“We sold a million copies”-The Role of Advertising Past Sales.

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Abstract

We model a two periods monopoly market with two-sided quality uncertainty. In the first period, the seller gathers information about consumers' tastes upon observing its sales. In the second period, the seller may or may not deliver the information. If the monopolist must commit either to reveal or conceal past-sales before observing them, committing to reveal is the dominant strategy whenever advertising cost is low, buyers are many and their private information is accurate. When the seller can postpone advertising decision and gains experience, past-sales revelation occurs partially. In equilibrium, delivery of sales-data occurs to induce some buyers' herding behaviour. We carry out the analysis for two different informational scenarios.
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1 Introduction

Agents' uncertainty about relevant products' characteristics is not the exception but the rule in the marketplace. The uncertainty is often two-sided, specially in markets for new products. Suppliers face the problem of knowing what they are selling precisely, whereas consumers do not know what they buy with certainty. These types of goods are referred to as *experience products.*[1] When suppliers decide on their first marketing decisions, they ignore how well consumers will like their goods. In other words, sellers do not know the demand they face accurately. However, as the market interaction evolves, a seller obtains valuable information and gains experience. This information often emerges from the observation of its sales, as quantities sold constitute an outcome of how well buyers' preferences match their products' characteristics. Past sales information is commonly private to the supplier.

A typical real-world example is the market for books. When a publisher introduces a new novel into the market he is uninformed about whether or not consumers will like it. Further, potential readers do not know the *value* of the new novel. Of course, all agents may possess some type of information about the quality of the novel. This information, usually noisy, stems from, for instance, critical reports, ex-ante word-of-mouth communication, or author's reputation. When the novel is marketed, aggregate sales indicate how well previous buyers have expected to like the product. If consumers of different generations (or cities, countries, etc.) exhibit similar tastes, data on quantities sold provide the seller with a (noisy) indicator of the "value" of the novel. Similar examples are the markets for museum exhibitions, music records, cinema movies, theater plays, concerts, etc. Yet, not only markets for products related to leisure-activities exhibit these features. Also markets for software products, stereo sets, cars and motorbikes may present two-sided uncertainty which is (partially) resolved over time.

In a casual glance to a Sunday's newspaper, it is easy to find advertisements where sellers publicly announce their past-sales. For example, Alfaguara publishers recently inserted an advertisement into Spanish newspaper El País where a picture of Javier Marías's novel entitled *Negra espalda del tiempo* appeared together with the following caption: "100.000 copies sold. One hundred thousand possible reasons to read this novel".[2] The existence of this sort of advertisements generates a number of questions. On the part of the consumers, what should they understand after seeing an advertisement of this type? Provided that false reporting does not occur, is the information given useful for consumers? If this information is useful *ex ante,* does this necessarily mean that buyers will be satisfied *ex post*? Finally, what is the informational content behind the decision

[1] Quality of experience goods can only be ascertained after consumers purchase them. This feature distinguishes them from *search goods,* whose quality is learned by buyers upon their simple observation (see Nelson (1970, 1974)).

[2] Other examples are the following: Advertisements of music records usually emphasize the number of copies sold. Publicity about theater plays or movies commonly inform about the number of weeks that they have been performing or on screen. TV and radio programs usually advertise the number (or an estimate) of people that watched or listened to them.

not to reveal sales data? On the part of the supply side of the market, one should ask under which conditions a seller has incentives to make public its private past-sales information. How do these incentives interplay with advertising costs and the exogenous information consumers have?

The foremost goal of this paper is to study the value of past-sales information in a monopoly experience good market and analyze the incentives of the seller to reveal his private sales data. We do not focus only on whether these incentives exist or not but, further, on whether the seller is even willing to pay for revealing past-sales, and, furthermore, when it is more likely to occur, before or after gaining experience in the market. The latter question is motivated by the modern firms' practices consisting of the automatic delivery of sales data to buyers through the so-called *push technologies (PTs).* According to the recent Marketing literature, PTs strategies consist of simply getting sales information to the people who need it most, via communication networks such as the Internet.[3] This form of commitment to release sales-data has been employed, for instance, by the car manufacturers Ford and General Motors. These companies are relying on PTs to get sales reports out to local dealers.[4] This type of commitment may also be reached through joining industry-wide trade associations. For instance, the American Electronic Association (AEA) periodically gathers and disseminates sales information from participating suppliers in the industry. Thus, any firm joining AEA credibly commits to deliver its sales-data to the association. In the book publishing industry, *The New York Times Best Sellers List* reports the fiction and non-fiction best-selling titles on a week basis.[5] Since a seller can instead wait to observe the performance of its good in the market, the timing of revelation deserves attention.

To analyze these issues, we present a two-sided uncertainty model where sales are an indicator of the good's quality, or equivalently, consumers' tastes. We consider a two period market where a single seller introduces a new product whose quality is uncertain to both himself and the consumers. The monopolist sells the good in both periods to buyers that live (and/or make purchases) only during one period. At the beginning of the first period, Nature selects the unknown parameter. While seller remains fully uninformed, consumers receive an informative signal (though noisy) about quality. We think of this noisy information to be a result of the typical seller's effort to launch a new good. After setting the first-period price, demand reveals, in aggregate terms, the private information buyers possess.[6] Sales are privately observed by the supplier. Of course, the accuracy of the aggregate information is larger than that conveyed

[3] See Berger (1997) and Stedman (1998).

[4] Other examples are the following: Nabisco Inc. clients can get sales information automatically by sending an email request to the firm, which then sends back sales reports. This information feeds about 2.500 business managers and salespeople data analysis tools. First Union bank is also planning to implement this type of strategy to deliver information about saving funds.

[5] Other lists are found in the *USA Today Best Seller List, Publishers Weekly* or *American Bookseller Association.*

[6] In the novel example, first-period demand reveals whether consumers' expectations about the quality of a book were high or low.

through individual signals. Therefore, in the subsequent period, the monopolist's information is more precise than that of the consumers; in other words, the supplier has gained experience. We then study whether delivering past-sales information is in the interest of the firm. The analysis is carried out under two scenarios regarding the information available to second-generation buyers. In the first scenario, second-period consumers are fully uninformed about the unknown parameter. We extend the analysis to allow for better informed buyers in the second scenario. For each informational regime, we study the optimal strategies when the seller (a) commits to reveal sales data, (b) commits to conceal sales data, and (c) waits to gain experience in the market and then decides whether to reveal sales data or not. Then, we check which of these strategies is more likely to be observed.

