0.75 N_H^1 + 0.375 N_H^2 + 0.15$. The conditions of Propositions 3 and 4 simplify to $\frac{24}{19} - \frac{41}{19} N_H^1 < N_H^2 < \frac{4}{11}$ and $1.2 - 2N_H^1 < N_H^2 < 0.4$, respectively.

Figure 1 combines the information from the two versions of the example, with and without an MBG allowed, to show the range of N_H^1 and N_H^2 within which experimentation is optimal. The range is substantial, including 40% of the parameter space in the MBG case. With an MBG unfeasible and $0.364 \approx S < N_H^2 < T = 0.4$, experimentation is not viable in the second period. This explains the region in which experimentation is optimal when an MBG is feasible but not when it is unfeasible (approximately 4.3% of the parameter space). There is also a small region (approximately 0.6% of the parameter space) in which experimentation is optimal when an MBG is unfeasible but not when it is feasible. For example, for $N_H^1 = 0.5$ this will be the case when $0.184 \approx \frac{7}{38} < N_H^2 < 0.2$.

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Figure 1 approximately here

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We conclude this section with some important observations about the experimentation strategy, the only strategy that involves price reductions or late introduction of an MBG.

Proposition 5. Suppose MBG's are allowed and there are no production costs.

(a) Heterogeneity in valuations across types is necessary for experimentation to be optimal.[14]

(b) Whenever experimentation is used, a full second period MBG (contingent on the low realization of N_H) is part of the optimal strategy.

(c) *Whenever experimentation is used, it includes a price reduction in the second period (contingent on the low realization of N_H) if and only if $V_L < qV_H$.*

Proof:

(a) If valuations are equal, then $T = 1$ and $N_H^1 > T$, a necessary condition for experimentation, is impossible.

(b) and (c) In all experimentation strategies, $p_1 = qV_H$ while $p_2 = V_H$ if N_H^1 is realized and $p_2 = m_2 = V_L$ if N_H^2 is realized. ∎

[14] This is true even without MBG's.

Part (b) of Proposition 5 contains an important result regarding the role that can be performed by money-back guarantees in the repeatedly purchased experience good case. Since each buyer claims a refund only if the product fails, the effective new price, implicitly reduced by an MBG offer, applies only to the buyers who try the good for the first time. Thus, while serving the same purpose as price reductions, money-back guarantees allow the monopolist to discriminate across the pool of buyers. Within the second period, the monopolist always prefers to include a full MBG rather than to use a pure price reduction.

V. Discussion and Conclusion

The results from the existing literature on monopoly experimentation, dealing with firms facing unknown demand parameters, state that it may be optimal for the firm to set the price in the first period in a way that allows it to obtain some information about the demand. However, in all those models there are either no changes in demand over time or those changes are random and exogenous.

We consider the repeatedly purchased experience goods case, where the buyers' experience in early periods affects the demand for the product later on. Therefore, unlike in conventional monopoly experimentation models, in our model the early period pricing strategy influences the rate of consumer experimentation and learning, making changes in demand endogenous. Thus, when devising a pricing strategy, the monopolist has to take into account the dynamic effect of that strategy as well. Another contribution of our paper to the literature on monopoly experimentation is that we allow the firm to use an MBG, which serves as another instrument in addition to the price of the good.

We show that extending the customer base in the second period, either by lowering the price or by using a money-back guarantee, can be optimal for a monopolist only as part of an experimentation strategy used when facing an uncertain distribution of buyers. We also compare the two experimentation tools and further show that, whenever money-back guarantees are feasible, an optimal experimentation strategy includes a money-back guarantee in the second period but not necessarily a price reduction.

The results we were able to obtain have several important implications, both theoretical and practical. First, they allow us better to understand the behavior of firms in the marketplace. Our results imply that in the case of repeatedly purchased experience goods, a price decrease observed over time is never a result of intertemporal price discrimination, often referred to as "skimming". Instead, such a path is likely to be a part of an experimentation strategy a firm would use when demand is uncertain. We also add a new insight into the role of money-back guarantees. In the repeatedly purchased experience goods case studied in the paper, an MBG proved to be not just a risk-sharing instrument but rather an important element in a successful experimentation strategy.

Our results may provide useful insights to firms concerned with marketing repeatedly purchased experience goods. For years, a penetration strategy was considered the only one appropriate for such goods. We show that in some cases it is dominated by experimentation, and derive the conditions for that domination.

