Online Consumer Review:
A New Element of Marketing Communications Mix

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July 2004

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The authors would like to thank Joseph Alba, David Sappington, Steven Shugan, Barton Weitz, and participants in Marketing Science Conference at Maryland (2003) and 6th Invitational Choice Symposium at CU-Boulder (2004) for their helpful comments.
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Abstract

Online consumer product review is an emerging market phenomenon that is playing an increasingly important role in consumers’ purchase decisions. This paper examines a fundamental issue concerning online consumer review, i.e., the functions such reviews have for an online marketer. We argue that online consumer reviews, a type of product information created by users based on personal usage experience, can serve as a new element of marketing communications mix and work as free “sales assistants” to help consumers identify the products that best match their idiosyncratic usage conditions. For many products, this marketing function is impossible or very costly for traditional marketing communications to achieve. However, this new communication mode does not come without cost because it eliminates a seller’s control over the content of product information accessible to consumers, and because consumer reviews may not be fully informative.

We examine four specific strategic issues: (1) when an online seller should provide consumer reviews to its customers, (2) how a seller’s decision to supply consumer reviews interacts with its product assortment strategy, (3) how the seller’s strategy regarding the supply of consumer reviews interacts with its traditional marketing communication strategy, and (4) what timing is best for the seller to offer consumer review information for a product.

Our results show that supplying online consumer reviews can benefit or hurt an online seller depending on product characteristics, the informativeness of the review, the seller’s product assortment strategy, the seller’s product value for the partially matched consumers, and consumer heterogeneity in product consumption expertise. We also show that the seller’s decision to provide consumer reviews will increase its incentive to offer more complete product information to consumers through its traditional marketing communications. Finally, we discover that offering consumer review information too early leads to a lower profit.

An empirical study based on data from online sellers in different product categories provides some preliminary support for our theory.

Keywords: Online Consumer Review, Independent Product Information, Word-of-Mouth, Information Asymmetry, Agency Theory, Marketing Communications
1. Introduction

Internet and information technology are creating a new opportunity for consumers to share their product evaluations online (Avery, Resnick and Zeckhauser 1999). Amazon.com started to offer consumers an option to post their comments on products on its website in 1995. Currently, Amazon.com has about 10 million consumer reviews on all its product categories, and these reviews are regarded as one of the most popular and successful features of Amazon (New York Times, Feb. 24, 2004). In recent years, an increasing number of online sellers (e.g., BevMo.com, BN.com, cduniverse.com, circuitcity.com, GameStop.com, computer4sure.com, c-source.com, half.com, goodguys.com, wine.com) are adopting the same strategy. These online sellers invite users of their products to post personal product evaluations on the sellers’ websites or provide their customers consumer review information offered by some third-party sources such as Epinions.com and CNET.com. Online consumer reviews are common for many product categories such as apparel, books, electronics, games, videos, music, beverages, games, and wine.

Recent evidence suggests that consumer reviews have become very important for consumer purchase decisions and product sales. A study by Forrester Research finds that half of those who visited the retailer sites with consumer postings reported that consumer reviews are important or extremely important in their buying decisions (Los Angeles Times, Dec. 3, 1999). Based on the data from Amazon.com and BN.com, Chevalier and Mayzlin (2003) find that online book reviews have significant impact on book sales.

Online consumer review is an emerging independent product information resource with growing popularity and importance. It has generated considerable attention in practitioners and popular presses. To better understand the fundamental role of this new information channel in the market place and its strategic implications to online marketers, more academic research is urgently needed.

In contrast to traditional sellers, an online seller can now provide two types of product information to its customers. It can (1) offer seller-created product information to consumers via its website or other traditional communication channels such as advertising, and (2) offer consumer-created product information by allowing consumers to post their comments on the seller’s website.
One important difference between the two types of product information is the degree of information credibility. Consumer-created information is likely to be more credible than seller-created information because credibility of information is often positively related to the trustworthiness of the information source (Wilson and Sherrell 1993). Several recent studies have begun to examine online consumer-created information from the perspective of information credibility. For example, Dellarocas (2003) examines the relationship between online consumer feedback information and an unknown seller’s reputation. Mayzlin (forthcoming) studies the credibility of the promotional messages in online chat rooms and the implication of such new information channels on sellers’ profitability. These studies have advanced our understanding of consumer-created information.

This paper is different from these recent studies in that it focuses on an under-explored but nonetheless important function of consumer reviews. We argue that online consumer reviews can serve as free “sales assistants” to help consumers identify the products that best match their idiosyncratic usage conditions.

Consumer-created review information can differ from seller-created information in the degree of relevance to consumers. Consumer-created information is likely to be more relevant to consumers than seller-created information (Bickart and Schindler 2001). Seller-created product information is more likely to be product-oriented since it often describes product attributes in terms of technical specifications and measures product performance by technical standards. It may not be possible for all consumers to map product attributes with their usage conditions based on the seller-created information. In contrast, the consumer-created product information is, by definition, user-oriented. It often describes product attributes in terms of usage situations and measures product performance from a user’s perspective (Bickart and Schindler 2001). More importantly, since this information is posted by users with different idiosyncratic preferences, technical backgrounds, levels of product knowledge, and usage situations, such information has the potential to be relevant to a wide variety of consumers. While sellers can also be motivated to supply highly relevant product information to consumers, sometimes it may be too costly or even impossible for a seller to acquire complete usage knowledge or to provide all possible mappings between
product attributes and usage conditions, especially when consumers have multi-dimensional preferences and extremely idiosyncratic usage conditions.

The essential contribution of this paper is to investigate the strategic implication of this information relevance advantage of consumer-created information. We propose that online consumer reviews can serve as a new element of marketing communications mix—they can provide relevant matching information to all kinds of consumers, including those who fail to benefit from the information provided by the seller. For many products, this function is impossible or very costly to achieve by the traditional elements of marketing communications mix such as advertising or personal selling (Kotler 2000). This marketing function is particularly important for less sophisticated consumers. Due to different levels of expertise, consumers have different information processing capabilities in diagnosing product information (Alba and Hutchinson 1987). For this reason, seller-created product information may be valuable only to more sophisticated consumers (i.e., technical experts). Consumer-created product information, however, can help less sophisticated consumers (i.e., technical novices) in finding their best-matched products. Note that experts, who are able to benefit from seller-created product information, are more likely to adopt a new product earlier than novices (Mahajan, Muller and Srivastava 1990). This suggests that the seller can benefit from offering consumer-created product information because the user-oriented information posted by the pioneer expert consumers is valuable to novice consumers. In this sense, the seller can create, at minimal cost, a “sales assistant” by allowing consumers to share their usage experiences via online self-posting consumer reviews.

However, the marketing function of consumer reviews does not come without inherent costs. Lewis and Sappington (1994) have shown that, when providing seller-created product information, a seller may benefit from only providing partial product information but not full information (i.e., a partial information strategy can be optimal) even if information supply is costless. However, since the seller has little control over the content of the consumer-created information, by allowing consumers to post their product evaluations on the seller’s website, the seller will no longer be able to fully control the information content available to consumers and thereby fail to implement a partial information strategy. Furthermore,
the seller is unable to ensure the accuracy of the consumer-created product information, and inaccurate review information may mislead consumers. This suggests that offering consumer-created product information may hurt the seller.

This paper examines when an online seller should offer consumer reviews to its customers, paying special attention to the interaction between the seller’s consumer review supply decision and its other marketing strategies. We address four specific research questions. First, when should an online seller provide consumer reviews to its customers? Second, how does the seller’s consumer review supply decision interact with its product assortment strategy? Third, how does the seller’s consumer review supply strategy interact with its traditional marketing communication strategy (i.e., seller-created information supply strategy)? Fourth, what is the optimal timing for the seller to offer consumer review information for a product?

We develop a normative model to address these questions and our results reveal several new findings. First, our results show that the seller will offer consumer reviews for a product only when the seller’s product matches the preferences of a sufficient number of consumers. The minimum size of the matched consumers for the seller to benefit from offering consumer reviews is decreasing with the review informativeness. Second, we discover that sellers with a wide assortment of products benefit more from offering consumer reviews than those with a narrow assortment. Third, we show that the seller’s information strategy on consumer-created information interacts with its information strategy on the seller-created information. Specifically, as an alternative communication strategy, consumer review supply decision, however, increases the seller’s incentive to provide full product information through its traditional marketing communications. Fourth, we find the seller’s consumer review supply decision also depends on the seller’s product value for the partially matched consumers and the consumer’s expertise level. Finally, we show that if it is possible for the seller to decide the timing to offer consumer reviews at the individual product level, it may not always be optimal to offer consumer reviews at a very early stage of new product introduction, even if such reviews are available.
We conducted an exploratory empirical study based on data from online sellers in several different product categories. The empirical results are consistent with the predictions of our theoretical model.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature. Section 3 presents our basic model of consumer review supply decision. Section 4 studies how firm product assortment strategy affects its consumer review supply strategy. Section 5 considers a general model and examines how a seller’s decision to offer consumer reviews interacts with its information supply strategy on traditional marketing communications. Section 6 discusses seller’s optimal timing decision to provide consumer reviews. Section 7 presents the results of our empirical study, and Section 8 provides conclusions and discusses future research.

2. Related Literature

First, this paper contributes to the emerging literature of independent product information (e.g., Eliashberg and Shugan 1997, Chen and Xie forthcoming). In many product categories, buyers and sellers typically have asymmetric information. Sellers have private product information that buyers may not share, and vice versa. Akerlof (1970) shows that such information asymmetry may lead to market failure. To address this problem, traditional economics and marketing literature shows how firms can use different marketing strategies to communicate product information to consumers (e.g., Milgrom and Roberts 1984, Gestner 1985). Recently, some authors have studied product information from different independent sources. In general, there are two types of independent product information. The first type is third-party product review information from various third parties such as consumer magazines and websites. Third parties such as Consumer Reports conduct independent product testing and publish evaluations to consumers. Consumer-generated review is the second type of independent information.

Over the past decade, the Internet and development of information technology have greatly reduced information delivery and search costs. Hence, independent product information has become widely accessible to and increasingly important for consumers. How this second information channel for consumers affects firms’ marketing strategies has become a very important research issue. Concerning independent product information from third parties, Chen and Xie (forthcoming) study how third-party
product reviews interact with firms’ marketing strategies. Specifically, they show when firms should choose advertising instead of pricing as the strategic responding variable, and how firms should adjust their advertising formats and spending to third-party product reviews. Other emerging literature addresses the independent product information from online consumers (e.g., Avery et al. 1999). Current limited research on online consumer reviews focuses on the credibility function of the consumer-created information. Dellarocas (2003) shows online consumer feedback information on the seller (instead of products) can help to build reputation for unknown sellers in marketplaces such as eBay.com. Mayzlin (forthcoming) demonstrates the credibility of firms’ promotional messages in online chartrooms and studies the implication of such new information channels on sellers’ profitability. In this paper, we argue that consumer reviews can work as free sales assistants for online marketers and investigate consumer reviews’ marketing function on providing consumers matching information to map their usage conditions with product attributes. Specifically, we characterize circumstances where a seller can benefit from offering consumer review information to its customers, and show how consumer review supply decision interacts with the seller’s other marketing strategies.

