

# Dynamic Pricing with Consumer-Generated Information

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## Abstract

We study a firm's pricing strategy in response to consumer-generated information (online word-of-mouth). The firm sells durable goods to consumers over two periods. After the first period sales, an aggregated signal about the second period demand is generated. The precision of consumer-generated information depends on the size of the user base in the first period. We show that, although a firm has no control over the content of information, it always cuts the first-period price to induce information (comparing to the case where there is no consumer-generated information). The consumer-generated information increases the firm's profitability.

**Keywords:** consumer-generated information, dynamic pricing, experience goods, durable goods, online word-of-mouth

## 1. Introduction

Consumer-generated information is essentially accessible to everyone with an Internet connection. Such information has started playing an increasingly important role in consumer decision making. According to a survey conducted by Nielsen, 26% of Internet users report that they have contributed online product reviews, and 61% report that they have found online consumer-generated product information valuable and trustworthy (Dellarocas et al. 2010). Empirical research also confirms that past consumer ratings have

significant impacts on future product demand in different experience product markets, such as books, music, movies, and computer games (e.g. Chevalier et al. 2006, Liu 2006, Zhu and Zhang 2010). The broad accessibility of consumer-generated product information, fundamentally changes the dynamics of the information structure and market demand.

However, little theoretical research provides guidance on how firms should respond to the new market condition. This paper attempts to fill the gap. Our research questions are: What pricing strategy should a firm adopt when consumer-generated product information affects future demand? Does the consumer-generated information increase (or decrease) a firm's profitability?

We answer these questions with a model where a monopoly firm sells a newly launched durable product to consumers over two periods. After sales in the first period, an aggregated signal about the uncertain demand is generated through consumer experience sharing. If first-period consumers report positive (negative) feedbacks, the second-period-demand is high (or low). The precision of the product signal depends on the first-period sales. The firm makes price decisions in both periods. The first-period price plays two roles. First, it determines the profit margin of period 1; second, it influences the precision of the information about the second-period demand. We derive the firm's optimal pricing strategy, and then identify the impact of consumer-

generated information on the firm's profitability.

Based on our model, several interesting results are derived. First, there may be a downward bias to the first period price with consumer-generated information compared to the price without consumer-generated information. We dub this as the *early-period price cut*. Although a price-cut reduces the firm's profit in the first period, the loss is outweighed by the value of the consumer-generated information. Second, although unfavorable information may be generated which hurts the second-period-demand, the consumer-generated information never makes the firm worse off in terms of the expected total profit over the two periods. In contrast to the previous understanding that firms primarily use favorable (or even manipulate) online reviews to drive up the demand (e.g. Kuksov and Xie 2010), we show that online consumer word-of-mouth is an important marketing instrument for resolving uncertainty (rather than for boosting expectation).

This paper contributes to the literature on a firm's reactions and proactive efforts to deal with consumer-generated information diffusion. Chen and Xie (2008) study a firm's marketing communication strategy in response to online consumer reviews. Kuksov and Xie (2010) investigate a model where consumers use previous consumer ratings to update their beliefs about the product's value. In contrast, we treat consumer reviews as an aggregate level informative signal of demand that is not subject to a firm's manipulation.

This research broadly adds to the literature in economics about dynamic pricing with consumer learning. In this line of inquiries, Bergemann and Valimaki (2006) study a monopolist's pricing trajectory in a perishable experience goods market in the presence of self-learning. Bose et al. (2006, 2008) study a monopolist's dy-

namic pricing strategy when buyers learn about product value from past purchase decisions and prices. In contrast, we study the pricing strategy in the durable goods market where consumers learn from online word-of-mouth.

Our work relates to the literature on the impacts of a firm's manipulation of online customer reviews, e.g. Dellarocas (2006) Mayzlin (2006), etc. In contrast to these papers, we focus on a firm's use of pricing strategy to adapt to consumer-generated information, instead of attempting to directly manipulate the content of that information to its advantage.

The rest of this paper is organized as follows. Section 2 introduces the model setup and examines the effects of consumer-generated information on the firm's pricing strategy and profit. Section 3 concludes.

## 2. Model Setup and Analysis

A monopoly firm launches a new durable product and sells it to consumers over two consecutive periods ( $t = \{1,2\}$ ). Assume that the demand for the product in period  $t$  is  $D(p_t) = A + \theta - p_t$ , where  $A$  is the average market potential,  $p_t$  is the price in period  $t$ , and  $\theta$  is a random variable representing demand uncertainty, with mean  $E[\theta] = 0$  and variance  $Var[\theta] = \sigma^2$ . After the first period sales, consumers share their experience about the product online, which influences the demand in the second period. For example, first-period consumers report positive (negative) feedbacks, the demand in the second period is optimistic (pessimistic). Formally, an aggregate level signal  $Y$  about  $\theta$  is generated by first-period consumers. The sequence of events is as follows:

1. At the beginning of period 1, the firm sets price  $p_1$ .
2. At the end of period 1, consumers ex-

perience the product and generate a signal  $Y$  about the uncertain demand  $\theta$ .

