

# UNDERSTANDING THE VALUE OF ONLINE CUSTOMER REVIEWS: THE CHANNEL PERSPECTIVE

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## Abstract

*The growing popularity of user-generated contents in the electronic commerce industry has allowed online customer reviews (OCRs) to play an increasingly important role in the customer decision-making process. The influences of OCRs have been studied extensively by academic researchers and industry practitioners from the customer side, whereas this study provides a complementary analysis of the value of OCRs from the channel side. We employ a game-theoretic model where a manufacturer sells to a group of customers through a single retailer. The customers are heterogeneous in their personal tastes and they use OCRs to update their knowledge of product functionalities. Surprisingly, we show with closed-form solution that positive OCRs could reduce the manufacturer's and retailer's profits because double marginalization in the decentralized channel might lead to overpricing. We also examine the case with information asymmetry where the manufacturer receives biased information of OCRs. The numerical results suggest that information asymmetry could significantly undermine both manufacturer's and retailer's profit, especially when the manufacturer tries to target a small group of customers with a high price premium.*

*Keywords: Channel analysis, Online customer reviews, Double marginalization.*

# 1 Introduction

The widespread use of information technology has resulted in unprecedented growth in the electronic commerce industry during recent decades. On the supply side, both the variety and complexity of product offerings have been quickly expanding. On the demand side, not surprisingly, customers are gradually falling behind fancy innovations such as eye-tracking devices and fingerprint scanners. For example, it has been reported that only 11% of elderly customers in US market have ever used smartphone applications whereas 53% of them use Internet frequently, while 70% of adults actually own smartphones (Orlov 2013). According to another survey by Vodafone among users of 35 to 55 years old, one-third of them did not know how to use the basic functions of smartphones (Pringle 2005).

Customers generally have two typical ways to collect product information: One is the product manual which is enclosed in the package, downloadable from official website, or available from sales people in storefronts; the other is the third-party resource that contains customer reviews (e.g., [www.cnet.com](http://www.cnet.com)), which provide access to peers' adoption experiences. Compared with official information from the firm, customer reviews are usually organized in a user-friendly fashion with descriptions on the product usage in real-life scenarios, and evaluations from the user's perspective (Chen & Xie 2008). Extensive evidences have demonstrated that online customer reviews (OCRs) have become increasingly influential in customers' decision-making process. For example, it is reported that, after reading OCRs, 43% of surveyed customers reinforced their original purchasing decision whereas another 43% of customers switched to other substitutable products. Furthermore, as many as 9% of the surveyed customers gave up purchasing after reading OCRs (Deloitte 2007).

While OCRs improve customers' understanding of the product features, their effects upon the supply side remain largely unexplored. Specifically, we are interested in OCRs' impacts on multi-level channels (e.g., smartphone manufacturers and BestBuy, publishers and Amazon.com, etc.) Intuitively, when OCRs are generally positive, all channel members may benefit by increasing the product price (alternatively, discounting less frequently), to take advantage of the positive feedbacks. Is this potential price markup always profit-improving for all channel members?

To address this question, we develop a game-theoretic model where a manufacturer sells to a group of customers through a single retailer. We assume that customers can collect information from OCRs to update their utility of purchasing the product. Benchmarked by a vertically-integrated channel, we investigate the pricing equilibrium in a decentralized channel. We find that central planner of a vertically-integrated channel is never worse off with positive OCRs, which agrees with aforementioned intuition. Surprisingly, we discover that positive and negative OCRs in the decentralized channel may respectively reduce and increase both the manufacturer's and retailer's profits because double marginalization might lead to the channel's overreaction in pricing. We also consider the extension where the manufacturer is less informed about OCRs. We discover that information asymmetry reduces the profits for both the manufacturer and the retailer, especially when the manufacturer targets a small customer group with a high price premium.

The remainder of this paper is organized as follows. Section 2 reviews prior studies related to our research. The model is presented in Section 3 and the benchmark case is examined in Section 4. In Section 5, we solve the pricing equilibrium in the context of a decentralized channel and extend our analysis to information asymmetry in Section 6. Section 7 discusses the implications and concludes the paper.

## 2 Literature Review

A wealth of literature has come out in recent years to examine the relationship between product sales and OCRs but mixed findings are reported. Chen et al. (2004) use data from Amazon.com to show that

consumer recommendations are more effective than customer ratings in inducing product sales. In the publishing industry, Chevalier and Mayzlin (2006) find that positive OCRs are profit-improving even for rival sellers. This positive relationship is also verified in Duan et al. (2008) with data obtained from film industry. Forman et al. (2008) investigate the importance of identity-descriptive information disclosure in OCRs. Their findings suggest that the disclosure of reviewers' identity information is positively associated with product sales. A recent study by Gu et al. (2012) differentiates retailer-hosted and third party-hosted reviews, and shows that external word-of-mouth effects has greater influence on retailer sales. In contrast, there are also studies identifying non-significant or even negative correlations between customer reviews and product sales. Berger et al. (2012) find that negative publicity damaged the sales of books by reputable authors, but it increases the sales of books with lower prior public awareness. Li et al. (2011) employ a game-theoretical model to show that OCRs could hurt the profit from repeated purchases by inducing price competition, which suggests that there is an optimal level of customer awareness. In this paper, we also discover that positive OCRs might lead to profit loss, which is caused by the double marginalization.