This paper also relates to the word-of-mouth (WOM) literature (e.g., Brown and Reingen 1987, Godes and Mayzlin forthcoming). There are two major distinctions between online consumer reviews and traditional WOM. First, the influence of traditional WOM is typically limited to a local social network (e.g., Brown and Reingen 1987, Biyalogorsky, Gerstner, and Libai 2001, Shi 2003). In contrast, the impact of online consumer reviews can reach far beyond the local community since any consumer all over the world can access a consumer review via the Internet. Second, traditional WOM is not a decision variable for the seller. However, for consumer reviews, an online seller can decide whether and when to provide them to its customers on its website. The seller (e.g., Amazon.com) can provide an option on its website to allow consumers to post their reviews along the listed product. Sometimes, the seller (e.g., c-source.com, half.com) can also license consumer reviews from intermediaries such as Epinions.com, and decide when to post them on its website.
From a theoretical perspective, this paper is related to the agency theory literature (e.g., Sappington 1991, Stiglitz 2002). In most of the agency models, the information structure between two parties is exogenous. Moreover, the information asymmetry between the principal and agent is one-sided. The private information resides either with the principal (signaling models, e.g., Spence 1973) or with the agent (moral hazard or adverse selection models, e.g., Holmstrom 1979, Baron and Myerson 1982, Sappington 1983). Lewis and Sappington (1994) propose a model with two-sided endogenous information structure to examine a seller’s information supply decision, and show the conditions under which the seller may provide different amounts of information to consumers. In their model, the seller (principal) has private product information, but no information about consumer tastes. In contrast, the consumers (agents) have private information about their own tastes but not product attributes. The information structure is endogenous. The seller can manipulate the degree of information asymmetry by providing different amounts of product information. However, in their model, there is only one information channel between the two parties. In contrast, in our model, the seller controls two information channels and can provide two types of information, the seller-created information and consumer review information. We study here how these two types of information interact with each other, and what type of product information a seller should supply to its customers.

Finally, this paper also relates to the marketing communications particularly informative advertising literature (e.g., Grossman and Shapiro 1984). To date, very few studies have examined a firm’s strategic decision on information content for its marketing communications. Wernerfelt (1994b) and Simester (1995) have investigated when and how firms should integrate price information in their advertising. Chen and Xie (forthcoming) examine a firm’s advertising format strategy in the presence of third-party product review, and find that using review-endorsed advertising (i.e., advertisements containing third-party award logos) to broadcast its victory can hurt the winning product of a product review. In this paper, we study a firm’s information content strategy by investigating how much and what type of product information a seller should provide to its customers.
3. Basic Model

In this section, we present our basic model and discuss when the seller should offer consumer reviews.

3.1. Basic Model Assumptions and Setting

We first specify key assumptions and setup for our basic model. Key notations are summarized in the Appendix.

3.1.1. Model Setting

In the basic model, we consider a single seller\(^1\) offering a single product assortment. We will examine the case of multiple assortments in Section 4. Let \(c\) denote the marginal cost of the product.

In our basic model, we allow consumer heterogeneity in two dimensions: (1) taste, (2) time to enter the market. The entire consumer size is normalized to one.

First, we allow consumers to differ in their preferences toward the seller’s product. Given a product, some consumers will find that the product matches their needs and others not. Hence, there are two types of consumers in the taste dimension: matched and unmatched, i.e., \(T = T_m, T_u\). Given full information on product attributes, the matched consumers find the seller’s product fits their usage conditions, and have a high valuation \(v_m\) on the product. In contrast, the unmatched consumers find the seller’s product does not match their usage conditions, and have a low valuation \(v_u\) on the product. Without loss of generality, we assume \(v_u = 0\). In the absence of product information, all consumers have the same expected value, \(\bar{v} = v_m / 2\). We further assume that the product cost is sufficiently low so that the seller can make a profit from consumer’s purchase in the absence of product information, \(c \leq \bar{v} = v_m / 2\). We will relax this assumption in section 5 and discuss the case where the seller can make a profit and consumers make purchases only if sufficient product information is available. Let \(\tau\), \(1 - \tau\) denote the fraction of the matched and unmatched consumers.

\(^1\) The seller’s monopoly position mainly results from consumers’ loyalty and limited search. Recent studies have demonstrated online consumers’ loyalty and limited search for online sellers. For example, Johnson et al. (2004) present empirical evidence that consumer online search is very limited during the shopping process. On average, consumers visit 1.2 book sites and 1.3 CD sites in each category. The monopoly model can help us understand the fundamental impact of the new information channel—online consumer review on firm marketing strategies (e.g., Shugan 2002).
Second, we allow some consumers to enter the market earlier than others. According to the diffusion literature (Rogers 1996), some consumers (i.e., innovators) are more eager to seek and try new products than others (i.e., majority consumers) due to their personality. Let $\delta$ denote the fraction of consumers who are innovators and enter the market earlier than majority consumers.

In our basic model, we assume all consumers are novices and lack product expertise to map the product attribute information with their usage conditions or needs (e.g., Werfernelt 1994a). Due to their limited information processing capability resulting from a lack of product expertise (Alba and Hutchinson 1987), consumers are unable to identify matching or mismatching products simply based on the attribute information offered by the seller. However, the novice consumers can identify matching or mismatching product by learning from the experiences of some existing users. In other words, in our basic model, all consumers cannot process seller-created information but consumer review information. We will allow consumer heterogeneity in their product expertise levels in section 5.

3.1.2. Information Structure

We allow a two-sided information asymmetry between the seller and consumers. The seller has private product information, but has no information on consumer characteristics. Consumers know their own tastes, but have no information on product attributes.

We also allow the information structure to be endogenous. In our basic model, since all consumers are novices and cannot process seller-created information, consumer review is the only information channel for consumers to learn product information even if the seller provides product attribute information. We will allow some consumers to learn product information from the seller-created attribute information in section 5. In the basic model, the seller can alter the information structure by deciding whether to offer consumers the option to post their product evaluations on its website.

Note that the seller is unable to ensure the accuracy of the consumer-created information. Due to the anonymity of online consumer review, the review information can also come from biased sources such as a disgruntled employee (Piller 1999). We use a measure, $\gamma$, to characterize the informativeness of
consumer-created review information, where $0 \leq \gamma \leq 1$. A higher informativeness corresponds to better information in the sense of Blackwell (1951). The consumer review information is perfectly accurate and informative when $\gamma = 1$, and purely uninformative when $\gamma = 0$. Intuitively, with the available product information from consumer reviews, the probability that matched consumers find the product is a match (or unmatched consumers find the product is a mismatch) is an increasing function of the review informativeness, $\gamma$, and approaches to 1 when $\gamma = 1$. Following Lewis and Sappington (1994), we formalize this probability function as $q(\gamma) = (1/2 + \gamma/2)$. Conversely, the probability that matched consumers find the product is a mismatch (or unmatched consumers find the product is a match) is a decreasing function of the review informativeness, $\gamma$, approaches to 0 when $\gamma = 1$, and can be formalized as $q(\gamma) = (1/2 - \gamma/2)$. We assume the seller cannot or does not want to manipulate the review information perhaps because of reputation concerns or regulatory requirements. In other words, $\gamma$ is exogenous in our model. Both parties can observe the review informativeness. Therefore $\gamma$ is public knowledge for both sides. Without loss of generality, we assume the seller’s information supply cost is zero considering the significantly reduced costs of collecting and distributing information via the Internet (Avery et al. 1999).

3.1.3. Model Timing

Our basic model has two periods, $t=1, 2$. At the very beginning of the game, the seller makes a decision as to whether or not to allow consumers to post their reviews on its website. Innovators enter the market in the beginning and exit at the end of period 1 ($t=1$). If the seller chooses to allow consumer self-posting on its website, then consumer review information will be available to potential buyers after period 1. The majority consumers enter the market at the beginning and exit at the end of period 2 ($t=2$). In each period $t$, the seller can set a different price $P_t$.

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2 For instance, New York Times (Feb. 24, 2004) reported how a technological accident on Amazon.com revealed the true identity of a best-seller book author’s self-promoting reviews and jeopardized his reputation.
3.2. Basic Model

In the absence of consumer reviews

In the absence of consumer reviews, all consumers have expected value $\overline{\nu} = v_m/2$. The seller’s expected profit is

$$\hat{\Pi} = \frac{v_m}{2} - c \quad (1)$$

In the presence of consumer reviews

In period 1, innovators enter the market. All innovators have expected value $\overline{\nu} = v_m/2$. Recalling $\delta$ is the fraction of the innovators among all consumers, the seller’s expected profit in period 1 is

$$\Pi_1 = (\frac{v_m}{2} - c)\delta \quad .$$

In period 2, majority consumers enter the market. With the available product information from consumer reviews, the expected values are $V_{T_m}(\gamma) = v_m\overline{\gamma}(\gamma) = v_m(1/2 + \gamma/2)$ for the matched consumers, and $V_{T_m}(\gamma) = v_m\overline{\gamma}(\gamma) = v_m(1/2 - \gamma/2)$ for the unmatched consumers. The seller can charge a high price at $P_2 = V_{T_m}(\gamma)$ and only serve type $T_m$ consumers or a low price at $P_2 = V_{T_m}(\gamma)$ to gain the demand from all consumers. It is optimal for the seller to charge a high price when $\gamma$ is sufficiently high, and a low price when $\gamma$ is sufficiently low. Therefore, the seller’s expected profit in period 2 is

$$\Pi_2(\gamma) = \begin{cases} \frac{v_m(1/2 + \gamma/2) - c(1-\delta)}{(1-\gamma)v_m - 2c} & \text{if } \tau \geq \overline{\tau} \\ \frac{v_m(1/2 - \gamma/2) - c(1-\delta)}{(1+\gamma)v_m - 2c} & \text{if } \tau < \overline{\tau} \end{cases}, \quad \text{where} \quad \overline{\tau} = \frac{[(1-\gamma)v_m - 2c]/[(1+\gamma)v_m - 2c]}{v_m}.$$

Hence, the seller’s overall profit over two periods in the presence of consumer reviews is

$$\Pi(\gamma) = \begin{cases} \frac{(v_m/2 - c) + [(1+\gamma)v_m/2 - c - (v_m/2 - c)](1-\delta)}{(1-\gamma)v_m - 2c} & \text{if } \tau \geq \overline{\tau} \\ \frac{(v_m/2 - c) - v_m\gamma(1-\delta)/2}{(1+\gamma)v_m - 2c} & \text{if } \tau < \overline{\tau} \end{cases} \quad (2)$$

From equations (1) and (2), we have the following proposition regarding when the seller should offer consumer reviews to its customers.