The first period of our model is common throughout the paper. All that it brings to the analysis is the information it provides and its particular nature (past-sales are informative about the unknown taste parameter). It is important to notice that since we assume that past-period prices are observable, our model is a jamming free signal one.[7] This implies that the optimal first-period price is identical across the informational scenarios we consider. This allows us to concentrate the analysis on the second-period of market interaction.

Our results are as follows. The first informational scenario is characterized by the fact that if sales data advertising was not verifiable (or prohibitively costly), the natural equilibrium would be of the pooling type. That is, any "type" of seller would charge the same price regardless of the quantity sold in the first-period (i.e. independently of the performance of the good). It is then shown that the credibility of advertising destroys the pooling outcome: the firm may find profitable to deviate by advertising its past-sales and charging a different price. This implies that a seller would never commit to conceal past-sales data voluntarily. In the hypothetical situation that a seller must commit either to deliver sales information or to conceal it, we demonstrate that committing to advertise sales data is the optimal strategy whenever the advertising cost is not too high and the accuracy of aggregate sales data information is high (i.e., the number of consumers is high and the noise associated to their signals is low).

When the seller does not need to commit to either of these policies, we demonstrate that full revelation never occurs provided that advertising cost are positive. The equilibrium we derive consists of two objects: First, a partition of the set of possible sales observations into two subsets: the advertising subset and the no-advertising one. The second object is a pricing function for each subset. Sales-data values falling into the advertising-subset are advertised and accompanied with a price which is contingent with the seller's sales observation. Sales-data values falling into the no-advertising subset are kept private and buyers only observe the corresponding price, which is not informative at all. Of course, consumers are rational and in equilibrium infer the set of sales-data values that are advertised correctly. Therefore, when they do not observe past-

[7] See Caminal and Vives (1996) for a two period duopoly model where quantities are observable and prices are not so that firms can signal-jam second-period buyers' inferences by quoting appropriate first-period prices.

sales information, they form the appropriate inferences (i.e. buyers somewhat understand how the seller's incentives to release sales-data interplay with the size of advertising costs). This "advertising equilibrium" gives higher expected profits than the "committing to reveal sales data" strategy whenever advertising cost in either of the policies is equal. The existence of PTs strategies is easily accommodated in our model by simply considering that there is a premium in terms of advertising costs by joining trade associations or booksellers lists.[8]

In the second part of the paper, we turn to an informational regime that allows for second-generation buyers to be better informed. This informational scenario is characterized by the fact that if advertising was unverifiable or prohibitive, then separating equilibria might happen. Like in the previous case, separation no longer occurs in equilibrium if the seller can deliver quantities information credibly. We concentrate on the separating equilibrium and find conditions such that revealing past-sales data is a dominant strategy when the seller must commit either to reveal or to conceal his past-sales. If the seller does not need to commit to either of these policies, then matters are as in the first scenario, though easier since when information is not delivered, the price signals the information observed by the seller. The "advertising equilibrium" is here more easily determined.

An important feature of our analysis is that some "herding behaviour"[9] on the part of the consumers is endogenized by seller's strategies. In the first informational regime, the delivery of past-sales information allows consumers to calculate the average belief of the previous generation. Since they are fully uninformed and this information is better than no information, the best buyers can do *ex ante* is following what the others did in the past. Therefore, it may very well happen that consumers purchase a good in mass that deceive them after all.[10] This is due to the very fact that buyers do not observe *ex-post* utilities of previous customers but their decisions (i.e. aggregate sales in case they are advertised), which are based on *ex-ante* utilities. In the second informational regime, consumers are better informed and therefore this effect is weaker. In either of the cases, our model highlights the importance of first-period signals in regard to the failure or success of new goods in markets.

The remainder of the paper is organized as follows. Next section describes the model and sets up the problem. The results for the case where second-generation buyers are fully uninformed are presented in Section 3. We extend the analysis to allow for better informed consumers in Section 4. Section 5 concludes.

[8]For the novel example, it is reasonable to think that the effectiveness of an individual bookseller's advertising campaign is lower than the American Bookseller Association (ABA) ones. This is simply because readers usually look at these centralized reports and then get the information more easily. Probably, reaching a certain percentage of readers is easier (i.e. cheaper) through the ABA's reports than by individual advertisements.

[9]See e.g. Banerjee (1992) and Bikhchandani *et al.* (1992).

[10]In the cinema industry this is very common. Even though people agglomerate at the cinemas' doors to get tickets of new films, occasionally the ex-post valuation of the movie is low. Here this would be a case where realization of q is low whereas realizations of signals are high.

2 The model

We consider a two period economy where there is two-sided uncertainty. A single firm sells a good of uncertain quality q to two successive generations of consumers.[11] The quality parameter q is a zero mean random variable distributed according to the density function $f(q)$. In this work, we follow Judd and Riordan (1994) and consider the quality q as a taste index rather than as a parameter of technical superiority. This perspective allows for the abstraction from the dependency of quality and costs. We thus normalize unit production cost to zero.

A new cohort of N customers enter the demand side of the market each period. It is assumed that they take the quadratic utility function $U(x;p,q) = (a+q)x - \frac{x^2}{2} - xp$, if they buy x units of a product of quality q at unitary price p. Consumers make purchases only once; then, they leave the market.[12] When the market opens, buyers within a cohort may differ in their information but they are all identical ex-ante. Under perfect information, then, the representative consumer of either of the generations would demand $x = (a+q) - p$.[13]

Before the market opens, q is drawn by Nature and neither firm nor customers receive full information about it. Here, seller's uncertainty is never fully resolved and consumers' uncertainty is resolved ex-post, i.e. after consumption occurs. The characteristics of each period market interaction are as follows. We assume that once Nature has chosen the taste index, all first-generation customers receive a private signal s_1^i, $i = 1, ..., N$, which conveys (noisy) information about q. More precisely, $s_1^i = q + \epsilon_1^i$, where q is the realized quality level and ϵ_1^i is a zero mean random variable with density function $f(\epsilon)$. One may think of this external information received by consumers to be a result of the natural effort that the firm must exert to introduce the good into the market (e.g. introductory advertising and product demonstrations). As to the second-period interaction, we analyze two informational scenarios. In Section 3, we study an informational regime where second-generation customers are fully uninformed, i.e. they do not have any external private information valuable. In Section 4, we allow for better informed consumers. Throughout, it is assumed that buyers do not exchange private information, neither within nor between cohorts. Also, we assume that customers observe prices but do not observe quantities sold.