Besides examining the relationship between sales and OCRs, there is also a line of researches that explore how firm can take advantage of OCRs more proactively. For example, Chen & Xie (2005) analyze a firm's strategic reactions toward OCRs and suggest that firms should choose advertising rather than pricing in response to product reviews. Dellarocas (2006) shows that manipulation of OCRs might not be profit-improving because firms are forced to overspend resources when the precision of honest consumer opinions is sufficiently high. Chen & Xie (2008) consider marketing communication with product reviews and find that seller-created product information and buyer-created review information could either be complementary or substitutable. Chen et al. (2011) show that moderation of OCRs directly affects a commentator's incentive to provide useful information and low-reputation commentators must achieve superior performance to build up a high reputation. While firms can manipulate OCRs on the demand side to induce sales, little is known about their strategies on the supply side. Most prior studies have assumed a single-vendor scenario to simplify the analysis, while most products are delivered through multi-level channels in practice. Our study aims to fill this gap by studying OCRs from the channel perspective.

In a pioneering study, Shaffer and Zettelmeyer (2002) consider a scenario where two competing manufacturers sell through a single retailer. They show that the retailer can be harmed by positive OCRs and the manufacturer can gain from positive OCRs for the rival's product. Their work is extended recently by Kwark et al. (2014) who consider both product fitness and quality. Our study is closely related to this stream of research. Instead of competition between manufacturers or retailers, we focus on the interplay between OCRs and overall channel efficiency. Similar to Clemons et al. (2006) and Kwark et al. (2014), our study incorporates the customers' concerns on product fitness. We find that double marginalization would potentially lead to a negative relationship between OCRs and channel profits.

### 3 The Model

Consider a classic channel setting where a manufacturer sells to a group of customers through a single retailer. The manufacturer first decides the wholesale price,  $w > 0$ . Then, the retailer chooses the retail price,  $p > 0$ . Finally, the customers decide whether to purchase the product.

There is a unit mass of customers who are heterogeneous in their personal tastes  $x$  which is distributed uniformly over  $[0, 1]$ . A customer's personal taste reflects her targeted level of the product functionalities. In particular, if a customer's personal taste  $x \rightarrow 1$ , it indicates that this customer favors a product with abundant features or functionalities (e.g., technology fans may strongly prefer mobile devices with advanced features such as a high-resolution camera, powerful chips, and large capacity, etc.). In contrast, when  $x \rightarrow 0$ , then customer only needs a few basic functionalities (e.g., elderly mobile users are not

sensitive to sophisticated features).

Customer make the purchasing decision based on their knowledge on product functionalities  $\theta$ .  $\theta$  can be formed or learned by talking to a salesperson, reading product descriptions, trying sample products, and reading customer reviews, etc. We assume that  $\theta$  is identical among all customers since the product information (including OCRs) is supposed to be accessible publicly. Therefore, given customer's personal taste  $x$  and their knowledge  $\theta$ , customer's willingness-to-pay (WTP) function  $u(x|\theta)$  is given by

$$u(x|\theta) = \begin{cases} K + x, & \theta \geq x; \\ K + \theta - b(x - \theta), & \theta < x, \end{cases} \quad (1)$$

where  $b$  is the positive coefficient for “mismatch cost”, and  $K$  is the customers' baseline utility they can obtain from product adoption. The implications of equation (1) are two-fold: first, the condition  $\theta \geq x$  indicates that the product offer functionalities which are beyond what customers actually need. In this case customers only benefit from the reservation utility  $K$  and the functionalities that are useful to them (represented by the customer's personal taste  $x$ ); second, the opposite condition  $\theta < x$  stands for the case that the customer's personal taste cannot be fully satisfied by the product, which incurs a mismatch cost which is sensitive to the gap between  $\theta$  and  $x$ . An example of the WTP function  $u(x|\theta)$  is visualized in Figure 1.

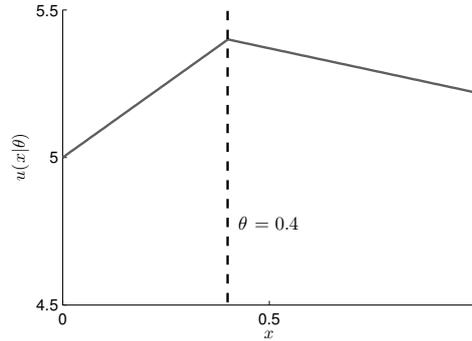


Figure 1. Example of customers' WTP ( $\theta = 0.4, b = 0.3, K = 5$ )

Similar setup for WTP functions is widely adopted in literature with heterogeneous customer tastes (Raghunathan 2000, Ghose & Sundararajan 2005, Shivendu & Zhang 2012). The right-hand side (RHS) of the utility curve in Figure 1 is similar to the classic Hotelling model (Hotelling 1929) in which heterogeneous transportation costs are incurred. The transportation cost in the Hotelling model is frequently interpreted as the “mismatch cost” or “unfit cost” in the literature of marketing and information systems (e.g., Desai 2001, Mehra et al. 2012, Markopoulos & Clemons 2013). On the left-hand side (LHS) of the utility curve in Figure 1, the “mismatch cost” is not considered because useless functionalities can be disposed freely. Lastly, the product is “ideal” to those who with  $x = \theta$  and thus they have the largest WTP among all customers.

Next, we introduce the mechanisms of OCRs. We allow customers to learn about  $\theta$  through reading OCRs, while their personal tastes  $x$  remain fixed. This implies that OCRs have no educational influences on customers' personal needs but help identify the functionalities of the product. Similar to Kwark et al. (2014), we consider a simplified scenario for information updating. Initially, when the product is launched, all customers form a initial belief  $\theta$  on the product functionalities. As OCRs gradually accumulate, all

potential customers update their knowledge of functionalities from  $\theta$  to  $\theta_r$ . Due to the inability to capture the entire evolution dynamics of OCRs, we choose to examine two polar cases, initial state of  $\theta$  and the steady state of  $\theta_r$ , instead of characterizing the entire accumulation process of OCRs. Furthermore, the price-related information contained in OCRs is excluded from our model. Thus, the OCRs only provide information that describes functionalities. In this way, OCRs are categorized to be “positive” if they contain evidences to show that the product has more functionalities than initial belief (i.e.,  $\theta_r \geq \theta$ ). “Negative” OCRs conform to the opposite logic. Our research questions are as follows. Do positive (negative) OCRs always lead to higher (lower) profits for channel members? What if the channel members have asymmetric information about OCRs?

