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A dynamic monopoly with risk-averse consumers

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ABSTRACT

I study the dynamically optimal pricing strategy of a forward-looking monopolist that introduces a novel product when facing a normalized population of risk-averse, non-strategic consumers. The product can be seen as an experience good in the first period. How well the product fits the consumers' taste is learned only after experimentation, allowing for signaling in the second period. I find that the larger the degree of risk aversion, the higher the probability of observing an introductory price. Moreover, after the realization of a relatively poor fit between the product and the consumers' taste, an introductory price is optimal from an ex-post perspective. Finally, a first-period price ceiling leads to a strictly larger level of welfare if and only if consumers are moderately risk averse.

1. Introduction

From time to time, a truly innovative product is introduced in the market: the Walkman was the first portable cassette player that consumers could actually buy,[1] the Virtual Boy was the first portable video game console capable of displaying true 3D graphics out of the box, and several prototypes of wearable technology with an optical head-mounted display are currently in progress.[2] When the products have such an innovative nature, both the monopolist and the consumers ignore how well they will fit the consumers' taste at the moment of being introduced.

In this context of incomplete information, the monopolist may have incentives to set a price low enough to induce experimentation, so that the parties involved in the transaction learn how well the product fits the consumers' taste. But observe that the aforesaid price might not be an introductory price: if consumers find that they dislike the product, the monopolist could be forced to decrease the price in the period following the experimentation, depending on the severity of the dislike.

I study the dynamically optimal pricing strategy of a forward-looking monopolist that introduces a novel product when facing a normalized population of risk-averse, non-strategic consumers. The product can be seen as an experience good[3] at the moment of the introduction, whilst, due to non-idiosyncratic tastes, signaling is possible afterward if the monopolist induced experimentation. The cost of inducing experimentation increases as the risk aversion increases, but the subsequent positive effect of removing the uncertainty could offset the negative effect of the realization of a poor fit between the product and the consumers' taste.

Section 2 describes the model. Section 3 characterizes the equilibrium pricing strategy, highlighting the dynamic role of the market penetration: besides being an informative signal for the inference process, it also determines the amount of consumers susceptible to being milked by the monopolist after experimentation. The model predicts that the more risk averse consumers are, the more likely it is to observe an increasing pattern of prices. Section 4 explores the scope of the public intervention, finding that a price ceiling improves the total welfare only for moderate values of the risk-aversion coefficient. Section 5 concludes.

■ Literature review

Dynamic pricing in the presence of uncertainty is an old question. A first research line considers forward-looking consumers and ignores signaling. Shapiro (1983) studies the dynamic pricing problem of a monopolist aware of its quality but unable to signal it; thus, consumers only learn through experience and introductory prices occur when consumers underestimate quality. In my model,

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[1] In fact, the first portable cassette player was the Stereobelt, invented by Andreas Pavel. Even though he filed a patent in 1977, at that time there was no major vendor interested in manufacturing the device. Sony began to commercialize the Walkman in 1979, with the subsequent legal battles that lasted until 2004.

[2] The reader may be familiar with the Google Glass, although the idea does not belong to Google; instead, the original device is the EyeTap, developed in the eighties by the father of wearable computing Steve Mann.

[3] According to Nelson (1970), an experience good is a product such that some of its characteristics cannot be observed in advance by the consumers, but instead are ascertained upon consumption.

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on the contrary, introductory prices may also happen when consumers find that they overestimated how well the product will fit their taste, due to the subsequent positive effect on utility of removing the initial uncertainty.

Another example is Cabral et al. (1999). The authors study the dynamic monopoly pricing when all the agents are initially uncertain about the number of high-type consumers, which in turn determines the extent of the network externality. The first-period price is below the expected second-period price in order to induce the high-type consumers to buy in the first period, and so the externality becomes observable in the second period. The monopolist also sets a low price aimed at removing the initial uncertainty in my framework, although it is due to the risk aversion of the consumers.

Bergemann and Valimaki (2006) and Villas-Boas (2006) consider frameworks in which the perception of the quality is subjective. The former examine a monopolist who dynamically changes its pricing policy depending on the relative sizes of the segments of informed and uninformed consumers, and find that introductory prices happen in niche markets. The latter examines a dynamic duopoly in which consumers have a relative preference for the variety they learn about in the first place, and concludes that the anti-competitive effect of exploiting the informational advantage dominates the pro-competitive effects.

Empirical studies support the hypothesis that, for some goods, consumers can only learn through experience.[4] For instance, Crawford and Shum (2005) use anti-ulcer drugs data and conclude that, while there is substantial heterogeneity in the effectiveness across patients, they and their doctors gradually reduce the costs of uncertainty through direct trial of the different drugs. Israel (2005) uses car insurance data and finds that consumers overestimate the quality when contracting the service, but that the impact of learning about the quality is mitigated as it is discovered only after a road accident.