Before proceeding further, some important observations are necessary. The first observation gives the basis of the problem we analyze. Notice that since first-generation consumers will demand the good according to their private information, then realized first-period sales constitute a piece of information private to the seller which is valuable for the agents (firm and buyers) to estimate the unknown parameter. It is valuable for the agents simply because consumers tastes are identical across generations. Thus, agents' estimations of q condi-

[11] The generalization of our model to more than two periods is immediate.

[12] The good is thus durable.

[13] Note that demand is negative if $p > a + q$. We are allowing for negative consumption since we will use the linear-quadratic-normal setup later (i.e. q will be normally distributed).

tional upon the observation of past-sales are more precise than their priors. Consequently, all agents in the marketplace would be able to make wiser decisions if they observed sales data, which raises the question of whether there may be gains for the seller from sharing this information with the buyers. Notice also that this information is obtained after first-period interaction, and that the seller's second-period strategy may be contingent on this observation.

To see this more clearly, let us calculate the first-period demand. First-generation consumer i's demand, conditional upon the privately observed signal and any other information available to him, will be

$$x_1^i = a + E[q \mid \Omega_1^i] - p_1,$$

where Ω_1^i denotes consumer i's information set. Particularly, in the first period, $\Omega_1^i = \{s_1^i, p_1\}$. Note that even though consumers also observe the price charged by the firm in period 1, p_1, it is not informative at all since the seller does not have any private information on q at that stage. Therefore $\Omega_1^i = \{s_1^i\}$. Average aggregate demand will then be

$$\overline{X}_1 = a + q_N - p_1,$$

where $q_N = \frac{1}{N}\sum_{i=1}^N E[q \mid \Omega_1^i]$ denotes the average aggregate consumers' expectation about the uncertain parameter q. Note that, since consumers' signals are private to them and they do not exchange information, realized first-period sales, $\overline{X}_1$, are private information to the seller. Consequently, the number q_N is known privately by the monopolist. Observe also that q_N is a random variable and that the seller can improve its inferences on q by calculating $E[q \mid q_N]$, which gives a more precise estimator of q as compared to the prior $E[q]$.[14] Therefore, the monopolist may want to condition its second-period strategy on its observation of q_N.

The second period of interaction then exhibits a key difference: the monopolist has now some *experience* in the market. In other words, it knows $\overline{X}_1$, and therefore q_N. And, importantly, this is common knowledge in the marketplace. We analyze the incentives of the seller to report its past-sales data at a certain cost in the second-period. More precisely, we compare the profitability of the following three different strategies: (a) the seller commits to deliver sales data at the beginning of the market interaction, (b) the seller commits to conceal sales information also at the commencement, and (c) the seller waits to observe sales data and then decides whether to report them or not.[15]

[14] To illustrate further, suppose that q and ϵ have zero-mean independent normal distributions with variances σ_q^2 and σ_ϵ^2 respectively. Then, first-period aggregate demand would equal $\overline{X}_1 = a + \delta_1(q + \frac{1}{N}\sum_{i=1}^N \epsilon_1^i) - p_1$, with $\delta_1 = \sigma_q^2/(\sigma_q^2 + \sigma_\epsilon^2)$. Once sales have been realized, the seller knows $\overline{X}_1$ and therefore can compute the number $q_N = (\overline{X}_1 - a + p_1)/\delta_1 = q + \frac{1}{N}\sum_{i=1}^N \epsilon_1^i$, which is an unbiased estimator of q. In fact, q_N is a random variable normally distributed with center at zero and variance $\frac{\sigma_q^4}{(\sigma_q^2+\sigma_\epsilon^2)}(\sigma_q^2 + \sigma_\epsilon^2/N)$.

[15] The strategy "committing to reveal sales data" is made on grounds of realism (e.g. the so-called *push technologies* described above). However, we agree that the strategy "committing to

The second observation is the following. Note that since second-generation consumers observe first-period prices, the seller cannot signal-jam buyers' inferences about the uncertain parameter q by quoting a particular first-period price. Therefore, our model is a jamming free signal one. This implies that the intertemporal feature of the monopolist's problem does not affect its first-period price decision. In fact, in the first period, independently of the advertising decision made, the monopolist will always set p_1 to maximize his expected short-run profits $E[\pi_1] = E[(a + q_N - p_1)p_1]$. Then, we will have that $p_1 = \frac{a}{2}$. Therefore, decisions on advertising will only depend on expected second-period profits; so, we can abstract from the first-period benefits when comparing the three cases we consider. The core of our analysis will thus be concentrated on the second-period strategies.[16]

Throughout, we will use the notion of perfect Bayesian equilibrium. This requires consumers' decisions to be optimal given the seller's strategy and their beliefs about q, and the seller's strategy to be a best-reply to consumers' actions. Besides, all agents' beliefs must conform to Bayes' rule whenever it applies.

3 The basic case: Second-generation buyers are uninformed

We first examine the case where second-generation consumers do not receive any individual signal. Since they do not observe first-period sales, they are completely uninformed, i.e. they have a prior belief $E[q] = 0$. This situation will reasonably appear when buyers only know the existence of the product and do not have any extra information. In the next section, we extend the analysis to allow for better informed second-period buyers (i.e. they will receive external informative signals).

Let us assume, for the moment, that the monopolist must commit either to reveal or to conceal his information about past-sales at the commencement of the market interaction. Next, we derive the potential profitability of these strategies.

Suppose that the seller commits to conceal the value of $\overline{X}_1$ before the market opens. Then, in the second period sales-data are not delivered and every buyer's

conceal sales data" may be a bit unrealistic because a seller can always break this commitment. This could be the case when a book seller does not joint a bookseller association list and later on advertises the number of copies sold independently. We believe that this modelling choice helps in the presentation and understanding of our intellectual exercise.