We start our analysis with characterization of OCRs’ impacts on customer side. After reading the OCRs, all potential customers update their knowledge from  $\theta$  to  $\theta_r$ . Throughout the paper the proofs are omitted due to the page limit but available from authors upon request.

**Lemma 1.** For the initial belief  $\theta$  and the updated knowledge  $\theta_r$ , the followings hold true ( $\tilde{\theta} = \frac{(4-3\theta)\theta^3 - (4-3\theta_r)\theta_r^3}{2[\theta^2(3-2\theta) - \theta_r^2(3-2\theta_r)]}$ ):

(i). If OCR is nonnegative (i.e.,  $\theta_r \geq \theta$ ),

- (mean-upshifting and aggregation) when the initial belief is low ( $\frac{b}{1+b} \geq \tilde{\theta}$ ), OCRs increase the mean but decrease the variance of the customers’ WTP;
- (mean-upshifting and dispersion) when the initial belief is high ( $\frac{b}{1+b} < \tilde{\theta}$ ), OCRs increase both the mean and variance of the customers’ WTP.

(ii). If OCR is negative ( $\theta > \theta_r$ ),

- (mean-downshifting and dispersion) when the initial belief is low ( $\frac{b}{1+b} \geq \tilde{\theta}$ ), OCRs decrease the mean but increase the variance of the customers’ WTP;
- (mean-downshifting and aggregation) when the initial belief is high ( $\frac{b}{1+b} < \tilde{\theta}$ ), OCRs decrease both the mean and the variance of the customers’ WTP.

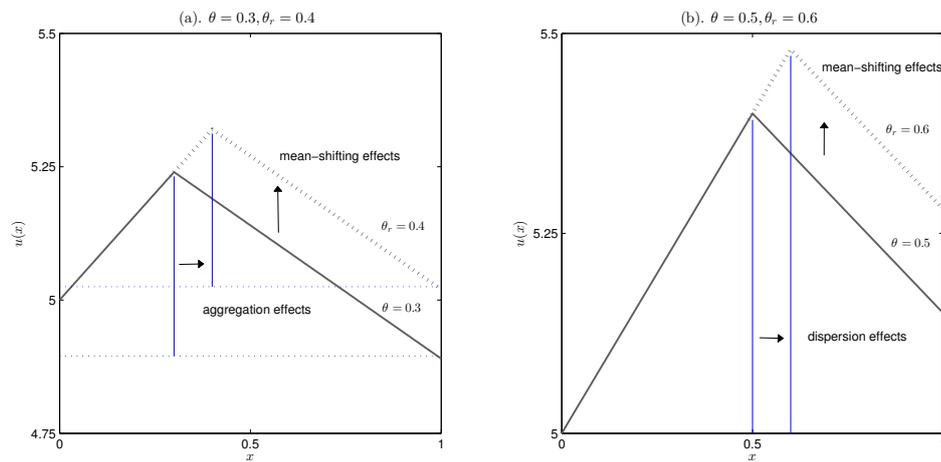


Figure 2. Impacts of nonnegative OCRs ( $\theta_r \geq \theta$ ,  $b = 0.5$ ,  $K = 5$ )

Figure 2 illustrates the impacts of nonnegative OCRs, in which WTP curve among customers on the RHS is shifted upward (i.e., those who with relatively higher personal tastes). Hence, the mean of customer WTP increases (mean-upshifting effects). Furthermore, when the initial belief  $\theta$  is low (represented by  $\frac{b}{1+b} \geq \tilde{\theta}$ ), positive OCRs contribute to the majority of the customers on the RHS, which leads to a smaller

variance in the WTP among all customers (i.e., aggregation effects; see Figure 2a). When the initial belief  $\theta$  is large ( $\frac{b}{1+b} < \tilde{\theta}$ ), only a minority of customers on the RHS benefit from OCRs. Thus, the WTP becomes even more dispersed among all customers (dispersion effects, see Figure 2b). This two-way pattern is also linked with the literature on customers' group attributes (Wei & Nault 2014).

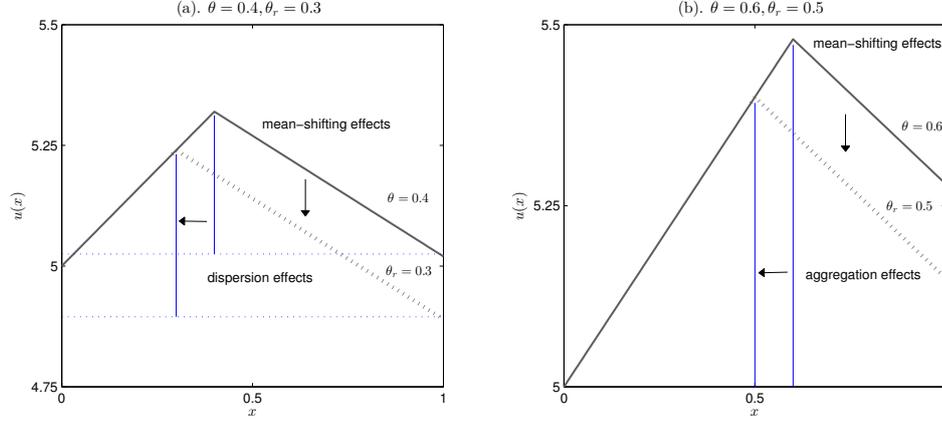


Figure 3. Impacts of negative OCRs ( $\theta_r < \theta$ ,  $b = 0.5$ ,  $K = 5$ )

Similarly, Figure 3 illustrates the impacts of negative OCRs ( $\theta_r < \theta$ ). In Figures 3a and 3b, the WTP is shifted downward among the customers with higher personal tastes. Hence, the mean of customer WTP always decreases (mean-downshifting effects). Moreover, when the initial belief  $\theta$  is low, negative OCRs lead to greater variance in the customer WTP because of the decreasing WTP among the majority of customers with higher personal taste (dispersion effects, see Figure 3a). In contrast, when the initial belief  $\theta$  is high, negative OCRs only reduce the WTP among a minority of customers on the RHS, which reduces the heterogeneity of the customer WTP (aggregation effects, see Figure 3b).