PROPOSITION 1 (Consumer Review Supply Decision)

The seller’s consumer review supply decision depends on the size of the matched consumers and the degree of review informativeness. Specifically,

(a) Supplying consumer review information increases the seller’s profit if the seller’s product matches sufficient consumers’ preferences.
(b) The minimum size of the matched consumers for the seller to benefit from supplying consumer review is decreasing with the review informativeness.

Mathematically, (a) $\Pi(\gamma) \geq \hat{\Pi}$ if $\tau \geq \bar{\tau}$, and (b) $\partial \tau / \partial \gamma < 0$ where $\bar{\tau} = (v_m - 2c) / [(1 + \gamma)v_m - 2c]$. 

Proposition 1 reveals that there is a required minimum size of the matched consumers ($\bar{\tau}$) above which the seller benefits from supplying consumer reviews. Consumer reviews provide matching information for consumers. It can increase the matched consumer’s willingness to pay and decrease the unmatched consumer’s valuation. Due to the information asymmetry between consumers and the seller, the seller does not have information on consumer taste. Offering consumer review information can help the seller to charge a premium price to screen out the unmatched consumers with low valuations, and only serve the high-value matched consumers. However, the seller can benefit from doing so only if the size of matched consumers is sufficiently large ($\tau > \bar{\tau}$) because the seller’s review supply decision is in fact a tradeoff between its profit gain from the matched consumers and its loss from the unmatched consumers. If the number of matched consumers is sufficiently large (i.e., the product is a mass-market product), the seller’s profit loss from the unmatched consumers is very small and dominated by the profit gain from the matched consumers.

Proposition 1 also reveals that the required minimum size of the matched consumer decreases with the review informativeness ($\partial \bar{\tau} / \partial \gamma < 0$), implying that the consumer review supply decision also depends on the review informativeness. This is because the review informativeness determines the extent to which the matched consumers increase their willingness to pay due to the availability of consumer reviews. The seller charges a low price, $v_m / 2$, when consumer reviews are not provided, but a high price, $v_m(1/2 + \gamma/2)$, when consumer reviews are provided. The more informative the consumer reviews are, the higher the matched consumers’ reservation prices will be in the presence of consumer reviews. As a result, when consumer review information is highly informative, offering consumer reviews can be profitable even if the size of the matched consumers is small.

In the basic model, the seller is a single assortment marketer in a product category. Now we allow the seller to carry multiple assortments and discuss how the seller’s product assortment strategy (e.g., Shugan 1989) will affect its consumer review supply decisions. Specifically, consider a seller who carries two product assortments matching two types of consumers respectively. To distinguish from the basic model, we use an “M” subscript to denote the variables in the case of multiple assortments.

**In the absence of consumer reviews**

Without consumer review information, all consumers have the same expected value $\bar{v} = v_m / 2$ for the two assortments. They randomly choose one. Seller’s expected profit is $\hat{\Pi}_m = v_m / 2 - c$.

**In the presence of consumer reviews**

If the seller supplies consumer review information, consumer valuation depends on the time when they enter the market. In period 1, innovators enter the market. Their expected value is $\bar{v} = v_m / 2$ and the seller’s expected profit from period 1 is $\Pi_{1,m} = (v_m / 2 - c)\delta$.

In period 2, majority consumers enter the market and can obtain product information from reading the reviews posted by the innovators. As explained in the basic model, consumer review information affects these consumers’ expected value. The expected value is $V_{1,m}(\gamma) = v_m (1/2 + \gamma / 2)$ for the matched consumers and $V_{1,m}(\gamma) = v_m (1/2 - \gamma / 2)$ for the unmatched consumers, respectively. The seller earns a highest profit by selling each assortment to only matched consumers at a price $P = v_m (1/2 + \gamma / 2)$. The seller’s expected profit from period 2 is $\Pi_{2,m}(\gamma) = [v_m (1/2 + \gamma / 2) - c](1 - \delta)$. Hence, the seller’s overall profit is $\Pi_m(\gamma) = (v_m / 2 - c) + (1 - \delta)v_m / 2$.

The comparison of the seller’s profits in the absence and presence of consumer reviews, $\hat{\Pi}_m$ and $\Pi_m(\gamma)$, reveals that supplying consumer review information is always more profitable than not supplying such information (i.e., $\forall \gamma$ and $\tau$, $\Pi_m(\gamma) \geq \hat{\Pi}_m$).
Comparing with the result of a single assortment (Proposition 1), we have the following proposition on how the seller’s assortment strategy affects its consumer review supply decision.

**PROPOSITION 2 (Consumer Review and Product Assortment Strategy)**

*The seller with wider product assortments is more likely to benefit from supplying consumer review information than the seller with narrower product assortments.*

As we discussed in the last section, a seller’s decision to provide consumer reviews is a tradeoff between its profit gain from the matched consumers and its loss from the unmatched consumers. When the seller carries wider assortments matching different types of consumers, it is more likely that all consumers will find a perfect match from the seller’s offerings. Therefore, wider product assortments lower the seller’s profit loss from the unmatched consumers because of consumer reviews. At the same time, the seller can still enjoy a profit increase from the increased willingness to pay of the perfectly matched consumers as a result of the consumer review information.

**5. Information Supply Strategy**

In our basic model, the product cost is sufficiently low so that the seller can make a profit from consumer’s purchase even in the absence of product information (i.e., $c \leq \overline{c}$). However, in reality, for many products, the product cost is sufficiently high so that the seller can profit from a consumer’s purchase only if enough product information is provided for consumers (i.e., $c > \overline{c}$). In addition, in the basic model, all consumers are novices and have no knowledge to match their usage conditions with the product even in the presence of product attribute information. Hence, the seller-created product information has no influence on consumers. In this section, we consider a generalized model where both seller-created product attribute information and consumer review information can influence consumer purchase decision, and examine how the seller’s information supply strategies concerning these two types of information interact with each other.

**5.1. A Generalized Model Setting**

In this section, we allow consumers to differ in their expertise and knowledge about the product (Alba and Hutchinson 1987). We consider two consumer segments: an expert segment and a novice segment. Let $S$
denote the segment, where \( S = N \) (Novices), \( E \) (Experts). Expert consumers are knowledgeable about the product and are able to correctly map their usage situations with the product attributes based on the attribute information offered by the seller. Novice consumers lack product knowledge to map the product attribute information with their usage conditions or needs. They are unable to identify the matching or mismatching product simply based on attribute information offered by the seller. The novice consumers can, however, identify a matching or mismatching product by learning from the experiences of some existing users. Let \( 0 \leq \eta \leq 1 \) denote the percentage of expert consumers. Let \( \Pi^S \) and \( \Pi^S \) denote the seller’s profit from segment \( S \) in the absence and presence of consumer reviews.

Consumers can learn product information from two sources: (1) seller-created product attribute information and (2) consumer review information. Both experts and novice consumers are able to identify their matching/mismatching attributes based on the consumer review information, but only the expert consumers can identify their matching/mismatching attributes based on the seller-created information.

The seller needs to make two information supply decisions. In addition to the consumer review supply strategy, the seller needs to decide its seller information content strategy on product attribute information. That is, the seller must decide how much attribute information to provide. Specifically, consider a product with two attributes, \( a_1 \) and \( a_2 \). The seller has a choice of providing attribute information on both attributes or only on one of the attributes. We call the former full information content strategy and the latter partial information content strategy. Let \( I = I^F, I^P \) denote the information content decision, where \( I^F \) and \( I^P \) present the case when the seller adopts full and partial information content strategy, respectively. Due to the seller’s reputation concern, we assume the seller-created product attribute information is accurate.

In addition, in our basic model, there are two types of consumers in the taste dimension: matched and unmatched consumers. In reality, for any product with multiple attributes, consumers can partially match the product in the sense that they find a match on some attributes and a mismatch on others. Specifically, for a two-attribute product, consumers can be categorized into four types according to their taste-
matching situations with the product: fully matched type $T_{mm}$ (matching on both attributes), partially matched consumers $T_{mn}$ and $T_{nm}$ (matching on attribute $a_1$ or $a_2$), and fully unmatched consumers $T_{nn}$ (matching on neither attribute). For simplicity, we assume the sizes of four types are equal. Let $v^f$, $v^p$, $v^0$ denote consumer valuations for fully matched, partially matched and fully unmatched consumers under full information on product attributes, respectively. Without loss of generality, we assume $v^0 = 0$. The consumer’s expected value in the absence of product information is $\bar{v} = (v^f + 2v^p) / 4$. As we state in the beginning of this section, we assume the product cost is sufficiently high so that the seller can profit from the consumer’s purchase only if enough product information is provided, i.e., $c > \bar{v} = (v^f + 2v^p) / 4$.

To distinguish consumer heterogeneity in the taste and expertise dimensions discussed above, hereafter we refer to consumers with a different taste as a different consumer type and consumers with a different expertise level as a different consumer segment. Precisely, as described earlier, there are four types of consumers with different preference-matching situations (i.e., $T = T_{mm}, T_{mn}, T_{nm}, T_{nn}$) and two segments of consumers with different expertise levels (i.e., $S = E, N$). The consumer preference heterogeneity and consumer expertise heterogeneity are orthogonal, i.e., for both the expert and novice consumer segments, there are four types of consumers with different preference-matching situations.

Finally, since experts are more likely to search for new product information than novices (Brucks 1985, Alba and Hutchinson 1987), the former are likely to enter the market earlier than the latter. Mahajan et al. (1990) empirically demonstrate that expert consumers are more likely to read product related advertising and adopt products earlier than novice consumers. They also find that innovators are usually the expert consumers. Hence, we assume experts enter the market earlier than novice consumers. Since experts can be either innovators or majority consumers depending on their personal characteristics, we further allow some experts to be majority experts who enter the market later than innovator experts but earlier than novice consumers. Let $\lambda$ denote the fraction of expert consumers who are innovators (i.e., there are $\lambda$ innovator experts and $1-\lambda$ majority experts). Specifically, we consider three time periods, $t = 1, 2, 3$. In each period, some consumers enter the market at the beginning and exit at the end of
the period. The order of entry is: innovator experts ($t=1$), majority experts ($t=2$), and novice consumers ($t=3$). The seller makes information supply decisions at the very beginning of the three-period game. Due to concern over reputation, we assume the seller is committed to its information supply decisions once such decisions are made. However, the seller can adjust its pricing decision in each period.

The seller’s information supply strategy is a two-stage decision, as shown in Figure 1. In stage 1, the seller decides whether to supply consumer review information to its customer. In stage 2, the seller decides whether to offer full or partial information to consumers via the seller-created information. The order of the decision is determined based on the fact that the consumer review information supply decision is often less flexible than the seller’s own product information content supply decision. We solve this two-stage decision problem using backward induction. First, in section 5.2, we derive the optimal seller information content strategies in the absence and presence of consumer reviews (stage 2). Then, in section 5.3, we derive the optimal consumer review supply strategy (stage 1).