[16] We have modelled the good's marketing process as a two period model with the purpose of giving more structure and economic intuition to the flow of information in the marketplace. As explained below, all that is important about the first-period is the information it provides to the seller and its nature. This is important because allows buyers to understand and interpret the information either inferred or observed correctly. In the literature on information sharing, a set of firms commonly pool information about the future characteristics of the market received through signals. To avoid credibility problems, it is argued that the pool of information is carried out through an independent agency, such as a trade association, so that false reporting is precluded. We think that information about quantities sold does not present this trouble since it is normally verifiable and cannot be manipulated without illegal sanctions.

set of information contains only the observed price, i.e. $\Omega_2^i = \{p_2\}$ for all i.[17] As a result, each customer's demand will be equal. Therefore, average aggregate demand will be

$$\overline{X}_2 = a + q_{2N} - p_2, \tag{1}$$

where $q_{2N} = \frac{1}{N}\sum_{i=1}^{N} E[q \mid p_2] = E[q \mid p_2]$.

Even though buyers may try to infer the firm's observation of q_N upon the observed price, in what follows, we show that if the inference is a Bayesian updating, then the price is completely uninformative. Thus, the optimal price will be uncorrelated with q_N, i.e. no inference rule can be an equilibrium. To see this, suppose that buyers made inferences according to the rule $p_2 = \phi(q_N)$. If the monopolist charges $\overline{p}$ then:

$$\overline{X}_2 = a + E[q \mid \phi(q_N) = \overline{p}] - \overline{p}.$$

Therefore, second-period expected profits, $E[\pi_2 \mid q_N]$, do not depend on q_N:

$$E[\pi_2 \mid q_N] = (a + E[q \mid \phi(q_N) = \overline{p}] - \overline{p})\overline{p}. \tag{2}$$

Hence, the optimal price $\bar{p}$, i.e. the price that maximizes (2) does not depend on q_N either, i.e. it is not a random variable. Therefore, in equilibrium $E[q \mid p_2] = E[q] = 0$ and $\bar{p} = a/2$.

Even though customers are rational and sophisticated and therefore, basing upon the observed price, may want to infer the value of $\overline{X}_1$ (and hence that of q_N), we have seen above that no inference rule can be an equilibrium.[18] The intuition is as follows. If buyers inferred seller's private information from the price, the monopolist, by means of his pricing behavior, would induce an incorrect belief on the part of consumers, which would result in higher profits after all. Consumers understand these incentives that any "type" of seller has, and therefore anticipate that if they made purchases according to an expectations rule such as $q_N = \varphi(p_2)$, they would be dissatisfied after consuming the good almost surely. As a result, they should expect any quality after observing any price. In equilibrium, consumers will disregard any information conveyed through the price, i.e. their posterior belief will equal their prior, for all p_2. This indeed causes the price to be uncorrelated with observed past-sales. The next lemma summarizes:

Lemma 1 *If the seller commits to conceal past-sales, then the unique second-period equilibrium price is* $p_2^c = \frac{a}{2}$, *which gives profits* $\pi_2^c = \frac{a^2}{4}$.

The pooling nature of this equilibrium (price does not depend on q_N) stems from the facts that the only device available for the seller through which it can

[17] Notice that although second-period consumers also observe the first-period price, this is not informative since the seller's choice was not contingent on any private information.

[18] Note again that knowing past-sales is equivalent to knowing q_N since first-period prices are assumed to be observable. Therefore, we can talk about advertising $\overline{X}_1$ and q_N interchangeably. Of course, empirically, the natural is to talk about revealing quantities sold, i.e. $\overline{X}_1$.

communicate its information is the price, and that consumers do not have extra sources of information. Buyers cannot trust any information signalled through the price since any type of seller has the same incentives to signal a high q_N.[19]

Suppose now that the seller commits to reveal its past-sales data prior to observe them. The important issue here is that by sharing this information with the consumers, the monopolist allows buyers to calculate q_N and, consequently, to make decisions based on more precise information. In second-period, consumers are now as well informed as the firm, i.e. $\Omega_2^i = I_2$ for all i. Suppose that the firm charges $\overline{p}$. Then, consumers' average aggregate belief will be $q_{2N} = E[q \mid q_N, p_2 = \overline{p}]$, which equals $E[q \mid q_N]$, since the price does not add any extra information. Then average demand will be $\overline{X} = a + E[q \mid q_N] - \overline{p}$ and expected second-period profits

$$E\pi_2 = (a\overline{p} - \overline{p}^2 + \overline{p}E[q \mid q_N]).$$

The optimal price is therefore

$$\overline{p} = \frac{a + E[q \mid q_N]}{2}.$$

By substituting this price into the profit function, we obtain $E\pi_2 = \overline{p}^2$. The following lemma summarizes:

Lemma 2 *If the seller commits to reveal its past-sales data, then the unique second-period equilibrium price is* $p_2^r = \frac{a+E[q|q_N]}{2}$ *and the optimal second-period profit is* $\pi_2^r = \left(\frac{a+E[q|q_N]}{2}\right)^2$.

An important characteristic of this equilibrium is that some "herding" behaviour on the part of the consumers occurs. And it happens as a result of their

[19]In the Industrial Organization literature, however, there are many models where prices charged by fully informed sellers signal qualities (see Bagwell and Riordan (1991), Milgrom and Roberts (1986), Wolinsky (1983) *inter alia).* What are the key elements in our model that preclude the existence of a signaling (separating) equilibrium? In first place, the absence of both cost asymmetries and repeated purchases. In a single-period model, Bagwell and Riordan (1991) show that separation is achieved in equilibrium when higher quality firms have higher costs of production. By pricing sufficiently above the optimal price under complete information, the seller signals high-quality in equilibrium. But even when cost asymmetries are negligible, a high quality type may distinguish himself from a low one whenever repeated purchases play an important role in the market: Milgrom and Roberts (1986) show, in the spirit of Nelson (1970, 1974), that a high-quality seller can convince consumers that he sells a high-quality good by charging a high price (and/or by spending certain amount of money in uninformative advertising) when buyers repeat purchases. The fact that consumers will be satisfied after consumption and make new purchases in the future allows the seller to recover relative losses due to such a "too-high" pricing policy (or due to the expenses in uninformative advertising). Consumers understand this reasoning and rationally infer high-quality from a high price (or high advertising expenditures).