## 4 Benchmark: Vertically-integrated Channel

We start with the vertically-integrated channel where manufacturer and retailer operate together as one entity with price  $p_c$  and integrated profit  $\pi_c$ . For simplification purpose, we set the marginal production cost to zero.

Given price  $p_c$ , the number of paying customers is computed by the total population of customers with WTP no less than  $p_c$ . Given the WTP function defined by equation (1), various market adoption outcomes may emerge under different pricing strategies (see Figure 4 below). When the price  $p_c$  is sufficiently low, all customers can afford the product (the full-coverage pricing strategy shown in Figure 4a). At the other extreme, when  $p_c$  is high, only a small group of customers with a very high WTP can afford (Figure 4d), which is denoted by “target pricing strategy”. Finally, a moderate price might lead to adoptions at either the high-end (Figure 4b) or the low-end (Figure 4c), depending on the distribution patterns of the customers' tastes. The dark area in Figure 4 represents the customer surplus under each candidate strategy. Based on Figure 4, the demand function  $D(p_c|\theta)$  can be obtained.

$$D(p_c|\theta) = \begin{cases} 1, & p_c < \min\{u(0|\theta), u(1|\theta)\}; \\ 1 + K - p_c, & u(0|\theta) < p_c < u(1|\theta); \\ \frac{K+(1+b)\theta - p_c}{(1+b)\frac{b}{K+\theta - p_c}}, & u(0|\theta) \geq p_c \geq u(1|\theta); \\ \frac{b}{(1+b)(K+\theta - p_c)}, & p_c \geq \max\{u(0|\theta), u(1|\theta)\}. \end{cases} \quad (2)$$

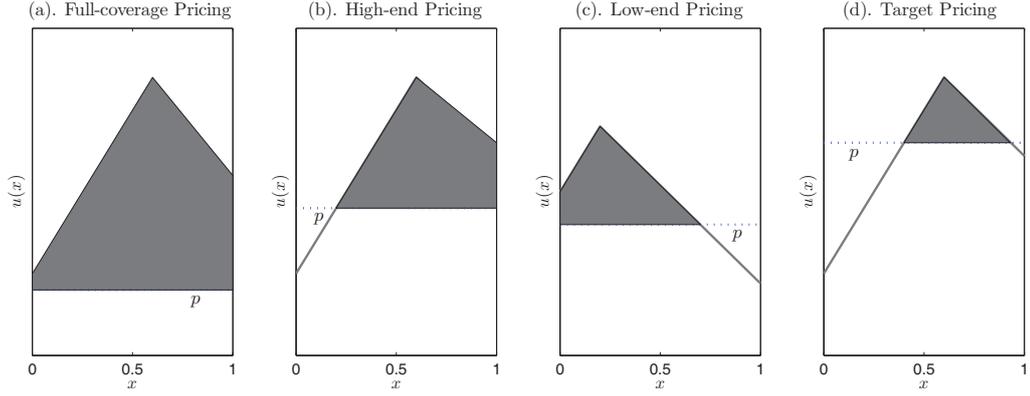


Figure 4. Illustrations of Candidate Pricing Strategies

Following Lemma 2 gives optimal prices and the corresponding profit. The regions in Lemma 2 are illustrated in Figure 5.

**Lemma 2. (Integrated Channel)** *Given the knowledge of functionalities  $\theta$ , the following cases emerge when the initial belief is low (i.e.,  $\theta < \frac{b}{1+b}$ ):*

- **Target pricing region:** *When  $K < \theta$ , it is optimal for the vertically-integrated channel to target those customers with personal tastes close to their knowledge of product functionalities. In this case,  $p_c^* = \frac{K+\theta}{2}$  and  $\pi_c^* = \frac{(1+b)(K+\theta)^2}{4b}$ .*
- **Low-end pricing region:** *When  $K \in [\theta, 2b - (1+b)\theta]$ , it is optimal for the vertically-integrated channel to cover the entire low end market on the LHS. Specifically,  $p_c^* = K$  and  $\pi_c^* = \frac{(1+b)K\theta}{b}$  for  $K \in [\theta, (1+b)\theta]$ , while  $p_c^* = \frac{K+(1+b)\theta}{2}$  and  $\pi_c^* = \frac{[K+(1+b)\theta]^2}{4b}$  for  $K \in [(1+b)\theta, 2b - (1+b)\theta]$ .*
- **Full-coverage pricing region:** *When  $K \geq 2b - (1+b)\theta$ , it is optimal for the vertically-integrated channel to cover the entire market. In this case,  $p_c^* = K + (1+b)\theta - b$  and  $\pi_c^* = K + (1+b)\theta - b$ .*

When the initial belief is high (i.e.,  $\theta \geq \frac{b}{1+b}$ ), we have another three different cases :