Finally, our findings have important implications for empirical studies of pricing strategies.[15] The fact that the choice of an optimal pricing strategy was largely determined

[15] For examples of empirical studies of pricing new pharmaceutical products, see Reekie (1978) and Lu and Comanor (1998).

by the amount of information the firm has about the demand suggests that it would be appropriate to try to account for this factor while performing such studies.

An interesting potential extension of the model is introducing market turnover (the flow of buyers in and out of the market). Intuitively, an increase in the turnover rate reduces the positive effect of the firm's learning and hence its incentive to experiment. Since the turnover rate is one of the characteristics that distinguish markets, rigorous analysis of a scenario including turnover may contribute insights into the applicability of experimentation for different types of products.

This research was inspired by specific examples from the pharmaceutical market, and for the sake of tractability, the model used in the paper is fairly simple. However, it is at the same time sufficiently general to address the questions at hand. The strategies considered in the paper cover all three major types of intertemporal price paths – decreasing, increasing and constant prices. Moreover, our results are not driven by the particular simple setup used, but are robust to generalizations of the model which were not included in the paper for the sake of brevity.[16]

Extending the analysis to include the $q_H \neq q_L$ case complicates the analysis without adding significant insights. The sets of conditions for the optimality of experimentation with and without an MBG allowed expand as there are more strategies to consider. However, the main qualitative result of the paper still holds, albeit with some

[16] The analysis of the model extensions discussed henceforth can be found in Nizovtsev (2001).

exceptions. The analog of part (a) of Proposition 5 for the case with no MBG allowed does not hold for a very narrow parameter region.[17]

Adding additional buyer types to the model expands the set of intertemporal price paths that can be associated with experimentation strategies. As a result, experimentation involving increasing price paths also becomes possible. A similar effect can be achieved by altering the form of the informational uncertainty the firm is facing.[18] The problem with either setup is that it makes experimentation indistinguishable from simple penetration strategies and therefore changes the original focus of the paper, which is to provide an explanation for some, seemingly counterintuitive, pricing strategies for repeatedly purchased experience goods.

Giving consumers the possibility to buy more than one unit of the good in the first period and to store it between periods changes only the specifics of the analysis, but not the qualitative results. The pattern of consumption induced by certain price paths changes, but all the propositions of the basic case still hold, with only minor changes to the conditions for the experimentation equilibrium in Propositions 2 and 4. As for the assumption regarding the absence of commitment power for the firm, it can be relaxed by, for example, allowing the firm to issue coupons to first-period buyers guaranteeing them a low second-period price. The availability of such an option can change profits

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[17] For example, $V_H = V_L = 1$, $q_H = 0.8$, $q_L = 0.6$, $\sigma = 0.5$, $N_H^1 = 0.995$ and $N_H^2 = 0.65$ satisfy all the conditions for the optimality of a price decrease in period 2.

[18] As an example, consider the case in which the firm knows the valuations of the two types and the size of the H-type, but does not know the size of the L-type, which can take two realizations with probabilities σ and $(1 - \sigma)$, respectively. In that case, an experimentation strategy will always be accompanied by an increasing price path.

associated with some strategies. As a result, for unusual parameter combinations, a second period decrease in price may be optimal even in the certainty case.

Among other generalizations that do not change the results significantly are changing the time horizon of the model to an infinite number of periods and adding discounting. The formal constraints change, but the main result holds – experimentation is part of an equilibrium within a certain range of parameters.[19] The form of this experimentation, however, changes. For instance, under the low realization of demand it will result in a non-monotone price path. At first, we observe a price decrease as a result of the firm learning the demand parameters, but then the price increases again due to the effect of the buyers' learning.

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[19] There is nothing surprising about this result. Earlier Mirman et al. (1993) and Trefler (1993) independently analyzed the case of exogenous changes in demand for finite and infinite time horizon, respectively and derived qualitatively identical results.