In second place, and as we will see in the next section, the fact that consumers do not receive external information is crucial for the absence of separating equilibria here. In a related paper, Judd and Riordan (1994) demonstrate that when consumers have information of their own, then signaling may occur in equilibrium. In Section 4 we extend our analysis to allow for this possibility.

rational behaviour. It is simply due to the fact that buyers prefer to employ the information revealed, rather than disregard it, because, on average, allows them to compute more precise estimations. This does not necessarily mean that buyers ex-post utilities will be higher, but it is the best consumers can do ex-ante. Imagine, for instance, that the drawn q is low and the realized noise is biased toward positive and high values. This means that first-generation consumers will demand much (ex-post utility will be low, however, and buyers will be relatively dissatisfied). Second-generation buyers, observing sales data will also demand much and there will be dissatisfaction again. However, second-generation consumers cannot do better than "following the crowd" at the time to make decisions.[20] According to our model, the success or failure of new products may very well depend on non-controllable market forces such as consumers external signals. Also, the importance of firms' "hidden" efforts at the time to introduce new goods to drive positive signals are clearly highlighted. These features appear repeatedly throughout.

We are now ready to state that:

Theorem 1 *Suppose that the seller must commit either to reveal or to conceal his past-sales. Suppose further that the cost of advertising is fixed $c > 0$. Then, the monopolist commits to deliver sales data if and only if $4c < E[E^2[q \mid q_N]]$.*

Proof. First, note that first-period profits are identical since in both situations the seller is completely uninformed. Consequently we can abstract from them. By concealing, the seller obtains expected profits $E[\pi_2^c] = \frac{a^2}{4}$. By revealing past-sales, expected benefits are $E[\pi_2^r] = E\left[\left(\frac{a+E[q|q_N]}{2}\right)^2\right] - c = \frac{a^2}{4} + \frac{E[E^2[q|q_N]]}{4} - c$. By establishing a comparison between optimal profits in the two cases, the theorem follows. QED

Remark 1 *Note that $E[E^2[q \mid q_N]] > 0$. If $E\left[q|q_N\right] \neq 0$ this is immediate. Suppose now that $E\left[q|q_N\right] = 0$. Since q and ϵ_N are independent, we have that $E[q\epsilon_N] = E[q]E[\epsilon_N] = 0$ Thus $E\left[q^2\right] = E\left[q\left(q+\epsilon_N\right)\right] = E\left[qq_N\right] = E[E\left[q|q_N\right]q_N] = 0$ a contradiction.*[21]

To gain some intuition about the condition in Theorem 1, let us look at the case where random variables are normally distributed. The condition reduces to $4c < \frac{\sigma_q^4}{\sigma_q^2+\sigma_\epsilon^2/N}$. Therefore, it tends to be satisfied when the number of consumers is high, and the noise of the informative signals and advertising cost is low.

[20] We believe that this type of situation may explain patterns of behaviour as, for instance, those observed in restaurants at touristic places. Casual empiricism tells us that a particular restaurant may be crowded certain day while another restaurant located just around the corner is relatively empty. The next day, however, it may very well happen the opposite. Becker (1991) argues that his may happen because consumers behaviour exhibit bandwagon effects. Our explanation, contrarily, is based on information.

[21] We are indebted to Claudio Landim, who showed us the later part of this proof.

The seller may not be obliged to conceal or reveal past-sales before the market opens. Instead, he may want to make this decision after gaining some experience, that is, after knowing how the product performs in the market. This raises an interesting problem that we next address. Suppose the seller commits neither to conceal nor to reveal $\overline{X}_1$. Recall that second-period optimal profits when the firm advertises and conceals past-sales are π_2^r and π_2^c respectively. By comparing these profits, it is easily seen that $\pi_2^r > \pi_2^c$ if and only if

$$(a + E[q \mid q_N\ ])^2 - 4c - a^2 = 2aE[q \mid q_N\ ] + E^2[q \mid q_N\ ] - 4c > 0.$$

Therefore, whether or not the seller obtains higher second-period profits by advertising past-sales depends on the observed $\overline{X}_1$, or, in other words, on the realizations of q_N. The relevant issue now consists of finding the equilibrium situation under these circumstances. One might be tempted to think that the seller will only advertise its observed $\overline{X}_1$ whenever $\pi_2^r > \pi_2^c$, i.e. as long as it receives "good news", in the sense that $2aE[q \mid q_N] + E^2[q \mid q_N] - 4c > 0$. But if this were so, then rational consumers should take this into account, and whenever they do not observe advertising, make the appropriate inferences. This makes the problem more interesting (although more complicated) since now the mere adoption of the strategy concealing-sales-information is informative for the consumers. The decision itself conveys information about the seller's observation. In what follows, we analyze the optimal advertising policy in this situation.

First, we define an advertising policy. Then, we define an advertising equilibrium and characterize it.

Definition 1 *An advertising policy is a set $A \subset \mathbb{R}$ such that $\{\omega \in \Omega; q_N(\omega) \in A\} \in \mathcal{A}$.*

Definition 2 *An advertising equilibrium is an advertising policy A and a pricing function $p(q_N) = p(A)\chi_A(q_N) + p(A^c)\chi_{A^c}(q_N)$, where χ_C denotes the characteristic function of the set C, such that:*

(a) *$p(A)$ (respectively $p(A^c)$) is optimal if $q_N \in A$ (respectively A^c).*

(b) *Consumers conjectures about the advertising policy A are correct.*

Theorem 2 *Suppose that the cost of advertising past sales is $c > 0$. Suppose also that the cumulative distribution of q_N is strictly increasing. Then there are μ, u and v such that the optimal advertising policy is $A = \mathbb{R} \setminus (u, v)$, where*

$$E[q \mid q_N \in [u, v]] = \mu,$$

$$u = -a - \sqrt{4c + (a + \mu)^2}, \text{ and } v = -a + \sqrt{4c + (a + \mu)^2}.$$

Proof. Suppose $B \subset \mathbb{R}$ is an advertising policy. As we have seen before, if the firm advertises previous sales, the optimal price is $\overline{p} = \frac{a+E[q|q_N\ ]}{2}$. If the firm does not advertise and charges p, consumers infer that $q_N^{-1}(B^c)$ occurred and hence the average demand is $\overline{X}_2 = a + E[q \mid q_N^{-1}(B^c)\ ] - p$. Therefore, the optimal price if the firm does not advertise is $\overline{p} = \frac{a+E[q|q_N^{-1}(B^c)]}{2}$. Firm's profits are then

$$\pi = \left(\left(\frac{a + E[q \mid q_N\ ]}{2}\right)^2 - c\right)\chi_B + \left(\frac{a + E[q \mid q_N^{-1}(B^c)]}{2}\right)^2 \chi_{B^c}. \qquad (3)$$