- **Target pricing region:** *When  $K < 2b - (1+2b)\theta$ , it is optimal for the vertically-integrated channel to target those customers with personal tastes that are similar to their knowledge of product functionalities. In this case,  $p_c^* = \frac{K+\theta}{2}$  and  $\pi_c^* = \frac{(1+b)(K+\theta)^2}{4b}$ .*
- **High-end pricing region:** *When  $K \in [2b - (1+b)\theta, 1)$ , it is optimal for the vertically-integrated channel to cover the entire low end market on the RHS. Specifically,  $p_c^* = K + (1+b)\theta - b$  and  $\pi_c^* = (1+b)(1-\theta)[K - b(1-\theta) + \theta]$  for  $K \in [2b - (1+b)\theta, 1 - 2\theta(1+b) + 2b]$ , while  $p_c^* = \frac{1+K}{2}$  and  $\pi_c^* = \frac{(1+K)^2}{4}$  for  $K \in [1 - 2\theta(1+b) + 2b, 1)$ .*
- **Full-coverage pricing region:** *When  $K \geq 1$ , it is optimal for the vertically-integrated channel to cover the entire market. In this case,  $p_c^* = K$  and  $\pi_c^* = K$ .*

In Figure 5, the vertical dashed line is the threshold  $\theta = \frac{b}{1+b}$ . Interestingly, the boundary of the full-coverage pricing strategy is divided into several subregions. As a result, when the initial belief  $\theta$  varies near the threshold  $\frac{b}{1+b}$ , the optimal market strategy for the vertically-integrated channel may switch quickly in an asymmetric manner. With a large  $K$  but small  $\theta$ , the full coverage pricing strategy is sensitive to  $\theta$  because it incurs large mismatch costs for customers with a large  $x$  (i.e., customers on the RHS). To maintain full-coverage pricing strategy, the optimal price has to satisfy  $p_c^* = u(1) = K + 1 - b(1 - \theta)$ , which depends on  $K$ ,  $b$ , and  $\theta$  at the same time. In sharp contrast, with both large  $K$  and large  $\theta$ , the

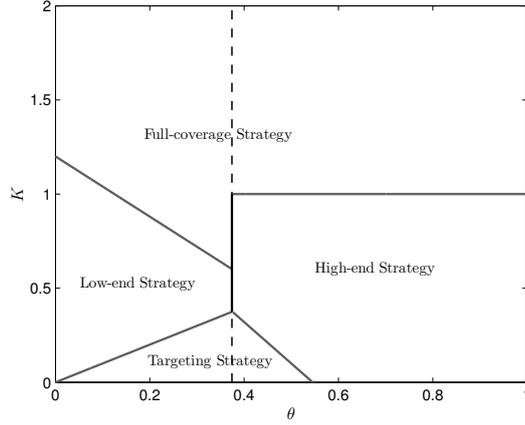


Figure 5. Strategy Regions for the Vertically-Integrated Channel ( $b = 0.6$ )

full-coverage pricing strategy is  $p_c^* = u(0) = K$ , which is not related to either  $b$  or  $\theta$ . These findings indicate that all of the parameters (i.e.,  $b$ ,  $K$ , and  $\theta$ ) are of nontrivial value for the optimal pricing strategy.

## 5 The Decentralized Channel

In the decentralized channel, the manufacturer moves first with wholesale price  $w$  and the retailer then chooses the market price  $p$ . We solve this sequential pricing equilibrium with backward induction. Due to the page limits, we omit the analysis on retailer's optimal strategy. The details are available from authors upon request. Following Proposition 1 characterizes the pricing strategies at the equilibrium.

**Proposition 1.** Let  $\rho_1 = \frac{b(2(1+b)-\sqrt{2(1+b)})}{(2+b)(1+b)}$ ,  $\rho_2 = \frac{2b+\sqrt{2(1+b)}}{2(1+b)+\sqrt{2(1+b)}}$ . Then  $0 < \rho_1 < \frac{b}{1+b} < \rho_2 < 1$  always hold. Given  $\theta$ , the following cases emerge at equilibrium when the initial belief is low (i.e.,  $\theta < \frac{b}{1+b}$ ):

- **Target pricing region:** When  $K < 3\theta$ , both the manufacturer and the retailer find that it is optimal to target those customers with personal tastes at a high price. In this case,  $w^* = \frac{K+\theta}{2}$  and  $p^* = \frac{3(K+\theta)}{4}$ .
- **Full-coverage region:** When  $K \geq \max[4b - \theta(1+b), \phi_2]$ , both the manufacturer and the retailer find that it is optimal to cover the entire market with  $w^* = K + (1+b)\theta - 2b$  and  $p^* = K + (1+b)\theta - b$ , in which  $\phi_2 = \frac{\theta(\theta+b)(1+b)-2b^2}{\theta-b(1-\theta)}$ .
- **Low-end pricing region:** For the remaining area, the low end market will be covered at the equilibrium. Specifically, when  $\theta < \rho_1$  and  $K \geq \phi_1$ , the interior solutions are optimal at equilibrium with  $w^* = \frac{K+\theta(1+b)}{2}$  and  $p^* = \frac{3[K+\theta(1+b)]}{4}$  in which  $\phi_1 = 3\theta(1+b) + 2\theta\sqrt{2b(1+b)}$ ; otherwise the boundary solutions are optimal with  $w^* = K - \theta$  and  $p^* = K$ .