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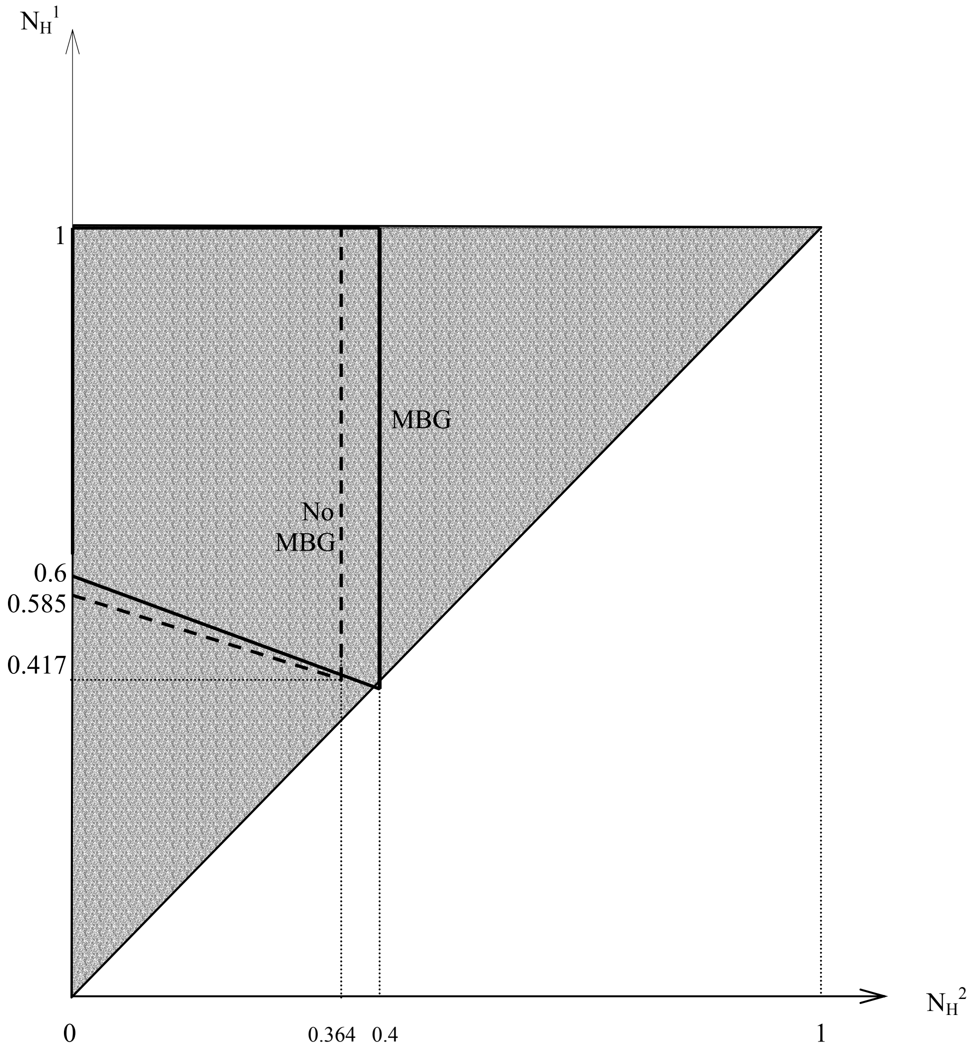
Sales in period		p_2	N_2	π_2	p_1	N_1	$\pi = \pi_1 + \pi_2$
1	2						
H	H	V_H	qN_H	qV_HN_H	qV_H	N_H	$2qV_HN_H$
A	A	V_L	q	qV_L	qV_L	1	$2qV_L$
A	H	V_H	qN_H	qV_HN_H	qV_L	1	$qV_L+ qV_HN_H$
H	A	qV_L	$qN_H+ N_L$	$qV_L(qN_H+N_L)$	$qV_H+qV_L(1-q)$	N_H	$qV_L+ qV_HN_H$

Table 1. Prices, sales, and profits for the case when an MBG is unfeasible. In the absence of production costs the profit is equal to the revenue from sales.

Sales in period		p_2	m_2	N_2	π_2	p_1	m_1	N_1	π_1	Name
1	2									
H	H	V_H	0	qN_H	qV_HN_H	qV_H	0	N_H	qV_HN_H	H,H
A	A	V_L	0	q	qV_L	qV_L	0	1	qV_L	A,A
A	H	V_H	0	qN_H	qV_HN_H	qV_L	0	1	qV_L	A,H
H	A	V_L	V_L	$qN_H + N_L$	qV_L	qV_H	0	N_H	qV_HN_H	H,AM

Table 2. Prices, sales, and profits for the case when an MBG is feasible. The ‘M’ character in the “name” indicates presence of an MBG in a particular period.



N_H^1
1
MBG
No
MBG
0.6
0.585
0.417
0
0.364
0.4
1
N_H^2

Figure 1. The feasible range of (N_H^1 , N_H^2) combinations is represented by the gray triangle. Bold lines show the borders of the experimentation range in the upper-left-hand corner (solid – with an MBG feasible, dashed – with an MBG unfeasible).