To save on notation, write $x = E[q \mid q_N\ ]$ and $y = E[q \mid q_N^{-1}(B^c)\ ]$. The firm will advertise q_N if and only if $(a+x)^2 - 4c \geq (a+y)^2$. Equivalently, whenever $|a+x| \geq \sqrt{4c+(a+y)^2}$. That is, for all $x \in \mathbb{R} \setminus (-a-\sqrt{4c+(a+y)^2}, -a+\sqrt{4c+(a+y)^2})$. Therefore B is optimal if and only if

$$B = \mathbb{R} \setminus (-a-\sqrt{4c+(a+y)^2}, -a+\sqrt{4c+(a+y)^2})$$

and

$$y = E[q \mid q_N \in (-a-\sqrt{4c+(a+y)^2}, -a+\sqrt{4c+(a+y)^2})].$$

The last equation allows us to determine y. Define $u = -a-\sqrt{4c+(a+y)^2}$ and $v = -a+\sqrt{4c+(a+y)^2}$. Then, y must solve the implicit equation

$$y = \frac{\int_{q_N \in (u,v)} q\ dP(\omega)}{P\left(q_N \in (u,v)\right)}. \qquad (4)$$

We may substitute $E[q \mid q_N]$ for q if desired. To prove the existence of such a y consider the function $g : \mathbb{R} \to \mathbb{R}$,

$$g(y) = \frac{\int_{q_N \in \left(-a-\sqrt{4c+(a+y)^2}, -a+\sqrt{4c+(a+y)^2}\right)} q\ dP(\omega)}{P\left(q_N \in \left(-a-\sqrt{4c+(a+y)^2}, -a+\sqrt{4c+(a+y)^2}\right)\right)} - y.$$

The denominator is never zero since the distribution of q_N is strictly increasing. Therefore $g(\cdot)$ is a continuous function. Since $\lim_{y\to\infty} g(y) = -\infty$ and $\lim_{y\to-\infty} g(y) = \infty$ there is a μ such that $g(\mu) = 0$. QED

Remark 2 *The solution for $c = 0$ is more delicate since the set A^c will be a zero measure set. Then Bayes' rule is not well defined when A^c occurs. If consumers for instance consider that $E[q \mid q_N] = -a$ when they do not observe past-sales, then, in equilibrium, the firm almost always advertises.*

Figure 1 illustrates Theorem 2. In equilibrium, the seller delivers the information whenever q_N lies in the set A. Otherwise, the seller conceals the information (set B). Notice that values of q_N at the left of u imply that demand is probably negative. Since $E[q \mid q_N]$ is a monotonic function of q_N, the monopolist advertises whenever he believes that the good is of relatively high quality. Notice also that the no-advertising set is non-empty provided advertising cost is positive. Therefore, costly full revelation never occurs.

<insert Figure 1 here>

To illustrate the necessary calculations to obtain μ, u and v, let us suppose that q is uniformly distributed in $[-1,1]$. Further, suppose that first-generation consumers signals are such that $q_N = q$, i.e. the seller is fully informed about q after first-period. From equation (4) we obtain

$$\begin{aligned}\mu &= \frac{\int_{\max\{-1,u\}}^{\min\{1,v\}} x dx}{\min\{1,v\} - \max\{-1,u\}} = \frac{\min\{1,v\}^2 - \max\{-1,u\}^2}{2(\min\{1,v\} - \max\{-1,u\})} \\ &= \frac{\min\{1,v\} + \max\{-1,u\}}{2}.\end{aligned}$$

Consider the following examples.

Example 1: If $4c \geq 1 + 2a$ we have that $\mu = 0$, $u = -a - \sqrt{4c + a^2} \leq -1$ and $v = -a + \sqrt{4c + a^2} \geq 1$ are solutions. Thus, in this case advertising never occurs (see Figure 2).

Example 2: Let us suppose now that $4c < 1 + 2a$ and for definiteness that $a > 1$. Then $u \leq -1$, $v = \frac{-1-2a+2\sqrt{(1-a)^2+12c}}{3} \in (-1,1)$ and $\mu = \frac{v-1}{2}$. If $a = 5$ and $c = 1$, advertising occurs if $q > -0.1389$ (see Figure 2).

Example 3: If $a = 0.5$ and $c = 0.01$, then we have that advertising occurs for all $q \in [-1,-0.7) \cup (-0.3,1]$ (see Figure 2).

<insert Figure 2 here>

Observe that in general the set of events for which advertising occurs shrinks as c increases. In fact, if c is very large relative to a, advertising never occurs.

The natural question arising now is the following. Would a seller want to commit to deliver past-sales data before observing them or, rather, prefer to wait to extract information about the product's performance in the market and then decide whether or not to advertise? We answer next.

Theorem 3 (It is better to wait.) *Suppose that advertising cost c is independent of whether firm commits to release past-sales before market opens or whether firm advertises after observing its sales. Then, firm's expected profit is higher if it waits to observe first-period sales and makes its decision about advertising past-sales contingent on its observation.*

Proof. We need to compare expected profits when the firm commits either to reveal ($\pi_2^r = E\left(\frac{a+E[q|q_N\ ]}{2}\right)^2 - c$) or to conceal past-sales data ($\pi_2^c = \frac{a^2}{4}$), with the expected profit of waiting to make a decision about revealing or not past sales. If this latter case, expected profit is, using (3):

$$\pi^w = E\left[\left(\left(\frac{a + E[q \mid q_N\ ]}{2}\right)^2 - c\right)\chi_B + \left(\frac{a + E[q \mid B^c]}{2}\right)^2 \chi_{B^c}\right]$$

where B is the optimal advertising set. We see from the proof of theorem 2 that $B=\left\{\omega\in\Omega;\left(\frac{a+E[q|q_N\ ]}{2}\right)^2-c\geq\left(\frac{a+E[q|B^c]}{2}\right)^2\right\}$. Thus we have that

$$\pi^w=E\left[\max\left\{\left(\frac{a+E[q\mid q_N\ ]}{2}\right)^2-c,\left(\frac{a+E[q\mid B^c]}{2}\right)^2\right\}\right]\geq$$
$$E\left(\frac{a+E[q\mid q_N\ ]}{2}\right)^2-c=\pi_2^r.$$