**Figure 1. Seller Information Supply Strategy**

### 5.2. Seller Information Content Strategy (Stage 2)
In this section, we analyze the seller’s information content strategies, i.e., whether a full or partial attribute information supply strategy is optimal for seller-created information, in the absence and presence of consumer reviews, respectively.
By assumption, only expert consumers can process the seller-created attribute information. The seller’s information content strategy will not affect novice consumers’ valuation and the seller’s demand from novice consumers. Hence, to study the seller’s information content strategy, we need only focus on its profit from the expert segment (\(\Pi^E\)), i.e., the sum of its profits from innovator experts in period 1 and from majority experts in period 2. Let \(V^S_T(I,\gamma)\) denote the expected value of type \(T\) consumers in segment \(S\) given attribute information \(I\) and review informativeness \(\gamma\), where \(T = T_{mm}, T_{mn}, T_{nm}, T_{nn}\) and \(S = E, N\).

Therefore, the seller’s problem concerning information content decision can be formalized as follows:

\[
\max_{I,\Pi} \Pi^E(I,\gamma,P) = \Pi_1(I,P_1) + \Pi_2(I,\gamma,P_2) \\
\text{s. t. } V^E_T(I,\gamma) \geq c
\]

(3)

where \(I = I^E, I^F; t = 1,2\).

Equation (3) characterizes the seller’s problem for both cases: in the absence of consumer reviews (i.e., \(\gamma = 0\)) and in the presence of consumer reviews (i.e., \(\gamma \in [0,1]\)). The seller maximizes its profit from the expert segment conditional on the expert consumers’ participation. In other words, the expected valuations of expert consumers have to meet IR (individual rationality) or participation constraints, \(V^S_T(I,\gamma) \geq c\). The seller either provides full attribute information on both attributes (\(I = I^E\)) or provides partial information on one attribute (\(I = I^F\)). In the following we derive the seller’s optimal information content strategies in the absence and presence of consumer reviews, respectively.

5.2.1 Information Content Strategy In the Absence of Consumer Reviews

In the absence of consumer reviews, the seller’s profit from the experts consumers, \(\hat{\Pi}^E(I)\), depends on whether the seller provides full information on both attributes (i.e., \(I = I^E\)) or only partial information on one of the attributes (i.e., \(I = I^F\)). We examine these two cases below in turn.

Providing Full Attribute Information (\(I = I^E\))

If the seller provides full information on both attributes, the valuations are zero for type \(T_{nn}\), \(v^F\) for type \(T_{mn}\) and \(T_{nm}\), and \(v^F\) for type \(T_{nn}\) expert consumers.
The seller can choose between selling to only one type of expert consumers ($T_{mm}$) at a high price, $P_1 = P_2 = v^f$, or to three types of expert consumers (i.e., $T_{mm}$, $T_{mn}$, and $T_{nn}$) at a low price, $P_1 = P_2 = v^p$. We assume the full match provides a sufficiently high value for consumers so that, when supplying full product information, the seller earns a higher profit to only serve its fully matched consumers ($T_{mm}$) by charging a high price $v^f$, i.e., $v^f > 3v^p - 2c$. Since $\eta$ of consumers are experts, the seller’s profit from the experts is

$$\hat{\Pi}^E (I^f) = \eta(v^f - c)/4$$  \hspace{1cm} (4)

**Providing Partial Attribute Information ($I = I^F$)**

If the seller provides information only on one attribute, for instance $a_1$, consumers whose tastes match the informed attribute (type $T_{mm}$ and $T_{mn}$) are certain about their match on the informed attribute ($a_1$) from the seller’s information. However, they remain uncertain about the uninformed attribute ($a_2$). Without information on the uninformed attribute, it is equally likely for them to believe the uninformed attribute is a match or mismatch. In other words, they believe there is an equal probability for them to have a valuation of $v^p$ and $v^f$. Hence, the expected valuation for the product is $(v^p + v^f)/2$ for type $T_{mm}$ and $T_{mn}$ experts. Similarly, we can find the expected valuations for other types of expert consumers. The seller’s profit from the experts is given in the following (see derivation in Appendix A.1):

$$\hat{\Pi}^E (I^F) = \eta ((v^p + v^f)/2 - c)/2$$  \hspace{1cm} (5)

Comparing the seller’s profits under full and partial information content strategy in the absence of consumer reviews (i.e., $\hat{\Pi}^E (I^F)$ and $\hat{\Pi}^E (I^F)$), we derive the following lemma regarding the seller’s information content strategy in the absence of consumer reviews (see the proof in Appendix A.1).

**LEMMA 1**

In the absence of consumer reviews, a full information content strategy is optimal if the seller’s product value for the partially matched consumers is sufficiently low. Otherwise, a partial information content strategy is optimal. Mathematically, the seller’s maximum profit from the experts is

$$\hat{\Pi}_{\text{max}}^E = \begin{cases} 
\hat{\Pi}^E (I^F), & \text{if } v^p < c \\
\hat{\Pi}^E (I^F), & \text{otherwise}
\end{cases}$$  \hspace{1cm} (6)
5.2.2. Information Content Strategy in the Presence of Consumer Reviews

In contrast to the case considered above in 5.2.1, in the presence of consumer reviews, the information structure is different in periods 1 and 2 because expert consumers in period 2 can observe both the seller-created information and consumer reviews.

**Providing Full Attribute Information** \((I = I^F)\)

If the seller provides full attribute information, expert consumers have full product information, and consumer reviews have no influence on the experts. The seller’s profit from the expert segment, \(\Pi^F(I^F, \gamma)\), is the same as in the full information case in the absence of consumer reviews, i.e., \(\hat{\Pi}^F(I^F)\) in equation (4).

**Providing Partial Attribute Information** \((I = I^P)\)

When the seller only provides partial attribute information, in period 1, the expected valuations of four types of early experts (innovators) are the same as in the absence of consumer reviews.

In period 2, when the seller only provides information on one attribute, for instance \(a_i\), for type \(T_{mm}\) majority experts, due to their matched tastes with attribute \(a_i\), the seller’s information on \(a_i\) excludes the possibility that their valuations is zero. Without information on the second attribute, they assign the same probabilities, 1/2, to valuation \(v^F\) and \(v^P\). With the consumer reviews, the probability for them to find the match in the second attribute and have a valuation \(v^F\) is \(q(\gamma) = 1/2 + \gamma/2\). In the same time, the probability for them to find the mismatch in the second attribute and have a valuation \(v^P\) is \(q(\gamma) = 1/2 - \gamma/2\). Therefore the expected valuation for type \(T_{mm}\) majority experts is \(V_{mm}(I^P, \gamma) = v^F q(\gamma) + v^P q(\gamma)\). Similarly, we can find the expected valuations for \(T_{mm}, T_{mm},\) and \(T_{mm}\) majority experts. The seller’s overall profit from all expert consumers, \(\Pi^E(I^P, \gamma)\), can be derived based on the valuations of different consumers types, and is given in Appendix A.2.
Comparing the seller’s profits under full and partial information content strategy in the presence of consumer reviews (i.e., $\Pi^f(I^f, \gamma)$ and $\Pi^p(I^p, \gamma)$), we derive the following lemma regarding the seller’s information content strategy in the presence of consumer reviews (see the proof in Appendix A.2).

**LEMMA 2**

*In the presence of consumer reviews, a full information content strategy is optimal if one of the two conditions holds: (I) the product value for the partially matched consumers is sufficiently low, (II) the product value for the partially matched consumers is high but the review informativeness is in a middle range. Otherwise, a partial information content strategy is optimal. Mathematically, the seller’s maximum profit from the experts is*

\[
\max_{\Pi^e} \begin{cases} 
\Pi^e(I^f, \gamma), & \text{if } (i) \, v^p < c, \text{ or (ii) } v^p \geq c, \text{ and } \gamma \in [\gamma, \tilde{\gamma}] \\
\Pi^e(I^p, \gamma), & \text{otherwise} 
\end{cases}
\]

\[
(7)
\]

*where $\gamma$ and $\tilde{\gamma}$ are given in Appendix A.2.*

Lemma 1 reveals that, in the absence of consumer reviews, a full information content strategy is optimal only if the seller’s product value for the partially matched consumers is sufficiently low ($v^p < c$).

Lemma 2 reveals that, in the presence of consumer reviews, a full information strategy can be optimal even if the product value for the partially matched consumer is high given a certain range of review informativeness ($v^p \geq c, \gamma \in [\gamma, \tilde{\gamma}]$).

**5.3. Seller’s Consumer Review Supply Decision (Stage 1)**

In this section, we first examine how consumer reviews affect the seller’s information content strategy and its profit. We do so by comparing the conditions given in Lemmas 1 and 2. Proposition 3 states the impact of consumer reviews on the seller’s information content strategy.

**PROPOSITION 3 (The Impact of Consumer Reviews on Information Content Strategy)**

*Offering consumer reviews increases the seller’s incentive to provide product attribute information such that a full information strategy is more likely to be optimal with than without consumer reviews.*

Proposition 3 reveals that the seller’s consumer review supply decision will increase its incentive to provide full attribute information. It is easy to see by comparing the conditions required for full information given in Lemmas 1 and 2 that this positive effect occurs when the seller’s product provides a sufficiently high value for the partially unmatched consumers, and the review is sufficiently informative.
When the seller’s product provides a sufficiently high value for the partially unmatched consumers, it is optimal for the seller to provide only partial information in the absence of consumer review information (see Lemma 1). This is because with a high value for the partially unmatched consumers, it is more profitable to provide partial information and sell to different types of consumers at a low price. It is less profitable to provide full information and serve only fully matched consumers at a high price given that full information increases valuation for the fully matched type but driving away other types. However, in the presence of consumer reviews, when the seller offers partial information, some mismatched consumers will find full attribute information from reading the consumer reviews and drop out of the market. For this reason, a partial information strategy generates a smaller demand in the presence of consumer reviews than in their absence. This negative effect increases with the degree of review informativeness. As a result, the seller can achieve a higher profit from providing full information and charging a high price than offering partial information and charging a low price if the review information is sufficiently informative.

Now we study how consumer reviews affects the seller’s overall profit, and derive the seller’s optimal consumer review supply decision by comparing its overall maximum profit in the absence of consumer reviews ($\hat{\Pi}^*$) and that in the presence of consumer reviews ($\Pi^*$). The seller’s overall profit is the sum of its profit from the expert consumers and novice consumers as shown in (8):

$$
\begin{align*}
\hat{\Pi}^* &= \hat{\Pi}^E(I, P_1, P_2) + \hat{\Pi}^N(P_1) & \text{In the absence of consumer reviews} \\
\Pi^* &= \Pi^E(I, \gamma, P_1, P_2) + \Pi^N(\gamma, P_1) & \text{In the presence of consumer reviews}
\end{align*}
$$

where $\hat{\Pi}^S$ and $\Pi^S$ denote the seller’s profit from the segment $S$ in the absence and presence of consumer reviews, and $S$ denotes consumer segment, $S = E, N$ (i.e., expert or novice segment).