A second research line deals with signaling considerations. Milgrom and Roberts (1986) consider a dynamic monopoly in which introductory prices and dissipative advertising are signals of the type, defined as the probability that a random consumer finds the product satisfactory.[5] In equilibrium, introductory prices are used if the good is not perceived as surely satisfactory. Bagwell and Riordan (1991) study the signaling problem of a static monopoly when some consumers are informed, finding that the price distortion necessary to signal a high type decreases as the number of informed consumers increases.

In my model, the problem of the second period is very similar to the one analyzed by Bagwell and Riordan (1991), although the amount of informed consumers was strategically determined by the monopolist in the first period.[6] In contrast to Milgrom and Roberts (1986), the price plays no signaling role when introducing the product, and to spend money in dissipative advertising is not allowed.

Judd and Riordan (1994) analyze a dynamic monopoly in which both the buyers and the seller acquire private, noisy information about the quality of the good after the first purchase. Higher prices signal higher qualities in the equilibrium of the second period, and the equilibrium expected second-period price exceeds the first-period price.[7] On the contrary, I allow for the possibility of not buying in the first period, so some consumers may not get information. Also, I consider that the information derived from the first purchase is accurate instead of noisy.

It is possible to consider signals other than price and advertising. For instance, in Bar-Isaac (2003), the signal is the decision of the monopolist of producing or not; in Bose et al. (2006), the signal for a consumer at a certain period is the history of previous purchases by other buyers. In the duopoly market considered by Caminal and Vives (1996), the previous market share also plays a crucial signaling role, leading to the use of introductory prices.

2. The model

Consider a firm that has developed a new product for which it is the only supplier during a game of two periods. The monopolist charges the prices p_1 and p_2, but price commitment across periods is not allowed. Its discount factor is equalized to 1 and all the production costs are normalized to 0.

There is a large number of risk-averse consumers. At time $t = 1, 2$, consumer i has the following concave preferences:[8]

$$U_{i,t} = \begin{cases} -e^{-\rho(q(I_{i,t})-p_t-x_i)} & \text{if she buys one unit at price } p_t, \\ -e^0 & \text{if she does not buy.} \end{cases} \quad (1)$$

In the previous equation, $\rho > 0$ reflects the concavity of the function and stands for the degree of risk aversion; q denotes the inferred quality of the matching between the product and the consumers' taste, based on the information set of consumer i at time t ($I_{i,t}$); p_t indicates the price set by the monopolist at time t; and x_i corresponds to the transportation cost and it is assumed to be uniformly distributed over the population of consumers. I normalize the size of the population to be equal to 1 (unit interval) in every period. Therefore, the total cost for consumer i at time t derived from acquiring the product is $p_t + x_i$.

At time $t = 1$, when the product is introduced, no agent has information about how well it will fit the consumers' taste; that is, the product can be seen as an experience good. Since the information set of all agents in the first period is the empty set, inference is not possible and the quality of the matching is assumed to be a random variable normally distributed:[9] $q(\emptyset) \sim N(\mu, \sigma)$. Observe that because of the assumption of normality and the constant absolute risk aversion utility function (CARA), the expected utility of the consumer given p_1 corresponds to the certainty equivalent below:[10]

$$CE_{i,1} = \begin{cases} \mu - \frac{1}{2}\rho\sigma^2 - p_1 - x_i & \text{if she buys at price } p_1, \\ 0 & \text{if she does not buy.} \end{cases} \quad (2)$$

Therefore, the first-period demand determined by the marginal consumer (bounded between 0 and 1) is

$$x^1(p_1; \mu, \sigma, \rho) = \mu - \frac{1}{2}\rho\sigma^2 - p_1. \quad (3)$$

The initial uncertainty can only be removed after experimentation; that is, when a strictly positive amount of units are traded, both the monopolist and the consumers who acquired the product

[4] Although not focused on the learning process, Farina (2012) studies a typical case of subjective quality: the market of ready-to-drink orange juice. Using data from Brazil, concludes that the firms should give their juices for free to convince the uninformed consumers to taste them.

[5] Ackerberg (2003) tests the effect of advertising in the introduction of a low-fat yogurt in the American market, and finds that it only has a signaling effect on inexperienced consumers.

[6] When offering a multiperiod interpretation of their static results, Bagwell and Riordan (1991) state that the ratio of informed to uninformed consumers in the mature period is independent of the quantity of sales in the first period.

[7] The realized second-period price is proportional to the private signal of the seller, so it can be below the first-period price if the signal is low enough.

[8] The utility function is assumed to be multiplicatively separable. It can be written as $U(q(I), x, p) = V(q(I))K(x, p) - G(x, p)$, with $V(q(I)) = -e^{-\rho q(I)}$, $K(x, p) = e^{\rho(x+p)}$ and $G(x, p) = 0$. With this specification, which follows Grossman and Hart (1983), the quality of the matching appears simply as a gain in monetary units.

[9] The larger the value of q, the better the product fits the consumers taste and so the larger the gross utility derived from consumption. A negative realization of the quality of the matching means that the gross utility derived from the consumption of the good is smaller than the utility derived from the outside option.

[10] A sketch of the proof can be found in the Appendix.

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