When the initial belief is high (i.e.,  $\theta \geq \frac{b}{1+b}$ ), the following cases emerge:

- **Target pricing region:** When  $K < 4b(1-\theta) - \theta$ , both the manufacturer and the retailer find that it is optimal to target those customers with personal tastes at a high price. In this case,  $w^* = \frac{K+\theta}{2}$  and  $p^* = \frac{3(K+\theta)}{4}$ .
- **Full-coverage region:** When  $K \geq \max[3, \phi_3]$ , both the manufacturer and the retailer find that it is optimal to cover the entire market with  $w^* = K - 1$  and  $p^* = K$ , in which  $\phi_3 = \frac{1-(1+b)[2b-\theta(1+4b-\theta(1+2b))]}{\theta(1+b)-b}$ .
- **High-end pricing region:** For the remaining area, the high-end market will be covered at the equilibrium. Specifically, when  $\theta \geq \rho_2$  and  $K \geq \phi_4$ , the interior solutions are optimal at equilibrium with  $w^* = \frac{1+K}{2}$  and  $p^* = \frac{3(1+K)}{4}$  in which  $\phi_4 = 3 + 4[b - \theta(1+b)] + 2\sqrt{2(1+b(1-\theta)^2 - \theta(2-\theta))}$ ;

otherwise the boundary solutions are optimal with  $w^* = K + \theta(1 + 2b) - 2b$  and  $p^* = K + (1 + b)\theta - b(1 + b)(1 - \theta)$ .

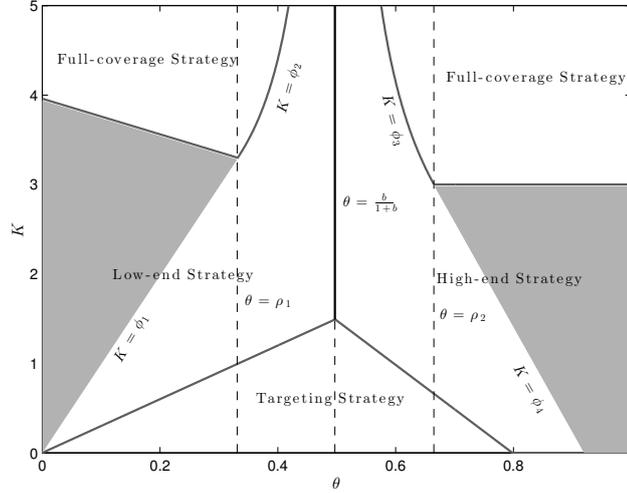


Figure 6. Regions for Pricing Strategies in the Decentralized Channel ( $b = 0.9$ )

Figure 6 shows the regions delineated by Proposition 1. Note that the boundaries of these regions are all functions of  $K$  and  $\theta$ . It can be shown that as  $K$  grows larger, the boundaries  $\phi_2$  and  $\phi_3$  both converge to  $\theta = \frac{b}{1+b}$  but they never overlap with each other. This implies that the low-end and high-end pricing strategies are always active for all possible  $K$ .

The dark area on both sides represents the regions where an interior solution is optimal for the low-end or high-end pricing strategies. It is important to differentiate the regions for the interior and boundary solutions because the optimal prices under boundary solution are not sensitive to  $\theta$ , which implies that OCRs do not play a role.

A comparison between Figure 5 and Figure 6 gives following observations: first, the region for the targeting strategy in Figure 6 is similar to our benchmark case shown in Figure 5; second, in Figure 6, the region for the full coverage strategy differs greatly from that in Figure 5, especially near the threshold value of  $\frac{b}{1+b}$ . In the decentralized channel, it is not optimal for the retailer to charge a low price and acquire the entire market due to the cost pressure from the manufacturer side. Instead, the manufacturer and retailer will find that it is optimal to cover either the low-end or high-end sides, rather than the entire market.

## 5.1 Impacts of OCRs

Next we focus on the effects of OCRs for both vertically-integrated and decentralized channels.

**Proposition 2.** *For the vertically-integrated channel, the optimal channel profit  $\pi_c^*$  is non-decreasing in  $\theta$ , which suggests that the integrated channel is never worse off with positive OCRs.*

Lemma 2 can be shown by the non-decreasing monotonicity of  $\pi_c^*$  in  $\theta \in [0, 1]$ . For any  $K$ , if  $\theta$  is sufficiently small and positive OCRs shift  $\theta$  upward to  $\theta_r$ , the channel's profit will not decrease because the feasible pricing area is extended (as shown in Figure 2). This finding appears intuitive, but they provide

a useful benchmark for examining the roles of OCRs and their impacts on optimal market strategies in the decentralized channel.

**Proposition 3. (Impacts of OCR on Manufacturer)** Let  $\rho_1, \rho_2, \phi_1, \phi_2, \phi_3$ , and  $\phi_4$  be as defined by Proposition 1. Define  $\rho_3 \in [0, \frac{b}{1+b})$ , which uniquely satisfies  $\pi_m(\rho_3) = \pi_m(1)$ . At equilibrium, the following regions emerge for the manufacturer:

- **Gain region:** If  $\theta \in [0, \rho_3]$ , then positive OCRs are always profit-improving;
- **Loss region:** If  $\theta \in [\frac{b}{1+b}, 1]$ , then positive OCRs are never profit-improving;
- **Other region:** If  $\theta \in [\rho_3, \frac{b}{1+b}]$ , then positive OCRs become profit-reducing when  $\theta_r$  is too high.

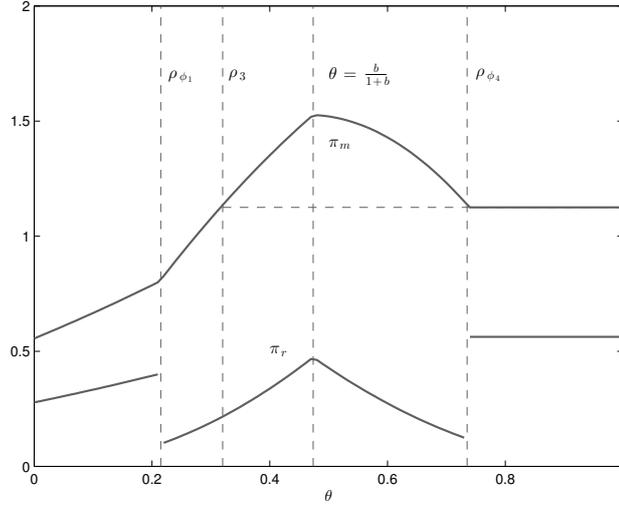


Figure 7. Optimal Profits in the Decentralized Channel ( $b = 0.9, K = 2$ )

Proposition 3 can be shown by proving that  $\pi_m^*$  is unimodal in  $\theta$ . Figure 7 shows the profit curves when  $K = 2$ , based on which it can be inferred from Figure 6 that only low-end or high-end strategies can be optimal. It can be found that  $\pi_m^*$  is non-decreasing on  $\theta \in [0, \frac{b}{1+b}]$  and non-increasing on  $\theta \in [\frac{b}{1+b}, 1]$ .