We first compare the seller’s maximum profit from the expert segment in the absence of consumer reviews (i.e. $\hat{\Pi}^E^*$ given in Lemma 1) with that in the presence of consumer reviews (i.e., $\Pi^E^*$ given in Lemma 2). Comparing $\hat{\Pi}^E^*$ with $\Pi^E^*$, Lemma 3 follows (see the proof in Appendix A.3).
LEMMA 3

Offering consumer reviews will either decrease or have no impact on the seller’s profit from the expert consumer segment. Mathematically, $\Pi^E \leq \Pi^E$. The sign is strict when $\Pi^E = \Pi^E(1^*)$.

Lemma 3 shows that supplying consumer review information can lead to a profit loss from the expert segment (i.e., $\Delta \Pi^E = \Pi^E - \Pi^E \leq 0$). This is because the seller can fully control the information content available to the expert segment in the absence of consumer reviews but not in their presence. When the seller’s optimal information content strategy in the absence of consumer reviews is to provide partial attribute information, the seller makes profit from both perfectly matched and some partially unmatched experts. However, consumer reviews will reveal the mismatch information to those partially unmatched experts, which will decrease their willingness to pay for the product and thereby drive down the seller’s profit from the expert segment.

We now compare the seller’s profit from the novice segment in the absence of consumer reviews (i.e., $\hat{\Pi}^N$) with its profit from the novice segment in the presence of consumer reviews (i.e., $\Pi^N$). Note that novice consumers have no product information and will not make a purchase in the absence of consumer reviews, i.e., $\hat{\Pi}^N = 0$. However, some novice consumers may make a purchase in the presence of consumer reviews because the matching information provided by the review increases their willingness to pay. As a result, $\Delta \Pi^N = \Pi^N - \hat{\Pi}^N \geq 0$.

It is clear that the seller’s decision as to whether or not to provide consumer reviews is based on the tradeoff between its gain from the novice segment, $\Delta \Pi^N \geq 0$, and its profit loss from the expert segment, $\Delta \Pi^E \leq 0$. Comparison of $\Delta \Pi^N$ and $\Delta \Pi^E$ leads to Proposition 4 (see the proof in Appendix A.4).

PROPOSITION 4 (Consumer Review Supply Strategy)

The seller’s decision to supply consumer reviews depends on consumer review informativeness, the seller’s product value for the partially matched consumers and consumer expertise level. Specifically, supplying consumer review information increases the seller’s profit if

(a) Consumer reviews are sufficiently informative, and

(b) (i) The seller’s product value for the partially matched consumers is sufficiently low, or (ii) the seller’s product value for the partially matched consumers is sufficiently high, but the expert segment is sufficiently small.
Mathematically, \( \Pi^* > \Pi^* \) when (a) \( \gamma \geq \underline{\gamma} \), and (b) (i) \( v^r < c \), or (ii) \( v^r \geq c \) and \( \eta < \eta^* \), where \( \eta^* \) and \( \underline{\gamma} \) are defined in Appendix A.4.

As stated earlier, the seller’s decision as to whether or not to provide online consumer review information depends on the tradeoff between its profit gain from novice consumers and loss from expert consumers. By offering consumer review information, the seller can bring novice consumers into the purchase process if the consumer reviews are sufficiently informative to significantly increase matched novice’s willingness to pay. However, consumer review information can incur profit loss from expert consumers. When the seller’s product provides sufficiently high value for the partially matched consumers, its optimal information content strategy in the absence of consumer reviews is to provide partial product information and serve some partially unmatched expert consumers. However, the consumer review information will reveal the mismatch information to these consumers, decrease their willingness to pay, and thereby reduce the seller’s profit from the expert segment. If there are fewer expert consumers in a market, the loss from the unmatched expert consumers is more likely to be negligible relative to the profit gain from novice consumers. The seller will offer consumer review information. When the product value for the partially matched consumers is sufficiently low, the seller provides full product attribution in the absence and presence of consumer reviews. In this case, consumer review information supply decision will not incur profit loss from expert consumers. The seller will thus provide consumer reviews as long as the review is sufficiently informative.

6. Timing Decision on Offering Consumer Reviews

In previous models, the timing for offering consumer review is not a decision variable. In practice, many online sellers do not have the flexibility to choose the timing for offering consumer reviews at the individual product level. For example, for a seller who adopts a general consumer review policy by allowing consumers to post their product valuation on its website (e.g., Amazon.com), consumers can post product reviews for any product as early as the first day of the product launch. However, it is possible for some online retailers to decide when to offer consumer reviews for a given product if they
license consumer reviews from third-party sources. For example, c-source.com licenses consumer reviews from Epinions.com, and can flexibly decide when to make these third-party consumer reviews available to its consumers. To model this flexibility in timing, in this section we allow timing of offering consumer reviews to be a decision variable. Specifically, we allow the seller to decide whether to offer consumer reviews at the end of period 1 (i.e., right after the review information is available) or the end of period 2. (Note that offering reviews at the end of period 3 is the same as the case without consumer reviews.)

Without loss of generality, we assume the license cost is zero. We use an “f” subscript to denote the variables when the review posting time is flexible. Specifically, we use “f1” and “f2” to denote the variables when reviews are provided in the end of period 1 and 2, respectively.

If consumer reviews are provided at the end of period 1, it is the same situation as discussed in the previous model (section 5). This is because consumers in period 2 and 3 can observe consumer reviews. The seller’s profit is \( \Pi_{f1} = \Pi^E + \Pi^N \).

If consumer reviews are provided at the end of period 2, only seller-created product information is available for consumers in the first two periods. The seller’s decision and profit from the expert segment is the same as in the absence of consumer reviews. In period 3, the consumer reviews are provided. The seller gets the same profit from the novice consumers as in the previous model. Therefore, its overall profit is \( \Pi_{f2} = \hat{\Pi}^E + \Pi^N \). Given \( \hat{\Pi}^E \geq \Pi^E \) from Lemma 3, we find \( \Pi_{f2} \geq \Pi_{f1} \).

We have the following proposition regarding the timing decision of supplying consumer review.

**PROPOSITION 5 (Timing Decision on Consumer Review Offering)**

*If the seller has control over the timing when consumer reviews become available at the individual product level, the seller will benefit from not offering consumer reviews too early. Mathematically, \( \Pi_{f2} \geq \Pi_{f1} \).*

Proposition 5 reveals that, if possible, the seller should not provide consumer reviews too early even if such consumer reviews are available. As we discussed in last section, by offering consumer reviews, the seller gains from the novice consumers and loses from the expert consumers. Expert consumers are more likely to adopt a product earlier than novice consumers (Mahajan et al. 1990). The seller can
decrease its profit loss from consumer reviews in the expert segment by delaying supplying consumer reviews. This is because when the seller provides consumer reviews relatively late, most of the experts will have already made the purchase by then. At the same time, the seller can still enjoy the profit gain from purchases made by novice consumers who enter the market late.

7. Empirical Evidence

To provide some external validity for our theoretical model, we conduct an exploratory empirical study to examine online sellers’ consumer review supply decisions based on data collected from different online sellers in several product categories. Our empirical study focuses on the impact of several factors identified in our theoretical model (i.e., width of product assortment, number of matched consumers, and length of time of the product on the market) on online sellers’ consumer review information supply decisions. We choose these factors because they can be reasonable measured directly or indirectly. Our results offer some preliminary evidences that are consistent with our theoretical results.

7.1 Data

First, to test whether the width of product assortment affects online sellers’ incentive to supplying consumer reviews at the store level as we predicted, we collected data in three product categories: MP3 Players, PDAs, and video games. For these three product categories, we identified a list of 68 online sellers from the referral list of the leading shop agent mySimon.com in June 18, 2003. Among 68 sellers, 22 stores offer consumer reviews. We also collected data on the number of assortments a seller carried in each product category.

Second, to test the impact of the number of matched consumers and the length of time of the product being on the market on the seller’s review supply decision at the individual product level, we collected data from Dell.com and CNET.com. Dell.com sells computer and electronic products from different competing brands in various categories. For each product offered on its website, Dell.com provides product attribute information. For some selected products, it offers consumer review information from CNET.com. We collected our data on April 18, 2003. Our data include the products in six product categories: digital cameras, PDAs, digital camcorders, Web cameras, printers and scanners. For each of
the six product categories, Dell.com carries multiple brands from different manufactures, and provides consumer reviews for only some selected models.

There are overall 121 models in six categories. We collected data on product review and product characteristics from CNET.com, which lists almost all the available models for many product categories. For each product, it asks existing users to post detailed comments and to vote on whether or not they regard this product positively. Consumers can find the descriptive review information about the product and a summary statistic on what percentage of consumers regard the product positively. In addition, for many products, CNET.com also publishes its own product review and presents an overall rating. We can also collect data on when the product was launched to the market from CNET.com. For each of 121 models, we collected data on product launch time, product rating by CNET.com, number of available consumer postings, and the percentage of positive consumer votes.

When Dell.com offers product review information for a model, it provides both CNET.com rating and consumer reviews. Therefore, to study its incentive to provide consumer reviews, we have to confine our sample in those products with both CNET review ratings and consumer reviews available. We found 57 out of 121 models have both CNET review ratings and consumer reviews available. We use these 57 models as the sample for our empirical analysis.

7.2 Empirical Findings

Impact of Product Assortment

Proposition 2 suggests that the width of product assortment positively affects the profitability of the seller’s consumer review supply policy. A binary Logit model is used to examine the impact of product assortment on online sellers’ consumer review supply decisions. The dependent variable is the binary choice for an online seller on whether it offered consumer reviews in a product category or not (i.e., 1 or 0). The independent variable is the number of assortments a seller carries in a product category. In addition, we include the two category dummy variables regarding three product categories as the control variables. Table 1 presents our empirical results.
Table 1. The Impact of Product Assortments

<table>
<thead>
<tr>
<th>Dependent Variable:</th>
<th>Whether Consumer Reviews were Offered by a Seller (N=68)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
</tr>
<tr>
<td>Number of Assortments in a Product Category</td>
<td>.03*</td>
</tr>
<tr>
<td>Product Category Dummy 1</td>
<td>.19</td>
</tr>
<tr>
<td>Product Category Dummy 2</td>
<td>.01</td>
</tr>
<tr>
<td>Model Correct Classification Rate</td>
<td></td>
</tr>
<tr>
<td>2 Log-likelihood (-2LL)</td>
<td></td>
</tr>
</tbody>
</table>

Note: A constant intercept is in the regression.
*: Significant at .05 level.

As shown in Table 1, the coefficient of the number of assortments is positive and significant (p<0.01), and both category dummy variable coefficients are insignificant. This suggests that, as predicted in Proposition 2, there is a significant positive relationship between the seller’s width of assortment and the likelihood for the seller to offer consumer review information. As discussed in our theoretical analysis, the seller with wider assortments is more likely to benefit from supplying consumer reviews and is thus more likely to facilitate such a new information channel.