3. At the beginning of period 2, the firm sets price  $p_2$  based on  $Y$ .

## 2.1. Benchmark: No Consumer-Generated Information

Without consumer-generated information (i.e., signal  $Y$ ), the firm faces identical markets in the two periods. In particular, the firm maximizes its single-period expected profit  $\pi = p_1^* E[D(p_1)]$ , which leads to the optimal price  $p_B = A/2$  and the corresponding optimal profit  $\pi_B = A^2/4$ .

## 2.2. Pricing and Profit with Consumer-Generated Product Information

Assume that the joint probability distribution of  $(\theta, Y)$  satisfies the following conditions: (C1)  $E[Y|\theta] = \theta$ , that is, the signal is unbiased; and (C2)  $E[\theta|Y] = kY$ , where  $k$  is a constant. The information structure implied by conditions (C1) and (C2) is general enough to include a variety of Bayesian updating structures with conjugate prior-posterior pairs such as the Normal-Normal, the Gamma-Poisson, and the Beta-Binomial pairs. The expected conditional precision of signal  $Y$  is  $1/E[\text{Var}[Y|\theta]]$ . Define  $t = \sigma^2/E[\text{Var}[Y|\theta]]$ , and  $t$  is an indicator of precision of the signal. We can show that  $E(\theta|Y) = tY / (1 + t)$  (e.g., Li 2002).

The signal precision is determined by the first-period sales. We assume that the precision indicator  $t$  increases in  $D(p_1)$  and hence decreases with  $p_1$ . Formally, let  $t = r(p_1)$ , where  $r(\cdot)$  is a decreasing function with  $r'(\cdot) < 0$ . Given a signal  $Y$ , the firm's optimal second-period price is given by  $p_2(Y) = A/2 + tY/(2(1+t))$ , and her second-period profit is  $\pi_2(Y) = (A + tY/(1 + t))^2/4$ . The firm's expected profit in the second period is  $\pi_2 = A^2/4 + t\sigma^2/4(1+t)$ .

**Lemma 1.**  $\pi_2 > \pi_B$ . Consumer-generated information adds value to the firm in the second period.

We call  $\pi_2 - \pi_B$  the value of information. At the beginning of the first period, the firm chooses  $p_1$  to maximize her total profit over the two periods  $\Pi(p_1) = p_1(A + E[\theta] - p_1) + A^2/4 + t/(4(1+t))\sigma^2$ . The first order condition w.r.t.  $p_1$  is  $A - 2p_1 + \sigma^2 / (4(1 + r(p_1))) r'(p_1) = 0$ . Since  $r'(p_1) < 0$ , the optimal  $p_1^*$  is smaller than  $p_B$ .

**Proposition 1.**  $p_1^* < p_B$ . With consumer-generated information, the firm sets a lower price in the first period, comparing to the benchmark case.

Reducing first-period price to induce consumer-generated information can benefit the firm in the second period, but it harms the firm's profitability in the first period. However, the benefit from information generation outweighs the loss from price reduction. We call the price difference,  $p_B - p_1^*$ , the firm's *early-period price cut*. Interestingly, we find that it is never in the interest of the firm to raise price to prevent consumer information sharing although she has little control over the signal generated. This is because the value of information is always positive (Lemma 1). Increasing first-period price not only hurts the firm's first-period profit (compared to the benchmark case), but it also reduces the benefit from getting more precise information.

**Proposition 2.**  $\Pi(p_1^*) > 2\pi_B$ . The firm always benefits from consumer-generated information.

Even though online consumer word-of-mouth is hardly controllable by the firm, the firm should nevertheless encourage consumer information sharing. Consumer-generated information helps the firm to resolve the market uncertainty. Thus, the firm can fine-tune her price accordingly.

Propositions 1 and 2 explain why more and more firms are sponsoring customer communities and encouraging consumer discussions in the market for experience goods such as books, music, and computer games. They also help to explain the rationale behind the price discount and trial use of products that are newly launched.

### 3. Conclusion

In this paper, we study a two-period dynamic pricing model where early consumers generate information influences the future demand. We find that consumer-generated information adds value to the firm. The firm makes an early-period price cut to induce consumer experience sharing and to get more precise information.

The results of this paper have important managerial implications. Online consumer word-of-mouth is a critical information source that the firm can use in making price decisions. Our results suggest that firms should adapt to the new market condition proactively. It is unwise for the firm to withdraw from facilitating online consumer word-of-mouth even if she feels intimidated by unfavorable news. Anticipating consumer-generated information, the firm should set a lower “introduction” price so that they can gain from that information. The firm should try to educate consumers and help them to generate objective evaluations which can increase the precision of consumer opinion.

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