**Proposition 4. (Impacts of OCRs on the Decentralized Channel)** Define  $\rho_{\phi_i}$ , which satisfies  $K = \phi_i|_{\theta=\rho_{\phi_i}}$ . In the region where the boundary high-end pricing strategy is optimal, both the manufacturer's and the retailer's profits are decreasing with positive OCRs.

The Proposition 4 can be observed directly from Figure 7 in the region  $\theta \in [\frac{b}{1+b}, \rho_{\phi_4}]$ , where the high-end pricing strategy with boundary solutions is optimal (see the uncolored area of the high-end pricing strategy in Figure 6). At the equilibrium with  $\theta \in [\frac{b}{1+b}, \rho_{\phi_4}]$ , both manufacturer and the retailer suffer from a profit loss when  $\theta$  increases, which never occurs for the integrated channel.

Lastly we take a quick look at the OCRs' impacts on the channel efficiency. It is widely known in literature that double marginalization effects lead to channel inefficiency. This is because the retailer, given the manufacturer's wholesale price, will charge a market price which deviates from the "efficient" price. A line of literature has been exploring price and nonprice controls to coordinate manufacturer and retailer's decisions (e.g., Iyer 1998). Following Lemma discusses the profit gap between the vertically-integrated and decentralized channels when customers have fitness concerns defined by our model.

**Lemma 3.** If  $K \geq \frac{3b}{1+b}$ , then decentralized channel is coordinated at  $\theta = \frac{b}{1+b}$ .

Lemma 3 can be shown by comparing the total profit in decentralized channel to the profit of vertically-integrated channel at  $\theta = \frac{b}{1+b}$ . Then condition  $K \geq \frac{3b}{1+b}$  is also the sufficient and necessary condition for neither type of the channel to choose “target pricing strategy” at  $\theta = \frac{b}{1+b}$ .

It should be noted that Lemma 3 is contradicted with the literature by showing that a decentralized channel may coordinate itself without any incentive-alignment contracts. This is because customers’ fitness concerns dominate the impacts of double marginalization effects when  $\theta = \frac{b}{1+b}$ . When  $K \geq \frac{3b}{1+b}$ , the optimal strategy is equivalent under both channel structures. Specifically, at  $\theta = \frac{b}{1+b}$ , high-end strategy is equivalent to low-end strategy. As a result, it is optimal for both types of channels to cover the entire market. This is only possible when customers on both ends of the market have same WTP, which implies that Lemma 3 is built on the existence of unfit disutility  $b$ .

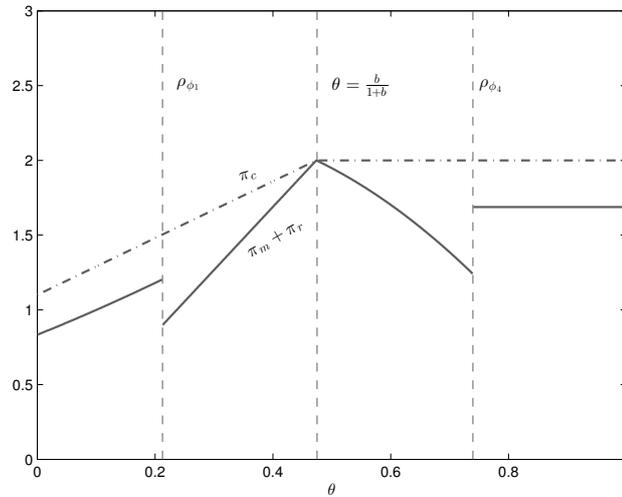


Figure 8. Channel Efficiency ( $K = 2, b = 0.9$ )

**Proposition 5.** An infinitesimal small amount of positive OCRs (1) increase channel efficiency when  $\theta$  is inside the region where boundary low-end pricing strategy is optimal ( $\theta \in (\rho_{\phi_1}, \frac{b}{1+b})$ ), and (2) decreases the channel efficiency when  $\theta$  is inside the region where boundary high-end pricing strategy is optimal ( $\theta \in (\frac{b}{1+b}, \rho_{\phi_4})$ ).

Proposition 5 can be obtained from the monotonicity of the curve  $\pi_m + \pi_r$  which is shown in Figure 8. Proposition 5 suggests that positive OCRs have two-way impacts: When  $\theta$  is smaller than  $\frac{b}{1+b}$ , positive OCRs reduces the profit gap between two types of channels by shrinking the gap between WTP of customers on both ends of the market, in which case the full-coverage pricing strategy is likely to be optimal; When  $\theta$  is greater than  $\frac{b}{1+b}$ , equivalent to Proposition 4, positive OCRs will increase the variance of customer WTP and force the decentralized channel to focus only on the high-end market, which reduces the total profit of the channel due to the double marginalization.

## 6 Model Extension: Information Asymmetry

Previous sections have investigated both the vertically-integrated and decentralized channels under the assumption that the manufacturer and the retailer can fully observe OCRs (i.e., OCR information is symmetric among channel members). In this section, we extend our model by examining the case of information asymmetry. To capture a more realistic scenario, we assume that the retailer is able to fully

observe  $\theta_r$  because it is relatively easier for the retailer to access customers, whereas the manufacturer with limited information believes that the customers' knowledge always remains at the initial level of  $\theta$ . Note that  $\theta > \theta_r$  or  $\theta < \theta_r$  indicates that the manufacturer overestimates or underestimates, respectively, customers' knowledge of functionalities.