Impact of Number of Matching Consumers and Product Launch Time

Proposition 1 suggests that the seller benefits from supplying consumer reviews if its product matches the preferences of a sufficient number of consumers. Proposition 5 suggest that offering consumer review too early can reduce its profit. As we described earlier, Dell.com offered consumer reviews for some selected models rather than all models it carries. The data we collected from Dell.com and CNET.com contain: (1) the launch time of 57 models, (2) the percentage of consumers who voted positively for each model, (3) the overall rating of each model by the third-party reviewer, CNET.com, (4) the number of available consumer postings for each model, and (5) which of the 57 models were offered consumer reviews. We used these data to examine empirically the impact of two factors on Dell’s consumer review supply decision: (a) the number of matched consumers and (b) the length of time since product launch.
A binary Logit model is used to test the impact of various factors on the consumer review information supply decision at the individual product level. The dependent variable is whether Dell.com offered consumer reviews for a product model. The independent variables are (1) length of time since product launch into the market, and (2) percentage of consumers who vote positively for a product. We use this percentage statistic as the measure for how many consumers find a product to be a match. To control the influence of CNET third-party review on Dell.com’s review supply decision, we add the CNET rating for a product as a control variable. In addition, to control the influence of product category and the number of available consumer postings, we also add five category dummy variables regarding six product categories and the number of available consumer postings as the control variables. Table 2 presents the test results.

Table 2. The Impact of Number of Matching Consumers and Product Launch Time

<table>
<thead>
<tr>
<th>Dependent Variable:</th>
<th>The Availability of Consumer Reviews for a Product Model (N=57)</th>
<th>Coefficient</th>
<th>Wald Statistic</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Launch Time Length</td>
<td>.02*</td>
<td>9.64</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>Percentage of Positive Consumer Votes</td>
<td>6.82*</td>
<td>3.75</td>
<td>.05</td>
<td></td>
</tr>
<tr>
<td>CNET.com Rating</td>
<td>.66</td>
<td>1.17</td>
<td>.28</td>
<td></td>
</tr>
<tr>
<td>Number of Available Consumer Postings</td>
<td>.01</td>
<td>.53</td>
<td>.47</td>
<td></td>
</tr>
<tr>
<td>Product Category Dummy 1</td>
<td>-8.25</td>
<td>.07</td>
<td>.80</td>
<td></td>
</tr>
<tr>
<td>Product Category Dummy 2</td>
<td>-9.49</td>
<td>.09</td>
<td>.80</td>
<td></td>
</tr>
<tr>
<td>Product Category Dummy 3</td>
<td>-7.96</td>
<td>.06</td>
<td>.80</td>
<td></td>
</tr>
<tr>
<td>Product Category Dummy 4</td>
<td>-8.22</td>
<td>.07</td>
<td>.80</td>
<td></td>
</tr>
<tr>
<td>Product Category Dummy 5</td>
<td>-8.26</td>
<td>.07</td>
<td>.80</td>
<td></td>
</tr>
<tr>
<td>Model Correct Classification Rate</td>
<td></td>
<td>80.7 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Log-likelihood (-2LL)</td>
<td></td>
<td>45.17</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: A constant intercept is in the regression.  
*: Significant at .05 level

Table 2 reveals several interesting findings on an online retailer’s consumer review supply decision. Note that Dell.com was able to determine whether and when to supply consumer reviews for an
individual product. First, the coefficient of the percentage of positive votes (the number of matched consumers) is positive (p<0.05), suggesting that Dell.com’s decision to offer consumer review for a given product was positively related to the percentage of consumers who find the product matches their preference. This is consistent with our theoretical finding in Proposition 1. Second, the coefficient of the product launch time length is positive (p<0.01), suggesting that Dell.com’s decision on offering consumer review for a given product was positively related to the time since the product was launched. This finding is consistent with our theoretical results in Proposition 5. Third, intuitively, one would expect that product quality should play an important role in a seller’s decision on which individual product to offer consumer reviews. Since third-party product ratings mainly convey product quality information (Chen and Xie, forthcoming), one would expect a significant effect of third-party product ratings on a seller’s review information supplying decision. Surprisingly, as shown in Table 2, the third-party product rating from CNET has no significant impact on Dell.com’s behavior on offering review information. This interesting finding seems to suggest that, for an online marketer, the benefit of offering consumer reviews seems to be linked more strongly with the product matching function served by consumer reviews than the product quality information that may be offered by consumers. Finally, as shown in Table 2, the number of available consumer postings is insignificant, suggesting that the number of postings was not a determining factor in Dell.com’s consumer review supply decision.

8. Conclusion
Recent developments in information technology have significantly increased online sellers’ information capacity. With the help of new technology, an online seller can not only present traditional seller-created information at a lower cost, but also has the new attractive option of supplying information to consumers by allowing them to post their product evaluations on the seller’s website or licensing consumer review information from third-party sources.

In this paper, we investigate an emerging research area: online consumer reviews and their implications on firm marketing strategies. Specifically, we study the marketing function of consumer reviews, show when an online seller should offer consumer reviews to its customers, and examine how
the decision to provide consumer-created information affects its other marketing strategies. An empirical study provides preliminary support for our theoretical model.

8.1. Online Consumer Review as a New Element of Marketing Communications Mix

New technology now is making it possible for an online seller to efficiently provide two different forms of product information to its potential buyers: (1) seller-created product information supplied by the seller via its website or other media, and (2) consumer-created information self-posted by consumers on the seller’s website. We argue that, since consumer-created information is user-oriented but seller-created information is product-oriented, the former has an advantage over the latter in helping consumers to find products matching their preferences. This is particularly important for those product categories where consumers’ usage conditions are so idiosyncratic that it is impossible, or very costly, for the seller to acquire this knowledge and list all possible mappings between the product attribute and usage condition spaces. As a result, consumer reviews can be deployed as a new element of marketing communications mix and work as an online seller’s free “sale assistants” to help consumers to identify products that best match their needs. Consumer reviews are particularly important for unsophisticated consumers who will be less likely to buy the seller’s product if only seller-created product information is available. However, this free sale assistant does not come without cost. By allowing consumers to post their own product evaluations, the seller creates a new information channel for consumers, which eliminates the seller’s capability to control the supply of product information (e.g., providing full vs. partial information to consumers).

8.2. The Strategic Implications of Online Consumer Review

Our model provides several normative implications for online sellers’ decisions related to online consumer reviews:

- The seller’s consumer review supply decision depends on the characteristics of its carried product category. Sellers carrying complicated, or high-tech products are more likely to benefit from providing consumer reviews than sellers carrying simple, or low-tech products. This is because (1) in the former markets, compared with seller-created information (i.e., traditional marketing
communications), consumer-created review information has the advantage of helping novice consumers to identify products that match their idiosyncratic preferences, and (2) there are fewer experts and more novice consumers in the former than the latter markets. When products are complex and the majority of consumers are unsophisticated, the benefit of providing consumer reviews becomes sufficiently high to outweigh a profit loss from the expert consumers.

- The seller’s consumer review supply decision depends on whether its product is a mass-market or niche product. Sellers benefit more from offering consumers reviews when their products are mass-market products and match the preferences of a large consumer segment than when their products are niche products and match the preferences of a small consumer segment. With the help of consumer-created information, more consumers are able to correctly identify their matched products. As a result, the gain (cost) from consumer reviews is higher (lower) if a seller’s product matches majority consumers’ preferences than if the seller’s product matches the minority consumers’ preferences.

- The seller’s consumer review supply decision depends on the informativeness of consumer reviews. Sellers can benefit from offering consumer reviews only if the consumer reviews are sufficiently informative. The consumer review’s matching function largely depends on the review informativeness. When consumer review information is not sufficiently informative, the matched consumers’, particularly novice consumers’, uncertainty reduction and willingness-to-pay increase are too limited to make the seller’s decision profitable.

- The seller’s consumer review supply decision depends on its product assortment strategy. Sellers carrying a wide product assortment benefit more from offering consumer reviews than sellers carrying a narrow product assortment. This is because consumer reviews increase product valuations of matched consumers but decrease product valuations of unmatched consumers. For a seller carrying a wide assortment, the negative impact of consumer reviews is limited since most consumers are able to find their matched products from the same seller. For a seller carrying
a narrow assortment, the negative impact of product review is significant because the seller may lose the unmatched consumers.

• Sellers’ two types of information supply strategies interact with each other. Specifically, as a new marketing communication strategy, the seller’s decision to offer consumer reviews will increase its incentive to provide full product attribute information through traditional marketing communications. Without consumer reviews, the seller can benefit from providing partial product information and serve both perfectly and partially matched expert consumers. Consumer reviews take away the seller’s full control over product information, and reveal some mismatch information to partially matched expert consumers, which decreases their willingness to pay and incurs seller’s profit loss. Providing full product information can increase perfectly matched consumers’ willingness to pay and reduce the seller’s profit loss from expert consumers.

• The seller’s consumer review supply decision also depends on the value its product provides for the partially matched consumers. Consumer reviews remove the seller’s full control over product information and reduce its profit from the expert consumers. This negative effect exists only when the seller’s product provides sufficiently high value for the partially matched consumers. When the seller’s product value for the partially matched consumers is sufficiently low, the seller provides full product information even in the absence of consumer reviews, and will not incur profit loss from offering consumer reviews. Hence the seller will provide consumer reviews to achieve higher profit from novice consumers’ purchase.