Analogously we prove that $\pi^w\geq\pi_2^c$. QED

In accordance to this result, a bookseller should not join a bookseller list without knowing the performance of its book in the market. Similarly, firms' modern practices such as the above mentioned PTs are not found to be optimal strategies. However, these real-world observations can be easily accommodated in our model by assuming that the advertising effectiveness is different across strategies. This may very well be the case for booksellers. It is reasonable to assume that the effectiveness of the information released by the American Bookseller Association (ABA) is higher that individual sellers advertisements simply because buyers are into the habit of looking at the ABA lists. In the model, this would be embodied by assuming advertising cost when firm commits to deliver past-sales before market opens, c_1, to be lower than cost of delivering sales information after having observed it, c_2, $c_1<c_2$. This would accommodate the empirically observed facts.

In what follows, we extend the analysis to allow for better informed second-generation consumers. Unfortunately, we have not been able to carry out an analysis as general as before regarding the distribution functions of the random variables. From now on, we assume that all variables are normally and independently distributed as follows: $q\sim N(0,\sigma_q^2)$, $\epsilon_1^i\sim N(0,\sigma_{\epsilon_1}^2)$, $\epsilon_2^i\sim N(0,\sigma_{\epsilon_2}^2)$. According to this, the private information to the firm after first-period interaction is $q_N=\delta_1(q+\frac{1}{N}\sum_{i=1}^N\epsilon_1^i)$, where $\delta_1=\frac{\sigma_q^2}{\sigma_q^2+\sigma_{\epsilon_1}^2}$.

4 Extensions: Second-generation consumers are better informed.

We now assume that second-period consumers exogenously receive extra information about the unknown quality parameter through the signals $s_2^i=q+\epsilon_2^i$, $i=1,...,N$. We proceed following the same steps as above.

Suppose for the moment that the monopolist commits to conceal the value of $\overline{X}_1$ before experiencing in the market. In the second-period, consumer i's information set is $\Omega_2^i=\{s_2^i,p_2\}$, $i=1,...,N$. As Judd and Riordan (1994) show, a signalling equilibrium does exist when consumers have an extra piece of information. Signalling emerges due to the fact that buyers have corroborating information of their own (here their private signals). In what follows, we characterize such an equilibrium.[22]

Suppose the firm charges $\bar{p}$. Then second-generation consumer i's demand will be given by

$$x_2^i = a + E[q \mid s_2^i, p_2 = \bar{p}] - \bar{p}.$$

As in the previous section, consumers may try to infer past-sales upon the observed price.[23] As it is usual in linear-normal-quadratic models, we focus on the case where agents employ linear rules for their decisions.[24] Suppose that consumers make inferences using the linear rule $p_2 = \alpha + \beta q_N$, $\beta \neq 0$. Since all variables are normally distributed, there are u and v such that $E[q \mid s_2^i, q_N] = us_2^i + vq_N$.[25] We also need that $E[s_2^i \mid q_N] = E[q \mid q_N]$ and $E[q \mid q_N] = hq_N$.[26]

Lemma 3 *It is true that $uh + v = h$.*

Proof. $E\left[q \mid q_N\right] = E\left[E\left[q \mid s_2^i, q_N\right] \mid q_N\right] = E\left[us_2^i + vq_N \mid q_N\right] = uE\left[s_2^i \mid q_N\right] + vq_N = uE[q \mid q_N] + vq_N$. Thus $E[q \mid q_N] = \frac{v}{1-u} q_N = hq_N$. Hence $v = (1-u)\,h$ ending the proof. QED

Average aggregate demand will be

$$\overline{X}_2 = a + \frac{u}{N} \sum_{i=1}^{N} s_2^i + v \frac{\bar{p} - \alpha}{\beta} - \bar{p}.$$

The firm maximizes expected profits conditional on its information set $I_2 = \{\overline{X}_1\} = \{q_N\}$, that is

$$E\pi_2 = \bar{p} \left(a + uE[q \mid q_N] + v \frac{\bar{p} - \alpha}{\beta} - \bar{p} \right).$$

Therefore, the optimal price is

$$p^c = \frac{a + uhq_N - v\alpha/\beta}{2(1 - v/\beta)}.$$

Since the customers' inference rule must be correct in equilibrium, it must be the case that

$$\alpha = \frac{a - v\alpha/\beta}{2(1 - v/\beta)} \text{ and } \beta = \frac{uh}{2(1 - v/\beta)}. \tag{5}$$

Solving the preceding system of equations (5) we obtain $\beta = \frac{h+v}{2}$ and $\alpha = \frac{a(h+v)}{2h}$. So the optimal pricing rule is

$$p_2^c = \frac{a\,(h+v)}{2h} + \frac{h+v}{2} q_N. \tag{6}$$

[22]Looking here at pooling equilibria is uninteresting because we would fall back to the results of the previous section.

[23]Clearly, consumers would like to infer seller's observation since estimates of q conditional on a larger set of information are more precise than those conditional on smaller sets.

[24]See Caminal and Vives (1996), Gal-Or (1985, 1986) and Vives (1984) *inter alia.*

[25]Explicitly, $u = \frac{\sigma_{\epsilon_1}^2 \sigma_q^2}{\sigma_{\epsilon_1}^2 \sigma_q^2 + N\sigma_q^2 \sigma_{\epsilon_2}^2 + \sigma_{\epsilon_2}^2 \sigma_{\epsilon_1}^2}$ and $v = \frac{u\sigma_{\epsilon_2}^2}{\delta_1 \sigma_{\epsilon_1}^2}$.

[26]Namely, $h = \frac{\sigma_q^2}{\delta_1 (\sigma_q^2 + \sigma_{\epsilon_1}^2 / N)}$.