Table 1 provides the numerical results for the profit  $\{\pi_m^*, \pi_r^*\}$  under asymmetric information  $\theta$  (the manufacturer's estimation) and  $\theta_r$  (the retailer's information). Several interesting patterns are shown in Table 1. First, on the retailer side, as  $\theta_r$  increases from left to right in each row (i.e., positive OCRs),  $\pi_r^*$  always increases. This implies that the retailer can always benefit from positive information. Second,  $\pi_m^*$  is not monotonic in  $\theta_r$  (for example, in the case where  $\theta = 0.5$ ,  $\pi_m^*$  first increases to 2.38 but drops to 1.68 subsequently). Take a close look at the case when  $\theta$  is at medium level near  $\theta = 0.5$ . In this case, the manufacturer is more likely to increase the wholesale price, which drives toward a targeting strategy. This case could be extremely dangerous for the retailer because the bias in  $\theta$  will largely undermine the retailer's profit. For example, in the cell of  $\{\theta = 0.5, \theta_r = 0.1\}$ , which represents the case where the manufacturer overestimates customers' knowledge, both the manufacturer and the retailer achieve the smallest profits according to the table. As  $\theta$  becomes sufficiently large, both profits are less sensitive to information asymmetry because the manufacturer will choose the full coverage strategy, which is independent of  $\theta$ . The following remark summarizes the findings described above.

**Remark 1.** (1) When the manufacturer has biased information and underestimates customers' knowledge, the retailer may be better off; but, (2) when the manufacturer overestimates customers' knowledge, the information asymmetry reduces both the manufacturer's and the retailer's profits.

$\{\pi_m^*, \pi_r^*\}$		$\theta_r$				
		0.1	0.3	0.5	0.7	0.9
$\theta$	0.1	{1.77, 0.70}	{1.77, 1.04}	{1.77, 1.23}	{1.77, 1.23}	{1.77, 1.23}
	0.3	{1.60, 0.40}	{2.11, 0.70}	{2.00, 0.89}	{2.00, 0.89}	{2.00, 0.89}
	0.5	{0.74, 0.05}	{1.70, 0.15}	{2.38, 0.30}	{1.68, 0.36}	{1.68, 0.36}
	0.7	{1.67, 0.49}	{2.00, 0.81}	{2.00, 1.00}	{2.00, 1.00}	{2.00, 1.00}
	0.9	{1.67, 0.49}	{2.00, 0.81}	{2.00, 1.00}	{2.00, 1.00}	{2.00, 1.00}

Table 1. Optimal Profits under Asymmetric Information ( $K = 3, b = 0.7$ )

The robustness of this numerical finding is robust under variation of parameters (omitted due to page limit). To conclude our analysis based on numerical results, information asymmetry is not always profit-reducing. Compared with the manufacturer's underestimation case, the manufacturer's overestimation case is more damaging for both the manufacturer and the retailer because the manufacturer will choose to overprice with underestimation.

## 7 Discussion and Conclusion

Prior studies have focused disproportionately on the impacts of OCRs on the customer side, whereas we analyze the impacts of OCRs on the supply side in this paper. In particular, we find that the distribution of the customer WTP can be modified by OCRs, thereby leading to changes in the channel's price strategies at the equilibrium. Benchmarked by a vertically-integrated channel, we find that positive OCRs could result in profit reductions for both the manufacturer and the retailer in the decentralized channel. This is because double marginalization drives manufacturers to overprice in response to positive OCRs. We also conduct a numerical analysis for the case when the manufacturer is less informed about OCRs than the retailer.

Our model results provide a line of implications for strategic use and manipulations of OCRs. First, on the contrary to vast literature, we show with Lemma 3 that decentralized channel can coordinate itself at a specific level of customer's knowledge of functionalities. This is due to the high-end customers' fitness concerns so that full-coverage pricing strategy may become optimal for both channel structures simultaneously. Based on this, we show in Proposition 5 that positive OCRs may either increase or decrease the channel efficiency by intensifying or alleviating double marginalization effects. The software package of Netscape, the pioneer web browser in 1990s, was once sold in software stores at \$79 in 1996 and tries to target wealthy computer users, which turns out to be a huge failure. In 2011, Hewlett-Packard (HP) released its first generation of Tablet computer, HP Touchpad with WebOS, which is widely believed to be "next iPad" with unique features such as multi-tasking and conference calls. However, HP aggressively set the price at \$499 (for 16GB version, which is exactly the same price of 16GB version of iPad 2) which leads to a huge loss too. The product line of HP Touchpad is soon eliminated only 49 days after the launch date. Our paper provides an explanation that positive OCRs may lead to overprice and thus cannibalize the profit, especially in the presence of strong fitness concern (customers may have stronger fitness concern with the existence of substitutes).

Second, our numerical findings also provide interesting insights on the information sharing mechanism of decentralized channel when the channel presents information asymmetry. Specifically, retailer has no incentive to share the information with manufacturer only when manufacturer overestimates the customer's knowledge. Therefore, the information passed from retailer to manufacturer is largely biased since retailer is not willing to share positive OCRs. We further highlight that, it may become extremely risky if manufacturer with limited information chooses to target a small group of customers. Our model implies that when manufacturer has little information, it is necessary for the manufacturer to share information with local sales agents or resellers via a vertically-integrated channel becomes necessary.

This research can be extended in multiple directions to address other aspects of the impacts of OCRs. For example, it would be very interesting to determine whether the dynamics of OCR accumulation can be controlled or manipulated endogenously.

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