• The timing of providing consumer review information can be an important strategic variable for a seller. When a seller is able to decide such timing at the individual product level (e.g., when the seller licenses consumer reviews from third-party sources), it may be unwise to supply consumer review information at a very early stage after a new product’s introduction, even if such reviews are available. Offering consumer reviews reduces the seller’s control over the product information available to consumers. Hence, providing consumer reviews too earlier will hurt the seller if a partial information strategy is optimal in the absence of consumer reviews.
While this research improves our understanding of online consumer review and its implications for firm marketing strategies, many other interesting questions remain unanswered and require further investigation. One limitation of this paper is that we study a monopoly model and focus on the matching function of online consumer review. Future research may study some other functions of online consumer reviews and investigate its implications for firm competition. Second, in our model, the review informativeness is exogenous. Future research may study how an online seller can design some mechanisms to increase consumer review informativeness. Finally, future research may study from the perspective of consumer review infomediaries such as Epinions.com, and examine their optimal marketing strategies.
Appendix

Summary of Notations

c Marginal cost of the seller’s product
T Consumer type
T = T_m, T_u in the basic model (T_m: matched; T_u: unmatched)
T = T_m, T_i, T_m, T_u in the generalized model (T_m: fully matched; T_i and T_u: partially matched; T_m: fully unmatched)

τ Fraction of matched consumers in the basic model

v_m Consumers’ evaluation on their matched product in the basic model
v_u Consumers’ evaluation on their unmatched product in the basic model (v_u is assumed to 0)

v Consumers’ expected valuation in the absence of product information
γ Consumer review informativeness

T Time period in the model (T = 1, 2 for the basic model, and T = 1, 2, 3 for the generalized model)

Π Seller’s overall profit in the absence of consumer reviews
Π Seller’s overall profit in the presence of consumer reviews
Π_t Seller’s profit in period t in the absence of consumer reviews
Π_t Seller’s profit in period t in the presence of consumer reviews
Π_M Seller’s overall profit from multiple assortments in the absence of consumer reviews
Π_M Seller’s overall profit from multiple assortments in the presence of consumer reviews

P_t Seller’s price in period t

S Consumer segment (S = E, N; E: expert; N: novice)
η Fraction of expert consumers among all consumers
λ Fraction of innovators among all expert consumers

Π^S Seller’s profit from segment S in the absence of consumer reviews
Π^S Seller’s profit from segment S in the presence of consumer reviews

I Product attribute information (I = I^F, I^P, I^I: full information; I^I: partial information)

V_T(S, I, γ) Expected valuation of type T consumers in segment S given attribute information I and review informativeness γ

v^F Consumers’ evaluation on their fully matched product in the generalized model
v^P Consumers’ evaluation on their partially matched product in the generalized model
v^o Consumers’ evaluation on their fully unmatched product in the generalized model (v^o is assumed to 0)

Π_f1 Seller’s overall profit when offering the consumer reviews in the end of period 1
Π_f2 Seller’s overall profit when offering the consumer reviews in the end of period 2
A.1. Proof of Lemma 1

In the absence of consumer reviews, when the seller provides full information, its profit from the experts is

\[ \hat{\Pi}^F(I^F) = \eta(v^F - c) / 4 \]  

(A.1)

When the seller provides partial information on one attribute, for instance \( a_1 \), the expected valuation for the product is \( (v^F + v_f^F) / 2 \) for type \( T_m \) and \( T_m \) experts who have matched tastes in the attribute \( a_1 \). For those consumers who have mismatched tastes in the attribute \( a_1 \) (type \( T_m \) and \( T_m \)), they have equal probabilities to find match and mismatch in \( a_2 \) and have a valuation of \( v^F \) and 0 on the product. Hence the expected valuation for them is \( v^F / 2 \). This valuation is lower than \( \sigma = (v^F + 2v^F) / 4 \) and \( c \), and fail to meet the participation constraint. The seller charges a price \( P_1 = P_2 = (v^F + v_f^F) / 2 \) and gain the demand from type \( T_m \) and \( T_m \) experts. Recalling that \( \lambda \) is the percentage of first period experts (innovators) among all experts and \( \eta \) is the fraction of the experts among all consumers, the seller’s profit is

\[ \hat{\Pi}^F(I^F) = (\lambda(P_1 - c) + (1 - \lambda)(P_2 - c)) \eta / 2 = \eta(v^F + v_f^F) / 2 - c / 2 \]  

(A.2)

Comparing (A.1) with (A.2), we find \( \hat{\Pi}^F(I^F) > \hat{\Pi}^F(I^F) \) and \( \hat{\Pi}^F(I^F) = \hat{\Pi}^F(I^F) \) iff \( v^F < c \). Q. E. D.

A.2. Proof of Lemma 2

In the presence of consumer reviews, when the seller provides full information, its profit from the experts is the same as in the full information case in the absence of consumer reviews, i.e.,

\[ \Pi^F(I^F, \gamma) = \eta(v^F - c) / 4 \]  

(A.3)

When the seller only provides information on one attribute, for instance \( a_1 \), the seller’s profit from the experts in period 1 is the same as in period 1 in the absence of consumer reviews, i.e.,

\[ \Pi_1(I^F) = ((v^F + v_f^F) / 2 - c) \eta \lambda / 2 \]  

(A.4)

In period 2, with the consumer reviews, we know the expected valuation for type \( T_m \) experts is

\[ V_{T_m}^E(I^F, \gamma) = v^F \bar{q}(\gamma) + v_f^F q(\gamma) = (v^F + v_f^F) / 2 + \gamma(v^F - v_f^F) / 2 \]  

For type \( T_m \) experts, the probability for them to find the mismatch in the second attribute and has a valuation \( v^F \) is \( \bar{q}(\gamma) = 1 / 2 + \gamma / 2 \). In the same time, the probability for them to find the match in the second attribute and has a valuation \( v^F \) is \( q(\gamma) = 1 / 2 - \gamma / 2 \). Therefore the expected valuation for type \( T_m \) majority experts is \( V_{T_m}^E(I^F, \gamma) = v^F \bar{q}(\gamma) + v_f^F q(\gamma) \). Due to their mismatched tastes with attribute \( a_1 \), type \( T_m \) and \( T_m \) experts find their valuations are \( v^F \) and 0 with the probability of \( \bar{q}(\gamma) \), and 0 and \( v^F \) with a probability of \( q(\gamma) \). Therefore the expected valuations for type \( T_m \) and \( T_m \) experts are

\[ V_{T_m}^E(I^F, \gamma) = v^F (1 + \gamma) / 2 \]  

and \( V_{T_m}^E(I^F, \gamma) = v^F (1 - \gamma) / 2 < c \), separately. The seller can charge a price at \( V_{T_m}^E(I^F, \gamma) \), \( V_{T_m}^E(I^F, \gamma) \), or \( V_{T_m}^E(I^F, \gamma) \) to serve different amount of consumers. Charging a price \( P_1 = V_{T_m}^E(I^F, \gamma) \) is always less profitable compared with \( P_1 = V_{T_m}^E(I^F, \gamma) \) noticing \( v^F > 3v^F - 2c \). For a sufficiently small \( \gamma \), it is profitable for the seller to charge a low price at \( (v^F + v_f^F) / 2 - \gamma(v^F - v_f^F) / 2 \) to gain the demand from both type \( T_m \) and \( T_m \) experts. For a
sufficiently large $\gamma$, it is profitable for the seller to charge a premium price at 
\[(v^p + v^f)/2 + \gamma (v^f - v^p)/2\] to serve only type $T_{\text{min}}$ experts. Therefore seller’s profit in period 2 is
\[
\Pi_2(I^f, \gamma) = \begin{cases} 
\frac{\eta(1-\lambda)}{2} \left( \frac{1}{2} (v^p + v^f) - \frac{\gamma}{2} (v^f - v^p) - c \right), & \text{if } \gamma \in [0, \tilde{\gamma}] \\
\frac{\eta(1-\lambda)}{4} \left( \frac{1}{2} (v^p + v^f) + \frac{\gamma}{2} (v^f - v^p) - c \right), & \text{if } \gamma \in (\tilde{\gamma}, 1]
\end{cases}
\]
where $\tilde{\gamma} = 1/3 + 2(v^f - c)/3(v^f - v^p)$.

The seller’s profit from the experts when only providing partial attribute information in
the presence of consume reviews is
\[
\Pi^e(I^f, \gamma) = \Pi_1(I^f, \gamma) + \Pi_2(I^f, \gamma) = \begin{cases} 
\frac{\eta(1-\lambda)}{2} \left( \frac{1}{2} (v^p + v^f) + \frac{\gamma}{2} (v^f - v^p) - c \right), & \text{if } \gamma \in [0, \tilde{\gamma}] \\
\frac{\eta(1-\lambda)}{4} \left( \frac{1}{2} (v^p + v^f) + \frac{\gamma}{2} (v^f - v^p) - c \right), & \text{if } \gamma \in [\tilde{\gamma}, 1]
\end{cases}
\]
Comparing the seller’s profits from providing the full and partial attribution information in
equation (A.3) and (A.6), we find, $\Pi^e(I^f, \gamma) > \Pi^e(I^f, \gamma)$ iff $v^f < c$, or $v^f \geq c$ and $\gamma \in [\gamma, \tilde{\gamma}]$, where $\gamma = (v^f - c)/(1 - \lambda)(v^f - v^p)$ and $\tilde{\gamma} = (v^f + v^f)/(v^f - v^p) - 2(v^f - c)/(1 - \lambda)(v^f - v^p)$.

Hence, $\Pi^e = \Pi^e(I^f, \gamma)$ iff $v^f < c$, or $v^f \geq c$ and $\gamma \in [\gamma, \tilde{\gamma}]$. Q. E. D.

A.3. Proof of Lemma 3

1) When $v^f < c$, the seller will provide full attribute information both in the absence and presence of consumer reviews. Its profits from the expert segment are the same, i.e., $\Pi^e = \tilde{\Pi}^e$

2) When $v^f \geq c$, in the presence of consumer reviews, from equation (A.3), when it provides full product information, the seller’s expected profit from the expert segment is
\[
\Pi^e(I^f, \gamma) = \eta(v^f - c)/4 = \tilde{\Pi}^e(I^f) - \eta(v^f - c)/4
\]
From equation (A.6), seller’s profit from the experts when it provides partial information in
the presence of consume reviews is
\[
\Pi^e(I^f, \gamma) = \begin{cases} 
\frac{\eta(1-\lambda)}{2} \left( \frac{1}{2} (v^p + v^f) + \frac{\gamma}{2} (v^f - v^p) - c \right), & \text{if } \gamma \in [0, \tilde{\gamma}] \\
\frac{\eta(1-\lambda)}{4} \left( \frac{1}{2} (v^p + v^f) + \frac{\gamma}{2} (v^f - v^p) - c \right), & \text{if } \gamma \in [\tilde{\gamma}, 1]
\end{cases}
\]
Note in the absence of consumer reviews, the seller’s maximum profit from the expert segment is $\hat{\Pi}^E = \hat{\Pi}^E(I^E)$. From equation (A.7) and (A.8), it is straightforward that both $\Pi^E(I^E, \gamma)$ and $\Pi^E(I^E, \gamma)$ are less than $\hat{\Pi}^E(I^E)$. Therefore, $\Pi^E < \hat{\Pi}^E$ when $v^E \geq c$.

Therefore $\hat{\Pi}^E \leq \hat{\Pi}^E$. Q. E. D.

A.4. Proof of Proposition 4

When the seller decides to provide consumer reviews, its problem can also be described as

$$
\max_{I, \gamma} \Pi(I, \gamma, P) = \Pi^E(I, \gamma, P, P_2) + \Pi^N(\gamma, P_2)
$$

s. t. 

$V^S_t(I, \gamma) \geq c$ (IR constraint for consumers) 

$\Pi(I, \gamma, P) \geq \hat{\Pi}^E$ (IC constraint for the seller) 

(A.9)

where $I = I^E, I^F, t = 1$ or $2$, $S = A$ or $E$; and $T = T_{mn}, T_{mn}, T_{mn}, T_{mn}$.