Equilibrium profits are easily computed:

$$\pi_2^c = \frac{uh}{h+v}\left(p_2^c\right)^2 = \frac{u\left(h+v\right)}{4h}\left(a+hq_N\right)^2. \tag{7}$$

The following lemma summarizes:

Lemma 4 *Suppose second generation consumers exogenously receive informative signals $s_2^i = q + \epsilon_2^i$, $i = 1, ..., N$. Suppose also that the monopolist commits to conceal past-sales information. Then, there exists a linear separating equilibrium where the firm charges the price given by (6) and obtains profits given by (7).*

Note that the coefficient of q_N is positive, i.e. $h + v > 0$. This means that the higher the observation of q_N (hence the firm's estimation of q), the higher is the price charged in the separating equilibrium. Since consumers' inference rule is correct in equilibrium, higher prices signal higher firm's *expected* qualities.[27]

We now investigate the optimal pricing rule and profits when the firm commits to reveal its past-period sales. If consumers are informed about the value of $\overline{X}_1$, they can compute q_N. Therefore, on average, they will demand

$$\overline{X}_2 = a + \frac{u}{N}\sum_{i=1}^{N} s_2^i + vq_N - p_2.$$

Expected profits will be

$$E\pi = p_2(a + uhq_N + vq_N - p_2) = p_2(a + hq_N - p_2)$$

since $uh + v = h$. Equilibrium price will therefore be[28]

$$p_2^r = \frac{a + hq_N}{2}. \tag{8}$$

As before, parameters α and β must be such that $\alpha = \frac{a}{2}$ and $\beta = \frac{h}{2}$. Equilibrium profits are in this case

$$\pi_2^r = (p_2^r)^2 = \left(\frac{a + hq_N}{2}\right)^2. \tag{9}$$

We are now ready to state that:

Theorem 4 *Suppose that the seller must commit either to reveal or conceal his past-sales. Suppose further that the cost of advertising is $c > 0$. Then, information is revealed in equilibrium if and only if parameters satisfy*

$$4c < a^2\left(\frac{v(1-u)}{h}\right) + \delta_1\sigma_q^2 v(1-u).$$

[27] An interesting observation is that when $\sigma_{\epsilon_2}^2$ converges to infinity, i.e. second-period signals are not informative, the coefficient of q_N converge to zero. This would be the case where price is uncorrelated to quality, i.e. a pooling situation.

[28] Notice that $p_2^r < p_2^c$ for all $q_N > 0$. This fact exhibits the usual upward price distortion occurring in separating equilibria.

Proof. By concealing past sales information the seller obtains expected benefits $E[\pi_2^c] = E\left[\frac{uh}{h+v}(p_2^c)^2\right] = \frac{uh(h+v)}{4}\left[\frac{a^2}{h^2} + E[q_N^2]\right]$. By revealing, the monopolist gets expected profits $E[\pi_2^r] = E\left[(p_2^r)^2\right] - c = E\left[\left(\frac{a+hq_N}{2}\right)^2\right] - c$. By comparing, $E[\pi_2^c]$ and $E[\pi_2^r]$ and using the fact that $E[q_N^2] = \frac{\delta_1 \sigma_q^2}{h}$, the theorem follows. QED

To end this section, we study whether a firm facing better informed second-generation consumers would also prefer to wait to gain experience before deciding on advertising. After all, matters are easier here. The reason is simple. If the firm does not advertise, consumers infer the observation of the seller by means of its price. So, the fact that the firm does not deliver information does not add any extra information which is not conveyed through the price. Note that if the firm advertises its past-sales, the optimal price is $p^r = \frac{a+hq_N}{2}$. On the contrary, if sales information is not delivered, consumers suppose that the pricing function is $p^c = \frac{u(h+v)}{h}p^r$. Then, the firm will advertise if and only if $\pi_2^r - c \geq \pi_2^c$, i.e. whenever

$$(a + hq_N)^2 \geq 4c + \frac{u(h+v)}{h}(a + hq_N)^2.$$

Collecting terms and simplifying, we obtain that advertising occurs if q_N does not lie on the set

$$\left(-\frac{a}{h} - 2\sqrt{\frac{c}{hv(1-u)}}, -\frac{a}{h} + 2\sqrt{\frac{c}{hv(1-u)}}\right). \tag{10}$$

In this case, provided that advertising cost is independent of whether the seller employs strategies "committing to reveals sales" or "waiting to observe them and then decide", it is evident that a seller would always prefer to wait to observe q_N and then decide whether to reveal past-sales information or not. The following result summarizes:

Theorem 5 *Suppose second-generation consumers exogenously receive informative signals $s_2^i = q + \epsilon_2^i$, $i = 1, ..., N$. Suppose also that advertising cost is $c > 0$. Then there is an advertising-separating equilibrium where (a) the seller advertises $\overline{X}_1$ iff q_N does not fall in set 10 and charges price 8, and (b) the seller conceals the value of $\overline{X}_1$ iff q_N lies on set 10 and charges the separating price 6.*

5 Conclusions

This paper studies the questions why and when a firm communicates its private information about sales. In a market where past-sales contain (noisy) information about product's quality, we have shown that a monopolist has typically an incentive to not conceal its private sales-data. By making such an information available to consumers, the supplier allows them to estimate the quality of the good with a higher accuracy. After all, past-sales are an indicator of the buyers' aggregate belief, which contains a more precise information than individual signals provided that buyers from different cohorts exhibit similar tastes.

We have shown that even when providing information about past-sales is costly, the seller may find profitable to invest some resources in advertising them. Particularly, as expected, if the monopolist obtains a demand relatively large (and hence he infers that quality is relatively high) and advertising is not prohibitively costly, the benefits from facing better-informed consumers are higher than the advertising expenses. More interestingly, the cheaper the advertising cost, the more a firm that expects to have low quality is interested in revealing itself as it is. Nevertheless, it is also shown that provided that advertising costs are positive, full revelation never occurs.

An interesting feature of our model is that the seller endogenizes some herding behaviour on the part of the consumers by advertising past-sales. Buyers, either having available other sources of information or not, can compute (ex-ante) more precise estimates of unknown parameters when the seller releases its private information acquired in previous market openings. Notice however that information released through past-sales advertisements is useful ex-ante but may be misleading ex-post. As a result of the rational behaviour of both seller and consumers, herding may occur in the sense that, since buyers base their decisions on noisy signals transferred through advertising activities to successors, even if quality is low, buyers may demand much simply because realized noisy signals were biased toward high values at the commencement of the market.

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