Table A1. Novice Consumer Expected Valuations in the Presence of Consumer Reviews

<table>
<thead>
<tr>
<th>Consumer Type ($T$)</th>
<th>Prob. of Attribute Match for Type $T$ Novices Given Consumer Review Informativeness $\gamma$</th>
<th>Consumer Expected Valuation $V^N_t(\gamma)$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mismatch in $a_1$ and $a_2$ ($v = 0$)</td>
<td>$q(\gamma)g(\gamma)$</td>
</tr>
<tr>
<td>$T_{mn}$</td>
<td>Mismatch in $a_1$, but not $a_2$ ($v = v^E$)</td>
<td>$\overline{g}(\gamma)q(\gamma)$</td>
</tr>
<tr>
<td></td>
<td>Mismatch in $a_2$, but not $a_1$ ($v = v^F$)</td>
<td>$\overline{g}(\gamma)\overline{q}(\gamma)$</td>
</tr>
<tr>
<td></td>
<td>Match in both $a_1$ and $a_2$ ($v = v^F$)</td>
<td>$2\overline{q}(\gamma)\overline{q}(\gamma)$</td>
</tr>
<tr>
<td>$T_{mnn}$</td>
<td>Mismatch in $a_1$, but not $a_2$ ($v = v^E$)</td>
<td>$\overline{g}(\gamma)\overline{q}(\gamma)$</td>
</tr>
<tr>
<td></td>
<td>Mismatch in $a_2$, but not $a_1$ ($v = v^F$)</td>
<td>$\overline{g}(\gamma)\overline{q}(\gamma)$</td>
</tr>
<tr>
<td></td>
<td>Match in both $a_1$ and $a_2$ ($v = v^F$)</td>
<td>$2\overline{q}(\gamma)\overline{q}(\gamma)$</td>
</tr>
<tr>
<td>$T_{mnn}$</td>
<td>Mismatch in $a_1$, but not $a_2$ ($v = v^E$)</td>
<td>$\overline{g}(\gamma)\overline{q}(\gamma)$</td>
</tr>
<tr>
<td></td>
<td>Mismatch in $a_2$, but not $a_1$ ($v = v^F$)</td>
<td>$\overline{g}(\gamma)\overline{q}(\gamma)$</td>
</tr>
<tr>
<td></td>
<td>Match in both $a_1$ and $a_2$ ($v = v^F$)</td>
<td>$2\overline{q}(\gamma)\overline{q}(\gamma)$</td>
</tr>
</tbody>
</table>

Note *: $\overline{q}(\gamma) = 1/2 + \gamma/2$, and $\overline{q}(\gamma) = 1/2 - \gamma/2$.

We have derived the seller’s profit from the experts. In the following, we derive its profit from novice consumers. In period 3, as shown in Table A1, for type $T_{mn}$ novices who are the perfect match consumers for the seller’s product, given the consumer review information, the probability for them to find the match in each attribute is $\overline{q}(\gamma) = 1/2 + \gamma/2$, which is increasing with the review informativeness. In contrast, the probability for them to find the mismatch in each attribute is $q(\gamma) = 1/2 - \gamma/2$, which is decreasing with the review informativeness. Therefore the probabilities for type $T_{mn}$ novices to have valuations of zero, $v^E$ and $v^F$ are $q(\gamma)g(\gamma)$, $2\overline{q}(\gamma)\overline{q}(\gamma)$, and $\overline{q}(\gamma)\overline{q}(\gamma)$, respectively. As a result, the expected valuation of type $T_{mn}$ novices is $(2v^E + v^F)/4 + \gamma v^E/2 - \gamma(2v^E - v^F)/4$. Similarly, as shown in Table A1, we can find the expected valuations for other three types of novices. The expected valuations for four types of novice consumers are
\[
\begin{pmatrix}
V_{T_{mm}}^N (\gamma) \\
V_{T_{mn}}^N (\gamma) \\
V_{T_{nm}}^N (\gamma) \\
V_{T_{mn}}^N (\gamma)
\end{pmatrix} = \begin{pmatrix}
(2v^p + v^f) / 4 + \gamma v^f / 2 - \gamma^2 (2v^p - v^f) / 4 \\
(2v^p + v^f) / 4 + \gamma^2 (2v^p - v^f) / 4 \\
(2v^p + v^f) / 4 + \gamma^2 (2v^p - v^f) / 4 \\
(2v^p + v^f) / 4 - \gamma v^f / 2 - \gamma^2 (2v^p - v^f) / 4
\end{pmatrix}
\]

From equation (A.10), we find \( V_{T_{mm}}^N (\gamma) \) is less than \( \gamma \) and therefore \( c \), and fails the participation constraint. The participation constraint for type \( T_{mm} \) novice consumers is:

\[
V_{T_{mm}}^N (\gamma) \geq c \tag{A.11}
\]

From (A.11), \( \gamma \geq \gamma \), where \( \gamma = \left( v^f + \sqrt{v^f - v^p}(4c - 2v^p - v^f) \right) / (2v^p - v^f) \).

The participation constraint for \( T_{mn} \), \( T_{mm} \) and \( T_{mm} \) types of novice consumers to buy is:

\[
\begin{align*}
V_{T_{mm}}^N (\gamma) & \geq c \\
V_{T_{mn}}^N (\gamma) & \geq c \\
V_{T_{mn}}^N (\gamma) & \geq c
\end{align*} \tag{A.12}
\]

From (A.12), \( \gamma \geq \gamma \), where \( \gamma = (4c - 2v^p - v^f) / (2v^p - v^f) > \gamma \).

The seller’s maximum profit from the novice consumers is

\[
\Pi^N = \begin{cases}
\Pi^N (\gamma, P_3 = V_{T_{mm}}^N (\gamma)), & \text{if } \gamma \in [\gamma, \hat{\gamma}] \cup [\gamma, 1] \\
\Pi^N (\gamma, P_3 = V_{T_{mn}}^N (\gamma)), & \text{if } \gamma \in [\hat{\gamma}, \overline{\gamma}] \\
\frac{1-\eta}{4} \left( \frac{2v^p + v^f}{4} + \frac{\gamma v^f}{2} - \frac{\gamma^2 (2v^p - v^f)}{4} - c \right), & \text{if } \gamma \in [\gamma, \hat{\gamma}] \cup [\gamma, 1] \\
\frac{3(1-\eta)}{4} \left( \frac{2v^p + v^f}{4} + \frac{\gamma^2 (2v^p - v^f)}{4} - c \right), & \text{if } \gamma \in [\hat{\gamma}, \overline{\gamma}]
\end{cases}
\]

where \( \hat{\gamma} = \frac{v^f - \sqrt{v^f} - 8(2v^p - v^f)(4c - v^p - v^f)}{4(2v^p - v^f)} < 0 \) and \( \overline{\gamma} = \frac{v^f + \sqrt{v^f} - 8(2v^p - v^f)(4c - v^p - v^f)}{4(2v^p - v^f)} > 1 \).

Hence the seller’s profit from the novice consumers is

\[
\Pi^N = \begin{cases}
\Pi^N (\gamma, P_3 = V_{T_{mm}}^N (\gamma)) \\
\frac{1-\eta}{4} \left( \frac{2v^p + v^f}{4} + \frac{\gamma v^f}{2} - \frac{\gamma^2 (2v^p - v^f)}{4} - c \right)
\end{cases} \tag{A.13}
\]

When \( v^p < c \), the seller will provide full attribute information in the absence of consumer reviews. The seller’s decision to provide consumer reviews does not affect its profit from the expert segment. Hence, when \( \gamma \geq \gamma \), the seller will provide consumer reviews and gain extra profit from the novice segment, i.e., \( \Pi^N > \Pi^* \).

When \( v^p \geq c \), the seller always provides partial information in the absence of consumer reviews, i.e., \( \Pi^* = \Pi(v^p) = \Pi^*(v^p) \). From equation (A.7), (A.8) and (A.13), when the seller provides consumer reviews,

1) For \( \gamma \in [\gamma, \gamma] \), its maximum overall profit is
\[ \Pi^* = \Pi^E(I^*, \gamma, P_1 = V_{I\gamma^*}^E(I^*, \gamma), P_2 = V_{I\gamma^*}^E(I^*, \gamma)) + \Pi^V^* \]
\[ = \hat{\Pi}^* - \frac{\eta(1 - \lambda)}{2} (v^r - v^p) + \frac{1 - \eta}{4} \left( \frac{2v^p + v^f}{4} + \frac{\gamma v^f}{2} - \frac{\gamma^2 (2v^r - v^p)}{4} - c \right) \]  
(A.14)

\[ \Pi^* > \hat{\Pi}^* \text{ if } \eta < \eta^*, \text{ where} \]
\[ \eta^* = \left( \frac{(1 - \lambda) (v^f - v^r)}{4} + \frac{\gamma v^f}{2} - \frac{\gamma^2 (2v^r - v^p)}{4} - c \right)^{-1} \]  
(A.15)

2) For \( \gamma \in [\gamma, \tilde{\gamma}] \), its maximum profit is
\[ \Pi^* = \Pi^E(I^*, \gamma) + \Pi^V^* \]
\[ = \hat{\Pi}^* - \frac{\eta}{4} (v^p - c) + \frac{1 - \eta}{4} \left( \frac{2v^p + v^f}{4} + \frac{\gamma v^f}{2} - \frac{\gamma^2 (2v^r - v^p)}{4} - c \right) \]  
(A.16)

\[ \Pi^* > \hat{\Pi}^* \text{ if } \eta < \eta^*, \text{ where} \]
\[ \eta^* = \left( \frac{(v^p - c)}{4} + \frac{\gamma v^f}{2} - \frac{\gamma^2 (2v^r - v^p)}{4} - c \right)^{-1} \]  
(A.17)

3) For \( \gamma \in [\tilde{\gamma}, 1] \), its maximum profit is
\[ \Pi^* = \Pi^E(I^*, \gamma, P_1 = V_{I\gamma^*}^E(I^*, \gamma), P_2 = V_{I\gamma^*}^E(I^*, \gamma)) + \Pi^V^* \]
\[ = \hat{\Pi}^* - \frac{\eta(1 - \lambda)}{4} \left( \frac{1}{2} (v^p + v^r) - \frac{\gamma}{2} (v^r - v^p) \right) + \frac{1 - \eta}{4} \left( \frac{2v^p + v^f}{4} + \frac{\gamma v^f}{2} - \frac{\gamma^2 (2v^r - v^p)}{4} - c \right) \]  
(A.18)

\[ \Pi^* > \hat{\Pi}^* \text{ if } \eta < \eta^*, \text{ where} \]
\[ \eta^* = \left( \frac{(1 - \lambda) ((v^p + v^r) - \gamma (v^r - v^p))}{4} + \frac{\gamma v^f}{2} - \frac{\gamma^2 (2v^r - v^p)}{4} - c \right)^{-1} \]  
(A.19)

Therefore, \( \Pi^* > \hat{\Pi}^* \) when (a) \( \gamma \geq \tilde{\gamma} \), and (b) (i) \( v^r < c \), or (ii) \( v^r \geq c \) and \( \eta < \eta^* \). Q. E. D.
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